AQA A-LEVEL CHEMISTRY

CHEMISTRY



EXAM QUESTION PACK

UNIT 1 OLD SPECIFICATION PAPERS

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Forename(s) _____

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AS CHEMISTRY

Unit 1 Foundation Chemistry

Friday 27 May 2016 Morning Time allowed: 1 hour 15 minutes

Materials

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a calculator.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator, where appropriate.
- The Periodic Table/Data Sheet is provided as an insert.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use scientific terminology accurately.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

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Section A

Answer **all** questions in the spaces provided.

1 Mass spectrometry is a technique that can be used to separate isotopes of an element in order to determine relative atomic mass.

1 (a) Give the meaning of the term relative atomic mass.

[2 marks]

1 (b) In a spectrometer, isotopes are converted into ions that are separated by deflection and are then detected.

1 (b) (i) Ions are deflected using

[1 mark]

Tick (✓) one box.

- an electric field ☐
- an electron gun ☐
- a magnetic field ☐
- a potential difference ☐

1 (b) (ii) Describe how the ions are detected.

[2 marks]

Do not write outside the box

1 (c) **Table 1** gives the relative abundance of each isotope in the mass spectrum of a sample of silicon, recorded using a high-resolution mass spectrometer.

Table 1

m/*z*	Relative abundance / %
27.976	92.23
28.976	4.67
29.973	3.10

Use the data to calculate a value for the relative atomic mass of this sample of silicon. Give your answer to 3 decimal places.

[2 marks]

1 (d) A second mass spectrum was recorded for the same sample of silicon.
The energy of the electrons from the electron gun was higher for this second spectrum.

State and explain **one** similarity and **one** difference between the two spectra.

[4 marks]

Similarity

Explanation

Difference

Explanation

11

Do not write outside the box

2 (a) Van der Waals' forces exist between all molecules.

Explain how these forces arise.

[3 marks]

2 (b) **Table 2** shows the boiling points of methanol (CH_3OH) and methanethiol (CH_3SH).

Table 2

Compound	Boiling point / ºC
Methanol	65
Methanethiol	6

2 (b) (i) Explain, in terms of their intermolecular forces, why the boiling points of these compounds are different.

[3 marks]

2 (b) (ii) Suggest how a mixture of methanol and methanethiol could be separated.

[1 mark]

Do not write outside the box

2 (c) Suggest why methaneselenol (CH_3SeH) has a higher boiling point than methanethiol (CH_3SH).

[2 marks]

2 (d) Sulfur forms many molecular compounds with the halogens.

2 (d) (i) Draw the shape of an SF_6 and of an SF_4 molecule.
Include any lone pairs that influence the shape.
State the bond angle(s) in SF_6 and in SF_4
Name the shape of SF_6

[6 marks]

	SF_6	**SF_4**
Shape		
Bond angle(s)		
Name of shape		

Do not write outside the box

2 (d) (ii) SCl_2 reacts with NaF to form SF_4 and S_2Cl_2 and one other product.

Write an equation for the reaction.

[2 marks]

17

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3 Compounds containing Cu^{2+}, OH^- and CO_3^{2-} ions are sometimes described as basic copper carbonates.

3 (a) Solid $Cu_2(OH)_2CO_3$ is added to an excess of dilute hydrochloric acid.
A solution of copper(II) chloride is formed, together with two other products.

3 (a) (i) Write an equation for the reaction.

[2 marks]

3 (a) (ii) Suggest **one** observation that could be made during the reaction.

[1 mark]

3 (b) A 5.000 g sample of a different basic copper carbonate contains 0.348 g of carbon, 0.029 g of hydrogen and 1.858 g of oxygen.

3 (b) (i) State what is meant by the term empirical formula.

[1 mark]

3 (b) (ii) Calculate the empirical formula of this basic copper carbonate.
Show your working.

[3 marks]

7

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4 (a) Octane (C_8H_{18}) is an important compound in petrol.

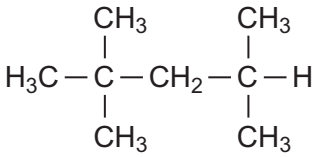
4 (a) (i) Identify the homologous series to which octane belongs.

[1 mark]

4 (a) (ii) Write an equation to show the complete combustion of C_8H_{18}

[1 mark]

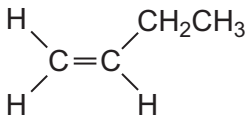
4 (a) (iii) An isomer of octane used to improve the performance of car engines is shown.



Give the IUPAC name of this isomer.

[1 mark]

4 (b) Compound **X** is produced when an alkane is cracked.



X

4 (b) (i) Give the IUPAC name for compound **X**.

[1 mark]

4 (b) (ii) One molecule of an alkane is cracked to produce one molecule of compound **X**, one molecule of octane and one molecule of ethene.

Deduce the molecular formula of this alkane.

[1 mark]

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4 (b) (iii) Name the type of cracking that produces a high yield of compound **X**.
Give **two** conditions required for this process.

[2 marks]

Type of cracking _____

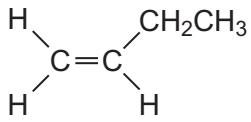
Conditions _____

_____

Question 4 continues on the next page

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4 (b) (iv) Compound **X** has several isomers. The structure of **X** is repeated here.



X

Draw the displayed formula of a chain isomer, a position isomer and a functional group isomer of compound **X**.

[3 marks]

Type of isomer	Displayed formula of isomer of compound X
Chain	
Position	
Functional group	

10

Do not write outside the box

Section B

Answer **all** questions in the spaces provided.

5 This question is about the periodicity of the Period 3 elements.

5 (a) State and explain the general trend in first ionisation energy across Period 3.

[4 marks]

5 (b) Give one example of an element which deviates from the general trend in first ionisation energy across Period 3.

Explain why this deviation occurs.

[3 marks]

Do not write outside the box

5 (c) **Table 3** shows successive ionisation energies of an element **Y** in Period 3.

Table 3

Ionisation number	1	2	3	4	5	6	7	8
Ionisation energy / kJ mol^{-1}	1000	2260	3390	4540	6990	8490	27 100	31 700

Identify element **Y**.

Explain your answer using data from **Table 3**.

[2 marks]

5 (d) Identify the Period 3 element that has the highest melting point.

Explain your answer by reference to structure and bonding.

[4 marks]

13

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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6 Phosphoric(V) acid (H_3PO_4) is an important chemical. It can be made by two methods. The first method is a two-step process.

6 (a) In the first step of the first method, phosphorus is burned in air at 500 ºC to produce gaseous phosphorus(V) oxide.

$$P_4(s) + 5O_2(g) \longrightarrow P_4O_{10}(g)$$

220 g of phosphorus were reacted with an excess of air.

Calculate the volume, in m^3, of gaseous phosphorus(V) oxide produced at a pressure of 101 kPa and a temperature of 500 ºC.
The gas constant $R = 8.31$ J K^{-1} mol^{-1}
Give your answer to 3 significant figures.

[4 marks]

6 (b) In the second step of the first method, phosphorus(V) oxide reacts with water to form phosphoric(V) acid.

$$P_4O_{10}(s) + 6H_2O(l) \longrightarrow 4H_3PO_4(aq)$$

Calculate the mass of phosphorus(V) oxide required to produce 3.00 m^3 of 5.00 mol dm^{-3} phosphoric(V) acid solution.

[3 marks]

Do not write outside the box

6 (c) In the second method to produce phosphoric(V) acid, 3.50 kg of $Ca_3(PO_4)_2$ are added to an excess of aqueous sulfuric acid.

$$Ca_3(PO_4)_2(s) + 3H_2SO_4(aq) \longrightarrow 2H_3PO_4(aq) + 3CaSO_4(s)$$

1.09 kg of phosphoric(V) acid are produced.

Calculate the percentage yield of phosphoric(V) acid.

[4 marks]

6 (d) Explain whether the first method or the second method of production of phosphoric acid has the higher atom economy.
You are not required to do a calculation.

[1 mark]

12

END OF QUESTIONS

There are no questions printed on this page

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A-LEVEL CHEMISTRY

CHEM1 – FOUNDATION CHEMISTRY

Mark Scheme

June 2016

Version: 1.0 Final

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

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Question	Marking Guidance	Mark	Comments
1(a)	Average/mean mass of 1 atom (of an element) 1/12 mass of one atom of ^{12}C ***OR*** Average/mean mass of atoms of an element 1/12 mass of one atom of ^{12}C ***OR*** Average/mean mass of atoms of an element x12 mass of one atom of ^{12}C ***OR*** (Average) mass of one mole of atoms 1/12 mass of one mole of ^{12}C ***OR*** (Weighted) average mass of all the isotopes 1/12 mass of one atom of ^{12}C ***OR*** Average mass of an atom/all isotopes (compared to C-12) on a scale in which an atom of C-12 has a mass of 12	1 1 This expression = 2 marks.	If moles and atoms mixed, max = 1 Mark top and bottom line independently. All key terms must be present for each mark.
1(b)(i)	Magnetic field	1	
1(b)(ii)	(Ions hit) plate/detector causing movement of electrons or (ions hit) plate/detector accept electrons current generated	1 1	Do not allow electron flow in wrong direction Allow M1 for ions hit detector and cause current

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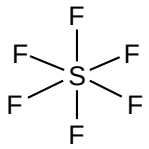
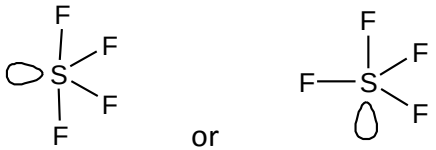
1(c)	(27.976 x 92.23) + (28.976 x 4.67) + (29.973 x 3.10) / 100 (= 28.084607) <u>28.085</u>	1 1	Correct answer with or without working scores 2 marks

1(d)	**Similarities**: (Some) peak(s) at same m/z same sample / element (is being ionised and detected) **Differences**: Additional peak(s) at ½ *m/z* value Two electrons knocked out	 1 1 1 1	Mark all independently Allow main peaks Not same height/abundance/A_r/M_r Not same number peaks (not same no isotopes) / not same molecular ion peak Allow 1/3 (or more) Allow 3 (or more)

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Question	Marking Guidance	Mark	Comments
2(a)	Electron movement in first molecule / temporary dipole Induces a dipole in another molecule (induced-temporary) attraction or δ+ attracts δ- in different/adjacent molecules	1 1 1	allow description allow description M3 dependent on M1 and M2 allow electrostatic attraction M3 could be scored in diagram If other type of force / metallic / ionic / polar bonds / permanent dipoles / difference in electronegativity mentioned CE = 0
2(b)(i)	(methanol) H-bonds / hydrogen bonding (methanethiol) dipole-dipole forces or van der Waals H-bonds are a stronger / are the strongest IMF	1 1 1	 Allow H-bonds require more energy to overcome If M1 and M2 not scored, allow 1 for methanol has stronger IMFs If breaking covalent bonds then CE=0
2(b)(ii)	(Fractional) distillation	1	Allow description Do not allow heating unqualified

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2(c)	(Methaneselenol is a) bigger molecule / larger Mr / larger no of electrons / Se bigger atom With <u>stronger/more</u> <u>vdw</u> forces <u>between molecules</u>	1 1	 If breaking covalent bonds then CE=0
2(d)(i)		1	diagram showing 6 bond pairs
	(bond angle) 90° for SF_6	1	ignore 180°
	Octahedral	1	
		1	diagram showing 4 bond pairs <u>and 1 lone pair</u>
	(bond angles) for SF_4 Any **two** from: • Allow 85 – 89° • Allow 100 – 119° • Allow 170 – 179°	 2	If shape of SF_4 is not based on 4 bond pairs <u>and 1 lone pair</u> cannot score M4 or M5 Do not allow 90° Do not allow 120° Do not allow 180°
2(d)(ii)	NaCl **(**as product in any equation) $3\ SCl_2 + 4\ NaF \rightarrow SF_4 + S_2Cl_2 + 4\ NaCl$	1 1	 Allow multiples Ignore states

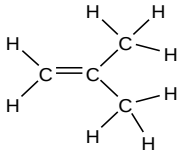
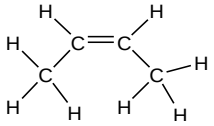
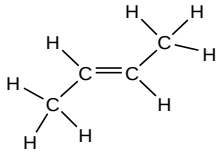
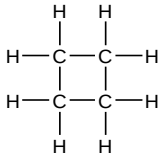
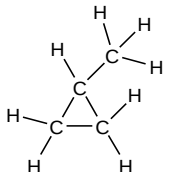
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Question	Marking Guidance	Mark	Comments
3(a)(i)	$H_2O + CO_2$ (as products in any equation) $Cu_2(OH)_2CO_3 + 4HCl \rightarrow 2CuCl_2 + 3H_2O + CO_2$	1 1	Allow $H_2O + H_2CO_3$ Allow multiples Ignore states
3(a)(ii)	bubbles or fizzing or effervescence or solid disappears or blue(-green) solution	1	Do not allow dissolves Ignore CO_2 gas or gas evolved
3(b)(i)	Simplest (whole-number) ratio of atoms of each element in a compound	1	Allow atoms of Cu, H & O in this compound
3(b)(ii)	Mass of copper = 2.765 dividing masses by A_r Cu C H O $\frac{2.765}{63.5}$ (= 0.0435) $\frac{0.348}{12.0}$ (= 0.029) $\frac{0.029}{1.0}$ (= 0.029) $\frac{1.858}{16.0}$ (= 0.116) Correct whole number ratio of integers or Cu:C:H:O 3:2:2:8 or correct empirical formula $Cu_3C_2H_2O_8$	1 1 1	 Any order Ignore $Cu_3(OH)_2(CO_3)_2$

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Question	Marking Guidance	Mark	Comments
4(a)(i)	Alk**a**ne(s)	1	Ignore C_nH_{2n+2}
4(a)(ii)	$C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O$	1	Allow multiples
4(a)(iii)	2, 2, 4-trimethylpentane	1	
4(b)(i)	But-1-ene	1	Ignore (E or Z)
4(b)(ii)	$C_{14}H_{30}$	1	
4(b)(iii)	Thermal High pressure / 7000kPa / 70 atms and High temperature/temperature in range 400-1000°C (673–1273K)	1 1	If catalytic CE = 0 (allow ≥1000 kPa or ≥10 atms – no upper value) Allow high temperature and pressure or high pressure and temperature If no units for temperature allow 673-1000

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4(b)(iv)			Must show unambiguous structure Penalise lack of displayed formula once only
		1	
	 	1	
	 	1	

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Question	Marking Guidance	Mark	Comments
5(a)	General increase	1	If not increase then CE
	Greater nuclear charge / more protons	1	
	Same shielding / electrons added to same shell	1	allow similar
	Stronger attraction (from nucleus) for outer electron(s)	1	Allow electron in outer shell
5(b)			CE if not Al or S
	Aluminium / Al (lower than Mg)	1	
	(outer) electron in (3)p orbital / sub-shell (level)	1	If 2p or 4p orbital lose M2 and M3
	(3p) higher in energy	1	allow more shielded or weaker nuclear attraction M3 is dependent on M2
	or		
	Sulfur / S (lower than P)		
	(outer) electrons in (3)p orbital begin to pair		If 2p or 4p orbital lose M2 and M3 allow 2 electrons in (3)p
	repel		M3 is dependent on M2
5(c)	Sulfur / S	1	CE if not S
	Large jump after 6th or between 6th and 7th	1	Do not allow M2 if atom/ion is removed

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5(d)	Silicon Giant covalent structure / macromolecule Covalent (bonds) Many / strong (covalent bonds) or (covalent bonds) need lots of energy to break	1 1 1 1	CE if not Si Giant covalent scores M2 and M3 CE for M2-M4 if molecules / metallic / ionic / IMFs mentioned

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Question	Marking Guidance	Mark	Comments
6(a)	Correct conversion of temperature and pressure (773 and 101 x 10^3)	1	correct answer with or without working scores 4 marks
	No moles P = (220 / 4 x 31.0) = 1.77	1	Max 2 (M1 and M3) if 31.0 used (=0.451 m^3 or if 220/31 rounded to 2 sf ie 7.1 then 0.452)
	V = nRT/P (correct rearrangement **or** insert of values V = 1.77 x 8.31 x 773 / 101 x 10^3 = 0.1128 m^3)	1	Max 2 (M1 and M3) if 284 (P_4O_{10}) used then 0.0493
	V = <u>0.113</u> (m^3)	1	Must be 3 sig figs
6(b)			correct answer with or without working scores 3 marks
	No moles H_3PO_4 = 3 x 10^3 (dm^3) x 5 = 15,000 (mols)	1	If M1 incorrect then can only score M2
	No moles phosphorus(V) oxide = $\frac{15\,000}{4}$ (= 3,750 mols)	1	M2 = $\frac{M1}{4}$ (process) If M2 incorrect can only score M1
	1.1 x 10^6 or 1.07 x 10^6 or 1.065 x 10^6 (g) or 1,100 or 1,070 or 1065 kg or 1.1 or 1.07 or 1.065 tonne	1	= (3.75 x 10^3 x 284.0) Min 2 sig fig

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6(c)			correct answer with or without working scores 4 marks
	No moles $Ca_3(PO_4)_2$ (= 3.50kg =) $\frac{\mathbf{3{,}500\ g}}{\mathbf{310}(.\mathbf{3})}$ = 11.28	1	If M1 incorrect can only score M2 and M3
	Theoretical No. moles H_3PO_4 = 11.28 x 2 = 22.56	1	If M2 incorrect can only score M1 and M3
	Theoretical mass H_3PO_4 = 22.56 x 98(.0) = 2211 **or** Actual No. moles H_3PO_4 produced = $\frac{1090}{98}$ = 11.12	1	If M3 incorrect can only score M1and M2
	49 – 49(.312) (%)	1	(% yield (moles) = ($\frac{11/.12}{22.56}$ x 100) or (% yield (mass) = ($\frac{1090}{2211}$ x 100)

6(d)	Method 1 / (a) & (b) because only one product / no other products formed / atom economy = 100% (even though two steps)	1	Allow calculations Do not allow if P_2O_5 is formed Allow converse explanation

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General principles applied to marking CHEM1 papers by CMI+ (June 2016)

It is important to note that the guidance given here is generic and specific variations may be made in the mark scheme.

Basic principles

- **Examiners should note that throughout the mark scheme, items that are underlined are required information to gain credit.**
- **Occasionally a response involves incorrect chemistry and the mark scheme records CE = 0, which means a chemical error has occurred and no credit is given for that section of the clip or for the whole clip.**

The "List principle" and the use of "ignore" in the mark scheme

If a question requires **one** answer and a candidate gives two answers, no mark is scored if one answer is correct and one answer is incorrect. There is no penalty if both answers are correct.

N.B. Certain answers are designated in the mark scheme as those that the examiner should "Ignore". These answers are not counted as part of the list and should be ignored and will not be penalised.

Incorrect case for element symbol

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip.

For example, penalise the use of "h" for hydrogen, "CL" for chlorine or "br" for bromine.

Spelling

In general

- The names of organic chemical compounds and functional groups **must be spelled correctly,** when specifically asked for, to gain credit.
- Phonetic spelling may be acceptable for some chemical compounds (e.g. amonia would be phonetically acceptable. However, ammoniam would be unacceptable since it is ambiguous).

N.B. Some terms may be required to be spelled correctly or an idea needs to be articulated with clarity, as part of the "Quality of Language" (**QoL**) marking. These will be identified in the mark scheme and marks are awarded only if the QoL criterion is satisfied.

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Equations

In general

- Equations **must** be balanced.
- State symbols are generally ignored, unless specifically required in the mark scheme

Lone Pairs

The following representations of lone pairs in structures are acceptable.

 with or without the 2 electrons shown **OR**  **OR** x x **OR** x x **OR** 

Reagents

The command word "Identify", allows the candidate to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when the name and formula contradict. Specific details will be given in mark schemes.

