EDEXCEL A-LEVEL CHEMISTRY

CHEMISTRY



EXAM QUESTION PACK

UNIT 2 OLD SPECIFICATION PAPERS

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Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Friday 9 June 2017 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

You must have: Scientific calculator

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which molecule is polar?

☒ **A** $BeCl_2$

☒ **B** CO_2

☒ **C** CH_4

☒ **D** H_2S

(Total for Question 1 = 1 mark)

2 Which is **not** a disproportionation reaction?

☒ **A** $3ClO^- \rightarrow 2Cl^- + ClO_3^-$

☒ **B** $I_2 + 5O_3 + H_2O \rightarrow 2HIO_3 + 5O_2$

☒ **C** $Br_2 + 2OH^- \rightarrow BrO^- + Br^- + H_2O$

☒ **D** $I_2 + H_2O \rightarrow HI + HIO$

(Total for Question 2 = 1 mark)

3 Two layers form when the non-polar solvent cyclohexane (density 0.78 g cm^{-3}) is mixed with a dilute solution of aqueous iodine (density 1.03 g cm^{-3}) and left to stand. The colours of the layers are

	Lower layer	Upper layer
☒ **A**	purple	brown
☒ **B**	brown	black
☒ **C**	yellow	purple
☒ **D**	brown	yellow

(Total for Question 3 = 1 mark)

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4 A solution of a metal salt produced a white precipitate with barium chloride solution and the mixture fizzed when dilute nitric acid was added. The metal salt could be

☒ **A** Na_2SO_4

☒ **B** $MgSO_4$

☒ **C** Na_2CO_3

☒ **D** $AgNO_3$

(Total for Question 4 = 1 mark)

5 The **least** soluble hydroxide and **least** soluble sulfate of barium and magnesium are

☒ **A** $Mg(OH)_2$ and $MgSO_4$

☒ **B** $Mg(OH)_2$ and $BaSO_4$

☒ **C** $Ba(OH)_2$ and $MgSO_4$

☒ **D** $Ba(OH)_2$ and $BaSO_4$

(Total for Question 5 = 1 mark)

6 The reaction which results in effervescence is

☒ **A** calcium and water.

☒ **B** strontium and chlorine.

☒ **C** magnesium oxide and water.

☒ **D** barium hydroxide and dilute nitric acid.

(Total for Question 6 = 1 mark)

7 Hydrogen can be produced from

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \qquad \Delta H = -41 \text{ kJ mol}^{-1}$$

Which will shift the equilibrium position to the right?

☒ **A** Raising the temperature

☒ **B** Increasing the pressure

☒ **C** Adding a catalyst

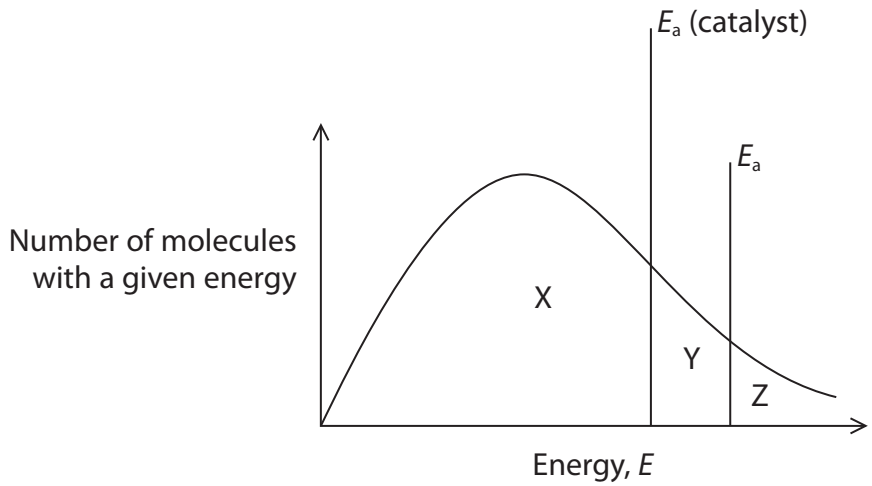
☒ **D** Removing the carbon dioxide

(Total for Question 7 = 1 mark)

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8 The Maxwell-Boltzmann diagram shows the distribution of molecular energies for a gaseous system with the activation energy labelled, both with and without a catalyst.



(a) The area indicating the number of molecules with energy exceeding the activation energy in the presence of a catalyst is

(1)

☒ **A** X + Y + Z

☒ **B** Y + Z

☒ **C** Y

☒ **D** Z

(b) When the temperature is **increased**, the peak in the Maxwell-Boltzmann diagram

(1)

☒ **A** moves to the left and the height stays the same.

☒ **B** moves to the left and the height increases.

☒ **C** moves to the right and the height stays the same.

☒ **D** moves to the right and the height decreases.

(Total for Question 8 = 2 marks)

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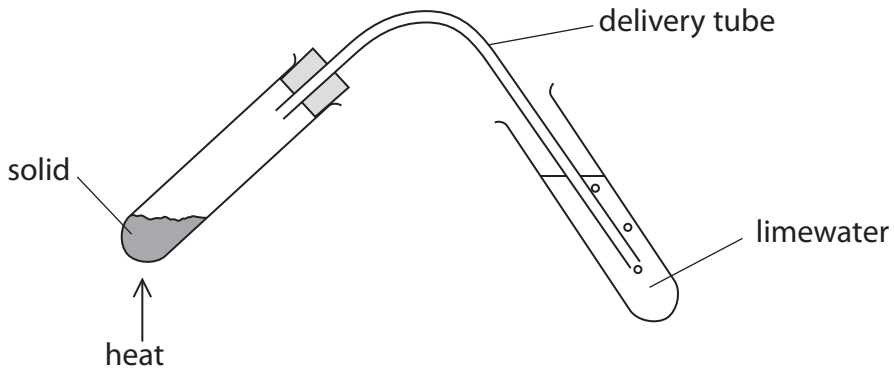
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9 The molecule with the strongest London forces is

- ☒ **A** CF_4
- ☒ **B** CHF_2Cl
- ☒ **C** CH_2Cl_2
- ☒ **D** CH_3I

(Total for Question 9 = 1 mark)

10 Separate samples of lithium carbonate and magnesium carbonate were heated using the apparatus shown.



(a) The limewater went cloudy for

(1)

- ☒ **A** both carbonates.
- ☒ **B** only lithium carbonate.
- ☒ **C** only magnesium carbonate.
- ☒ **D** neither carbonate.

(b) In a test with limewater, the cloudiness is due to the formation of a precipitate of

(1)

- ☒ **A** calcium carbonate.
- ☒ **B** calcium hydrogencarbonate.
- ☒ **C** calcium hydroxide.
- ☒ **D** calcium oxide.

(Total for Question 10 = 2 marks)

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11 Anhydrous calcium nitrate decomposes on heating.

(a) This action of heat produces a white solid and

(1)

☒ **A** only a brown gas.

☒ **B** only a gas that relights a glowing splint.

☒ **C** both a brown gas and a gas that relights a glowing splint.

☒ **D** only a colourless, inert gas.

(b) Decomposition occurs quite easily because of the

(1)

☒ **A** polarisation of the calcium ion by the nitrate ion.

☒ **B** polarisation of the nitrate ion by the calcium ion.

☒ **C** distortion of the calcium electron cloud by the nitrate ion.

☒ **D** repulsion of the nitrate electron cloud by the calcium ion.

(Total for Question 11 = 2 marks)

12 Given the following boiling temperatures, select the likely boiling temperature for hydrogen fluoride, HF.

Hydrogen halide	Boiling temperature / K
HCl	188
HBr	206
HI	238

☒ **A** 156 K

☒ **B** 172 K

☒ **C** 184 K

☒ **D** 293 K

(Total for Question 12 = 1 mark)

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13 The fragment with a peak of *m/e* = 43 is present in the mass spectrum of

☒ **A** $CH_3CH(CH_3)CH_2Br$ and $CH_3CBr(CH_3)_2$

☒ **B** $CH_3CH_2CH_2CH_2Br$ and $CH_3CHBrCH_2CH_3$

☒ **C** $CH_3CH_2CH_2CH_2Br$ and $CH_3CH(CH_3)CH_2Br$

☒ **D** $CH_3CH(CH_3)CH_2Br$ and $CH_3CHBrCH_2CH_3$

(Total for Question 13 = 1 mark)

14 Depending on the conditions, ethanol, CH_3CH_2OH, can be oxidized to ethanal, CH_3CHO, ethanoic acid, CH_3COOH or mixture of the two.

Mass spectrometry can be used to identify the products.

The **absence** of a fragment ion peak m/e = 45 indicates that

☒ **A** all the product is ethanoic acid.

☒ **B** all the product is ethanal.

☒ **C** none of the ethanol has been oxidized.

☒ **D** the product is a mixture of ethanal and ethanoic acid.

(Total for Question 14 = 1 mark)

15 Trichlorofluoromethane, $CFCl_3$, is a greenhouse gas because it

☒ **A** absorbs infrared radiation and forms chlorine free radicals.

☒ **B** absorbs infrared radiation and re-radiates it back to Earth.

☒ **C** absorbs ultraviolet radiation and forms chlorine free radicals.

☒ **D** absorbs ultraviolet radiation and re-radiates it back to Earth.

(Total for Question 15 = 1 mark)

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16 A 0.990 g sample of 1,2-dichloroethane was completely hydrolysed and silver nitrate was then added to produce a white precipitate. The maximum mass of precipitate possible is

[Molar masses: 1,2-dichloroethane = 99 g mol^{-1}, silver chloride = 143.4 g mol^{-1}]

☒ **A** 0.990 g

☒ **B** 1.434 g

☒ **C** 2.424 g

☒ **D** 2.868 g

(Total for Question 16 = 1 mark)

17 Which observations about silver chloride and silver bromide are correct?

	Action of sunlight	Action of dilute ammonia
☒ **A**	both turn grey	only silver chloride dissolves
☒ **B**	only silver chloride turns grey	both silver halides dissolve
☒ **C**	only silver bromide turns grey	only silver chloride dissolves
☒ **D**	no effect on either silver halide	both silver halides dissolve

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

18 This is a question about the structure of substances.

(a) Predict the H—N—H bond angle in NH_4^+ and the H—O—H bond angle in H_3O^+.

(2)

NH_4^+ .....

H_3O^+ .....

(b) Name the shapes of the BF_3 and PH_3 molecules and explain why they are different.

(4)

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*(c) Explain, with reference to the structure and bonding of each substance, why the electrical conductivity of graphite is 1.0×10^{5} S m^{-1} but that of diamond is 1.0×10^{-2} S m^{-1}.

(4)

(d) Explain why the Cl—Cl bond length is 0.199 nm, but the I—I bond length is 0.267 nm.

(3)

(Total for Question 18 = 13 marks)

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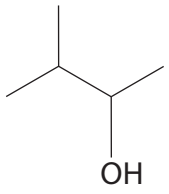
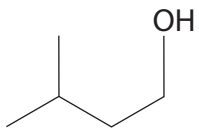
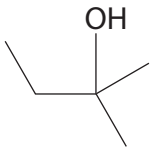
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19 This is a question about alcohols and compounds made from them.

(a) (i) Complete the table about some of the structural isomers with the molecular formula $C_5H_{12}O$.

(3)

Name	Skeletal Formula	Classification
2,2-dimethylpropan-1-ol		Primary
		Secondary
3-methylbutan-1-ol		
2-methylbutan-2-ol		

(ii) Identify, by name or formula, the alcohol which is the **branched** structural isomer with molecular formula $C_5H_{12}O$ that is **not** in the table.

(1)

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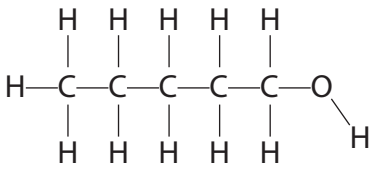
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(iii) Explain why 2,2-dimethylpropan-1-ol has a significantly lower boiling temperature than the isomer pentan-1-ol.

(2)

(iv) Draw a hydrogen bond between a water molecule and the pentan-1-ol molecule. Clearly label the bond angle about the hydrogen involved in the hydrogen bond.

(2)



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(b) Ethanol, C_2H_5OH, can be oxidized to ethanoic acid, CH_3COOH.

(i) Give the formula of a suitable oxidizing agent and the conditions required.

(2)

Oxidizing agent .....

Conditions .....

(ii) Using the symbol, [O], for the oxidizing agent, write the equation for the oxidation of ethanol to ethanoic acid. State symbols are not required.

(1)

(iii) Draw, and fully label, the apparatus that would be used to carry out the complete oxidation of ethanol to ethanoic acid. Include any material that would be used to ensure that boiling is controlled and not violent.

(3)

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(c) A sample of ethanol was oxidized completely. After separation, 5.00 g of a mixture of ethanoic acid and water was obtained.

The mixture was added to a 500 cm^3 volumetric flask, made up to the mark with deionized water and shaken thoroughly. The concentration of this diluted solution was determined by titration with sodium hydroxide solution, of concentration 0.200 mol dm^{-3}. The following results were obtained using 25.0 cm^3 pipetted aliquots of this diluted ethanoic acid solution.

Titration	Trial	1	2	3
Final volume /cm^3	14.20	19.50	34.45	49.00
Initial volume /cm^3	0.00	5.00	20.00	34.45
Volume added /cm^3	14.20	14.50	14.45	14.55

Mean titre = 14.50 cm^3

(i) State what is unusual about the value of the trial titre.

Suggest a possible fault with the use of a pipette that could explain this value.

You may assume that the bottom of the meniscus was correctly aligned to the mark on the pipette.

(2)

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(ii) The reaction between ethanoic acid and sodium hydroxide has a 1:1 mole ratio.

Calculate the concentration of the diluted ethanoic acid solution in mol dm^{-3}.

(2)

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(iii) Calculate the mass of ethanoic acid in 500 cm^3 of the diluted solution.

(2)

(d) Alcohols can undergo complete or incomplete combustion.

(i) Write the equation for the complete combustion of hexan-1-ol, $C_6H_{13}OH$.
State symbols are not required.

(1)

(ii) Write the equation for the incomplete combustion of hexan-1-ol which produces **only** carbon and water. State symbols are not required.

(1)

(iii) Calculate the volume of oxygen, measured at room temperature and pressure, required for the complete combustion of one mole of hexan-1-ol.

State the likely observation if 500 dm^3 of air containing 20% of oxygen was present for the combustion of one mole of hexan-1-ol.
Justify your answer.

[Molar volume = 24.0 dm^3 mol^{-1} at room temperature and pressure]

(3)

Volume =

Observation and justification .....

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(Total for Question 19 = 25 marks)

TOTAL FOR SECTION B = 38 MARKS

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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

20 Fireworks are designed to explode in a controlled manner with bursts of brightly coloured light and loud bangs. It is believed that fireworks originated in China, after the discovery of gunpowder over 1000 years ago. Fireworks essentially consist of:

- colour-producing compounds (often metal salts)
- fuel
- oxidizer
- binders (often a type of starch)
- fuse.

In addition, there may be substances known as chlorine donors to strengthen the colour, regulators to control the rate of reaction and reducing agents to produce hot gases. Inside the firework are small globules, called stars, which give fireworks their colour when they explode, for example calcium carbonate is used to produce an orange-red colour. If these stars are arranged randomly, then they will spread out in the sky on explosion. However, if the stars are packed in a regular pattern, then, on explosion, a particular shape can be created in the sky.

(a) Give the **formulae** of two metal carbonates that could be used to produce a bright red colour from an exploding firework.

(2)

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*(b) Explain, by reference to electronic transitions, how the metal ions produce the colours of the firework.

(3)

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(c) Suggest a metal which may be used to produce a white colour in a firework and give the name of the compound produced.

(2)

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.....

(d) Gunpowder is often used in fireworks. It is a mixture of charcoal, sulfur and potassium nitrate.

(i) Complete the equation for one of the chemical reactions that occurs when gunpowder burns.

(2)

.....KNO_3 + ...S + ...C → .....K_2S + ...N_2 + ...

(ii) Identify two different atoms that have been reduced and state the change in their oxidation numbers.

(3)

Atom..... Oxidation number change from ..... to .....

Atom..... Oxidation number change from ..... to .....

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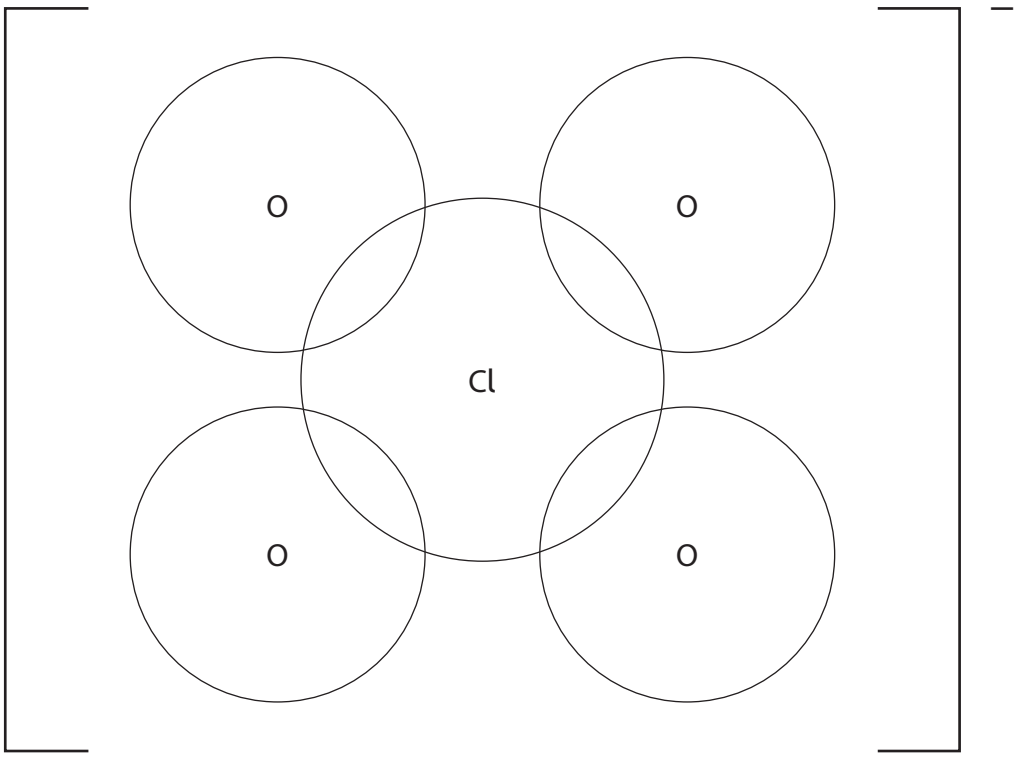
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(e) In the 1830s, the more explosive oxidizers called chlorates were discovered.
One of these is potassium chlorate(VII), $KClO_4$.

(i) Suggest how the dot-and-cross diagram for the chlorate(VII) ion may be completed.

Use dots (•) for the chlorine electrons, crosses (×) for the oxygen electrons and an asterisk(*) for the extra electron on one of the oxygen atoms.

(2)



(ii) Environmentalists have raised concerns about the use of potassium chlorate(VII) so alternatives are being investigated.

Suggest **one** possible impact on the environment that potassium chlorate(VII) may have.

(2)

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*(f) Describe fully how the fuse in a firework starts the chemical reaction and why it is not a catalyst.

(3)

*(g) Use your knowledge of reaction kinetics to suggest **two** factors that could affect the rate of reaction of the solids in a firework. Justify your answer.

(3)

(Total for Question 20 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

Summer 2017

Pearson Edexcel GCE In Chemistry (6CH02/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Answer	Mark
1	**1. The only correct answer is D** ***A*** *is not correct because* $BeCl_2$ *is linear and the bond polarities cancel to make the molecule non-polar* ***B*** *is not correct because* CO_2 *is linear and the bond polarities cancel to make the molecule non-polar* ***C*** *is not correct because* CH_4 *is tetrahedral and the bond polarities cancel to make the molecule non-polar*	1

Question Number	Answer	Mark
2	**2. The only correct answer is B** ***A*** *is not correct because chlorine is oxidised from +1 to +5 and reduced to -1* ***C*** *is not correct because bromine is oxidised from 0 to +1 and reduced to -1* ***D*** *is not correct because iodine is oxidised from +1 to +1 and reduced to -1*	1

Question Number	Answer	Mark
3	**3. The only correct answer is C** ***A*** *is not correct because the purple layer will be the upper layer* ***B*** *is not correct because iodine does not produce a black colour in cyclohexane* ***D*** *is not correct because iodine does not produce a yellow colour in cyclohexane*	1

Question Number	Answer	Mark
4	**4. The only correct answer is C** ***A*** *is not correct because there would be no fizzing with dilute nitric acid* ***B*** *is not correct because there would be no fizzing with dilute nitric acid* ***D*** *is not correct because there would be no fizzing with dilute nitric acid*	1

Question Number	Answer	Mark
5	**5. The only correct answer is B** ***A*** *is not correct because Group 2 solubility's decrease down the group* ***C*** *is not correct because both hydroxide and sulfate solubility trends are incorrect* ***D*** *is not correct because Group 2 hydroxides decrease up the group*	1

Question Number	Answer	Mark
6	**6. The only correct answer is A** ***B*** *is not correct because this reaction does not produce effervescence, only a white solid* ***C*** *is not correct because this reaction does not produce effervescence, only some dissolving of the white solid* ***D*** *is not correct because this reaction does not produce effervescence, only the white solid disappears*	1

Question Number	Answer	Mark
7	**7. The only correct answer is D** ***A*** *is not correct because this will shift the equilibrium to the left and decrease hydrogen production* ***B*** *is not correct because this will shift not affect the equilibrium as there are equal moles each side of the equation and so not affect hydrogen production* ***C*** *is not correct because this will not affect the equilibrium position, merely the rate at which equilibrium reached and so not affect hydrogen production*	1

Question Number	Answer	Mark
8(a)	**8(a). The only correct answer is B** ***A*** *is not correct because this is all of the molecules present and not just those affected by the catalyst* ***C*** *is not correct because this is only the additional molecules that can react in the presence of a catalyst* ***D*** *is not correct because this is only the additional molecules that can react in the absence of a catalyst*	1

Question Number	Answer	Mark
8(b)	**8(b). The only correct answer is D** ***A*** *is not correct because peak height decreases and lowering the temperature moves the peak to the left* ***B*** *is not correct because this is the effect of lowering the temperature* ***C*** *is not correct because the height of the peak must decrease to keep the total number of molecules the same*	1

Question Number	Answer	Mark
9	**9. The only correct answer is D** ***A*** *is not correct because* CF_4 *only has 42 electrons compared to 62 for* CH_3I ***B*** *is not correct because* CHF_2Cl *only has 42 electrons compared to 62 for* CH_3I ***C*** *is not correct because* CH_2Cl_2 *only has 42 electrons compared to 62 for* CH_3I	1

Question Number	Answer	Mark
10(a)	**10(a). The only correct answer is A** ***B*** *is not correct because magnesium carbonate also decomposes on heating* ***C*** *is not correct because lithium carbonate also decomposes on heating* ***D*** *is not correct because both carbonates decompose on heating*	1

Question Number	Answer	Mark
10(b)	**10(b). The only correct answer is A** ***B*** *is not correct because calcium hydrogencarbonate is soluble* ***C*** *is not correct because calcium hydroxide is limewater solution* ***D*** *is not correct because this is not formed by bubbling carbon dioxide through calcium hydroxide solution*	1

Question Number	Answer	Mark
11(a)	**11(a). The only correct answer is C** ***A*** *is not correct because oxygen gas is also evolved* ***B*** *is not correct because brown nitrogen dioxide is also evolved* ***D*** *is not correct because brown nitrogen dioxide is evolved and colourless oxygen is not inert*	1

Question Number	Answer	Mark
11(b)	**11(b). The only correct answer is B** ***A*** *is not correct because the cation is not polarised but polarising* ***C*** *is not correct because this is a description of polarisation but the cation is the polariser and not polarised* ***D*** *is not correct because the nitrate electron cloud is attracted by the calcium ion and not repelled*	1

Question Number	Answer	Mark
12	**12. The only correct answer is D** ***A*** *is not correct because the hydrogen bonding in HF results in a much higher boiling temperature than even HI which has the strongest London forces and not the lowest boiling temperature* ***B*** *is not correct because the hydrogen bonding in HF results in a much higher boiling temperature than even HI which has the strongest London forces and not the lowest boiling temperature* ***C*** *is not correct because the hydrogen bonding in HF results in a much higher boiling temperature than even HI which has the strongest London forces and not the lowest boiling temperature*	1

Question Number	Answer	Mark
13	**13. The only correct answer is C** ***A*** *is not correct because there is no* $C_3H_7^+$ *fragment produced from* $CH_3CBr(CH_3)_2$ ***B*** *is not correct because there is no* $C_3H_7^+$ *fragment produced from* $CH_3CHBrCH_2CH_3$ ***D*** *is not correct because there is no* $C_3H_7^+$ *fragment produced from* $CH_3CHBrCH_2CH_3$	1

Question Number	Answer	Mark
14	**14. The only correct answer is B** ***A*** *is not correct because ethanoic acid would produce a fragment* $COOH^+$ *m/e=45* ***C*** *is not correct because ethanol would produce a fragment* $C_2H_5O^+$ *m/e=45* ***D*** *is not correct because if ethanoic acid was present then it would produce a fragment* $COOH^+$ *m/e=45*	1

Question Number	Answer	Mark
15	**15. The only correct answer is B** ***A*** *is not correct because chlorine free radicals are not absorbed from absorbing infrared radiation* ***C*** *is not correct because the absorption of ultraviolet does not result in a compound being a green house gas* ***D*** *is not correct because i*	1

Question Number	Answer	Mark
16	**16. The only correct answer is D** ***A*** *is not correct because the ratio 2:1 has been used the wrong way round* ***B*** *is not correct because this is the result for the presence of mono-substituted chloroalkane not d-substituted* ***C*** *is not correct because this is adding a factor of two more moles, which give a 1:3 ratio, instead of doubling by two*	1

Question Number	Answer	Mark
17	**17. The only correct answer is A** ***B*** *is not correct because silver bromide would decompose in sunlight and silver bromide does not dissolve in dilute ammonia* ***C*** *is not correct because silver chloride would also decompose in sunlight* ***D*** *is not correct because both silver halides would decompose in sunlight and only silver chloride would dissolve in dilute ammonia*	1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
18 (a)	(NH_4^+) $109.5^{(o)}$ / 109° 28′ ALLOW $109^{(o)}$ (1) (H_3O^+) $107^{(o)}$ (1) ALLOW $106 - 108^{(o)}$ ALLOW The true value of $113^{(o)}$ but with no latitude		2

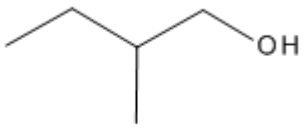
Question Number	Acceptable Answers	Reject	Mark
18 (b)	BF_3 is trigonal planar ALLOW Triangular planar (1) PH_3 is (triangular/trigonal) pyramidal (1) PH_3 has a lone pair of electrons (1) and four areas of electron repulsion (not three) OR BF_3 has three areas of electron repulsion (not four) (1)		4

Question Number	Acceptable Answers	Reject	Mark
18 (c)	Graphite has delocalised electrons but diamond does not have delocalised electrons (1) In graphite each carbon atom forms 3 covalent bonds **and** one electron delocalised (1) All the electrons in diamond are involved in bonding/all the electrons in diamond are localised in bonding/each carbon atom forms 4 covalent bonds (1) Delocalised electrons can move (and carry charge hence the greater conductivity in graphite) (1)		4

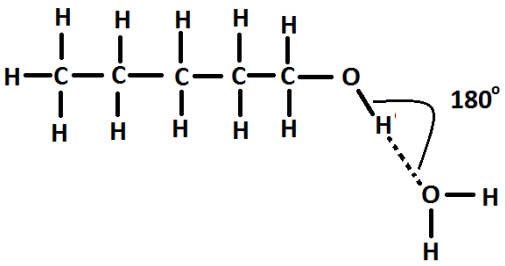
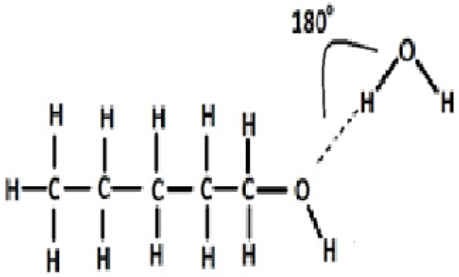
Question Number	Acceptable Answers	Reject	Mark
18 (d)	Iodine has more shells of electrons/has a larger atomic radius (1) therefore Iodine has greater shielding (of its nuclear charge) (1) there is less attraction between the nucleus and the **bonding** pair of electrons (even though iodine has more protons) (1) ALLOW reverse argument for chlorine IGNORE References to electronegativity	Ionic radius Iodine molecules	3

(Total for Question 18 = 13 MARKS)

Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	(skeletal formula)  IGNORE Bond lengths, bond angles and orientation Bond to the H of the OH (1) (Name) 3-methylbutan-2-ol IGNORE punctuation (1) (Classification) (3-methylbutan-1-ol) Primary **and** (2-methylbutan-2-ol) Tertiary (1)		3

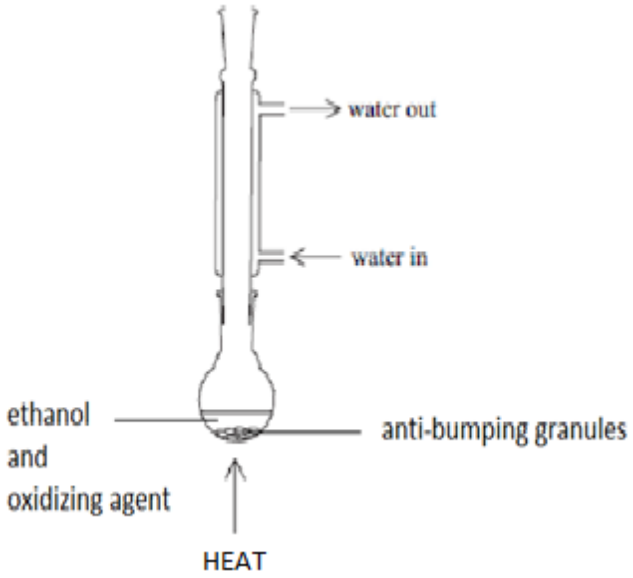
Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	Either 2-methylbutan-1-ol OR  OR displayed /structural formula If name and formula are given then both must be correct		1

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iii)	2,2-dimethylpropan-1-ol has weaker London forces/van der Waals' forces/instantaneous dipole induced dipole forces/dispersion forces IGNORE Reference to intermolecular forces (1) Because the branching reduces the surface area (contact possible between the molecules) ALLOW Molecules are unable to arrange themselves as closely together/pack less well Suitable labelled diagram (1) Ignore references to —OH group/hydrogen bonding ALLOW reverse arguments for pentan-1-ol	Different numbers of electrons	2

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iv)	Diagram such as  Linear O—H ……O hydrogen bond (1) 180° with clear label (1) IGNORE presence or absence of dipoles and lone pairs Alternative diagram  If two hydrogen bonds are drawn then both must be correct IGNORE length of hydrogen bond ALLOW (1) if a hydrogen bond is drawn correctly between two pentan-1-ol molecules	Label to the H or O atoms	2

Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	(Oxidizing agent) $Na_2Cr_2O_7$ / $K_2Cr_2O_7$ ALLOW $Cr_2O_7^{2-}$ IGNORE name of oxidizing agent, even if incorrect (1) (Conditions) Acidic/acidified/sulfuric acid /H^+ **and** reflux/heat ALLOW Acidified on the line for oxidizing agent IGNORE References to acid concentration (1) Second mark dependant on an oxidizing agent	HCl/ Hydrochloric acid/ Heat in a closed system	2

Question Number	Acceptable Answers	Reject	Mark
19 (b)(ii)	$C_2H_5OH + 2[O] \rightarrow CH_3COOH + H_2O$ OR Multiples ALLOW Structural / display /skeletal IGNORE state symbols even if incorrect	Molecular formulae O_2	1

Question Number	Acceptable Answers	Reject	Mark
19 (b)(iii)	Any suitable diagram of reflux, e.g.  **Marking point 1** Vertical condenser with water in/out shown correctly (1) **Marking point 2** suitable flask containing reagents and heat/electrical heater COMMENT Allow water bath Flask should have some contents shown (1) **Marking point 3** Anti-bumping granules (1) Diagrams of distillation can score **MP2** and **MP3** only	Thermometer/ Sealed apparatus / gaps between apparatus Conical flask	3

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	Trial titre is less than the mean titre/is an undershoot (1) An air bubble in the pipette so less than 25.00 cm^3 of acid tested OR Pipette only washed with (deionised) water and not the acid/pipette contained water from washing ALLOW Pipette tip not touched on the solution to remove the full volume of acid IGNORE Reference to some acid left in the pipette Pipette not washed properly (1)	Not filled to the mark	2

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	n = (0.0145 x 0.2 =) 2.90 x 10^{-3}/0.00290 (1) c = (2.90 x 10^{-3} ÷ 0.025=) 0.116 (mol dm^{-3}) (1) IGNORE SF except 1SF		2

Question Number	Acceptable Answers	Reject	Mark
19 (c)(iii)	Method 1 n = (0.116 ÷ 2 =) 0.058 or n = (0.0029 x (500÷ 25) =) 0.058 (1) m = (0.058 x 60 =) 3.48 (g) (1) OR Method 2 m = (0.00290 x 60 =) 0.0174 (g in 25 cm^3) (1) m = (0.0174 x 25 =) 3.48 (g in 500 cm^3) (1) IGNORE SF except 1SF		2

Question Number	Acceptable Answers	Reject	Mark
19 (d)(i)	$C_6H_{13}OH + 9O_2 \rightarrow 6CO_2 + 7 H_2O$ ALLOW Multiples Ignore state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
19 (d)(ii)	$C_6H_{13}OH + 3O_2 \rightarrow 6C + 7 H_2O$ ALLOW Multiples IGNORE state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
19 (d)(iii)	Volume = (9 x 24 =) 216 (dm^3) (1) COMMENT Not clipped so allow 9½ x 24 = 228 (dm^3) (Observation) Black smoke/black soot ALLOW just 'soot' / black carbon Ignore just 'carbon' (1) (justification) Only 100 dm^3 of oxygen (20% of 500) is present Ignore just 'there is insufficient oxygen' (1)		3

Total for Question 19 = 25 MARKS
TOTAL FOR SECTION B = 38 MARKS

Section C

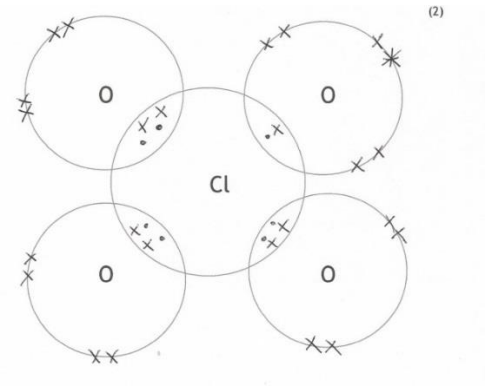
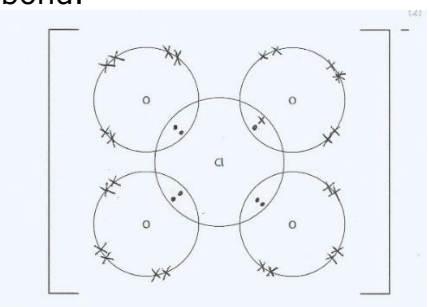
Question Number	Acceptable Answers	Reject	Mark
20 (a)	$SrCO_3$ (1) Li_2CO_3 (1) Penalise use of names rather than formulae once only	$CaCO_3$ Sr^{2+} Rb_2CO_3 Li^+	2

Question Number	Acceptable Answers	Reject	Mark
20 (b)	Heat (from the exploding firework) excites/ promotes electrons to a higher energy level (1) These electrons return to the ground state (1) Energy is released in the visible part of the spectrum (1)		3

Question Number	Acceptable Answers	Reject	Mark
20 (c)	(Metal) magnesium/Mg/ Aluminium/Al/ Titanium/Ti (1) (Compound) Magnesium oxide/MgO/ Aluminium oxide/Al_2O_3/Titanium oxide/TiO_2 ALLOW Magnesium nitride/ Mg_3N_2 (1)	Beryllium Magnesium carbonate	2

Question Number	Acceptable Answers	Reject	Mark
20 (d)(i)	$2KNO_3$ + (1)S + 3C → (1)K_2S + (1)N_2 + 3CO_2 Product of CO_2 (1) Balancing ALLOW multiples (1)		2

Question Number	Acceptable Answers	Reject	Mark
20 (d)(ii)	Nitrogen **and** sulfur/ N **and** S (are reduced) (1) (Nitrogen/N) goes from (+)5 to 0 (1) (Sulfur/S) goes from 0 to −2 (1) ALLOW Nitrogen and sulfur in any order IGNORE Carbon going from 0 to +4	 N_2 S_8	3

Question Number	Acceptable Answers	Reject	Mark
20 (e)(i)	Example diagram such as  Correct dots and crosses on three oxygens for the double bonds to the chlorine (1) Correct dots, crosses and asterisk on the fourth oxygen ALLOW The asterisk electron to be anywhere on the fourth oxygen (1) ALLOW Three dative bonds from the chlorine and one covalent bond.  ALLOW Any combination of dative and double bonds to the oxygen that result in an appropriate number of electrons in the outer shell of each respective atom		2

Question Number	Acceptable Answers	Reject	Mark
20 (e)(ii)	(potassium) chlorate(VII) may reach/enter groundwater sources / end up in drinking water (1) And it is toxic/poisonous IGNORE References to acidity (1) ALLOW Chlorine compounds may reach the ozone layer OR Free radicals/$Cl^{\bullet}$/$ClO^{\bullet}$ (1) And result in ozone depletion/ free radicals/$Cl^{\bullet}$/$ClO^{\bullet}$ result in ozone depletion (1) OR Ozone may be formed in the (lower) atmosphere (1) Which is toxic (1)	Toxic gases such as HCl/ Cl_2 Greenhouse Effect	2

Question Number	Acceptable Answers	Reject	Mark
20 (f)	The fuse burns releasing energy/reacts exothermically (1) Which provides the activation energy (1) It is used up in the reaction OR It does not lower the activation energy OR It does not provide an alternative reaction pathway (and so is not a catalyst) (1)		3

Question Number	Acceptable Answers	Reject	Mark
20 (g)	Reference to two suitable factors from surface area, temperature, concentration (1) Any two from (Surface area) – increase will increase reaction rate because more particle-particle contact for reaction (1) (Temperature) – more exothermic/more heat given off will increase reaction rate because particles will have more kinetic energy for reaction (1) (Concentration) – more tightly-packed will increase reaction rate because more particle-particle contact for reaction (1) ALLOW Reverse arguments to slow the reaction down		3

TOTAL FOR SECTION C (Question 20) = 22 MARKS

TOTAL FOR PAPER = 80 MARKS

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Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Tuesday 2 June 2015 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The bond angle in beryllium chloride, $BeCl_2$, is most likely to be

- ☒ **A** 90°
- ☒ **B** 104.5°
- ☒ **C** 120°
- ☒ **D** 180°

(Total for Question 1 = 1 mark)

2 Graphite and buckminsterfullerene are forms of carbon. Buckminsterfullerene dissolves in octane but graphite does not. This is because

- ☒ **A** the bonds between carbon atoms in buckminsterfullerene are weaker than those in graphite.
- ☒ **B** buckminsterfullerene is molecular whereas graphite is a giant structure.
- ☒ **C** graphite has delocalised electrons but buckminsterfullerene does not.
- ☒ **D** graphite has covalent bonds and London forces but buckminsterfullerene has just London forces.

(Total for Question 2 = 1 mark)

3 Which of the following molecules is polar?

- ☒ **A** Carbon dioxide, CO_2
- ☒ **B** Silicon tetrachloride, $SiCl_4$
- ☒ **C** Ammonia, NH_3
- ☒ **D** Boron trifluoride, BF_3

(Total for Question 3 = 1 mark)

P 4 4 8 8 1 A 0 2 2 4
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4 In which series of compounds does covalent character **increase** when going from left to right?

☒ **A** KI, KBr, KCl

☒ **B** NaI, KI, RbI

☒ **C** NaCl, $MgCl_2$, $AlCl_3$

☒ **D** SO_2, P_4O_{10}, SiO_2

(Total for Question 4 = 1 mark)

5 Hydrogen bromide has a lower boiling temperature than hydrogen iodide. This is because

☒ **A** hydrogen bromide has a smaller permanent dipole than hydrogen iodide.

☒ **B** hydrogen bromide has weaker London forces than hydrogen iodide.

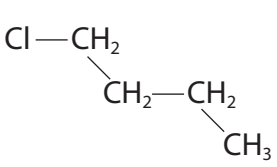
☒ **C** hydrogen iodide forms hydrogen bonds but hydrogen bromide does not.

☒ **D** the H—I bond is stronger than the H—Br bond.

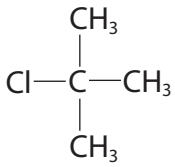
(Total for Question 5 = 1 mark)

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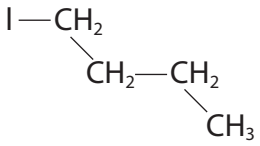
6 Consider the following compounds, **E**, **F**, **G** and **H**.



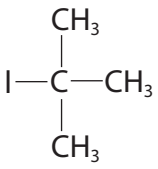
E



F



G



H

The boiling temperature of these compounds **increases** in the order

☒ **A** **H G F E**

☒ **B** **G H E F**

☒ **C** **E F G H**

☒ **D** **F E H G**

(Total for Question 6 = 1 mark)

7 In which of the following reactions is sulfuric(IV) acid, H_2SO_3, acting as an oxidizing agent?

☒ **A** $H_2SO_3 + H_2O \rightarrow H_3O^+ + HSO_3^-$

☒ **B** $H_2SO_3 \rightarrow SO_2 + H_2O$

☒ **C** $H_2SO_3 + 2FeCl_3 + H_2O \rightarrow 2FeCl_2 + H_2SO_4 + 2HCl$

☒ **D** $H_2SO_3 + 2H_2S \rightarrow 3H_2O + 3S$

(Total for Question 7 = 1 mark)

P 4 4 8 8 1 A 0 4 2 4
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8 Which of the following properties **decreases** on descending Group 2 of the Periodic Table?

- ☒ **A** Solubility of the sulfates.
- ☒ **B** Solubility of the hydroxides.
- ☒ **C** Reactivity of the elements.
- ☒ **D** Ionic character of the oxides.

(Total for Question 8 = 1 mark)

9 Compound **X** is an anhydrous, white solid which decomposes on heating to form a white solid residue, a colourless gas, and a colourless vapour which condenses to a colourless liquid.

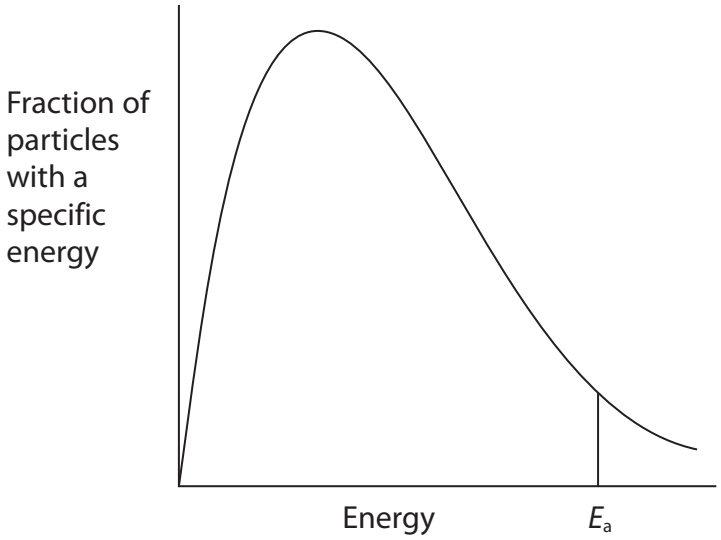
Compound **X** is

- ☒ **A** sodium carbonate.
- ☒ **B** sodium hydrogencarbonate.
- ☒ **C** sodium nitrate.
- ☒ **D** sodium sulfate.

(Total for Question 9 = 1 mark)

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10 These questions concern the Maxwell-Boltzmann energy distribution shown below.



(a) What is the best way to describe the activation energy, E_a, of a reaction?

(1)

☒ **A** The average energy of the particles that react.

☒ **B** The minimum energy required for a reaction to occur.

☒ **C** The energy difference between the reactants and products.

☒ **D** The energy produced by the particles that react.

(b) How does the curve above change when the temperature is **increased**?

(1)

☒ **A** The peak increases in height and moves to the left.

☒ **B** The peak increases in height and moves to the right.

☒ **C** The peak decreases in height and moves to the left.

☒ **D** The peak decreases in height and moves to the right.

P 4 4 8 8 1 A 0 6 2 4
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(c) What would be the effect on the diagram if the reactant concentrations were **increased**?

(1)

- ☒ **A** There would be no change.
- ☒ **B** The E_a line would move to the right.
- ☒ **C** The E_a line would move to the left.
- ☒ **D** The peak decreases in height and moves to the right.

(d) What would be the effect on the diagram if a catalyst was added?
The activation energy would

(1)

- ☒ **A** be unchanged and the peak would move to the right.
- ☒ **B** move to the left and the peak would move to the right.
- ☒ **C** move to the left and the peak would move to the left.
- ☒ **D** move to the left and the peak would be unchanged.

(Total for Question 10 = 4 marks)

11 Propanal, CH_3CH_2CHO, and propanone, CH_3COCH_3, are carbonyl compounds. When these compounds are compared using physical methods of analysis, which of the following statements is **not** correct?

- ☒ **A** The compounds produce different patterns in the fingerprint region of the IR spectrum.
- ☒ **B** The carbonyl groups absorb at frequencies in the same region of the IR spectrum.
- ☒ **C** The compounds produce different fragmentation patterns in a mass spectrum.
- ☒ **D** The compounds have molecular ion peaks at different mass to charge ratios in a mass spectrum.

(Total for Question 11 = 1 mark)

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12 A sample of propanone, CH_3COCH_3, was heated under reflux with potassium dichromate(VI) acidified with sulfuric acid, and then the mixture was distilled. Apart from the peaks due to the C—C and C—H bonds, what peak(s) would be present in the IR spectrum of the distillate?

- ☒ **A** A peak due to the C═O only.
- ☒ **B** A peak due to the O—H only.
- ☒ **C** Peaks due to C═O and O—H.
- ☒ **D** Peaks due to C—O, C═O and O—H.

(Total for Question 12 = 1 mark)

13 Which of the following describes the appearance of iodine under the stated conditions?

	Solid	Dissolved in aqueous potassium iodide	Dissolved in a liquid hydrocarbon
☒ **A**	purple	brown	purple
☒ **B**	brown	blue-black	yellow
☒ **C**	shiny grey	brown	purple
☒ **D**	shiny grey	brown	brown

(Total for Question 13 = 1 mark)

14 Why do calculations of global warming exclude the effect of water vapour in the atmosphere?

- ☒ **A** Water vapour is not a greenhouse gas.
- ☒ **B** Water vapour is a much less potent greenhouse gas than carbon dioxide.
- ☒ **C** The average concentration of water vapour in the atmosphere is fairly constant.
- ☒ **D** The concentration of water vapour in the atmosphere is much lower than that of carbon dioxide.

(Total for Question 14 = 1 mark)

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15 A compound of nitrogen and hydrogen only is analyzed and found to contain 97.7% by mass of nitrogen. What is the empirical formula of the compound?

Molar masses /g mol^{-1}: H = 1; N = 14

☒ **A** NH_3

☒ **B** NH_2

☒ **C** N_3H_5

☒ **D** N_3H

(Total for Question 15 = 1 mark)

16 Chlorofluorocarbons, CFCs, damage the ozone layer. The mechanism of the process involves

☒ **A** homolytic fission.

☒ **B** heterolytic fission.

☒ **C** electrophilic addition.

☒ **D** nucleophilic substitution.

(Total for Question 16 = 1 mark)

17 Electrophiles are

☒ **A** electron pair donors that are attracted to regions of high electron density.

☒ **B** electron pair donors that are attracted to regions of low electron density.

☒ **C** electron pair acceptors that are attracted to regions of high electron density.

☒ **D** electron pair acceptors that are attracted to regions of low electron density.

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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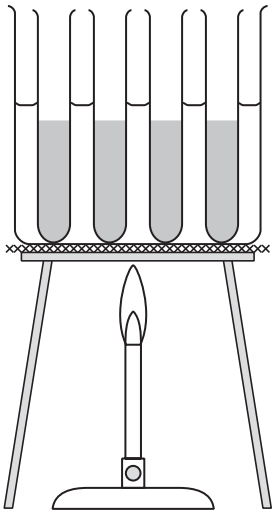
SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

18 Halogenoalkanes react slowly with water to form alcohols. The equation for the reaction is

$$RX + H_2O \rightarrow ROH + H^+ + X^-$$

(a) The rate of this reaction for different halogenoalkanes was investigated using the apparatus below.



In one experiment, equal amounts of 1-chlorobutane, 1-bromobutane and 1-iodobutane were placed in separate test tubes with 5 cm^3 of ethanol. These test tubes were placed in the water bath together with a test tube containing aqueous silver nitrate. After about 5 minutes, 1 cm^3 of the silver nitrate solution was added to each test tube containing a halogenoalkane and the time taken for a precipitate to form in each test tube was noted. The temperature of the water bath was maintained at 50 °C.

(i) Why is ethanol used as a solvent in this experiment?

(1)

.....

.....

(ii) Explain why the apparatus was left for 5 minutes before the silver nitrate was added.

(1)

.....

.....

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(iii) **Name** the precipitate formed in the test tube containing 1-bromobutane and write an **ionic** equation for the formation of this precipitate. State symbols are not required.

(2)

Precipitate .....

Ionic equation

(iv) Predict the order (fastest first) in which the halogenoalkanes form precipitates. Explain your answer.

(2)

Order .....

.....

Explanation .....

.....

.....

.....

(b) Alcohols are usually prepared from halogenoalkanes using aqueous alkali, rather than water, as the reaction is faster.

(i) Name the mechanism and type of reaction occurring when 1-bromobutane reacts with aqueous alkali.

(2)

.....

(ii) Explain why the formation of alcohols is faster with aqueous alkali than with water.

(1)

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.....

.....

(iii) Give the mechanism for the reaction of 1-bromobutane with aqueous alkali.

Show the lone pair involved in the mechanism and any relevant dipoles and curly arrows.

(3)

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(iv) One student suggested that the final reaction mixture could be tested for the presence of an alcohol using phosphorus(V) chloride while another suggested using potassium dichromate(VI) with sulfuric acid.

Describe the result of a positive test for alcohols using each of these reagents.

Explain which test is better for the final reaction mixture.

(3)

Observation with PCl_5 .....

Observation with acidified $K_2Cr_2O_7$ .....

Explanation .....

.....

.....

(c) 1-bromobutane is classified as a **primary** halogenoalkane and is one of the four structural isomers with a molecular formula C_4H_9Br.

Give the **skeletal** formula of the three isomers, other than 1-bromobutane, classifying the halogenoalkane in each case.