Marking calculations

In general

- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- If a candidate has made an arithmetical error or a transcription error deduct one mark, but continue marking (error carried forward).

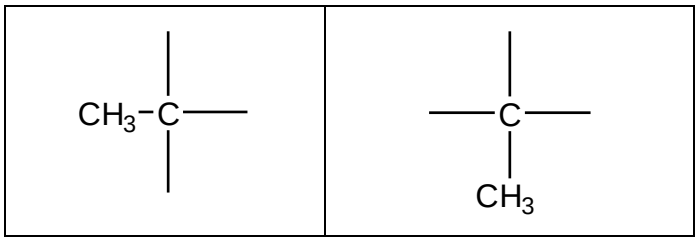
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Organic structures

In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Bonds should be drawn correctly between the relevant atoms.
- Latitude should be given to the representation of C ─ C bonds in structures, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.

- The following representations are allowed:-



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Additional text here (if required) (Remove line if there is no text on the back page)

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19 July 2016

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2015

Chemistry CHEM1

Unit 1 Foundation Chemistry

Friday 22 May 2015 9.00 am to 10.15 am

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a calculator.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator, where appropriate.
- The Periodic Table/Data Sheet is provided as an insert.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use scientific terminology accurately.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

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Do not write outside the box

Section A

Answer **all** questions in the spaces provided.

1 This question is about the elements in Period 3 of the Periodic Table.

1 (a) State the element in Period 3 that has the highest melting point.
Explain your answer.

[3 marks]

Element .....

Explanation .....

.....

.....

.....

.....

1 (b) State the element in Period 3 that has the highest first ionisation energy.
Explain your answer.

[3 marks]

Element .....

Explanation .....

.....

.....

.....

.....

1 (c) Suggest the element in Period 3 that has the highest electronegativity value.

[1 mark]

.....

Do not write outside the box

1 (d) Chlorine is a Period 3 element.
Chlorine forms the molecules ClF_3 and CCl_2

1 (d) (i) Use your understanding of electron pair repulsion to draw the shape of ClF_3 and the shape of CCl_2
Include any lone pairs of electrons that influence the shape.

[2 marks]

Shape of ClF_3

Shape of CCl_2

1 (d) (ii) Name the shape of CCl_2

[1 mark]

.....

1 (d) (iii) Write an equation to show the formation of one mole of ClF_3 from its elements.

[1 mark]

.....

11

Turn over for the next question

Do not write outside the box

2 Tellurium is the element with atomic number of 52

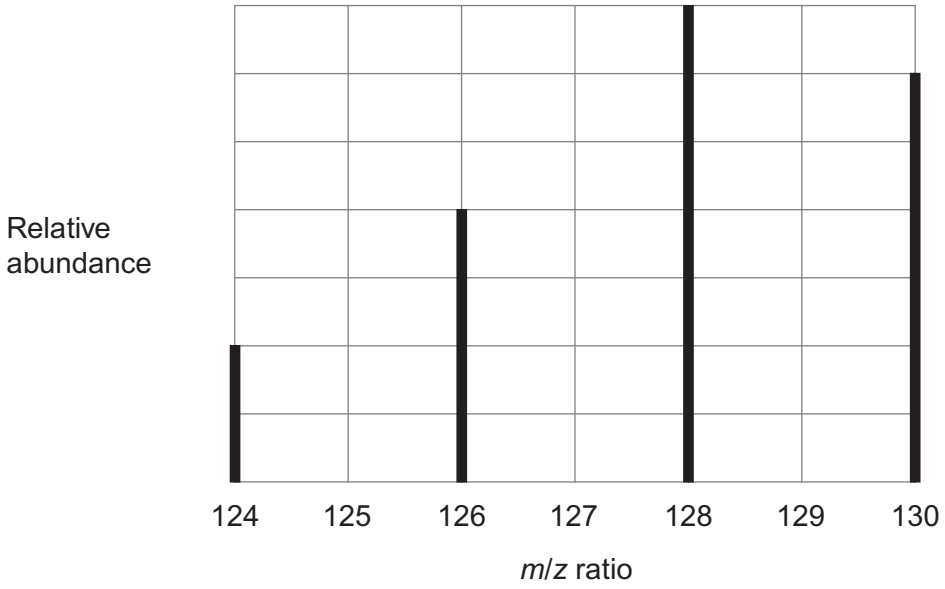
2 (a) Using information from the Periodic Table, complete the electron configuration of tellurium.

[1 mark]

[Kr] .....

2 (b) The mass spectrum of a sample of tellurium is shown in **Figure 1**.

Figure 1



2 (b) (i) Use **Figure 1** to calculate the relative atomic mass of this sample of tellurium. Give your answer to one decimal place.

[3 marks]

.....

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2 (b) (ii) Suggest what might cause the relative atomic mass of this sample to be different from the relative atomic mass given in the Periodic Table.

[1 mark]

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Do not write outside the box

2 (c) Write an equation for the reaction that occurs when a tellurium ion hits the detector.

[1 mark]

.....

2 (d) State the *m*/*z* value of the ions that produce the biggest current at the detector when the spectrum in **Figure 1** is recorded.
Give a reason for your answer.

[2 marks]

m/*z* value .....

Reason .....

.....

.....

2 (e) The mass spectrum of tellurium also has a small peak at *m*/*z* = 64

Explain the existence of this peak.

[2 marks]

.....

.....

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.....

2 (f) Predict whether the atomic radius of ^{124}Te is larger than, smaller than or the same as the atomic radius of ^{130}Te
Explain your answer.

[2 marks]

Atomic radius of ^{124}Te compared to ^{130}Te .....

Explanation .....

.....

.....

.....

12

Do not write outside the box

3 Silicon dioxide (SiO_2) has a crystal structure similar to diamond.

3 (a) Give the name of the type of crystal structure shown by silicon dioxide.

[1 mark]

.....

3 (b) Suggest why silicon dioxide does **not** conduct electricity when molten.

[1 mark]

.....

.....

.....

3 (c) Silicon dioxide reacts with hydrofluoric acid (HF) to produce hexafluorosilicic acid (H_2SiF_6) and one other substance.

Write an equation for this reaction.

[1 mark]

.....

3

Do not write outside the box

4 A sample of hydrated nickel sulfate ($NiSO_4.xH_2O$) with a mass of 2.287 g was heated to remove all water of crystallisation. The solid remaining had a mass of 1.344 g.

4 (a) Calculate the value of the integer x.
Show your working.

[4 marks]

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4 (b) Suggest how a student doing this experiment could check that all the water had been removed.

[2 marks]

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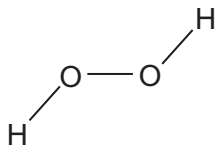
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6

Turn over for the next question

Do not write outside the box

5 A hydrogen peroxide molecule can be represented by the structure shown.



5 (a) Suggest a value for the H–O–O bond angle.

[1 mark]

.....

5 (b) Hydrogen peroxide dissolves in water.

5 (b) (i) State the strongest type of interaction that occurs between molecules of hydrogen peroxide and water.

[1 mark]

.....

5 (b) (ii) Draw a diagram to show how one molecule of hydrogen peroxide interacts with one molecule of water.
Include all lone pairs and partial charges in your diagram.

[3 marks]

Do not write outside the box

5 (c) Explain, in terms of electronegativity, why the boiling point of H_2S_2 is lower than H_2O_2.

[2 marks]

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7

Turn over for the next question

Do not write outside the box

6 Central heating fuel, obtained by the fractional distillation of crude oil, contains saturated hydrocarbons with the molecular formula $C_{16}H_{34}$

6 (a) Give the meaning of the terms **saturated** and **hydrocarbon** as applied to saturated hydrocarbons.

[2 marks]

Saturated .....

.....

Hydrocarbon .....

.....

6 (b) If the boiler for a central heating system is faulty, a poisonous gas may be produced during the combustion of $C_{16}H_{34}$

Write an equation for the reaction that forms this poisonous gas and one other product only.

[1 mark]

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6 (c) Explain why the sulfur compounds found in crude oil should be removed from the fractions before they are used for central heating fuel.

[2 marks]

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Do not write outside the box

6 (d) A hydrocarbon $C_{16}H_{34}$ can be cracked to form C_8H_{18}, ethene and propene.

6 (d) (i) Write an equation to show this cracking reaction.

[1 mark]

.....

6 (d) (ii) Suggest **one** important substance manufactured on a large scale from propene.

[1 mark]

.....

6 (d) (iii) Draw the **displayed formula** of the functional group isomer of propene.

[1 mark]

6 (e) There are many structural isomers with the molecular formula C_8H_{18}

Draw the structure of 2,3,3-trimethylpentane.

[1 mark]

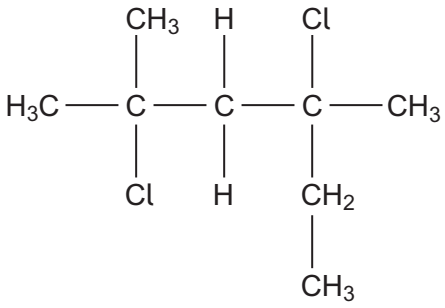
Question 6 continues on the next page

Do not write outside the box

6 (f) A compound C_8H_{18} reacts with chlorine to give several haloalkanes.

Give the IUPAC name of the following haloalkane.

[1 mark]



.....

10

Do not write outside the box

Section B

Answer **all** questions in the spaces provided.

7 Some airbags in cars contain sodium azide (NaN_3).

7 (a) Sodium azide is made by reacting dinitrogen monoxide gas with sodium amide ($NaNH_2$) as shown by the equation.

$$2NaNH_2 + N_2O \longrightarrow NaN_3 + NaOH + NH_3$$

Calculate the mass of sodium amide needed to obtain 550 g of sodium azide, assuming there is a 95.0% yield of sodium azide.
Give your answer to 3 significant figures.

[5 marks]

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Question 7 continues on the next page

Do not write outside the box

7 (b) If a car is involved in a serious collision, the sodium azide decomposes to form sodium and nitrogen as shown in the equation.

$$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)$$

The nitrogen produced then inflates the airbag to a volume of 7.50×10^{-2} m^3 at a pressure of 150 kPa and temperature of 35 ºC.

Calculate the minimum mass of sodium azide that must decompose.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

[6 marks]

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Do not write outside the box

7 (c) Sodium azide is toxic. It can be destroyed by reaction with an acidified solution of nitrous acid (HNO_2) as shown in the equation.

$$2NaN_3 + 2HNO_2 + 2HCl \longrightarrow 3N_2 + 2NO + 2NaCl + 2H_2O$$

7 (c) (i) A 500 cm^3 volume of the nitrous acid solution was used to destroy completely 150 g of the sodium azide.

Calculate the concentration, in mol dm^{-3}, of the nitrous acid used.

[3 marks]

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7 (c) (ii) Nitrous acid decomposes on heating.

Balance the following equation for this reaction.

[1 mark]

$$.....HNO_2 \longrightarrow .....HNO_3 + ...NO + ...H_2O$$

7 (d) Sodium azide has a high melting point.

Predict the type of bonding in a crystal of sodium azide.
Suggest why its melting point is high.

[3 marks]

Type of bonding .....

Reason for high melting point .....

.....

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Question 7 continues on the next page

Do not write outside the box

7 (e) The azide ion has the formula N_3^-

7 (e) (i) The azide ion can be represented as $N \equiv N - N^-$
One of these bonds is a co-ordinate bond.

On the following diagram, draw an arrowhead on one of the bonds to represent the direction of donation of the lone pair in the co-ordinate bond.

[1 mark]

$$N \equiv N - N^-$$

7 (e) (ii) Give the formula of a molecule that has the same number of electrons as the azide ion.

[1 mark]

.....

7 (e) (iii) Which is the correct formula of magnesium azide?

[1 mark]

Tick (✓) **one** box.

Mg_3N ☐

MgN ☐

MgN_6 ☐

Mg_3N_2 ☐

21

END OF QUESTIONS

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AQA Qualifications

A-LEVEL

Chemistry

CHEM1 Foundation Chemistry
Mark scheme

2420
June 2015

Version 1 – Final Mark Scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

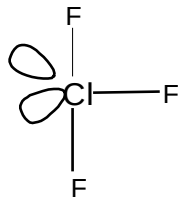
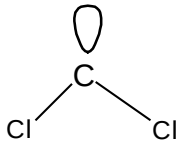
It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available from aqa.org.uk

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Question	Marking Guidance	Mark	Comments
1(a)	Silicon / Si	1	If not silicon then CE = 0/3
	<u>covalent</u> (bonds)	1	M3 dependent on correct M2
	Strong or many of the (covalent) bonds need to be <u>broken</u> / needs a lot of energy to <u>break</u> the (covalent) bonds	1	Ignore hard to break
1(b)	Argon / Ar	1	If not argon then CE = 0/3. But if Kr chosen, lose M1 and allow M2+M3
	Large(st) number of protons / large(st) nuclear charge	1	Ignore smallest atomic radius
	Same amount of shielding / same number of shells / same number of energy levels	1	Allow similar shielding
1(c)	Chlorine / Cl	1	Not Cl_2, Not C**L, not** Cl^2

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1(d)(i)	 	1 1	Or any structure with 3 bonds and 2 lone pairs Ignore any angles shown Or a structure with 2 bonds and 1 lone pair
1(d)(ii)	Bent / v shape	1	Ignore non-linear, angular and triangular Apply list principle
1(d)(iii)	$\frac{1}{2}Cl_2 + \frac{3}{2}F_2 \longrightarrow ClF_3$	1	No multiples Ignore state symbols

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Question	Marking Guidance	Mark	Comments
2(a)	$5s^2\ 4d^{10}\ 5p^4$ / $4d^{10}\ 5s^2\ 5p^4$	1	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^4$ or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^4$ Allow any order but must finish with $5p^4$
2(b)(i)	$\frac{(124 \times 2) + (126 \times 4) + (128 \times 7) + (130 \times 6)}{19}$ or $\frac{2428}{19}$ 127.8 Or $\frac{(124 \times 10.5) + (126 \times 21.1) + (128 \times 36.8) + (130 \times 31.6)}{100}$ 127.8	1 1 1 Or 1 1 1	M1 for top line M2 for correct denominator 127.8 with no working shown scores 3 marks Mark for 100 dependent on top line correct
2(b)(ii)	Other isotopes present/some isotopes absent /different abundances of isotopes	1	
2(c)	$Te^+ + e^{(-)} \rightarrow Te$	1	Ignore state symbols Allow $Te^{2+} + 2e^{(-)} \rightarrow Te$

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2(d)	128 Most abundant ion (QoL – superlative)	1 1	Only M2 dependent on correct M1
2(e)	2+ ion formed / 2 electrons removed From ^{128} (Te)	1 1	Due to $^{128}Te^{2+}$ = 2 marks Mark independently

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2(f)	Same (Each isotope has the) same number of protons/same nuclear charge <u>and</u> same number of electrons / electronic configuration	1 1	If not same CE = 0/2 Ignore more neutrons in ^{130}Te

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Question	Marking Guidance	Mark	Comments
3(a)	Macromolecular / giant covalent / giant molecule	1	Not giant atomic
3(b)	No delocalised electrons / no free ions / no free charged particles	1	
3(c)	$SiO_2 + 6HF \longrightarrow H_2SiF_6 + 2H_2O$	1	Accept multiples

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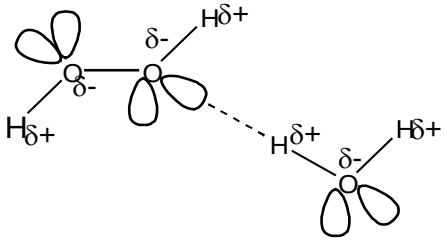
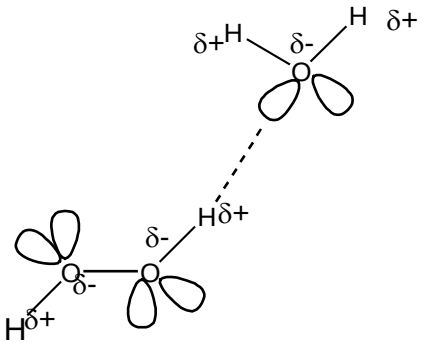
Question	Marking Guidance	Mark	Comments
4(a)	0.943 g water (M1) $NiSO_4$ H_2O $\frac{1.344}{154.8}$ (M2) $\frac{0.943}{18}$ (M3) (8.68×10^{-3} 0.052) 1 6 or $x = \frac{6}{}$ (M4) Allow other methods eg M_r ($NiSO_4$) = 58.7 + 32.1 + 64.0 = 154.8 n($NiSO_4$) = $\frac{1.344}{154.8}$ = 0.008682 mol (M1) M_r ($NiSO_4.xH_2O$) = $\frac{2.287}{0.008682}$ = (263.4) (M2) so $18x$ = 263.4 – 154.8 = (108.6) (M3) so $x = \frac{108.6}{18} = \frac{6}{}$ (M4)	4	If Mr of $NiSO_4$ wrong, can allow M1 and M3 from method 1 i.e. max 2 Allow Mr = 155 If using alternative method and Mr of $NiSO_4$ wrong, allow ecf to score M2 and M3 only i.e. max 2
4(b)	re-heat check that mass is unchanged	1 1	Heat to constant mass = 2 marks M2 dependent on M1 Allow as alternative:

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			M1: record an IR spectrum M2: peak between 3230 and 3550 (cm^{-1})

Question	Marking Guidance	Mark	Comments
5(a)	94–105.5^{o}	1	
5(b)(i)	Hydrogen bond(ing) / H bonding/H bonds	1	Not just hydrogen

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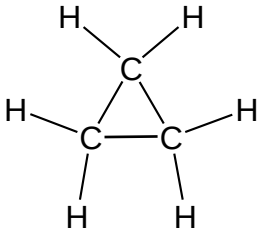
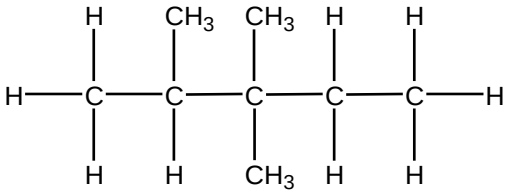
5(b)(ii)	 **OR** 	3	1 mark for all lone pairs 1 mark for partial charges on the O and the H that are involved in H bonding 1 mark for the H-bond, from Hδ+ on one molecule to lone pair on O of other molecule

5(c)	Electronegativity of S lower than O or electronegativity difference between H and S is lower No hydrogen bonding <u>between H_2S_2 molecules</u> Or <u>only</u> van der Waals / <u>only</u> dipole-dipole forces <u>between H_2S_2 molecules</u>	1 1	Mark independently If breaking covalent bonds CE = 0

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Question	Marking Guidance	Mark	Comments
6(a)	Saturated – single bonds only / no double bonds Hydrocarbon – contains carbon and hydrogen (atoms) <u>only</u>	1 1	
6(b)	$C_{16}H_{34} + 16.5O_2 \longrightarrow 16CO + 17H_2O$	1	Allow multiples
6(c)	(On combustion) SO_2 produced Which causes acid rain	1 1	Allow equation to produce SO_2. Ignore sulfur oxides. If formula shown it must be correct M2 is dependent on M1. But if M1 is sulfur oxides, allow M2. For M2 allow consequence of acid rain or SO_2. Ignore greenhouse effect and toxic
6(d)(i)	$C_{16}H_{34} \longrightarrow C_8H_{18} + C_2H_4 + 2C_3H_6$	1	Allow multiples

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6(d)(ii)	polypropene / propan(-1 or 2-)ol / propane(-1,2-)diol / isopropanol / propanone / propanal	1	Accept alternative names Ignore plastic and polymer
6(d)(iii)		1	
6(e)		1	Allow any unambiguous representation
6(f)	2,4-dichloro-2,4-dimethylhexane	1	Only but ignore punctuation

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Question	Marking Guidance	Mark	Comments
7(a)	M1 $550 \times \frac{100}{95} = 579$ g would be 100% mass M2 So $\frac{579}{65} = 8.91$ moles NaN_3 **or** M1 $\frac{550}{65} = 8.46$ moles NaN_3 (this is 95%) M2 So 100% would be $8.46 \times \frac{100}{95} = 8.91$ moles NaN_3 Then M3 Moles $NaNH_2 = 8.91 \times 2 = (17.8(2)$ moles) M4 mass $NaNH_2 = 17.8(2) \times 39$ M5 693 or 694 or 695 (g)	1 1 1 1 1	Allow alternative methods. There are 4 process marks: 1: mass ÷ 65 2: mass or moles × 100/95 or × 1.05 3: moles NaN_3 × 2 4: moles $NaNH_2$ × 39 If 693, 694 or 695 seen to 3 sig figs award 5 marks

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7(b)	M1 308 K and 150 000 Pa	1	
	M2 $n = \frac{PV}{RT}$ or $\frac{150\,000 \times 7.5 \times 10^{-2}}{8.31 \times 308}$	1	
	M3 = 4.4(0) or 4.395 moles N_2	1	Allow only this answer but allow to more than 3 sig figs
	M4 Moles NaN_3 = 4.395 $\times \frac{2}{3}$ (= 2.93)	1	M4 is for M3 $\times \frac{2}{3}$
	M5 Mass NaN_3 = (2.93) $\times$ 65	1	M5 is for moles M4 × 65
	M6 = 191 g	1	Allow 190 to 191 g allow answers to 2 sig figs or more

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7(c)(i)	150/65 = 2.31 moles NaN_3 or 2.31 moles nitrous acid	1	
	Conc = $2.31 \times \frac{1000}{500}$	1	M2 is for M1 × 1000/500
	4.6(1) or 4.6(2) (mol dm^{-3})	1	Only this answer
7(c)(ii)	$3HNO_2 \longrightarrow HNO_3 + 2NO + H_2O$	1	Can allow multiples
7(d)	Ionic	1	If not ionic then CE = 0/3
	Oppositely charged ions / Na^+ and N_3^- ions	1	Penalise incorrect ions here but can allow M3
	Strong attraction between (oppositely charged) ions / lots of energy needed to overcome (strong) attractions (between ions)	1	M3 dependent on M2

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7(e)(i)	$N \equiv N \longrightarrow N^-$	1	Only
7(e)(ii)	CO_2 / N_2O / BeF_2/HN_3	1	Allow other correct molecules
7(e)(iii)	MgN_6	1	Only

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General principles applied to marking CHEM1 papers by CMI+ (June 2015)

It is important to note that the guidance given here is generic and specific variations may be made in the mark scheme.

Basic principles

- **Examiners should note that throughout the mark scheme, items that are underlined are <u>required information</u> to gain credit.**
- **Occasionally a response involves incorrect chemistry and the mark scheme records CE = 0, which means a chemical error has occurred and no credit is given for that section of the clip or for the whole clip.**

The "List principle" and the use of "ignore" in the mark scheme

If a question requires **one** answer and a student gives two answers, no mark is scored if one answer is correct and one answer is incorrect. There is no penalty if both answers are correct.

NB Certain answers are designated in the mark scheme as those that the examiner should "Ignore". These answers are not counted as part of the list and should be ignored and will not be penalised.

Incorrect case for element symbol

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip.

For example, penalise the use of "h" for hydrogen, "CL" for chlorine or "br" for bromine.

Spelling

In general

- The names of organic chemical compounds and functional groups **must be spelled correctly**, when specifically asked for, to gain credit.
- Phonetic spelling may be acceptable for some chemical compounds (eg amonia would be phonetically acceptable. However, ammoniam would be unacceptable since it is ambiguous).

NB Some terms may be required to be spelled correctly or an idea needs to be articulated with clarity, as part of the "Quality of Language" (**QoL**) marking. These will be identified in the mark scheme and marks are awarded only if the QoL criterion is satisfied.

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Equations
In general

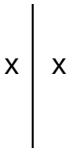
- Equations **must** be balanced.
- State symbols are <u>generally</u> ignored, unless specifically required in the mark scheme.

Lone Pairs

The following representations of lone pairs in structures are acceptable.


with or without the 2 electrons shown **OR**


OR


OR

OR



Reagents

The command word "Identify", allows the candidate to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when the name and formula contradict. Specific details will be given in mark schemes.

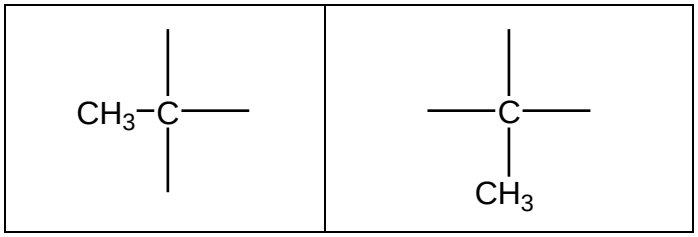
Marking calculations
In general

- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- If a candidate has made an arithmetical error or a transcription error deduct one mark, but continue marking (error carried forward).

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Organic structures
In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Bonds should be drawn correctly between the relevant atoms.
- Latitude should be given to the representation of C ─ C bonds in structures, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- The following representations are allowed:-



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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2014

Chemistry CHEM1

Unit 1 Foundation Chemistry

Friday 23 May 2014 9.00 am to 10.15 am

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a calculator.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- The Periodic Table/Data Sheet is provided as an insert.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use scientific terminology accurately.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

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Do not write outside the box

Section A

Answer **all** questions in the spaces provided.

1 (a) **Table 1** shows some data about fundamental particles in an atom.

Table 1

Particle	proton	neutron	electron
Mass / g	1.6725×10^{-24}	1.6748×10^{-24}	0.0009×10^{-24}

1 (a) (i) An atom of hydrogen can be represented as ^{1}H

Use data from **Table 1** to calculate the mass of this hydrogen atom.

[1 mark]

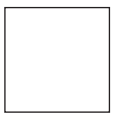
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1 (a) (ii) Which **one** of the following is a fundamental particle that would **not** be deflected by an electric field?

A electron
B neutron
C proton

Write the correct letter, **A**, **B** or **C**, in the box.

[1 mark]



Do not write outside the box

1 (b) A naturally occurring sample of the element boron has a relative atomic mass of 10.8 In this sample, boron exists as two isotopes, ^{10}B and ^{11}B

1 (b) (i) Calculate the percentage abundance of ^{10}B in this naturally occurring sample of boron.

[2 marks]

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1 (b) (ii) State, in terms of fundamental particles, why the isotopes ^{10}B and ^{11}B have similar chemical reactions.

[1 mark]

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1 (c) Complete **Table 2** by suggesting a value for the third ionisation energy of boron.

[1 mark]

Table 2

	First	Second	Third	Fourth	Fifth
Ionisation energy / kJ mol^{-1}	799	2420		25 000	32 800

1 (d) Write an equation to show the process that occurs when the **second** ionisation energy of boron is measured. Include state symbols in your equation.

[1 mark]

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1 (e) Explain why the second ionisation energy of boron is higher than the first ionisation energy of boron.

[1 mark]

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8

Do not write outside the box

2 When heated, iron(III) nitrate (M_r = 241.8) is converted into iron(III) oxide, nitrogen dioxide and oxygen.

$$4Fe(NO_3)_3(s) \longrightarrow 2Fe_2O_3(s) + 12NO_2(g) + 3O_2(g)$$

A 2.16 g sample of iron(III) nitrate was completely converted into the products shown.

2 (a) (i) Calculate the amount, in moles, of iron(III) nitrate in the 2.16 g sample.
Give your answer to 3 significant figures.

[1 mark]

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2 (a) (ii) Calculate the amount, in moles, of oxygen gas produced in this reaction.

[1 mark]

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2 (a) (iii) Calculate the volume, in m^3, of **nitrogen dioxide** gas at 293 ºC and 100 kPa produced from 2.16 g of iron(III) nitrate.
The gas constant is R = 8.31 $J\,K^{-1}\,mol^{-1}$.

(If you have been unable to obtain an answer to Question **2 (a) (i)**, you may assume the number of moles of iron(III) nitrate is 0.00642. This is **not** the correct answer.)

[4 marks]

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Do not write outside the box

2 (b) Suggest a name for this type of reaction that iron(III) nitrate undergoes.

[1 mark]

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2 (c) Suggest why the iron(III) oxide obtained is pure.
Assume a complete reaction.

[1 mark]

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8

Turn over for the next question

Do not write outside the box

3 (a) Nickel is a metal with a high melting point.

3 (a) (i) State the block in the Periodic Table that contains nickel.

[1 mark]

.....

3 (a) (ii) Explain, in terms of its structure and bonding, why nickel has a high melting point.

[2 marks]

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3 (a) (iii) Draw a labelled diagram to show the arrangement of particles in a crystal of nickel. In your answer, include at least six particles of each type.

[2 marks]

3 (a) (iv) Explain why nickel is ductile (can be stretched into wires).

[1 mark]

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Do not write outside the box

3 (b) Nickel forms the compound nickel(II) chloride ($NiCl_2$).

3 (b) (i) Give the full electron configuration of the Ni^{2+} ion.

[1 mark]

.....

3 (b) (ii) Balance the following equation to show how anhydrous nickel(II) chloride can be obtained from the hydrated salt using $SOCl_2$
Identify **one** substance that could react with both gaseous products.

[2 marks]

.....$NiCl_2.6H_2O(s)$ + ... $SOCl_2(g)$ ⟶ .....$NiCl_2(s)$ + ...$SO_2(g)$ + ...$HCl(g)$

Substance .....

9

Turn over for the next question

Do not write outside the box

4 (a) Ammonia gas readily condenses to form a liquid when cooled.

4 (a) (i) Name the strongest attractive force between two ammonia molecules.

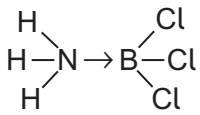
[1 mark]

.....

4 (a) (ii) Draw a diagram to show how two ammonia molecules interact with each other in the liquid phase.
Include all partial charges and all lone pairs of electrons in your diagram.

[3 marks]

4 (b) Ammonia reacts with boron trichloride to form a molecule with the following structure.



State how the bond between ammonia and boron trichloride is formed.

[1 mark]

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Do not write outside the box

4 (c) **Table 3** shows the electronegativity values of some elements.

Table 3

	H	Li	B	C	O	F
Electronegativity	2.1	1.0	2.0	2.5	3.5	4.0

4 (c) (i) Give the meaning of the term **electronegativity**.

[2 marks]

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4 (c) (ii) Suggest the formula of an ionic compound that is formed by the chemical combination of two different elements from **Table 3**.

[1 mark]

.....

4 (c) (iii) Suggest the formula of the compound that has the least polar bond and is formed by chemical combination of two of the elements from **Table 3**.

[1 mark]

.....

9

Turn over for the next question

Do not write outside the box

5 Some oil-fired heaters use paraffin as a fuel.
One of the compounds in paraffin is the straight-chain alkane, dodecane ($C_{12}H_{26}$).

5 (a) Give the name of the substance from which paraffin is obtained.
State the name of the process used to obtain paraffin from this substance.

[2 marks]

Substance .....

Process .....

5 (b) The combustion of dodecane produces several products.

Write an equation for the **incomplete** combustion of dodecane to produce gaseous products only.

[1 mark]

.....

5 (c) Oxides of nitrogen are also produced during the combustion of paraffin in air.

5 (c) (i) Explain how these oxides of nitrogen are formed.

[2 marks]

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5 (c) (ii) Write an equation to show how nitrogen monoxide in the air is converted into nitrogen dioxide.

[1 mark]

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5 (c) (iii) Nitric acid (HNO_3) contributes to acidity in rainwater.

Deduce an equation to show how nitrogen dioxide reacts with oxygen and water to form nitric acid.

[1 mark]

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Do not write outside the box

5 (d) Dodecane ($C_{12}H_{26}$) can be cracked to form other compounds.

5 (d) (i) Give the general formula for the homologous series that contains dodecane.

[1 mark]

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5 (d) (ii) Write an equation for the cracking of one molecule of dodecane into equal amounts of two different molecules each containing the same number of carbon atoms.
State the empirical formula of the straight-chain alkane that is formed.
Name the catalyst used in this reaction.

[3 marks]

Equation .....

Empirical formula of alkane .....

Catalyst .....

5 (d) (iii) Explain why the melting point of dodecane is higher than the melting point of the straight-chain alkane produced by cracking dodecane.

[2 marks]

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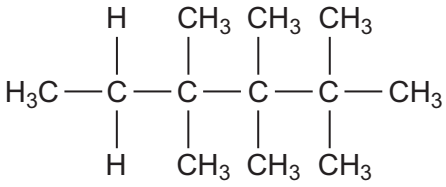
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Question 5 continues on the next page

Do not write outside the box

5 (e) Give the IUPAC name for the following compound and state the type of structural isomerism shown by this compound and dodecane.

[2 marks]



IUPAC name .....

Type of structural isomerism .....

5 (f) Dodecane can be converted into halododecanes.

Deduce the formula of a substance that could be reacted with dodecane to produce 1-chlorododecane and hydrogen chloride only.

[1 mark]

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16

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

Section B

Answer **all** questions in the spaces provided.

6 (a) Calcium phosphate reacts with aqueous nitric acid to produce phosphoric acid and calcium nitrate as shown in the equation.

$$Ca_3(PO_4)_2 + 6HNO_3 \longrightarrow 2H_3PO_4 + 3Ca(NO_3)_2$$

6 (a) (i) A 7.26 g sample of calcium phosphate reacted completely when added to an excess of aqueous nitric acid to form 38.0 cm^3 of solution.

Calculate the concentration, in mol dm^{-3}, of phosphoric acid in this solution.
Give your answer to 3 significant figures.

[5 marks]

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6 (a) (ii) Calculate the percentage atom economy for the formation of calcium nitrate in this reaction.
Give your answer to 1 decimal place.

[2 marks]

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Do not write outside the box

6 (b) Write an equation to show the reaction between calcium hydroxide and phosphoric acid to produce calcium phosphate and water.

[1 mark]

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6 (c) Calcium dihydrogenphosphate can be represented by the formula $Ca(H_2PO_4)_x$ where x is an integer.
A 9.76 g sample of calcium dihydrogenphosphate contains 0.17 g of hydrogen, 2.59 g of phosphorus and 5.33 g of oxygen.

Calculate the empirical formula and hence the value of x.
Show your working.

[4 marks]

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12

Turn over for the next question

Do not write outside the box

7 Thallium is in Group 3 of the Periodic Table.
Thallium reacts with halogens to form many compounds and ions.

7 (a) Draw the shape of the $TlBr_3^{2-}$ ion and the shape of the $TlCl_4^{3-}$ ion.
Include any lone pairs of electrons that influence the shapes.

Name the shape made by the atoms in $TlBr_3^{2-}$ and suggest a value for the bond angle.
[4 marks]

.....

7 (b) Thallium(I) bromide (TlBr) is a crystalline solid with a melting point of 480 °C.

Suggest the type of bonding present in thallium(I) bromide and state why the melting point is high.
[3 marks]

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7 (c) Write an equation to show the formation of thallium(I) bromide from its elements.
[1 mark]

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8

END OF QUESTIONS

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AQA Qualifications

A-LEVEL
CHEMISTRY

CHEM1 Foundation Chemistry
Mark scheme

2420
June 2014

Version 1.2 Final

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Question	Marking Guidance	Mark	Comments
1(a)(i)	1.6734×10^{-24} (g) 1.6734×10^{-27} kg	1	Only. Not 1.67×10^{-24} (g)
1(a)(ii)	**B**	1	
1(b)(i)	$\frac{10x + 11y}{x + y} = 10.8$ **OR** ratio 10:11 = 1:4 **OR** 20:80 etc abundance of ^{10}B is 20(%) **OR** $\frac{10x}{100} + \frac{11(100-x)}{100} = 10.8$ $10x + 1100 - 11x = 1080$ $\therefore x = 1100 - 1080 = 20\%$	1 1	Allow idea that there are 5 × 0.2 divisions between 10 and 11 Correct answer scores M1 and M2
1(b)(ii)	Same number of electrons (in outer shell or orbital) Same electronic configuration / arrangement	1	Ignore electrons determine chemical properties. Ignore protons unless wrong.

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1(c)	Range between 3500 and 10 000 kJ mol^{-1}	1	
1(d)	$B^{+}(g) \longrightarrow B^{2+}(g) + e^{(-)}$ $B^{+}(g) - e^{(-)} \longrightarrow B^{2+}(g)$ $B^{+}(g) + e^{(-)} \longrightarrow B^{2+}(g) + 2e^{(-)}$	1	Ignore state symbol on electron even if wrong.
1(e)	Electron being removed from a positive ion (therefore need more energy) / electron being removed is closer to the nucleus	1	Must imply removal of an electron. Allow electron removed from a + particle/ species or from a 2+ ion. Not electron removed from a higher/lower energy level / shell. Not electron removed from a higher energy sub-level / orbital. Ignore electron removed from a lower energy sub-level / orbital. Ignore 'more protons than electrons'. Not 'greater nuclear charge'. Ignore 'greater effective nuclear charge'. Ignore shielding.

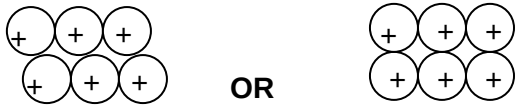
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Question	Marking Guidance	Mark	Comments
2(a)(i)	2.16 ÷ 241.8 = 0.00893 or 8.93×10^{-3} (mol)	1	Penalise if not 3 significant figures.
2(a)(ii)	$n(O_2)$ = 0.00893 × 0.75 (= 0.00670 mol)	1	Allow (a)(i) × 0.75
2(a)(iii)	M1 = T = 566 K and P = 100 000 Pa	1	If M1 incorrect can only score M2 and M3
	M2 = Moles NO_2 = 0.0268 (mol)	1	If M2 incorrect can only score M1 and M3 Allow moles of NO_2 = student's answer to (a)(i) × 3 **OR** (a)(ii) × 4 and consequential M4 Minimum of 2 significant figures.
	M3 = $V = \frac{nRT}{p}$ **OR** = $\frac{0.0268 \times 8.31 \times 566}{100\,000}$	1	If M3 incorrect can only score M1 and M2
	M4 = 0.00126 (m^3) or 1.26×10^{-3} (m^3)	1	Allow minimum of 2 significant figures. Allow no units but incorrect units loses M4 **If 0.00642 moles used:** M2 = Moles NO_2 = 0.0193 mol M3 = $V = \frac{nRT}{p} = \frac{0.0193 \times 8.31 \times 566}{100\,000}$ M4 = 9.06×10^{-4} (m^3) allow 9.06 to 9.08 × 10^{-4}

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2(b)	(Thermal) decomposition	1	Do not allow catalytic decomposition.

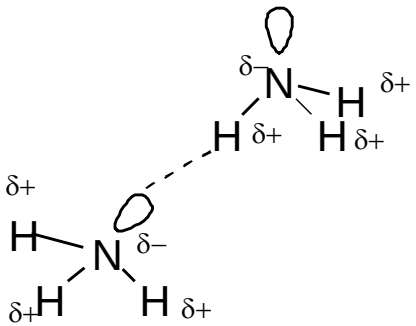
2(c)	Other products are gases / other products escape easily	1	Allow no other solid (or liquid) product.