(3)

Skeletal formula	Classification

(Total for Question 18 = 18 marks)

P 4 4 8 8 1 A 0 1 3 2 4
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19 Two white powders, **A** and **B**, known to be Group 2 carbonates, are investigated.

(a) (i) The presence of the carbonate ion is usually confirmed using a simple test carried out in two stages at room temperature. Describe this test and its results.

(2)

Test .....

.....

Results .....

.....

.....

(ii) Using barium carbonate as your example, write the equation for each of the stages of the carbonate test. Include state symbols in both equations.

(3)

First equation (test)

Second equation (result)

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(b) When a flame test is carried out on the two powders, **A** gives no colour and **B** gives a yellow-red flame.

(i) Describe how a flame test is carried out.

(3)

(ii) Give the **formulae** of the metal ions in **A** and **B**.

(2)

A ..... **B** .....

*(iii) Explain the origin of the flame colour.

(3)

(iv) Suggest why compound **A** produces no flame colour.

(1)

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*(c) When Group 2 metal carbonates are heated strongly, they decompose forming the metal oxide and carbon dioxide.

Explain why the thermal stability of the metal carbonates increases as the group is descended.

(3)

(Total for Question 19 = 17 marks)

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20 Induced hydraulic fracturing, commonly known as fracking, which was developed in 1947, is a technique for extracting natural gas (mainly methane) from shale deposits. While natural gas is a much cleaner fuel than coal, it is difficult to carry out fracking without leakage. Because methane is a far more potent greenhouse gas than carbon dioxide, it has been calculated that leakage rates of around 2% are sufficient to increase global warming.

(a) Suggest what is meant by 'natural gas is a much cleaner fuel than coal'.

(1)

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(b) Explain how greenhouse gases cause global warming.

(2)

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(c) Suggest why methane is a far more potent greenhouse gas than carbon dioxide.

(1)

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(Total for Question 20 = 4 marks)

TOTAL FOR SECTION B = 39 MARKS

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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

21

Swimming Pool Chemistry

The circulation of water in swimming pools is much slower than that in most natural water courses, but the number of people using a given volume of water is often far greater. If steps are not taken to keep microorganisms and other contaminants under control, the water will become hazardous. Filters are used to remove solid material and chemicals are added to disinfect the water.

The most common method of disinfection involves the use of chlorine compounds, but systems using bromine have advantages. These systems depend on their oxidizing properties. With chlorine systems, the key species is the chlorate(I) ion (OCl^-) which kills bacteria by damaging the structure of their cell walls and disrupting enzyme activity.

A simple way of adding chlorate(I) ions to water is by using chlorine. The weak acid, chloric(I) acid (HOCl), is formed and this dissociates producing the chlorate(I) ion.

(a) The equation for the reaction of chlorine with water is:

$$Cl_2(aq) + H_2O(l) \rightleftharpoons HOCl(aq) + HCl(aq)$$

By referring to the relevant oxidation numbers, explain why this is a disproportionation reaction.

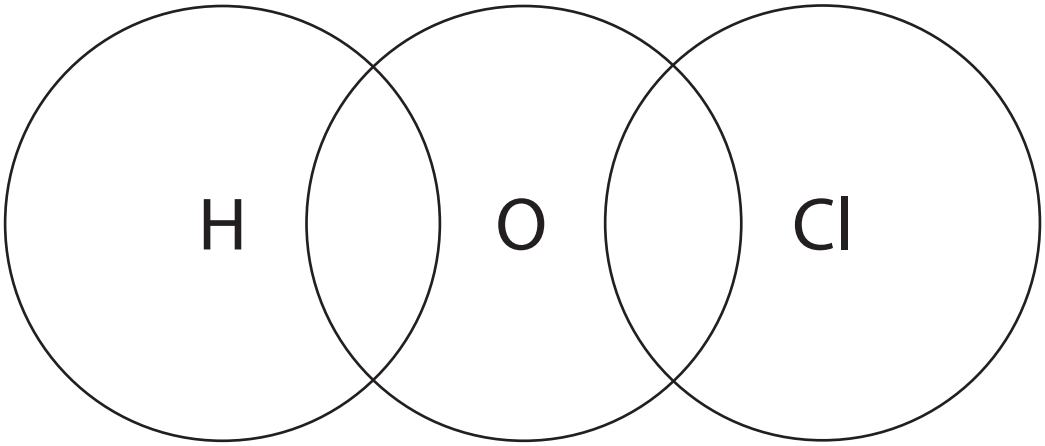
(3)

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(b) (i) Complete the dot and cross diagram for chloric(I) acid (HOCl). Use a dot (•) to represent the hydrogen electron, circles (o) to represent the oxygen electrons and crosses (×) to represent the chlorine electrons.

Show the outer electrons only, but include non-bonding electrons.

(2)



*(ii) Predict the bond angle in chloric(I) acid. Explain your answer fully.

(5)

Bond angle = ...

.....

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(c) If the concentration of chlorate(I) ions in a swimming pool is too low, bacteria will flourish. If it is too high, swimmers will be harmed. In the United Kingdom, it is recommended that the concentration of chlorine be in the range 1–2 mg dm^{-3}. The total amount of chlorine, Cl_2, present can be measured by titration.

In such a determination, excess sulfuric acid and potassium iodide were added to a 1.00 dm^3 sample of swimming pool water and the resulting solution required 9.65 cm^3 of 0.00550 mol dm^{-3} sodium thiosulfate for complete reaction.

The equations for the reactions are:

$$Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$$

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

(i) Show that the concentration of chlorine, Cl_2, in this sample meets the UK recommended requirements.
All steps in your calculation must be shown.

(3)

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(ii) Analysing a single sample of swimming pool water in this way is likely to give unreliable results because it is not possible to repeat the titration.
Suggest another way in which this method is unreliable.

(1)

.....

.....

(d) One advantage of the bromine disinfection system is that, while chloric(I) acid decomposes in sunlight forming hydrogen chloride and oxygen, bromic(I) acid (HOBr) is stable. Another advantage is that bromine is less volatile than chlorine.

(i) Write an equation for the decomposition of chloric(I) acid in sunlight.
State symbols are not required.

(1)

(ii) Explain why bromine is less volatile than chlorine.

(2)

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(e) The pH of the swimming pool affects the performance of the disinfectant. The data below show how the concentrations of bromine species vary with pH.

pH	% bromine as HOBr	% bromine as OBr^-
6.0	100	0.0
7.0	98.0	2.0
8.0	83.0	17.0
8.5	57.0	43.0

The equation for the reaction of bromic(I) acid in water is

$$HOBr(aq) \rightleftharpoons H^+(aq) + OBr^-(aq)$$

(i) Assume the pH of the swimming pool is neutral. Explain how any changes in the pH of the swimming pool affect the concentration of the bromine species.

(3)

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(ii) The higher the concentration of bromate(I) ions, the more effective the disinfectant.

Suggest a disadvantage of too high a pH.

(1)

.....

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(Total for Question 21 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

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Mark Scheme (Results)

Summer 2015

GCE Chemistry (6CH02/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	D	1

Question Number	Correct Answer	Mark
2	B	1

Question Number	Correct Answer	Mark
3	C	1

Question Number	Correct Answer	Mark
4	C	1

Question Number	Correct Answer	Mark
5	B	1

Question Number	Correct Answer	Mark
6	D	1

Question Number	Correct Answer	Mark
7	D	1

Question Number	Correct Answer	Mark
8	A	1

Question Number	Correct Answer	Mark
9	B	1

Question Number	Correct Answer	Mark
10(a)	B	1
(b)	D	1
(c)	A	1
(d)	D	1

Question Number	Correct Answer	Mark
11	D	1

Question Number	Correct Answer	Mark
12	A	1

Question Number	Correct Answer	Mark
13	C	1

Question Number	Correct Answer	Mark
14	C	1

Question Number	Correct Answer	Mark
15	D	1

Question Number	Correct Answer	Mark
16	A	1

Question Number	Correct Answer	Mark
17	C	1

Section B

Question Number	Acceptable Answers	Reject	Mark
18 (a)(i)	Ethanol dissolves silver nitrate / silver ions **and** halogenoalkanes OR Ethanol (molecule) is polar and non-polar (solvent) OR Ethanol dissolves ionic and covalent compounds ALLOW Ethanol dissolves ionic and non-polar compounds Ethanol dissolves both types (of compound) So that the reactants can mix 'miscible' for 'dissolves' IGNORE Any references to rate	Ethanol is non-polar Just 'ethanol dissolves halogenoalkanes' Just 'water does not dissolve halogenoalkanes' Just 'they dissolve in ethanol'	1

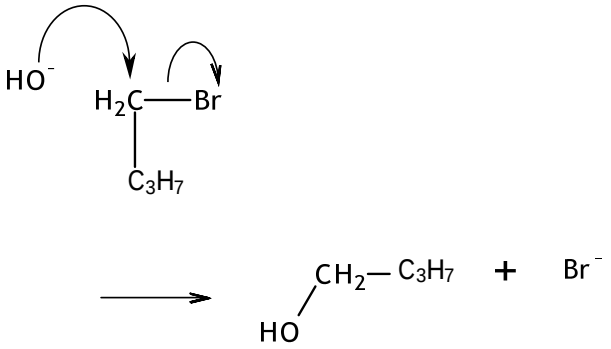
Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	To allow the temperature (of all the liquids) to equilibrate / to reach 50°C OR So that all the substances are at the same temperature ALLOW So that the temperature is constant		1

Question Number	Acceptable Answers	Reject	Mark
18(a)(iii)	Silver bromide IGNORE Formula even if incorrect (1) $Ag^+ + Br^- \rightarrow AgBr$ (1) TE on incorrect silver halide ALLOW Ionic equations with uncancelled ions Ag^+Br^- as product IGNORE state symbols even if incorrect	Non-ionic equations	2

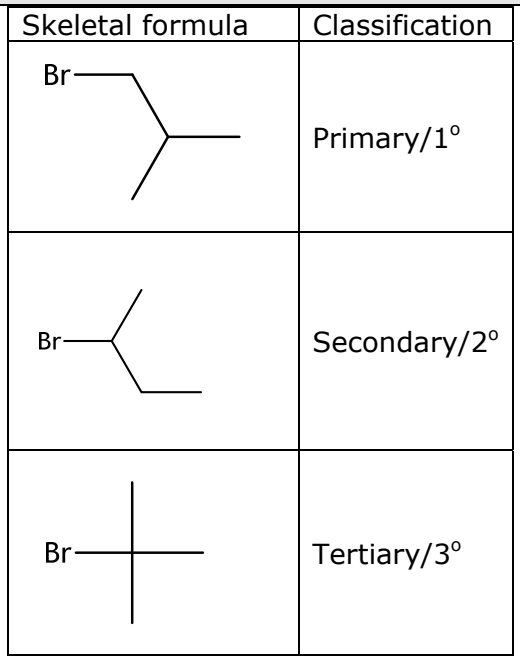
Question Number	Acceptable Answers	Reject	Mark
18(a)(iv)	Order: iodo, bromo, chloro ALLOW AgI, AgBr, AgCl OR I, Br, Cl OR Iodine, bromine, chlorine (1) C—I is the weakest bond OR I^- is best leaving group ALLOW (if MP1 awarded) Rate depends on the strength of the C—X bond (1) IGNORE Explanations of the bond strengths, even if incorrect. References to bond length and atomic radius/size ALLOW Reverse argument for MP2	 I_2, Br_2, Cl_2 Rate depends on the reactivity of X / X^-	2

Question Number	Acceptable Answers	Reject	Mark
18(b)(i)	nucleophilic (1) substitution (1) Stand alone marks S_N2 alone scores one mark	 S_N1	2

Question Number	Acceptable Answers	Reject	Mark
18(b)(ii)	Some comparison is required. Hydroxide ion /OH^- is a stronger nucleophile (than water) ALLOW OH^- is a better electron pair donor (than water) Concentration of hydroxide ion / OH^- is higher OR Hydroxide ion / OH^- is charged More hydroxide ion / OH^- in NaOH (than water) IGNORE OH^- is more basic / alkaline Alkali is a stronger nucleophile OH^- is more reactive ALLOW Reverse argument	Use of NaOH/OH for OH^- Just 'NaOH/alkali forms OH^- more readily'	1

Question Number	Acceptable Answers	Reject	Mark
18 (b)(iii)	Penalise omission of charge on hydroxide ion once only (in MP2) **First mark**  Both curly arrows First curly arrow from any part of the hydroxide ion (or the charge) to the carbon atom Second curly arrow from the C—Br bond to the bromine atom or just beyond (1) **Second mark** Lone pair on **oxygen** of OH^- {HO:} (1) **Third mark** Partial charge on C—Br bond { $C^{\delta+}$—$Br^{\delta-}$} (1) ALLOW Correct S_N1 mechanism for full marks Curly arrow from hydroxide group from any part of the group including the charge. IGNORE transition state (even if incorrect) products (even if incorrect)	OH with no / partial charge C^+—Br^-	3

Question Number	Acceptable Answers	Reject	Mark
18(b)(iv)	PCl_5: misty /steamy /white fumes/gas IGNORE Tests on product (e.g. turns blue litmus red) (1) $K_2Cr_2O_7$: orange solution turns green ALLOW Orange to blue (1) $K_2Cr_2O_7$ preferred because PCl_5 reacts with water (as well as alcohols) ALLOW $K_2Cr_2O_7$ preferred because PCl_5 reacts with alkali / OH^- /OH (1) IGNORE References to primary, secondary and tertiary alcohols	smoke Just 'fumes'/ 'effervescence' PCl_5 reacts with carboxylic acids	3

Question Number	Acceptable Answers	Reject	Mark
18(c)	 Look at the structural formulae first: three structures correct scores 2 marks. two structures correct scores 1 If all three structures correct (any format), then all **three** classifications correct scores 1 Penalise displayed, partially displayed or structural formulae once only IGNORE Bond angles and names	Just the classifications	3

Total for Question 18 = 18 marks

Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	Add hydrochloric acid / HCl(aq) / nitric acid / HNO_3(aq) ALLOW Just 'acid' only if a suitable acid is given in equation one Sulfuric acid / H_2SO_4((aq)) or HCl (1) IGNORE 'conc' Gas / carbon dioxide / CO_2 evolved turns lime water milky / cloudy / produces a white precipitate (1) MP2 is a stand alone mark but there must be some indication that a gas is being tested	Just 'acid' OR heating the carbonate	2

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	**ALLOW** H_2CO_3(aq) for H_2O(l) + CO_2(g) $BaCO_3$(s) + 2HCl(aq) → $BaCl_2$(aq) + H_2O(l) + CO_2(g) OR $BaCO_3$(s) + 2HNO_3(aq) → $Ba(NO_3)_2$(aq) + H_2O(l) + CO_2(g) OR CO_3^{2-}(s) + 2H^+(aq) → H_2O(l) + CO_2(g) **ALLOW** $BaCO_3$(s) + H_2SO_4(aq) → $BaSO_4$(s/aq) + H_2O(l) + CO_2(g) OR $BaCO_3$(s) → BaO(s) + CO_2(g) (1) $Ca(OH)_2$(aq) + CO_2(g) → $CaCO_3$(s) + H_2O(l) (1) **All** state symbols in **both** equations correct (1) **ALLOW** State symbols mark if first equation not balanced but ALL species are correct. No TE on other equations		3

Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	**MP1 and MP2** Dip (clean) nichrome / platinum wire ALLOW loop / rod for wire OR Silica rod (1) in hydrochloric acid / HCl(aq) ALLOW any mention of HCl(aq) e.g. cleaning or mixing solid and acid HCl for HCl(aq) (1) ALLOW (for MP1 and MP2) (Wooden) splint (1) Soaked in distilled / deionised water (1) **MP3** then dipped in solid **and** placed in (hot / roaring / blue-cone) (Bunsen) **flame** ALLOW On / over / under / above for 'in' (1) IGNORE inoculating / flame-test (wire)	Nickel / chrome / chromium spatula Other acids just 'water'	3

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	A = Mg^{2+} (1) B = Ca^{2+} (1) Penalise omission of $^{2+}$ only once Correct ions with correct charge but the wrong way round scores 1 mark Correct ions with incorrect / no charge scores 1 IGNORE Names / compounds		2

Question Number	Acceptable Answers	Reject	Mark
19(b)*(iii)	Read the whole answer before awarding marks. If no mention of electrons only MP3 may be awarded. Electrons promoted to higher energy level (by thermal energy / heat from (Bunsen) flame) (1) (Promoted) electrons fall / drop / relax to lower energy level / orbital / shell / subshell OR Electrons return to ground state (1) Emitting radiation / light / photons (in the visible region) (1) IGNORE Colour	 Just 'electrons promoted/ excited' Just 'energy lost' Just 'energy given out	3

Question Number	Acceptable Answers	Reject	Mark
19(b)(iv)	Emitted radiation is not in the visible region (of the spectrum) ALLOW Emitted radiation is in IR / UV		1

Question Number	Acceptable Answers	Reject	Mark
19(c)	As group is descended... **First mark (metal ion size)** (Metal) ion radius increases / has more (electron) shells (but charge remains the same) OR Charge density of metal ion decreases ALLOW (Metal) atomic radius increases / has more (electron) shells (1) **Second mark (polarizing species)** Polarizing (ALLOW distorting) power of **cation / metal ion** decreases (1) **Third mark (polarized species)** Polarization / distortion of (electron cloud of) carbonate ion /anion decreases ALLOW C—O / C═O for carbonate ion (1) (so carbonate more stable to heat) ALLOW reverse argument for ascent of the group.	Just "metal" Just 'ion' Just 'ion or bond'	3

Total for Question 19 = 17 marks

Question Number	Acceptable Answers	Reject	Mark
20(a)	Methane undergoes more complete combustion / produces less CO OR Burning methane emits no (allow less) soot / carbon particles / particulates OR Burning methane emits no (allow less) sulfur / sulfur oxides OR Sulfur compounds are much more easily removed from methane OR Methane produces less CO_2 per unit of energy than coal ALLOW Any of these points reversed for coal IGNORE 'less CO_2 / greenhouse gases' 'carbon footprint' and 'emissions'		1

Question Number	Acceptable Answers	Reject	Mark
20(b)	Any mention of the ozone layer scores zero (A greenhouse gas) absorbs & re-emits / absorbs / traps / reflects IR (radiation) / heat (1) (re-radiating) **from the Earth** ALLOW **Back** to the Earth (1)	UV **absorbed** etc Absorbs from the sun	2

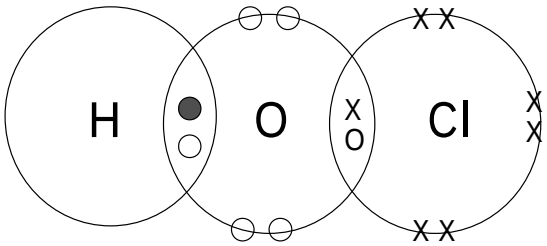
Question Number	Acceptable Answers	Reject	Mark
20(c)	Methane (molecule) absorbs IR radiation more effectively (because it has more IR active vibrations) OR Methane has a longer life in the atmosphere ALLOW Methane (molecule) absorbs more (IR) radiation OR Methane has more (vibrating polar) bonds OR Methane has 4 (polar) bonds (rather than 2)	C—H more polar than C=O	1

Total for Question 20 = 4 marks

Total for Section B = 39 marks

Section C

Question Number	Acceptable Answers	Reject	Mark
21(a)	Chlorine / Cl_2 / same species / element / atom is oxidized and reduced (in the same reaction) (1) Chlorine **oxidized** from 0 to +1 in HOCl /OCl^- /chlorate(I) (1) Chlorine **reduced** from 0 to −1 in HCl / Cl^- / chloride (1) If oxidized and /or reduced omitted or the wrong way round, max 1 (out of final 2 marks)		3

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	 Two bonding pairs (1) Five non-bonding electron pairs (1) IGNORE Lines representing bonds ALLOW Bonding pairs on the same horizontal line Different symbols for electrons max 1		2

Question Number	Acceptable Answers	Reject	Mark
21(b)*(ii)	No TE on incorrect structure in b(i) Penalise omission of "pairs" once only **First mark** Bond angle = 104.5° ALLOW 102°—106° (1) **Second mark** 2 bond pairs and 2 lone pairs (of electrons in valence shell of the oxygen atom) (1) **Third & fourth marks** (stand alone) (valence) electron pairs at minimum repulsion ALLOW maximum separation / distance apart (1) lone pair repulsion > bond pair repulsion (1) **Fifth mark** So tetrahedral bond angle reduced ALLOW 109° / 109.5° /109° 28' (angle) reduced (1)	'Bonds' for 'electron pairs'	5

Question Number	Acceptable Answers	Reject	Mark
21c(i)	Amount of $S_2O_3^{2-}$ = 9.65 x 0.00550 ÷ 1000 * (= 5.3075 x 10^{-5} mol) (1) Amount of Cl_2 (in 1 dm^3) = 0.5 x * = 0.5 x 9.65 x 0.00550 ÷1000 ** (= 2.65375 x 10^{-5} mol) (1) Mass of Cl_2 (in 1 dm^3) = 71 x 1000 x ** = 1.8842 (mg dm^{-3}) (1) (so within limits) ALLOW 1.8842x10^{-3} g dm^{-3} **and** so within limits An answer lower than 1 or higher than 2 mg dm^{-3} only scores a TE mark if there is a comment relating to the limits Correct answer with no working scores 1 Ignore SF except 1 SF **Note** If 0.5 omitted in MP2 and 35.5 used in MP3 then final answer is numerically correct; this scores only MP1	Incorrect units	3

Question Number	Acceptable Answers	Reject	Mark
21c(ii)	Concentration of chlorine might be different in different parts of the pool / at different times OR Sample size small in relation to pool volume IGNORE Just 'sample size is small' References to experimental uncertainty		1

Question Number	Acceptable Answers	Reject	Mark
21d(i)	$2HOCl \rightarrow 2HCl + O_2$ OR $HOCl \rightarrow HCl + ½O_2$ OR Other multiples ALLOW HClO or $H^+ + ClO^-$ for HOCl		1

Question Number	Acceptable Answers	Reject	Mark
21d(ii)	London forces / dispersion forces / induced dipole- induced dipole attractions (ALLOW van der Waals / vdw forces) (1) Stronger because bromine (molecule) has more electrons / electron shells ALLOW greater surface area 'more' for 'stronger' (1)	dipole-dipole forces	2

Question Number	Acceptable Answers	Reject	Mark
21e(i)	All three marks are stand alone Lowering pH increases $[H^+]$ OR Increasing pH reduces $[H^+]$ ALLOW More/less H^+ IGNORE More acidic/alkaline (1) Lowering pH / increased $[H^+]$ shifts equilibrium to the left (so [HOBr] increases) (1) Increasing pH / reduced $[H^+]$ shifts equilibrium to the right (so $[OBr^-]$ increases) (1) Explanations must refer to equilibrium, but this may be implied	Just repeating information from the table	3

Question Number	Acceptable Answers	Reject	Mark
21e(ii)	Alkaline solutions are irritant (to the eyes) ALLOW caustic / corrosive saponifies / burns skin / chemical burns stings eyes IGNORE Harmful	toxic	1

Total for Question 21 = 21 marks
Total for Section C = 21 marks

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Surname	Other names

Pearson Edexcel GCE

Centre Number | Candidate Number

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Tuesday 3 June 2014 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 When sodium is added to ethanol, which of the following observations would be made?

☒ **A** Colour change of orange to green

☒ **B** Effervescence

☒ **C** Yellow flame

☒ **D** No change

(Total for Question 1 = 1 mark)

2 Which of the following substances does **not** have intermolecular hydrogen bonds?

☒ **A** Ethanoic acid, CH_3COOH

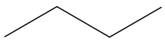
☒ **B** Propanone, CH_3COCH_3

☒ **C** Methanol, CH_3OH

☒ **D** Water, H_2O

(Total for Question 2 = 1 mark)

3 Which of the following molecules has the lowest boiling temperature?



A

Pentane

B

C_3H_6

C



D

☒ **A**

☒ **B**

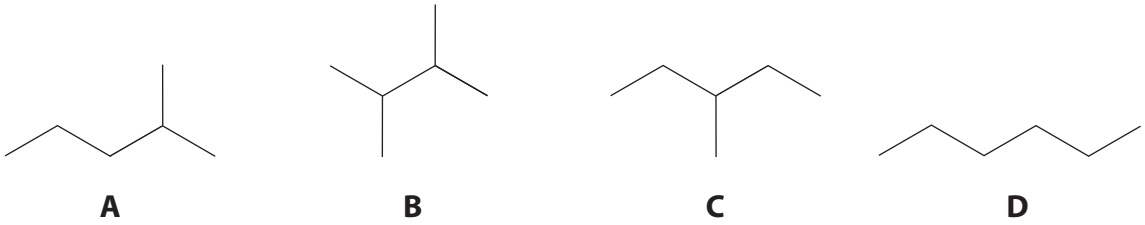
☒ **C**

☒ **D**

(Total for Question 3 = 1 mark)

P 4 2 9 7 1 A 0 2 2 4
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4 Which of the following molecules has the highest melting temperature?



A **B** **C** **D**

☒ **A**

☒ **B**

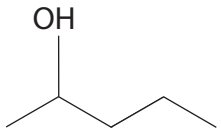
☒ **C**

☒ **D**

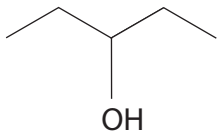
(Total for Question 4 = 1 mark)

5 Which of the following isomeric alcohols, with molecular formula $C_5H_{12}O$, can be oxidized to a carboxylic acid with five carbon atoms?

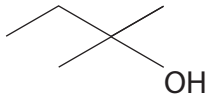
☒ **A**



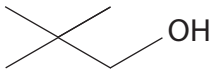
☒ **B**



☒ **C**



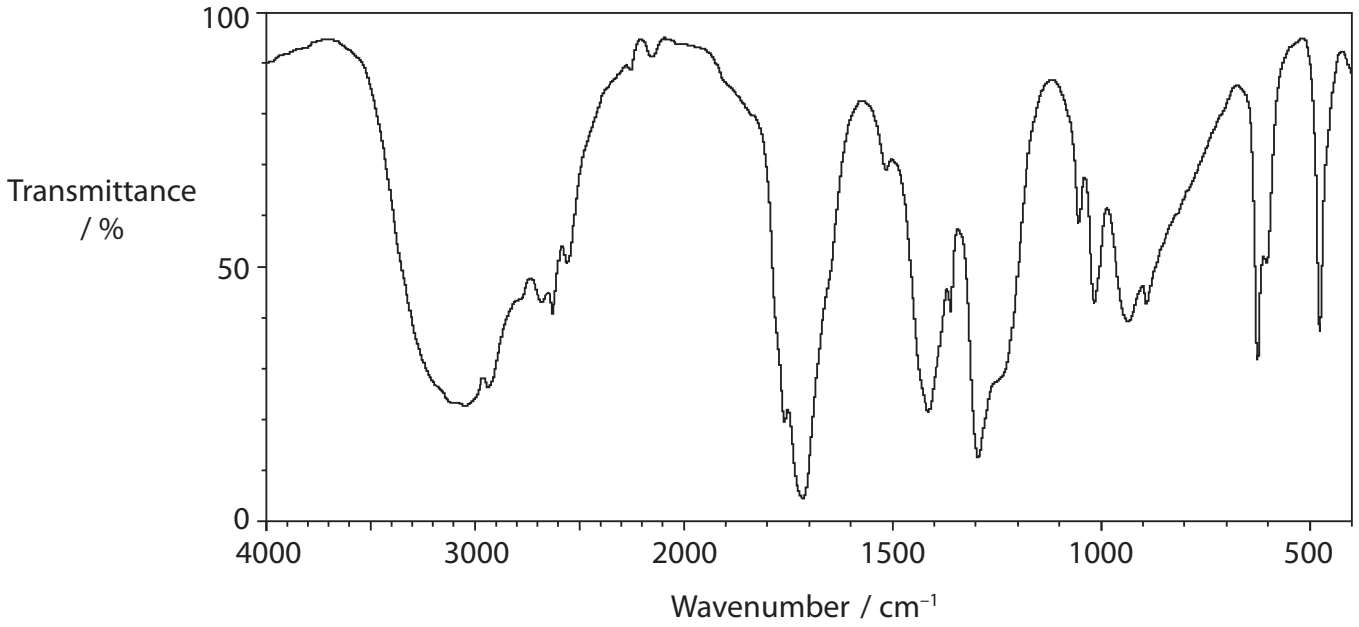
☒ **D**



(Total for Question 5 = 1 mark)

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6 Consider the infrared spectrum shown below.



The IR absorption ranges associated with some organic functional groups are given below.

O—H stretching in alcohols (variable, broad)	3750 – 3200 cm^{-1}
O—H stretching in carboxylic acids (weak)	3300 – 2500 cm^{-1}
C=O stretching in aldehydes (strong)	1740 – 1720 cm^{-1}
C=O stretching in ketones (strong)	1700 – 1680 cm^{-1}
C=O stretching in carboxylic acids, alkyl (strong)	1725 – 1700 cm^{-1}
C—H stretching in aldehydes (weak)	2900 – 2820 cm^{-1} and 2775 – 2700 cm^{-1}

Which of the following could have produced the above spectrum?

☒ **A** An aldehyde

☒ **B** An alcohol

☒ **C** A carboxylic acid

☒ **D** A ketone

(Total for Question 6 = 1 mark)

P 4 2 9 7 1 A 0 4 2 4
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7 In a mass spectrum of butane, C_4H_{10}, where would a peak be seen for the molecular ion if it had a charge of 2+?

☒ **A** 29

☒ **B** 56

☒ **C** 58

☒ **D** 60

(Total for Question 7 = 1 mark)

8 When a flame test is carried out on calcium iodide, the colour of the flame is

☒ **A** yellow-red.

☒ **B** pale green.

☒ **C** purple.

☒ **D** crimson.

(Total for Question 8 = 1 mark)

9 The indicator methyl orange is a weak acid and may be represented by the formula HA(aq). The equation for its dissociation is shown below.

$$HA(aq) \rightleftharpoons A^-(aq) + H^+(aq)$$

Colour: Red Yellow

Under certain conditions, at equilibrium, a solution of HA has a yellow colour. On addition of a small volume of dilute sodium hydroxide, the colour of this solution would

☒ **A** change from yellow to red.

☒ **B** change from yellow to orange.

☒ **C** change from yellow to orange and then to red.

☒ **D** not change.

(Total for Question 9 = 1 mark)

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10 Consider the following Group 2 compounds.

Group 2 hydroxides	Group 2 sulfates
$Mg(OH)_2$	$MgSO_4$
$Ca(OH)_2$	$CaSO_4$
$Sr(OH)_2$	$SrSO_4$

The solubility

- ☒ **A** increases down the group for both hydroxides and sulfates.
- ☒ **B** increases down the group for hydroxides but increases up the group for sulfates.
- ☒ **C** increases up the group for hydroxides but increases down the group for sulfates.
- ☒ **D** increases up the group for both hydroxides and sulfates.

(Total for Question 10 = 1 mark)

11 Which of the following is the correct equation for the decomposition of the corresponding nitrate?

- ☒ **A** $4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$
- ☒ **B** $4NaNO_3 \rightarrow 2Na_2O + 4NO_2 + O_2$
- ☒ **C** $Mg(NO_3)_2 \rightarrow Mg(NO_2)_2 + O_2$
- ☒ **D** $Ba(NO_3)_2 \rightarrow Ba(NO_2)_2 + O_2$

(Total for Question 11 = 1 mark)

12 What is the oxidation number of phosphorus in P_4O_6?

- ☒ **A** +3
- ☒ **B** +4
- ☒ **C** +5
- ☒ **D** +6

(Total for Question 12 = 1 mark)

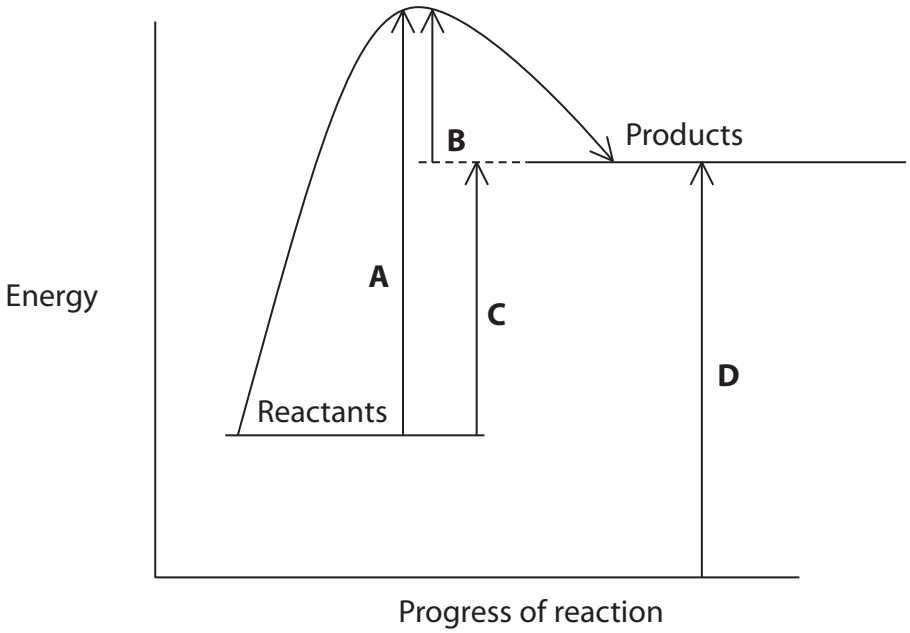
P 4 2 9 7 1 A 0 6 2 4
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13 For barium, the third ionization energy is higher than the second ionization energy because

- ☒ **A** there is an increase in the number of protons.
- ☒ **B** there is an increase in the shielding.
- ☒ **C** the ionic radius is greater.
- ☒ **D** the electron being removed is closer to the nucleus.

(Total for Question 13 = 1 mark)

14 The reaction profile for an endothermic reaction is shown below.



(a) Which arrow represents the activation energy for the **forward** reaction?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(b) Which arrow represents the activation energy for the **backward** reaction?

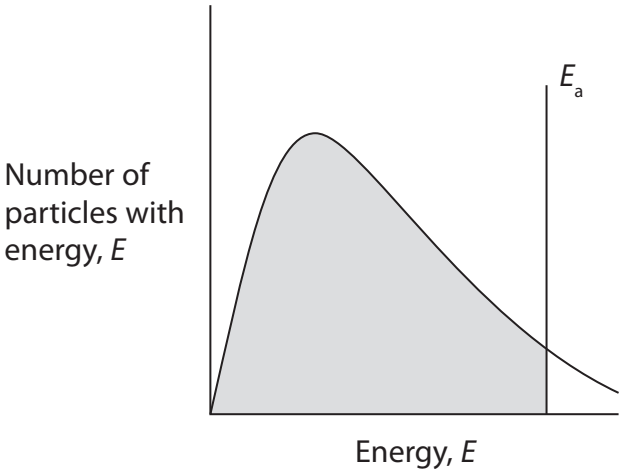
(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 14 = 2 marks)

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15 Consider the Maxwell-Boltzmann distribution of energies for a gas shown below. E_a represents the activation energy.



The shaded area of the diagram indicates the total number of particles that

☒ **A** do have enough energy to react.

☒ **B** do not have enough energy to react.

☒ **C** do have enough energy to react in the presence of a catalyst.

☒ **D** do not have enough energy to react in the presence of a catalyst.

(Total for Question 15 = 1 mark)

16 Which of the following is a pure form of carbon that has both hexagonal and pentagonal rings in its structure and can conduct electricity?

☒ **A** Charcoal

☒ **B** Buckminsterfullerene

☒ **C** Diamond

☒ **D** Graphite

(Total for Question 16 = 1 mark)

17 Hydrogen, H_2, is not a completely 'carbon neutral' fuel. Which of the following is an **incorrect** reason for this?

☒ **A** Some CO_2 is released in the transportation of H_2 fuel.

☒ **B** CO_2 is made when the electricity is generated for the manufacture of H_2.

☒ **C** A small amount of CO_2 is produced on the combustion of H_2 fuel.

☒ **D** CO_2 is released during the construction of the H_2 manufacturing plant.

(Total for Question 17 = 1 mark)

P 4 2 9 7 1 A 0 8 2 4
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18 When steam is passed over heated magnesium, which of the following occurs?

☒ **A** $Mg + H_2O \rightarrow MgO + H_2$

☒ **B** $Mg + H_2O \rightarrow MgOH + \frac{1}{2}H_2$

☒ **C** $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$

☒ **D** There is no reaction with the magnesium.

(Total for Question 18 = 1 mark)

19 Which of the following will **not** affect the rate of the reaction below?

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

☒ **A** Surface area

☒ **B** Concentration

☒ **C** Pressure

☒ **D** Temperature

(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

20 Brand **X** is unlike many conventional toilet cleaners in that it does not contain bleach, but instead contains hydrochloric acid. The label states that the toilet cleaner contains 9 g of HCl per 100 cm^3 of the toilet cleaner.

An industrial technician was given the task of checking the validity of this statement. Using 25.0 cm^3 portions of the toilet cleaner, the technician carried out a titration using 2.50 mol dm^{-3} sodium hydroxide solution and obtained the following results.

Titration	Trial	1	2
Final Volume /cm^3	25.00	49.60	24.50
Initial Volume /cm^3	0.00	25.00	0.00
Volume Added /cm^3			

(a) (i) Complete the table and calculate the mean titre by selecting the appropriate results.

(1)

(ii) Write the equation for the titration reaction. State symbols are not required.

(1)

(iii) Calculate the number of moles of sodium hydroxide that reacted.

(1)

P 4 2 9 7 1 A 0 1 0 2 4
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(iv) Hence state the number of moles of hydrochloric acid that reacted with the sodium hydroxide.

(1)

(v) Calculate the mass of HCl present in 100 cm^3 of the toilet cleaner. Give your answer to 3 significant figures.

(2)

(vi) Using the technician's results, comment on the validity of the manufacturer's statement that the toilet cleaner contained 9 g of HCl per 100 cm^3. Justify your answer.

(1)

.....

.....

.....

(vii) Explain why titrations involving the use of a 2.50 mol dm^{-3} sodium hydroxide solution would **not** be advisable in a school or college laboratory.

(1)

.....

.....

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(b) Conventional toilet cleaners contain a bleaching agent. Chloric(I) acid, HOCl, is one such substance.

Draw the dot and cross diagram for chloric(I) acid. Show outer electrons only.

(1)

(c) The instructions for the use of Brand **X** state that the toilet cleaner should not be used with bleaching agents.

Complete the equation for the reaction between the hydrochloric acid in the toilet cleaner and the chloric(I) acid in the bleaching agent. Give a reason why this reaction is to be avoided in accordance with the instructions for the use of the toilet cleaner.

(2)

Equation HCl + HOCl →

Reason .....

.....

.....

(d) Another bleaching agent is sodium chlorate(I), NaClO, which can be purchased as a solution. It can also be obtained by bubbling chlorine gas into sodium hydroxide solution.

(i) Give the oxidation numbers of the chlorine-containing species in the equation below and classify the reaction as a result of your answer.

$$2NaOH(aq) + Cl_2(g) \longrightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$$

Oxidation Number ....

(2)

Type of reaction .....

P 4 2 9 7 1 A 0 1 2 2 4
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(ii) State how the reaction conditions would need to be changed in order to produce sodium chlorate(V) instead of sodium chlorate(I).

(1)

.....

.....

(iii) Give the equation for the reaction between chlorine and sodium hydroxide solution that forms sodium chlorate(V) as one of the products. State symbols are not required.

(2)

(Total for Question 20 = 16 marks)

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21 This is a question about halogenoalkanes.

(a) Halogenoalkanes can react with hydroxide ions in different ways depending on the conditions used. Using 1-chloro-1-fluoroethane, CH_3CHClF, as an example of a halogenoalkane, the following reaction could occur in aqueous solution.

$$CH_3CHClF + OH^- \rightarrow CH_3CHOHF + Cl^-$$

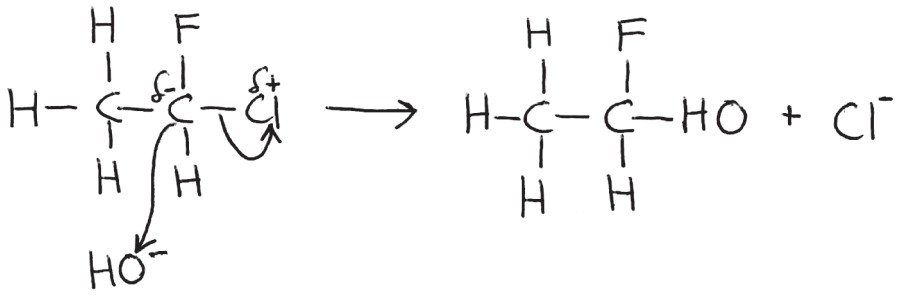
(i) Suggest why it is unlikely that the fluorine atom in CH_3CHClF would be substituted by the hydroxide ion.

(1)

.....

.....

*(ii) A student attempted to draw the reaction mechanism for the reaction in (a)(i), but made a total of three errors.



Identify these errors and state how they should be corrected.

(3)

First error .....

.....

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Second error .....

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Third error .....

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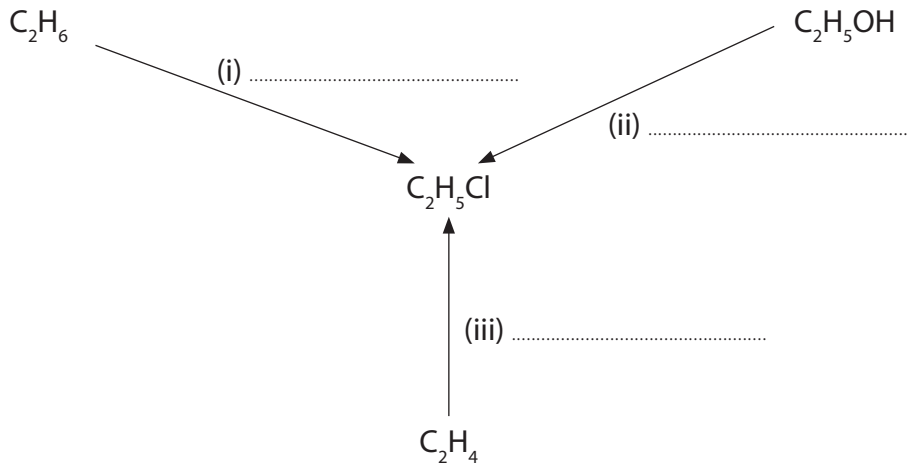
(iii) In hot alcoholic solution, a different reaction may occur between halogenoalkanes and hydroxide ions.

Write the equation for the reaction between 1-chloro-1-fluoroethane, CH_3CHClF, and hydroxide ions in alcoholic solution.

(2)

(b) Chloroethane can be produced in various ways as shown below. Identify, by name or formula, the reagent needed for each of these reactions.

(3)



(c) (i) Chloroethane will react with alcoholic ammonia **initially** to produce ethylamine. Complete the equation for this reaction.

(1)

..... + NH_3 → ..... + ...

(ii) Name the type and mechanism of the reaction occurring in (c)(i).

(2)

.....

.....

(iii) What feature of the ammonia molecule enables the reaction in (c)(i) to take place?

(1)

.....

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(iv) If aqueous ammonia was used in (c)(i), instead of alcoholic ammonia, suggest the identity of the organic product that would be formed.

(1)

.....

(d) Dichlorodifluoromethane, CCl_2F_2, is also known as Freon 12 and its manufacture was banned in 1994 under the terms of the Montreal Protocol.

(i) Complete the equation for the initiation stage and suggest equations for two of the propagation stages and a termination stage for the mechanism of the reaction that this molecule might undergo with ozone.

(4)

Initiation $CCl_2F_2 \rightarrow$

Propagation 1

Propagation 2

Termination

*(ii) Explain why the effect of Freon 12 molecules on the ozone layer was such a serious issue that scientists recommended its use to be discontinued.

(2)

.....

.....

.....

.....

(iii) Freon 12, CCl_2F_2, could also be described as a "greenhouse gas". Explain what the term 'greenhouse gas' means.

(2)

.....

.....

.....

.....

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(iv) Freon 12, and other similar molecules, are not normally viewed as contributors to the greenhouse effect. Suggest why this is so.

(1)

.....

.....

(Total for Question 21 = 23 marks)

TOTAL FOR SECTION B = 39 MARKS

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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

22

Spontaneous combustion is often a subject of fantasy in movies, but it does actually happen with some chemical compounds. One such compound is silane, SiH_4, which is analogous to methane, CH_4. Methane is the main gas that is used in school and college laboratories with Bunsen burners, but it requires a spark or a lighted splint to ignite. Silane does not require any such ignition, and at room temperature is spontaneously flammable. This can make an interesting chemical demonstration.

One method of making silane is by mixing together two solids, silicon dioxide and magnesium, with the magnesium being in excess. The two chemicals are thoroughly mixed together. This mixture is then heated to red-heat and initially produces powdered silicon. The silicon then reacts further with the excess magnesium powder and forms magnesium silicide, Mg_2Si. The two reactions which occur are shown in the equations below.

$$SiO_2 + 2Mg \longrightarrow 2MgO + Si$$

$$Si + 2Mg \longrightarrow Mg_2Si$$

The magnesium silicide formed is then reacted with hydrochloric acid to form silane, SiH_4.

(a) Complete and balance the equation for this reaction. State symbols are not required.

(2)

Mg_2Si + ...HCl ⟶ ..... + ...

(b) Bubbles of silane rise to the surface in the reaction mixture and spontaneously combust with oxygen in the air.

Suggest the names or formulae of the products of the reaction between silane and oxygen.

(2)

.....

.....

(c) Predict the molecular shape of silane, SiH_4, and suggest the bond angle.

(2)

Shape .....

Bond angle .....

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(d) Explain why the Si—H bond is longer than the C—H bond.

(2)

*(e) Identify the intermolecular forces present in pure samples of both silane and methane.

Explain why silane has a higher boiling temperature than methane and why both are gases at room temperature.

(4)

(f) (i) Define the term **electronegativity**.

(2)

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*(ii) Some Pauling electronegativity values for selected elements are given below.

H 2.1						
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0

Using the values in the table above, compare the polarity of the bonds in a molecule of methane with that found in a molecule of silane.

Comment on the significance of any difference.

(3)

(iii) Using the table in (f)(ii), choose an element which, when covalently bonded to hydrogen, forms a molecule containing bonds that are more polar than those in silane or methane. Give the formula of the hydride of your chosen element and state the electronegativity difference.

(2)

(iv) Explain why it is possible for the bonds within a molecule to be polar, but for the molecule itself to be non-polar. Give an example of such a molecule.

(2)

(Total for Question 22 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS

TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

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Mark Scheme (Results)

June 2014

GCE Chemistry 6CH02/01

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	B		1

Question Number	Correct Answer	Reject	Mark
2	B		1

Question Number	Correct Answer	Reject	Mark
3	C		1

Question Number	Correct Answer	Reject	Mark
4	D		1

Question Number	Correct Answer	Reject	Mark
5	D		1

Question Number	Correct Answer	Reject	Mark
6	C		1

Question Number	Correct Answer	Reject	Mark
7	A		1

Question Number	Correct Answer	Reject	Mark
8	A		1

Question Number	Correct Answer	Reject	Mark
9	D		1

Question Number	Correct Answer	Reject	Mark
10	B		1

Question Number	Correct Answer	Reject	Mark
11	A		1

Question Number	Correct Answer	Reject	Mark
12	A		1

Question Number	Correct Answer	Reject	Mark
13	D		1

Question Number	Correct Answer	Reject	Mark
14 (a)	A		1

Question Number	Correct Answer	Reject	Mark
14 (b)	B		1

Question Number	Correct Answer	Reject	Mark
15	B		1

Question Number	Correct Answer	Reject	Mark
16	B		1

Question Number	Correct Answer	Reject	Mark
17	C		1

Question Number	Correct Answer	Reject	Mark
18	A		1

Question Number	Correct Answer	Reject	Mark
19	C		1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
	In (a) any units given must be correct. **Penalise incorrect units once only.** **Ignore SF except 1 SF in (i), (iii) and (iv). Penalise once only**		
20 (a)(i)	<table><tr><td>Volume Added/cm^3</td><td>25(.00)</td><td>24.6(0)</td><td>24.5(0)</td></tr></table> 24.55 (cm^3) Allow 24.6 (cm^3)	 24.70 24.60	1

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	$NaOH + HCl \rightarrow NaCl + H_2O$ Ignore state symbols even if incorrect		1

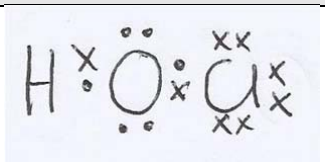
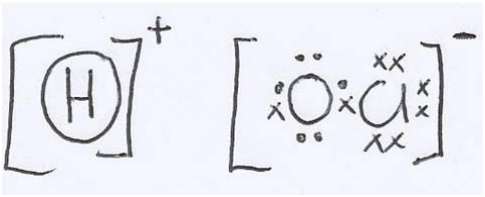
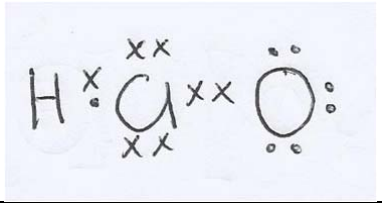
Question Number	Acceptable Answers	Reject	Mark
20 (a)(iii)	Number of moles of NaOH $= (\frac{24.55}{1000} \times 2.5) = 6.1375 \times 10^{-2} = 0.061375$(mol) OR $6.14 \times 10^{-2} = 0.0614$ OR $6.1 \times 10^{-2} = 0.061$ Allow TE from 20(a)(i)	 0.0613 0.06	1

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iv)	6.1375×10^{-2} /0.061375/ 6.14×10^{-2} / 0.0614/0.061(mol) Allow TE = answer to (a)(iii)		1

Question Number	Acceptable Answers	Reject	Mark
20 (a)(v)	Multiply by 4 and by 36.5 **(1)** Using 6.1375 x 10^{-2} gives 8.96075 = 8.96 (g) OR Using 6.14 x 10^{-2} gives 8.9644 = 8.96(g) OR Using 6.1 x 10^{-2} gives 8.906 = 8.91(g) Answer to **3 SF** **(1)** Correct answer without working score (2) Allow TE from (a)(iv) ALLOW one mark for correct answer to 3SF where the multiplication by 4 has been omitted, e.g. (6.1375 x 10^{-2} x 36.5 = 2.2401875 =) 2.24(g) **(1)**		2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(vi)	The statement is valid as 8.96 ~9/very close Allow appropriate comment from answer to (a)(v) e.g 2.24 is not valid because it is too far away from 9g.	Just 'not valid / valid'	1

Question Number	Acceptable Answers	Reject	Mark
20 a(vii)	(Too) corrosive Damages eyes/burns (skin)/caustic Ignore Dangerous/Strong/Too concentrated	Just 'Harmful/Irritant/Toxic/Hazardous' Acid	1

Question Number	Acceptable Answers	Reject	Mark
20 (b)	 Allow all dots or all crosses ALLOW ionic dot and cross  Or dative covalent bond from chlorine 		1

Question Number	Acceptable Answers	Reject	Mark
20 (c)	$HCl + HOCl \rightarrow H_2O + Cl_2$ **(1)** Ignore state symbols even if incorrect Chlorine is toxic/poisonous **(1)** Allow fumes are toxic Ignore references to smell or colour	 Just 'Harmful/ irritant/dangerous/ hazardous'	2

Question Number	Acceptable Answers	Reject	Mark
20 (d)(i)	($2NaOH + Cl_2 \rightarrow NaCl + NaClO + H_2O$) 0 -1 +1 All oxidation numbers correct **(1)** Type: Disproportionation **(1)** Allow phonetic spellings Allow redox **and** disproportionation Second mark consequential on the first except if (i) all the oxidation numbers are zero (ii) the plus sign is missing, (iii) the first two oxidation numbers are correct and the third one is positive If all the elemental oxidation numbers are given correctly then both marks are available	Just redox	2

Question Number	Acceptable Answers	Reject	Mark
20 (d)(ii)	Heat/increase temperature ALLOW (more) concentrated NaOH	Just 'warm' / 'excess NaOH' Acid	1

Question Number	Acceptable Answers	Reject	Mark
20 (d)(iii)	$3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$ OR $3Cl_2 + 6OH^- \rightarrow 5Cl^- + ClO_3^- + 3H_2O$ Formula of $NaClO_3$ / ClO_3^- **(1)** Rest of equation correct **(1)** Ignore state symbols even if incorrect		2

TOTAL FOR Q20 = 16 MARKS

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	**C-F** bond is strong(er than C-Cl bond/C-OH bond) OR **C-F** bond is hard(er) to break (than C-Cl bond/C-OH bond) OR **C-F** bond enthalpy is high(er than C-Cl bond/C-OH bond) Ignore references to electronegativity	H-F bond is strong	1

Question Number	Acceptable Answers	Reject	Mark
21 (a)(ii)	The C-Cl dipole is the wrong way round **(1)** Allow reference to either only the carbon or only the chlorine having the wrong partial charge, e.g. "the carbon should be δ^+ not δ^-" The arrow goes from the carbon to the (oxygen of the) hydroxide ion but should be the other way around OR The pair of electrons goes from the carbon to the (oxygen of the) hydroxide ion but should be the other way around **(1)** Use of the term 'carbocation' means that only one of the first two marks may be awarded. The carbon bond to the hydroxy group should be to the oxygen and not to the hydrogen **(1)** Allow the above points to be drawn out correctly instead of stated in words Standalone marks IGNORE δ^- on fluorine atom Reference to lack of transition state Reference to absence of lone pair of electrons on the hydroxide ion	C+ Cl^- OH **group** Hydroxide	3

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iii)	$CH_3CHClF + OH^- \rightarrow CH_2CHF + Cl^- + H_2O$ Organic product **(1)** Rest of equation correct **(1)** The organic molecules can be drawn displayed Allow any suitable metal hydroxide, e.g. $CH_3CHClF + NaOH \rightarrow CH_2CHF + NaCl + H_2O$ Allow C_2H_3F for the organic product Ignore state symbols even if incorrect.	 CH_3CF	2

Question Number	Acceptable Answers	Reject	Mark
21 (b)	(i) Cl_2/chlorine (gas) **(1)** (ii) PCl_5/phosphorus (V) chloride **(1)** Allow Any other suitable reagents, such as HCl (and $ZnCl_2$) OR NaCl + concentrated H_2SO_4 OR $SOCl_2$ OR PCl_3 OR (concentrated) hydrochloric acid for (ii) (iii) HCl/hydrogen chloride **(1)** Ignore Reaction conditions	Cl_2(aq)/Cl• HCl(aq)	3

Question Number	Acceptable Answers	Reject	Mark
21 (c)(i)	$CH_3CH_2Cl + NH_3 \rightarrow CH_3CH_2NH_2 + HCl$ OR $CH_3CH_2Cl + NH_3 \rightarrow CH_3CH_2NH_3^{(+)}Cl^{(-)}$ OR $CH_3CH_2Cl + NH_3 \rightarrow CH_3CH_2NH_3^{(+)} + Cl^{(-)}$ OR $C_2H_5Cl + NH_3 \rightarrow C_2H_5NH_2 + HCl$ OR $CH_3CH_2Cl + 2NH_3 \rightarrow CH_3CH_2NH_2 + NH_4^{(+)}Cl^{(-)}$ OR $C_2H_5Cl + 2NH_3 \rightarrow C_2H_5NH_2 + NH_4^{(+)}Cl^{(-)}$	C_2H_7N	1

Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii)	Nucleophilic **(1)** Substitution **(1)** ALLOW Just 'S_N2' for (1)	Elimination Addition S_N1	2

Question Number	Acceptable Answers	Reject	Mark
21 (c)(iii)	A **lone** pair (of electrons on the nitrogen atom)/ pair of non-bonding electrons	Pairs Just 'spare pair'	1

Question Number	Acceptable Answers	Reject	Mark
21 (c) (iv)	Ethanol / C_2H_5OH / CH_3CH_2OH	Alcohol	1

Question Number	Acceptable Answers	Reject	Mark
21 (d)(i)	Initiation $CCl_2F_2 \rightarrow CClF_2^{\bullet} + Cl^{\bullet}$ **(1)** --- Propagation 1 This must include a free radical from the initiation step reacting with ozone $Cl^{(\bullet)} + O_3 \rightarrow ClO^{(\bullet)} + O_2$ OR $CClF_2^{(\bullet)} + O_3 \rightarrow CClF_2O^{(\bullet)} + O_2$ **(1)** Propagation 2 $ClO^{(\bullet)} + O^{(\bullet)} \rightarrow Cl^{(\bullet)} + O_2$ OR $ClO^{(\bullet)} + O_3 \rightarrow Cl^{(\bullet)} + 2O_2$ **(1)** Allow propagation steps starting from $CClF_2^{\bullet}/CClF_2O^{(\bullet)}$ or either of the equations from propagation 1 --- Termination $Cl^{\bullet} + Cl^{\bullet} \rightarrow Cl_2$ OR $CClF_2^{\bullet} + Cl^{\bullet} \rightarrow CCl_2F_2$ OR $ClO^{\bullet} + ClO^{\bullet} \rightarrow Cl_2 + O_2$ **(1)** Allow other combinations of free radicals using those shown above. Ignore curly arrows	Any charges	4

Question Number	Acceptable Answers	Reject	Mark
21 (d)(ii)	The depleted ozone layer allows in (more) **UV** (radiation) **(1)** Which results in (skin) cancer/cataracts/mutation/ DNA damage/ Any reference to a chain reaction/ One $Cl^{(\bullet)}$ destroys many ozone molecules/ $Cl^{(\bullet)}$ is regenerated/ $Cl^{(\bullet)}$ catalyst/ death of marine organisms such as phytoplankton **(1)** Standalone marks Any reference to greenhouse effect or global warming or infrared radiation scores (0)	Cancer from $Cl^{(\bullet)}$	2

Question Number	Acceptable Answers	Reject	Mark
21 (d)(iii)	(A greenhouse gas) traps/absorbs/reflects AND Infrared (radiation)/heat/ longer wavelength radiation OR Stops infrared (radiation) /heat escaping **(1)** (Reflected/(Re)radiated/(Re)emitted) **from the Earth**('s surface) Allow **Back** to the earth **(1)** Mention of ozone layer depletion/acid rain max 1	UV scores 0 overall. From the sun	2

Question Number	Acceptable Answers	Reject	Mark
21 (d)(iv)	Low concentration/amount/abundance in the atmosphere Short residency time	Just "they are no longer being used/they are not increasing".	1

TOTAL FOR Q21 = 23 MARKS
TOTAL FOR SECTION B = 39 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
22 (a)	$Mg_2Si + 4HCl \longrightarrow 2MgCl_2 + SiH_4$ Correct formulae of products **(1)** Balancing of equation **(1)** Second mark dependent on first Ignore state symbols even if incorrect Allow one mark for the following equation $Mg_2Si + 4HCl \longrightarrow Mg_2Cl_4 + SiH_4$		**2**

Question Number	Acceptable Answers	Reject	Mark
22 (b)	Silicon dioxide/ SiO_2 /Silica **(1)** Water/H_2O **(1)** Allow names or formulae or both together but they both must be correct. Allow incorrect spellings if unambiguous Allow products to be given in an equation which does not have to be balanced.	Silicon oxide/ SiO CO_2 Silicone/Silicane dioxide H_2	**2**

Question Number	Acceptable Answers	Reject	Mark
22 (c)	Tetrahedral **(1)** $109.5^{(o)}$ **(1)**	 109°	**2**

Question Number	Acceptable Answers	Reject	Mark
22 (d)	Silicon (atom) is larger OR Because it has more shells of electrons **(1)** Weaker attraction/bond OR Greater shielding in silicon **(1)** Reverse argument applies in both marking points Stand-alone marks Ignore references to electronegativity/bond polarity	Ions/ionic radius Charge density Molecule Just 'more electrons' Reference to intermolecular forces	2

Question Number	Acceptable Answers	Reject	Mark
22 (e)	**Marking Point 1** London forces/Dispersion forces Temporary/instantaneous dipole induced dipole forces **(1)** ALLOW van der Waals forces **Marking Point 2** Silane/silicon has more electrons **(1)** **Marking Point 3** Silane has stronger/more London forces **(1)** **Marking Point 4** London forces are weak OR Little energy is required to break London forces (hence both are gases) **(1)** Ignore references to surface area	Dipole-dipole Induced dipole-induced dipole Hydrogen bonds Larger molar mass/ Great density of electrons/ larger electron cloud Break Si-H or C-H bonds	4

Question Number	Acceptable Answers	Reject	Mark
22 (f)(i)	The ability (of an atom) to attract/to pull/to draw the electrons **(1)** in/of a covalent bond Allow 'shared electron pair' **(1)** Allow species/element for atom		2

Question Number	Acceptable Answers	Reject	Mark
22 (f)(ii)	**Marking Point 1** In methane difference is 0.4 and silane difference is 0.3/Methane has a difference of 0.1 more than silane **(1)** **Marking Point 2** Hydrogen is more electronegative than silicon but less electronegative than carbon OR In methane, hydrogen will have a δ+ charge but in silane hydrogen will have a δ- charge OR The C-H bonds in methane are more polar (than the Si-H bonds in silane) **(1)** **Marking Point 3** The difference is small and so not significant, or has a minor effect **(1)** Ignore references to bond strength		3

Question Number	Acceptable Answers	Reject	Mark
22 (f)(iii)	Any suitable example and electronegativity difference scores 2 marks $NH_3/H_2O/HF/HCl$ **(1)** 0.9/1.4/1.9/0.9 **(1)** Second mark consequential on the first, but if the formula is incorrect, e.g. HF_2, but the difference is correct of 1.9, then allow second mark. Allow one mark for an ionically-bonded hydride with a correct electronegativity difference greater than 0.4, e.g. NaH and 1.2 (1) Allow H_2S and the difference of 0.4 for 1 mark.	BH_3 / B_2H_6 / PH_3 scores 0	2

Question Number	Acceptable Answers	Reject	Mark
22 (f)(iv)	Bond polarities cancel in a symmetrical molecule/ centres of charge coincide in a symmetrical molecule OR Linking bond polarities cancelling due to the molecular shape which needs to be stated/drawn **(1)** Allow polar bonds for bond polarities Any suitable example, e.g. CCl_4/CO_2 / BF_3 / SF_6 **(1)** Allow CH_4 / SiH_4 Standalone marks	H_2	2

TOTAL FOR SECTION C (Question 22) = 21 MARKS

TOTAL FOR PAPER = 80 Marks

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Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Tuesday 4 June 2013 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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10/5/6/7/

P 4 1 6 5 0 A 0 1 2 4

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following molecules has the smallest bond angle?

☒ **A** H_2O

☒ **B** NH_3

☒ **C** CH_4

☒ **D** SF_6

(Total for Question 1 = 1 mark)

2 A charged rod is held beside a stream of liquid coming from a burette. Which of the following liquids would NOT be significantly deflected?

☒ **A** H_2O

☒ **B** CCl_4

☒ **C** C_2H_5OH

☒ **D** C_2H_5Br

(Total for Question 2 = 1 mark)

3 Which of the following statements about electronegativity is true?

☒ **A** Non-metals have lower electronegativity than metals.

☒ **B** Electronegativity decreases across a period in the Periodic Table.

☒ **C** Electronegativity decreases going down a group in the Periodic Table.

☒ **D** The bonds between atoms with equal electronegativity are always weak.

(Total for Question 3 = 1 mark)

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4 In which series of compounds does the covalent character increase, going from left to right?

☒ **A** NaCl, $MgCl_2$, $AlCl_3$, $SiCl_4$

☒ **B** SiO_2, Al_2O_3, MgO, Na_2O

☒ **C** LiI, NaI, KI, RbI

☒ **D** KI, KBr, KCl, KF

(Total for Question 4 = 1 mark)

5 Going down Group 2 from calcium to barium

☒ **A** the first ionization energy of the element increases.

☒ **B** the strength of the metallic bonding increases.

☒ **C** the polarizing power of the 2+ ion decreases.

☒ **D** the stability of the nitrate to heat decreases.

(Total for Question 5 = 1 mark)

6 Fullerenes, graphite and diamond are all forms of carbon. Fullerenes dissolve in petrol, but diamond and graphite do not. This is because

☒ **A** the bonds between the carbon atoms in fullerenes are weaker than in diamond or graphite.

☒ **B** diamond and graphite are giant structures but fullerenes are molecular.

☒ **C** there are delocalized electrons in diamond and graphite but not in fullerenes.

☒ **D** there are covalent bonds in diamond and graphite, but not in fullerenes.

(Total for Question 6 = 1 mark)

7 Sodium chloride is more soluble in water than in hexane because

☒ **A** the intermolecular forces between water molecules are stronger than those between hexane molecules.

☒ **B** hexane molecules cannot fit between the ions in the sodium chloride lattice.

☒ **C** energy is released when the ions in sodium chloride are hydrated.

☒ **D** sodium ions and chloride ions form hydrogen bonds with water.

(Total for Question 7 = 1 mark)

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8 Hydrochloric acid and sodium carbonate solution react as shown below.

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

Which sample of sodium carbonate solution will be neutralized by 20 cm^3 of 0.05 mol dm^{-3} hydrochloric acid?

	Volume of sodium carbonate/ cm^3	Concentration of sodium carbonate/ mol dm^{-3}
☒ **A**	10	0.05
☒ **B**	40	0.05
☒ **C**	40	0.10
☒ **D**	10	0.10

(Total for Question 8 = 1 mark)

9 A white solid produces oxygen when it is heated, but no other gases. The solid could be

☒ **A** lithium nitrate.

☒ **B** potassium nitrate.

☒ **C** strontium nitrate.

☒ **D** calcium oxide.

(Total for Question 9 = 1 mark)

10 A solid is soluble in water and produces steamy acidic fumes with concentrated sulfuric acid. The solid could be

☒ **A** potassium carbonate.

☒ **B** magnesium sulfate.

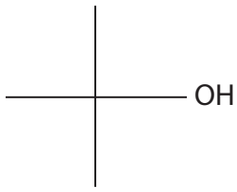
☒ **C** silver chloride.

☒ **D** sodium chloride.

(Total for Question 10 = 1 mark)

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11



The systematic name of the compound with skeletal formula shown above is

☒ **A** 1,1-dimethylethanol.

☒ **B** 2,2-dimethylethanol.

☒ **C** 2-methylpropan-1-ol.

☒ **D** 2-methylpropan-2-ol.

(Total for Question 11 = 1 mark)

12 Samples of 1-chloropropane and 1-bromopropane are warmed with water containing dissolved silver nitrate in the presence of ethanol. The 1-chloropropane reacts more slowly because

☒ **A** the C—Cl bond is more polar than the C—Br bond.

☒ **B** the C—Cl bond is stronger than the C—Br bond.

☒ **C** 1-chloropropane is less soluble than 1-bromopropane.

☒ **D** 1-chloropropane is a weaker oxidizing agent than 1-bromopropane.

(Total for Question 12 = 1 mark)

13 The reaction of 1-chloropropane with water containing dissolved silver nitrate in the presence of ethanol is

☒ **A** a redox reaction.

☒ **B** a nucleophilic substitution.

☒ **C** an electrophilic substitution.

☒ **D** a free radical substitution.

(Total for Question 13 = 1 mark)

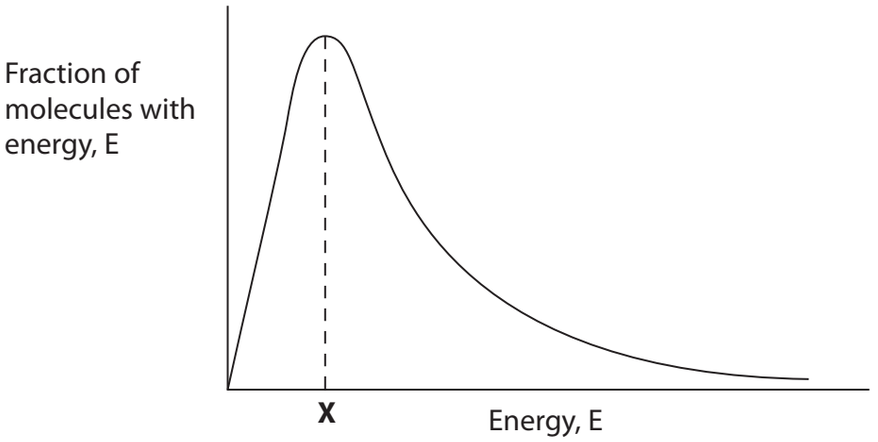
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14 The compound with formula $CH_3CH(NH_2)CH_3$ can be made by reacting alcoholic ammonia with

- ☒ **A** propane.
- ☒ **B** propene.
- ☒ **C** 2-chloropropane.
- ☒ **D** propan-2-ol.

(Total for Question 14 = 1 mark)

15



The energy marked **X** in the Maxwell-Boltzmann distribution shows

- ☒ **A** the most common energy of the molecules.
- ☒ **B** the activation energy of the reaction.
- ☒ **C** the activation energy of a catalysed reaction.
- ☒ **D** the number of molecules with energy greater than the activation energy.

(Total for Question 15 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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16 In the industrial process involving gas phase reactions to produce ammonia, many collisions between molecules are unsuccessful because

☒ **A** gas phase reactions are reversible.

☒ **B** the collisions are not energetic enough to break the bonds in the molecules.

☒ **C** gas phase reactions can only occur when a catalyst is present.

☒ **D** gas phase reactions can only occur when UV light is present.

(Total for Question 16 = 1 mark)

17 The molecular (parent) ion in the mass spectrum of a hydrocarbon containing ^{12}C and ^{1}H only

☒ **A** is the peak with highest relative abundance.

☒ **B** is the peak with highest charge.

☒ **C** is the peak produced by the most stable fragment.

☒ **D** is the peak with highest mass to charge ratio.

(Total for Question 17 = 1 mark)

18 A compound which has major peaks with mass / charge ratio at 29, 57 and 58 in the mass spectrum could be

☒ **A** propanal, CH_3CH_2CHO.

☒ **B** propanone, CH_3COCH_3.

☒ **C** propan-1-ol, $CH_3CH_2CH_2OH$.

☒ **D** propan-2-ol, $CH_3CH(OH)CH_3$.

(Total for Question 18 = 1 mark)

19 Which of the following would **not** be used to assess whether the use of a biofuel produced from a crop of sugar cane is carbon neutral?

The amount of

☒ **A** fuel used to operate farm machinery.

☒ **B** pesticides and fertilisers used.

☒ **C** energy released per tonne of biofuel.

☒ **D** fuel used to process the crop.

(Total for Question 19 = 1 mark)

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20 The principal reason why scientists have recommended that chlorofluorocarbons (CFCs) are not used in aerosols is that they cause

☒ **A** global warming.

☒ **B** acid rain.

☒ **C** ozone depletion.

☒ **D** water pollution.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

P 4 1 6 5 0 A 0 8 2 4

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 (a) (i) An alkaline solution is produced when barium reacts with cold water. Write the equation for this reaction, including all state symbols.

(2)

(ii) The reaction in (a)(i) is a redox reaction. State the initial and final oxidation number of any element that changes its oxidation number.

(2)

.....

.....

.....

.....

(b) Dilute hydrochloric acid is added to the solution produced in (a)(i). Write the equation for the reaction which occurs. State symbols are **not** required.

(1)

(c) Dilute sulfuric acid is added to another sample of the solution produced in (a)(i). How would the appearance of the resulting mixture differ from the mixture produced in (b)? Explain this difference.

(2)

Appearance .....

Explanation .....

.....

.....

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(d) (i) Two white powders are known to be barium carbonate and magnesium carbonate.

How could you distinguish between the two powders by heating them?
[No practical details are required.]

Include the equation for the action of heat on one of these carbonates. State symbols are not required.

(2)

.....

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.....

Equation:

(ii) Suggest another test, other than heating or the use of an acid, which could be used to distinguish between magnesium carbonate and barium carbonate. State the results for both compounds.

(2)

Test .....

Result with magnesium carbonate .....

.....

Result with barium carbonate .....

.....

(Total for Question 21 = 11 marks)

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22 (a) The products of the reaction when 2-chlorobutane is heated with sodium hydroxide depend on the conditions.

(i) What condition, other than a suitable temperature and sodium hydroxide concentration, would produce a mixture of but-1-ene and but-2-ene?

(1)

.....

(ii) What type of reaction occurs in (a)(i)?

(1)

.....

(iii) What condition, other than a suitable temperature and sodium hydroxide concentration, would produce butan-2-ol in the reaction of 2-chlorobutane with sodium hydroxide?

(1)

.....

(iv) Suggest the mechanism for the reaction of 2-chlorobutane with hydroxide ions to form butan-2-ol. Use curly arrows to show the movement of electron pairs.

(2)

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(b) Phosphorus(V) chloride, PCl_5, can be used to test for the –OH group.

Describe what would be seen when phosphorus(V) chloride is added to butan-2-ol. Give the equation for the reaction. State symbols are not required.

(2)

Observation .....

Equation

(c) A tertiary alcohol, **A**, is an isomer of butan-2-ol.

(i) Butan-2-ol and **A** can be distinguished by warming separate samples with a mixture of potassium dichromate(VI) and sulfuric acid. State the observations which would be made with each alcohol.

(2)

Observation with butan-2-ol .....

.....

Observation with **A** .....

.....

(ii) Give the structural formula of the organic product which forms when butan-2-ol is oxidized.

(1)

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(iii) Explain how infrared spectroscopy could be used to detect whether butan-2-ol has been oxidized.

(1)

.....

.....

.....

.....

(Total for Question 22 = 11 marks)

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23 The boiling temperatures of fluorine and two of its compounds are given below.

Substance	F_2	CH_3F	HF
T_b/K	85	195	293

(a) A molecule of F_2 has 18 electrons.

Which intermolecular force depends to a large extent on the number of electrons in the molecule?

(1)

(b) Calculate the number of electrons in a molecule of CH_3F.

(1)

(c) Explain why the boiling temperature of CH_3F is greater than that of F_2, referring to the intermolecular forces present.

(1)

(d) Explain why the boiling temperature of HF is the highest in the series.

(2)

P 4 1 6 5 0 A 0 1 6 2 4

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(e) Explain why the values of the boiling temperatures for Cl_2, CH_3Cl and HCl do not follow the same trend as F_2, CH_3F and HF.

(1)

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(Total for Question 23 = 6 marks)

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24 The percentage by mass of tin in a piece of rock containing tin(IV) oxide, SnO_2, was determined as described in the procedure below.

Step 1 A sample of rock, with mass 10.25 g, was crushed and dissolved in sulfuric acid.

Step 2 The solution was treated with a reducing agent to convert the Sn^{4+} to Sn^{2+} ions.

Step 3 50 cm^3 of aqueous iodine solution with concentration 0.250 mol dm^{-3} was added to the solution of Sn^{2+} ions. The following reaction occurred:

$$Sn^{2+}(aq) + I_2(aq) \rightarrow Sn^{4+}(aq) + 2I^-(aq)$$

Step 4 The **excess** iodine was titrated with sodium thiosulfate solution with concentration 0.100 mol dm^{-3}. The volume of sodium thiosulfate solution required was 11.60 cm^3.

(a) Thiosulfate ions react with iodine as shown below.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

(i) Calculate the number of moles of sodium thiosulfate which were used in **Step 4**.

(1)

(ii) Calculate the number of moles of iodine which reacted with this amount of sodium thiosulfate.

(1)

(iii) Calculate the number of moles of iodine added to the solution of Sn^{2+} ions in **Step 3**.

(1)

(iv) Use your results from (ii) and (iii) to calculate the number of moles of iodine which reacted with the Sn^{2+} ions from the rock.

(1)

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(v) Hence calculate the percentage by mass of tin in the rock.

(2)

(b) (i) What change could be made in **Step 4** to improve the reliability of the result?

(1)

.....

.....

.....

(ii) The error each time the burette was read was ± 0.05 cm^3. Calculate the percentage error in the titre value of 11.60 cm^3.

(1)

(iii) How could the percentage error in the titre value be reduced without using a different burette?

(1)

.....

.....

(c) The titration can be carried out with or without an indicator. What colour **change** would be seen at the end-point if an indicator was **not** used? The tin ions are colourless.

(1)

.....

(Total for Question 24 = 10 marks)

TOTAL FOR SECTION B = 38 MARKS

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SECTION C

Answer ALL the questions in this section. Write your answers in the spaces provided.

25 (a) Sea water is a source of chemicals. The most abundant chemical dissolved in sea water is sodium chloride. Compounds of magnesium and bromine are also present. Magnesium occurs at 1300 parts per million (ppm) and bromine at 60 ppm by mass.

The solution left after crystallizing sodium chloride from sea water is even richer in bromine, and contains around 2.2 g dm^{-3} of bromine.

Bromine is extracted from this solution by passing in chlorine gas. The mixture is acidified to prevent hydrolysis of bromine by the reaction

$$Br_2(aq) + H_2O(l) \rightleftharpoons 2H^+(aq) + Br^-(aq) + BrO^-(aq)$$

The bromine can be separated by heating the solution to collect bromine vapour which is then condensed, or by blowing air through the solution.

(i) Show by calculation that a solution containing 2.2 g dm^{-3} of bromine is richer in bromine than one containing 60 ppm.

[Assume that the mass of 1 dm^3 of the bromine solution is 1000 g]

(1)

(ii) Write an ionic equation, including state symbols, for the reaction in which chlorine gas reacts with bromide ions in solution to produce bromine.

(2)

(iii) What would be observed when the reaction in (ii) occurs?

(1)

.....

.....

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(iv) Explain why the addition of an acid, such as hydrochloric acid, prevents hydrolysis of bromine.

(2)

(v) Assuming the hydrolysis of bromine is endothermic, explain how an increase in temperature would affect the equilibrium position for the hydrolysis of bromine.

(2)

(vi) Use your knowledge of activation energy to explain why an increase in temperature increases the rate of hydrolysis of bromine.

(1)

(vii) Use the equation for the hydrolysis of bromine to show that it is a disproportionation reaction.

$$Br_2(aq) + H_2O(l) \rightleftharpoons 2H^+(aq) + Br^-(aq) + BrO^-(aq)$$

(2)

(b) At the surface of the sea, there is a dynamic equilibrium between carbon dioxide gas in air and dissolved carbon dioxide in the surface sea water.

$$CO_2(g) \rightleftharpoons CO_2(aq)$$

(i) State **two** features of a system which has reached dynamic equilibrium.

(2)

1. .....

.....

.....

2. .....

.....

.....

*(ii) Carbon dioxide dissolves more easily in seawater than in pure water because seawater contains carbonate ions, $CO_3^{2-}(aq)$, and the following reaction occurs.

$$CO_2(aq) + H_2O(l) + CO_3^{2-}(aq) \rightleftharpoons 2HCO_3^-(aq)$$

Explain how an increase in concentration of carbonate ions in sea water affects the amount of carbon dioxide gas in the atmosphere.

(2)

.....

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.....

.....

(iii) Carbon dioxide and water vapour both contain polar bonds.

What effect does infrared radiation have on the bonds in these molecules?

(1)

.....

.....

.....

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*(iv) Outline the mechanism by which molecules such as carbon dioxide and water cause global warming.

(2)

*(v) Without water vapour in the atmosphere, the earth would be many degrees colder than it is at present. Why are many climate change scientists more concerned about warming due to carbon dioxide in the atmosphere, than warming due to the presence of water vapour? Refer to the difference between anthropogenic climate change and natural climate change in your answer.

(4)

(Total for Question 25 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH02/01
Application of Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	D		1

Question Number	Correct Answer	Reject	Mark
2	B		1

Question Number	Correct Answer	Reject	Mark
3	C		1

Question Number	Correct Answer	Reject	Mark
4	A		1

Question Number	Correct Answer	Reject	Mark
5	C		1

Question Number	Correct Answer	Reject	Mark
6	B		1

Question Number	Correct Answer	Reject	Mark
7	C		1

Question Number	Correct Answer	Reject	Mark
8	A		1

Question Number	Correct Answer	Reject	Mark
9	B		1

Question Number	Correct Answer	Reject	Mark
10	D		1

Question Number	Correct Answer	Reject	Mark
11	D		1

Question Number	Correct Answer	Reject	Mark
12	B		1

Question Number	Correct Answer	Reject	Mark
13	B		1

Question Number	Correct Answer	Reject	Mark
14	C		1

Question Number	Correct Answer	Reject	Mark
15	A		1

Question Number	Correct Answer	Reject	Mark
16	B		1

Question Number	Correct Answer	Reject	Mark
17	D		1

Question Number	Correct Answer	Reject	Mark
18	A		1

Question Number	Correct Answer	Reject	Mark
19	C		1

Question Number	Correct Answer	Reject	Mark
20	C		1

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	$Ba(s) + 2H_2O(l) \rightarrow Ba(OH)_2(aq) + H_2(g)$ OR $Ba(s) + 2H_2O(l) \rightarrow Ba^{2+}(aq) + 2OH^-(aq) + H_2(g)$ Correct products **(1)** State symbols and balancing **(1)**	Ba_2 $H_2O(aq)$ BaO_2	**2**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	Ba(increases in ON) from 0 to +2 **(1)** H (decreases in ON) from +1 to 0 **(1)** TE from (a)(i) Stand-alone marks	Inclusion of oxygen changes will lose 1 mark	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)	$Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O$ IGNORE state symbols even if incorrect ALLOW $H^+ + OH^- \rightarrow H_2O$ TE from (a)(i): $BaO + 2HCl \rightarrow BaCl_2 + H_2O$		**1**

Question Number	Acceptable Answers	Reject	Mark
21(c)	**White** precipitate / **white** solid / **white** crystals (rather than colourless solution) **(1)** Barium sulfate is insoluble (whereas barium chloride is soluble) **(1)** Stand-alone marks	'Cloudy' alone	**2**

Question Number	Acceptable Answers	Reject	Mark
21(d)(i)	**If flame test is described in (d)(i) then award appropriate marks for (d)(ii). A correct decomposition equation given in (d)(i) would score 1 mark.** **Allow valid discussion of thermal stability appearing in (d)(ii) for mark in (d)(i)** Barium carbonate is more thermally stable (than magnesium carbonate) / requires more heating / needs a higher temperature / decomposes more slowly / produces carbon dioxide more slowly OR Reverse argument ($MgCO_3$ decomposes faster) ALLOW $BaCO_3$ doesn't decompose on heating but $MgCO_3$ does **(1)** $MCO_3 \rightarrow MO + CO_2$ Where M stands for Mg or Ba **(1)** IGNORE state symbols even if incorrect	Just 'barium' Just 'produces more carbon dioxide' Just 'magnesium'	**2**

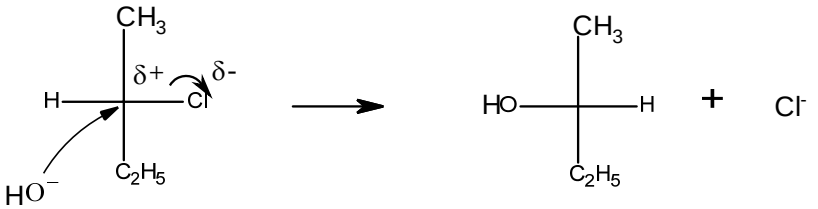
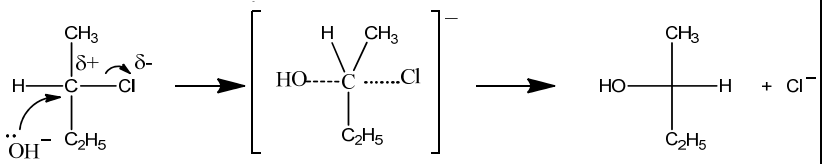
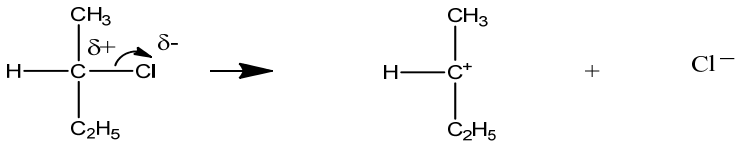
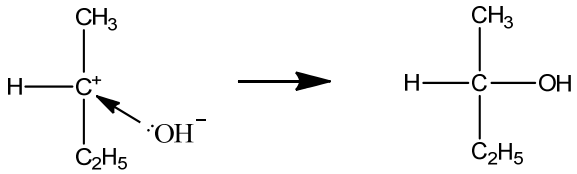
Question Number	Acceptable Answers	Reject	Mark
21(d)(ii)	Flame test or description of: Mg does not colour flame **(1)** ALLOW colourless / clear Ba: (pale / apple) green flame **(1)** Stand-alone marks	Magnesium gives white / bright flame 'blue-green' Instrument analysis	2

Total for Question 21 = 11 Marks

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	Alcohol /ethanol (as solvent for NaOH) IGNORE heat / pressure	Any other reagents	1

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	Elimination		1

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	Water (as solvent for NaOH) / aqueous (NaOH) / aqueous (ethanol)	Aqueous silver nitrate	1

Question Number	Acceptable Answers	Reject	Mark
22 (a)(iv)	  ALLOW   Arrow from OH^- to appropriate C (connected / previously connected) to Cl **(1)** Arrow from C-Cl bond to Cl producing Cl^- **(1)** Accept three dimensional diagrams ; displayed formulae; CH_3CH_2 for C_2H_5 Use of C_4H_9Cl as formula can score 1 for arrow from C-Cl bond to Cl Lone pair on hydroxide ion need not be shown ALLOW solid lines instead of dotted lines in the transition state	OH without charge $Cl^{\cdot}$ (chlorine radical)	**2**

Question Number	Acceptable Answers	Reject	Mark
22(b)	Steamy / misty / white **and** fumes / gas **(1)** IGNORE fizzing $CH_3CH_2CH(OH)CH_3 + PCl_5 \rightarrow CH_3CH_2CHClCH_3 + HCl + POCl_3$ **(1)** ALLOW C_4H_9OH and C_4H_9Cl ALLOW PCl_3O Accept displayed formulae ALLOW missing bracket in alcohol Stand alone marks	White smoke Solid $CH_3CH_2CH_2CH_2OH$ $C_4H_{10}O$	**2**

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	With butan-2-ol: (change from orange) to green / blue **(1)** With **A**: remains orange / no change **(1)** ALLOW 'no reaction' Any reference to 'yellow': max 1	Reference to gas given off or formation of precipitate Green-blue Just 'nothing'	**2**

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	$CH_3CH_2COCH_3$ ALLOW displayed or skeletal		**1**

Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	Absorption /peak /trough for O-H / C-O / OH bond / alcohol CO bond would disappear OR Absorption / peak / trough for C=O / CO ketone bond would appear	Just - OH / CO Just 'alcohol peak' Just 'ketone peak'	**1**

Total for Question 22 = 11 Marks

Question Number	Acceptable Answers	Reject	Mark
23(a)	London (forces) / van der Waals (forces) / temporary dipole-induced dipole (attractions) / dispersion forces / instantaneous dipole-dipole	Dipole-dipole Permanent dipole-dipole Just abbreviations, eg ID-ID, VdW	**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)	18 /eighteen		**1**

Question Number	Acceptable Answers	Reject	Mark
23(c)	(Permanent) dipole-dipole attractions (also) present	Hydrogen bonds Reference to CH_3F having more electrons than F_2	**1**

Question Number	Acceptable Answers	Reject	Mark
23(d)	Hydrogen bonds (also) present **(1)** Which are stronger / which require more energy to break than dipole-dipole / London forces / van der Waals' forces / Or strongest intermolecular force **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
23(e)	HCl does not have hydrogen bonds (between molecules) IGNORE references to electronegativity	Just 'chlorine does not have hydrogen bonds'	US035563

Total for Question 23 = 6 Marks

Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	**In (a) any units given must be correct. Penalise once only.** **IGNORE SF except 1SF. Penalise once only.** **TE throughout** ((0.1x11.6)/(1000) = 1.16 x 10^{-3}/ 0.00116/ 0.0012/1.2 x 10^{-3}(mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	(1.16 x 10^{-3} / 2) = 5.8x10^{-4} / 0.00058 (mol I_2 react with thiosulfate) 6.0x 10^{-4} if 1.2 x 10^{-3} used	6 x 10^{-4}	**1**

Question Number	Acceptable Answers	Reject	Mark
24(a)(iii)	((50x0.25)/1000) = 1.25x10^{-2} / 12.5x10^{-3} / 0.0125 (mol)	0.012	**1**

Question Number	Acceptable Answers	Reject	Mark
24(a)(iv)	= Answer to (a)(iii)- answer to a(ii) (1.25 x 10^{-2} - 5.8x10^{-4}) = 1.192 x10^{-2}/0.01192 (mol reacted with tin) 1.19 x10^{-2}/0.0119 (mol) if 6.0x 10^{-4} used ALLOW 1.2 x 10^{-2}/0.012 (mol)	1.20 x 10^{-2}	**1**

Question Number	Acceptable Answers	Reject	Mark
24(a)(v)	Mass of tin = answer to (a)(iv) x118.7/ = 1.414904/ 1.415 g **(1)** % tin = $\frac{1.415 \times 100}{10.25}$ = 13.803941 = 13.8 % **(1)** TE from mass if only 1 error in its calculation 13.83/ 13.8% if 1.194 x10^{-2} used If answer to(a)(iv) = 5.8x10^{-4} mol I_2 this gives 0.068846 g Sn and 0.67167 % Sn scores (2) Correct answer without working scores (2) ALLOW (1) for 17.5% of SnO_2		**2**

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	Divide solution into separate portions for titration	Just 'repeat the titration' Use starch	**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	$\frac{0.05 \times 2 \times 100}{11.6}$ = (±) 0.86% ALLOW 0.9%	 0.90%	**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(iii)	Use more dilute thiosulfate (to make titration reading bigger) / Use a larger volume or moles of excess iodine	Use more rock	**1**

Question Number	Acceptable Answers	Reject	Mark
24(c)	(Pale) yellow / straw-coloured to colourless	Clear for colourless Blue / black to colourless Orange / grey / brown	**1**

Total for Question 24 = 10 Marks

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	2.2 g in 1000 g = 2200 g per 1 000 000 g / 2200 (ppm) (greater than 60) OR 60ppm = 0.060 (g dm^{-3}) (less than 2.2) OR 2.2g dm^{-3} = 0.22% which is more than 60ppm = 0.006% (Both values needed as neither is given in question) OR 2.2 ÷ 1000 = 2.2 x 10^{-3} and 60 ÷ 1000000 = 6 x 10^{-5}		**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(ii)	Cl_2 (g/aq) + $2Br^-$ (aq) → $2Cl^-$ (aq) + Br_2 (aq) Correct species **(1)** Balancing and state symbols **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	(Colourless to) yellow / orange / brown / red-brown colour (or any combination of these colours) appears	'Effervescence'	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iv)	Addition of hydrochloric acid increases the concentration of H^+ **(1)** Equilibrium shifts to the left/ favours the backwards reaction / H^+ combines with Br^- **and** BrO^- to make H_2O and Br_2 **(1)** OR The equilibrium will not produce H^+ **(1)** So forward reaction will not occur **(1)** Standalone marks		**2**

Question Number	Acceptable Answers	Reject	Mark
25(a)(v)	The equilibrium shifts to the right / favours the forward reaction **(1)** To absorb added heat (energy) / in the endothermic / positive ΔH direction **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
25(a)(vi)	Greater proportion of / more molecules with energy more than (or equal to) activation energy / sufficient energy to react (at higher temperature) ALLOW particles. ALLOW 'overcome' for 'more than'.	Atoms Lowers activation energy Just 'more successful collisions'	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(vii)	Bromine (atoms) are (simultaneously) oxidized from 0 to +1 in BrO^- **(1)** And reduced to -1 in Br^- **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
25(b)(i)	The forward and backward reactions occur at the same **rate** **(1)** The concentrations or amounts or moles of reactants and products remain constant / intensive or macroscopic properties (e.g. colour) are constant **(1)** IGNORE reference to 'closed system'	Concentrations of products and reactants are the same	**2**

Question Number	Acceptable Answers	Reject	Mark
25(b)(ii)	Equilibrium shifts to the right so more $CO_2(g)$ dissolves / equilibrium shifts to the right so reducing the concentration of $CO_2(aq)$ **(1)** So amount of CO_2 in atmosphere / gaseous decreases **(1)** Second mark depends on first unless qualified by a near miss		**2**

Question Number	Acceptable Answers	Reject	Mark
25(b)(iii)	(Bonds) bend / stretch / vibrate (more)/ bonds change polarity or dipole (moment)	Molecules vibrate Bonds break.	**1**

Question Number	Acceptable Answers	Reject	Mark
25(b)(iv)	Infrared radiation / heat is absorbed by greenhouse gases / by carbon dioxide and water **(1)** And one of the following: When energy from the sun is (re-)emitted from the earth's surface (allow 'reflected') OR IR / heat cannot escape from earth's atmosphere OR IR / heat is (re-)emitted back to the earth **(1)**	IR absorbed from the sun UV radiation	**2**

Question Number	Acceptable Answers	Reject	Mark
25(b)(v)	• Anthropogenic climate change is caused by human activity **(1)** • Natural climate change is caused by volcanic eruptions etc **(1)** Up to any three of the following to a max of (4) • Water vapour levels always relatively constant / water levels fluctuate normally / water levels vary only to a small extent • CO_2 levels increasing due to (fossil) fuel combustion/deforestation / industrial revolution • CO_2 **molecules** absorb more IR radiation than H_2O **molecules** OR CO_2 **molecules** have a greater 'greenhouse effect' than H_2O **molecules** • Increase in CO_2 levels has accompanied rise in global temperatures • Concern due to melting of ice packs / rising sea levels / flooding / change in sea pH etc	Reference to UV Reference to ozone depletion negates this mark	**4**

Total for Question 25 = 22 Marks

Total for Paper = 80 Marks

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Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Wednesday 16 January 2013 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P41213A

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7/6/5/4/5/

P 4 1 2 1 3 A 0 1 2 4

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of these bond angles is the **largest**?

☒ **A** Cl—B—Cl in BCl_3

☒ **B** H—N—H in NH_3

☒ **C** Cl—Be—Cl in $BeCl_2$

☒ **D** H—O—H in H_2O

(Total for Question 1 = 1 mark)

2 In propene, $CH_2{=}CH{-}CH_3$,

☒ **A** the C=C double bond is longer and stronger than the C—C single bond.

☒ **B** the C=C double bond is shorter and stronger than the C—C single bond.

☒ **C** the C=C double bond is shorter and weaker than the C—C single bond.

☒ **D** the C=C double bond is longer and weaker than the C—C single bond.

(Total for Question 2 = 1 mark)

3 Which of the following molecules is **not** polar?

☒ **A** HCl

☒ **B** CH_3Cl

☒ **C** $CHCl_3$

☒ **D** CCl_4

(Total for Question 3 = 1 mark)

4 The O—H bond in water is polar because, compared with the hydrogen atom, the oxygen atom has

☒ **A** more electrons.

☒ **B** more neutrons.

☒ **C** greater electronegativity.

☒ **D** a larger atomic radius.

(Total for Question 4 = 1 mark)

P 4 1 2 4 3 A 0 2 2 4
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5 Which of the following compounds has the highest boiling temperature?

☒ **A** CH_4

☒ **B** CH_3Cl

☒ **C** HCHO

☒ **D** CH_3OH

(Total for Question 5 = 1 mark)

6 The oxidation number of sulfur in thiosulfate ions, $S_2O_3^{2-}$, is

☒ **A** +2

☒ **B** +3

☒ **C** +4

☒ **D** +6

(Total for Question 6 = 1 mark)

7 Which of the following is a redox reaction?

☒ **A** $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

☒ **B** $MgO + H_2O \rightarrow Mg(OH)_2$

☒ **C** $NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$

☒ **D** $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

(Total for Question 7 = 1 mark)

8 A solid gives a red colour in a flame test and reacts with concentrated sulfuric acid to produce steamy fumes, but no other gases. The solid could be

☒ **A** lithium bromide.

☒ **B** strontium chloride.

☒ **C** calcium bromide.

☒ **D** sodium chloride.

(Total for Question 8 = 1 mark)

9 Which of the following statements is correct?

☒ **A** Barium sulfate is less soluble in water than calcium sulfate.

☒ **B** Barium hydroxide is less soluble in water than calcium hydroxide.

☒ **C** Barium nitrate undergoes thermal decomposition more readily than calcium nitrate.

☒ **D** Barium shows more than one oxidation state in its compounds.

(Total for Question 9 = 1 mark)

10 Going down Group 7 from chlorine to iodine

☒ **A** the boiling temperature of the hydrogen halide decreases.

☒ **B** the polarity of the hydrogen halide bond increases.

☒ **C** the reducing power of the halide ion increases.

☒ **D** the oxidizing power of the halogen element increases.

(Total for Question 10 = 1 mark)

11 What colour is the vapour which forms when concentrated sulfuric acid is added to solid potassium iodide?

☒ **A** Green

☒ **B** Orange

☒ **C** Brown

☒ **D** Purple

(Total for Question 11 = 1 mark)

12 Calculate the volume of dilute hydrochloric acid, concentration 0.200 mol dm^{-3}, needed to neutralize 20 cm^3 of aqueous calcium hydroxide, concentration 0.100 mol dm^{-3}.

$$2HCl(aq) + Ca(OH)_2(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

☒ **A** 10 cm^3

☒ **B** 20 cm^3

☒ **C** 40 cm^3

☒ **D** 80 cm^3

(Total for Question 12 = 1 mark)

P 4 1 2 4 3 A 0 4 2 4
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13 The reaction of heated magnesium with steam is faster than the reaction of magnesium with cold water. This is mainly because

☒ **A** in cold water, the water molecules do not collide as frequently with magnesium.

☒ **B** the coating of oxide on magnesium decomposes when it is heated.

☒ **C** the fraction of particles with energy greater than the activation energy is higher in the reaction with steam.

☒ **D** the reaction with steam goes by an alternative route with lower activation energy.

(Total for Question 13 = 1 mark)

14 Which of these compounds would **not** react when heated with a mixture of potassium dichromate(VI) and sulfuric acid?

☒ **A** CH_3OH

☒ **B** $CH_3(CH_2)_2OH$

☒ **C** $(CH_3)_2CHOH$

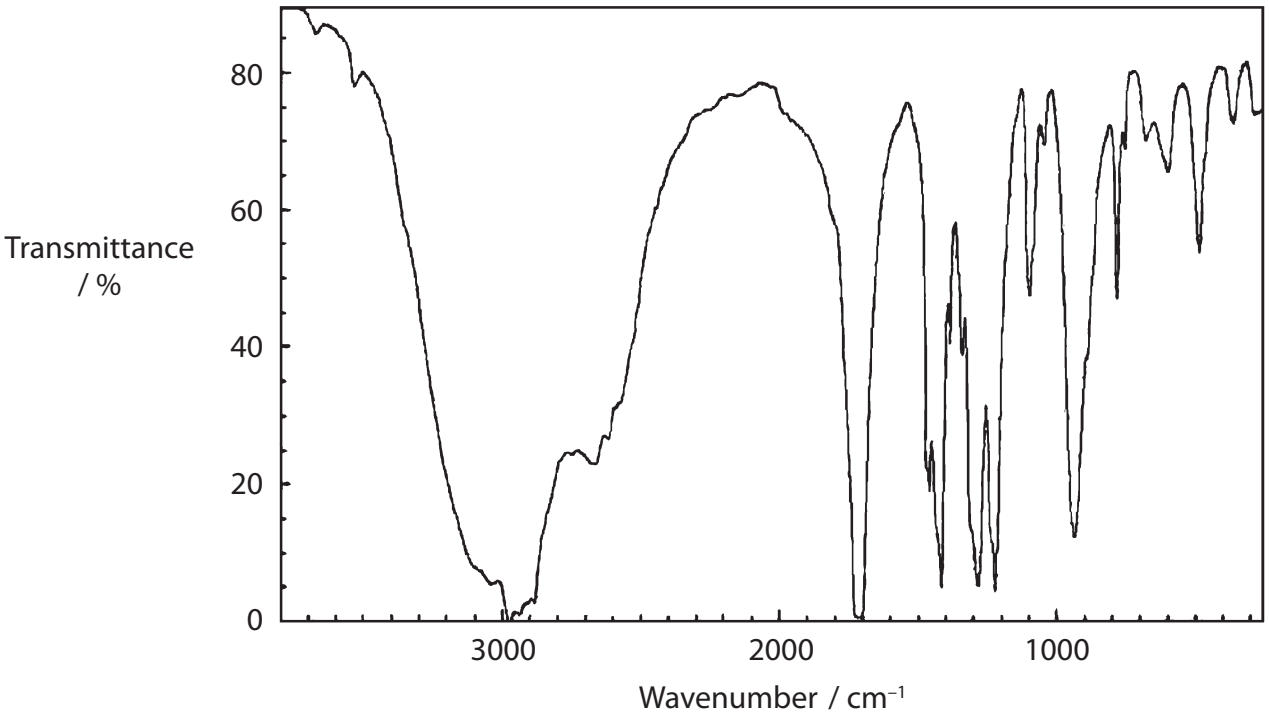
☒ **D** $(CH_3)_3COH$

(Total for Question 14 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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15 Under certain conditions, butan-1-ol can be oxidized to the compound with infrared spectrum shown below.



O—H stretching vibrations alcohols	3750 – 3200 cm^{-1}
O—H stretching vibrations carboxylic acids	3300 – 2500 cm^{-1}
C=O stretching vibrations aldehydes and ketones	1740 – 1680 cm^{-1}
C=O stretching vibrations carboxylic acids	1725 – 1700 cm^{-1}

The compound is most likely to be

☒ **A** butan-2-ol.

☒ **B** butanal.

☒ **C** butanone.

☒ **D** butanoic acid.

(Total for Question 15 = 1 mark)

16 Which of the following is a **secondary** alcohol?

☒ **A** 2-methylpentan-3-ol

☒ **B** 2-methylpropan-2-ol

☒ **C** 2,2-dimethylpropan-1-ol

☒ **D** ethane-1,2-diol

(Total for Question 16 = 1 mark)

P 4 1 2 4 3 A 0 6 2 4
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17 Propanal, CH_3CH_2CHO, and propanone, CH_3COCH_3, are isomers, but only propanal has a significant peak in its mass spectrum at mass/charge ratio

- ☒ **A** 15
- ☒ **B** 29
- ☒ **C** 43
- ☒ **D** 58

(Total for Question 17 = 1 mark)

18 The reaction of the halogenoalkane, C_2H_5Cl, with alcoholic ammonia is

- ☒ **A** nucleophilic substitution.
- ☒ **B** electrophilic substitution.
- ☒ **C** reduction.
- ☒ **D** elimination.