Question	Marking Guidance	Mark	Comments
3(a)(i)	d (block) **OR** D (block)	1	Ignore transition metals / series. Do not allow any numbers in the answer.
3(a)(ii)	Contains positive (metal) ions or protons or nuclei and <u>delocalised / mobile / free / sea of</u> electrons <u>Strong attraction</u> between them or <u>strong metallic</u> bonds	1 1	Ignore atoms. Allow 'needs a lot of energy to break / overcome' instead of 'strong'. If strong attraction between incorrect particles, then CE = 0/2 If molecules / intermolecular forces / covalent bonding / ionic bonding mentioned then CE=0
3(a)(iii)	 **OR**	2	M1 is for regular arrangement of atoms / ions (min 6 metal particles). M2 for + sign in each metal atom / ion. Allow 2+ sign.
3(a)(iv)	<u>Layers / planes / sheets of atoms or ions</u> can slide over one another	1	QoL
3(b)(i)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ (4s^0)$	1	Only.

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3(b)(ii)	$NiCl_2 \cdot 6H_2O$ + **6** $SOCl_2$ $\longrightarrow$ $NiCl_2$ + **6** SO_2 + **12** HCl	1	Allow multiples.
	NaOH / NH_3 / $CaCO_3$ / CaO	1	Allow any name or formula of alkali or base. Allow water.

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Question	Marking Guidance	Mark	Comments
4(a)(i)	Hydrogen bonds / H bonds	1	Not just hydrogen.
4(a)(ii)		3	M1 – lone pair on each N M2 – correct partial charges must be shown on the N and H of a bond in each molecule. M3 – for the H bond from lone pair on N to the Hδ+ on the other NH_3 molecule. If not ammonia molecules, CE = 0/3
4(b)	Lone pair / both electrons / 2 electrons / electron pair on N(H_3) is donated to B(Cl_3)	1	Allow both electrons in the bond come from N(H_3)

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4(c)(i)	The power of an <u>atom</u> or <u>nucleus</u> to withdraw or attract electron<u>s</u> or electron density or a pair of electrons (towards itself) in a <u>covalent</u> bond	1 1	
4(c)(ii)	LiF **OR** Li_2O **OR** LiH	1	Allow Li_2O_2, allow correct lithium carbide formula.
4(c)(iii)	BH_3 / H_3B	1	Allow B_2H_6 / H_6B_2 Do not allow lower case letters.

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Question	Marking Guidance	Mark	Comments
5(a)	Crude oil **OR** petroleum Fractional distillation / fractionation	1 1	Not petrol. Not distillation alone.
5(b)	$C_{12}H_{26} + 12.5O_2 \longrightarrow 12CO + 13H_2O$	1	Allow balanced equations that produce CO_2 in addition to CO Accept multiples.
5(c)(i)	M1 Nitrogen and oxygen (from air) <u>react / combine</u> / allow a correct equation M2 at high temperatures	1 1	If nitrogen from petrol / paraffin / impurities CE=0/2 Allow temperatures above 1000 °C or spark. Not just heat or hot. M2 dependent on M1 But allow 1 mark for nitrogen and oxygen together at high temperatures.
5(c)(ii)	$2NO + O_2 \longrightarrow 2NO_2$	1	Allow multiples.
5(c)(iii)	$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$	1	Allow multiples.
5(d)(i)	C_nH_{2n+2} CnH2n+2	1	Allow C_xH_{2x+2} Allow CxH2x+2

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5(d)(ii)	$C_{12}H_{26} \longrightarrow C_6H_{14} + C_6H_{12}$	1	Only.
	C_3H_7	1	Only.
	Zeolite / aluminosilicate(s)	1	Ignore aluminium oxide.

5(d)(iii)	Larger molecule / longer carbon chain / more electrons / larger surface area	1	
	More / stronger <u>van der Waals' forces between molecules</u>	1	Allow dispersion forces / London forces / temporary induced dipole-dipole forces <u>between molecules.</u> If breaking bonds, CE = 0/2

5(e)	2,2,3,3,4,4-hexamethylhexane	1	Only. Ignore punctuation.
	Chain	1	Ignore branch(ed).

5(f)	Cl_2 Cl–Cl	1	Only. Not CL_2 or Cl2 or CL2 or Cl^2 or CL^2 Ignore Chlorine.

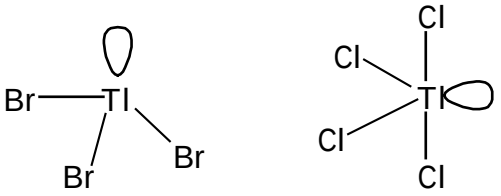
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Question	Marking Guidance	Mark	Comments
6(a)(i)	M1 - M_r calcium phosphate = 310(.3)	1	If M_r wrong, lose M1 and M5
	M2 - Moles calcium phosphate = $\frac{7.26}{M1}$ (= 0.0234)	1	0.0234 moles can score M1 and M2 If M_r incorrect, can score M2 for $\frac{7.26}{M1}$ Allow M2 and/or M3 to 2 significant figures here but will lose M5 if answer not 1.23
	M3 - Moles phosphoric acid = 2 × 0.0234 = 0.0468	1	Allow student's M2 × 2. If not multiplied by 2 then lose M3 and M5
	M4 - Vol phosphoric acid = 0.038(0) dm^3 Conc phosphoric acid = $\frac{0.0468}{0.038(0)}$	1	If not 0.038(0) dm^3 then lose M4 and M5
	M5 = 1.23 **(**mol dm^{-3})	1	This answer only – unless arithmetic or transcription error that has been penalised by 1 mark. Allow no units but incorrect units loses M5

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6(a)(ii)	$\frac{492.3}{688.3} \times 100$ **OR** $\frac{492}{688} \times 100$ = 71.5%	2	1 mark for both M_r correctly placed.
6(b)	$3Ca(OH)_2 + 2H_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 6H_2O$	1	Allow multiples.
6(c)	Ca: $\frac{1.67}{40.1} = 0.042$, $\frac{0.042}{0.042} = 1$ H: $\frac{0.17}{1} = 0.17$, $\frac{0.17}{0.042} = 4$ P: $\frac{2.59}{31} = 0.084$, $\frac{0.084}{0.042} = 2$ O: $\frac{5.33}{16} = 0.333$, $\frac{0.333}{0.042} = 8$ $CaH_4P_2O_8$ **OR** $Ca(H_2PO_4)_2$ **OR** x = 2 **Alternative** Ca: $\frac{1.67}{40.1} = 0.042$, $\frac{0.042}{0.042} = 1$ H_2PO_4: $\frac{8.09}{97.0} = 0.083$, $\frac{0.083}{0.042} = 2$ $CaH_4P_2O_8$ **OR** $Ca(H_2PO_4)_2$ **OR** x = 2	1 1 1 1 1 1	If x=2 with no working, allow M4 only. Ca = 1.67 g (M1). Mark for dividing by correct A_r in Ca and P (M2). If M1 incorrect can only score M2 Correct ratio (M3). Value of x or correct formula (M4). Ca = 1.67 g (M1). Mark for dividing by correct A_r / M_r in Ca and H_2PO_4 (M2). If M1 incorrect can only score M2 Correct ratio (M3). Value of x or correct formula (M4).

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Question	Marking Guidance	Mark	Comments
7(a)		2	Mark is for correct number of bonds and lone pair in each case. Ignore charges if shown.
	Pyramidal/ trigonal pyramid	1	Allow tetrahedral.
	107^0	1	Allow 107 to 107.5º
7(b)	M1 Ionic	1	CE = 0/3 if not ionic.
	M2 Oppositely charged ions / Tl^+ and Br^- ions	1	If molecules / intermolecular forces / metallic bonding, CE=0
	M3 <u>Strong attraction</u> between ions	1	M3 dependent on M2 Allow 'needs a lot of energy to break / overcome' instead of 'strong'.
7(c)	$Tl + \frac{1}{2}Br_2 \longrightarrow TlBr$	1	Allow multiples. Ignore state symbols even if incorrect.

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General principles applied to marking CHEM1 papers by CMI+ (June 2014)

It is important to note that the guidance given here is generic and specific variations may be made in the mark scheme.

Basic principles

- **Examiners should note that throughout the mark scheme, items that are underlined are <u>required information</u> to gain credit.**
- **Occasionally a response involves incorrect chemistry and the mark scheme records CE = 0, which means a chemical error has occurred and no credit is given for that section of the clip or for the whole clip.**

The "List principle" and the use of "ignore" in the mark scheme

If a question requires **one** answer and a student gives two answers, no mark is scored if one answer is correct and one answer is incorrect. There is no penalty if both answers are correct.

NB Certain answers are designated in the mark scheme as those that the examiner should "Ignore". These answers are not counted as part of the list and should be ignored and will not be penalised.

Incorrect case for element symbol

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip.

For example, penalise the use of "h" for hydrogen, "CL" for chlorine or "br" for bromine.

Spelling

In general

- The names of organic chemical compounds and functional groups **must be spelled correctly,** when specifically asked for, to gain credit.
- Phonetic spelling may be acceptable for some chemical compounds (eg amonia would be phonetically acceptable. However, ammoniam would be unacceptable since it is ambiguous).

NB Some terms may be required to be spelled correctly or an idea needs to be articulated with clarity, as part of the "Quality of Language" (**QoL**) marking. These will be identified in the mark scheme and marks are awarded only if the QoL criterion is satisfied.

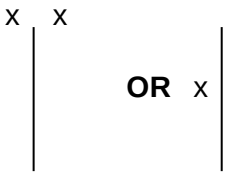
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Equations
In general

- Equations **must** be balanced.
- State symbols are <u>generally</u> ignored, unless specifically required in the mark scheme.

Lone Pairs

The following representations of lone pairs in structures are acceptable.

 with or without the 2 electrons shown **OR**  **OR** x x **OR** x x **OR** 

Reagents

The command word "Identify", allows the student to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when the name and formula contradict. Specific details will be given in mark schemes.

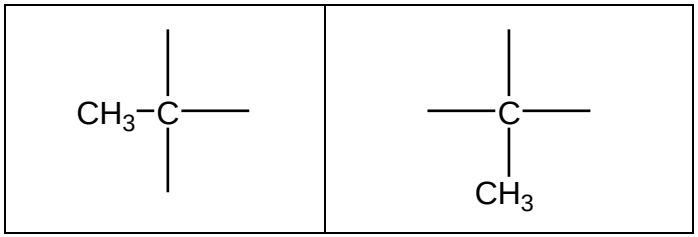
Marking calculations
In general

- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- If a student has made an arithmetic error or a transcription error deduct one mark, but continue marking (error carried forward).

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Organic structures
In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Bonds should be drawn correctly between the relevant atoms.
- Latitude should be given to the representation of C ─ C bonds in structures, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- The following representations are allowed:-



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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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7	
8	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2013

Chemistry CHEM1

Unit 1 Foundation Chemistry

Thursday 23 May 2013 9.00 am to 10.15 am

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a calculator.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- The Periodic Table/Data Sheet is provided as an insert.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use scientific terminology accurately.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

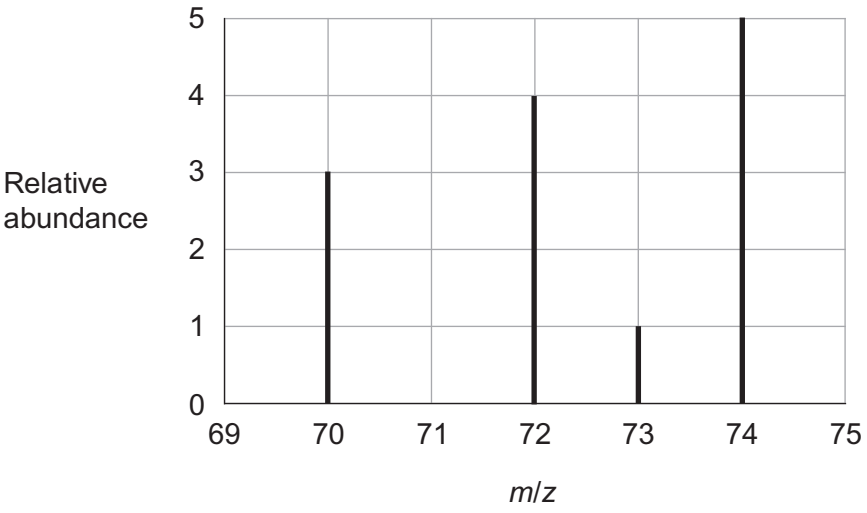
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Section A

Answer **all** questions in the spaces provided.

1 The mass spectrum of the isotopes of element **X** is shown in the diagram.



1 (a) Define the term *relative atomic mass*.

.....

.....

.....

.....

(2 marks)

1 (b) Use data from the diagram to calculate the relative atomic mass of **X**.

Give your answer to one decimal place.

.....

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.....

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(3 marks)

Do not write outside the box

1 (c) Identify the ion responsible for the peak at 72

.....

(1 mark)

1 (d) Identify which **one** of the isotopes of **X** is deflected the most in the magnetic field of a mass spectrometer. Give a reason for your answer.

Isotope .....

Reason .....

(2 marks)

1 (e) In a mass spectrometer, the relative abundance of each isotope is proportional to the current generated by that isotope at the detector.

Explain how this current is generated.

.....

.....

.....

.....

(2 marks)

1 (f) **X** and **Zn** are different elements.

Explain why the chemical properties of ^{70}**X** and ^{70}**Zn** are different.

.....

.....

(1 mark)

11

Do not write outside the box

2 (a) The hydrocarbon but-1-ene (C_4H_8) is a member of the homologous series of alkenes. But-1-ene has structural isomers.

2 (a) (i) State the meaning of the term *structural isomers*.

.....

.....

.....

.....

(2 marks)

2 (a) (ii) Give the IUPAC name of the **position** isomer of but-1-ene.

.....

(1 mark)

2 (a) (iii) Give the IUPAC name of the **chain** isomer of but-1-ene.

.....

(1 mark)

2 (a) (iv) Draw the displayed formula of a **functional group** isomer of but-1-ene.

(1 mark)

Do not write outside the box

2 (b) But-1-ene burns in a limited supply of air to produce a solid and water only.

2 (b) (i) Write an equation for this reaction.

.....

(1 mark)

2 (b) (ii) State **one** hazard associated with the solid product in part **(b) (i)**.

.....

(1 mark)

2 (c) One mole of compound **Y** is cracked to produce two moles of ethene, one mole of but-1-ene and one mole of octane (C_8H_{18}) only.

2 (c) (i) Deduce the molecular formula of **Y**.

.....

(1 mark)

2 (c) (ii) Other than cracking, give **one** common use of **Y**.

.....

(1 mark)

2 (d) In cars fitted with catalytic converters, unburned octane reacts with nitrogen monoxide to form carbon dioxide, water and nitrogen only.

2 (d) (i) Write an equation for this reaction.

.....

(1 mark)

2 (d) (ii) Identify a catalyst used in a catalytic converter.

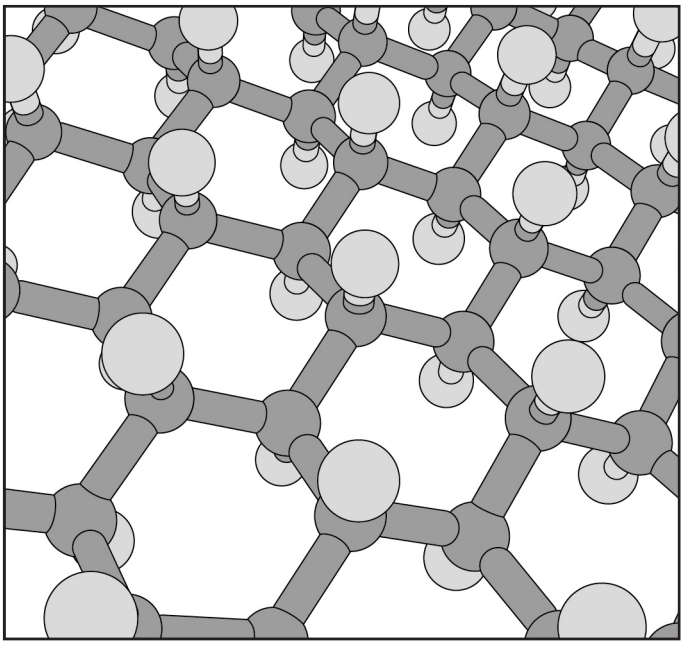
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(1 mark)

11

Do not write outside the box

3 In 2009 a new material called graphane was discovered. The diagram shows part of a model of the structure of graphane. Each carbon atom is bonded to three other carbon atoms and to one hydrogen atom.



3 (a) Deduce the type of crystal structure shown by graphane.

.....

(1 mark)

3 (b) State how two carbon atoms form a carbon–carbon bond in graphane.

.....

.....

(1 mark)

3 (c) Suggest why graphane does **not** conduct electricity.

.....

.....

(1 mark)

3 (d) Deduce the empirical formula of graphane.

.....

(1 mark)

4

Do not write outside the box

4 Fritz Haber, a German chemist, first manufactured ammonia in 1909.
Ammonia is very soluble in water.

4 (a) State the strongest type of intermolecular force between one molecule of ammonia and one molecule of water.

.....

(1 mark)

4 (b) Draw a diagram to show how one molecule of ammonia is attracted to one molecule of water. Include all partial charges and all lone pairs of electrons in your diagram.

(3 marks)

4 (c) Phosphine (PH_3) has a structure similar to ammonia.

In terms of intermolecular forces, suggest the main reason why phosphine is almost insoluble in water.

.....

.....

(1 mark)

5

Do not write outside the box

5 Aluminium and thallium are elements in Group 3 of the Periodic Table.
Both elements form compounds and ions containing chlorine and bromine.

5 (a) Write an equation for the formation of aluminium chloride from its elements.

.....

(1 mark)

5 (b) An aluminium chloride molecule reacts with a chloride ion to form the $AlCl_4^-$ ion.

Name the type of bond formed in this reaction. Explain how this type of bond is formed in the $AlCl_4^-$ ion.

Type of bond .....

Explanation .....

.....

.....

(2 marks)

5 (c) Aluminium chloride has a relative molecular mass of 267 in the gas phase.

Deduce the formula of the aluminium compound that has a relative molecular mass of 267

.....

(1 mark)

5 (d) Deduce the name or formula of a compound that has the same number of atoms, the same number of electrons and the same shape as the $AlCl_4^-$ ion.

.....

(1 mark)

5 (e) Draw and name the shape of the $TlBr_5^{2-}$ ion.

Shape of the $TlBr_5^{2-}$ ion.

Name of shape .....

(2 marks)

Do not write outside the box

5 (f) (i) Draw the shape of the $TlCl_2^+$ ion.

(1 mark)

5 (f) (ii) Explain why the $TlCl_2^+$ ion has the shape that you have drawn in part **(f) (i)**.

.....

.....

.....

(1 mark)

5 (g) Which **one** of the first, second or third ionisations of thallium produces an ion with the electron configuration [Xe] $5d^{10}6s^1$?

Tick (✓) **one** box.

First ☐

Second ☐

Third ☐

(1 mark)

10

Turn over ▶

Do not write outside the box

6 The elements in Period 2 show periodic trends.

6 (a) Identify the Period 2 element, from carbon to fluorine, that has the largest atomic radius. Explain your answer.

Element .....

Explanation .....

.....

.....

.....

(3 marks)

6 (b) State the general trend in first ionisation energies from carbon to neon.
Deduce the element that deviates from this trend and explain why this element deviates from the trend.

Trend .....

Element that deviates .....

Explanation .....

.....

.....

.....

(4 marks)

6 (c) Write an equation, including state symbols, for the reaction that occurs when the first ionisation energy of carbon is measured.

.....

(1 mark)

Do not write outside the box

6 (d) Explain why the second ionisation energy of carbon is higher than the first ionisation energy of carbon.

.....

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(1 mark)

6 (e) Deduce the element in Period 2, from lithium to neon, that has the highest second ionisation energy.

.....

(1 mark)

10

Turn over for the next question

Do not write outside the box

Section B

Answer **all** questions in the spaces provided.

7 Zinc forms many different salts including zinc sulfate, zinc chloride and zinc fluoride.

7 (a) People who have a zinc deficiency can take hydrated zinc sulfate ($ZnSO_4.xH_2O$) as a dietary supplement.

A student heated 4.38 g of hydrated zinc sulfate and obtained 2.46 g of anhydrous zinc sulfate.

Use these data to calculate the value of the integer x in $ZnSO_4.xH_2O$
Show your working.

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(3 marks)

Do not write outside the box

7 (b) Zinc chloride can be prepared in the laboratory by the reaction between zinc oxide and hydrochloric acid.
The equation for the reaction is

$$ZnO + 2HCl \longrightarrow ZnCl_2 + H_2O$$

A 0.0830 mol sample of pure zinc oxide was added to 100 cm^3 of 1.20 mol dm^{-3} hydrochloric acid.

Calculate the maximum mass of anhydrous zinc chloride that could be obtained from the products of this reaction.

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(4 marks)

Question 7 continues on the next page

Do not write outside the box

7 (c) Zinc chloride can also be prepared in the laboratory by the reaction between zinc and hydrogen chloride gas.

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

An impure sample of zinc powder with a mass of 5.68 g was reacted with hydrogen chloride gas until the reaction was complete. The zinc chloride produced had a mass of 10.7 g.

Calculate the percentage purity of the zinc metal.
Give your answer to 3 significant figures.

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(4 marks)

7 (d) Predict the type of crystal structure in solid zinc fluoride and explain why its melting point is high.

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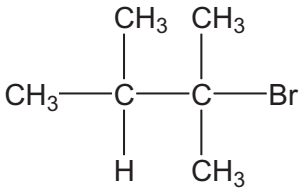
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(3 marks)

14

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8 (a) The structure of the bromoalkane **Z** is



Give the IUPAC name for **Z**.

Give the general formula of the homologous series of straight-chain bromoalkanes that contains one bromine atom per molecule.

Suggest **one** reason why 1-bromohexane has a higher boiling point than **Z**.

.....

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.....

.....

(3 marks)

(Extra space) .....

.....

.....

8 (b) Draw the displayed formula of 1,2-dichloro-2-methylpropane.

State its empirical formula.

.....

.....

(2 marks)

END OF QUESTIONS

5

There are no questions printed on this page

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Version 1.0



General Certificate of Education (A-level)
June 2013

Chemistry CHEM1

(Specification 2420)

Unit 1: Foundation Chemistry

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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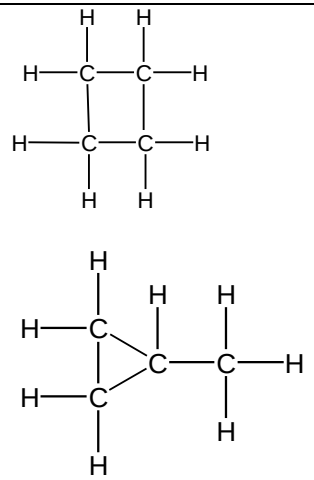
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Question	Marking Guidance	Mark	Comments
1(a)	Average/mean mass of 1 atom (of an element) 1/12 mass of one atom of ^{12}C ***OR*** Average/mean mass of atoms of an element 1/12 mass of one atom of ^{12}C ***OR*** Average/mean mass of atoms of an element x12 mass of one atom of ^{12}C ***OR*** (Average) mass of one mole of atoms 1/12 mass of one mole of ^{12}C ***OR*** (Weighted) average mass of all the isotopes 1/12 mass of one atom of ^{12}C ***OR*** Average mass of an atom/isotope (compared to C-12) on a scale in which an atom of C-12 has a mass of 12	1 1	If moles and atoms mixed, max = 1 Mark top and bottom line independently. All key terms must be present for each mark. This expression = 2 marks.
1(b)	$\frac{(70x3) + (72x4) + 73 + (74x5)}{13} = \frac{941}{13}$ $= 72.4$	1 1 1	72.4 only.
1(c)	$^{(72)}Ge^{+}$ or germanium^{+}	1	Must show '+' sign. Penalise wrong mass number.

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1(d)	70 Lowest mass / lowest m/z	1 1	If M1 incorrect or blank CE = 0/2 Ignore symbols and charge even if wrong. Accept lightest. Accept fewest neutrons.
1(e)	Electron(s) transferred / flow (at the detector) (From detector / plate) to the (+) ion	1 1	M1 must refer to electron flow at the detector. If M1 incorrect CE = 0/2 Do not allow from a charged plate.
1(f)	They do not have the same electron configuration / they have different number of electrons (in the outer shell)	1	Ignore electrons determine the properties of an atom. Ignore they are different elements or different number of protons.

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Question	Marking Guidance	Mark	Comments
2(a)(i)	(Compounds with the) same molecular formula But different structural formula / different displayed formula/different structures / different skeletal formula	1 1	Allow same number and type of atom for M1 Ignore same general formula. M2 dependent on M1 Not different positions of atoms/bonds in space.
2(a)(ii)	But-2-ene	1	Allow but-2-ene. Allow but 2 ene. Ignore punctuation.
2(a)(iii)	(2)-methylprop-(1)-ene	1	Do not allow 2-methyleprop-1-ene.
2(a)(iv)		1	Do not allow skeletal formulae. Penalise missing H and missing C
2(b)(i)	$C_4H_8 + 2O_2 \rightarrow 4C + 4H_2O$	1	Accept multiples.

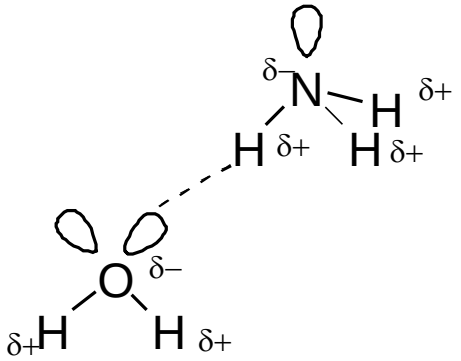
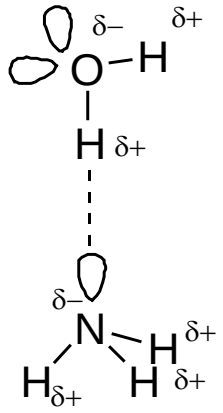
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2(b)(ii)	Exacerbates asthma / breathing problems / damages lungs / smog / smoke / global dimming	1	Ignore toxic / pollutant / soot / carcinogen. Do not allow greenhouse effect / global warming / acid rain / ozone.
2(c)(i)	$C_{16}H_{34}$	1	Allow $H_{34}C_{16}$ C and H must be upper case.
2(c)(ii)	Jet fuel / diesel / (motor) fuel / lubricant / petrochemicals / kerosene / paraffin / central heating fuel / fuel oil	1	Ignore oil alone. Not petrol / bitumen / wax / LPG / camping fuel.
2(d)(i)	$C_8H_{18} + 25NO \rightarrow 8CO_2 + 12.5\ N_2 + 9H_2O$	1	Accept multiples.
2(d)(ii)	Ir / iridium ***OR*** Pt / platinum ***OR*** Pd / palladium ***OR*** Rh / rhodium	1	

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Question	Marking Guidance	Mark	Comments
3(a)	Giant covalent / giant molecular / macromolecular	1	Not giant alone. Not covalent alone.
3(b)	Shared pair of electrons / one electron from each C atom	1	
3(c)	No delocalised / free / mobile electrons	1	Allow all (outer) electrons involved in (covalent) bonds. Ignore ions.
3(d)	CH	1	Allow HC C and H must be capital letters.

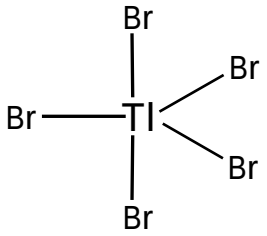
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Question	Marking Guidance	Mark	Comments
4(a)	Hydrogen bonding / hydrogen bonds / H-bonding / H-Bonds	1	Not just hydrogen.
4(b)	 ***OR*** 	3	One mark for minimum of 4 correct partial charges shown on the N-H and O-H One mark for the 3 lone pairs. One mark for H bond from the lone pair on O or N to the $H^{\delta+}$ The N-H-O should be linear but can accept if the lone pair on O or N hydrogen bonded to the $H^{\delta+}$ If wrong molecules or wrong formula, CE = 0/3

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4(c)	(Phosphine) does not form hydrogen bonds (with water)	1	

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Question	Marking Guidance	Mark	Comments
5(a)	$Al + 1.5Cl_2 \rightarrow AlCl_3$	1	Accept multiples. Also $2Al + 3Cl_2 \rightarrow Al_2Cl_6$ Ignore state symbols.
5(b)	Coordinate / dative (covalent) Electron pair on Cl^- donated to Al(Cl_3)	1 1	If wrong CE=0/2 if covalent mark on. QoL Lone pair from Cl^- not just Cl Penalise wrong species.
5(c)	Al_2Cl_6 or $AlBr_3$	1	Allow Br_3Al or Cl_6Al_2 Upper and lower case letters must be as shown. Not $2AlCl_3$
5(d)	$SiCl_4$ / silicon tetrachloride	1	Accept silicon(4) chloride or silicon(IV) chloride. Upper and lower case letters must be as shown. Not silicon chloride.
5(e)	 Trigonal bipyramid(al)	1 1	Accept shape containing 5 bonds and no lone pairs from Tl to each of 5 Br atoms. Ignore charge.

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5(f)(i)	Cl—— Tl —— Cl	1	Accept this <u>linear</u> structure only with no lone pair on Tl
5(f)(ii)	(Two) bonds (pairs of electrons) repel equally / (electrons in) the bonds repel to be as far apart as possible	1	Dependent on linear structure in 5(f)(i). Do not allow electrons /electron pairs repel alone.
5(g)	Second	1	

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Question	Marking Guidance	Mark	Comments
6(a)	Carbon / C	1	If M1 incorrect, CE = 0/3
	Fewest protons / smallest nuclear charge / least attraction between protons (in the nucleus) and electrons / weakest nuclear attraction to electrons	1	Allow comparative answers. Allow converse answers for M2
	Similar shielding	1	Allow same shielding.
6(b)	<u>Increase</u>	1	
	Oxygen / O	1	If not oxygen, then cannot score M2, M3 and M4
	<u>Paired</u> electrons in a (2)<u>p</u> orbital	1	If paired electrons in incorrect p orbital, lose M3 but can award M4
	(Paired electrons in a p orbital) repel	1	
6(c)	$C(g) \rightarrow C^{+}(g) + e^{(-)}$ ***OR*** $C(g) + e^{(-)} \rightarrow C^{+}(g) + 2e^{(-)}$ ***OR*** $C(g) - e^{(-)} \rightarrow C^{+}(g)$	1	Ignore state symbols for electron.
6(d)	(More energy to) remove an electron from a (more) positive ion / cation	1	Allow electron closer to the nucleus in the positive ion.
6(e)	Lithium / lithium / Li	1	If formula given, upper and lower case letters must be as shown.

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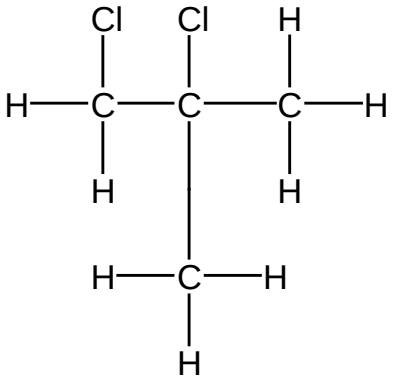
Question	Marking Guidance		Mark	Comments
7(a)	Method 1	Method 2		
	Mass of H_2O = 4.38-2.46 (= 1.92 g)	Percentage of H_2O = 44%	1	If there is an AE in M1 then can score M2 and M3 If M_r incorrect can only score M1
	$ZnSO_4$ H_2O 2.46 1.92 161.5 18	ZnSO4 H2O 56 44 161.5 18	1	
	(0.0152 0.107) (1 : 7)	(0.347 2.444) (1 : 7)		
	x = 7	x = 7	1	If x = 7 with working then award 3 marks. Allow alternative methods. If M1 incorrect due to AE, M3 must be an integer.
7(b)	Moles HCl = 0.12(0)		1	
	mol $ZnCl_2$ = 0.06(0) ***OR*** 0.12 / 2		1	If M2 incorrect then CE and cannot score M2, M3 and M4.
	mass $ZnCl_2$ = 0.06 × 136.4		1	Allow 65.4 + (2 × 35.5) for 136.4
	= 8.18(4) (g) ***OR*** 8.2 (g)		1	Must be to 2 significant figures or more. Ignore units.

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7(c)	Moles $ZnCl_2$ = $\frac{10.7}{136.4}$ (= 0.0784) ***OR*** moles Zn = 0.0784 Mass Zn reacting = 0.0784 × 65.4 = (5.13 g) % purity of Zn = $\frac{5.13}{5.68}$ × 100 = 90.2% ***OR*** 90.3%	1 1 1 1	M2 is for their M1 × 65.4 M3 is M2 × 100 / 5.68 provided M2 is < 5.68 Allow alternative methods. M1 = Moles $ZnCl_2$ = $\frac{10.7}{136.4}$ (= 0.0784) M2 = Theoretical moles Zn = $\frac{5.68}{65.4}$ (= 0.0869) M3 = M1 × 100 / M2 = (0.0784 × 100 / 0.0869) M4 = 90.2% ***OR*** 90.3%

7(d)	Ionic Strong (electrostatic) attraction (between ions) between oppositely charged ions / + and – ions / F^- and Zn^{2+} ions	1 1 1	If not ionic CE = 0/3 If IMF, molecules, metallic bonding implied CE = 0/3

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Question	Marking Guidance	Mark	Comments
8(a)	2-bromo-2,3-dimethylbutane	1	Ignore punctuation.
	$C_nH_{2n+1}Br$ or $C_nH_{2n+1}X$ or $C_xH_{2x+1}Br$	1	Any order.
	Stronger / more <u>vdw</u> (forces) <u>between molecules</u>	1	QoL
	(of 1-bromohexane)		Allow converse arguments for Z Not just more IMF. Ignore size of molecule.
8(b)		1	
	C_2H_4Cl	1	Any order.

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General principles applied to marking CHEM1 papers by CMI+ (June 2013)

It is important to note that the guidance given here is generic and specific variations may be made in the mark scheme.

Basic principles

- **Examiners should note that throughout the mark scheme, items that are underlined are required information to gain credit.**
- **Occasionally a response involves incorrect chemistry and the mark scheme records CE = 0, which means a chemical error has occurred and no credit is given for that section of the clip or for the whole clip.**

The "List principle" and the use of "ignore" in the mark scheme

If a question requires **one** answer and a candidate gives two answers, no mark is scored if one answer is correct and one answer is incorrect. There is no penalty if both answers are correct.

N.B. Certain answers are designated in the mark scheme as those that the examiner should "Ignore". These answers are not counted as part of the list and should be ignored and will not be penalised.

Incorrect case for element symbol

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip.

For example, penalise the use of "h" for hydrogen, "CL" for chlorine or "br" for bromine.

Spelling

In general

- The names of organic chemical compounds and functional groups **must be spelled correctly,** when specifically asked for, to gain credit.
- Phonetic spelling may be acceptable for some chemical compounds (e.g. amonia would be phonetically acceptable. However, ammoniam would be unacceptable since it is ambiguous).

N.B. Some terms may be required to be spelled correctly or an idea needs to be articulated with clarity, as part of the "Quality of Language" (**QoL**) marking. These will be identified in the mark scheme and marks are awarded only if the QoL criterion is satisfied.

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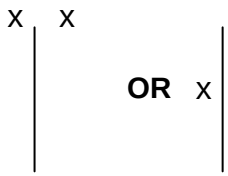
Equations

In general

- Equations **must** be balanced.
- State symbols are generally ignored, unless specifically required in the mark scheme

Lone Pairs

The following representations of lone pairs in structures are acceptable.

 with or without the 2 electrons shown **OR**  **OR** x x **OR** x x **OR** 

Reagents

The command word "Identify", allows the candidate to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when the name and formula contradict. Specific details will be given in mark schemes.

Marking calculations

In general

- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- If a candidate has made an arithmetical error or a transcription error deduct one mark, but continue marking (error carried forward).

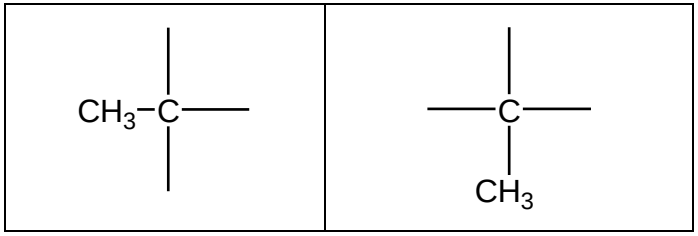
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Organic structures

In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Bonds should be drawn correctly between the relevant atoms.
- Latitude should be given to the representation of C ─ C bonds in structures, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.

- The following representations are allowed:-



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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2013

Chemistry CHEM1

Unit 1 Foundation Chemistry

Thursday 10 January 2013 9.00 am to 10.15 am

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a calculator.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator, where appropriate.
- The Periodic Table/Data Sheet is provided as an insert.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use scientific terminology accurately.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

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Section A

Answer **all** questions in the spaces provided.

1 (a) State the meaning of the term *mass number* of an isotope.

.....

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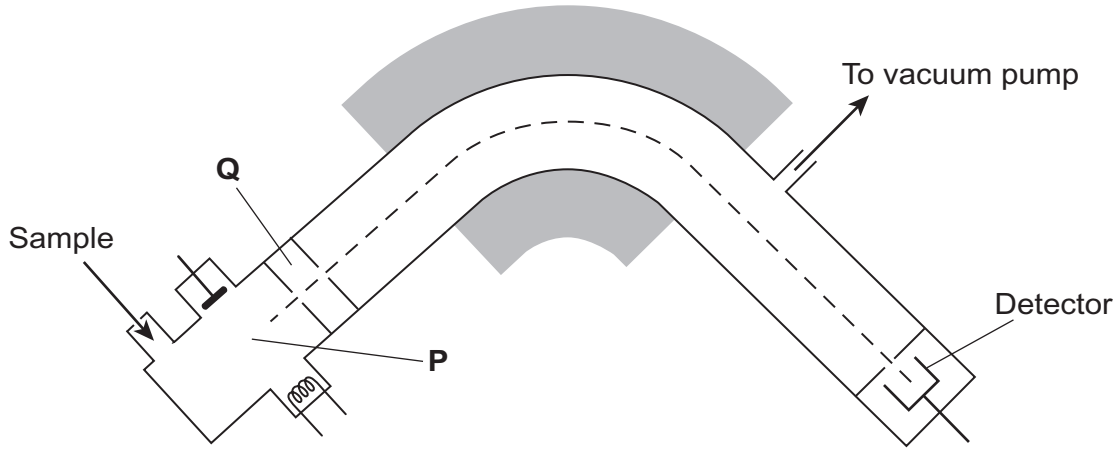
(1 mark)

1 (b) Give the symbol of the element that has an isotope with a mass number of 68 and has 38 neutrons in its nucleus.

.....

(1 mark)

1 (c) The following shows a simplified diagram of a mass spectrometer.



1 (c) (i) State what happens to the sample in the parts labelled **P** and **Q**.

P .....

Q .....

(2 marks)

Do not write outside the box

1 (c) (ii) In a mass spectrometer, the isotopes of an element are separated.
Two measurements for each isotope are recorded on the mass spectrum.

State the **two** measurements that are recorded for each isotope.

Measurement 1 .....

Measurement 2 .....

(2 marks)

1 (d) A sample of element **R** contains isotopes with mass numbers of 206, 207 and 208 in a 1:1:2 ratio of abundance.

1 (d) (i) Calculate the relative atomic mass of **R**. Give your answer to one decimal place.

.....

.....

.....

.....

.....

(3 marks)

1 (d) (ii) Identify **R**.

.....

(1 mark)

1 (d) (iii) All the isotopes of **R** react in the same way with concentrated nitric acid.

State why isotopes of an element have the same chemical properties.