(Total for Question 18 = 1 mark)

19 The formation of a carbocation from a halogenoalkane is an example of

- ☒ **A** homolytic fission.
- ☒ **B** heterolytic fission.
- ☒ **C** an initiation reaction.
- ☒ **D** a propagation reaction.

(Total for Question 19 = 1 mark)

20 The equations below show some reactions which occur in the upper atmosphere.

$$O_3 \rightarrow O + O_2$$
$$NO + O_3 \rightarrow NO_2 + O_2$$
$$NO_2 + O \rightarrow NO + O_2$$

Which of the following statements is **not** correct?

- ☒ **A** Oxygen free radicals are formed by the action of ultraviolet light.
- ☒ **B** NO acts as a catalyst.
- ☒ **C** NO acts as an oxidizing agent.
- ☒ **D** NO is released by aircraft engines.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 Chlorine is used to prevent the growth of bacteria in swimming pool water. It reacts as shown below.

$$Cl_2(aq) + H_2O(l) \rightleftharpoons HCl(aq) + HClO(aq)$$

(a) (i) By giving appropriate oxidation numbers, explain why this is a disproportionation reaction.

(3)

(ii) State and explain the effect on the position of equilibrium if concentrated hydrochloric acid is added to a sample of chlorinated swimming pool water.

(2)

P 4 1 2 4 8 A 0 8 2 4
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(b) In a similar reaction, chlorine reacts with sodium hydroxide to make household bleach.

$$Cl_2(aq) + 2NaOH(aq) \rightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$$

The concentration of NaClO in diluted bleach was measured by titration.
A 25.0 cm^3 sample of bleach was pipetted into a conical flask. Approximately 1.5 g of solid potassium iodide and 10 cm^3 of hydrochloric acid with concentration 2.00 mol dm^{-3} were added. Each mole of ClO^-, from the NaClO in the solution of bleach, produced one mole of iodine, I_2, which was titrated with sodium thiosulfate solution.

(i) Complete the ionic half-equations below for the reaction of ClO^- with acidified potassium iodide by balancing them and **adding electrons** where required.

(2)

$$ClO^- + \text{.....}H^+ \rightarrow Cl^- + H_2O$$

$$\text{.....}I^- \rightarrow I_2$$

(ii) Use your answer to (a)(i) to write the overall ionic equation for the reaction between ClO^- and I^- ions in acidic conditions.

(1)

(iii) The iodine in the sample required a mean (average) titre of 24.20 cm^3 of 0.0500 mol dm^{-3} sodium thiosulfate solution. Thiosulfate ions react with iodine as shown below.

$$2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$$

Calculate the number of moles of iodine in the solution.

(2)

(iv) What is the number of moles of ClO^- ions in the sample of diluted bleach?

(1)

(v) Hence calculate the concentration, in mol dm^{-3}, of ClO^- in the diluted bleach.

(1)

(vi) 1.5 g of potassium iodide, KI, contains 9.04×10^{-3} mol of I^-. Use your answers to (b)(ii) and (b)(iv) to show by calculation why this amount was suitable.

(2)

.....

.....

(vii) A student carrying out this titration measured the mean (average) titre as 24.50 cm^3.

What is the percentage difference in this student's titre, compared with the accurate value of 24.20 cm^3?

(1)

P 4 1 2 3 3 A 0 1 2 4
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(viii) The difference between the student's mean titre and the accurate value was **not** due to the limitations in the accuracy of the measuring instruments.

Suggest one possible reason for this difference.

(1)

.....

.....

.....

(c) Suggest **one** damaging effect to the upper atmosphere which could be caused by the presence of chlorine compounds.

(1)

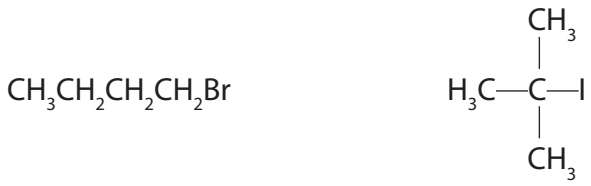
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(Total for Question 21 = 17 marks)

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22 This question is about two halogenoalkanes, **X** and **Y**, which have the structures shown below.



X **Y**

(a) (i) Draw the skeletal formula of **X**.

(1)

(ii) Name **Y**.

(1)

(iii) Write an equation for the reaction of **X** with an alcoholic solution of ammonia, and name the organic product.

(2)

Name of product .....

(iv) When **Y** is heated with an **aqueous** solution of potassium hydroxide, an alcohol is formed in a two-step reaction. Write the mechanism for this reaction using 'curly arrows' where appropriate and clearly showing the structure of the intermediate.

(3)

P 4 1 2 3 4 3 A 0 1 2 2 4
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(v) When **Y** is heated with an **alcoholic** solution of potassium hydroxide, the alkene C_4H_8 is formed. What type of reaction occurs to produce the alkene?

(1)

.....

(b) Separate ethanolic solutions of **X** and **Y** were warmed with water containing dissolved silver nitrate. Describe what would be seen in each case, ignoring any differences in the rates of reaction.

(2)

Observation with **X**

.....

Observation with **Y**

.....

(c) The rates of hydrolysis of primary halogenoalkanes are affected by the strength of the bond between the carbon and the halogen atom.

Is the C—Br bond weaker or stronger than the C—I bond? Explain why the bond strength differs.

(2)

.....

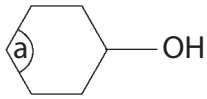
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(Total for Question 22 = 12 marks)

23 The skeletal formula of cyclohexanol is shown below.



(a) (i) The actual bond angles differ from the angles in the two dimensional diagram shown.

What is the angle of the C—C—C bond labelled **a**?

(1)

Angle .....

*(ii) What is the angle of the C—O—H bond? Justify your answer, explaining why the size of the angle is different from the angle in (i).

(3)

Angle .....

Explanation .....

.....

.....

.....

.....

(b) (i) Suggest what you would expect to **see** when cyclohexanol reacts with sodium.

(2)

.....

.....

.....

.....

P 4 1 2 3 4 3 A 0 1 4 2 4
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(ii) Phosphorus(V) chloride (phosphorus pentachloride) is used to test for the presence of an —OH group. Write the equation for the reaction of cyclohexanol with phosphorus(V) chloride.

(2)

(iii) Give the chemical test you could use to identify the gas produced, and the observation you would make.

(1)

.....

.....

.....

(iv) Cyclohexanol reacts with hot acidified potassium dichromate(VI) solution.

Give the skeletal formula of the organic product of this reaction.

(1)

(v) What colour change would you observe as this reaction takes place?

(1)

From ..... to .....

(c) The mass spectrum of cyclohexanol has a prominent peak at mass / charge ratio 82. Suggest the molecular formula of the fragment which causes this peak.

(1)

.....

(Total for Question 23 = 12 marks)

TOTAL FOR SECTION B = 41 MARKS

P 4 1 2 3 5 A 0 1 6 5 2 4
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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

24

Carbon capture is the name given to some processes used to prevent carbon dioxide entering the atmosphere. Carbon capture is carried out because carbon dioxide is a greenhouse gas.

Flue gases in chimneys contain carbon dioxide produced from burning fossil fuels. Various different compounds can be used to react with the carbon dioxide to capture it. Alternatively, carbon dioxide can be separated from other gases by a physical process.

Many sources of natural gas contain carbon dioxide, which can be removed by freezing.

Captured carbon dioxide must then be stored to prevent it entering the atmosphere. It can be injected into depleted oil and gas formations, or into porous rocks full of salt water. These are usually over 1 km below the Earth's surface and have non-porous rocks above them. Eventually the carbon dioxide dissolves, forming carbonate ions and then new minerals.

(a) Greenhouse gases can absorb infrared radiation. Explain why carbon dioxide absorbs infrared radiation but oxygen cannot.

(2)

(b) A solution of the compound aminoethanol, $H_2NCH_2CH_2OH$, can be used to absorb carbon dioxide.

$$2H_2NCH_2CH_2OH + CO_2 + H_2O \rightleftharpoons (H_3NCH_2CH_2OH)_2CO_3$$

(i) Explain why aminoethanol is soluble in water.

(1)

P 4 1 2 3 6 A 0 1 6 2 4
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(ii) The position of this equilibrium moves to the left on heating. This frees the captured carbon dioxide for storage. Use this information to decide whether the forward reaction is exothermic or endothermic. Explain your answer.

(2)

.....

.....

.....

.....

(c) The composition of a sample of natural gas and the melting temperatures of four of its components are shown below.

	Percentage	Melting temperature / K
Methane	95.2	91.1
2-methylpropane	0.8	113.7
Butane	0.9	134.7
Other hydrocarbons	2.4	
Carbon dioxide	0.7	216.5

(i) Draw a dot and cross diagram for carbon dioxide.

(2)

(ii) The London forces between molecules of carbon dioxide are stronger than the London forces between molecules of methane. Suggest a reason for this.

(1)

.....

.....

(iii) Use your knowledge of intermolecular forces to suggest why butane has a higher melting temperature than 2-methylpropane.

(2)

.....

.....

.....

.....

.....

(d) When carbon dioxide dissolves, it may eventually form minerals such as magnesium carbonate and calcium carbonate.

(i) State the results of flame tests carried out on these two minerals.

(2)

Magnesium carbonate .....

Calcium carbonate .....

P 4 1 2 3 8 A 0 1 8 2 4
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*(ii) Magnesium carbonate and calcium carbonate both undergo thermal decomposition, but they have different stability to heat. The difference in stability to heat can be compared in an experiment.

Suggest how this experiment could be carried out. You should indicate

- how to detect when the thermal decomposition occurs
- the measurement you would make to compare the stability to heat
- how to make the comparison fair.

You may include a diagram if you wish but it is not essential.

(4)

*(iii) State and explain which of the two carbonates is more stable to heat.

(3)

(Total for Question 24 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

P 4 1 2 8 T E M 3 P . A C O U N 2 4 2 4

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Mark Scheme (Results)

January 2013

GCE Chemistry (6CH02) Paper 01 Application of Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	**C**		1

Question Number	Correct Answer	Reject	Mark
2	**B**		1

Question Number	Correct Answer	Reject	Mark
3	**D**		1

Question Number	Correct Answer	Reject	Mark
4	**C**		1

Question Number	Correct Answer	Reject	Mark
5	**D**		1

Question Number	Correct Answer	Reject	Mark
6	**A**		1

Question Number	Correct Answer	Reject	Mark
7	**A**		1

Question Number	Correct Answer	Reject	Mark
8	**B**		1

Question Number	Correct Answer	Reject	Mark
9	**A**		1

Question Number	Correct Answer	Reject	Mark
10	**C**		1

Question Number	Correct Answer	Reject	Mark
11	**D**		1

Question Number	Correct Answer	Reject	Mark
12	**B**		1

Question Number	Correct Answer	Reject	Mark
13	**C**		1

Question Number	Correct Answer	Reject	Mark
14	**D**		1

Question Number	Correct Answer	Reject	Mark
15	**D**		1

Question Number	Correct Answer	Reject	Mark
16	**A**		1

Question Number	Correct Answer	Reject	Mark
17	**B**		1

Question Number	Correct Answer	Reject	Mark
18	**A**		1

Question Number	Correct Answer	Reject	Mark
19	**B**		1

Question Number	Correct Answer	Reject	Mark
20	**C**		1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	**First two marks** Cl in Cl_2 is 0 Goes to +1 in HClO Goes to −1 in HCl **(2)** All three correct for two marks Any two correct for one mark Ignore correct oxidation numbers for other elements If three correct numbers given without saying what species they are in max 1 for these two marks **Third mark** Cl/Cl_2/the same element is both oxidized and reduced Allow same molecule/species/ type of atom is both oxidized and reduced if answer elsewhere has been in terms of chlorine OR Cl/Cl_2/the same element both increases and decreases in oxidation number OR Chlorine both loses and gains electrons **(1)**	Only 'Cl^{+}' for oxidation number +1 Only 'Cl^{-}' for oxidation number -1 (treat each separately) For each incorrect oxidation number change for O and H, lose one mark. 0 to +1 described as reduction and/or 0 to -1 described as oxidation (for third mark)	**3**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	Equilibrium moves to the left / moves in reverse direction / moves to increase concentration of reactants **(1)** To use up (some of) added HCl/ to react with added HCl/ to stop formation of HCl/ restores equilibrium by producing more chlorine and water **(1)** Second mark depends on first Allow 'moves to decrease concentration of products/HCl' for both marks	Just "reverse reaction is **favoured**" Just "to counteract the change in the system" To minimise effect of HCl	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	$ClO^- + 2H^+ + 2e^{(-)} \rightarrow Cl^- + H_2O$ ALLOW $ClO^- + 2H^+ \rightarrow Cl^- + H_2O - 2e^{(-)}$ **(1)** $2I^- \rightarrow I_2 + 2e^{(-)}$ ALLOW $2I^- - 2e^{(-)} \rightarrow I_2$ **(1)** Allow multiples Ignore state symbols even if incorrect	Equations without electrons	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	$ClO^- + 2H^+ + 2I^- \rightarrow Cl^- + H_2O + I_2$ Mark independently. No TE on 21(b)(i)	Equations including electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	Moles thiosulfate = (24.20 x 0.0500 / 1000) = 1.21×10^{-3} /1.2×10^{-3} /0.00121/ 0.0012 (mol) **(1)** Moles iodine = half moles of thiosulfate = 6.05×10^{-4} / 6.1×10^{-4} / 0.000605 / 0.00061 (mol) **(1)** Correct answer without working **(2)**	1.20×10^{-3} (mol) $1x\ 10^{-3}$/ 0.001 6.0×10^{-4} (mol) 6×10^{-4} (mol)	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	Moles ClO^- = 6.05×10^{-4} (mol) TE on (b)(ii) and (b)(iii): If ratio ClO^- :I_2 = 2:1 answer is 2 x answer to (b)(iii) If ratio ClO^- :I_2 = 1:2 answer is half of answer to (b)(iii)		**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(v)	Concentration = ($6.05 \times 10^{-4} \times 1000/25$) = 2.42×10^{-2} / 0.0242/ 0.024/ 2.4×10^{-2} (mol dm^{-3}) TE. Answer to (b)(iv) x 1000÷ 25	Answers to 1 significant figure	**1**

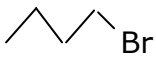
Question Number	Acceptable Answers	Reject	Mark
21(b)(vi)	(Minimum) amount of I^- to react with OCl^- =2 x answer to (b)(iv) = $2 \times 6.05 \times 10^{-4}$ = 1.21×10^{-3} (mol) **(1)** Allow TE for 2 x answer to (b)(iv) Ignore s.f. Moles of I^- (9.04×10^{-3}) is more than this number of moles of ClO^- / I^- is in excess / KI is in excess / so that all the ClO^- can react **(1)** **OR** 9.04×10^{-3} mol I^- can react with 4.52×10^{-3} mol OCl^- **(1)** Ignore s.f. TE from incorrect equation in (b)(ii) Moles OCl^- (6.05×10^{-4}) is less than this/ I^- is in excess / KI is in excess / so that all the ClO^- can react **(1)**	"KI is in excess" if no calculation has been done.	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(vii)	0.30 x 100 / 24.2 (=1.2396694) = 1.24/ 1.2 %		**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(viii)	Judgement (of colour change) at end point / adding starch too early in the titration / jet of burette not filled Errors must cause an increase in titre. Ignore Just "Human error" Just 'overshot endpoint' Transfer errors / spillage Errors due to misreading burette / pipette	Some potassium iodide did not dissolve Leaving funnel in burette Errors which affect both the students titre and an accurate titre using the same solutions e.g. impure solutions	**1**

Question Number	Acceptable Answers	Reject	Mark
21(c)	(Cl radicals) break down ozone (layer)/ ozone depletion / ozone (layer) thinning Allow damage ozone (layer)/ react with ozone	Global warming Causes acid rain	**1**

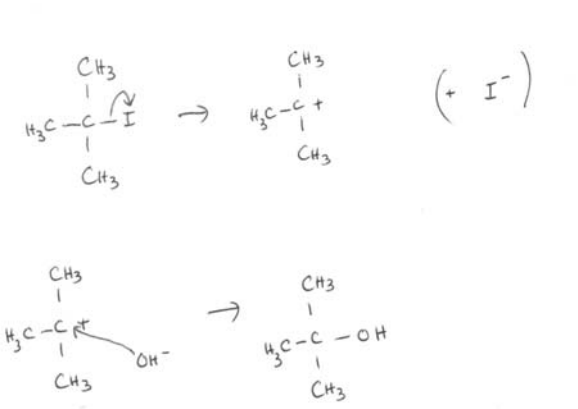
Total for Q21 = 17 marks

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	  Allow the bond to Br to be before or after the zig-zag line representing the 4C atoms, and to be at any angle Ignore bonds of unequal length		**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	2-iodo–(2-)methylpropane Accept (2-)methyl–2-iodopropane Ignore punctuation (brackets, hyphens, commas)	2,2-iodomethylpropane 2-iodobutane	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	$C_4H_9Br + 2NH_3 \rightarrow C_4H_9NH_2 + NH_4Br$ **OR** $C_4H_9Br + NH_3 \rightarrow C_4H_9NH_2 + HBr$ **OR** $C_4H_9Br + NH_3 \rightarrow C_4H_9NH_3^{(+)}Br^{(-)}$ **(1)** Accept structural / skeletal formula for **X** and product Allow inorganic product as ions Butylamine / 1-aminobutane / 1-butylamine/ 1-butanamine/ butan-1-amine **(1)** Ignore incorrect spacing and punctuation **OR** (N) butyl ammonium bromide if third equation given **(1)** **OR** Answers with multiple substitutions giving $(C_4H_9)_2$ NH **(1)** dibutylamine **(1)** $(C_4H_9)_3$ N **(1)** tributylamine **(1)** $(C_4H_9)_4 N^{(+)}$ $Br^{(-)}$ **(1)** tetrabutyl ammonium bromide **(1)** No TE on naming a product in an incorrect equation **except** if C_4H_8 is shown in a correct or incorrect elimination equation then 1 mark for naming it but-1-ene	Just word equations Molecular formula for organic product i.e. $C_4H_{11}N$ Equation for elimination reaction Aminobutane Butamine Any am**ide**	**2**

	If correct equation and name (e.g. 2-amino-2-methylpropane) are given using **Y** max 1		

Question Number	Acceptable Answers	Reject	Mark
22 (a)(iv)	 Arrow to I from within C-I bond **(1)** Formula of carbocation **(1)** Arrow from OH^- to C^+ **(1)** If both arrows are shown **before** formation of intermediate max 2 Charge on OH^- essential for third mark. Lone pair need not be shown. Ignore partial charges on C and I in **Y** Ignore arrows showing hydroxide ion formation in KOH / covalent KOH Ignore K^+ ions combining with I^- / inorganic products Mechanism for **X** instead of **Y** Max 2 Correct SN2 mechanism can score first mark and third mark for arrow from OH^- to $C^{(\delta+)}$	Half arrows, but don't penalise twice δ^+ charge on intermediate	**3**

Question Number	Acceptable Answers	Reject	Mark
22(a)(v)	(Nucleophilic) elimination (reaction) (of HI)	Electrophilic elimination Nucleophilic substitution Dehydration	**1**

Question Number	Acceptable Answers	Reject	Mark
22(b)	**X** Cream precipitate Allow off white / creamy white / white-cream / (very) pale yellow **(1)** **Y** yellow precipitate **(1)** One mark for two correct colours but not precipitates Mention of precipitate without colours doesn't score Ignore identity of precipitates even if incorrect	Yellow/ creamy yellow precipitate for **X** Pale yellow precipitate for **Y**	**2**

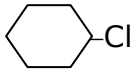
Question Number	Acceptable Answers	Reject	Mark
22(c)	C-Br stronger / C–I weaker with an attempt at an explanation (correct or incorrect) **(1)** as bond is shorter/ Br (atom) is smaller / as nuclei are closer OR reverse argument **(1)** Allow Br is more electronegative/ there is a bigger electronegativity difference / bond is more polar / $C^{\delta+}$ and $Br^{\delta-}$ attract more strongly / Br is less shielded Second mark depends on first	Br_2 is smaller References to Br^- implying bond is ionic. Br is more reactive	**2**

Total for Q22 = 12 marks

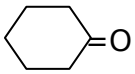
uestion Number	Acceptable Answers	Reject	Mark
23(a)(i)	109 (°) / 109.5 (°) / 109° 28′		**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	104 – 106 (°) **(1)** O atom has **two** lone pairs (and 2 bonding pairs) **(1)** This mark can be given independently of the first and third mark Lone pairs repel each other more than bonding pairs / angle is reduced to minimise repulsion (by lone pairs) / to maximise separation (of lone pairs) **(1)** Ignore 'bonds repel each other' Angle in (ii) must be smaller than in (i) for third mark to be given	Lone pairs repel H atoms	**3**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	Any **two** from Fizzing / effervescence / bubbles (of gas) **(1)** Sodium dissolves / disappears / reduces in size **(1)** **White** solid /precipitate forms **(1)** Ignore identification of products even if incorrect. Ignore sodium melting / moving around / sinking / floating Ignore colourless solution forms Ignore temperature changes / sodium going on fire	Just "Hydrogen forms"/"gas forms" Fumes	**2**

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	$C_6H_{11}OH + PCl_5 \rightarrow HCl + C_6H_{11}Cl + POCl_3$ **(1)** **(1)** **(1)** for HCl **(1)** for rest of the equation correct Cyclohexanol can be skeletal, $C_6H_{11}OH$/ $C_6H_{12}O$ Accept 'PCl_3O' instead of $POCl_3$ Accept skeletal formula for $C_6H_{11}Cl$  Ignore state symbols	 $C_5H_{11}COH$ $CH_2CH_2CH_2CH_2CH_2CHOH$ Unless a bond is shown connecting C1 and C6	**2**

Question Number	Acceptable Answers	Reject	Mark
23(b)(iii)	White smoke / solid with ammonia Allow white fumes / dense white fumes / steamy white fumes OR White precipitate with silver nitrate Ignore reference to ammonia solution unless HCl is specifically bubbled into solution Ignore using an indicator to show gas is acidic with one of the above tests Ignore description of appearance of HCl before testing	 Just steamy / misty fumes Just testing with an indicator Bleaches litmus	**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(iv)			**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(v)	(Colour change from) Orange to green / blue / brown	blue- green green-blue yellow to green	**1**

Question Number	Acceptable Answers	Reject	Mark
23(c)	$C_6H_{10}^{(+)}$	$C_6H_{10}^{-}$ $(CH_2)_5C$ $C_5H_{10}C$ C_6H_{11} $(CH)_5OH$ $C_2(CH_2)_3O$	**1**

Total for Q23 = 12 marks

Question Number	Acceptable Answers	Reject	Mark
24(a)	CO_2 has polar bonds / oxygen does not have polar bonds **(1)** Ignore O_2 is a non polar molecule (As it vibrates) polarity of CO_2 changes / dipole moment changes / shifts **(1)** Allow "Oxygen has no difference in electronegativity so polarity does not change" for 2 marks	CO_2 is a polar molecule	**2**

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	Hydrogen bonds can form **with water** Allow full description of hydrogen bonds in absence of name. Ignore incorrect naming of functional groups in aminoethanol.	Just "it is polar"	**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	Exothermic, with attempt at a reason OR reverse reaction is endothermic, with attempt at a reason **(1)** Reaction will go in the endothermic direction on heating / equilibrium moves to left to use up heat supplied **(1)** Second mark depends on the reaction being exothermic in first mark	Just "exothermic"	**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	 Electrons in double bond **(1)** Other electrons **(1)** Second mark dependent on first Only bonding electrons need be shown If inner shell electrons are included they must be correct. Electrons may be on circles, within circles or no circles may be shown.		**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	Number of electrons (per molecule) is greater in CO_2 (than methane). If numbers are given must be correct. CO_2 has $22e^-$, methane has $10e^-$. Ignore CO_2 has larger surface area than methane	double bonds in CO_2 as the cause	**1**

Question Number	Acceptable Answers	Reject	Mark
24(c)(iii)	Butane has a greater surface area / butane is less branched **(1)** so more contact between (neighbouring) molecules / (neighbouring) molecules pack better **(1)** OR Reverse argument for 2-methylpropane		**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	Mg – no colour in flame **(1)** Allow 'no flame visible' Ca brick red / red / yellow-red / red-orange **(1)**	Mg: white flame Bright / white light Clear flame Just orange	**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	**First mark:** Detect thermal decomposition by Passing gas into / reacting gas with lime water OR By collecting the gas evolved (in syringe or by displacement) OR By measuring change of mass **(1)** **Second mark:** Measure time for (same volume) of lime water to go milky OR Measure volume of gas produced in a measured time OR Measure time for a specified / same volume of gas to form OR Find loss of mass after heating samples for equal time **(1)** The mark for measurement should only be given if it matches the suggested method of detection. **Third and fourth marks:** For fair comparison Any **two** from: Keep strength of flame constant **(1)** Distance of flame from containing tube constant **(1)** Use carbonates with similar particle size **(1)** Same volume of lime water **(1)** Heat equal moles / same amount of each carbonate **(1)** Judge equal milkiness of lime water using a piece of paper marked with a cross **(1)** The marks for fair comparison should only be given if they match the suggested method of detection. Ignore 'heat same mass' and 'known mass' Ignore using water bath as source of heat	First mark: Combustion Heating carbonate solution Second mark: Just "measure volume of gas produced" Measure time for a specified change in mass to occur	**4**

	Ignore 'heat to same temperature' Ignore 'use same heat source' Ignore 'constant heat' These points could be shown on a diagram but marks are for the principles, not the detail of drawing a sketch diagram.		

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	$CaCO_3$ more stable / $MgCO_3$ less stable **(1)** Mg^{2+} is smaller than Ca^{2+} / magnesium ions are smaller than calcium ions / charge density of Mg^{2+} is greater than Ca^{2+} / Ca^{2+} has more shells **(1)** EITHER Mg^{2+} causes more distortion of carbonate ion / more weakening of C-O / more polarisation of carbonate / more polarisation of anion / has more polarising power OR More energy is given out when MgO forms as the MgO lattice is stronger than CaO /as the 2+ ions can get closer to the 2^- ions on decomposition **(1)** Second and third marks can be scored if conclusion given in first mark is wrong	Mg is smaller "It" (unspecified) is smaller $MgCO_3$ is smaller More disruption of ion Polarisation of carbonate molecules CaO is less stable than MgO	**3**

Total for Q24 = 19 marks

TOTAL FOR SECTION B = 60 MARKS

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Edexcel GCE

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Wednesday 23 May 2012 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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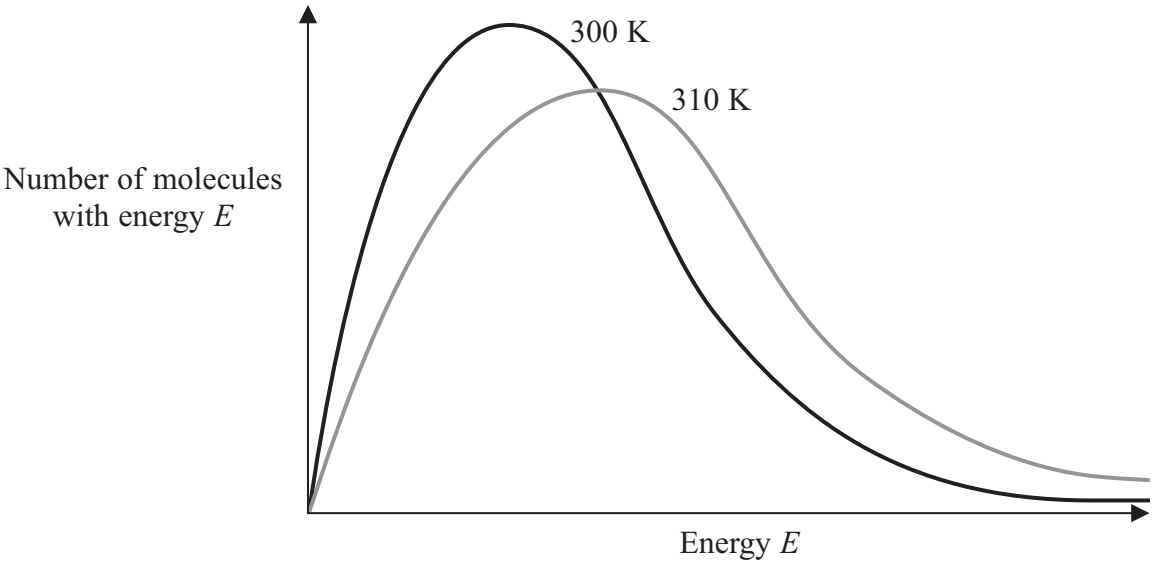
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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The diagram below shows the Maxwell-Boltzmann distribution of molecular energies for a gaseous system at two temperatures.



(a) The energy plotted on the horizontal axis is **mainly**

(1)

☒ **A** activation.

☒ **B** kinetic.

☒ **C** rotation.

☒ **D** vibration.

(b) The rate of a chemical reaction increases with temperature **mainly** because

(1)

☒ **A** the activation energy increases.

☒ **B** the activation energy decreases.

☒ **C** more collisions occur with energy greater than the activation energy.

☒ **D** the molecules collide more frequently.

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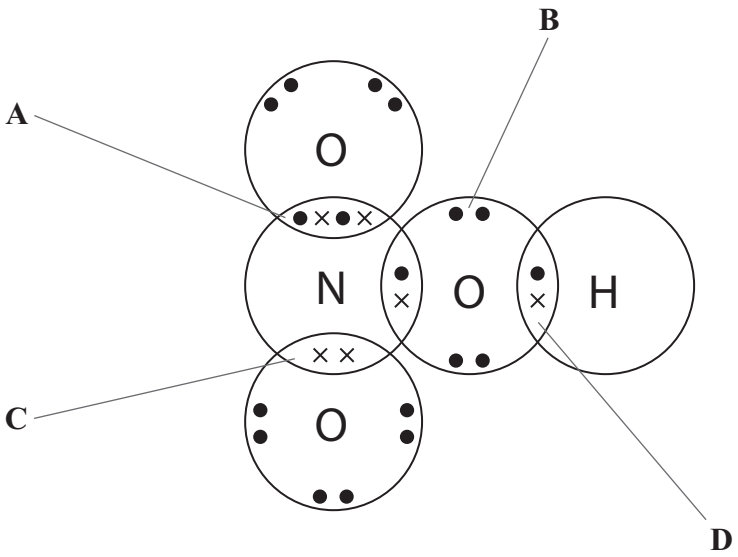
(c) The total area under each curve

(1)

- ☒ **A** decreases with increasing temperature.
- ☒ **B** increases with increasing temperature.
- ☒ **C** increases or decreases with increasing temperature, depending on the size of the molecules.
- ☒ **D** does not change with temperature.

(Total for Question 1 = 3 marks)

2 The diagram below shows a dot and cross diagram of nitric acid.



(a) Identify which of the labelled sets of electrons represents a dative covalent bond.

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(b) In terms of orbital overlap, the double bond is

(1)

- ☒ **A** a π bond.
- ☒ **B** two σ bonds.
- ☒ **C** two π bonds.
- ☒ **D** a σ bond and a π bond.

(Total for Question 2 = 2 marks)

3 The colour observed in a flame test is due to

☒ **A** electrons jumping to a higher energy level, absorbing energy.

☒ **B** electrons jumping to a higher energy level, emitting energy.

☒ **C** electrons dropping from a higher energy level, absorbing energy.

☒ **D** electrons dropping from a higher energy level, emitting energy.

(Total for Question 3 = 1 mark)

4 The best way to confirm the presence of **iodine** in an aqueous solution is

☒ **A** adding hexane to form a purple layer.

☒ **B** adding hexane to form an orange layer.

☒ **C** adding acidified silver nitrate solution to form a yellow precipitate which is soluble in concentrated ammonia.

☒ **D** adding acidified silver nitrate solution to form a yellow precipitate which is insoluble in concentrated ammonia.

(Total for Question 4 = 1 mark)

5 The oxidation number of sulfur in sodium hydrogensulfide, NaHS, is

☒ **A** –2

☒ **B** –1

☒ **C** +1

☒ **D** +2

(Total for Question 5 = 1 mark)

6 Which of the following is **not** a disproportionation reaction?

☒ **A** $Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$

☒ **B** $Cu_2O + H_2SO_4 \rightarrow CuSO_4 + Cu + H_2O$

☒ **C** $3IO^- \rightarrow 2I^- + IO_3^-$

☒ **D** $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$

(Total for Question 6 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

P 3 9 3 0 7 A 0 4 2 0
S T E M U P . C O . U K

7 Hydrogen iodide has a higher boiling temperature than hydrogen bromide. This is because

☒ **A** the H—I bond is stronger than the H—Br bond.

☒ **B** hydrogen iodide has stronger London forces than hydrogen bromide.

☒ **C** hydrogen iodide has a larger permanent dipole than hydrogen bromide.

☒ **D** hydrogen iodide forms hydrogen bonds but hydrogen bromide does not.

(Total for Question 7 = 1 mark)

8 Butane has a higher boiling temperature than 2-methylpropane. This is because butane has

☒ **A** stronger C—H bonds.

☒ **B** more electrons.

☒ **C** a larger surface area.

☒ **D** hydrogen bonds.

(Total for Question 8 = 1 mark)

9 The oxygen atom in a molecule of water has two bonding pairs and two lone pairs of electrons. Based on the electron-pair repulsion theory, the H—O—H bond angle is most likely to be

☒ **A** 180°

☒ **B** 109.5°

☒ **C** 107°

☒ **D** 104.5°

(Total for Question 9 = 1 mark)

10 The shape of a molecule of boron trifluoride, BF_3, is

☒ **A** trigonal planar.

☒ **B** pyramidal.

☒ **C** tetrahedral.

☒ **D** T-shaped.

(Total for Question 10 = 1 mark)

11 When solid samples of sodium carbonate and magnesium carbonate are strongly heated

☒ **A** both compounds decompose.

☒ **B** sodium carbonate decomposes but magnesium carbonate does not.

☒ **C** magnesium carbonate decomposes but sodium carbonate does not.

☒ **D** neither compound decomposes.

(Total for Question 11 = 1 mark)

12 As Group 2 is **descended**

☒ **A** the solubility of hydroxides and of sulfates increases.

☒ **B** the solubility of hydroxides increases and of sulfates decreases.

☒ **C** the solubility of hydroxides decreases and of sulfates increases.

☒ **D** the solubility of hydroxides and of sulfates decreases.

(Total for Question 12 = 1 mark)

13 These questions concern the use of infrared (IR) spectra to identify organic compounds. The IR absorption ranges associated with some organic functional groups are given below.

A O—H stretching in alcohols at 3750 – 3200 cm^{-1}

B C═O stretching in aldehydes at 1740 – 1720 cm^{-1}

C C═O stretching in ketones at 1700 – 1680 cm^{-1}

D C═O stretching in carboxylic acids at 1725 – 1700 cm^{-1}

(a) When propan-2-ol is refluxed with potassium dichromate(VI) and sulfuric acid, the **product** will show a peak due to

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) When propan-1-ol is heated with potassium dichromate(VI) and sulfuric acid, the **product**, that is distilled off as it is formed, will show a peak due to

(1)

☒ **A**

☒ **B**

☒ **C**

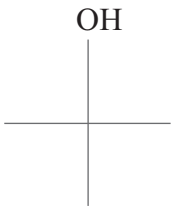
☒ **D**

(Total for Question 13 = 2 marks)

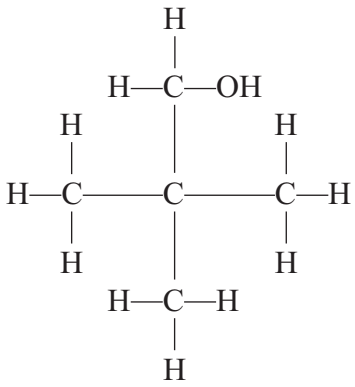
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14 Which of the following formulae does **not** represent 2,2-dimethylpropan-1-ol?

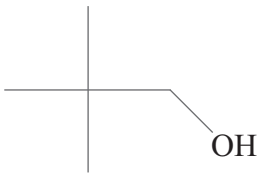
☒ **A**



☒ **B**



☒ **C**



☒ **D** $(CH_3)_3CCH_2OH$

(Total for Question 14 = 1 mark)

15 Nucleophiles are

☒ **A** electron pair donors that attack regions of high electron density.

☒ **B** electron pair donors that attack regions of low electron density.

☒ **C** electron pair acceptors that attack regions of high electron density.

☒ **D** electron pair acceptors that attack regions of low electron density.

(Total for Question 15 = 1 mark)

16 Which of the following is **not** true? Chlorofluorocarbons, CFCs,

☒ **A** are flammable.

☒ **B** are greenhouse gases.

☒ **C** damage the ozone layer.

☒ **D** are excellent refrigerants.

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

17 (a) Ozone, O_3, is formed when oxygen is exposed to ultraviolet (UV) radiation or to an electric discharge. Ozone is a blue gas whereas oxygen is colourless. When the two gases are mixed, an equilibrium is established as shown in the following equation.

$$3O_2(g) \rightleftharpoons 2O_3(g) \qquad \Delta H = +143 \text{ kJ mol}^{-1}$$

(i) When the temperature of the pale blue equilibrium mixture is increased at constant volume, the colour darkens. Explain this observation in terms of the changes to the equilibrium.

(2)

(ii) State and explain what you would **see** if the pressure of the system at equilibrium were increased.

(2)

(iii) A small amount of oxygen gas containing the isotope ^{18}O is added to the equilibrium mixture. After a few hours, ozone containing ^{18}O is detected. Given that the equilibrium position is **not** affected, explain this observation.

(1)

P 3 9 3 0 7 A 0 8 2 0
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(b) The concentration of ozone in the atmosphere may be determined by bubbling air through a solution of acidified potassium iodide. Iodine is formed in solution, the concentration of which may be determined by titration with a solution of sodium thiosulfate of known concentration. The equations for the reactions are

$$O_3 + 2I^- + 2H^+ \rightarrow O_2 + H_2O + I_2 \qquad \text{Equation 1}$$

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-} \qquad \text{Equation 2}$$

In an experiment to determine the concentration of ozone in a sample of air, 100 m^3 of air was bubbled through 100 cm^3 of a solution containing an excess of acidified potassium iodide.

The resulting solution was titrated against a solution of sodium thiosulfate of concentration 0.0155 mol dm^{-3}. The volume of sodium thiosulfate solution required for complete reaction was 25.50 cm^3.

(i) Calculate the number of moles of sodium thiosulfate that react.

(1)

(ii) Calculate the number of moles of iodine that reacted with the sodium thiosulfate.

(2)

(iii) Use equation 1 to deduce the number of moles of ozone that reacted with the acidified potassium iodide.

(1)

(iv) Calculate the volume of ozone, measured in m^3, present in the original sample of air. Assume that all gas volumes were measured at room temperature and pressure and that the molar volume of any gas under these conditions is 0.024 m^3 mol^{-1}.

(1)

(v) Calculate the concentration of ozone in the sample of air in units of parts per million (ppm) by volume.

(1)

(vi) A student suggested that the 100 cm^3 of acidified potassium iodide should be divided into four portions before the titration. Explain how this change increases the reliability and decreases the accuracy of the experiment.

(3)

Increases reliability.....

.....

.....

Decreases accuracy.....

.....

.....

.....

.....

P 3 9 3 7 0 M U P . C O U K 0 2 0

(c) Give the oxidation numbers of oxygen in equation 1, shown below. Hence state the role of ozone in this reaction.

(3)

$$O_3 + 2I^- + 2H^+ \rightarrow O_2 + H_2O + I_2$$

Oxidation number of O ....

Role of ozone .....

(d) Ozone is used as an alternative to chlorine to disinfect flood damaged buildings, to remove residual smoke odours from fires and in the treatment of drinking water. Suggest one advantage of using ozone rather than chlorine, given that chlorine and ozone are both toxic.

(1)

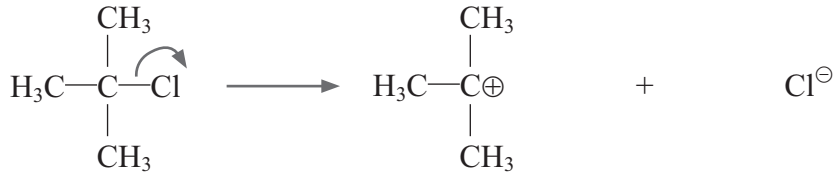
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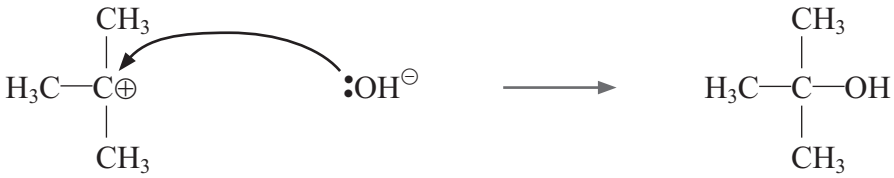
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(Total for Question 17 = 18 marks)

18 The steps below show the reaction mechanism for the reaction of a halogenoalkane with sodium hydroxide in aqueous solution to form an alcohol.



X **Y**



Z

(a) (i) Name **X** and **Z**.

(2)

X .....

Z .....

(ii) Draw the **skeletal** formula of **X**.

(1)

(iii) What type of alcohol is **Z**?

(1)

.....

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(b) (i) Name the mechanism and type of reaction shown above.

(2)

(ii) Explain what the curly arrows shown in the mechanism represent.

(1)

*(iii) Suggest the shape of the intermediate **Y**. Explain your answer.

(3)

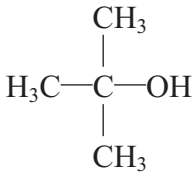
(iv) If the reaction is carried out in alcoholic (ethanolic) rather than aqueous solution, a different type of reaction occurs and a different product is formed. Name the type of reaction that occurs in alcoholic (ethanolic) solution and identify the product by name or formula.

(2)

Type of reaction .....

Product

(c) The alcohol **Z** (shown below) resists oxidation. However, **Z** has three structural isomers which are readily oxidized. On complete oxidation, one isomer forms a ketone and the other two isomers form carboxylic acids.



Z

(i) Draw the structural formula of the isomer of **Z** that forms a ketone.

(1)

(ii) Draw the structural formulae of the isomers of **Z** that form carboxylic acids.

(2)

(Total for Question 18 = 15 marks)

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19 Metal nitrates decompose on heating. Potassium nitrate, KNO_3, decomposes to form potassium nitrite and oxygen, whereas calcium nitrate, $Ca(NO_3)_2$, decomposes to form calcium oxide, nitrogen dioxide and oxygen.

(a) Write equations for the decomposition of each of these metal nitrates. State symbols are **not** required.

(2)

(i) Potassium nitrate

(ii) Calcium nitrate

(b) State **two** things that you would **see** when anhydrous calcium nitrate is heated.

(2)

*(c) Explain why potassium nitrate and calcium nitrate decompose to form different products.

(3)

(Total for Question 19 = 7 marks)

TOTAL FOR SECTION B = 40 MARKS

P 3 9 3 5 0 7 A 0 1 5 2 0
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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

20

Fuels of the Future

Concerns about the future availability of fossil fuels, and the fact that their combustion produces greenhouse gases, have led to a search for alternative sources of energy. A great deal of attention has been directed at developing the use of hydrogen as a fuel. Since the only product of its combustion is water, hydrogen is considered to be a clean fuel.

However, the use of hydrogen has major drawbacks. The small size of the hydrogen molecule means that it is difficult to prevent leaks and, to store enough to provide a reasonable amount of fuel for a car, hydrogen must be compressed to around 700 atmospheres. Furthermore, the main source of hydrogen is currently fossil fuels such as methane, which is combined with steam in a series of reactions to form carbon dioxide and hydrogen.

One suggested alternative to hydrogen is ammonia. Ammonia, which is obtained by combining nitrogen and hydrogen at temperatures around 450 °C and pressures of about 150 atmospheres, also has serious disadvantages: it is a toxic, corrosive and pungent gas which is difficult to ignite.

However, burning ammonia produces only nitrogen and water and it is relatively easy to liquefy, having a boiling temperature of just –33 °C. Furthermore, the technology works: ammonia was used as a fuel for Belgian buses in the Second World War and, in 2007, the 'NH3 Car' project based in Ann Arbor, Michigan, used a mixture of ammonia and petrol to fuel a 2500 mile journey, from Detroit to San Francisco, in a modified pickup truck.

(a) (i) Explain the term **greenhouse gas**.

(2)

P 3 9 3 6 0 7 A 0 0 1 6 2 0
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*(ii) State and explain whether or not water (in the gaseous state) is a greenhouse gas.

(2)

(iii) Write the equation for the formation of hydrogen from methane and steam. State symbols are **not** required.

(2)

(iv) Suggest why using methane to form hydrogen in this way is preferable to burning methane directly.

(1)

(v) Storing hydrogen at a pressure of 700 atmospheres is a disadvantage to its use as a fuel because of the costs involved. Suggest why using such high pressures is so expensive.

(1)

(b) (i) Draw a dot and cross diagram for ammonia, showing the outer electrons only.

(1)

P 3 9 3 7 0 7 A 0 0 U K 7 2 0
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*(ii) By considering the intermolecular forces involved, explain why methane has a boiling temperature of 109 K while ammonia has a boiling temperature of 240 K, although these two compounds have very similar molar masses.

(4)

(c) (i) Write the equation for the combustion of ammonia. State symbols are **not** required.

(2)

(ii) The enthalpy change of combustion of methane is –890.3 kJ mol^{-1} and that of ammonia is –510.1 kJ mol^{-1}. Suggest **two** additional items of information, **not** connected with environmental factors or the fact that methane is non-renewable, which would be useful in comparing methane and ammonia as fuels.

(2)

(iii) The fact that ammonia has a pungent smell is listed as a disadvantage of its use as a fuel. Suggest why this might also be an advantage.

(1)

P 3 9 3 7 0 A 0 1 6 8 2 0
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(iv) Suggest why ammonia was mixed with petrol in the 'NH3 Car' project.

(1)

.....

.....

.....

(v) State, with a reason, whether hydrogen or ammonia can currently be considered to be long term replacements for fossil fuels.

(1)

.....

.....

.....