.....

.....

(1 mark)

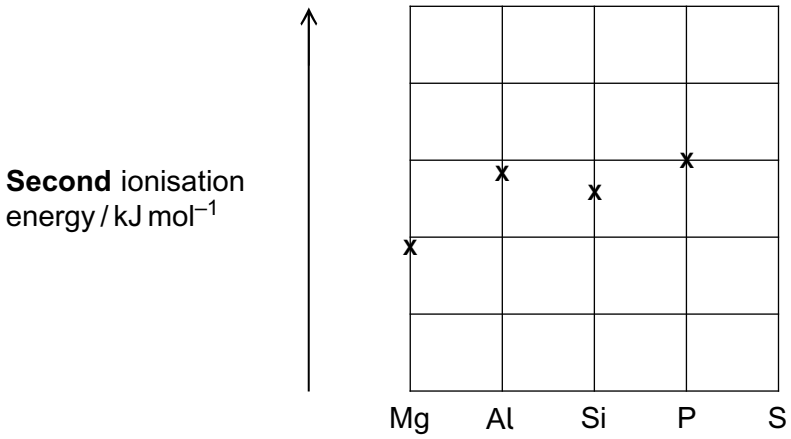
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11

Do not write outside the box

2 (a) Use your knowledge of electron configuration and ionisation energies to answer this question.
The following diagram shows the **second** ionisation energies of some Period 3 elements.



2 (a) (i) Draw an '**X**' on the diagram to show the **second** ionisation energy of sulfur.

(1 mark)

2 (a) (ii) Write the full electron configuration of the Al^{2+} ion.

.....

(1 mark)

2 (a) (iii) Write an equation to show the process that occurs when the **second** ionisation energy of aluminium is measured.

.....

(1 mark)

2 (a) (iv) Give **one** reason why the **second** ionisation energy of silicon is lower than the **second** ionisation energy of aluminium.

.....

.....

.....

(1 mark)

Do not write outside the box

2 (b) Predict the element in Period 3 that has the highest **second** ionisation energy. Give a reason for your answer.

Element .....

Reason .....

.....

.....

(2 marks)

2 (c) The following table gives the successive ionisation energies of an element in Period 3.

	First	Second	Third	Fourth	Fifth	Sixth
Ionisation energy / kJ mol^{-1}	786	1580	3230	4360	16 100	19 800

Identify this element.

.....

(1 mark)

2 (d) Explain why the ionisation energy of every element is endothermic.

.....

.....

.....

(1 mark)

(Extra space) .....

.....

8

Do not write outside the box

3 The following table shows the electronegativity values of the elements from lithium to fluorine.

	Li	Be	B	C	N	O	F
Electronegativity	1.0	1.5	2.0	2.5	3.0	3.5	4.0

3 (a) (i) State the meaning of the term *electronegativity*.

.....

.....

.....

(2 marks)

(Extra space) .....

.....

3 (a) (ii) Suggest why the electronegativity of the elements increases from lithium to fluorine.

.....

.....

.....

(2 marks)

(Extra space) .....

.....

3 (b) State the type of bonding in lithium fluoride.
Explain why a lot of energy is needed to melt a sample of solid lithium fluoride.

Bonding .....

Explanation .....

.....

.....

(3 marks)

(Extra space) .....

.....

Do not write outside the box

3 (c) Deduce why the bonding in nitrogen oxide is covalent rather than ionic.

.....

.....

(1 mark)

(Extra space) .....

.....

3 (d) Oxygen forms several different compounds with fluorine.

3 (d) (i) Suggest the type of crystal shown by OF_2

.....

(1 mark)

3 (d) (ii) Write an equation to show how OF_2 reacts with steam to form oxygen and hydrogen fluoride.

.....

(1 mark)

3 (d) (iii) One of these compounds of oxygen and fluorine has a relative molecular mass of 70.0 and contains 54.3% by mass of fluorine.

Calculate the empirical formula and the molecular formula of this compound. Show your working.

Empirical formula .....

.....

.....

.....

.....

.....

Molecular formula .....

.....

(4 marks)

14

Turn over ▶

Do not write outside the box

4 The following table shows the boiling points of some straight-chain alkanes.

	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}
Boiling point / °C	–162	–88	–42	–1	36

4 (a) State a process used to separate an alkane from a mixture of these alkanes.

.....

(1 mark)

4 (b) Both C_3H_8 and C_4H_{10} can be liquefied and used as fuels for camping stoves.

Suggest, with a reason, which of these two fuels is liquefied more easily.

.....

.....

.....

(1 mark)

4 (c) Write an equation for the complete combustion of C_4H_{10}

.....

(1 mark)

4 (d) Explain why the complete combustion of C_4H_{10} may contribute to environmental problems.

.....

.....

.....

(1 mark)

4 (e) Balance the following equation that shows how butane is used to make the compound called maleic anhydride.

$$\text{.....}CH_3CH_2CH_2CH_3 + \text{.....}\ O_2 \longrightarrow \text{.....}C_2H_2(CO)_2O + \text{.....}\ H_2O$$

(1 mark)

Do not write outside the box

4 (f) Ethanethiol (C_2H_5SH), a compound with an unpleasant smell, is added to gas to enable leaks from gas pipes to be more easily detected.

4 (f) (i) Write an equation for the combustion of ethanethiol to form carbon dioxide, water and sulfur dioxide.

.....

(1 mark)

4 (f) (ii) Identify a compound that is used to react with the sulfur dioxide in the products of combustion before they enter the atmosphere.

Give **one** reason why this compound reacts with sulfur dioxide.

Substance .....

Reason .....

.....

(2 marks)

4 (f) (iii) Ethanethiol and ethanol molecules have similar shapes.

Explain why ethanol has the higher boiling point.

.....

.....

.....

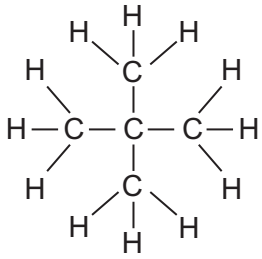
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(2 marks)

Question 4 continues on the next page

Do not write outside the box

4 (g) The following compound **X** is an isomer of one of the alkanes in the table on page 8.



4 (g) (i) Give the IUPAC name of **X**.

.....

(1 mark)

4 (g) (ii) **X** has a boiling point of 9.5 °C.

Explain why the boiling point of **X** is lower than that of its straight-chain isomer.

.....

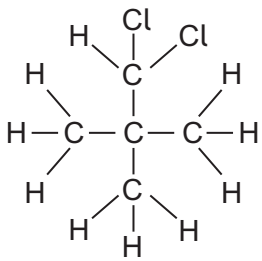
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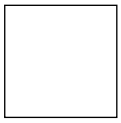
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(2 marks)

4 (g) (iii) The following compound **Y** is produced when **X** reacts with chlorine.



Deduce how many **other** position isomers of **Y** can be formed.
Write the number of **other** position isomers in this box.



(1 mark)

Do not write outside the box

4 (h) Cracking of one molecule of an alkane **Z** produces one molecule of ethane, one molecule of propene and two molecules of ethene.

4 (h) (i) Deduce the molecular formula of **Z**.

.....

(1 mark)

4 (h) (ii) State the type of cracking that produces a high proportion of ethene and propene. Give the **two** conditions for this cracking process.

Type of cracking .....

Conditions .....

.....

(2 marks)

17

Turn over for the next question

Do not write outside the box

Section B

Answer **all** questions in the spaces provided.

5 Ammonia is used to make nitric acid (HNO_3) by the Ostwald Process.
Three reactions occur in this process.

Reaction **1** $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$

Reaction **2** $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

Reaction **3** $3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$

5 (a) In one production run, the gases formed in Reaction **1** occupied a total volume of 4.31 m^3 at 25 °C and 100 kPa.

Calculate the amount, in moles, of NO produced.
Give your answer to 3 significant figures.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

.....

.....

.....

.....

.....

.....

(4 marks)

(Extra space) .....

.....

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Do not write outside the box

5 (b) In another production run, 3.00 kg of ammonia gas were used in Reaction **1** and all of the NO gas produced was used to make NO_2 gas in Reaction **2**.

5 (b) (i) Calculate the amount, in moles, of ammonia in 3.00 kg.

.....

.....

.....

.....

(2 marks)

5 (b) (ii) Calculate the mass of NO_2 formed from 3.00 kg of ammonia in Reaction **2** assuming an 80.0% yield.
Give your answer in kilograms.
(If you have been unable to calculate an answer for part **(b) (i)**, you may assume a value of 163 mol. This is **not** the correct answer.)

.....

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(3 marks)

(Extra space) .....

.....

.....

Question 5 continues on the next page

Turn over ▶

Do not write outside the box

5 (c) Consider Reaction **3** in this process.

$$3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$$

Calculate the concentration of nitric acid produced when 0.543 mol of NO_2 is reacted with water and the solution is made up to 250 cm^3.

.....

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

5 (d) Suggest why a leak of NO_2 gas from the Ostwald Process will cause atmospheric pollution.

.....

.....

(1 mark)

5 (e) Give **one** reason why excess air is used in the Ostwald Process.

.....

.....

(1 mark)

5 (f) Ammonia reacts with nitric acid as shown in this equation.

$$NH_3 + HNO_3 \longrightarrow NH_4NO_3$$

Deduce the type of reaction occurring.

.....

(1 mark)

14

Do not write outside the box

6 Chlorine can form molecules and ions that contain only chlorine, or that contain chlorine combined with another element.

6 (a) Use your understanding of the electron pair repulsion theory to draw the shape of the $AsCl_3$ molecule and the shape of the Cl_3^+ ion.
Include any lone pairs of electrons that influence the shape.

Name the shape made by the atoms in the $AsCl_3$ molecule and in the Cl_3^+ ion.

.....

.....

(4 marks)

(Extra space) .....

.....

6 (b) Explain why the $AsCl_4^+$ ion has a bond angle of 109.5º

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

6

END OF QUESTIONS

There are no questions printed on this page

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Version 1.4



General Certificate of Education (A-level)
January 2013

Chemistry CHEM1

(Specification 2420)

Unit 1: Foundation Chemistry

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Question	Marking Guidance	Mark	Comments
1(a)	(Total number of) protons and neutrons (in nucleus of atom)	1	(number of) nucleons
1(b)	Zn	1	Do not allow Zn^{-1} or Zn^{+1} or ZN Ignore numbers
1(c)(i)	P = ionise (sample) Q = accelerate (sample)	1 1	Allow removing an electron / forms (+) ions Allow speeds (ions) up Penalise molecules / atoms
1(c)(ii)	m/z (relative) abundance / (relative) intensity	1 1	Allow mass / charge QoL Allow M1 + M2 in any order
1(d)(i)	$\frac{206 + 207 + (208 \times 2)}{4} = \frac{(829)}{4}$ $= 207.3$	1 1 1	M1 = topline M2 = ÷ 4 Only 207.3 = 3 marks
1(d)(ii)	Lead/Pb	1	Not PB
1(d)(iii)	Same number of electrons (in outer shell) / same electronic configuration	1	Ignore electrons determine chemical properties Ignore reference to p and n if correct Penalise if incorrect

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Question	Marking Guidance	Mark	Comments
2(a)(i)	Higher than P	1	
2(a)(ii)	$1s^2\ 2s^2 2p^6 3s^1$	1	Allow any order
2(a)(iii)	$Al^+(g) + e^{(-)} \longrightarrow Al^{2+}(g) + 2e^{(-)}$ ***OR*** $Al^+(g) \longrightarrow Al^{2+}(g) + e^{(-)}$ ***OR*** $Al^+(g) - e^{(-)} \longrightarrow Al^{2+}(g)$	1	
2(a)(iv)	Electron in Si (removed from) (3)p orbital / electron (removed) from higher energy orbital or sub-shell / electron in silicon is more shielded	1	Accept converse arguments relating to Al Penalise incorrect p-orbital
2(b)	Sodium / Na Electron (removed) from the 2nd shell / 2p (orbital)	1 1	Allow Na^+ M2 is dependent on M1 Allow electron from shell nearer the nucleus (so more attraction)
2(c)	Silicon / Si	1	Not SI
2(d)	Heat or energy needed to overcome the attraction between the (negative) electron and the (positive) nucleus or protons Or words to that effect eg electron promoted to higher energy level (infinity) so energy must be supplied	1	Not breaking bonds QoL

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Question	Marking Guidance	Mark	Comments
3(a)(i)	The power of an <u>atom</u> or <u>nucleus</u> to withdraw or attract electrons ***OR*** electron density ***OR*** a pair of electrons (towards itself) In a <u>covalent</u> bond	1 1	Ignore retain
3(a)(ii)	More protons / bigger nuclear charge Same or similar shielding / electrons in the same shell or principal energy level / atoms get smaller	1 1	 Not same sub–shell Ignore more electrons
3(b)	Ionic Strong or many or lots of (electrostatic) <u>attractions</u> (between ions) Between + and – ions / between Li^+ and F^- ions / oppositely charged ions	1 1 1	If not ionic then CE = 0/3 If blank lose M1 and mark on If molecules / IMF / metallic / atoms lose M2 + M3, penalise incorrect ions by 1 mark Allow strong (ionic) bonds for max 1 out of M2 and M3
3(c)	Small electronegativity difference / difference = 0.5	1	Must be comparative Allow 2 non-metals
3(d)(i)	(simple) <u>molecular</u>	1	Ignore simple covalent
3(d)(ii)	$OF_2 + H_2O \longrightarrow O_2 + 2HF$	1	Ignore state symbols Allow multiples Allow OF_2 written as F_2O

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3(d)(iii)	45.7% O (O F) (45.7 54.3) (16 19) (2.85 2.85) (1 1) EF = OF or FO MF (= 70.0/35) = O_2F_2 or F_2O_2	1 1 1 1	If students get M2 upside down lose M2 + M3 Check that students who get correct answer divide by 16 and 19 (not 8 and 9). If dividing by 8 and 9 lose M2 and M3 but could allocate M4 ie max 2 Calculation of OF by other correct method = 3 marks Penalise Fl by 1 mark

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Question	Marking Guidance	Mark	Comments
4(a)	Fractional distillation / fractionation / GLC / gas liquid chromatography	1	
4(b)	C_4H_{10} Because it has a higher bp / has stronger IMF / larger molecule / longer chain / larger surface (area)	1	Need C_4H_{10} **and** the reason for the mark
4(c)	$C_4H_{10} + 6½\ O_2 \longrightarrow 4CO_2 + 5H_2O$	1	Accept multiples Ignore state symbols
4(d)	CO_2 or H_2O evolved is a greenhouse gas / CO_2 or H_2O evolved contribute to global warming / the products are greenhouse gases	1	Ignore climate change
4(e)	$CH_3CH_2CH_2CH_3 + 3.5O_2 \longrightarrow C_2H_2(CO)_2O + 4H_2O$	1	Accept multiples Allow with or without a number 1 before the organic molecules
4(f)(i)	$C_2H_5SH + 4.5O_2 \longrightarrow 2CO_2 + 3H_2O + SO_2$	1	Accept multiples
4(f)(ii)	Calcium oxide / calcium carbonate Neutralises the SO_2 / acid base reaction / it is a base	1 1	Allow any base or alkali Allow correct formulae Can only score M2 if base or alkali used in M1 Allow M2 if blank in M1

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4(f)(iii)	Ethanol contains Hydrogen bonding Which is stronger than IMF (VDW / dipole-dipole forces) in ethanethiol/ (H bonding) is the strongest IMF	1 1	Breaking covalent bonds CE = 0/2 Only award M2 if M1 given, but allow IMF in ethanol are stronger than in ethanethiol for maximum 1 mark
4(g)(i)	(2,2-)dimethylpropane	1	Ignore punctuation
4(g)(ii)	Because molecule is smaller / less polarisable / has less surface (area)/ is more spherical / molecules can't get as close to one another (to feel the vdW forces) vdW intermolecular forces or vdW force between molecules are weaker or fewer	1 1	Allow converse answers referring to straight chain isomers CE = 0/2 if breaking bonds Need vdW rather than just IMF
4(g)(iii)	1 or one	1	
4(h)(i)	C_9H_{20}	1	$H_{20}C_9$
4(h)(ii)	Thermal (cracking) High pressure AND high temperature ***OR*** Pressure of ≥ 10 atm, ≥ 1 MPa ≥ 1000 kPa AND temp of 400 ^{0}C ≤ T ≤ 1000 ^{0}C or 650 K ≤ T≤ 1300 K	1 1	If not thermal cracking CE = 0/2 If blank mark on Allow high P and T Do not allow high heat If no units for T, then range must be 650-1000

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Question	Marking Guidance	Mark	Comments
5(a)	P = 100 000 Pa and T = 298 K	1	Wrong conversion of V or incorrect conversion of P/T lose M1 + M3
	$n = \frac{PV}{RT}$ or $\frac{100\,000 \times 4.31}{8.31 \times 298}$	1	If not rearranged correctly then cannot score M2 and M3
	n(total) = 174(.044)	1	
	n (NO) = $\frac{69.6}{}$	1	Allow student's M3 x 4/10 but must be to 3 significant figures
5(b)(i)	$\frac{3000}{17}$	1	Allow answer to 2 significant figures or more
	176.5	1	Allow 176–177 But if answer = 0.176 – 0.18 (from 3/17) then allow 1 mark

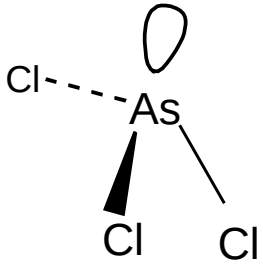
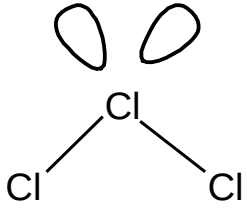
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5(b)(ii)	176.47 x 46 = 8117.62 8117.62 x $\frac{80}{100}$ (= 6494 g) $\frac{6494}{1000}$ = 6.5 ***OR*** If 163 mol used: 163 x 46 = 7498 (1) 7498 x $\frac{80}{100}$ = 5998.4 g (1) 6.00 kg (1)	1 1 1	M1 is for the answer to (b)(i) x 46. But lose this mark if 46 ÷ 2 at any stage However if 92 ÷ 2 allow M1 M2 is for M1 x 80/100 M3 is for the answer to M2 ÷ 1000 to min 2 significant figures (kg)

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5(c)	0.543 x $\frac{2}{3}$ (= 0.362) 0.362 x $\frac{1000}{250}$ = 1.45 (mol dm^{-3})	1 1	If not x $\frac{2}{3}$ CE = 0/2 Allow 1.447-1.5 (mol dm^{-3}) for 2 marks
5(d)	NO_2 contributes to acid rain / is an acid gas / forms HNO_3 / NO_2 is toxic / photochemical smog	1	Ignore references to water, breathing problems and ozone layer. Not greenhouse gas
5(e)	Ensure the ammonia is used up / ensure complete reaction or combustion ***OR*** Maximise the yield of nitric acid or products	1	
5(f)	Neutralisation	1	Allow acid vs alkali or acid base reaction

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Question	Marking Guidance	Mark	Comments
6(a)		1	Mark is for 3 As-Cl bonds and 1 lone pair
	(Trigonal) pyramid(al) / tetrahedral	1	Allow triangular pyramid
		1	Mark is for 2 Cl-Cl bonds and 2 lone pairs Do not penalise if + not shown
	Bent / V-shaped / triangular	1	Not trigonal
6(b)	There are 4 bonds or 4 pairs of electrons (around As)	1	Can show in a diagram. If lone pair included in shape, CE = 0/2
	(Electron pairs / bonds) repel equally	1	QoL

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General principles applied to marking CHEM1 papers by CMI+ (January 2013)

It is important to note that the guidance given here is generic and specific variations may be made in the mark scheme.