(Total for Question 20 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS

P 3 9 3 7 0 A 0 0 U K 9 2 0
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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

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Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH02) Paper 01 Application of Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1 (a)	B		**1**
(b)	C		**1**
(c)	D		**1**

Question Number	Correct Answer	Reject	Mark
2 (a)	C		**1**
(b)	D		**1**

Question Number	Correct Answer	Reject	Mark
3	D		**1**

Question Number	Correct Answer	Reject	Mark
4	A		**1**

Question Number	Correct Answer	Reject	Mark
5	A		**1**

Question Number	Correct Answer	Reject	Mark
6	D		**1**

Question Number	Correct Answer	Reject	Mark
7	B		**1**

Question Number	Correct Answer	Reject	Mark
8	C		**1**

Question Number	Correct Answer	Reject	Mark
9	D		**1**

Question Number	Correct Answer	Reject	Mark
10	A		**1**

Question Number	Correct Answer	Reject	Mark
11	C		**1**

Question Number	Correct Answer	Reject	Mark
12	B		**1**

Question Number	Correct Answer	Reject	Mark
13 (a)	C		**1**
(b)	B		**1**

Question Number	Correct Answer	Reject	Mark
14	A		**1**

Question Number	Correct Answer	Reject	Mark
15	B		**1**

Question Number	Correct Answer	Reject	Mark
16	A		**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17 (a)(i)	More O_3 is formed/equilibrium shifts to the right **(1)** Because (increase in temperature) favours **endothermic** reaction ALLOW (Forward) reaction is **endothermic** ALLOW ΔH is positive for endothermic **(1)** IGNORE references to rate and pressure change	equilibrium shifts to the left (scores zero overall)	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(ii)	The mixture becomes darker ALLOW: more blue/bluer **(1)** (Increase in pressure) favours side with fewer moles/molecules (of gas) (so equilibrium shifts to the right) **(1)** IGNORE references to rate Marks are stand alone	Just 'more ozone' Blue gas formed Mixture becomes blue Atoms/particles	**2**

Question Number	Acceptable Answers	Reject	Mark
17(a)(iii)	The equilibrium is dynamic OR Forward & reverse reactions still occurring OR O_3 continues to be formed from O_2 at the same rate as O_3 decomposes OR O_3 continues to be formed from O_2 with no nett change in composition		**1**

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	**In (b) Any units given must be correct. Penalise once** **IGNORE SF except 1 SF. Penalise once** **TE at each step through calculation** Amount of thiosulfate = $0.0155 \times 25.50 \times 10^{-3}$ = 3.9525×10^{-4} (mol) Or correct answer with no working		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(ii)	1 mol I_2 reacts with 2 mol $S_2O_3^{2-}$ ALLOW 'using equation 2' ∴ Amount of iodine = answer in (b)(i) / 2 **(1)** = $3.9525 \times 10^{-4} / 2 = 1.97625 \times 10^{-4}$ (mol) **(1)** Correct answer with no working **(2)** If ratio reversed, TE only if ratio is stated		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iii)	Amount of iodine = Amount of ozone = answer in (b)(ii) = 1.97625×10^{-4} (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b) (iv)	Volume of ozone = answer in (b)(iii) x 0.024 = $1.97625 \times 10^{-4} \times 0.024$ = 4.743×10^{-6} (m^3 in 100 m^3)		**1**

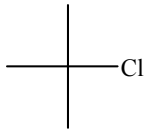
Question Number	Acceptable Answers	Reject	Mark
17 (b)(v)	Volume of ozone in ppm = answer in (b)(iv) $\times 10^6 \div 100$ = $4.743 \times 10^{-6} \times 10^4$ = $4.743 \times 10^{-2} = 0.04743$ (ppm)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(vi)	(Increase reliability) because a mean (average) value can be used/ anomalous results (ALLOW outliers) may be identified ALLOW the **titration** can be repeated **(1)** (Decrease accuracy) because smaller **titration** volume/volume of **thiosulfate** ALLOW volume of (acidified) **KI** ALLOW 'amount' for 'volume' **(1)** **so** percentage error/uncertainty will increase **(1)** The % error mark is NOT stand alone but 'smaller volume increases percentage error' scores final mark	Experiment can be repeated More results	**3**

Question Number	Acceptable Answers	Reject	Mark
17(c)	Oxygen in O_3 = 0 **and** O_2 = 0 **(1)** in H_2O = −2 /2− **(1)** Ozone acts as an oxidizing agent. ALLOW 'is reduced' / oxidizes I^- **(1)** Third mark is stand alone; No TE on incorrect oxidation numbers		**3**

Question Number	Acceptable Answers	Reject	Mark
17(d)	(Residual) ozone is (quickly) converted into (odourless) oxygen OR chlorine has a persistent/unpleasant odour or taste OR Chlorine forms HCl/ hydrochloric acid (in drinking water)	(Oxygen) and water Ozone is odourless/cheap /more available Chlorine forms free radicals/ hazardous compounds/ reacts with hydrogen/ damages ozone layer	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (a)(i)	**X** = 2-chloro-2-methylpropane ALLOW **X** = 2,2-chloromethylpropane **X** = 2-methyl-2-chloropropane **X** = 2,2-methylchloropropane **X** = 2-chloromethylpropane **(1)** **Z** = 2-methylpropan-2-ol **(1)** ALLOW methylpropan-2-ol ALLOW propane for propan IGNORE omission of (or extra) commas and hyphens IGNORE spaces	 2-methylchloropropane Hydroxy for -ol	**2**

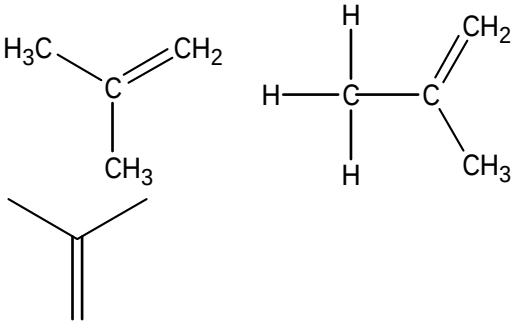
Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	 ALLOW any angles	Any other type of structure	**1**

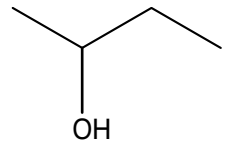
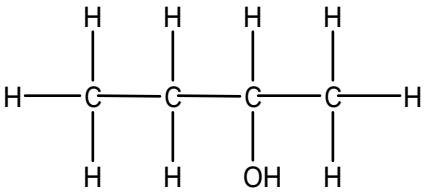
Question Number	Acceptable Answers	Reject	Mark
18 (a)(iii)	Tertiary ALLOW recognisable abbreviations: $3^{y}/3^{o}$		**1**

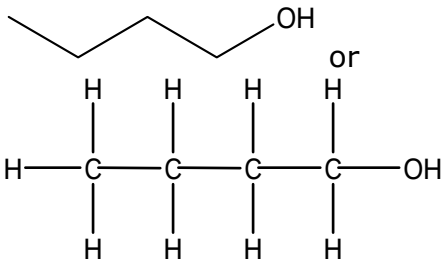
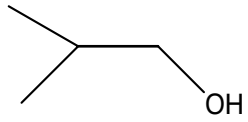
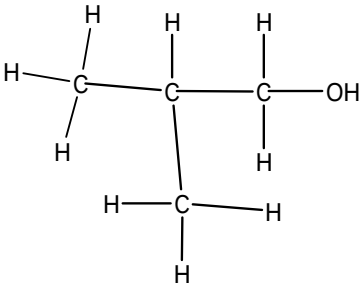
Question Number	Acceptable Answers	Reject	Mark
18 (b)(i)	Nucleophilic **(1)** Substitution **(1)** S_N1 scores 1/2	 S_N2	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (b)(ii)	Movement (ALLOW Transfer/donation)/ start and finish positions of an electron pair ALLOW two electrons for pair IGNORE bonded/unbonded for electrons IGNORE heterolytic bond breaking and bond formation	electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b)(iii)	These marks are stand alone Trigonal (ALLOW triangular) planar/ planar with bond angles of 120º **(1)** 3 bond pairs (no lone pairs) of electrons **(1)** ALLOW 3 pairs of electrons **around the central atom / carbon** Arranged at **minimum** repulsion **(1)** ALLOW **maximum** separation / distance apart IGNORE references to the positive charge	Bonds or 'areas of electron density' for pairs Just '3 pairs of electrons' Just 'repel' Repel as much as possible	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (b)(iv)	(Type of reaction:) elimination ALLOW dehydrohalogenation **(1)** IGNORE nucleophilic Product: 2-methylpropene ALLOW methylpropene 2-methylprop-1-ene Methylprop-1-ene any correct formula e.g. $(CH_3)_2CCH_2$ ALLOW $CH_3C(CH_3)CH_2$  **(1)** If a displayed formula or part displayed formula is used, all the atoms must be shown.	2-methylprop-2-ene methylprop-2-ene	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(i)	If a displayed formula or part displayed formula is used, all the atoms must be shown. If a carbon is *clearly* shown bonded to the H in OH, penalise once in (c) $CH_3CH_2CH(OH)CH_3$ ALLOW  OR  		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	$CH_3CH_2CH_2CH_2OH$ **(1)** ALLOW  or $(CH_3)_2CHCH_2OH$ **(1)** ALLOW  OR  If 2 correct carboxylic acids are shown, 1 out of 2	Aldehydes	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	$2KNO_3 \rightarrow 2KNO_2 + O_2$ Or multiples or equation divided by 2 ALLOW O_2 on LHS if balanced by additional O_2 on RHS IGNORE state symbols even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	$2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$ Or multiples or equation divided by 2 ALLOW O_2 on LHS if balanced by additional O_2 on RHS IGNORE state symbols even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (b)	Brown gas (ALLOW fumes or vapour) evolved **(1)** IGNORE Effervescence/bubbles EITHER (White) solid melts (and then solidifies/freezes) OR (Colourless) liquid forms **(1)** IGNORE white solid formed		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)	Penalise any omission of reference to ion in MP 1 only but calcium ions or Ca^{2+} and potassium ions or K^+ are equivalent **<u>Marking Point 1</u>** Calcium **ions** have greater positive charge (than potassium **ions**) OR Calcium **ions** 2+ but potassium **ions** 1+ OR Ca^{2+} but K^+ OR calcium **ions** are smaller (than potassium **ions**) OR calcium **ions** have greater charge density **(1)** **<u>Marking Point 2</u>** ∴ Calcium (ions) more **polarising** or **cause greater distortion** **(1)** **<u>Marking Point 3</u>** Of... nitrate (ion) OR anion OR N—O / N=O(bond) OR nitrate electron cloud **(1)** Reverse argument for K^+ gains full marks		**3**

TOTAL FOR SECTION B = 40 MARKS

Section C

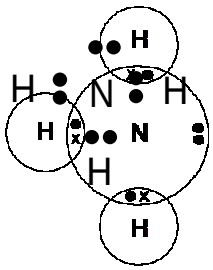
Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	(A greenhouse gas) traps/absorbs/ reflects IR (radiation) / heat **(1)** (re-radiating) **from the earth** **(1)** ALLOW **Back** to the earth	Absorbs UV (heat) from the sun From the earth's atmosphere	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	(water is a greenhouse gas) because it absorbs infrared (IR) radiation **(1)** The polarity of the water molecule changes when its bonds vibrate ALLOW Water is a polar molecule/has polar bonds **(1)**	Reflects (for absorbs) Heat (for IR) Traps IR/heat from the earth	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iii)	$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$ ALLOW $CH_4 + H_2O \rightarrow CO + 3H_2$ Species **(1)** balance **(1)** No TE on incorrect species	$CH_4 + 2H_2O \rightarrow CO_2 + 8H$ $CH_4 + H_2O \rightarrow CO + 6H$	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iv)	Hydrogen is obtained from the water (as well as from the methane) OR Easier to capture the CO_2 in a chemical plant than in a moving vehicle ALLOW Higher yield of/more hydrogen		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(v)	(High cost of) energy needed (to generate the pressure) OR (High cost of) **construction / maintenance** of the equipment OR (High cost of) the equipment required to **withstand** / **contain** the high pressure	High pressure is expensive	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (b)(i)	ALLOW  Accept dots and/or crosses for electrons, provided there are 3 bond pairs plus 2 electrons with or without lines for the bonds With or without circles		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (b)(ii)	**Comment** Any incorrect statement cancels a correct one. The order of the marking points is not important. **Marking Point 1** Ammonia has hydrogen bonds (as well as London forces) **(1)** IGNORE permanent dipole-dipole forces here **Marking Point 2** Methane (only) has London / dispersion forces **(1)** ALLOW van der Waals forces **Marking Point 3** (So) Intermolecular forces (stated or implied) in ammonia are (much) stronger than those in methane **(1)** **Marking Point 4** (Ammonia has hydrogen bonds) because nitrogen is very electronegative **(1)** (and has a lone pair) OR London forces are similar in both methane and ammonia (because they have the same number of electrons) **(1)** OR So more energy is needed to separate ammonia molecules (than methane molecules)		**4**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(i)	$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$ Species **(1)** balance **(1)** ALLOW Equation forming nitrogen monoxide $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$ Species **(1)** balance **(1)**	$4NH_3 + 3O_2 \rightarrow 4N + 6H_2O$	**2**

	No TE on incorrect species		

Question Number	Acceptable Answers	Reject	Mark
20 (c)(ii)	Any two Energy density / energy per unit volume of the fuels ALLOW miles per gallon or equivalent **(1)** Cost / Ease of Production **(1)** Storage **(1)** Transport **(1)** Liquefaction **(1)** Ease of ignition **(1)** Corrosiveness **(1)** IGNORE references to Environment Renewability Safety Boiling temperatures Atom economy		**2**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(iii)	Leaks would be easy to detect IGNORE reference to spillage		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(iv)	Ammonia is difficult to ignite/does not burn/combust easily	Ammonia is unreactive	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(v)	No because hydrogen is obtained from fossil fuels (and ammonia from hydrogen) OR Yes because hydrogen can be obtained by electrolysis of water **using renewable energy sources**		**1**

TOTAL FOR SECTION C = 20 MARKS

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Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Thursday 19 January 2012 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P39303A

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7/7/5/3/

P 3 9 3 0 3 A 0 1 2 4

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 This question concerns the shapes of molecules and ions:

A linear

B trigonal planar

C pyramidal

D tetrahedral

Select from **A to D** the shape of

(a) boron trichloride, BCl_3

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) the ammonium ion, NH_4^+

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) carbon dioxide, CO_2

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 3 marks)

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2 Tetrachloromethane, CCl_4, is a

☒ **A** polar molecule with polar bonds.

☒ **B** polar molecule with non-polar bonds.

☒ **C** non-polar molecule with polar bonds.

☒ **D** non-polar molecule with non-polar bonds.

(Total for Question 2 = 1 mark)

---

3 The difference in boiling temperature between methane (T_b = 109 K) and ethane (T_b = 185 K) is best explained by the different numbers of

☒ **A** protons.

☒ **B** electrons.

☒ **C** covalent bonds.

☒ **D** hydrogen bonds.

(Total for Question 3 = 1 mark)

---

4 What is the oxidation number of oxygen in OF_2?

☒ **A** −2

☒ **B** −1

☒ **C** +1

☒ **D** +2

(Total for Question 4 = 1 mark)

---

5 In which of the following reactions is sulfuric(IV) acid, H_2SO_3, acting as an oxidizing agent?

☒ **A** $2NaOH + H_2SO_3 \rightarrow Na_2SO_3 + 2H_2O$

☒ **B** $2FeCl_3 + H_2SO_3 + H_2O \rightarrow 2FeCl_2 + H_2SO_4 + 2HCl$

☒ **C** $2H_2S + H_2SO_3 \rightarrow 3H_2O + 3S$

☒ **D** $H_2SO_3 \rightarrow H_2O + SO_2$

(Total for Question 5 = 1 mark)

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6 Ethanol is soluble in water. The **best** explanation for this is

☒ **A** ethanol molecules form hydrogen bonds with water molecules.

☒ **B** ethanol molecules form London (dispersion) forces with water molecules.

☒ **C** ethanol molecules form permanent dipole interactions with water molecules.

☒ **D** ethanol and water are miscible liquids.

(Total for Question 6 = 1 mark)

7 During a titration, when the solution in a pipette is transferred to a conical flask, a small amount of liquid remains in the tip of the pipette. This situation should be dealt with by

☒ **A** leaving the liquid in the pipette which is calibrated to allow for it.

☒ **B** slightly over-filling the pipette to compensate for the additional volume.

☒ **C** carefully blowing the liquid out of the pipette to ensure that it is empty.

☒ **D** repeating the titration.

(Total for Question 7 = 1 mark)

8 The tolerance of a 25 cm^3 pipette is ±0.06 cm^3. The percentage error in the measurement of 25 cm^3 using this pipette is

☒ **A** ±0.06%

☒ **B** ±0.12%

☒ **C** ±0.24%

☒ **D** ±0.48%

(Total for Question 8 = 1 mark)

9 A series of titrations is carried out using the same conical flask. Before carrying out each titration, the conical flask **must** be

☒ **A** rinsed with ethanol.

☒ **B** rinsed with distilled or deionised water.

☒ **C** rinsed with the solution that it will contain.

☒ **D** dried to remove all traces of liquid.

(Total for Question 9 = 1 mark)

P 3 9 3 0 3 A 0 4 2 4
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10 When excess calcium is added to water, effervescence occurs and

☒ **A** a clear colourless solution is formed.

☒ **B** a cloudy suspension is formed.

☒ **C** an orange-red flame is seen.

☒ **D** a yellow flame is seen.

(Total for Question 10 = 1 mark)

11 When samples of magnesium nitrate, $Mg(NO_3)_2$, and calcium nitrate, $Ca(NO_3)_2$, are heated

☒ **A** both compounds decompose to form the corresponding nitrite and oxygen.

☒ **B** both compounds decompose to form the corresponding oxide, nitrogen dioxide and oxygen.

☒ **C** magnesium nitrate decomposes to form magnesium nitrite and oxygen whereas calcium nitrate decomposes to form calcium oxide, nitrogen dioxide and oxygen.

☒ **D** magnesium nitrate decomposes to form magnesium oxide, nitrogen dioxide and oxygen whereas calcium nitrate decomposes to form calcium nitrite and oxygen.

(Total for Question 11 = 1 mark)

12 Which of the following properties of the elements chlorine, bromine and iodine **increases** with increasing atomic number?

☒ **A** Boiling temperature

☒ **B** Bond enthalpy

☒ **C** Electronegativity

☒ **D** First ionization energy

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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13 Which of the following is a secondary alcohol?

☒ **A** butan-1-ol

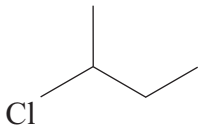
☒ **B** butan-2-ol

☒ **C** 2-methylpropan-1-ol

☒ **D** 2-methylpropan-2-ol

(Total for Question 13 = 1 mark)

14 The compound



has the systematic name

☒ **A** 2-chlorobutane

☒ **B** 3-chlorobutane

☒ **C** 1-chloro-1-methylpropane

☒ **D** 1-chloro-2-methylbutane

(Total for Question 14 = 1 mark)

15 When a chloroalkane is heated with aqueous sodium hydroxide

☒ **A** no reaction occurs with primary, secondary or tertiary chloroalkanes.

☒ **B** a reaction occurs with primary and secondary chloroalkanes but not with tertiary chloroalkanes.

☒ **C** a reaction occurs with tertiary chloroalkanes but not with primary and secondary chloroalkanes.

☒ **D** a reaction occurs with primary, secondary and tertiary chloroalkanes.

(Total for Question 15 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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16 Brown nitrogen dioxide, NO_2, exists in equilibrium with colourless dinitrogen tetroxide, N_2O_4.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \quad \Delta H = -57.2 \text{ kJ mol}^{-1}$$
brown colourless

(a) The **pressure** is increased. When equilibrium is restored, the appearance of the mixture of gases will be

(1)

☒ **A** colourless.

☒ **B** unchanged.

☒ **C** paler brown.

☒ **D** darker brown.

(b) The **temperature** is increased. When equilibrium is restored, the appearance of the mixture of gases will be

(1)

☒ **A** colourless.

☒ **B** unchanged.

☒ **C** paler brown.

☒ **D** darker brown.

(Total for Question 16 = 2 marks)

17 When propanal, CH_3CH_2CHO, and propanone, CH_3COCH_3, are compared using physical methods of analysis, which of the following is **not** correct?

☒ **A** The carbonyl groups absorb at very similar frequencies of the IR spectrum.

☒ **B** The compounds will have different patterns in the fingerprint region of the IR spectrum.

☒ **C** The compounds will form different fragmentation patterns in a mass spectrum.

☒ **D** The compounds will have molecular ion peaks at different mass to charge ratios in a mass spectrum.

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

18 The boiling temperatures of some hydrides are given below.

Compound	Boiling temperature / K
HF	293
HCl	188
HBr	206
HI	238
H_2O	373

*(a) Explain, by comparing the forces involved, why HI has a higher boiling temperature than HBr.

(3)

*(b) Explain, by comparing the types of forces involved, why HF has a higher boiling temperature than HCl.

(3)

P 3 9 3 8 3 A 0 8 2 4
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(c) Suggest why H_2O has a higher boiling temperature than HF.

(1)

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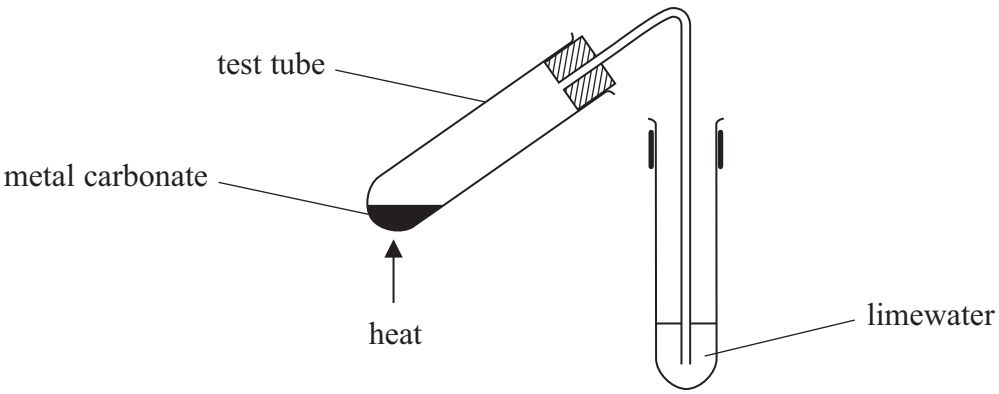
(Total for Question 18 = 7 marks)

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19 The carbonates of Group 2 in the Periodic Table decompose on heating to form the corresponding metal oxide and carbon dioxide. A general equation for the reaction is

$$MCO_3(s) \rightarrow MO(s) + CO_2(g)$$

The thermal stability of these carbonates can be compared in the laboratory using the apparatus in the diagram below. The test tube on the left contains a sample of a metal carbonate and the tube on the right contains limewater.



(a) (i) State the measurement that you would make in this experiment.

(1)

.....

.....

(ii) Suggest **three** ways to make sure that, when carrying out this experiment, the thermal stabilities of the different carbonates are compared fairly.

(3)

1 .....

.....

2 .....

.....

3 .....

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P 3 9 3 0 3 A 0 0 4 0 2 4
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(b) (i) State the trend in the thermal stability of the metal carbonates as the group is descended.

(1)

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*(ii) Explain this trend in stability.

(3)

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(Total for Question 19 = 8 marks)

P 3 9 3 0 3 A 0 1 1 2 4
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20 Chlorine disinfectants are essentially solutions containing chlorine molecules and chlorate(I) ions in an equilibrium summarised by the equation

$$Cl_2(aq) + H_2O(l) \rightleftharpoons 2H^+(aq) + ClO^-(aq) + Cl^-(aq) \qquad \textbf{Equation 1}$$

The chlorine content of a disinfectant was determined using the following procedure.

1. 10.0 cm^3 of the disinfectant was transferred to a 250 cm^3 volumetric flask.

2. Approximately 20 cm^3 of nitric acid and 20 cm^3 potassium iodide solution (both in excess) were added to the volumetric flask.

3. The solution in the volumetric flask was made up to the mark with distilled water and then mixed thoroughly.

4. 10.0 cm^3 portions of the solution in the volumetric flask were titrated against a solution of sodium thiosulfate, concentration 0.109 mol dm^{-3}. Starch solution was added near the end-point of the titration and the mean (average) titre was 27.35 cm^3.

The equations for the reactions involved in this procedure are

$$Cl_2(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2Cl^-(aq) \qquad \textbf{Equation 2}$$

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq) \qquad \textbf{Equation 3}$$

(a) (i) Calculate the number of moles of sodium thiosulfate used in the titration.

(2)

(ii) Calculate the number of moles of iodine, I_2, that reacted in the titration (step 4).

(1)

(iii) Hence state the number of moles of chlorine, Cl_2, in 10.0 cm^3 of the solution in the volumetric flask.

(1)

P 3 9 3 0 3 A 0 0 1 2 2 4
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(iv) Calculate the concentration of chlorine, in mol dm^{-3}, in the **original** disinfectant.

(2)

(b) **Equation 1** is an example of a disproportionation reaction. Define the term 'disproportionation' and explain, by considering the relevant oxidation numbers, why this reaction is a disproportionation.

(3)

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(c) State the colours of the titration solution just before the starch solution is added, after the starch solution is added and the colour change at the end-point of the reaction.

(2)

Colour just before adding the starch .....

Colour after adding the starch .....

Colour at the end-point .....

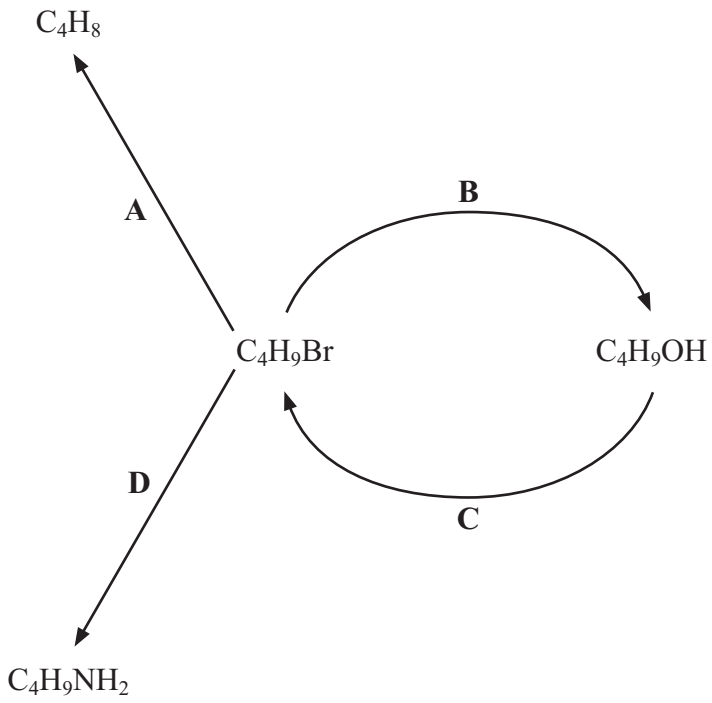
(Total for Question 20 = 11 marks)

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21 Halogenoalkanes are important intermediates in organic chemistry. The scheme below summarises some important reactions of a halogenoalkane.



(a) Identify the reagents and any specific conditions required for the reactions in the diagram. (You may assume that a suitable temperature is maintained in each reaction.)

(4)

A .....

B .....

C .....

D .....

(b) (i) Classify the type of reaction in each of **A** and **D**.

(2)

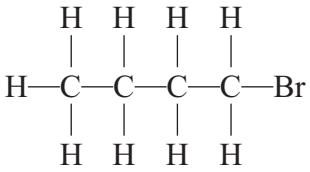
A .....

D .....

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*(ii) Reaction **B** can proceed via two possible reaction mechanisms, depending on the structure of the original compound. For each of the two isomers of C_4H_9Br shown below, draw the structure of the intermediate or transition state which is formed during the reaction. Explain in each case why the specified structure is more favourable.

(4)



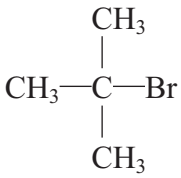
Intermediate or transition state

Explanation .....

.....

.....

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Intermediate or transition state

Explanation .....

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(iii) If C_4H_9I is used instead of C_4H_9Br in reaction **D**, the rate of formation of $C_4H_9NH_2$ increases. Explain why the rate of reaction increases.

(1)

.....

.....

.....

(c) Halogenoalkanes are widely used as refrigerants and belong to the class of refrigerants that cool by change of state (typically by boiling).

(i) Suggest how halogenoalkanes cool by change of state.

(1)

.....

.....

.....

(ii) Suggest **two** characteristics or properties desirable in a refrigerant.

(2)

1 .....

.....

2 .....

.....

(Total for Question 21 = 14 marks)

TOTAL FOR SECTION B = 40 MARKS

P 3 9 3 0 3 A 0 1 7 2 4
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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

22 Nitrogen monoxide is an unusual molecule both in its chemical structure (shown below) and in its impact on our lives.



Nitrogen monoxide is an important chemical messenger in all mammals and, at appropriate concentrations, it is vital to life; however, at high concentrations in the body, it is extremely toxic.

Nitrogen monoxide is considered a dangerous atmospheric pollutant; it is involved in the formation of a range of toxic substances, including ozone, at low altitudes, and in the depletion of the ozone layer at high altitudes.

Nitrogen monoxide is formed by the direct combination of nitrogen and oxygen at high temperatures, a reaction that occurs naturally in lightning discharges, and as a by-product of the reactions in internal combustion and jet engines. Catalytic converters reduce nitrogen monoxide emissions from car engines by catalysing the reaction between nitrogen monoxide and carbon monoxide to form nitrogen and carbon dioxide.

The reactions of nitrogen monoxide which involve ozone in the atmosphere are summarised below.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

$$NO_2(g) \xrightarrow{\text{UV radiation}} NO(g) + O(g)$$

$$O_2(g) + O(g) \longrightarrow O_3(g)$$

$$NO(g) + O_3(g) \longrightarrow NO_2(g) + O_2(g)$$

When the ratio of nitrogen dioxide to nitrogen monoxide is high (> 3), the rate of formation of ozone is faster than its rate of removal. When the ratio is low (< 0.3), the reverse is true.

Ozone causes breathing difficulties, headaches, fatigue and can aggravate respiratory problems. The reaction of nitrogen monoxide with hydrocarbons can also produce other toxic compounds, such as aldehydes.

(a) Write the equation for the formation of nitrogen monoxide from nitrogen and oxygen. State symbols are **not** required.

(1)

P 3 9 3 8 3 A 0 1 8 2 4
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(b) The electronic structure of nitrogen monoxide is unusual in that it has an unpaired electron.

(i) What name is given to a chemical species such as nitrogen monoxide that has an unpaired electron?

(1)

.....

(ii) Chemical species with unpaired electrons occur as intermediates in some chemical reactions. What type of bond breaking produces these species?

(1)

.....

(c) (i) Suggest the most likely source of the hydrocarbons that react with nitrogen monoxide to form toxic compounds.

(1)

.....

(ii) Suggest the type of reaction that is involved when a hydrocarbon is converted into an aldehyde.

(1)

.....

(iii) Draw the **skeletal** formula of the aldehyde with three carbon atoms.

(1)

(iv) By considering the equation

$$NO(g) + O_3(g) \longrightarrow NO_2(g) + O_2(g)$$

explain the effect of the reaction of hydrocarbons with nitrogen monoxide on the breakdown of ozone.

(1)

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(d) Suggest why the proportion of nitrogen dioxide might be reduced at high altitudes.

(2)

(e) Explain why it is important to maintain the concentration of ozone in the upper atmosphere.

(2)

(f) (i) Write an equation for the reaction on a catalytic converter described in the passage. State symbols are **not** required.

(1)

P 3 9 3 0 3 A 0 0 2 0 2 4
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(ii) Draw an energy profile for the exothermic reaction in (f)(i). Label the axes, the reactants and products, the enthalpy change and the activation energy.

(3)

*(iii) By referring to your energy profile, explain how a catalyst speeds up a chemical reaction.

(3)

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(g) Jet aircraft are considered a greater threat to the ozone layer than road vehicles. Suggest an explanation for this.

(2)

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(Total for Question 22 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS

TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

P 3 9 3 T E M 3 P . A C O U N 2 4 2 4

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Mark Scheme (Results)
January 2012

GCE Chemistry (6CH02) Paper 01
Application of Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

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Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

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Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1 (a)	B		**1**
(b)	D		**1**
(c)	A		**1**

Question Number	Correct Answer	Reject	Mark
2	C		**1**

Question Number	Correct Answer	Reject	Mark
3	B		**1**

Question Number	Correct Answer	Reject	Mark
4	D		**1**

Question Number	Correct Answer	Reject	Mark
5	C		**1**

Question Number	Correct Answer	Reject	Mark
6	A		**1**

Question Number	Correct Answer	Reject	Mark
7	A		**1**

Question Number	Correct Answer	Reject	Mark
8	C		**1**

Question Number	Correct Answer	Reject	Mark
9	B		**1**

Question Number	Correct Answer	Reject	Mark
10	B		**1**

Question Number	Correct Answer	Reject	Mark
11	B		**1**

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Question Number	Correct Answer	Reject	Mark
12	A		**1**

Question Number	Correct Answer	Reject	Mark
13	B		**1**

Question Number	Correct Answer	Reject	Mark
14	A		**1**

Question Number	Correct Answer	Reject	Mark
15	D		**1**

Question Number	Correct Answer	Reject	Mark
16 (a)	C		**1**
(b)	D		**1**

Question Number	Correct Answer	Reject	Mark
17	D		**1**

TOTAL FOR SECTION A = 20 MARKS

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Section B

Question Number	Acceptable Answers	Reject	Mark
18(a)	London/dispersion forces greater (ALLOW 'more') (in HI) ALLOW van der Waals forces/ temporary dipole (forces)/induced dipole (forces) Just 'Intermolecular (forces)' does not score this mark Stand alone mark **(1)** **Any two from** Because (Iodine/HI) has more electrons/iodine has more electron shells ALLOW bigger surface area **(1)** (So) more energy needed (ALLOW 'harder') to separate molecules / break the (London) forces ALLOW more energy needed to boil compound ALLOW intermolecular (forces) here **(1)** Permanent dipole in HI is weaker than the permanent dipole in HBr **(1)** The increase in London forces (from HCl to HI) outweighs the decrease in permanent dipole **(1)**	Iodide/bromide More electrons in the bond HI has more electron shells Just 'easier to boil compound'	**3**

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Question Number	Acceptable Answers	Reject	Mark
18(b)	HF has hydrogen bonding (and HCl does not) Stand alone mark **(1)** **Any two from** Fluorine very electronegative/more electronegative than chlorine **(1)** Hydrogen bonding is (much) stronger (than other/named intermolecular forces) ALLOW Hydrogen bonding is (very) strong **(1)** So more energy needed (ALLOW 'harder') to separate molecules/ break the hydrogen bonds ALLOW more energy needed to boil compound **(1)** HCl has London/dispersion (and (weak) dipole-dipole) forces ALLOW (weak) dipole-dipole forces ALLOW 'Only London/dispersion forces' **(1)** ALLOW van der Waals forces/ temporary or induced dipole forces for London/dispersion	Just 'HF has stronger intermolecular forces (than HCl)' HF/F^- for fluorine Just 'easier to boil compound'	**3**

Question Number	Acceptable Answers	Reject	Mark
18(c)	Water forms (up to) two hydrogen bonds (per molecule but HF only one). IGNORE references to numbers of lone pairs.	More/stronger/ greater than two	**1**

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Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	**Time** for the first (permanent) cloudiness to appear in the limewater ALLOW **Time** for the limewater to turn milky/cloudy ALLOW **Time** for the limewater to turn milky/cloudy and (ppt) to dissolve ALLOW how long for time IGNORE references to volume of CO_2	How fast/how quickly	**1**

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	**Any three from** Constant Bunsen flame/electrical heater setting Fixed height of test tube above the flame Fixed moles/(ALLOW mass/amount) of carbonate Fixed volume/amount/mass of limewater Penalise use of quantity once only Same surface area/particle size (of solid) Standardise cloudiness of limewater using the disappearance of a cross (or similar) IGNORE repeats & use same measuring instruments /same person	 Constant temp/ heat Water bath Fixed angle Volume/quantity Concentration / quantity	**3**

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Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	More stable/(thermal stability) increases (as the group is descended)		**1**

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	Ignore an incorrect answer to 19b(i) and mark statements given independently Cation/positive (ALLOW metal) ion becomes larger (charge unchanged) OR cation charge density reduced **(1)** IGNORE references to shielding Polarisation/distortion reduced **(1)** (ALLOW polarising power reduced) of carbonate electron cloud/ carbonate ion/C-O bonds /anion **(1)** OR reverse argument for stability *decreasing* as group *ascended*	Atomic/metal radius/charge density of **atom**/ molecule	**3**

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Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	Throughout 20 (a): IGNORE sf except 1 sf (penalise once) correct answer with no working scores full marks mark consequentially IGNORE units unless incorrect $0.109 \times 27.35 \times 10^{-3}$ **(1)** $= 2.98115 \times 10^{-3}$ (mol) $= 2.98 \times 10^{-3}$ / 0.00298(mol) **(1)** cq only on some concentration x some volume	0.003	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	Moles I_2 = 0.5 x moles thiosulfate **= 0.5 x answer to (a)(i)** $= 1.490575 \times 10^{-3} = 1.49 \times 10^{-3}$ /0.00149(mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iii)	Moles of Cl_2 = moles of I_2 **= answer to (a)(ii)** $= 1.49 \times 10^{-3}$ /0.00149(mol)		**1**

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Question Number	Acceptable Answers	Reject	Mark
20 (a)(iv)	**Mark consequentially on answer in (a)(iii)** Amount in volumetric flask = 25 x answer to (a)(iii) (= 25 x 1.490575 x 10^{-3} = 3.72644 x 10^{-2}) OR (25 x 1.49 x 10^{-3} = 3.725 x 10^{-2}) **(1)** (= amount in 10 cm^3 of disinfectant) Concentration = 100 x previous value (= 1000 x 3.73 x 10^{-2} /10 = 3.73 (mol dm^{-3})) **(1)** Concentration = 100 x answer to (a)(iii) scores **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)	(Atoms of) the same element (in the same species) are oxidized and reduced **(1)** ALLOW chlorine for 'element' Chlorine ON 0 oxidized to (+)1 in ClO^- **(1)** and reduced to −1 in Cl^- **(1)** Only penalise once if oxidized and reduced omitted Just 'Chlorine ON 0 oxidized to (+)1 and reduced to −1' or 'Chlorine oxidized to chlorate(I) and reduced to chloride'(1 mark only) Only penalise once if oxidized and reduced reversed	Molecule/substance/ reactant /species Just Cl oxidized & reduced	**3**

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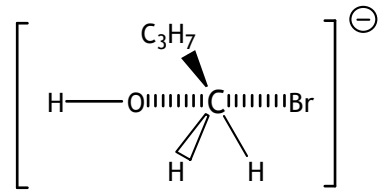
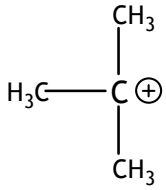
Question Number	Acceptable Answers	Reject	Mark
20(c)	Colour just before adding the starch: (very) pale yellow/straw coloured **(1)** Colour after adding the starch: Blue-black (ALLOW black or (dark) blue) Colour at the end point: colourless **(1)** **Both** colours required IGNORE 'Clear'	Just 'yellow', brown, gold purple	**2**

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Question Number	Acceptable Answers	Reject	Mark
21(a)	Names OR Formulae A = NaOH/KOH in ethanol /alcohol **(1)** B = NaOH/KOH in water/ aqueous **(1)** IGNORE any reference to ethanol /alcohol /dilute C = NaBr/KBr & (50% or moderately conc) H_2SO_4 / P & Br_2 / PBr_3 /PBr_5 /NaBr /KBr & H_3PO_4 /HBr ALLOW phosphorus bromide **(1)** IGNORE red/white (phosphorus) D = NH_3 (in alcohol /in a sealed tube /at high pressure) **(1)** IGNORE aqueous	Water + ethanol /water + alcohol For A and B OH^-/alkali (penalise once) Dilute H_2SO_4 any mention of alkali any mention of acid	**4**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	A = elimination **(1)** IGNORE 'nucleophilic' D = (nucleophilic) substitution **(1)**	mention of dehydration in A mention of electrophilic in A or D	**2**

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Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	Mark the diagrams; then mark the explanation sections together Score **(1)** for intermediate/ transition state wrong way round  IGNORE geometry and missing minus sign and δ+/ δ- **(1)**  **(1)** **Any two from** Tertiary carbocation more stable (than primary carbocation) ALLOW Tertiary carbocation very stable/fairly stable/stable **(1)** This mark can be awarded even if structures and other explanations are incorrect or missing Methyl groups stabilise charge (of carbocation) (through positive inductive effect) Steric hindrance (by methyl groups) inhibits formation of (trigonal bipyramid) transition state/attack by nucleophile with tertiary compound Steric hindrance is less with the primary halogenoalkane/more with tertiary halogenoalkane ALLOW a description of steric hindrance e.g. blocking/less space	Full O—C—Br bonds OH—C + sign δ+ Just 'primary carbocation unstable'	**4**

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Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	C–I bond weaker ALLOW C–I bond easier to break ALLOW iodine forms weaker bonds than bromine without mention of carbon ALLOW reverse arguments with C–Br bond stronger IGNORE Explanations in terms of electronegativity or bond polarity or activation energy or shielding even if incorrect	Just C–I bond longer	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (c)(i)	(Boiling) absorbs heat (allow energy)/latent heat (of vaporization)/enthalpy of vaporization from the surroundings/endothermic. If bonds are mentioned they must be intermolecular		**1**

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Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii)	**Any two from** Not flammable Not toxic Unreactive/inert/non-corrosive (only one of these can score) (easily) compressible does not harm the ozone layer Boiling temperature below target temperature ALLOW low boiling temperature high heat of vaporization high gas density high critical temperature IGNORE Non-polluting/ environmentally friendly/ cheap/easily manufactured/ easy to store/easy to contain /take up little space/low melting point/endothermic/ harmful	 Does not produce CFCs Gas/solid stable	**2**

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Question Number	Acceptable Answers	Reject	Mark
22 (a)	$N_2 + O_2 \rightarrow 2NO$ or $\frac{1}{2}N_2 + \frac{1}{2}O_2 \rightarrow NO$ Or multiples ALLOW extra oxygen or nitrogen molecules provided equation is balanced IGNORE state symbols even if incorrect ALLOW $\rightleftharpoons$ and 2NO.		**1**

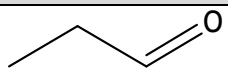
Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	Free radical(s) ALLOW recognisable spellings e.g. radicle		**1**

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	Homolytic (fission) ALLOW recognisable spellings e.g. homolitic		**1**

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	(unburnt) fuel/petrol/diesel/ kerosene (aviation fuel) ALLOW Car exhaust fumes/ fossil fuels/oil IGNORE burning/combustion except if stated as complete	Engines/factories/cattle/ methane/ethane/crude oil/ natural gas/coal/pollution	**1**

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	Oxidation ALLOW partial oxidation	Redox Addition oxidation	**1**

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Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	 IGNORE angles provided clearly 3 carbons	displayed or structural or molecular formulae or skeletal showing any H atoms	**1**

Question Number	Acceptable Answers	Reject	Mark
22(c)(iv)	NO removed so less O_3 broken down/NO reacts with hydrocarbon rather than O_3 so less O_3 broken down IGNORE build up of ozone	Just 'less O_3 broken down'	**1**

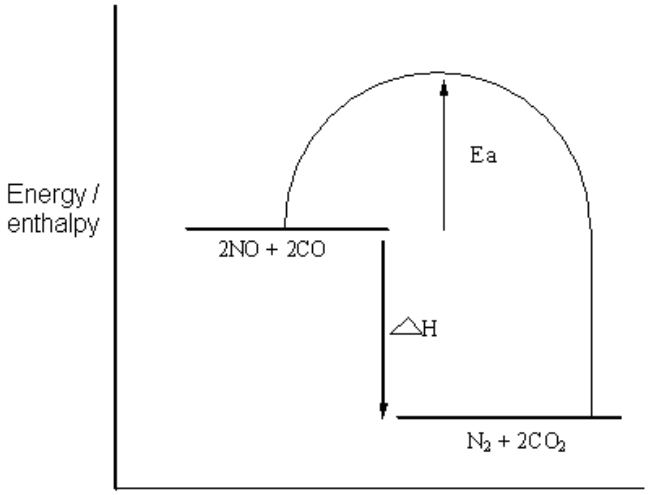
Question Number	Acceptable Answers	Reject	Mark
22(d)	(At high altitudes) intensity of UV (radiation/light) is greater **(1)** ALLOW more UV So conversion of NO_2 to NO will increase **(1)** ALLOW (At high altitudes) pressure is lower **(1)** So equilibrium $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ shifts to the left **(1)**	NO_2 removed before it gets to high altitudes more sunlight less oxygen	**2**

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Question Number	Acceptable Answers	Reject	Mark
22(e)	Ozone absorbs/blocks/filters/ protects against ALLOW removes (all) **UV** radiation **(1)** UV/sunlight is biologically harmful/causes genetic damage/causes (skin) cancer/causes eye cataracts **(1)** Reference to global warming max **(1)**	Sunlight; Infrared; reflects Just 'harmful' Effect of radiation without any mention of UV or sunlight	**2**

Question Number	Acceptable Answers	Reject	Mark
22(f)(i)	$2NO + 2CO \rightarrow N_2 + 2CO_2$ OR $NO + CO \rightarrow \frac{1}{2}N_2 + CO_2$ Or multiples IGNORE state symbols even if incorrect ALLOW ⇌		**1**

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Question Number	Acceptable Answers	Reject	Mark
22(f)(ii)	 ALLOW names or symbols in diagram ALLOW double headed arrows or headless arrows IGNORE Maxwell Boltzmann distributions **First mark** Labelled y axis and reactants and products ALLOW potential energy **(1)** IGNORE units IGNORE formula errors and x axis labels even if incorrect ALLOW 'reactants' and 'products' as labels **Second mark** **Exothermic** reaction **and** △H label **(1)** IGNORE negative sign on △H **Third mark** Activation energy line and label OR a double hump with higher first (smooth curve is not needed) **(1)**	Reversed arrows Energy change or enthalpy change or △H Any other humped diagram	**3**

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Question Number	Acceptable Answers	Reject	Mark
22(f)(iii)	Catalyst provides an alternative route/mechanism **(1)** with lower activation energy ALLOW low activation energy **(1)** So a higher proportion (ALLOW more) molecules / collisions (ALLOW reactants) have energy equal to or greater than Ea ALLOW 'so more molecules react' **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
22(g)	Aircraft (release NO) closer to the ozone layer/(atmosphere) at high altitude/in the stratosphere **(1)** IGNORE greenhouse gases at this point So less NO is lost through competing / other reactions **(1)** ALLOW broken down ALLOW NO (released at ground level) dissipated (e.g. by reaction with oxygen or hydrocarbons or by reaction to form ozone (as in the passage))	Just 'atmosphere'	**2**

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

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Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Friday 27 May 2011 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 3 8 4 7 9 A 0 1 2 0

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The correct balanced equation for the reaction between heated magnesium and steam, including state symbols, is

☒ **A** $Mg(s) + H_2O(l) \rightarrow MgO(s) + H_2(g)$

☒ **B** $Mg(s) + 2H_2O(g) \rightarrow Mg(OH)_2(aq) + H_2(g)$

☒ **C** $Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$

☒ **D** $Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$

(Total for Question 1 = 1 mark)

2 This question concerns the trends in properties on descending Group 2 of the Periodic Table.

(a) What are the trends in solubility of sulfates and hydroxides down Group 2?

(1)

☒ **A** Sulfates increase, hydroxides decrease.

☒ **B** Sulfates decrease, hydroxides increase.

☒ **C** Sulfates increase, hydroxides increase.

☒ **D** Sulfates decrease, hydroxides decrease.

(b) What are the trends in thermal stability of carbonates and nitrates down Group 2?

(1)

☒ **A** Carbonates increase, nitrates decrease.

☒ **B** Carbonates decrease, nitrates increase.

☒ **C** Carbonates increase, nitrates increase.

☒ **D** Carbonates decrease, nitrates decrease.

(c) What are the trends in first ionization energy and electronegativity of the elements down Group 2?

(1)

☒ **A** Ionization energy increases, electronegativity decreases.

☒ **B** Ionization energy decreases, electronegativity increases.

☒ **C** Ionization energy increases, electronegativity increases.

☒ **D** Ionization energy decreases, electronegativity decreases.

(Total for Question 2 = 3 marks)

P 3 8 4 7 9 A 0 2 2 0
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3 Which silver halide is a cream coloured solid which darkens in sunlight and dissolves in concentrated ammonia solution?

- ☒ **A** AgF
- ☒ **B** AgCl
- ☒ **C** AgBr
- ☒ **D** AgI

(Total for Question 3 = 1 mark)

4 What is the FBF bond angle in boron trifluoride, BF_3?

- ☒ **A** 180°
- ☒ **B** 120°
- ☒ **C** 109.5°
- ☒ **D** 90°

(Total for Question 4 = 1 mark)

5 What is the total number of electrons in the covalent bonds in a beryllium chloride molecule, $BeCl_2$?

- ☒ **A** 2
- ☒ **B** 4
- ☒ **C** 6
- ☒ **D** 8

(Total for Question 5 = 1 mark)

6 Which of the following molecules is linear?

- ☒ **A** CO_2
- ☒ **B** C_2H_4
- ☒ **C** H_2O
- ☒ **D** NH_3

(Total for Question 6 = 1 mark)

7 Which of the following molecules is **non-polar**?

☒ **A** CH_3Cl

☒ **B** CH_2Cl_2

☒ **C** $CHCl_3$

☒ **D** CCl_4

(Total for Question 7 = 1 mark)

8 Methanol dissolves in water mainly due to the formation of new

☒ **A** hydrogen bonds.

☒ **B** dipole-dipole forces.

☒ **C** London forces.

☒ **D** covalent bonds.

(Total for Question 8 = 1 mark)

9 Which of the following molecules does **not** absorb infrared radiation?

☒ **A** N_2

☒ **B** NO_2

☒ **C** CO

☒ **D** CO_2

(Total for Question 9 = 1 mark)

10 There would be a major peak in the mass spectrum for butan-1-ol, $CH_3CH_2CH_2CH_2OH$, but **not** for butan-2-ol, $CH_3CH_2CH(OH)CH_3$, at *m/e* value

☒ **A** 15

☒ **B** 17

☒ **C** 29

☒ **D** 43

(Total for Question 10 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

P 3 8 4 7 9 A 0 4 2 0
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11 How many molecular ion peaks (parent ion peaks) occur in the mass spectrum of 1,2-dibromoethane, CH_2BrCH_2Br?

Assume the only isotopes present are ^{1}H, ^{12}C, ^{79}Br and ^{81}Br.

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(Total for Question 11 = 1 mark)

12 The following reactions have been used in the chemical industry to make liquid and solid products, allowing any gaseous products to escape into the atmosphere:

A $CH_3OH(g) + CO(g) \rightarrow CH_3COOH(l)$

B $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

C $CH_4(g) + 3Cl_2(g) \rightarrow CHCl_3(l) + 3HCl(g)$

D $CH_2CH_2(g) + Cl_2(g) \rightarrow CH_2ClCH_2Cl(l)$

(a) Which reaction has an atom economy by mass of 56%?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which reaction causes the most immediate damage to the environment?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which reaction is an electrophilic addition?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 12 = 3 marks)

P 3 8 4 7 9 A 0 5 2 0
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13 Propan-1-ol and propan-2-ol are separately oxidized under mild conditions by acidified sodium dichromate(VI) and the product immediately distilled off. What is the oxidation product in each case?

		Propan-1-ol	Propan-2-ol
☒	**A**	propanal	propanone
☒	**B**	propanoic acid	propanone
☒	**C**	propanal	propanoic acid
☒	**D**	propanone	propanal

(Total for Question 13 = 1 mark)

14 Unsaturated vegetable oils are hardened to make margarine by reaction with hydrogen and a nickel catalyst. Which terms could both be used to describe this type of reaction?

☒ **A** Substitution and oxidation

☒ **B** Substitution and reduction

☒ **C** Addition and oxidation

☒ **D** Addition and reduction

(Total for Question 14 = 1 mark)

15 When iodomethane, CH_3I, is heated in a sealed tube with an excess of alcoholic ammonia, which of the following **cannot** be formed?

☒ **A** Methylamine, CH_3NH_2

☒ **B** Ethylamine, $CH_3CH_2NH_2$

☒ **C** Dimethylamine, $(CH_3)_2NH$

☒ **D** Ammonium iodide, NH_4I

(Total for Question 15 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

P 3 8 4 7 9 A 0 6 2 0
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16 The enthalpy change of neutralization of an acid by an alkali is measured by adding 10.0 cm^3 of hydrochloric acid to 10.0 cm^3 of sodium hydroxide. 10.0 cm^3 pipettes with an accuracy of ±0.04 cm^3 are used to measure out both solutions.

The overall percentage error in measuring the total volume of the reaction mixture is

☒ **A** ±0.04%

☒ **B** ±0.08%

☒ **C** ±0.4%

☒ **D** ±4.0%

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

17 This question is about the element chlorine and its compounds.

(a) When chlorine is bubbled through water, a solution of chlorine water forms. What is the colour of chlorine water?

(1)

.....

(b) Chlorine water is added to potassium iodide solution.

(i) State the colour of the solution produced.

(1)

.....

(ii) Write the **ionic** equation for the reaction, including state symbols.

(2)

(c) The concentration of chlorine water was found by taking 10.0 cm^3 of solution, adding an excess of potassium iodide solution, and titrating with 0.0100 mol dm^{-3} of sodium thiosulfate solution. The experiment was repeated.

The following results were obtained.

Titration number	1	2
Final burette reading / cm^3	38.60	47.60
Initial burette reading / cm^3	29.50	38.60
Volume added / cm^3	9.10	9.00

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(i) Name a suitable indicator for the titration. State the colour change you would expect to see at the end point.

(2)

Indicator .....

Colour change from ..... to .....

(ii) Calculate the mean titre and use this value to calculate the number of moles of sodium thiosulfate used in the titration.

(1)

Mean titre = ... cm^3

Moles of sodium thiosulfate

(iii) Complete the ionic equation for the reaction between iodine and thiosulfate ions.

(2)

$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow$

(iv) Calculate the number of moles of iodine which reacted with the sodium thiosulfate solution.

(1)

(v) Hence state the number of moles of chlorine present in 10.0 cm^3 of the chlorine water.

(1)

(vi) Calculate the concentration of the chlorine water, in mol dm^{-3}.

(1)

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(d) Potassium burns in chlorine to form potassium chloride.

(i) Give the colour of the flame when potassium burns in chlorine.

(1)

.....

(ii) Write the equation for the reaction between potassium and chlorine. State symbols are **not** required.

(1)

(e) Concentrated sulfuric acid is added to potassium chloride in a test tube. Steamy fumes are given off which react with ammonia to give dense white smoke.

(i) Name the gas given off in this reaction.

(1)

.....

(ii) Steamy fumes are observed at the mouth of the test tube. Explain how these fumes are formed.

(1)

.....

.....

(iii) The steamy fumes react with ammonia to give a dense white smoke. Identify the white smoke by name or formula.

(1)

.....

(f) 2-chlorobutane can be made from butan-2-ol.

(i) Name the chemical you would add to butan-2-ol in the laboratory to make 2-chlorobutane.

(1)

.....

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(ii) 2-chlorobutane reacts with alcoholic potassium hydroxide at a high temperature to form a mixture of gaseous alkenes.

Draw a fully labelled diagram of the apparatus you would use to prepare and collect this mixture.

(3)

(Total for Question 17 = 21 marks)

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18 This question is about ethanethiol, CH_3CH_2SH. Thiols are like alcohols, but the oxygen atom has been replaced by a sulfur atom. They react in a similar way to alcohols.

(a) (i) Draw a dot and cross diagram for ethanethiol, showing outer electrons only.

(2)

(ii) Give the value for the CSH bond angle in ethanethiol. Justify your answer.

(3)

CSH angle .....

Justification .....

.....

.....

.....

(b) There are hydrogen bonds between ethanol molecules but not between ethanethiol molecules.

(i) Explain why the bond angle around the hydrogen atom involved in a hydrogen bond is 180°.

(2)

.....

.....

.....

.....

(ii) Explain why there are no hydrogen bonds between ethanethiol molecules.

(1)

.....