Basic principles

- **Examiners should note that throughout the mark scheme, items that are underlined are required information to gain credit.**
- **Occasionally a response involves incorrect chemistry and the mark scheme records CE = 0, which means a chemical error has occurred and no credit is given for that section of the clip or for the whole clip.**

The "List principle" and the use of "ignore" in the mark scheme

If a question requires **one** answer and a student gives two answers, no mark is scored if one answer is correct and one answer is incorrect. There is no penalty if both answers are correct.
N.B. Certain answers are designated in the mark scheme as those that the examiner should "Ignore". These answers are not counted as part of the list and should be ignored and will not be penalised.

Incorrect case for element symbol

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip.
For example, penalise the use of "h" for hydrogen, "CL" for chlorine or "br" for bromine.

Spelling

In general

- The names of organic chemical compounds and functional groups **must be spelled correctly,** when specifically asked for, to gain credit.
- Phonetic spelling may be acceptable for some chemical compounds (eg amonia would be phonetically acceptable. However, ammoniam would be unacceptable since it is ambiguous).

N.B. Some terms may be required to be spelled correctly or an idea needs to be articulated with clarity, as part of the "Quality of Language" (**QoL**) marking. These will be identified in the mark scheme and marks are awarded only if the QoL criterion is satisfied.

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Equations

In general

- Equations **must** be balanced.
- State symbols are <u>generally</u> ignored, unless specifically required in the mark scheme

Lone Pairs

The following representations of lone pairs in structures are acceptable.

 with or without the 2 electrons shown **OR** x x **OR** x x **OR** x x **OR** ••

Reagents

The command word "Identify", allows the student to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when the name and formula contradict. Specific details will be given in mark schemes.

Marking calculations

In general

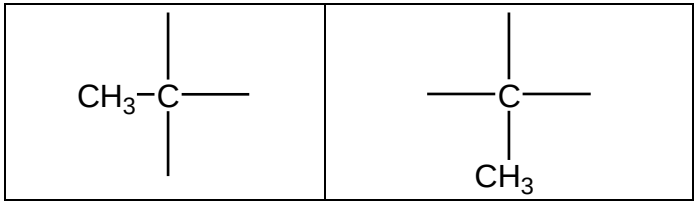
- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- If a student has made an arithmetic error or a transcription error deduct one mark, but continue marking (error carried forward).

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Organic structures

In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Bonds should be drawn correctly between the relevant atoms.
- Latitude should be given to the representation of C ─ C bonds in structures, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- The following representations are allowed:-



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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2012

Chemistry CHEM1

Unit 1 Foundation Chemistry

Tuesday 15 May 2012 1.30 pm to 2.45 pm

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a calculator.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- The Periodic Table/Data Sheet is provided as an insert.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use accurate scientific terminology.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

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Do not write outside the box

Section A

Answer **all** questions in the spaces provided.

1 The element rubidium exists as the isotopes ^{85}Rb and ^{87}Rb

1 (a) State the number of protons and the number of neutrons in an atom of the isotope ^{85}Rb

Number of protons .....

Number of neutrons .....

(2 marks)

1 (b) (i) Explain how the gaseous atoms of rubidium are ionised in a mass spectrometer.

.....

.....

.....

.....

(2 marks)

1 (b) (ii) Write an equation, including state symbols, to show the process that occurs when the **first** ionisation energy of rubidium is measured.

.....

(1 mark)

1 (c) The table shows the first ionisation energies of rubidium and some other elements in the same group.

Element	sodium	potassium	rubidium
First ionisation energy / kJ mol^{-1}	494	418	402

State **one** reason why the first ionisation energy of rubidium is lower than the first ionisation energy of sodium.

.....

.....

.....

(1 mark)

Do not write outside the box

1 (d) (i) State the block of elements in the Periodic Table that contains rubidium.

.....

(1 mark)

1 (d) (ii) Deduce the full electron configuration of a rubidium atom.

.....

(1 mark)

1 (e) A sample of rubidium contains the isotopes ^{85}Rb and ^{87}Rb only.
The isotope ^{85}Rb has an abundance 2.5 times greater than that of ^{87}Rb

Calculate the relative atomic mass of rubidium in this sample.
Give your answer to one decimal place.

.....

.....

.....

.....

(3 marks)

1 (f) By reference to the relevant part of the mass spectrometer, explain how the abundance of an isotope in a sample of rubidium is determined.

Name of relevant part .....

Explanation .....

.....

.....

(2 marks)

1 (g) Predict whether an atom of ^{88}Sr will have an atomic radius that is larger than, smaller than or the same as the atomic radius of ^{87}Rb. Explain your answer.

Atomic radius of ^{88}Sr compared to ^{87}Rb .....

Explanation .....

.....

.....

.....

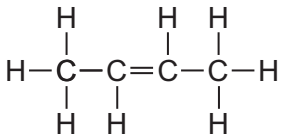
(3 marks)

16

Turn over ▶

Do not write outside the box

2 Compound **X** is shown below. It is a member of a homologous series of hydrocarbons.



2 (a) (i) Deduce the general formula of the homologous series that contains **X**.

.....

(1 mark)

2 (a) (ii) Name a process used to obtain a sample of **X** from a mixture containing other members of the same homologous series.

.....

(1 mark)

2 (b) There are several isomers of **X**.

2 (b) (i) Give the IUPAC name of the position isomer of **X**.

.....

(1 mark)

2 (b) (ii) Draw the structure of a functional group isomer of **X**.

(1 mark)

2 (c) At high temperatures, one molecule of $C_{15}H_{32}$ can be converted into two molecules of **X** and one molecule of another compound.

2 (c) (i) Write an equation for this reaction.

.....

(1 mark)

Do not write outside the box

2 (c) (ii) State the name of the process used to obtain a high yield of **X** from $C_{15}H_{32}$
Give **one** reason why this process is used in industry.

Name .....

Reason .....

.....

(2 marks)

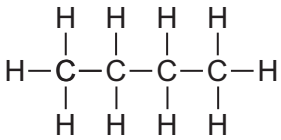
2 (c) (iii) State why high temperatures are needed for this process.

.....

.....

(1 mark)

2 (d) Compound **X** can be converted into compound **Y**.
Compound **Y** is shown below.



2 (d) (i) Suggest the formula of a reagent that could be added to **X** in order to convert it into **Y**.

.....

(1 mark)

2 (d) (ii) Give **one** use of **Y**.

.....

(1 mark)

2 (d) (iii) Write an equation to show the reaction of **Y** in a limited supply of air to produce a solid and water only.

.....

(1 mark)

Question 2 continues on the next page

Do not write outside the box

2 (d) (iv) When a sample of **Y**, contaminated with CH_3SH, is burned completely in air, a toxic gas is formed.
Identify this toxic gas and suggest a compound that could be used to remove the toxic gas from the products of combustion.

Toxic gas .....

Compound used to remove toxic gas .....

.....

(2 marks)

2 (d) (v) Suggest the name of the process that occurs when the toxic gas in part **(d) (iv)** is removed.

.....

(1 mark)

2 (e) Explain why the boiling points of **X** and **Y** are similar.

.....

.....

.....

.....

(2 marks)

16

Do not write outside the box

3 The following equation shows the reaction of a phosphine molecule (PH_3) with an H^+ ion.

$$PH_3 + H^+ \longrightarrow PH_4^+$$

3 (a) Draw the shape of the PH_3 molecule. Include any lone pairs of electrons that influence the shape.

(1 mark)

3 (b) State the type of bond that is formed between the PH_3 molecule and the H^+ ion. Explain how this bond is formed.

Name of bond .....

How bond is formed .....

.....

(2 marks)

3 (c) Predict the bond angle in the PH_4^+ ion.

.....

(1 mark)

3 (d) Although phosphine molecules contain hydrogen atoms, there is no hydrogen bonding between phosphine molecules.
Suggest an explanation for this.

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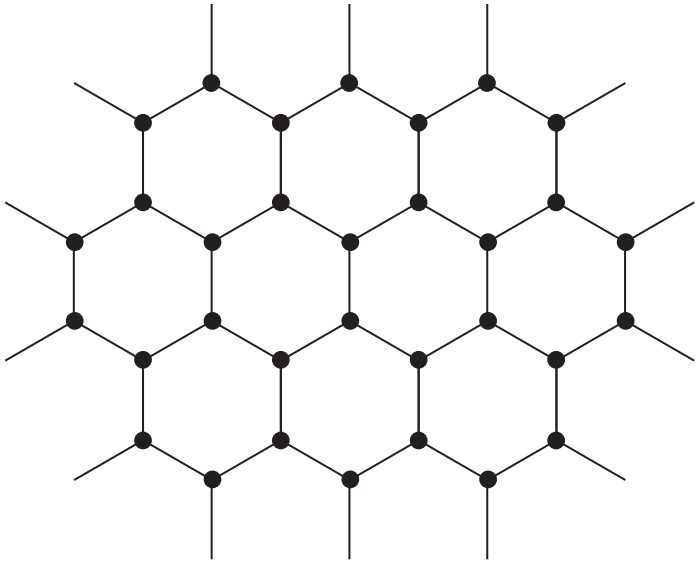
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(1 mark)

5

Do not write outside the box

4 (a) Graphene is a new material made from carbon atoms. It is the thinnest and strongest material known. Graphene has a very high melting point and is an excellent conductor of electricity.
Part of the structure of graphene is illustrated in the diagram.



4 (a) (i) Deduce the type of crystal structure shown by graphene.

.....

(1 mark)

4 (a) (ii) Suggest why graphene is an excellent conductor of electricity.

.....

.....

.....

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(2 marks)

4 (a) (iii) Explain, in terms of its structure and bonding, why graphene has a high melting point.

.....

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.....

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(2 marks)

Do not write outside the box

4 (b) Titanium is also a strong material that has a high melting point. It has a structure similar to that of magnesium.

4 (b) (i) State the type of crystal structure shown by titanium.

.....

(1 mark)

4 (b) (ii) Explain, in terms of its structure and bonding, why titanium has a high melting point.

.....

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(2 marks)

4 (c) Titanium can be hammered into objects with different shapes that have similar strengths.

4 (c) (i) Suggest why titanium can be hammered into different shapes.

.....

.....

(1 mark)

4 (c) (ii) Suggest why these objects with different shapes have similar strengths.

.....

.....

(1 mark)

4 (d) Magnesium oxide (MgO) has a melting point of 3125 K.
Predict the type of crystal structure in magnesium oxide and suggest why its melting point is high.

Type of crystal structure .....

Explanation .....

.....

.....

.....

(3 marks)

13

Do not write outside the box

Section B

Answer **all** questions in the spaces provided.

5 (a) Boron trichloride (BCl_3) can be prepared as shown by the following equation.

$$B_2O_3(s) + 3C(s) + 3Cl_2(g) \longrightarrow 2BCl_3(g) + 3CO(g)$$

A sample of boron oxide (B_2O_3) was reacted completely with carbon and chlorine. The two gases produced occupied a total volume of 5000 cm^3 at a pressure of 100 kPa and a temperature of 298 K.

Calculate the mass of boron oxide that reacted.
Give your answer to 3 significant figures.

(The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$)

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(5 marks)

(Extra space) .....

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Do not write outside the box

5 (b) Boron trichloride can also be prepared from its elements.

Write an equation for this reaction.
Explain why boron trichloride has a trigonal planar shape with equal bond angles.

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

5 (c) (i) Boron trichloride is easily hydrolysed to form two different acids as shown in the following equation.

$$BCl_3(g) + 3H_2O(l) \longrightarrow H_3BO_3(aq) + 3HCl(aq)$$

Calculate the concentration, in mol dm^{-3}, of hydrochloric acid produced when 43.2 g of boron trichloride are added to water to form 500 cm^3 of solution.
Give your answer to 3 significant figures.

.....

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(4 marks)

(Extra space) .....

.....

5 (c) (ii) Boric acid (H_3BO_3) can react with sodium hydroxide to form sodium borate and water.
Write an equation for this reaction.

.....

(1 mark)

Question 5 continues on the next page

Turn over ▶

Do not write outside the box

5 (d) Boron trichloride can be reduced by using hydrogen to form pure boron.

$$BCl_3(g) + 1\tfrac{1}{2}H_2(g) \longrightarrow B(s) + 3HCl(g)$$

Calculate the percentage atom economy for the formation of boron in this reaction.

Apart from changing the reaction conditions, suggest **one** way a company producing pure boron could increase its profits from this reaction.

.....

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.....

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.....

(3 marks)

(Extra space) .....

.....

5 (e) A different compound of boron and chlorine has a relative molecular mass of 163.6 and contains 13.2% of boron by mass.

Calculate the molecular formula of this compound.
Show your working.

.....

.....

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.....

(4 marks)

(Extra space) .....

.....

20

END OF QUESTIONS

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Version 1.1



General Certificate of Education (A-level)
June 2012

Chemistry CHEM1

(Specification 2420)

Unit 1: Foundation Chemistry

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Question	Marking Guidance	Mark	Comments
1(a)	37 48	1 1	These answers only. Allow answers in words. Ignore any sum(s) shown to work out the answers.
1(b)(i)	Electron gun / high speed/high energy electrons Knock out electron(s)	1 1	Not just electrons. Not highly charged electrons. Remove an electron.
1(b)(ii)	$Rb(g) \rightarrow Rb^{+}(g) + e^{(-)}$ ***OR*** $Rb(g) + e^{(-)} \rightarrow Rb^{+}(g) + 2e^{(-)}$ ***OR*** $Rb(g) - e^{(-)} \rightarrow Rb^{+}(g)$	1	Ignore state symbols for electron.
1(c)	Rb is a bigger (atom) / e further from nucleus / electron lost from a higher energy level/ More shielding in Rb / less attraction of nucleus in Rb for outer electron / more shells	1	Answer should refer to Rb not Rb molecule. If converse stated it must be obvious it refers to Na Answer should be comparative.
1(d)(i)	s / block s / group s	1	Only
1(d)(ii)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^1$	1	Allow $3d^{10}$ before $4s^2$ Allow in any order.

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1(e)	$\frac{(85 \times 2.5) + 87 \times 1}{3.5}$ = 85.6 ***OR*** $\frac{(85 \times 5) + 87 \times 2}{7}$ = 85.6	1 1 1 1 1 1	M1 is for top line Only ***OR*** M1 ^{85}Rb 71.4% and ^{87}Rb 28.6% M2 divide by 100 M3 = 85.6
1(f)	Detector Current / digital pulses / electrical signal related to abundance	1 1	Mark independently. Allow detection (plate). Not electrical charge.
1(g)	Smaller Bigger nuclear charge / more protons in Sr Similar/same shielding	1 1 1	Chemical error if not smaller, CE = 0/3 If blank mark on. Not bigger nucleus. QWC (Outer) electron entering same shell/sub shell/orbital/same number of shells. Do not allow incorrect orbital.

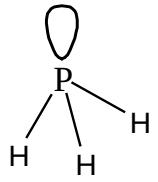
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Question	Marking Guidance	Mark	Comments
2(a)(i)	C_nH_{2n} / C_xH_{2x}	1	
2(a)(ii)	Fractional distillation / GLC / gas liquid chromatography / fractionation	1	Do **not** allow cracking / distillation
2(b)(i)	But-1-ene / but1ene	1	Ignore hyphens and commas Do **not** allow butene-1 / but-2-ene / butane / butane /alkene / C_4H_8 / propene / straight-chain alkene
2(b)(ii)	A structure of cyclobutane or methyl-cyclopropane	1	Allow skeletal formula.
2(c)(i)	$C_{15}H_{32} \rightarrow 2C_4H_8 + C_7H_{16}$	1	Do not accept multiples.
2(c)(ii)	Thermal cracking To produce products that are in greater demand / more valuable / more expensive / more profitable	1 1	Not catalytic cracking or cracking. The (unsaturated) alkene or the (unsaturated) molecule or X produced can be polymerised or can be made into plastics. Ignore more useful products.
2(c)(iii)	Break (C-C or C-H) bonds	1	Allow to overcome the activation energy. Allow to break the carbon chain. Penalise breaking wrong bonds.
2(d)(i)	H_2	1	Only.

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2(d)(ii)	Fuel / LPG	1	Allow camping gas, lighter fuel, propellant, refrigerant, cordless appliances. Do not allow petrol or motor fuel. Ignore natural gas.
2(d)(iii)	$C_4H_{10} + 2.5O_2 \rightarrow 4C + 5H_2O$	1	Accept multiples.
2(d)(iv)	SO_2 / sulfur dioxide	1	If other sulfur oxides, mark on.
	Calcium oxide / CaO / lime / quicklime	1	Allow $CaCO_3$ / allow $Ca(OH)_2$ or names. Allow any solid base. M2 dependent on M1. Do not allow limewater.
2(d)(v)	Neutralisation	1	Allow acid-base reaction. Allow flue gas desulfurisation / FGD
2(e)	(Molecules) are similar sizes / have similar M_r / have similar number of electrons	1	Chemical error CE = 0/2 if breaking bonds. Allow similar number of carbon and hydrogen atoms / similar surface area / similar chain length. Can accept same number of carbon atoms. Do not accept same number of H atoms / same number of bonds. Ignore similar amount of bonds.
	Similar van der Waals forces <u>between molecules</u> / similar <u>intermolecular</u> forces (IMF)	1	Not similar incorrect IMF eg dipole-dipole

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Question	Marking Guidance	Mark	Comments
3(a)		1	Need to see 3 P-H bonds and one lone pair (ignore shape).
3(b)	Coordinate / dative Pair of electrons on P(H_3) donated (to H+)	1 1	If not coordinate / dative then chemical error CE=0 unless blank or covalent then M1 = 0 and mark on. Do not allow a generic description of a coordinate bond.
3(c)	109.5° / 109½ / 109° 28’	1	Allow answers in range between 109° to 109.5°
3(d)	Difference in electronegativity between P and H is too small	1	Allow P not very electronegative / P not as electronegative as N, O and F / P not electronegative enough / P not one of the 3 most electronegative elements. Do not allow phosphine is not very electronegative.

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Question	Marking Guidance	Mark	Comments
4(a)(i)	Macromolecular / giant covalent / giant molecular / giant atomic	1	If covalent, molecular, giant, lattice, hexagonal or blank mark on. If metallic, ionic or IMF chemical error CE = 0 for 4(a)(i), 4(a)(ii) and 4(a)(iii).
4(a)(ii)	Delocalised electrons / free electrons Able to move / flow (through the crystal)	1 1	 Allow M2 for electrons can move / flow. Ignore electrons can carry a current / charge.
4(a)(iii)	Covalent bonds Many /strong / hard to break / need a lot of energy to break	1 1	 M2 dependent on M1. Ignore van der Waals' forces.
4(b)(i)	(Giant) metallic / metal (lattice)	1	If FCC or BCC or HCP or giant or lattice, mark on. If incorrect 4(b)(i), chemical error CE for 4(b)(ii) and 4(c)(ii).
4(b)(ii)	Nucleus / protons / positive ions and delocalised electrons (are attracted) Strong attraction	1 1	QWC Must be delocalised electrons – not just electrons. Chemical error = 0/2 for 4(b)(ii) if other types of bonding or IMF mentioned. Allow strong metallic bonding for one mark if M1 and M2 are not awarded.
4(c)(i)	Layers of atoms/ions slide (over one another)	1	Do not allow just layers.

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4(c)(ii)	(Strong) (metallic) bonding re-formed / same (metallic) bonding / retains same (crystal) structure / same <u>bond strength</u> / same attraction between protons and delocalised electrons as before being hammered or words to that effect	1	If IMF, molecules, chemical error CE = 0/1 for 4(c)(ii). If metallic not mentioned in 4(b)(i) or 4(b)(ii) it must be mentioned here in 4(c)(ii) to gain this mark. Do not allow metallic bonds broken alone. Ignore same shape or same strength.
4(d)	(giant) Ionic Between + and – ions / oppositely charged ions or Mg^{2+} and O^{2-} <u>Strong attraction</u>	1 1 1	If not ionic, chemical error CE = 0/3 If molecules mentioned in explanation lose M2 and M3 Allow one mark for a strong attraction between incorrect charges on the ions.