.....

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(c) (i) Describe the formation of London forces.

(2)

(ii) Explain why the London forces in ethanethiol are stronger than those in ethanol.

(1)

(d) The reaction of sodium with ethanethiol, CH_3CH_2SH, is similar to its reaction with ethanol.

(i) Suggest one observation you would make when sodium is added to ethanethiol.

(1)

(ii) Suggest a balanced equation for this reaction. State symbols are **not** required.

(1)

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(e) Ethanol can be made from bromoethane by reaction with aqueous potassium hydroxide, KOH(aq), under suitable conditions.

(i) Write the equation for this reaction. State symbols are **not** required.

(1)

(ii) State the type and mechanism of this reaction.

(2)

Type .....

Mechanism .....

(iii) Suggest the formula of a suitable chemical to make ethanethiol from bromoethane.

(1)

.....

(f) When ethanethiol undergoes complete combustion in air, a gas is produced which is not formed on the complete combustion of ethanol. Identify the gas and suggest why it is damaging to the environment.

(2)

.....

.....

.....

.....

(Total for Question 18 = 19 marks)

TOTAL FOR SECTION B = 40 MARKS

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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

19 This question is about nitrogen monoxide, NO, which can be described both as a friend and a foe.

Chemists have discovered that nitrogen monoxide plays an important role in the body by dilating blood vessels. If someone is suffering from blood circulatory or heart problems, a chemical may be given which will quickly break down to give nitrogen monoxide. Years ago, nitroglycerine was used for this purpose. Interestingly, the same chemical Nobel had used to make dynamite was used to treat him in old age.

In the laboratory, nitrogen monoxide can be prepared by adding concentrated nitric acid to powdered silver. Nitrogen monoxide is a colourless gas which is partially soluble in water. It is difficult to detect its smell, because it reacts with oxygen in the air to form pungent-smelling nitrogen dioxide.

Nitrogen monoxide is formed when a mixture of air and oxygen is heated to a high temperature. This reaction occurs in the engines of cars and aeroplanes. Nitrogen monoxide has a disastrous effect on the ozone layer because it is a free radical. Nitrogen monoxide is also a greenhouse gas.

(a) (i) What is meant by the term **free radical**?

(1)

.....

.....

(ii) Suggest a dot and cross diagram for nitrogen monoxide, showing outer shell electrons only, remembering that it is a free radical.

(2)

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(b) (i) **Part** of the **unbalanced** equation for the preparation of nitrogen monoxide from nitric acid is shown below.

$$Ag(s) + HNO_3(aq) \rightarrow NO(g) + AgNO_3(aq)$$

Identify the elements which are oxidized and reduced and give their oxidation numbers.

(3)

Element oxidized .....

Oxidation number initial ..... final .....

Element reduced .....

Oxidation number initial ..... final .....

(ii) Complete and balance the equation for the reaction between silver and nitric acid.

(2)

.....$Ag(s)$ + ...$HNO_3(aq)$ → $NO(g)$ + ...$AgNO_3(aq)$ + ...

(c) The reaction between nitrogen and oxygen to form nitrogen monoxide reaches equilibrium.

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g) \qquad \Delta H^{\ominus} = +180.4 \text{ kJ mol}^{-1}$$

(i) Explain why the yield of nitrogen monoxide is increased when the temperature is increased.

(1)

.....

.....

*(ii) State and explain the effect, if any, on the yield of nitrogen monoxide when the pressure is increased.

(2)

.....

.....

.....

.....

.....

.....

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(iii) State and explain how the rate of the reaction is affected by an increase in pressure.

(2)

*(d) (i) Explain why a jet aeroplane in flight causes much more damage to the ozone layer than cars carrying the same number of passengers at sea level. You should assume that the nitrogen monoxide outputs for both methods of conveying the passengers are the same.

(2)

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(ii) The reactions of chlorine free radicals with ozone may be represented by the following equations.

$$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$$

$$ClO\bullet + O_3 \rightarrow Cl\bullet + 2O_2$$

Write corresponding equations for the reactions of the free radical nitrogen monoxide with ozone. Combine your two equations to show the overall reaction.

Use these equations to explain why a small quantity of nitrogen monoxide can have a continuing effect on the ozone layer.

(5)

Equations

Explanation .....

.....

.....

.....

.....

.....

(Total for Question 19 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

June 2011

GCE Chemistry (6CH02) Paper 01 Application of Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	C	**1**

Question Number	Correct Answer	Mark
2 (a)	B	**1**

Question Number	Correct Answer	Mark
2 (b)	C	**1**

Question Number	Correct Answer	Mark
2 (c)	D	**1**

Question Number	Correct Answer	Mark
3	C	**1**

Question Number	Correct Answer	Mark
4	B	**1**

Question Number	Correct Answer	Mark
5	B	**1**

Question Number	Correct Answer	Mark
6	A	**1**

Question Number	Correct Answer	Mark
7	D	**1**

Question Number	Correct Answer	Mark
8	A	**1**

Question Number	Correct Answer	Mark
9	A	**1**

Question Number	Correct Answer	Mark
10	D	**1**

Question Number	Correct Answer	Mark
11	C	**1**

Question Number	Correct Answer	Mark
12 (a)	B	**1**

Question Number	Correct Answer	Mark
12 (b)	C	**1**

Question Number	Correct Answer	Mark
12 (c)	D	**1**

Question Number	Correct Answer	Mark
13	A	**1**

Question Number	Correct Answer	Mark
14	D	**1**

Question Number	Correct Answer	Mark
15	B	**1**

Question Number	Correct Answer	Mark
16	C	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17 (a)	**Pale / light and green / yellow** Allow (virtually) colourless	clear yellow green any other colour	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(i)	Red/brown (solution) Allow yellow Ignore (From….) to….	Purple (or in combination with red or brown) Pale yellow Orange (or in combination with red or brown) Reject any other colours alone or in combination Grey/black (or any other colour alone or in combination) solid	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(ii)	$Cl_2(aq) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(aq)/(s)$ Entities **(1)** Balancing **and** all four state symbols Dependent on correct entities **(1)** $Cl_2(aq) + 2KI(aq) \rightarrow 2KCl(aq) + I_2(aq)/(s)$ 1 max $K^+(aq)$ on both sides of otherwise correct equation 1 max		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(i)	Starch **(1)** Blue/black to colourless Dependent on starch indicator **(1)** Accept: no indicator needed **(1)** Yellow to colourless **(1)** Blank for indicator and yellow to colourless 1max	Any other indicator e.g. methyl orange/ phenolphthalein = 0/2 Colourless to blue/black Blue/black to clear Any mention of purple	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(ii)	(ii) – (vi) General comments: Allow correct answers with no working in all parts N.B. Mark each part to mark scheme answer first then allow TE from earlier parts. Minimum correct to 2SF. Penalise SF for 1SF once only. But incorrect rounding e.g. 4.525 to 4.52 is penalised once separately as well. Penalise wrong units once only as well. (Mean titre = 9.05) $\frac{9.05 \times 0.01}{1000}$ $= 9.05 \times 10^{-5}$ /0.0000905(mol) Allow 9.1×10^{-5}/0.000091(mol)	$9.(0) \times 10^{-5}$ / 0.00009(0)	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(iii)	$(I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow)$ $\mathbf{2I^-}((aq)) + \mathbf{S_4O_6^{2-}}((aq))$ **(1) (1)** Marks stand alone for entities with balancing Either of these on their own scores 1 mark regardless of anything else that is written Multiples/fractions of equation allowed Ignore state symbols even if incorrect		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(iv)	$\frac{9.05 \times 10^{-5}}{2}$ $= 4.525 \times 10^{-5}$ /0.00004525(mol) Allow 4.53×10^{-5} /0.0000453 etc Allow TE $\frac{\text{ans (ii)}}{2}$ Accept TE from (iii) if you see it		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(v)	4.525×10^{-5} /0.00004525 (mol) Allow TE = ans (iv) [Allow 'ans (iv)' with no numbers for this part only]		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(vi)	$4.525 \times 10^{-5} \times \frac{1000}{10}$ = 4.525/4.53 x 10^{-3} /0.004525/0.00453 (mol dm^{-3}) Accept TE ans (v) x 100 [a calculated number must be given]		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (d)(i)	Lilac Allow (light) purple or mauve	Violet Reject any other colours alone or in combination	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (d)(ii)	$2K + Cl_2 \rightarrow 2KCl$ Accept multiples/fractions Ignore state symbols even if incorrect Ignore correct charges on ions in KCl	K_2 and/or KCl_2 Charges on reactants K and/or Cl_2	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (e)(i)	Hydrogen chloride This may be accompanied by HCl	Hydrochloric acid HCl /HCl(g)/HCl (gas) alone SO_2 H_2S Anything else	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (e)(ii)	Dissolves in moisture/water/water vapour (in the air) **Or** reacts with moisture/water/water vapour (in the air)	HCl condenses	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (e)(iii)	NH_4Cl / Ammonium chloride/ $ClNH_4$ $NH_4^+Cl^-$ / $H_4N^+Cl^-$/ $Cl^-NH_4^+$ Ignore any states even if incorrect	Ammonia chloride / NH_3Cl	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (f)(i)	Any one of: Phosphorus(V) chloride/pentachloride Phosphorus(III) chloride/trichloride Allow (III/V) anywhere **Conc**entrated hydrochloric acid Hydrogen chloride (gas) Sodium/potassium chloride and **conc**entrated sulfuric acid Thionyl chloride Allow correct formula(e) for all above But note: **conc** HCl /**conc** H_2SO_4	Phosphorus chloride Hydrochloric acid/HCl/ HCl(aq) Chlorine	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (f)(ii)	Be generous here Horizontal test tube with ceramic fibre/ any sort of wool except iron **(1)** soaked in 2-chlorobutane and (alcoholic) potassium hydroxide/reactants/ reagents/ chemicals/reaction mixture… …with **heat** (or any diagram of a heat source or the word heat) **(1)** OR Round bottom/pear shaped flask/sloping test/boiling tube and **heat** (or any diagram of a heat source or the word heat) **(1)** containing 2-chlorobutane and (alcoholic) potassium hydroxide/reactants/ reagents/ chemicals/reaction mixture **(1)** Ignore: any use of aluminium oxide/pumice reflux/distillation set up Gas collection over water **(1)** Ignore Bunsen valves Allow: Collection in a gas syringe Note: This does not constitute a sealed apparatus	Sealed apparatus but ignore inadvertent closures owing to poor cross-sectional drawings (-1) Poor diagram e.g. clear air gaps at intermediate joints in the apparatus(-1) Solution/substances alone An arrow on its own Conical/flat bottomed flask N.B. contradiction between drawing and any label Solution/substances alone A poor diagram mark (which can be the second) should be deducted for the delivery tube through the side of trough and/or the delivery tube missing the collection tube.	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (a)(i)	H H .x .x xx H.xC.xC.xSx.H .x .x xx H H **All** Bonding electrons **(1)** Ignore any circles/bonds with electrons Two lone pairs on sulfur Dependent on eight electrons around sulfur **(1)** Accept all dots/crosses Fully correct methanethiol 1max	missing Hs/Cs (-1)	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	104.5 (^{o}) (accept 91 to 105)**(1)** (Four pairs/two bonding pairs and two non-bonding pairs of electrons in) **minimum repulsion / maximum separation / as far apart as possible** (tetrahedral arrangement) Ignore the number of pairs of electrons **(1)** And **lone / non bonding pair(s)** of electrons **repel more** (than bond pairs/CH bonds) **(1)** Mark independently	atoms… Linear shape (-1) …repel any sort of atoms	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (b)(i)	**Two** pairs of electrons/**two** bonds (around the H atom) OR Can be shown on a diagram either with electrons or bonds (in approximate straight line) around the hydrogen **(1)** (Repel to) maximum separation/minimum repulsion/as far apart as possible **(1)** Dependent on first mark except: Allow: It has a **linear** shape due to maximum separation/minimum repulsion 1 max	Linear shape on its own	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (b)(ii)	Sulfur is less electronegative (than oxygen)/not electronegative enough OR oxygen is more electronegative (than sulfur) / electronegative enough OR Hydrogen bonds can only occur between H and either N, O, or F **due to the large difference in electronegativity**	Bigger/higher rmm/ atom/molecule alone Hydrogen not bonded to N, O, or F alone	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(i)	Temporary asymmetrical distribution/ random arrangement of electrons/ charge (density) Ignore references to atoms/molecules OR instantaneous/temporary dipole **(1)** (these produce) induced dipoles OR description of induction **(1)** Mark independently Ignore references to atoms/molecules	Any mention of permanent dipoles = 0/2 d+ and d- /∂+ and ∂- unless clearly temporary	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	Ethanethiol/sulfur has more electrons (so forces are stronger) Allow sulfur has an extra shell **of electrons** OR ethanol/oxygen has fewer/less electrons (so forces are weaker) Allow oxygen has one fewer shell **of electrons**	Larger charge cloud/ larger electron cloud/ more outer electrons on their own Any reference to size/radius/rmm unless with correct answer	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (d)(i)	Any one from: Bubbles (of gas) /fizzing /effervescence Sodium disappears/dissolves/gets smaller White solid forms Multiple answers: number correct minus number wrong to give a maximum of 1 and a minimum of 0 Ignore: sodium floats or sinks and/or heat given out and/or hydrogen produced	Sodium rushes about (i.e. any confusion with reaction of sodium with water) Flames Steam	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (d)(ii)	$Na + CH_3CH_2SH \rightarrow CH_3CH_2SNa + ½H_2$ Accept multiples Ignore charges on sodium salt/state symbols even if incorrect	H for hydrogen CH_3CH_2NaS	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (e)(i)	$C_2H_5Br + KOH \rightarrow C_2H_5OH + KBr / K^+ + Br^-$ Accept ionic equation $C_2H_5Br + OH^- \rightarrow C_2H_5OH + Br^-$ Allow molecular formula of alcohol, C_2H_6O		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (e)(ii)	Type – substitution **(1)** Mechanism – Nucleophilic **(1)** Accept words in either order. Both words may be given on either line. N.B. This is the **only** way to score 2 marks!		**2**

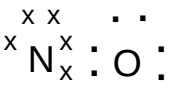
Question Number	Acceptable Answers	Reject	Mark
18 (e)(iii)	KSH /NaSH Allow KHS/NaHS or H_2S Ignore state symbols		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (f)	Sulfur dioxide/SO_2 **(1)** Causes acid rain **(1)** Allow effects of acid rain e.g. acid lakes/lake pollution/ crop or forest damage/**limestone** building damage/**named metal** which corrodes. [It is quite possible candidates will give details of oxidation of sulfur dioxide to sulfur trioxide and formation of sulfuric acid. Ignore any of this additional information.] Allow triggers asthma Ignore any reference to greenhouse gas/ global warming/any reference to sea pollution or sea creatures Second mark dependent on first mark except allow: If SO_2 not mentioned then, SO_3/H_2SO_4 causes acid rain for 1 mark	SO_3 CO_2 Attacks ozone layer CO_2 causes acid rain	**2**

TOTAL FOR SECTION B = 40 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	An atom/ molecule (or ion)/species/entity with an unpaired electron Ignore any references to homolytic bond fission but penalise a reference to heterolytic bond fission	Lone/single/free electron with unpaired electron**s** A free radical is an unpaired electron	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	 Double bond **(1)** Other electrons correct Dependent on double bond **(1)** Allow: all dots or all crosses or any combination	N single bond O Reject unpaired electron on oxygen	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	Wherever it appears in the answer: Ag/silver (oxidized) 0 to +1/1+ **(1)** Wherever it appears in the answer: N/Nitrogen = +5/5+ **(1)** (Element reduced) **N / nitrogen** … to +2/2+ **(1)** N.B. Some candidates give …+2/2+ and +5/5+ which is correct for both nitrogen products Only penalise no positive charges once		**3**

Question Number	Acceptable Answers	Reject	Mark
***19 (b)(ii)**	$3Ag(s) + 4HNO_3(aq) \rightarrow NO(g) + 3AgNO_3(aq) + 2H_2O(l)$ 3Ag reacting to form NO and $3AgNO_3$ **(1)** $4HNO_3$ and $2H_2O$ **(1)** mark independently of (b)(i) No TE from (b)(i)		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	The reaction is **endothermic** (so goes to remove heat/lower the temperature) Allow ***ΔH* is positive** (so goes to remove heat/lower the temperature)	Reaction/equilibrium moves to the right/to oppose change without any other statement	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	The yield is not changed OR No change OR no effect on the equilibrium **(1)** as there is no change in the number of (moles of) (gaseous) **molecules** OR as there is no change in the number of (gaseous) moles/particles **(1)** Allow: cylinder surface acts as catalyst **(1)** And all sites are filled so pressure has no affect **(1)** Second mark dependent on first in both cases Ignore any comment on rate whether correct or not	Reference to atoms or ions instead of molecules	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(iii)	**Rate increases because** (increase in pressure) means more particles per unit volume/less space for molecules/molecules closer together/greater or increased concentration **(1)** Comment: A correct statement of why the rate increases is needed with **rate increases** (somewhere in the answer) for the first mark which increases the frequency / increases the number of collisions/more chance of (successful) collisions (between molecules) **(1)** Ignore any references to (activation/kinetic) energy Mark independently	more particles per unit area Reference to atoms or ions instead of molecules	**2**

Question Number	Acceptable Answers	Reject	Mark
***19 (d)(i)**	Jet aeroplanes fly (much) close(r)/near(er) to the ozone (layer)/ stratosphere (so more NO to deplete ozone layer) **(1)** ALLOW: Jet aeroplanes fly in the ozone (layer)/ stratosphere Some NO from cars reacts (e.g. with O_2 to give NO_2) OR NO from planes does not react before it can react with the ozone **(1)** Mark independently	Anything else e.g. aeroplanes fly in the ionosphere NO absorbed by plants NO from cars dissociates/ decomposes/break down NO from planes does not dissociate/decompose/break down NO from cars takes a long time to reach the ozone layer NO dissolves	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (d)(ii)	Comment: Please underline Key Points with highlighter, or annotate with tick at Key Point, or annotate with Key Point number from mark scheme wherever mark awarded. This ensures that it is easy to count up marks for this part. **KP1** $NO(\bullet) + O_3 \rightarrow (\bullet)NO_2 + O_2$ **(1)** Comment: Dots are not required for KP1 **KP2** $\bullet NO_2 + O_3 \rightarrow NO\bullet + 2O_2$ **(1)** Comment: Dots can be on either side of both free radicals ALLOW for KP2: $O_3 \rightarrow O\bullet + O_2$ $\bullet NO_2 + O\bullet \rightarrow NO\bullet + O_2$ **N.B. Both** equations required here The overall equation is: **KP3** $2O_3 \rightarrow 3O_2$ **(1)** ALLOW: equilibrium arrow This mark is independent of KP1 and KP2 **KP4** NO/the free radical (Allow Cl•) is regenerated/a catalyst or wtte **(1)** **KP5** and one molecule can break down large numbers of ozone molecules OR NO (Allow Cl•) continues to react (with ozone)/reaction is continuous OR Mention of chain reaction **(1)** Ignore any reference to global warming **as an additional problem** KP4 and 5 marks are independent	Overall equation with nothing cancelled If Cl^- is referred to as the radical then neither KP4 nor KP5 can be gained If the candidate makes clear that any of these **processes lead to** global warming loses KP4 or 5 but not both.	**5**

TOTAL FOR SECTION C = 20 MARKS

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Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Thursday 20 January 2011 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/5/2/

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The equation for the reaction between limewater and hydrochloric acid, including state symbols, is

☒ **A** $CaOH(s) + HCl(aq) \rightarrow CaCl(aq) + H_2O(l)$

☒ **B** $Ca(OH)_2(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(aq)$

☒ **C** $CaOH(aq) + HCl(aq) \rightarrow CaCl(aq) + H_2O(aq)$

☒ **D** $Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$

(Total for Question 1 = 1 mark)

---

2 As you go down Group 2 of the Periodic Table, which of the following decreases?

☒ **A** The reactivity of the elements.

☒ **B** The solubility of the hydroxides of the elements.

☒ **C** The solubility of the sulfates of the elements.

☒ **D** The thermal stability of the carbonates of the elements.

(Total for Question 2 = 1 mark)

---

3 Which concentrated acid would be best for mixing with a salt to carry out a flame test?

☒ **A** Hydrochloric acid

☒ **B** Nitric acid

☒ **C** Phosphoric(V) acid

☒ **D** Sulfuric acid

(Total for Question 3 = 1 mark)

---

4 The flame produced by a compound containing barium in a flame test is

☒ **A** colourless.

☒ **B** green.

☒ **C** red.

☒ **D** yellow.

(Total for Question 4 = 1 mark)

N 3 7 9 6 3 A 0 2 2 4
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5 Which of the following is a greenhouse gas?

☒ **A** Argon

☒ **B** Nitrogen

☒ **C** Oxygen

☒ **D** Water vapour

(Total for Question 5 = 1 mark)

---

6 For parts (a) and (b), use your knowledge of intermolecular forces to predict the compound with the highest boiling temperature.

(a) ☒ **A** HF

☒ **B** H_2O

☒ **C** NH_3

☒ **D** CH_4

(1)

(b) ☒ **A** 1-iodobutane

☒ **B** 1-chlorobutane

☒ **C** 2-methyl-2-iodopropane

☒ **D** 2-methyl-2-chloropropane

(1)

(Total for Question 6 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

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7 Consider the following organic liquids:

A ethanal

B ethanol

C tetrachloromethane

D trichloromethane

(a) Each liquid is run from a burette. Which liquid would **not** be deflected significantly by a charged rod?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which liquid would react with phosphorus(V) chloride to give a gas which fumes in moist air?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which liquid would you expect to have the peak at the greatest mass/charge ratio in its mass spectrum?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) Which liquid has an infrared spectrum with a broad absorption due to hydrogen bonding?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 7 = 4 marks)

N 3 7 9 6 3 A 0 4 2 4
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8 Which of the following best defines the meaning of the term **anthropogenic** change?

It is a change caused by

☒ **A** nature.

☒ **B** plants.

☒ **C** animals.

☒ **D** humans.

(Total for Question 8 = 1 mark)

9 Which of the following equations represents the change when concentrated sulfuric acid is added to solid potassium chloride at room temperature?

☒ **A** $8KCl + 5H_2SO_4 \rightarrow 4K_2SO_4 + H_2S + 4Cl_2 + 4H_2O$

☒ **B** $2KCl + 3H_2SO_4 \rightarrow 2KHSO_4 + SO_2 + Cl_2 + 2H_2O$

☒ **C** $6KCl + 4H_2SO_4 \rightarrow 3K_2SO_4 + S + 3Cl_2 + 4H_2O$

☒ **D** $KCl + H_2SO_4 \rightarrow KHSO_4 + HCl$

(Total for Question 9 = 1 mark)

10 The Maxwell-Boltzmann distribution of molecular energies is useful for explaining why increasing temperature affects the rate of a chemical reaction.

(a) Which of the following statements describes how the shape of the Maxwell-Boltzmann distribution curve changes as temperature increases?

(1)

☒ **A** The peak decreases in height and moves to the left.

☒ **B** The peak increases in height and moves to the left.

☒ **C** The peak decreases in height and moves to the right.

☒ **D** The peak increases in height and moves to the right.

(b) The **main** reason that reaction rates increase with temperature is that

(1)

☒ **A** all the molecules move faster.

☒ **B** all the molecules collide more frequently.

☒ **C** more molecules collide with the correct orientation.

☒ **D** a larger proportion of molecules have high energies.

(Total for Question 10 = 2 marks)

11 Four organic reactions are given below:

A $CH_3CH_3 \rightarrow CH_2{=}CH_2 + H_2$

B $nCH_2{=}CH_2 \rightarrow -(-CH_2{-}CH_2-)_n-$

C $CH_2{=}CH_2 + HBr \rightarrow CH_3CH_2Br$

D $CH_3CH_2Br + H_2O \rightarrow CH_3CH_2OH + HBr$

(a) Which reaction is a substitution reaction?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which reaction is an electrophilic addition reaction?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which reaction involves initial attack by a nucleophile?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) Which reaction requires an initiator?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 11 = 4 marks)

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12 Which of the following statements is true?

- ☒ **A** CFCs and nitrogen monoxide, NO, are involved in the depletion of the ozone layer.
- ☒ **B** CFCs act as catalysts for the depletion of the ozone layer, while nitrogen monoxide, NO, does not.
- ☒ **C** CFCs and ozone are free radicals.
- ☒ **D** CFCs and nitrogen monoxide, NO, are decomposed by UV radiation.

(Total for Question 12 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

13 This question is about iodine and its compounds.

(a) (i) The element iodine can be obtained from seaweed. One step in the procedure is to extract the iodine from aqueous solution by shaking with a hydrocarbon solvent in a separating funnel.

Draw a diagram of a separating funnel containing the separated layers. Label the hydrocarbon layer, and state its colour.

[Density of hydrocarbon layer 0.660 g cm^{-3}]

(3)

Diagram

Colour of hydrocarbon layer .....

(ii) Iodine is also formed when an aqueous solution containing iodide ions reacts with an aqueous solution of iron(III) ions.

Write the ionic equation for this reaction. State symbols are **not** required.

(1)

N 3 7 9 6 3 A 0 9 2 4
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(b) Hydrogen iodide gas is usually prepared by adding phosphoric(V) acid to solid potassium iodide.

(i) Suggest why phosphoric(V) acid is used in this preparation rather than concentrated sulfuric acid.

(1)

.....

.....

.....

(ii) Describe what you would see if a test tube of hydrogen iodide gas was inverted in a beaker of water.

(1)

.....

.....

(iii) When hydrogen iodide gas reacts with ammonia, dense white fumes form. Write the equation for this reaction, including state symbols.

(2)

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(c) 1-iodobutane can be made by reacting butan-1-ol with phosphorus(III) iodide, PI_3, formed by reacting moist red phosphorus with iodine.

(i) Complete the following equation for the formation of 1-iodobutane.

(1)

PI_3 + ... $C_4H_9OH \rightarrow$

(ii) Identify the intermolecular forces present between molecules of 1-iodobutane.

(1)

.....

.....

.....

(iii) 1-iodobutane reacts with hot aqueous silver nitrate solution. Describe what you would see when this reaction takes place.

(1)

.....

(iv) Give the structural formula for the organic product of the reaction between 1-iodobutane and ammonia.

(1)

(Total for Question 13 = 12 marks)

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N 3 7 9 6 3 A 0 1 2 2 4
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14 This question is about methanol, CH_3OH, and ethanol, CH_3CH_2OH.

(a) (i) Draw a dot and cross diagram for **methanol**, showing outer electrons only.

(1)

(ii) Give the approximate values for the HCH and COH bond angles in methanol. Justify your answers.

(4)

HCH angle .....

Justification .....

.....

.....

COH angle .....

Justification .....

.....

.....

(iii) Using displayed formulae, draw a diagram to show a hydrogen bond between two methanol molecules. On your diagram, show the bond angle around the hydrogen atom of the hydrogen bond and give its value.

(2)

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(b) Methanol reacts with sodium.

(i) State what you would observe in this reaction.

(2)

.....

.....

(ii) Write the equation for this reaction. State symbols are **not** required.

(1)

(c) **Ethanol** can be used to make ethanal.

(i) Identify, by name or formula, the two chemicals you would use to make ethanal from ethanol in the laboratory.

(2)

.....

.....

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(ii) Draw a diagram of the apparatus you would use to prepare ethanal from ethanol in the laboratory and collect the product.

(2)

(iii) Both ethanal and propane have a molar mass of 44 g mol^{-1}, but their boiling temperatures are different.

Suggest which substance has the higher boiling temperature. Justify your answer by comparing the intermolecular forces in each compound.

(2)

.....

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.....

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(Total for Question 14 = 16 marks)

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15 The ingredients list on the label of a commercial indigestion remedy states that each tablet contains 680 mg of calcium carbonate.

To check this, the following experiment was carried out.

One tablet was crushed. 50.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid, an excess, was then added and the mixture was transferred to a volumetric flask. The volume was made up to exactly 100 cm^3 with distilled water. 10.0 cm^3 of this solution was titrated with 0.300 mol dm^{-3} sodium hydroxide solution. The following results were obtained.

Run	Rough	1	2
Final burette reading / cm^3	21.80	33.20	44.40
Initial burette reading / cm^3	10.00	21.80	33.20
Volume added / cm^3	11.80	11.40	11.20

(a) (i) What should be used to crush the tablet?

(1)

.....

(ii) Name a suitable indicator for the titration. State the colour change you would expect to see.

(2)

Indicator .....

Colour change from ..... to .....

N 3 7 9 6 3 A 0 1 7 2 4
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(b) (i) Select appropriate readings and calculate the mean titre.

(1)

(ii) Calculate the number of moles of sodium hydroxide used.

(1)

(iii) Use your answer to (ii) to write down the number of moles of hydrochloric acid left in 10.0 cm^3 of the solution used in the titration.

(1)

(iv) Calculate the number of moles of hydrochloric acid left in 100 cm^3 of solution.

(1)

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(v) 50.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid contains 0.0500 mol of hydrochloric acid.

Use this and your answer to (iv) to calculate the number of moles of hydrochloric acid that reacted with the indigestion tablet.

(1)

(vi) The equation for the reaction between hydrochloric acid and calcium carbonate is:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

Use this, and your answer to (v), to calculate the number of moles of calcium carbonate in one tablet.

(1)

(vii) Calculate the mass of calcium carbonate in one tablet.

[Assume that the molar mass of $CaCO_3$ is 100 g mol^{-1}]

(1)

(viii) Suggest a reason, other than experimental error, why your value differs from the value given on the label.

(1)

.....

.....

.....

.....

(Total for Question 15 = 11 marks)

TOTAL FOR SECTION B = 39 MARKS

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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

16 This question is about some reactions which can be used in the manufacture of hydrogen.

Reaction 1 uses two naturally occurring chemicals, water and natural gas. Steam is reacted with methane to form carbon monoxide and hydrogen in an equilibrium reaction.

Reaction 1 $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$ $\Delta H = +210 \text{ kJ mol}^{-1}$

In reaction 2, carbon monoxide and steam are passed over copper at high temperature. This forms carbon dioxide and hydrogen.

Reaction 2 $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

The carbon dioxide formed is removed by passing it through potassium carbonate solution in reaction 3.

Reaction 3 $K_2CO_3(aq) + CO_2(g) + H_2O(l) \rightarrow 2KHCO_3(aq)$

The potassium carbonate is regenerated by heating the potassium hydrogencarbonate solution in reaction 4. The carbon dioxide gas produced is released into the atmosphere.

Reaction 4 $2KHCO_3(aq) \rightarrow K_2CO_3(aq) + CO_2(g) + H_2O(l)$

(a) For each of the first three reactions, state the initial and final oxidation numbers of any elements that change their oxidation numbers. Hence decide which are redox reactions.

(5)

Reaction 1 .....

.....

.....

Reaction 2 .....

.....

.....

Reaction 3 .....

.....

.....

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*(b) (i) Discuss, with reasons, the conditions of temperature and pressure that would favour the production of hydrogen in **reaction 1**. You should consider the effect of the conditions on both yield and rate.

(7)

(ii) Excess steam is used in **reaction 1**. State why an excess of a reagent is used and suggest why steam, rather than methane, is chosen.

(2)

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(c) Copper is a catalyst in **reaction 2**. Explain how a catalyst increases the rate of a reaction.

(2)

(d) (i) State **one** economic advantage of **reaction 4**.

(1)

*(ii) **Reaction 4** contributes to global warming. Identify the substance formed in this reaction which is likely to be responsible and explain the processes that lead to an increase in global temperatures.

Suggest **two** effects an increase in global temperatures might have on the environment.

(4)

(Total for Question 16 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)
January 2011

GCE

GCE Chemistry (6CH02/01)

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Section A (multiple choice)

Question Number	Correct Answer	Mark
1	D	**1**

Question Number	Correct Answer	Mark
2	C	**1**

Question Number	Correct Answer	Mark
3	A	**1**

Question Number	Correct Answer	Mark
4	B	**1**

Question Number	Correct Answer	Mark
5	D	**1**

Question Number	Correct Answer	Mark
6 (a)	B	**1**

Question Number	Correct Answer	Mark
6 (b)	A	**1**

Question Number	Correct Answer	Mark
7 (a)	C	**1**

Question Number	Correct Answer	Mark
7 (b)	B	**1**

Question Number	Correct Answer	Mark
7 (c)	C	**1**

Question Number	Correct Answer	Mark
7 (d)	B	**1**

Question Number	Correct Answer	Mark
8	D	**1**

Question Number	Correct Answer	Mark
9	D	**1**

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Question Number	Correct Answer	Mark
10 (a)	C	**1**

Question Number	Correct Answer	Mark
10 (b)	D	**1**

Question Number	Correct Answer	Mark
11 (a)	D	**1**

Question Number	Correct Answer	Mark
11 (b)	C	**1**

Question Number	Correct Answer	Mark
11 (c)	D	**1**

Question Number	Correct Answer	Mark
11 (d)	B	**1**

Question Number	Correct Answer	Mark
12	A	**1**

TOTAL FOR SECTION A = 20 MARKS

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Section B

Question Number	Acceptable Answers	Reject	Mark
13 (a) (i)	Each mark is independent Diagram of separating funnel with tap. Sides can be straight or bulbous. Top can be stoppered or unstoppered, but not sealed (eg inverted test-tube with tap at bottom). **(1)** Allow straight sides with an open top Two layers. Upper layer is hydrocarbon layer **(1)** Colour – pink/purple/mauve. Allow violet **(1)**	 Filter funnel with tap Three layers Mention of any other colours on their own (e.g. grey, brown, red) or in combination with those accepted.	**3**

Question Number	Acceptable Answers	Reject	Mark
13 (a) (ii)	$2Fe^{3+} + 2I^{-} \rightarrow 2Fe^{2+} + I_2$ Ignore state symbols Allow multiples/half amounts shown Accept answers involving I_3^{-}	Formation of Fe^{+}	**1**

Question Number	Acceptable Answers	Reject	Mark
13 (b)(i)	Answers must refer to oxidation/reduction Sulfuric acid oxidizes (hydrogen/potassium) iodide (to iodine) OR (hydrogen) iodide reduces sulfuric acid OR Phosphoric((V)) acid does not oxidize (hydrogen) iodide (to iodine) (as well as sulfuric acid does) Allow sulfuric acid is a strong(er)/good oxidizing agent/phosphoric(V) acid is a weaker oxidizing agent	 Sulfuric acid oxidizes iodine/oxidizes iodide to iodide Phosphoric acid is a better reducing agent Comments about hazards or strength of sulfuric acid alone Stability of phosphoric(V) acid alone	**1**

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Question Number	Acceptable Answers	Reject	Mark
13 (b) (ii)	Water rises in the test tube Allow the gas /HI is soluble / dissolves	Steamy fumes Any coloured solutions forming even if with the acceptable/allowed answer Water would displace the gas	**1**

Question Number	Acceptable Answers	Reject	Mark
13 (b) (iii)	$NH_3(g)/(aq) + HI(g) \rightarrow NH_4I(s)$ Species and balanced equation **(1)** Allow $NH_4^+ + I^-$ for product All state symbols present (dependent on the entities above) **(1)**	NH_3I NH_3HI NIH_4	**2**

Question Number	Acceptable Answers	Reject	Mark
13 (c) (i)	$PI_3 + 3C_4H_9OH \rightarrow 3C_4H_9I + H_3PO_3$ Accept multiples Allow $P(OH)_3$, PH_3O_3, $H_2O + HPO_2$, as product/s		**1**

Question Number	Acceptable Answers	Reject	Mark
13 (c) (ii)	**Both points required** Van der Waals'/ London / dispersion / induced dipole / temporary dipole (forces) in 1-iodobutane Allow recognisable spelling of van der Waals' **and** (permanent) dipole dipole/permanent dipole (forces) Allow dipolar-dipolar	Any mention of hydrogen bonding (0)	**1**

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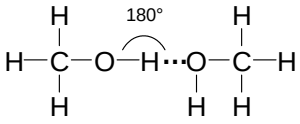
Question Number	Acceptable Answers	Reject	Mark
13 (c) (iii)	Yellow precipitate /ppt /ppte / solid The answer may appear with additional words and phrases: e.g. two clear colourless solutions form a yellow precipitate which is insoluble in concentrated ammonia solution Allow bright yellow, sunshine yellow Allow recognisable spelling eg yello percipitate	Off-white Cream Any other colours and combinations of yellow with any other colours Any other qualifications of yellow eg pale/light Any answers which include bubbles, fizzing, effervescence	**1**

Question Number	Acceptable Answers	Reject	Mark
13 (c) (iv)	$CH_3CH_2CH_2CH_2NH_2$ /$CH_3(CH_2)_3NH_2$ /$CH_2(NH_2)CH_2CH_2CH_3$ / $NH_2CH_2CH_2CH_2CH_3$ / $H_2NCH_2CH_2CH_2CH_3$ /$(CH_3CH_2CH_2CH_2)_2NH$ /$(CH_3CH_2CH_2CH_2)_3N$ Allow displayed and skeletal formulae, $C_4H_9NH_2$ Salts of amines which must include a positively charged ion and I^-	NH_4I NH_3 instead of NH_2 Three carbon chains Missing hydrogens $C_4H_{11}N$	**1**

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Question Number	Acceptable Answers	Reject	Mark
14 (a) (i)	H .x xx H.x C.x O .xH .x xx H Allow all dots / crosses, combinations of dots, crosses and other symbols like triangles Allow extra inner electrons around carbon and /or oxygen	Missing symbols Missing non-bonding electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
14 (a) (ii)	Each mark is independent of the next unless the bond angle is greater than 119 ^{o} 109 ^{o} / 109.5^{o} **(1)** **Minimum repulsion** / **maximum separation** (between four bond pairs of electrons / bonds) **(1)** 104^{o} – 105^{o} **(1)** (Two) lone pairs / non-bonding pairs (of electrons) repel more (than bonding pairs)/repel a lot **(1)**	Four bond pairs give tetrahedral shape	**4**

Question Number	Acceptable Answers	Reject	Mark
14 (a) (iii)	 Correct atoms in the hydrogen bond (O—H···O) **(1)** Allow CH_3 groups not displayed, correct ethanol formulae. Hydrogen bond can be shown as dots horizontal or vertical dashes. If it is a bond-like line it must be labelled. Second mark dependent on correct atoms involved. O-H...O in straight line (within small tolerance) and 180^{o} bond angle given in the correct place **(1)**	Hydrogen bond between methanol and water does not score	**2**

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Question Number	Acceptable Answers	Reject	Mark
14 (b) (i)	Any two from: Bubbles/ fizzing / effervescence (of gas) forming **(1)** Sodium /solid disappearing /dissolving (to form a clear colourless solution) **(1)** White solid /precipitate forming **(1)**	 Vigorous reaction White solution/fumes form Clear colourless solution forms alone	**2**

Question Number	Acceptable Answers	Reject	Mark
14 (b) (ii)	$CH_3OH + Na \rightarrow CH_3O^{(-)}Na^{(+)} + ½H_2$ Allow multiples, $NaOCH_3$ as product, ethanol as CH_3CH_2OH/C_2H_5OH with sodium ethoxide as product, Ignore state symbols and charges	Na^+ as reactant $CH_3O—Na$ CH_3NaO or $NaCH_3O$	**1**

Question Number	Acceptable Answers	Reject	Mark
14 (c) (i)	$Na_2Cr_2O_7$ / $K_2Cr_2O_7$ / Sodium / potassium dichromate((VI)) **(1)** Allow recognisable spelling of potassium and dichromate If name and formula given, both must be correct. H_2SO_4 / (Dilute / concentrated) sulfuric acid **(1)** Second mark dependent on recognisably correct oxidizing agent Allow acidified / H^+ and dichromate((VI)) / $Cr_2O_7^{2-}$ for 1 mark Allow potassium manganate((VII)) and **dilute** sulfuric acid for 1 mark	 Other oxidation numbers Potassium/sodium dichromate(VI) **ions** Other acids e.g. hydrochloric, nitric, phosphoric Other oxidation numbers	**2**

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Question Number	Acceptable Answers	Reject	Mark
14 (c) (ii)	Round-bottomed/pear shaped flask with **heat** Still head **(1)** Delivery tube and exit above/in (cooled) collection vessel **(1)** A condenser may be included Sealed apparatus (max. 1)	Reflux apparatus or reflux followed by distillation scores 0 Conical flask Open still head	**2**

Question Number	Acceptable Answers	Reject	Mark
14 (c) (iii)	**Mark independently** (Permanent) dipole dipole/permanent dipole (forces) in ethanal **(1)** **Ethanal higher** because both compounds have (similar) London /van der Waals'/etc forces OR no (permanent) dipole dipole /permanent dipole (forces) in propane OR propane (only) has London /van der Waals' /etc forces **(1)**	Ethanal has hydrogen bonds loses **first mark only**	**2**

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Question Number	Acceptable Answers	Reject	Mark
15 (a) (i)	Pestle (and mortar) / mortar and pestle Allow any recognisable spelling eg pessl, morta	Anything else, including hammer, mallet, heavy metal object, spatula, glass rod, crusher, grinder	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (a) (ii)	Methyl /methly orange **(1)** Red to orange / peach (allow yellow) **(1)** Accept other acid–base indicators eg phenolphthalein **(1)** Accept recognisable spelling for all acid-base indicators Correct colour change, the correct way round, to end point or beyond **(1)**	Litmus, Universal Indicator score 0/2	**2**

Question Number	Acceptable Answers	Reject	Mark
15 (b) (i)	(11.20 and 11.40 give) 11.3(0) (cm^3)		**1**

Question Number	Acceptable Answers	Reject	Mark
15 (b) (ii)	$\frac{11.3 \times 0.300}{1000}$ = 3.39×10^{-3} / 0.00339 (mol) If mean titre value is 11.47 then 3.44×10^{-3}	Ignore SF unless only one, in which case penalise this only once.	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (b) (iii)	3.39×10^{-3} (mol) Or answer to (ii)		**1**

Question Number	Acceptable Answers	Reject	Mark
15 (b) (iv)	3.39×10^{-2} (mol) answer (iii) x 10		**1**

Question Number	Acceptable Answers	Reject	Mark
15 (b) (v)	0.05 – 0.0339 = 0.0161 (mol) Or 0.05 – (answer to (iv)) If mean titre value is 11.47 then 0.0156		**1**

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Question Number	Acceptable Answers	Reject	Mark
15 (b) (vi)	0.00805 (mol) Or answer to (v) divided by 2 If mean titre value is 11.47 then 0.0078		**1**

Question Number	Acceptable Answers	Reject	Mark
15 (b) (vii)	0.00805 x 100 = 0.805 (g) / 805 **mg** Or answer to (vi) x 100 If mean titre value is 11.47 then 0.780		**1**

Question Number	Acceptable Answers	Reject	Mark
15 (b) (viii)	Reason – there must be some other ant acid present / substance/chemical which reacts with acid	Experimental / calculation error	**1**

TOTAL FOR SECTION B = 39 MARKS

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Section C

Question Number	Acceptable Answers	Reject	Mark
16 (a)	**1** Reaction 1: C goes from —4 to +2, **(1)** **2** H from +1 to 0 (redox reaction) **(1)** **3** Reaction 2: C goes from +2 to +4 **(1)** **4** H from +1 to 0 (redox reaction) **(1)** Allow from 2(+1) to 0 For each mark **both** correct oxidation states are needed Additional incorrect oxidation numbers of oxygen lose 1 mark per reaction Allow number followed by charge Penalise missing plus signs only once Penalise wrong use of the terms reduced and oxidized only once Penalise correct oxidation states and **not** a redox reaction only once **5** Reaction 3 **no** (elements) **change** (oxidation number) / **details for carbon / hydrogen calculated** **AND** so this is **not a redox reaction** **OR** Redox mentioned in reactions 1 and 2 but 'not redox' omitted in reaction 3 **(1)**	H from +2 to 0 H from +2 to 0	**5**

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Question Number	Acceptable Answers	Reject	Mark
***16 (b) (i)**	Any seven from: **1** A higher temperature would increase the yield /favour the forward reaction /produce more hydrogen… **(1)** **2** …(as) the reaction is endothermic **(1)** **3** Increased temperature would increase the rate/speed of reaction /make the reaction go faster… **(1)** **4 …**(as) a greater proportion of /more molecules have sufficient /higher/activation energy (to react) **(1)** **5** Decreased pressure increases the yield /favour the forward reaction /produce more hydrogen… **(1)** **6**…(as) the forward reaction is favoured with more (gaseous) molecules /mole **(1)** **7** Decreased pressure would decrease the rate of reaction… **(1)** **8** …(as) collision frequency decreases/less collisions **(1)** Points may muddle into one another **Reverse statements allowed** e.g. 'lower temperature decreases yield because reaction is endothermic'. **Contradictory statements** in each pair lose both marks e.g. 'lower temperature increases yield because reaction is endothermic'.	'More (successful) collisions' alone	**7**

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Question Number	Acceptable Answers	Reject	Mark
16 (b) (ii)	An excess is used to drive the equilibrium to the right / to ensure all the methane reacts (as the reaction responds to remove steam by Le Chatelier's principle) **(1)** Methane is more expensive (so it is better to increase the amount of steam) / steam is cheaper /readily available /renewable OR Methane is not renewable **(1)**	…to get a better yield of hydrogen /to allow reaction to happen fully / so all the reactants react / to make the reaction go to completion Methane is a greenhouse gas / dangers associated with methane e.g. flammable	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (c)	The catalyst provides an alternative route for the reaction **(1)** (with) a lower activation energy **(1)** Allow 'catalyst lowers activation energy' alone for one mark		**2**

Question Number	Acceptable Answers	Reject	Mark
16 (d) (i)	It regenerates /reforms potassium carbonate /reactant(s) (which reduces the cost of the process) OR potassium carbonate can be re-used Allow recycles potassium carbonate	Regenerates some of the other reactants. Chemicals are regenerated	**1**

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Question Number	Acceptable Answers	Reject	Mark
***16 (d) (ii)**	**1** Carbon dioxide / CO_2 Allow both water and carbon dioxide **(1)** **2** Traps longer wavelength radiation / traps radiation / IR emitted (from the earth) OR Absorbs/traps heat /IR OR Prevents loss of IR / heat **(1)** **3,4 Any two from:** Rising sea levels / flooding Polar ice / ice caps /glacier(s) / glacial / habitat **ice melting** Changing (sea /air) currents Changing weather patterns /more extreme weather / climate change **(2)** Other acceptable alternatives only if well justified e.g. more malaria because more breeding areas for mosquitoes But more malaria /desertification /forest fires alone is insufficient Three or more correct answers get 2 marks Three or more answers, where some are wrong, are marked 1 mark for each correct answer and –1 mark for each incorrect answer e.g. Two correct and one wrong award 1 mark Three correct and two wrong award 1 mark etc One on list and one wrong award 1. Ignore neutral statements	Water alone Mark is lost if any mention of UV / ozone layer depletion Absorbs IR / heat from the sun Increased UV Increased skin cancer/melanoma	**4**

TOTAL FOR SECTION C = 21 MARKS

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Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Monday 7 June 2010 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 This question is about bond angles.

A 90°

B 104°

C 107°

D 109.5°

Select, from A to D above, the most likely value for the bond angle of

(a) HCH in methane, CH_4.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) FSF in sulfur hexafluoride, SF_6.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) FOF in oxygen difluoride, OF_2.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 3 marks)

N 3 6 3 9 0 A 0 2 2 4

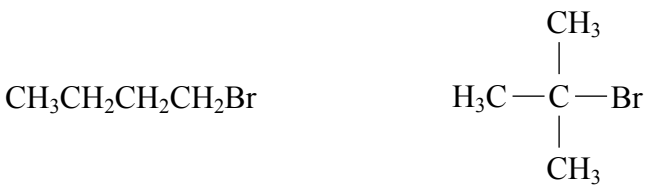
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2 Consider the following compounds, **P**, **Q**, **R** and **S**.



Compound P

Compound Q



Compound R

Compound S

The boiling temperatures of compounds P, Q, R and S **increase** in the order

☒ **A** P Q R S

☒ **B** R S P Q

☒ **C** Q S P R

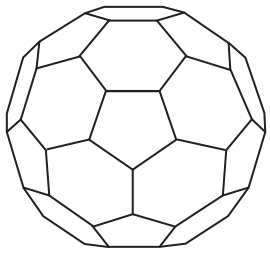
☒ **D** Q P S R

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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3 Buckminsterfullerene has the formula C_{60}. Its structure is shown below.



The bonding in buckminsterfullerene is similar to the bonding in graphite.

Which of the following is true?

☒ **A** All the bond angles in buckminsterfullerene are 120°.

☒ **B** The melting temperature of buckminsterfullerene is higher than that of graphite.

☒ **C** There are delocalized electrons in buckminsterfullerene.

☒ **D** On complete combustion, buckminsterfullerene forms carbon dioxide and water.

(Total for Question 3 = 1 mark)

4 When concentrated sulfuric acid is added to solid sodium bromide, bromine is produced.

When concentrated sulfuric acid is added to solid sodium chloride, **no** chlorine is produced.

The reason for this difference is

☒ **A** sulfuric acid is a strong acid.

☒ **B** hydrogen chloride is a weak acid.

☒ **C** the chloride ion is a weaker reducing agent than the bromide ion.

☒ **D** bromine is less volatile than chlorine.

(Total for Question 4 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

N 3 6 3 9 0 A 0 4 2 4

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5 Compound **X** is a white solid. On heating this compound, a colourless, acidic gas is the only gaseous product. A flame test is carried out on the solid residue and a reddish flame is observed.

Compound **X** is

☒ **A** calcium nitrate.

☒ **B** calcium carbonate.

☒ **C** magnesium carbonate.

☒ **D** strontium nitrate.

(Total for Question 5 = 1 mark)

6 Which of the following does **not** apply to the elements Mg, Ca, Sr and Ba in Group 2 of the Periodic Table?

☒ **A** Their oxides, MO, are all basic.

☒ **B** Their metal hydroxides, $M(OH)_2$, become more soluble down the group.

☒ **C** Their oxides, MO, react with water to form the metal hydroxide, $M(OH)_2$.

☒ **D** Their carbonates, MCO_3, all decompose on gentle heating.

(Total for Question 6 = 1 mark)

7 Which of the following compounds shows hydrogen bonding in the liquid state?

☒ **A** Hydrogen bromide, HBr

☒ **B** Hydrogen sulfide, H_2S

☒ **C** Silane, SiH_4

☒ **D** Ammonia, NH_3

(Total for Question 7 = 1 mark)

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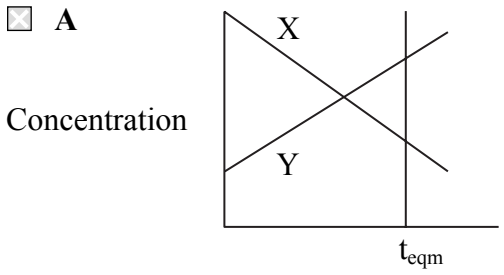
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8 For the reversible reaction

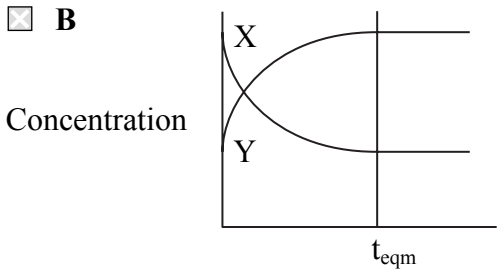
$$X \rightleftharpoons Y$$

which of the following could represent the change in the concentrations of X and Y with time, starting with a mixture of both X and Y? Equilibrium is reached at time t_{eqm}.

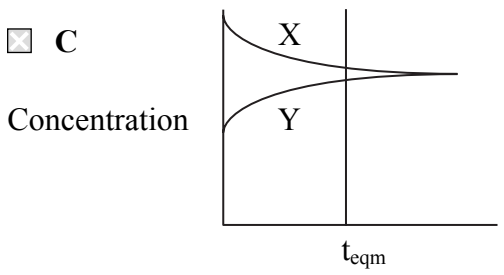
☒ **A**



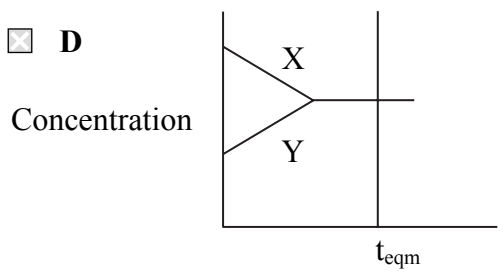
☒ **B**



☒ **C**



☒ **D**



(Total for Question 8 = 1 mark)

9 Which of the following molecules is polar?

☒ **A** Carbon dioxide, CO_2

☒ **B** Beryllium chloride, $BeCl_2$

☒ **C** Ammonia, NH_3

☒ **D** Boron trifluoride, BF_3

(Total for Question 9 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

N 3 6 3 9 0 A 0 6 2 4

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10 The electronegativities of four pairs of elements are given below. Which pair would form the compound with the greatest ionic character?

☒ **A** 0.7 and 4.0

☒ **B** 0.7 and 3.5

☒ **C** 1.0 and 4.0

☒ **D** 0.8 and 2.8

(Total for Question 10 = 1 mark)

11 Which of the following statements about the elements in Group 7 is **incorrect**?

☒ **A** They all show variable oxidation states in their compounds.

☒ **B** They all form acidic hydrides.

☒ **C** Electronegativity decreases as the group is descended.

☒ **D** They all exist as diatomic molecules.

(Total for Question 11 = 1 mark)

12 What are the products, other than water, when chlorine is passed through cold, dilute aqueous sodium hydroxide solution?

☒ **A** NaCl and NaClO

☒ **B** NaClO and $NaClO_3$

☒ **C** NaCl and $NaClO_3$

☒ **D** NaClO and $NaClO_4$

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

13 When solutions of iodine are titrated with aqueous sodium thiosulfate solution, $Na_2S_2O_3(aq)$, the thiosulfate ions are oxidized to

☒ **A** $S_2O_4^{2-}$

☒ **B** $S_2O_6^{2-}$

☒ **C** $S_2O_8^{2-}$

☒ **D** $S_4O_6^{2-}$

(Total for Question 13 = 1 mark)

14 The best method of converting ethanol, C_2H_5OH, into iodoethane, C_2H_5I, is to

☒ **A** heat iodine and ethanol under reflux.

☒ **B** react ethanol and potassium iodide in the presence of dilute acid.

☒ **C** heat potassium iodide and ethanol with concentrated sulfuric acid.

☒ **D** heat red phosphorus, ethanol and iodine under reflux.

(Total for Question 14 = 1 mark)

15 The use of poly(ethene) packaging has been criticised mainly because

☒ **A** the complete combustion of poly(ethene) produces dangerous fumes.

☒ **B** large amounts of oil are consumed in producing the monomer, ethene.

☒ **C** poly(ethene) degrades to form toxic products.

☒ **D** the catalyst used in the polymerization of ethene is expensive.

(Total for Question 15 = 1 mark)

16 Which of the following is essential if a species is to act as a nucleophile?

☒ **A** A lone pair of electrons.

☒ **B** A negative charge.

☒ **C** An unpaired electron.

☒ **D** A strongly polar bond.

(Total for Question 16 = 1 mark)

N 3 6 3 9 0 A 0 8 2 4

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17 Calculate the volume of dilute sulfuric acid, concentration 0.500 mol dm^{-3}, required to neutralize 20.0 cm^3 aqueous sodium hydroxide, concentration 0.100 mol dm^{-3}.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

☒ **A** 2.0 cm^3

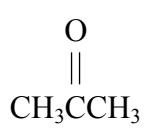
☒ **B** 4.0 cm^3

☒ **C** 8.0 cm^3

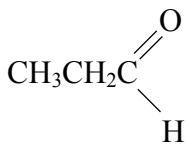
☒ **D** 20.0 cm^3

(Total for Question 17 = 1 mark)

18 Which of the following features is shown by the mass spectra of propanone and propanal?



propanone



propanal

		m/e of the molecular ion	Fragmentation pattern
☒	**A**	same	same
☒	**B**	same	different
☒	**C**	different	same
☒	**D**	different	different

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

N 3 6 3 9 0 A 0 9 2 4

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

19 A student carried out an experiment to determine the concentration of ethanoic acid in a solution of vinegar.

- The student used a measuring cylinder to measure out 25.0 cm^3 of the vinegar solution.
- This solution was then transferred to a 250 cm^3 volumetric flask and the liquid level was carefully made up to the mark with distilled water.
- A pipette was used to transfer 25.0 cm^3 portions of the acidic solution to conical flasks.
- The solution was then titrated with sodium hydroxide solution, concentration 0.100 mol dm^{-3}, using phenolphthalein as the indicator.

$$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$$

Results

Titration number	1	2	3	4
Burette reading (final) / cm^3	28.55	28.00	40.35	28.05
Burette reading (initial) / cm^3	0.00	0.05	12.30	0.05
Volume of NaOH used / cm^3	28.55	27.95	28.05	28.00

(a) In this titration, what is the colour change of the phenolphthalein indicator?

(2)

From ..... **to** .....

(b) Explain why the mean titre should be based only on titrations 2, 3 and 4.

(1)

.....

.....

.....

N 3 6 3 9 0 A 0 1 0 2 4

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(c) Calculate the mean titre in cm^3.

(1)

(d) (i) Using your answer to (c), calculate the number of moles of sodium hydroxide in the mean titre.

(1)

(ii) Hence state the number of moles of ethanoic acid, CH_3COOH, in 25.0 cm^3 of the **diluted** solution used in the titration.

(1)

(iii) Calculate the concentration of the **diluted** acid solution in mol dm^{-3}.

(1)

(iv) Hence calculate the concentration of the ethanoic acid in the **original** vinegar solution in mol dm^{-3}.

(1)

(v) Use your answer from (d)(iv) to state the concentration of the ethanoic acid in the **original** vinegar solution in units of g dm^{-3}.

[The molar mass of the ethanoic acid is 60 g mol^{-1}.]

(1)

(e) Suggest, with a reason, how the student's method of preparing the diluted solution could be improved.

(2)

Improvement

.....

.....

Reason

.....

.....

.....

N 3 6 3 9 0 A 0 1 2 2 4

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(f) The burette used in the titration had an uncertainty for each reading of ± 0.05 cm^3.

(i) Identify, by letter, which ONE of the following should be regarded as the true value of the titre in titration number **2**?

X Between 27.90 and 28.00 cm^3

Y Between 27.925 and 27.975 cm^3

Z Between 27.85 and 28.05 cm^3

(1)

.....

.....

(ii) Suggest ONE reason why a student may obtain volumes outside the uncertainty of the burette when performing a titration.

(1)

.....

.....

(Total for Question 19 = 13 marks)

20 (a) Propene, C_3H_6, reacts with hydrogen bromide, HBr, in an electrophilic addition reaction.

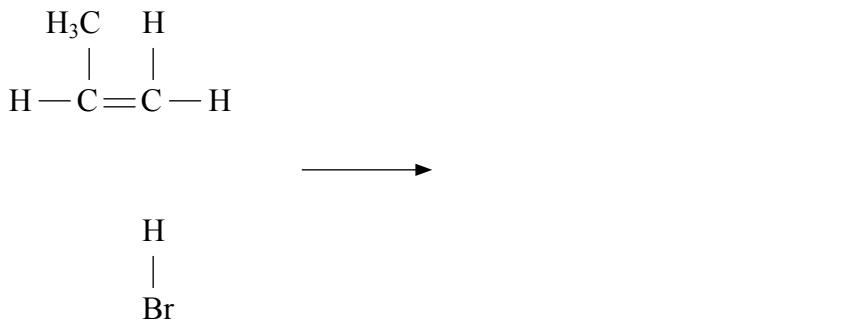
2-bromopropane is formed as the major product.

$$H_3CCH{=}CH_2 + HBr \rightarrow H_3CCH(Br)CH_3$$

(i) Complete the mechanism for the reaction, using 'curly arrows' where appropriate. Show clearly the structure of the intermediate carbocation formed.

(3)

Mechanism



N 3 6 3 9 0 A 0 1 4 2 4

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(ii) Draw the structure of the alternative carbocation that can be formed in the reaction between propene and hydrogen bromide.

(1)

(b) Four isomers, each with the molecular formula $C_4H_{10}O$, are shown below.

Isomer **A**: $CH_3CH_2CH_2CH_2OH$

Isomer **B**: $CH_3CH_2CH(OH)CH_3$

Isomer **C**: $(CH_3)_3COH$

Isomer **D**: $CH_3CH(CH_3)CH_2OH$

(i) Which isomer is a secondary alcohol? Justify your answer.

(2)

(ii) Which isomer is resistant to oxidation when heated with acidified potassium dichromate(VI)? Justify your answer in terms of the structure of the isomer.

(2)

(iii) Which isomer can be oxidized to a ketone? Draw the displayed formula of the ketone produced.

(1)

(iv) Which isomers can be oxidized to an aldehyde?

(1)

(v) Phosphorus(V) chloride (phosphorus pentachloride), PCl_5, is used to test for the presence of an –OH group.

What would you expect to see when any of the above four isomers, A, B, C or D, are reacted with phosphorus(V) chloride?

(1)

(vi) Complete the equation for the reaction shown below. State symbols are **not** required.

(2)

$C_4H_9OH + PCl_5 \rightarrow$

(Total for Question 20 = 13 marks)

N 3 6 3 9 0 A 0 1 6 2 4

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21 (a) In the catalytic converter of a car engine's exhaust system, the following reaction occurs.

$2NO(g) + 2CO(g) \rightleftharpoons N_2(g) + 2CO_2(g)$ $\Delta H = -745$ kJ mol^{-1}

The temperature in a catalytic converter is high.

(i) State the effect, if any, on the position of equilibrium if the temperature is lowered. Give a reason for your answer.

(2)

Effect .....

Reason .....

.....

(ii) The gases from the engine are **not** cooled before entering the converter. Explain why this is so.

(2)

.....

.....

.....

.....

(iii) State the effect, if any, on the position of equilibrium if the pressure on the reacting gases is increased. Give a reason for your answer.

(2)

Effect .....

Reason .....

.....

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(b) Nitrogen monoxide, NO, is formed when nitrate ions, NO_3^-, in acidic solution are reduced by silver metal.

(i) Calculate the oxidation number of nitrogen in NO and in NO_3^-.

(2)

In NO .....

In NO_3^- .....

(ii) Balance the half-equation for the reduction of nitrate ions, NO_3^-, in acidic solution.

(1)

NO_3^- + ...H^+ + ...e^- → NO + ...H_2O

(iii) Write the half-equation for the oxidation of silver metal, Ag, to silver ions, Ag^+.

(1)

(iv) Hence deduce the full ionic equation for the reaction between silver metal and nitrate ions in acidic solution. State symbols are **not** required.

(2)

(Total for Question 21 = 12 marks)

TOTAL FOR SECTION B = 38 MARKS

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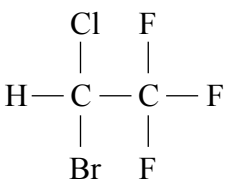
SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

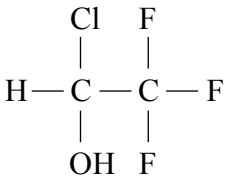
22 This question is about the chemistry of some halogenoalkanes.

Halothane is a colourless and sweet-smelling liquid. It has a boiling temperature of 50 °C. Halothane vapour was used as a general anaesthetic in hospitals during the mid to late 20th Century. Patients inhaled the halothane vapour under medical supervision. However, halothane was found to have some adverse side-effects and was therefore replaced by other halogenoalkane anaesthetics.

Halothane has the structure



In an experiment, halothane was heated in a test tube with aqueous silver nitrate and ethanol, using a water bath. Compound **X** and bromide ions were formed. The structure of compound **X** is shown below.



Compound **X**

(a) (i) Give the systematic name of halothane.

(1)

(ii) Suggest the types of intermolecular force present between molecules of liquid halothane.

(2)

N 3 6 3 9 0 A 0 1 9 2 4

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(iii) In the above experiment, suggest ONE reason why a water bath was used rather than heating the test tube containing the reaction mixture directly over a Bunsen flame.

(1)

.....

.....

.....

(iv) Suggest why ethanol was used in this experiment.

(1)

.....

.....

.....

(v) What would be seen in the test tube as the reaction progressed?

(1)

.....

.....

(vi) Write an ionic equation to show the reaction between aqueous silver ions and aqueous bromide ions. Include state symbols in your equation.

(1)

(b) Chloroethane, C_2H_5Cl, can also be used as an anaesthetic. In an experiment, chloroethane was hydrolysed by aqueous sodium hydroxide, NaOH.

(i) Name, and give the structural formula of, the organic product of the hydrolysis of chloroethane.

(2)

Name .....

Structural formula .....

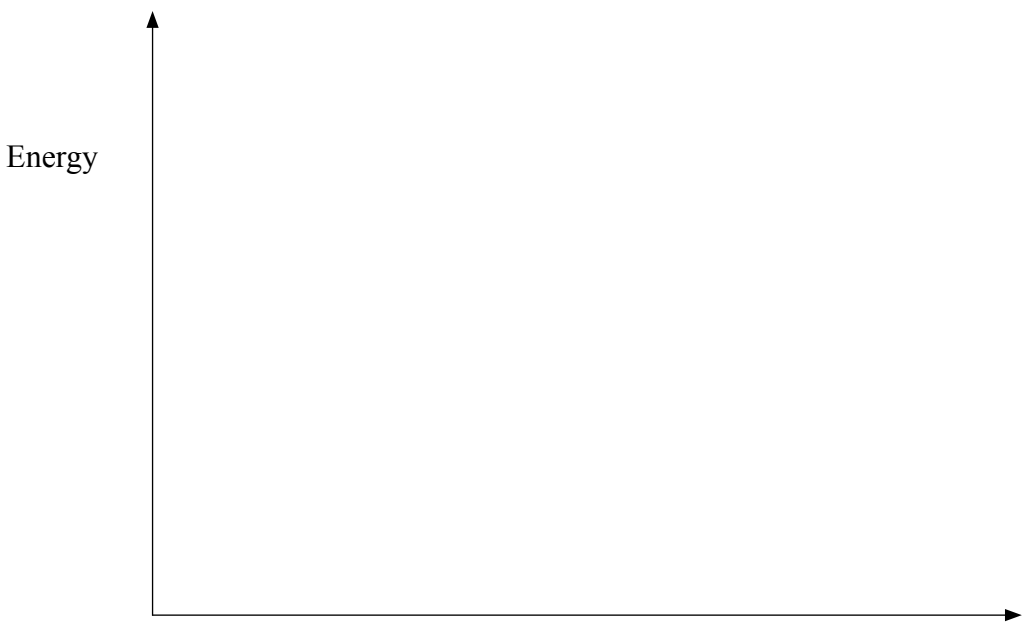
N 3 6 3 9 0 A 0 2 0 2 4

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(ii) The hydrolysis of chloroethane is an exothermic reaction which takes place in a single step.

On the diagram below, draw the energy profile for the reaction. Label clearly the activation energy for the reaction.

(3)



(c) In the early 1900s, the CFC with formula CCl_2F_2, was identified as a refrigerant which was both non-flammable and non-toxic.

(i) What does the term **CFC** stand for?

(1)

.....

(ii) Suggest ONE use for CFCs other than as a refrigerant.

(1)

.....

*(iii) In the stratosphere, CFCs are broken down by absorption of UV radiation to form chlorine free radicals.

The following two reactions occur.

$$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$$

$$ClO\bullet + O \rightarrow Cl\bullet + O_2$$

Combine these two equations to give the overall equation for the reaction of ozone in the stratosphere. State the role played by the chlorine free radical in the overall reaction. Hence explain why many scientists consider the effect of CFCs on ozone to be harmful.

(5)

N 3 6 3 9 0 A 0 2 2 2 4

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(d) The compound of formula CH_2F_2 has replaced several CFCs for commercial use. If molecules of CH_2F_2 reach the stratosphere, they do not break down to produce fluorine free radicals.

(i) Suggest why C–F bonds are **not** broken in the stratosphere.

(1)

.....

.....

.....

.....

*(ii) The compound CH_2F_2 acts as a greenhouse gas when it absorbs a particular type of radiation.

Name the type of radiation and explain why a molecule of CH_2F_2 is able to absorb this radiation.

(2)

.....

.....

.....

.....

(Total for Question 22 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 80 MARKS

N 3 6 3 9 0 A 0 2 3 2 4

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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June 2010

GCE

GCE Chemistry (6CH02/01)

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Summer 2010

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6CH02_01
1006

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Section A (multiple choice)

Question Number	Correct Answer	Mark
1(a)	D	**1**

Question Number	Correct Answer	Mark
1(b)	A	**1**

Question Number	Correct Answer	Mark
1(c)	B	**1**

Question Number	Correct Answer	Mark
2	D	**1**

Question Number	Correct Answer	Mark
3	C	**1**

Question Number	Correct Answer	Mark
4	C	**1**

Question Number	Correct Answer	Mark
5	B	**1**

Question Number	Correct Answer	Mark
6	D	**1**

Question Number	Correct Answer	Mark
7	D	**1**

Question Number	Correct Answer	Mark
8	B	**1**

Question Number	Correct Answer	Mark
9	C	**1**

Question Number	Correct Answer	Mark
10	A	**1**

Question Number	Correct Answer	Mark
11	A	**1**

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Question Number	Correct Answer	Mark
12	A	**1**

Question Number	Correct Answer	Mark
13	D	**1**

Question Number	Correct Answer	Mark
14	D	**1**

Question Number	Correct Answer	Mark
15	B	**1**

Question Number	Correct Answer	Mark
16	A	**1**

Question Number	Correct Answer	Mark
17	A	**1**

Question Number	Correct Answer	Mark
18	B	**1**

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Section B

Question Number	Acceptable Answers	Reject	Mark
19 (a)	**Mark independently** **From:** colourless **(1)** **To:** pink / (pale) red **(1)** If colour change wrong way round **max (1)**	**From:** clear **To:** magenta / purple / cerise	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b)	(Titres 2, 3 and 4) are concordant / within 0.2 (cm^3) / within 0.1 (cm^3) / consistent **OR** Titre 1 is rough / trial / a rangefinder / too far out / overshot *ALLOW* Titre 1 is an outlier / is anomalous	**Just** "very similar" / within 0.05 / within 0.5 Titre 1 "very different" **Just** "not accurate" "Titration 1 is a control experiment"	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (c)	28.00 (cm^3) / 28.0 (cm^3) / 28 (cm^3)	28.14 (cm^3) / 28.1 (cm^3) / 28.13 (cm^3)	**1**

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IN (d)(i) to (d)(v), IGNORE UNITS EVEN IF INCORRECT AND
ALLOW ANSWER IN EACH CASE WHETHER BY TE OR MARK SCHEME ANSWER, REGARDLESS OF ANY WORKING SHOWN

Question Number	Acceptable Answers	Reject	Mark
19 (d)(i)	$\frac{0.100 \times 28.00}{1000}$ = **0.0028 / 2.8×10^{-3}** (mol) *ALLOW* TE from (c) *IGNORE* sf except one sf		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d)(ii)	**0.0028 / 2.8×10^{-3}** (mol) OR **Same answer** to (d)(i) if TE applied *IGNORE* sf except one sf		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d)(iii)	$\frac{0.0028}{0.025}$ = **0.112** (mol dm^{-3}) OR **Answer** to $\frac{\text{(d)(ii)}}{0.025}$ if TE applied from (d)(ii) *IGNORE* sf except one sf		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d)(iv)	10 x 0.112 = **1.12** (mol dm^{-3}) OR **Answer** to (d)(iii) x 10 if TE applied from (d)(iii) *IGNORE* sf except one sf		**1**

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Question Number	Acceptable Answers	Reject	Mark
19 (d)(v)	1.12 x 60 = **67.2** (g dm^{-3}) OR **Answer** to (d)(iv) x 60 if TE applied from (d)(iv) *IGNORE* sf except one sf	67.1	**1**

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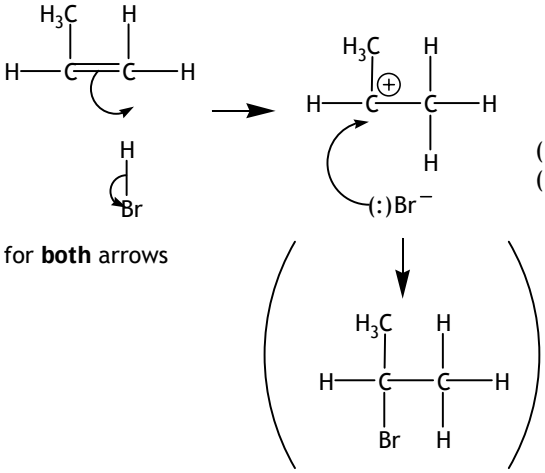
Question Number	Acceptable Answers	Reject	Mark
19 (e)	*NOTE*: answer must refer to making up the diluted solution and not the titration *NOTE:* the Reason mark must be correctly linked to the Improvement **Improvement:** Use a pipette / burette to measure acid (solution) **(1)** **Reason:** Pipette / burette more accurate (than a measuring cylinder) **(1)** *ALLOW* "more precise" **OR** **Improvement:** Shake / invert **the volumetric flask** (thoroughly) **(1)** **Reason:** To ensure a uniform concentration **(1)** **OR** **Improvement:** Rinse out measuring cylinder (and transfer washings to the volumetric flask) **(1)** **Reason:** To ensure **all** the acid is transferred (to the volumetric flask) **(1)** **OR** **Improvement:** Use a (teat) pipette to make up to the mark (in volumetric flask) **(1)** **Reason:** To ensure volume of solution accurately measured **(1)**	Use of volumetric flask for **initial** measurement of volume of vinegar solution "more reliable" swirl (the flask) to ensure "fully dissolved" **just** "rinse out apparatus" Any suggested improvements relating to the titration part of this experiment	**2**

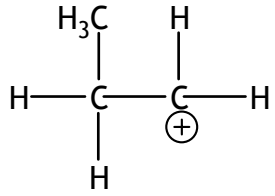
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Question Number	Acceptable Answers	Reject	Mark
19 (f)(i)	**Z *I*** between 27.85 and 28.05 (cm^3) *ALLOW* 27.95 ±0.10 (cm^3)		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (f)(ii)	Any **one** of the following / a statement equivalent to: • overshoots/misses end-point • water left in burette / pipette • air lock below tap in burette / air in pipette • burette not vertical • alkali not at stated concentration • leaking tap • not reading meniscus at eye-level • funnel left in top of burette • not reading level against a white background • not reading meniscus correctly • washing pipette between titres • washing the flask with the solution that will go in it • not swirling flask / mixture *IGNORE* "errors in calculation"	"water left in conical flask" **just** "measurements may be inaccurate" "there could be uncertainty with other equipment" "contamination of the vinegar"	**1**

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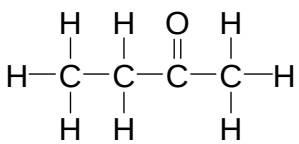
Question Number	Acceptable Answers	Mark
20 (a)(i)	 (1) for carbocation (1) for arrow (1) for **both** arrows **1st mark:** • top arrow must start from the double bond / close to the double bond and **not** from either of the C atoms of the C=C bond • top arrow can end on, or close to, the H in HBr • lower arrow must start from the bond and **not** the H atom in HBr *REJECT* **full** charges on the HBr **2nd mark:** the carbocation must have a full + and **not** δ+ **3rd mark:** • the bromide ion must have a full ⁻ and **not** δ⁻ • the lone pair need not be shown on the Br^- • arrow from bromide ion can start anywhere on the Br^- or from the minus sign or the lone pair (if shown) on Br^- and can go to the C or the + sign on the intermediate 3rd mark available even if an incorrect intermediate has been drawn	**3**

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	 OR $CH_3\,CH_2\,CH_2^+$		**1**

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Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	B /$CH_3CH_2CH(OH)CH_3$ /butan-2-ol **(1)** Because the C atom bearing the OH is attached to two other C atoms / C with OH group attached to one H (atom) **(1)** *ALLOW* Because the C atom bearing the OH is attached to two alkyl groups **These marks are stand alone**	**Just** "OH is on the second C atom" / "OH is in the chain, not on the end" OR "OH attached to two **methyl** / two **CH_3** groups" OH^- (instead of -OH)	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	C /$(CH_3)_3COH$ /(2-)methylpropan-2-ol **(1)** Because it is a **tertiary** (alcohol)/no C-H bonds to break **(1)** *ACCEPT* a description of a tertiary alcohol **These marks are stand alone**	"tertiary **structure"** / "tertiary **carbon"** / "tertiary **carbocation"**	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	**BOTH** B / $CH_3CH_2CH(OH)CH_3$ / butan-2-ol **AND**  **BOTH required for the one mark**	Structural / skeletal formula	**1**

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Question Number	Acceptable Answers	Reject	Mark
20(b)(iv)	A / $CH_3CH_2CH_2CH_2OH$ / butan-1-ol **and** D / $CH_3CH(CH_3)CH_2OH$ / (2-)methylpropan-1-ol **BOTH needed for one mark**		**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)(v)	Steamy fumes / misty fumes / white mist	White **smoke**	**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)(vi)	(C_4H_9OH + PCl_5 →) **C_4H_9Cl + $POCl_3$ + HCl** **(1)** for HCl **(1)** for rest of the equation correct *NOTE:* Equation must be completely correct for the second mark. *ACCEPT* "PCl_3O" instead of $POCl_3$		**2**

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Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	**Mark the two points independently, subject to the constraint in Reject column** **Effect:** (Equilibrium) shifts to the right **(1)** *ALLOW:* "favours forward reaction" / "increase the amount of product" / "increase the yield (of product)" **Reason:** Exothermic (in forward direction) **(1)** *NOTE:* **Just** "(equilibrium) shifts in the exothermic direction" scores **(1)**	**"Equilibrium shifts to left" will score (0) for (a)(i)**	**2**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	**First mark:** Activation energy for the reaction is too high / (if cooled) molecules would not have enough energy to react / few(er) molecules have the required E_a/more molecules have energy ≥ E_a at higher temperatures **OR** not (technologically) feasible to cool the gases before they enter the converter/costly to cool the gases **(1)** **Second mark:** (cooling the gases would make) the rate (too) slow /rate is faster if the temperature is high (so the gases are not cooled) **(1)**	Cooling the gases decreases the yield (of products) /an incorrect Le Chatelier argument	**2**

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Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	**Mark the two points independently, subject to the constraint in Reject column** **Effect:** (Equilibrium) shifts to the right *ALLOW:* "favours forward reaction" / "increase the amount of product" / "increase the yield of product" **(1)** **Reason:** Shifts / moves in the direction of fewer (moles of gas) molecules *ALLOW* "shifts in direction of fewer moles (of gas molecules)" **(1)** *IGNORE* effect on the rate	**"Equilibrium shifts to left" will score (0) for (a)(iii)** "…. fewer **atoms**"	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	**(In NO):** +2 / 2+ **(1)** (**In NO_3^-):** +5 / 5+ **(1)** *NOTE:* **(In NO):** Just "2" **AND** (**In NO_3^-):** Just "5" scores **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	NO_3^- + **4**H^+ + **3**e^- → NO + **2**H_2O *ACCEPT* multiples		**1**

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Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	$Ag \rightarrow Ag^+ + e^{(-)}$ / $Ag - e^{(-)} \rightarrow Ag^+$ *ACCEPT* multiples *IGNORE* state symbols, even if incorrect	"$Ag + e^- \rightarrow Ag^+$"	**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	$3Ag + NO_3^- + 4H^+ \rightarrow 3Ag^+ + NO + 2H_2O$ **(2)** **(1)** for multiplication of the silver half-equation by three or cq multiple from (b)(ii) **(1)** for rest of equation correct *NOTE:* Equation must be completely correct for the second mark. *IGNORE* state symbols, even if incorrect	if any e^- are left in the final equation, second mark cannot be scored	**2**

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SECTION C

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	2-bromo-2-chloro-1,1,1-trifluoroethane *ALLOW* 1-bromo-1-chloro-2,2,2-trifluoroethane *IGNORE* incorrect punctuation and incorrect order of the halogen atoms	**"**1-bromo-1-chloro-**2**-trifluoroethane"	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	London (forces) / instantaneous dipole / induced dipole / dispersion / van der Waals' (forces) **(1)** permanent dipole (-permanent dipole) (forces) / dipole-dipole (forces) / dipole (forces) **(1)** *IGNORE* **any** references to hydrogen bonding		**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	Any **one** of the following / a statement equivalent to: **Ethanol** is **flammable** [Note: if any reference to **only** the halogenoalkane being flammable scores **(0)**] OR reference to greater control of heating (e.g. "to control the rate of reaction" / "to prevent the reaction being too vigorous" / "to prevent the reaction getting out of control") *ALLOW* "so that the reaction takes place slowly" OR "(reaction) mixture is flammable/it is flammable" OR "Bunsen flame too hot / too vigorous" OR "(Bunsen flame) would cause too much evaporation to occur" OR "(allows) constant heating"/ "even heating"	Compound **X** is flammable **Just** "to prevent an explosion" **Just** "to minimise the risk"	**1**

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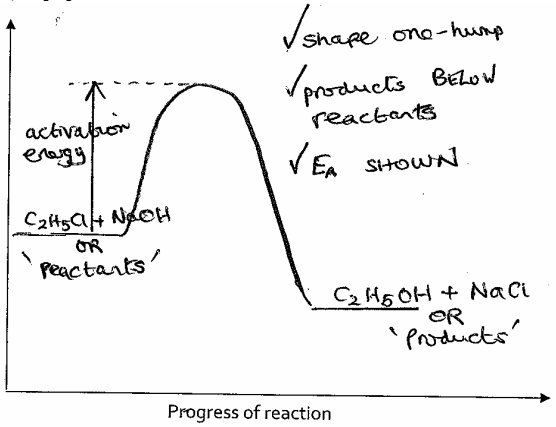
Question Number	Acceptable Answers	Reject	Mark
22(a)(iv)	Solvent (for both reactants) OR To dissolve (the reactants) OR To mix the reactants *ALLOW* "To enable the mixture to dissolve"	**Just** "mixing" "to acidify the silver nitrate"	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(v)	Cream / **off-**white / **pale**-yellow **precipitate** *ALLOW* Cream / **off-**white / **pale**-yellow **solid** *IGNORE* incorrect identification of this precipitate *NOTE:* **both** colour **and** state (of the AgBr) needed	**Just** "Yellow" (precipitate/ solid) OR "**white** precipitate" OR "white-yellow precipitate" **(0)** if contradictory observation given, eg "cream precipitate and fizzing"	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(vi)	Ag^{+}**(aq)** + Br^{-} **(aq)** → AgBr**(s)** Must include **state symbols** *ACCEPT* multiples	If NO_3^- left on either side	**1**

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Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	**Mark independently** **Name:** ethanol **(1)** *ALLOW* "ethan-1-ol" **Structural formula:** CH_3CH_2OH or C_2H_5OH **(1)** *Allow* displayed formula *ALLOW* brackets around the OH	C_2H_6O	**2**

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	**Mark independently** **1st mark:** Energy of products, **labelled**, **below** that of reactants, **labelled** **(1)** *Note* if the words 'reactants' and 'products' are written, ignore any formulae *Note* if the words 'reactants' and 'products' are not written, both formulae of the reactants and both formulae of the products must be given. (Na^+ ions can be omitted.) **2nd mark:** Shape of profile with one 'hump' **(1)** **3rd mark:** Activation energy / "E_a" correctly shown **with a single-headed arrow** to the peak (or close to it) **(1)**  	**Maxwell-Boltzmann curve scores (0) for (b)(ii)** **Double-headed** arrow showing E_a	**3**

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Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	Chlorofluorocarbon Accept ..flouro… spelling		**1**

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	Any **one** of the following / a statement equivalent to: aerosol / propellant / spray cans OR (degreasing) solvent OR fire retardant *ALLOW* fire extinguishers / putting out fires *ALLOW* making expanded polystyrene / making plastics / making polymers	pesticides / anaesthetics **just** "retardant" anti-freeze air-conditioning frying pans detergents	**1**

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Question Number	Acceptable Answers	Reject	Mark
22(c)(iii) QWC	**Mark independently** **1st mark:** $O + O_3 \rightarrow 2O_2$ *IGNORE* any state symbols **(1)** **2nd mark:** (chlorine free radical acts as a) **catalyst (1)** **Last 3 marks:** any **three** from: • (the chlorine free radical) persists in the atmosphere / continues to attack / is regenerated / (starts) a chain reaction **(1)** *NOTE* 'chain reaction' may be described in terms of a chlorine radical breaking down many / a large number of / a specified number of, eg 10,000, O_3 (molecules). *NOTE:* As written, this response also earns the scoring point relating to ozone depletion. • less ozone / ozone decreases / causes hole(s) in ozone layer / breakdown of ozone (layer) / damages ozone layer / depletes ozone layer **(1)** • **UV** (reaching Earth's surface) increases / less **UV** absorbed / (more) UV reaches Earth's surface **(1)** • causes (skin) cancer/mutation / DNA damage occurs **(1)** *IGNORE* any references to "global warming" / "Greenhouse Effect"	If Cl● and / or ClO● left in equation OR $2O_3 \rightarrow 3O_2$ **Just** (UV) "harmful"	**5**

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Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	The C-F bond is (very) strong OR C-F bond is (much) harder to break than the C-Cl bond **OR** UV/radiation does not have enough energy /does not have (high) enough frequency	Any mention of electronegativity **OR** mention of bond polarity scores (0)	**1**

Question Number	Acceptable Answers	Reject	Mark
22(d)(ii) **QWC**	(long wavelength) IR /infrared radiation **(1)** The molecule is polar OR (the molecule) changes its polarity OR "polar bonds" OR vibrational energy/vibrations of the **bonds** / stretching or bending increases OR (IR causes) **bonds** to vibrate **(1)** **Marks are stand alone**	UV / ultraviolet **Just "molecule** vibrates" **(0)**	**2**

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Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Thursday 21 January 2010 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

1 Which of the following bond angles occur in a molecule of ethanol, C_2H_5OH?

☒ **A** 90° and 180°

☒ **B** 104.5° and 180°

☒ **C** 104.5° and 109.5°

☒ **D** 109.5° and 120°

(Total for Question 1 = 1 mark)

2 Which of the following molecules is linear?

☒ **A** Carbon dioxide, CO_2

☒ **B** Sulfur dioxide, SO_2

☒ **C** Water, H_2O

☒ **D** Methanal, HCHO

(Total for Question 2 = 1 mark)

3 Which of the following molecules contains polar bonds but is **not** a polar molecule?

☒ **A** Chlorine, Cl_2

☒ **B** Hydrogen chloride, HCl

☒ **C** Trichloromethane, $CHCl_3$

☒ **D** Tetrachloromethane, CCl_4

(Total for Question 3 = 1 mark)

4 Which of the following has dipole-dipole interactions between its molecules, but no hydrogen bonding?

☒ **A** Methane, CH_4

☒ **B** Methanol, CH_3OH

☒ **C** Ammonia, NH_3

☒ **D** Hydrogen iodide, HI

(Total for Question 4 = 1 mark)

N 3 5 6 9 2 A 0 2 2 4

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5 Which list below shows the compounds in order of **increasing** boiling temperature?

☒ **A** CH_4, HCl, HF

☒ **B** HF, CH_4, HCl

☒ **C** HCl, HF, CH_4

☒ **D** HF, HCl, CH_4

(Total for Question 5 = 1 mark)

6 Which of the following has the highest boiling temperature?

☒ **A** Pentane, $CH_3CH_2CH_2CH_2CH_3$

☒ **B** Hexane, $CH_3CH_2CH_2CH_2CH_2CH_3$

☒ **C** 2-methylbutane, $CH_3CH(CH_3)CH_2CH_3$

☒ **D** 2-methylpentane, $CH_3CH(CH_3)CH_2CH_2CH_3$

(Total for Question 6 = 1 mark)

7 Which of the following could **not** be an element in Group 2?

☒ **A** An element with an oxide which forms a solution of pH 10.

☒ **B** An element with an insoluble sulfate.

☒ **C** An element with a chloride which is liquid at room temperature.

☒ **D** An element with a carbonate which decomposes on heating.

(Total for Question 7 = 1 mark)

8 Chlorides of Group 1 elements produce coloured flames when

☒ **A** electrons become excited to a higher energy level.

☒ **B** excited electrons move from a higher to a lower energy level.

☒ **C** an outer electron leaves the atom.

☒ **D** electrons move between the negative and positive ions.

(Total for Question 8 = 1 mark)

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9 This question is about the following compounds.

A Barium carbonate

B Lithium nitrate

C Potassium bromide

D Potassium nitrate

(a) Which compound gives a green colour in a flame test?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which compound gives a lilac colour in a flame test and does **not** decompose on heating?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

N 3 5 6 9 2 A 0 4 2 4

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10 20 cm^3 of sulfuric acid, concentration 0.25 mol dm^{-3}, was neutralized in a titration with barium hydroxide, concentration 0.50 mol dm^{-3}. The equation for the reaction is

$$Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$$

(a) The volume of barium hydroxide required was

(1)

☒ **A** 10 cm^3

☒ **B** 20 cm^3

☒ **C** 25 cm^3

☒ **D** 40 cm^3

(b) During the titration, the barium hydroxide was added until it was present in excess. The electrical conductivity of the titration mixture

(1)

☒ **A** increased steadily.

☒ **B** decreased steadily.

☒ **C** increased and then decreased.

☒ **D** decreased and then increased.

(Total for Question 10 = 2 marks)

11 Which of the following trends occurs going down the elements in Group 2?

☒ **A** The solubility of the hydroxides increases.

☒ **B** The first ionization energy increases.

☒ **C** The solubility of the sulfates increases.

☒ **D** The stability of the carbonates to heat decreases.

(Total for Question 11 = 1 mark)

12 Which of the following is **not** a true statement about hydrogen iodide?

☒ **A** It forms steamy fumes in moist air.

☒ **B** It dissolves in water to form an acidic solution.

☒ **C** It forms a cream precipitate with silver nitrate solution.

☒ **D** It forms dense white smoke with ammonia.

(Total for Question 12 = 1 mark)

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13 Chemical reactions may involve

A oxidation

B reduction

C no change in oxidation number

D disproportionation

Which of the terms above best describes what happens to the **chlorine** in the following reactions?

(a) $Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HOCl(aq)$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) $Cl_2(g) + 2Na(s) \rightarrow 2NaCl(s)$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) $NaCl(s) + H_2SO_4(l) \rightarrow HCl(g) + NaHSO_4(s)$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 13 = 3 marks)

N 3 5 6 9 2 A 0 6 2 4

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14 When chloroethane is heated with a concentrated solution of potassium hydroxide in **ethanol**, the reaction which occurs is

☒ **A** substitution.

☒ **B** elimination.

☒ **C** hydrolysis.

☒ **D** redox.

(Total for Question 14 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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15 Chloroethane reacts with **aqueous** potassium hydroxide solution, producing ethanol as the organic product.

(a) The hydroxide ion is acting as

(1)

☒ **A** an electrophile.

☒ **B** a nucleophile.

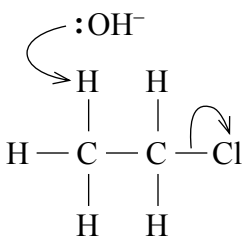
☒ **C** an oxidizing agent.

☒ **D** a reducing agent.

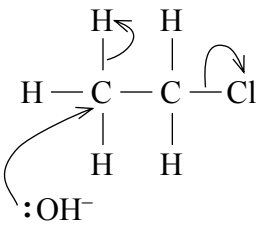
(b) Which of the following shows the correct electron-pair movements in this reaction?

(1)

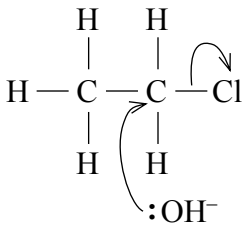
☒ **A**



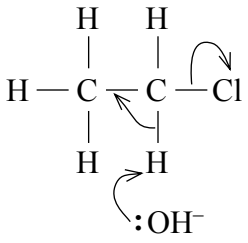
☒ **B**



☒ **C**



☒ **D**



(Total for Question 15 = 2 marks)

TOTAL FOR SECTION A = 20 MARKS

N 3 5 6 9 2 A 0 8 2 4

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

16 Magnesium nitrate, $Mg(NO_3)_2$, decomposes when it is heated. One product is the brown gas, nitrogen dioxide.

(a) (i) Write an equation for this reaction. State symbols are **not** required.

(2)

(ii) Calcium nitrate decomposes in a similar way to magnesium nitrate, but at a higher temperature.

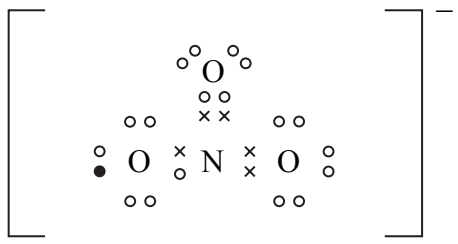
Explain why the two nitrates have different stability to heat.

(2)

(b) Sodium nitrate decomposes to give different products to magnesium nitrate. Write an equation for the decomposition of sodium nitrate. State symbols are **not** required.

(1)

(c) A student suggested that the structure of the nitrate ion, NO_3^-, is



Scientists have found that the bonds between nitrogen and oxygen in the nitrate ion are all the same length. Is the student's suggestion supported by this evidence? Explain your answer.

(1)

(d) Nitrogen dioxide gas can dimerize to dinitrogen tetroxide, N_2O_4, a very pale yellow gas, as shown in the equation below.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -58 \text{ kJ mol}^{-1}$$

(i) What would you see when an equilibrium mixture of these gases is warmed gently? Explain your answer.

(2)

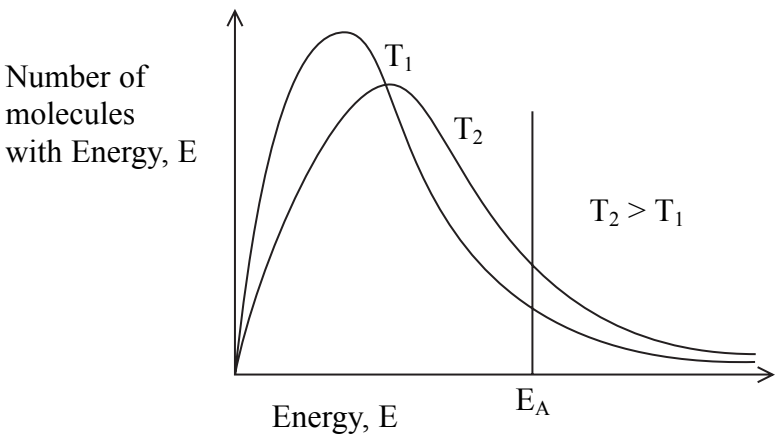
N 3 5 6 9 2 A 0 1 0 2 4

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(ii) Explain why an equilibrium mixture of these gases eventually becomes paler in colour when the pressure on it is increased.

(2)

(e) Two Maxwell-Boltzmann distributions showing the energy of particles in a gas at different temperatures, T_1 and T_2, are shown below. The activation energy for the reaction is labelled E_A.



Use the distributions to explain why gases react faster when the temperature is increased.

(2)

(Total for Question 16 = 12 marks)

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17 This question is about some reactions of halogens and halide ions.

(a) (i) When chlorine is added to a solution containing bromide or iodide ions, a colour change occurs. What solvent would you add to the mixture to confirm the identity of the halogen produced?

(1)

(ii) Give the result for the test with this solvent in a reaction in which bromine is produced.

(1)

(b) (i) Solid potassium bromide and potassium iodide can be distinguished by their reactions with concentrated sulfuric acid.

Potassium bromide reacts with concentrated sulfuric acid initially to produce hydrogen bromide. This reacts further, as shown below, to produce a sharp smelling gas and a brown fuming liquid.

$$2HBr(g) + H_2SO_4(l) \rightarrow SO_2(g) + Br_2(l) + 2H_2O(l)$$

Show, by use of oxidation numbers for sulfur, that the sulfuric acid has been reduced.

(2)

(ii) State TWO observations, which would differ from those with potassium bromide, when potassium iodide reacts with concentrated sulfuric acid.

(2)

N 3 5 6 9 2 A 0 1 2 2 4

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(iii) One product of the reaction with potassium iodide is hydrogen sulfide, H_2S.
How does this show that iodide ions are more powerful reducing agents than bromide ions?

(1)

.....

.....

.....

.....

.....

(c) In areas where the natural concentration of fluoride ions in rocks is low, some water authorities add fluoride to the water supply to improve the dental health of children. An alternative would be to supply free fluoride tablets.

Give ONE reason why it could be considered more ethical to supply free fluoride tablets rather than to add fluoride compounds to the water supply.

(1)

.....

.....

.....

.....

(Total for Question 17 = 8 marks)

18 Butan-1-ol and three other alcohols, **X**, **Y** and **Z**, are isomers.

(a) (i) Give TWO observations you would make when any one of the alcohols reacts with sodium.

(2)

.....

.....

.....

.....

(ii) Give the molecular formula of the organic product of the reaction.

(1)

.....

(b) Isomer **X** does **not** react with a mixture of potassium dichromate(VI) and sulfuric acid.

Draw the displayed formula of **X** and name it.

(2)

Name .....

(c) When isomer **Y** is heated under reflux with a mixture of potassium dichromate(VI) and sulfuric acid, it forms 2-methylpropanoic acid.

Deduce the structural formula of the alcohol **Y**.

(1)

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(d) (i) Isomer **Z** reacts with a mixture of potassium dichromate(VI) and sulfuric acid to form a compound **Q**, which does **not** react with Fehling's or Benedict's solution.

Deduce the structural formula of the alcohol **Z**.

(1)

(ii) What would be the principal difference between the infrared spectrum of **Q** and the infrared spectrum of 2-methylpropanoic acid?

You are **not** expected to quote absorption values.

(1)

(e) One of the isomers, **X**, **Y** or **Z** can be converted to 2-chlorobutane.

What reagent would you use to carry out this conversion?

(1)

(f) (i) 2-chlorobutane reacts with silver nitrate in a mixture of ethanol and water as a solvent. What would you see when the reaction occurred?

(1)

*(ii) Both ethanol and water contain hydrogen bonds. By considering the hydrogen bonding on these two solvents, suggest why 2-chlorobutane is more soluble in ethanol than in water.

(2)

(Total for Question 18 = 12 marks)

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19 The concentration of iodine in solution can be measured by titration with sodium thiosulfate solution.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

(a) Name a suitable indicator which could be used for this titration.

(1)

(b) The amount of sulfur dioxide in the atmosphere can be measured by passing a known volume of air through iodine solution. Sulfur dioxide converts iodine to iodide ions.

$$SO_2(g) + I_2(aq) + 2H_2O(l) \rightarrow SO_4^{2-}(aq) + 4H^+(aq) + 2I^-(aq)$$

In an experiment, 100 m^3 of air were passed through 100 cm^3 of iodine, concentration 0.0100 mol dm^{-3}. The remaining iodine was titrated with sodium thiosulfate solution and reacted with 12.60 cm^3 of sodium thiosulfate, concentration 0.100 mol dm^{-3}.

(i) How many moles of iodine were present in the solution of the iodine at the start of the experiment?

(1)

(ii) How many moles of iodine remained in the solution at the end of the experiment?

(2)

(iii) Calculate the number of moles of iodine which **reacted** with the sulfur dioxide, and hence the number of moles of sulfur dioxide in 100 m^3 of air.

(2)

N 3 5 6 9 2 A 0 1 6 2 4

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(iv) The European Commission recommend exposure to sulfur dioxide in air should be less than 350 micrograms (350×10^{-6} g) per cubic metre.

Calculate whether the sulfur dioxide in this sample of air was within this limit. One mole of sulfur dioxide has mass 64.1 g.

(2)

(c) Explain whether the changes below would or would not improve the experimental procedure for measuring the concentration of sulfur dioxide in air used in (b).

(i) The 100 cm^3 of iodine was divided into 25 cm^3 samples before titration.

(1)

(ii) The concentration of sodium thiosulfate used to titrate the iodine was changed from 0.100 mol dm^{-3} to 0.050 mol dm^{-3}.

(2)

(iii) 150 m^3 of air was passed through the iodine. The solutions used were of the same concentrations as in the original experiment.

(2)

(Total for Question 19 = 13 marks)

TOTAL FOR SECTION B = 45 MARKS

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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

20

Fuel from the air?

A new catalyst that can break down carbon dioxide gas could allow us to use carbon from the atmosphere as a fuel source in a similar way to plants.

Plants break the stable bonds in carbon dioxide during photosynthesis. In the natural process, the carbon dioxide molecule is initially bonded to nitrogen atoms, making reactive compounds called carbamates. Carbamates are derivatives of carbamic acid, NH_2CO_2H. These compounds can then be broken down, allowing the carbon to be used in the synthesis of other plant products such as sugars and proteins.

A new catalyst produced by scientists is a graphite-like compound made from flat layers of carbon and nitrogen atoms arranged in hexagons. Carbon dioxide binds to the catalyst and takes part in the following reaction, which occurs at 150 °C and at about three times atmospheric pressure.

$$\underset{\text{benzene}}{C_6H_6} + CO_2 \rightarrow \underset{\text{phenol}}{C_6H_5OH} + CO$$

Carbon monoxide can then be used to make liquid fuels such as methanol.

The energy required for photosynthesis comes from light, and experiments are now going on to develop a light activated catalyst which could break down carbon dioxide in a new process.

(Source: adapted from an article from the *NewScientist.com* by Tom Simonite, March 2007)

*(a) Why are the bonds **within** a layer of carbon atoms in graphite stronger than the bonds **between** the layers of carbon atoms?

(2)

N 3 5 6 9 2 A 0 1 8 2 4

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(b) The data below gives the relative electrical conductivity of a pure graphite crystal.

Relative conductivity in plane of carbon hexagons	Relative conductivity perpendicular to plane of carbon hexagons
3.7	0.0017

Explain why the relative electrical conductivity of graphite differs with direction.

(2)

(c) Suggest why the strength of the bond between the layers in graphite would increase if some carbon atoms were replaced with nitrogen atoms.

(2)

(d) Suggest ONE benefit of using a light activated catalyst for the new process.

(1)

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(e) The liquid fuel, methanol, is made by reacting carbon monoxide with hydrogen.

Write an equation for this reaction. State symbols are **not** required.

(1)

*(f) Benzene, which is needed for the new process of breaking down carbon dioxide, can be made from coal. It is now usually made by catalytic treatment of one fraction of crude oil at temperatures of around 500 °C and 20 atmospheres pressure.

Suggest the benefits and disadvantages of breaking down carbon dioxide using benzene and the catalyst as described in the passage. You should consider

- the energy and resources needed
- the effects on the atmosphere
- whether it is a beneficial method for producing energy compared to direct use of fossil fuels.

(6)

N 3 5 6 9 2 A 0 2 0 2 4

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(g) Carbon exists in forms other than graphite. Nanotubes are rolls of graphite layers, and fullerenes are cages of carbon atoms. Both nanotubes and fullerenes can trap other substances in their structures, and fullerenes can be coated with other substances.

Give ONE application of carbon nanotubes or fullerenes which exploits this behaviour.

(1)

.....

(Total for Question 20 = 15 marks)

TOTAL FOR SECTION C = 15 MARKS
TOTAL FOR PAPER = 80 MARKS

N 3 5 6 9 2 A 0 2 1 2 4

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N 3 5 6 9 2 A 0 2 2 2 4

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N 3 5 6 9 2 A 0 2 3 2 4

The Periodic Table of Elements

1	2												3	4	5	6	7	0 (8) (18)
						1.0 H hydrogen 1												4.0 He helium 2
(1)	(2)												(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4												10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)		27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30		69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111								

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)
January 2010

GCE

GCE Chemistry (6CH02/01)

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January 2010

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the Mark Scheme

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

6CH02/01

Section A

Question Number	Correct Answer	Reject	Mark
1	C		**1**

Question Number	Correct Answer	Reject	Mark
2	A		**1**

Question Number	Correct Answer	Reject	Mark
3	D		**1**

Question Number	Correct Answer	Reject	Mark
4	D		**1**

Question Number	Correct Answer	Reject	Mark
5	A		**1**

Question Number	Correct Answer	Reject	Mark
6	B		**1**

Question Number	Correct Answer	Reject	Mark
7	C		**1**

Question Number	Correct Answer	Reject	Mark
8	B		**1**

Question Number	Correct Answer	Reject	Mark
9(a)	A		**1**

Question Number	Correct Answer	Reject	Mark
9(b)	C		**1**

Question Number	Correct Answer	Reject	Mark
10(a)	A		**1**

Question Number	Correct Answer	Reject	Mark
10(b)	D		**1**

Question Number	Correct Answer	Reject	Mark
11	A		**1**

Question Number	Correct Answer	Reject	Mark
12	C		**1**

Question Number	Correct Answer	Reject	Mark
13(a)	D		**1**

Question Number	Correct Answer	Reject	Mark
13(b)	B		**1**

Question Number	Correct Answer	Reject	Mark
13(c)	C		**1**

Question Number	Correct Answer	Reject	Mark
14	B		**1**

Question Number	Correct Answer	Reject	Mark
15 (a)	B		**1**

Question Number	Correct Answer	Reject	Mark
15 (b)	C		**1**

Section B

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$ Correct formulae (1) Balancing (1) **ALLOW** multiples or equation divided by 2 Second mark on correct species only Ignore state symbols even if incorrect **ALLOW** N_2O_4 Extra oxygen molecules on both sides in a balanced equation		**2**

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	Stand alone marks Mg^{2+} / Magnesium **ion** smaller or fewer electron **shells** / greater charge density (1) **OR** Magnesium **ion** has same charge (as calcium ion) but is smaller (1) Causes more polarisation /distortion of nitrate / anion (electron clouds) / N—O (bond)(1) **OR** MgO produced has stronger lattice (1) **OR** production of MgO is more exothermic (1) **OR** reverse argument based on Ca^{2+}	Magnesium / calcium / atoms / molecules	**2**

Question Number	Acceptable Answers	Reject	Mark
16(b)	$2NaNO_3 \rightarrow 2NaNO_2 + O_2$ **ALLOW** multiples or equation divided by 2 Ignore state symbols even if incorrect **ALLOW** Extra oxygen molecules on both sides in a balanced equation		**1**

Question Number	Acceptable Answers	Reject	Mark
16(c)	No as…. double bond would be shorter (than single bond) / shorter than dative (covalent) bond. **ALLOW** Structure has double and single bonds (between N and O) Double and single bonds have different lengths	Implication that the single covalent and dative covalent bonds have different lengths	**1**

Question Number	Acceptable Answers	Reject	Mark
16(d)(i)	Mark independently Goes darker (brown) (1) ALLOW Goes browner Ignore comments on mixture first becoming paler if volume increases Equilibrium moves in the endothermic direction (1) **OR** Equilibrium moves left as forward reaction is exothermic (1) For second mark **ALLOW** Equilibrium moves left to counteract addition of heat / increase in temperature(1) **OR** Reaction removes added heat by moving left (1)	Brown (gas evolved)	**2**

Question Number	Acceptable Answers	Reject	Mark
16(d)(ii)	Equilibrium moves right (ALLOW forwards) (so NO_2 concentration decreases) (1) **OR** Reaction reduces pressure (1) As fewer moles / molecules(ALLOW particles) (of gas) on RHS (1) Stand alone marks		**2**

Question Number	Acceptable Answers	Reject	Mark
16(e)	At T_2 more molecules/collisions have energy greater than (or equal to) E_A (1) This can be shown on the diagram by indicating areas to right of vertical line Energy must be at least E_A for successful collision / for reaction (1) **OR** So more collisions have sufficient energy to react(1) Ignore references to the average energy and speed of the molecules		**2**

Question Number	Acceptable Answers	Reject	Mark
17(a)(i)	A hydrocarbon (solvent) / volasil / named hydrocarbon solvent / tetrachloromethane Formulae	Ethanol Alkenes	**1**

Question Number	Acceptable Answers	Reject	Mark
17(a)(ii)	Red / brown /orange / amber / yellow Or any combination No TE on incorrect / no reagent		**1**

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	Oxidation number of S in H_2SO_4 =(+)6 Oxidation number of S in SO_2 =(+)4 (1) Oxidation number had decreased (1) ALLOW S has gained electrons for second mark Second mark stands alone provided oxidation numbers have decreased, even if calculated wrongly	Just 'S has gained electrons' without calculating oxidation numbers	**2**

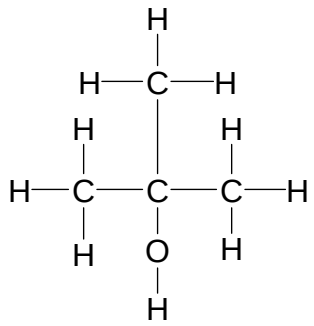
Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	Black / (shiny) grey solid (1) Purple / violet / pink vapour / fumes (1) Smell of (bad) eggs (1) Yellow solid (1) **ALLOW** Brown liquid (1) Any two	Purple solid	**2**

Question Number	Acceptable Answers	Reject	Mark
17(b)(iii)	Oxidation number of S has reduced more / to –2 (in H_2S) (1) OR Oxidation number of S is lower in H_2S (than in SO_2) If ON of S in H_2S is calculated it must be correct		**1**

Question Number	Acceptable Answers	Reject	Mark
17(c)	People can choose whether to take extra fluoride ALLOW Fluoride is not released into the environment	Fluoride can be monitored	**1**

Question Number	Acceptable Answers	Reject	Mark
18(a)(i)	Effervescence / fizzing / bubbles (of colourless gas) (1) Mixture gets hot (1) White solid (ALLOW ppt) produced / sodium dissolves or disappears (1) Any two Ignore inferences unless incorrect		**2**

Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	C_4H_9ONa / $C_4H_9O^-Na^+$ /structural or displayed formulae of any of the isomers: $CH_3CH_2CH_2CH_2ONa$ $(CH_3)_2CHCH_2ONa$ $(CH_3)_3CONa$ $CH_3CH(ONa)CH_2CH_3$	Structures showing a covalent bond between O and Na C_4H_9NaO / $C_4H_9Na^+O^-$	**1**

Question Number	Acceptable Answers	Reject	Mark
18(b)	 Do not penalise undisplayed CH_3 or O-H (1) (2-)methylpropan-2-ol(1) Marks are stand alone	Missing hydrogen atoms Skeletal formula	**2**

Question Number	Acceptable Answers	Reject	Mark
18(c)	$(CH_3)_2CHCH_2OH$ OR correct displayed formula OR semi-displayed formula **ALLOW** $CH_3CH(CH_3)CH_2OH$ **ALLOW** missing bracket round CH_3 in this version Ignore names	Missing hydrogen atoms Skeletal formula	**1**

Question Number	Acceptable Answers	Reject	Mark
18(d)(i)	CH_3CH_2 $CH(OH)CH_3$ (1) OR correct displayed formula OR semi-displayed formula Do not penalise missing bracket round OH Ignore names	Missing hydrogen atoms Skeletal formula	**1**

Question Number	Acceptable Answers	Reject	Mark
18(d)(ii)	O—H absorption / peak in 2-methylpropanoic acid / No O—H absorption / peak in **Q** ALLOW C—O absorption / peak in 2-methylpropanoic acid / No C—O absorption / peak in **Q** Ignore references to broad or sharp peaks and to the fingerprint region		**1**

Question Number	Acceptable Answers	Reject	Mark
18(e)	PCl_5 / PCl_3 / conc HCl / $SOCl_2$ / mixture of NaCl + H_2SO_4 / mixture of KCl + H_2SO_4 Ignore reference to concentration of H_2SO_4 OR Names	Hydrogen chloride Conc hydrogen chloride HCl PCl_5(aq), PCl_3(aq), $SOCl_2$(aq)	**1**

Question Number	Correct Answer	Reject	Mark
18(f)(i)	White precipitate/ white solid		**1**

Question Number	Acceptable Answers	Reject	Mark
18(f)(ii) QWC	Water has 2 hydrogen bonds per molecule (on average) whereas ethanol only has 1 (1) **ALLOW** Water has more hydrogen bonds (per molecule) than ethanol Needs more energy to break H bonds in water (so less soluble) / H bonding (ALLOW intermolecular forces) stronger in water (1) Second mark dependent on first. Ignore references to London, dispersion and van der Waals forces		**2**

Question Number	Acceptable Answers	Reject	Mark
19(a)	Starch (solution)		**1**

Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	I_2 at start = 1 x 10^{-3} / 0.001 (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	1.26 x 10^{-3} (mol) thiosulfate (1) 6.3(0) x 10^{-4} / 0.00063 (mol) I_2 (1) Correct answer with no working (2) Ignore SF except 1 SF		**2**

Question Number	Acceptable Answers	Reject	Mark
19(b)(iii)	I_2 used = (1 x 10^{-3} - 6.30 x 10^{-4}) = 3.70 x 10^{-4} (mol) (1) Mol SO_2 = mol I_2 = 3.70 x 10^{-4} / 0.00037 (mol) (1) Correct answer with no working (1) **ALLOW** TE from (i) and (ii) Ignore SF except 1 SF		**2**

Question Number	Acceptable Answers	Reject	Mark
19(b)(iv)	Mass SO_2 in 100 m^3 =(64.1 x 3.70 x 10^{-4}) (1) Mass SO_2 in 1 m^3 = 64.1 x 3.70 x 10^{-4} /100 = 237(.2) x 10^{-6} g = 2.37 x 10^{-4}g (1) (= 237.2 / 237 / 240 μg) units required (∴ within limit) Allow TE from (iii) Ignore SF except 1 SF		**2**

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	Improved because titration may be repeated /averages could be taken **ALLOW** Smaller titration reading so greater (%) error		**1**

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	Larger titration reading (1) So smaller (%)error in titration reading (1) OR Smaller mass of sodium thiosulfate used to make solution (1) So greater %) error in the mass measurement (1) Second mark dependent on correct first or near miss		**2**
Question Number	Acceptable Answers	Reject	Mark
19(c)(iii)	Smaller titration reading as more I_2 reacts/ less I_2 left (1) So greater (%) error in titration reading (1) Second mark dependent on correct first or near miss) OR Smaller (%) error in measuring volume of air (1)		**2**

Section C

Question Number	Acceptable Answers	Reject	Mark
20(a) **QWC**	(Strong) covalent bonds between atoms within the layers / good overlap of electron orbitals in layers (1) (Weak) London / dispersion / induced dipole-induced dipole (ALLOW van der Waals) forces between layers (1)	Intermolecular forces alone	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)	Within a layer, one electron per carbon is (ALLOW electrons are) **delocalized** (so electrons can move easily along layers) (1) Energy gap (ALLOW distance) between layers is too large for (easy) electron transfer (1)	Electrons between layers not delocalized	**2**

Question Number	Acceptable Answers	Reject	Mark
20(c)	N has **one** more (outer shell) electron than C(1) Would increase number of (delocalised) electrons … contributing to the London / dispersion (ALLOW van der Waals) forces (1) OR holding layers together (1)	Just London / dispersion / van der Waals) forces stronger	**2**

Question Number	Acceptable Answers	Reject	Mark
20(d)	No **heat** energy required / low energy requirement / high temperatures not needed / sunlight (which is renewable) could be used Ignore generalisations such as ‘greener’, ‘environmentally friendly’ ‘smaller carbon footprint’ cheaper or fossil fuels not used.		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (e)	$CO + 2H_2 \rightarrow CH_3OH$ OR Structural and displayed formulae ALLOW CH_4O for CH_3OH		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (f) QWC	Score 1 mark for each clearly made point 1. Need energy to make benzene / catalyst / hydrogen 2. High energy / temperature / pressure needed for the reaction (ALLOW stated T or P) 3. Fossil fuel (oil or coal) used as source of energy, benzene or hydrogen 4. Hydrogen has to be manufactured 5. Hydrogen has to be stored 6. Fossil fuels non-renewable 7. Reduces CO_2 in atmosphere / recycles CO_2 8. CO_2, is a greenhouse gas / causes global warming 9. CO toxic 10. Benzene toxic / carcinogenic 11. 100% atom economy in making methanol 12. Beneficial if phenol useful / not beneficial if phenol a waste product Ignore generalisations such as 'greener', 'smaller carbon footprint' or 'environmentally friendly'.	References to the ozone layer	**6**

Question Number	Acceptable Answers	Reject	Mark
20 (g)	Delivering drugs to cells **ALLOW** Delivering drugs to specific / targeted parts of the body Catalyst with big surface area	Just drug delivery	**1**

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Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Wednesday 3 June 2009 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/3/

H 3 4 4 7 2 A 0 1 2 4

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 What is the oxidation number of chlorine in the ClO_3^- ion?

☒ **A** –1

☒ **B** +4

☒ **C** +5

☒ **D** +6

(Total for Question 1 = 1 mark)

2 Which of these reactions is **not** a redox reaction?

☒ **A** $Mg(NO_3)_2(s) \rightarrow MgO(s) + 2NO_2(g) + ½O_2(g)$

☒ **B** $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

☒ **C** $Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$

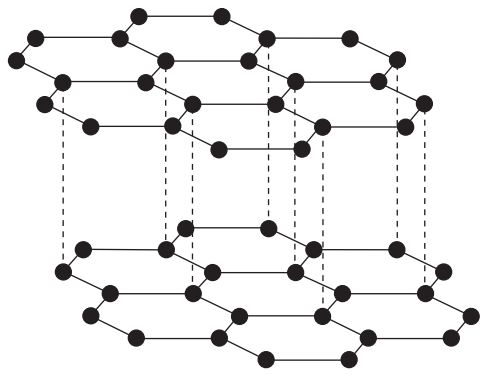
☒ **D** $Cl_2(aq) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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3 Which of these carbon structures is represented by the diagram below?



☒ **A** Graphite

☒ **B** Diamond

☒ **C** A fullerene

☒ **D** A carbon nanotube

(Total for Question 3 = 1 mark)

---

4 What colour precipitate would you expect to see if 1-bromopropane was heated with a solution of silver nitrate?

☒ **A** Orange

☒ **B** White

☒ **C** Yellow

☒ **D** Cream

(Total for Question 4 = 1 mark)

---

5 Which of these bond angles is the smallest?

☒ **A** HNH in NH_3

☒ **B** HCH in CH_4

☒ **C** HOH in H_2O

☒ **D** OCO in CO_2

(Total for Question 5 = 1 mark)

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6 Which statement best describes the shape and bond angles in the molecule SF_6?

☒ **A** Octahedral, 90° and 180°

☒ **B** Trigonal bipyramidal, 90° and 180°

☒ **C** Octahedral, 90° and 120°

☒ **D** Trigonal bipyramidal, 90° and 120°

(Total for Question 6 = 1 mark)

7 Which of the following values for the mass/charge ratio for singly charged ions would be present in the mass spectrum of propanal, CH_3CH_2CHO, but not of propanone, CH_3COCH_3?

☒ **A** 15

☒ **B** 29

☒ **C** 43

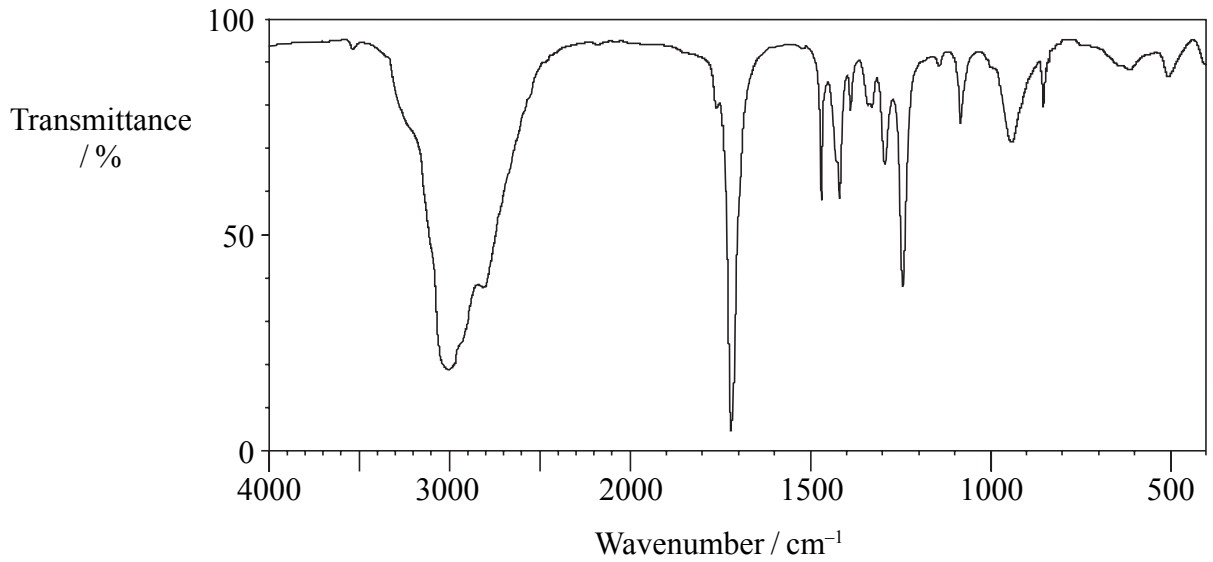
☒ **D** 58

(Total for Question 7 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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8 The infrared spectrum below is most likely to be that of a member of which homologous series?



C—Cl stretching vibrations 600 – 800 cm^{-1}
O—H stretching vibrations 2500 – 3300 cm^{-1}
C═O stretching vibrations 1680 – 1740 cm^{-1}

☒ **A** Alcohol

☒ **B** Chloroalkane

☒ **C** Aldehyde

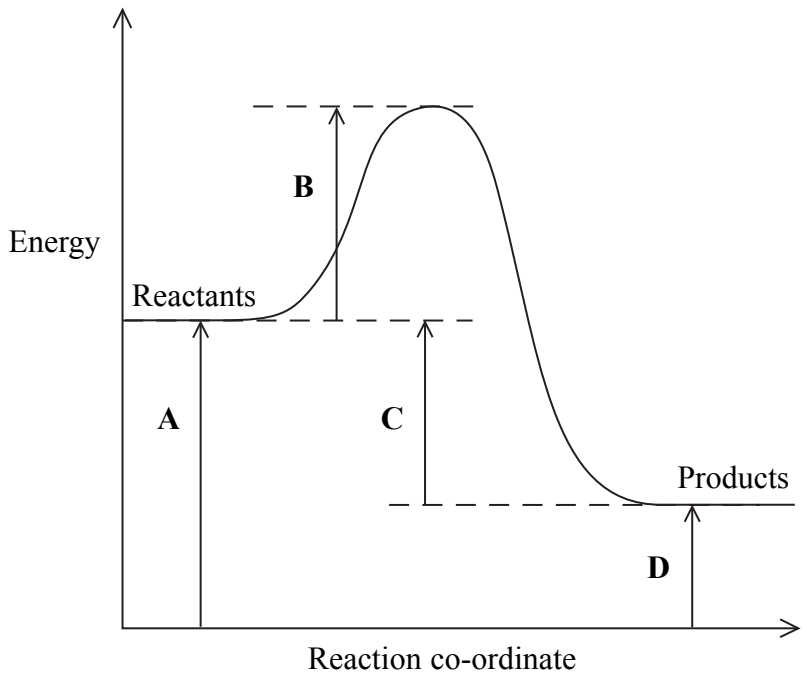
☒ **D** Carboxylic acid

(Total for Question 8 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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9 In the reaction profile below, which energy change would alter if a catalyst was added to the reaction?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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10 In the equilibrium below, what effect would the changes described have on the system?

$$2H_2S(g) + SO_2(g) \rightleftharpoons 3S(s) + 2H_2O(g) \qquad \Delta H \text{ is negative}$$

(a) Increase in temperature

(1)

☒ **A** increase rate, decrease yield

☒ **B** increase rate, increase yield

☒ **C** decrease rate, decrease yield

☒ **D** decrease rate, increase yield

(b) Decrease in pressure

(1)

☒ **A** increase rate, decrease yield

☒ **B** increase rate, increase yield

☒ **C** decrease rate, decrease yield

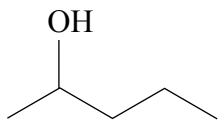
☒ **D** decrease rate, increase yield

(Total for Question 10 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

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11 What is the correct systematic name for the alcohol shown below?



- ☒ **A** hexan-4-ol
- ☒ **B** hexan-2-ol
- ☒ **C** pentan-4-ol
- ☒ **D** pentan-2-ol

(Total for Question 11 = 1 mark)

12 Which of these compounds is a secondary halogenoalkane?

- ☒ **A** $CH_3CH(OH)CH_3$
- ☒ **B** $CH_3CCl(CH_3)CH_3$
- ☒ **C** $CH_3CHClCH_3$
- ☒ **D** $CH_3CH_2CH_2Cl$

(Total for Question 12 = 1 mark)

13 The bonding in **gaseous** hydrogen halides is best described as

- ☒ **A** mainly covalent with an increasing tendency towards ionic as you go down the group.
- ☒ **B** mainly covalent with an increasing tendency towards ionic as you go up the group.
- ☒ **C** mainly ionic with an increasing tendency towards covalent as you go down the group.
- ☒ **D** mainly ionic with an increasing tendency towards covalent as you go up the group.

(Total for Question 13 = 1 mark)

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14 What would be the colour of the solution when iodine is dissolved in a hydrocarbon solvent?

☒ **A** Grey

☒ **B** Brown

☒ **C** Yellow

☒ **D** Purple

(Total for Question 14 = 1 mark)

15 Starch is often used as an indicator in titrations between sodium thiosulfate and iodine solutions. What colour change would you see at the end-point as sodium thiosulfate is added to iodine solution in the presence of starch?

☒ **A** Yellow to colourless

☒ **B** Colourless to yellow

☒ **C** Blue-black to colourless

☒ **D** Colourless to blue-black

(Total for Question 15 = 1 mark)

16 An electric field can affect the direction of a stream of some liquids. Which of these liquids would be affected by an electric field?

☒ **A** 1-chloropropane

☒ **B** Pentane

☒ **C** Tetrachloromethane

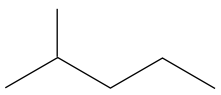
☒ **D** Cyclopentane

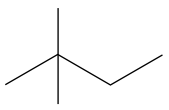
(Total for Question 16 = 1 mark)

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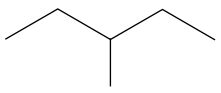
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17 Which of these isomers has the highest boiling temperature?

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 17 = 1 mark)

18 Which of the following statements is **true**?

☒ **A** Calcium hydroxide is more soluble in water than magnesium hydroxide.

☒ **B** Chlorine is more electronegative than fluorine.

☒ **C** Iodine is a stronger oxidizing agent than bromine.

☒ **D** The first ionization energy of barium is greater than that of strontium.

(Total for Question 18 = 1 mark)

19 Iodine can react with sodium hydroxide solution to form $NaIO_3(aq)$, according to the equation below.

$$3I_2(aq) + 6NaOH(aq) \rightarrow 5NaI(aq) + NaIO_3(aq) + 3H_2O(l)$$

Which of the statements about the reaction is **false**?

☒ **A** The oxidation number of some iodine atoms goes up.

☒ **B** At high temperatures NaIO(aq) also forms.

☒ **C** Sodium ions are spectator ions.

☒ **D** The oxidation number of some iodine atoms goes down.

(Total for Question 19 = 1 mark)

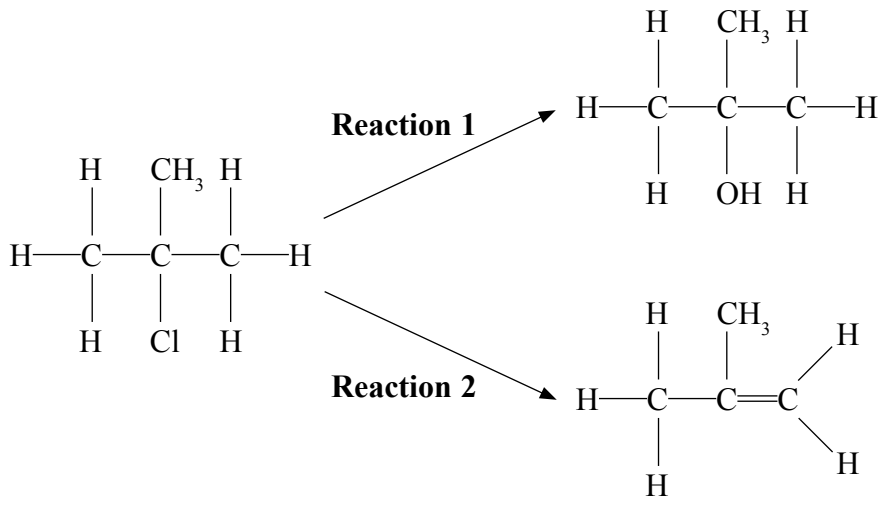
TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

20 When 2-chloro-2-methylpropane is heated in a mixture of water and ethanol at 65 °C, two types of reaction occur. A mixture of two organic products, 2-methylpropan-2-ol and 2-methylpropene, is formed.



(a) (i) Name the two reaction types that are taking place.

(2)

Reaction 1 .....

Reaction 2 .....

*(ii) Explain how the two products form, by describing the role of the water in each case.

(4)

Reaction 1 .....

.....

.....

.....

Reaction 2 .....

.....

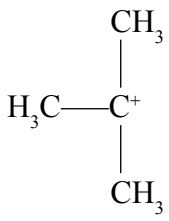
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(b) A proposed mechanism for **Reaction 1** involved the formation of the carbocation,



(i) What type of bond breaking must have occurred during the carbocation formation?

(1)

(ii) Suggest why 1-chlorobutane reacts with water via a different mechanism.

(2)

(c) Another halogenoalkane, 2-chlorobutane, behaves in a similar way to 2-chloro-2-methylpropane but in **Reaction 2** can form three different alkenes. Suggest how **three** different alkenes can form and give their displayed formulae.

(4)

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(d) Suggest why 2-fluoro-2-methylpropane would react more slowly than 2-chloro-2-methylpropane in **Reaction 1**.

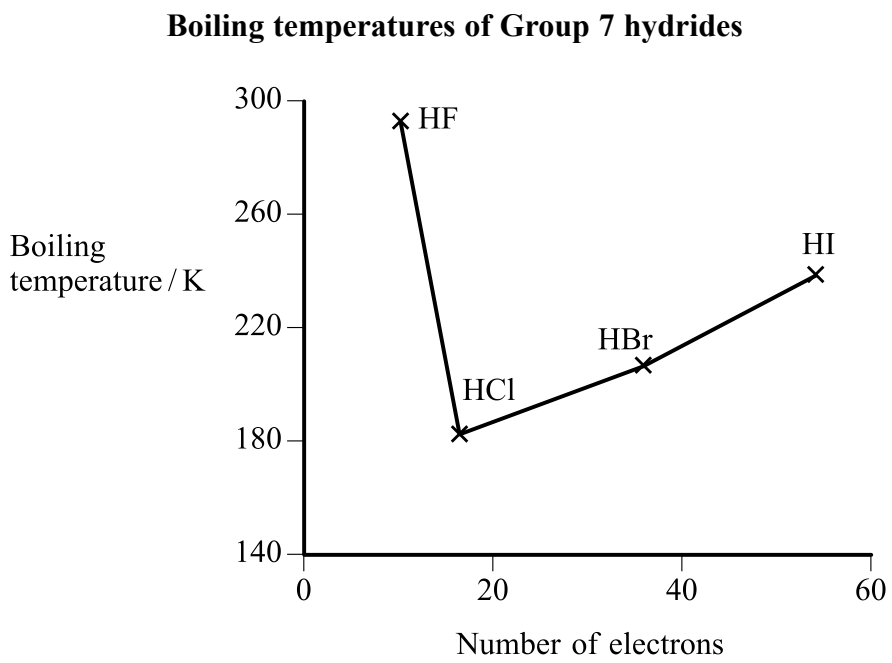
What reagent could you use instead of water to increase the rate of this reaction involving 2-fluoro-2-methylpropane? Explain why the reagent would have this effect.

(3)

(Total for Question 20 = 16 marks)

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21 The graph below shows the boiling temperatures of the hydrides of Group 7.



(a) (i) Identify the type of intermolecular force that gives rise to the unusually high boiling temperature of hydrogen fluoride.

(1)

(ii) State and explain whether the electronegativity of fluorine is greater than, similar to or less than, that of bromine.

Hence explain why hydrogen fluoride can form the type of intermolecular force named in (a)(i) but hydrogen bromide cannot.

(3)

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(iii) Use the graph to predict what the boiling temperature of hydrogen fluoride would be without the presence of the type of intermolecular force named in (a)(i).

(1)

(b) Propanone, CH_3COCH_3, is a useful solvent for cleaning glassware in laboratories.

(i) Why is propanone able to dissolve a wide range of substances?

(1)

(ii) Propanone can be used to remove both water and octane from glassware.

For each of these substances, identify the strongest intermolecular force formed with propanone and the feature of the propanone molecule involved.

(2)

Water

Octane

(Total for Question 21 = 8 marks)

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22 Calcium oxide, known as quicklime, is produced by the thermal decomposition of calcium carbonate, found naturally in limestone.

(a) (i) Explain what is meant by the term **thermal decomposition**.

(2)

(ii) Write an equation for the thermal decomposition of calcium carbonate, including state symbols.

(1)

(iii) Other Group 2 carbonates can also undergo thermal decomposition. Describe and explain the trend in thermal stability of carbonates down Group 2.

(3)

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(b) 0.121 g of an impure sample of quicklime was dissolved in 50.0 cm^3 of hydrochloric acid, concentration 0.100 mol dm^{-3}. The excess hydrochloric acid was titrated with sodium hydroxide solution, concentration 0.100 mol dm^{-3}, and 18.0 cm^3 was needed to just neutralize the acid. The indicator used was methyl orange.

The equations for the reactions involved are shown below.

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$$

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

(i) What colour would the indicator be at the end-point?

(1)

(ii) Calculate the number of moles of hydrochloric acid that reacted with the sodium hydroxide solution.

(1)

(iii) Calculate the number of moles of hydrochloric acid originally added to the quicklime. Use this answer and your answer to (b)(ii) to calculate the number of moles of quicklime that reacted with the hydrochloric acid.

(2)

(iv) Calculate the percentage purity of the sample of quicklime. Give your answer to **three** significant figures.

(2)

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(c) (i) Describe how to carry out a flame test on the impure sample of quicklime to confirm that it contains calcium ions.

(3)

.....

.....

.....

.....

.....

.....

(ii) If the flame test gave a green colour, in addition to the expected brick red flame, which Group 2 metal is also likely to be present?

(1)

.....

(Total for Question 22 = 16 marks)

TOTAL FOR SECTION B = 40 MARKS

H 3 4 4 7 2 A 0 1 8 2 4

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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

23

As levels of fossil fuel resources are getting lower, society is increasingly looking at the use of biofuels as alternatives to coal, oil and gas. Biofuels are derived from plants and examples include bioethanol, biodiesel and *Miscanthus*, a plant more commonly known as elephant grass. These fuels have the advantage of being renewable and the plants take in carbon dioxide as they grow.

Bioethanol is produced from crops such as sugar cane or corn. The raw plant material is treated to produce a sugary solution which is then fermented to produce ethanol, water and carbon dioxide gas. The ethanol is removed by distillation. The resulting solution contains about 96 % ethanol. The remaining water has to be removed by absorption using a suitable drying agent so that the ethanol can burn efficiently. The bioethanol can then be burnt alone or mixed with petrol in vehicle engines.

Biodiesel is formed by the hydrolysis of vegetable oils using sodium hydroxide solution, followed by esterification with methanol and a sodium hydroxide catalyst. Biodiesel can then be used on its own in diesel-engined vehicles or mixed with diesel derived from crude oil. Plants which are used to produce the vegetable oils include rapeseed in the UK, soya bean in the USA and palm oil in Asia.

Miscanthus, or elephant grass, is a quick growing, high-yield plant that grows up to four metres in height. After harvesting, the grass is left to dry and then burnt in power stations designed to run on solid fuels such as coal. In the United Kingdom, farms that produce elephant grass are normally situated within 50 miles of such a power station.

In an experiment to simulate the production of bioethanol, a student produced a water/ethanol mixture by fermentation of sucrose solution using yeast. It was then proposed to separate the ethanol from water by carrying out a distillation on the mixture. The mixture would then be dried using a suitable drying agent.

(a) Draw a diagram to show the most significant intermolecular force between an ethanol molecule and a water molecule. Label the bond angle between the molecules and state its value.

(2)

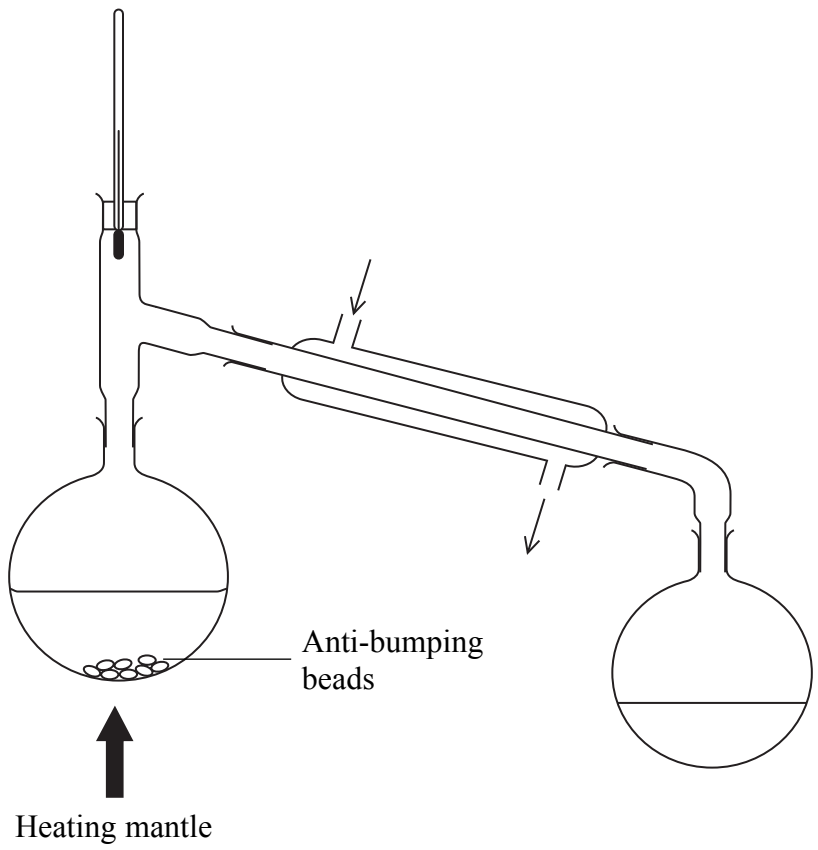
(b) The student proposed to set up the apparatus as shown below to carry out the distillation to try to separate the ethanol from water.

There are **three** errors with the set-up. Draw a circle around each error.

Describe what effect these errors would have if the student attempted to carry out the separation as shown.

[Clamps are not shown in the diagram but you can assume the apparatus is supported adequately.]

(6)



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(c) If a balance accurate to two decimal places was used to record the mass of ethanol collected, what would be the percentage error due to the balance readings if the total mass of ethanol collected was 20.10 g?

(1)

(d) Suggest a suitable drying agent to absorb the water remaining with the ethanol after distillation. Describe how you would use it to produce a dry sample of ethanol.

(2)

(e) Describe a chemical test you could carry out to confirm the presence of the –OH group in ethanol. What result would you expect to see?

(2)

Test .....

.....

Result .....

(f) *(i) Explain what is meant by a **carbon neutral fuel**.

(2)

*(ii) Suggest TWO reasons why these biofuels may **not** be carbon neutral and describe TWO effects that large scale production of biofuels may have on society. Which of the three biofuels do you think is the most sustainable? Justify your choice.

(5)

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(Total for Question 23 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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GCE

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Summer 2009

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General Marking Guidance

· All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.

· Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.

· Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.

· There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.

· All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.

· Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.

· When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.

· Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the mark scheme

1 / means that the responses are alternatives and either answer should receive full credit.

2 ( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

3 [ ] words inside square brackets are instructions or guidance for examiners.

4 Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

5 OWTTE means or words to that effect

6 ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

· show clarity of expression

· construct and present coherent arguments

· demonstrate an effective use of grammar, punctuation and spelling.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated "QWC" in the mark scheme BUT this does not preclude others.

6CH02/01

Section A

Question Number	Correct Answer	Reject	Mark
1	C		**1**

Question Number	Correct Answer	Reject	Mark
2	B		**1**

Question Number	Correct Answer	Reject	Mark
3	A		**1**

Question Number	Correct Answer	Reject	Mark
4	D		**1**

Question Number	Correct Answer	Reject	Mark
5	C		**1**

Question Number	Correct Answer	Reject	Mark
6	A		**1**

Question Number	Correct Answer	Reject	Mark
7	B		**1**

Question Number	Correct Answer	Reject	Mark
8	D		**1**

Question Number	Correct Answer	Reject	Mark
9	B		**1**

Question Number	Correct Answer	Reject	Mark
10 (a)	A		**1**

Question Number	Correct Answer	Reject	Mark
10 (b)	C		**1**

Question Number	Correct Answer	Reject	Mark
11	D		**1**

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Question Number	Correct Answer	Reject	Mark
12	C		**1**

Question Number	Correct Answer	Reject	Mark
13	B		**1**

Question Number	Correct Answer	Reject	Mark
14	D		**1**

Question Number	Correct Answer	Reject	Mark
15	C		**1**

Question Number	Correct Answer	Reject	Mark
16	A		**1**

Question Number	Correct Answer	Reject	Mark
17	C		**1**

Question Number	Correct Answer	Reject	Mark
18	A		**1**

Question Number	Correct Answer	Reject	Mark
19	B		**1**

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Section B

Question Number	Correct Answer	Reject	Mark
20 (a)(i)	**Reaction 1** – (nucleophilic) substitution **(1)** **Reaction 2** – elimination **(1)**		**2**

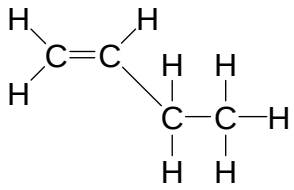
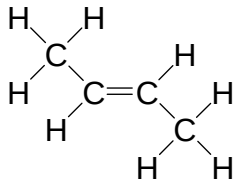
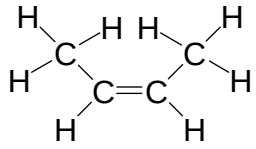
Question Number	Correct Answer	Reject	Mark
20 (a)(ii) QWC	**Reaction 1** - Water can behave as a nucleophile /water can donate a lone pair (from oxygen)/water has a lone pair/water forms an $^{-}$OH ion **(1)** And attack (positive) carbon (originally attached to Cl)/bonds to the carbon/bonds to the carbocation **(1)** **Reaction 2** - behaves as a base **(1)** and accepts a hydrogen ion/proton / donates e^{-} pair to H/removes a proton/removes a hydrogen ion/removes a H^{+} **(1)** In each case a correctly drawn mechanism could get **(2)**	Removes a H **atom**	**4**

Question Number	Correct Answer	Reject	Mark
20 (b)(i)	Heterolytic (fission) **Notes** Accept phonetic/incorrect spelling as long as the word is recognisable		**1**

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Question Number	Correct Answer	Reject	Mark
20 (b)(ii)	Butyl group less electron releasing/butyl group has less of a (positive) inductive effect **(1)** so less stable (positive charge on) carbocation **(1)** **0R** 1- chlorobutane is a primary halogenoalkane/the carbon only has 1 other C attached **(1)** So forms a less stable carbocation **(1)** **0R** Primary carbocation is less stable than a tertiary carbocation **(2)** **0R** Water/$^{-}$OH can attack C on 1˚ chloroalkane more easily (so no need to form cation) OWTTE / 1˚ chloroalkane reacts via SN2 mechanism/C–O bond forms before C–Cl breaks **(1)** As the carbon attacked is not surrounded by bulky groups OWTTE **(1)**	Negative inductive effect	**2**

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Question Number	Correct Answer	Reject	Mark
20 (c)	Hydrogen (ion) can be eliminated from C on either side (of C attached to Cl)/double bond can form between 1st and 2nd or 2nd and 3rd carbon OWTTE **(1)** **OR** double bond can't rotate (so methyl group and hydrogens can be fixed in position) to form E and Z isomers / geometric isomers/cis and trans/stereoisomers/or named in diagrams OWTTE **(1)** allow descriptions in terms of cis and trans  **(1)**  **(1)**  **(1)** Methyl and ethyl groups do not need to be fully displayed Structural formulae/skeletal formulae For all 3 **(2)** For 2 **(1)** For 1 **(0)** For an incorrect haloalkane structure that can form 3 isomers including cis/trans **(2 max)** (eg 2-chloropentane)		**4**

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Question Number	Correct Answer	Reject	Mark
20 (d)	(Slower) as C–F bond is stronger (than C-Cl)/fluorine bonds more strongly/fluorine holds the carbon more strongly **OR** Slower as **F^-** is a poorer leaving group (than Cl^-) **(1)** Use sodium hydroxide /NaOH/ potassium hydroxide /KOH/ hydroxide ions **(1)** As OH^- is a stronger nucleophile / OH^- has a full negative charge/ more strongly attracted to $C^{\delta+}$ /OH^- has more lone pairs (than water)/ OH^- is more negative than water **(1)**	 Alkali Hydroxide	**3**

Question Number	Correct Answer	Reject	Mark
21 (a)(i)	Hydrogen bonding Hydrogen bond(s) H bonding H bond(s) **Notes** Accept phonetic/incorrect spelling as long as the word is recognisable	Not "hydrogen" on its own Dipole-dipole bond Permanent dipole-dipole bond Covalent bond van der Waals' (forces) Temporary dipole-dipole Induced dipole-dipole London forces Any correct answer in conjunction with an incorrect response, eg hydrogen dipole-dipole bond.	**1**

Question Number	Correct Answer	Reject	Mark
21 (a)(ii)	(Fluorine atom) is more electronegative **(1)** Because it has less shielding / (bonding) electrons closer to the nucleus/ smaller /has less shells (so greater pull from nucleus on bonding electrons) **(1)** so HF has a (greater) dipole moment/$H^{\delta+}$ on HF (greater than on HBr)/HF is (more) polar **(1)**		**3**

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Question Number	Correct Answer	Reject	Mark
21 (a)(iii)	Between 150 – 180 (K) Accept a range within the range e.g. '150-170'	°C	**1**

Question Number	Correct Answer	Reject	Mark
21 (b)(i)	Because propanone has both polar and non polar characteristics/can form both London forces and H bonds/can form London forces and dipole-dipole forces OWTTE **(1)** London forces can be described as Van der Waals VDW Temporary dipole-dipole Instantaneous dipole-induced dipole		**1**

Question Number	Correct Answer	Reject	Mark
21 (b)(ii)	**Water**: Hydrogen bonds with the (oxygen of the) carbonyl group/H bonds to the oxygen **(1)** **Octane:** London forces with methyl groups/carbon chain/CH groups/ H atoms **(1)** Both forces given allow **(1)**	Carbon atoms	**2**

Question Number	Correct Answer	Reject	Mark
22 (a)(i)	Use of heat **(1)** To break down (a reactant)/one reactant into more than one product **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
22 (a)(ii)	$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ Allow correct multiples		**1**

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Question Number	Correct Answer	Reject	Mark
22 (a)(iii)	Group 2 carbonates are more (thermally) stable as you go down the group **(1)** as the cations get bigger/charge density gets less/cation has more shells **(1)** So have less of a polarising effect/distortion on the carbonate (ion)/less of a weakening effect on C–O **(1)** 2nd and 3rd marks cq on first	Metal gets bigger/element gets bigger Carbonate molecule	**3**

Question Number	Correct Answer	Reject	Mark
22 (b)(i)	orange	Yellow Any colour in conjunction with orange	**1**

Question Number	Correct Answer	Reject	Mark
22 (b)(ii)	$(18.0/1000 \times 0.100) = 1.8 \times 10^{-3}$ /0.0018/2×10^{-3}/0.002 *IGNORE* sf and units even if incorrect		**1**

Question Number	Correct Answer	Reject	Mark
22 (b)(iii)	$(50/1000 \times 0.100) = 5 \times 10^{-3}$ **(1)** [If candidate fails to divide by 1000 in both (b)(ii) and b(iii) penalise only once] Moles HCl reacted = 3.2×10^{-3} (can get first mark here if 5×10^{-3} not shown above) So moles CaO = 1.6×10^{-3} **(1)** *IGNORE* sf Allow TE from b **(ii)**		**2**

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Question Number	Correct Answer	Reject	Mark
22 (b)(iv)	Mass CaO = ($1.6 \times 10^{-3} \times 56.1$) = 0.0898 g **(1)** % purity = 0.0898/0.121 x100 = 74.2% **(1)** OR Allow % calculated in terms of moles e.g moles of CaO should be 0.121 x 56.1 = 0.0021568 (mol) **(1)** % purity = 0.0016/0.0021568 = 74.2% **(1)** **Accept** = ($1.6 \times 10^{-3} \times 56$) = 0.0896 g **(1)** % purity = 0.0896/0.121 x100 = 74.0% **(1)** Allow TE of incorrect moles of CaO from (b)(iii) Allow TE from incorrect mass of CaO if answer is ≤100% 0.09 g and 74.4% is 1 out of 2 (rounding too soon)	Any % purity without 3 sf for second mark	**2**

Question Number	Correct Answer	Reject	Mark
22 (c)(i)	(Clean) nichrome/platinum wire/ceramic rod/silica/nickel/chrome rod **(1)** (In conc.) HCl/HCl(aq)/dilute HCl **(1)** Heat/place in (blue Bunsen) flame **(1)**	Metal loop/inoculating loop/glass rod/silver/spatula Place in yellow Bunsen flame/burn	**3**

Question Number	Correct Answer	Reject	Mark
22 (c)(ii)	Barium/Ba/Ba^{2+}		**1**

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Question Number	Correct Answer	Reject	Mark
23 (a)	H bond between appropriate O and H atom **(1)** Angle of 180˚ between molecules **(1)** 2nd mark is dependent on first Compounds other than ethanol showing correct H bond and angle **(1 max)**	O---H-O if not in a straight line	**2**

Question Number	Correct Answer	Reject	Mark
23 (b)	Incorrect water flow through condenser **(1)** so takes longer to collect product / lower amount of product collected / inner tube in condenser could crack / backflow of water due to gravity/air bubbles/inefficient cooling/condenser does not fill up with water **(1)** Thermometer bulb too high **(1)** so incorrect boiling point reading/product collected at incorrect temp OWTTE **(1)** Sealed apparatus **(1)** so risk of explosion/pressure build up **(1)** 2nd mark in each pair dependent on 1st mark 1st mark can be obtained by circling correct point on diagram or by description Circle for 3rd error must cover joint to collection flask and/or delivery adaptor If the whole apparatus is circled to indicate sealed 2 marks could be awarded if the problem of the pressure build up is explained Circling the whole apparatus with no or incorrect explanation = 0 marks		**6**

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Question Number	Correct Answer	Reject	Mark
23 (c)	(0.005 x 2)/20.10 x 100 = 0.05/0.04975 (%) *IGNORE* sf		**1**

Question Number	Correct Answer	Reject	Mark
23 (d)	Suitable drying agent e.g anhydrous magnesium sulfate/anhydrous sodium sulfate/calcium oxide **(1)** **Accept** anhydrous calcium chloride silica (gel) Add to ethanol (leave) and then filter/Add to ethanol (leave) and then decant **(1)** Mark independently	Concentrated sulfuric acid OR Sodium and potassium hydroxide Anhydrous copper sulfate Anhydrous cobalt chloride	**2**

Question Number	Correct Answer	Reject	Mark
23 (e)	Add PCl_5 /phosphorous(v)chloride/ phosphorous pentachloride (1) Misty fumes (of HCl) seen/steamy fumes/fumes that form white smoke with NH_3/fumes that turn blue litmus red **(1)** **OR** Add Na (to dried ethanol) **(1)** Bubbles (of H_2) seen/fizzing/effervescence **(1)** **OR** Add acidified (sodium) dichromate((VI))/$Cr_2O_7^{2-}$ and H^+ **(1)** Blue/green colour observed **(1)** **OR** Add acidified (potassium) manganate((VII))/MnO_4^- & H^+ **(1)** Loss of (purple) colour/colour fades/decolourises **(1)** 2nd mark dependent on sensible attempt at test reagent	PCl_3 White smoke on its own White fumes on its own	**2**

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Question Number	Correct Answer	Reject	Mark
23 (f)(i) QWC	A fuel (derived from a plant) that takes in as much CO_2 (as it forms/grows) **(1)** as is released during its production /combustion/when used **(1)** **OR** A fuel (such as hydrogen) that produces no CO_2 when burnt **(1)** Nor in its production/processing **(1)**		**2**

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Question Number	Correct Answer	Reject	Mark
23 (f)(ii) QWC	**2 specific reasons** e.g • energy used to heat/distil (ethanol water mixture after fermentation) may require burning a fuel/energy • energy required to manufacture fertilisers (to grow plants for biofuels in good yield) • energy required to manufacture inseticides (to grow plants for biofuels in good yield) • energy required to transport fuel to the power plant • biofuels less effective at absorbing CO_2 than (rain)forests/trees **(2)** **2 well reasoned effects on society** e.g • use of food crops to produce biofuels reduces food supply • (use of land) for biofuels reduces biodiversity • use of land to grow biofuels leads to reduced food supply • leads to deforestation/leads to habitat loss • new jobs created to grow crops on new farmland • increased price of car/car service due to engine modifications • less CO_2 so less global warming • less SO_2 so less acid rain • less SO_2 so less respiratory illnesses e.g asthma **(2)** **Choice of most sustainable biofuel with appropriate reasoning** e.g • elephant grass as it requires little/no energy to process before it is burnt • elephant grass grows very quickly • elephant grass is a high yield crop • Any of the fuels can be burnt using existing technology **(1)**		**5**

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