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Question	Marking Guidance	Mark	Comments
5(a)	P = 100 000 (Pa) and V = 5.00×10^{-3} (m^3)	1	M1 is for correctly converting P and V in any expression or list Allow 100 (kPa) and 5 (dm^3) for M1.
	$n = \frac{PV}{RT} = \frac{100\,000 \times 5.00 \times 10^{-3}}{8.31 \times 298}$	1	M2 is correct rearrangement of PV = nRT
	= 0.202 moles (of gas produced)		This would score M1 and M2.
	Therefore $\frac{0.202}{5}$ = 0.0404 moles B_2O_3	1	M3 is for their answer divided by 5
	Mass of B_2O_3 = 0.0404 x 69.6	1	M4 is for their answer to M3 x 69.6
	= 2.81 (g)	1	M5 is for their answer to 3 sig figures. 2.81 (g) gets 5 marks.
5(b)	B + 1.5 Cl_2 → BCl_3	1	Accept multiples.
	3 bonds	1	
	Pairs repel equally/ by the same amount	1	Do not allow any lone pairs if a diagram is shown.

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5(c)(i)	43.2/117.3 (= 0.368 moles BCl_3) 0.368 x 3 (= 1.105 moles HCl) Conc HCl = $\frac{1.105 \times 1000}{500}$ = 2.20 to 2.22 mol dm^{-3}	1 1 1 1	 Allow their BCl_3 moles x 3 Allow moles of HCl x 1000 / 500 Allow 2.2 Allow 2 significant figures or more
5(c)(ii)	$H_3BO_3 + 3NaOH \rightarrow Na_3BO_3 + 3H_2O$	1	Allow alternative balanced equations to form acid salts. Allow $H_3BO_3 + NaOH \rightarrow NaBO_2 + 2H_2O$
5(d)	$\frac{10.8}{120.3}$ (x 100) 8.98(%) Sell the HCl	1 1 1	Mark is for both M_r values correctly as numerator and denominator. Allow 9(%).

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5(e)	Cl = 86.8% B Cl $\frac{13.2}{10.8}$ $\frac{86.8}{35.5}$ 1.22 2.45 or ratio 1:2 or BCl_2 BCl_2 has M_r of 81.8 so 81.8 x 2 = 163.6 Formula = B_2Cl_4	1 1 1 1	Alternative method Cl = 142 g B Cl $\frac{21.6}{10.8}$ $\frac{142}{35.5}$ 2:4 ratio B_2Cl_4 Allow 4 marks for correct answer with working shown. Do not allow $(BCl_2)_2$

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General principles applied to marking CHEM1 papers by CMI+ (June 2012)

It is important to note that the guidance given here is generic and specific variations may be made in the mark scheme.

Basic principles

- **Examiners should note that throughout the mark scheme, items that are underlined are required information to gain credit.**
- **Occasionally a response involves incorrect chemistry and the mark scheme records CE = 0, which means a chemical error has occurred and no credit is given for that section of the clip or for the whole clip.**

A. The "List principle" and the use of "ignore" in the mark scheme

If a question requires **one** answer and a candidate gives two answers, no mark is scored if one answer is correct and one answer is incorrect. There is no penalty if both answers are correct.

N.B. Certain answers are designated in the mark scheme as those that the examiner should "Ignore". These answers are not counted as part of the list and should be ignored and will not be penalised.

B. Incorrect case for element symbol

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip.

For example, penalise the use of "h" for hydrogen, "CL" for chlorine or "br" for bromine.

C. Spelling

In general

- The names of organic chemical compounds and functional groups **must be spelled correctly,** when specifically asked for, to gain credit.
- Phonetic spelling may be acceptable for some chemical compounds (eg amonia would be phonetically acceptable. However, ammoniam would be unacceptable since it is ambiguous).

N.B. Some terms may be required to be spelled correctly or an idea needs to be articulated with clarity, as part of the "Quality of Language" (**QoL**) marking. These will be identified in the mark scheme and marks are awarded only if the QoL criterion is satisfied.

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D. Equations

In general

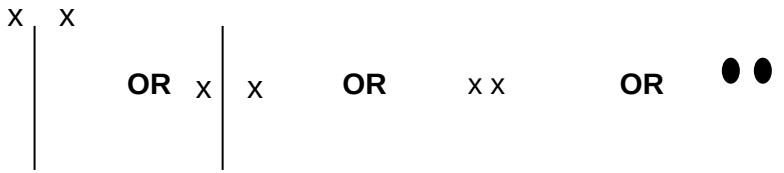
- Equations **must** be balanced.
- State symbols are generally ignored, unless specifically required in the mark scheme.

E. Lone Pairs

The following representations of lone pairs in structures are acceptable.



with or without the 2 electrons shown **OR**



F. Reagents

The command word "Identify", allows the candidate to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when the name and formula contradict. Specific details will be given in mark schemes.

G. Marking calculations

In general

- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- If a candidate has made an arithmetic error or a transcription error deduct one mark, but continue marking (error carried forward).

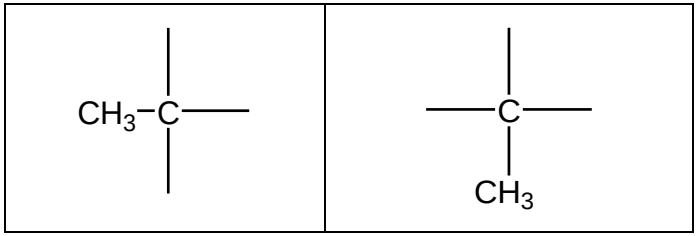
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H. Organic structures

In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Bonds should be drawn correctly between the relevant atoms.
- Latitude should be given to the representation of C ─ C bonds in structures, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.

- The following representations are allowed:-



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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2012

Chemistry CHEM1

Unit 1 Foundation Chemistry

Friday 13 January 2012 1.30 pm to 2.45 pm

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a calculator.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- The Periodic Table/Data Sheet is provided as an insert.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use accurate scientific terminology.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

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Do not write outside the box

Section A

Answer **all** questions in the spaces provided.

1 Fluorine forms compounds with many other elements.

1 (a) Fluorine reacts with bromine to form liquid bromine trifluoride (BrF_3).
State the type of bond between Br and F in BrF_3 and state how this bond is formed.

Type of bond .....

How bond is formed .....

.....

(2 marks)

1 (b) Two molecules of BrF_3 react to form ions as shown by the following equation.

$$2BrF_3 \longrightarrow BrF_2^+ + BrF_4^-$$

1 (b) (i) Draw the shape of BrF_3 and predict its bond angle.
Include any lone pairs of electrons that influence the shape.

Shape of BrF_3

Bond angle .....

(2 marks)

1 (b) (ii) Draw the shape of BrF_4^- and predict its bond angle.
Include any lone pairs of electrons that influence the shape.

Shape of BrF_4^-

Bond angle .....

(2 marks)

Do not write outside the box

1 (c) BrF_4^- ions are also formed when potassium fluoride dissolves in liquid BrF_3 to form $KBrF_4$
Explain, in terms of bonding, why $KBrF_4$ has a high melting point.

.....

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

1 (d) Fluorine reacts with hydrogen to form hydrogen fluoride (HF).

1 (d) (i) State the strongest type of intermolecular force between hydrogen fluoride molecules.

.....

(1 mark)

1 (d) (ii) Draw a diagram to show how two molecules of hydrogen fluoride are attracted to each other by the type of intermolecular force that you stated in part **(d) (i)**. Include all partial charges and all lone pairs of electrons in your diagram.

(3 marks)

1 (e) The boiling points of fluorine and hydrogen fluoride are –188 °C and 19.5 °C respectively.
Explain, in terms of bonding, why the boiling point of fluorine is very low.

.....

.....

.....

(2 marks)

(Extra space) .....

.....

15

Do not write outside the box

2 Trends in physical properties occur across all Periods in the Periodic Table.
This question is about trends in the Period 2 elements from lithium to nitrogen.

2 (a) Identify, from the Period 2 elements lithium to nitrogen, the element that has the largest atomic radius.

.....

(1 mark)

2 (b) (i) State the general trend in first ionisation energies for the Period 2 elements lithium to nitrogen.

.....

(1 mark)

2 (b) (ii) Identify the element that deviates from this general trend, from lithium to nitrogen, and explain your answer.

Element .....

Explanation .....

.....

.....

(3 marks)

(Extra space) .....

.....

2 (c) Identify the Period 2 element that has the following successive ionisation energies.

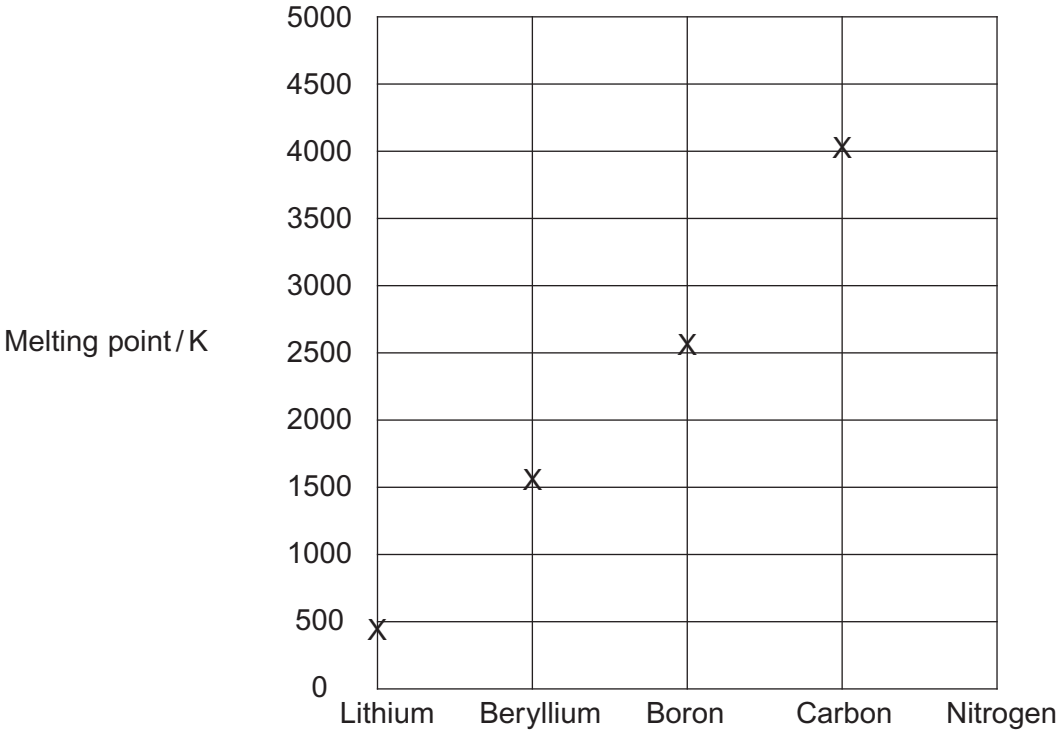
	First	Second	Third	Fourth	Fifth	Sixth
Ionisation energy / kJ mol^{-1}	1090	2350	4610	6220	37 800	47 000

.....

(1 mark)

Do not write outside the box

2 (d) Draw a cross on the diagram to show the melting point of nitrogen.



(1 mark)

2 (e) Explain, in terms of structure and bonding, why the melting point of carbon is high.

.....

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

10

Turn over ▶

Do not write outside the box

3 Hexane (C_6H_{14}) is a member of the homologous series of alkanes.

3 (a) (i) Name the raw material from which hexane is obtained.

.....

(1 mark)

3 (a) (ii) Name the process used to obtain hexane from this raw material.

.....

(1 mark)

3 (b) C_6H_{14} has structural isomers.

3 (b) (i) Deduce the number of structural isomers with molecular formula C_6H_{14}

Write the number in this box.

(1 mark)

(*Space for working)*

3 (b) (ii) State **one** type of structural isomerism shown by the isomers of C_6H_{14}

.....

(1 mark)

3 (c) One molecule of an alkane **X** can be cracked to form one molecule of hexane and two molecules of propene.

3 (c) (i) Deduce the molecular formula of **X**.

.....

.....

(1 mark)

Do not write outside the box

3 (c) (ii) State the type of cracking that produces a high percentage of alkenes. State the conditions needed for this type of cracking.

Type of cracking .....

Conditions .....

.....

(2 marks)

3 (c) (iii) Explain the main economic reason why alkanes are cracked.

.....

.....

(1 mark)

3 (d) Hexane can react with chlorine under certain conditions as shown in the following equation.

$$C_6H_{14} + Cl_2 \longrightarrow C_6H_{13}Cl + HCl$$

3 (d) (i) Both the products are hazardous. The organic product would be labelled 'flammable'. Suggest the most suitable hazard warning for the other product.

.....

(1 mark)

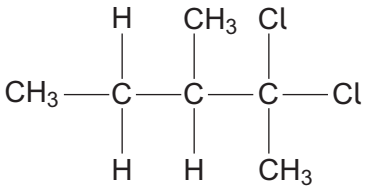
3 (d) (ii) Calculate the percentage atom economy for the formation of $C_6H_{13}Cl$ (M_r = 120.5) in this reaction.

.....

.....

(1 mark)

3 (e) A different chlorinated compound is shown below. Name this compound and state its empirical formula.



Name .....

Empirical formula .....

(2 marks)

12

Turn over ▶

Do not write outside the box

4 Alkanes are used as fuels. A student burned some octane (C_8H_{18}) in air and found that the combustion was incomplete.

4 (a) (i) Write an equation for the incomplete combustion of octane to produce carbon monoxide as the only carbon-containing product.

.....

(1 mark)

4 (a) (ii) Suggest **one** reason why the combustion was incomplete.

.....

.....

(1 mark)

4 (b) Catalytic converters are used to remove the toxic gases NO and CO that are produced when alkane fuels are burned in petrol engines.

4 (b) (i) Write an equation for a reaction between these two toxic gases that occurs in a catalytic converter when these gases are removed.

.....

(1 mark)

4 (b) (ii) Identify a metal used as a catalyst in a catalytic converter.
Suggest **one** reason, other than cost, why the catalyst is coated on a ceramic honeycomb.

Metal .....

Reason .....

.....

(2 marks)

Do not write outside the box

4 (c) If a sample of fuel for a power station is contaminated with an organic sulfur compound, a toxic gas is formed by complete combustion of this sulfur compound.

4 (c) (i) State **one** environmental problem that can be caused by the release of this gas.

.....

.....

(1 mark)

4 (c) (ii) Identify **one** substance that could be used to remove this gas.
Suggest **one** reason, other than cost, why this substance is used.

Substance .....

Reason why used .....

.....

(2 marks)

8

Turn over for the next question

There are no questions printed on this page

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5 The element nitrogen forms compounds with metals and non-metals.

5 (a) Nitrogen forms a nitride ion with the electron configuration $1s^2\ 2s^2\ 2p^6$
Write the formula of the nitride ion.

.....

(1 mark)

5 (b) An element forms an ion **Q** with a single negative charge that has the same electron configuration as the nitride ion.
Identify the ion **Q**.

.....

(1 mark)

5 (c) Use the Periodic Table and your knowledge of electron arrangement to write the formula of lithium nitride.

.....

(1 mark)

5 (d) Calcium nitride contains 81.1% by mass of the metal.
Calculate the empirical formula of calcium nitride.
Show your working.

.....

.....

.....

.....

.....

.....

(3 marks)

5 (e) Write an equation for the reaction between silicon and nitrogen to form silicon nitride, Si_3N_4

.....

(1 mark)

7

Turn over ▶

Do not write outside the box

Section B

Answer **all** questions in the spaces provided.

6 The metal lead reacts with warm dilute nitric acid to produce lead(II) nitrate, nitrogen monoxide and water according to the following equation.

$$3Pb(s) + 8HNO_3(aq) \longrightarrow 3Pb(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$$

6 (a) In an experiment, an 8.14 g sample of lead reacted completely with a 2.00 mol dm^{-3} solution of nitric acid.

Calculate the volume, in dm^3, of nitric acid required for complete reaction.
Give your answer to 3 significant figures.

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(3 marks)

(Extra space) .....

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Do not write outside the box

6 (b) In a second experiment, the nitrogen monoxide gas produced in the reaction occupied 638 cm^3 at 101 kPa and 298 K.
Calculate the amount, in moles, of NO gas produced.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

.....

.....

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(3 marks)

(Extra space) .....

.....

.....

6 (c) When lead(II) nitrate is heated it decomposes to form lead(II) oxide, nitrogen dioxide and oxygen.

6 (c) (i) Balance the following equation that shows this thermal decomposition.

.....$Pb(NO_3)_2(s)$ ⟶ ..... $PbO(s)$ + ...$NO_2(g)$ + ...$O_2(g)$

(1 mark)

6 (c) (ii) Suggest **one** reason why the yield of nitrogen dioxide formed during this reaction is often less than expected.

.....

.....

(1 mark)

6 (c) (iii) Suggest **one** reason why it is difficult to obtain a pure sample of nitrogen dioxide from this reaction.

.....

.....

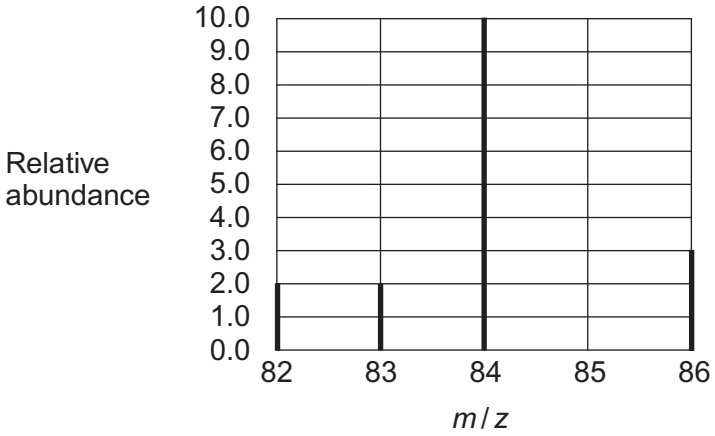
(1 mark)

9

Turn over ▶

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7 The mass spectrum of a sample of krypton taken from a meteorite is shown below.



7 (a) Use this spectrum to calculate the relative atomic mass of this sample of krypton. Give your answer to one decimal place.

Explain why the value you have calculated is slightly different from the relative atomic mass given in the Periodic Table.

.....

.....

.....

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.....

(4 marks)

(Extra space) .....

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7 (b) State how krypton is ionised in the mass spectrometer.

Write an equation, including state symbols, to show the reaction that occurs when the **first** ionisation energy of Kr is measured.

Sometimes the mass spectrum of Kr has a very small peak with an *m*/*z* value of 42 Explain the occurrence of this peak.

.....

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(5 marks)

(Extra space) .....

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9

END OF QUESTIONS

There are no questions printed on this page

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Version 2.1



General Certificate of Education (A-level)
January 2012

Chemistry CHEM1

(Specification 2420)

Unit 1: Foundation Chemistry

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available from: aqa.org.uk

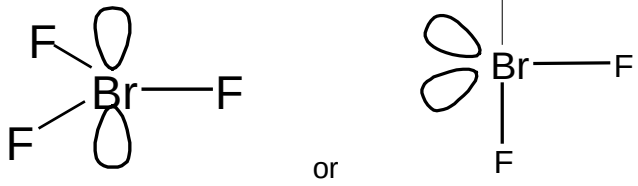
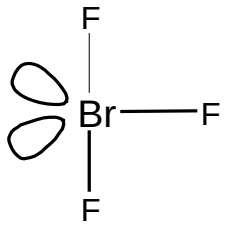
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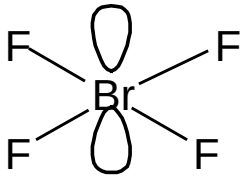
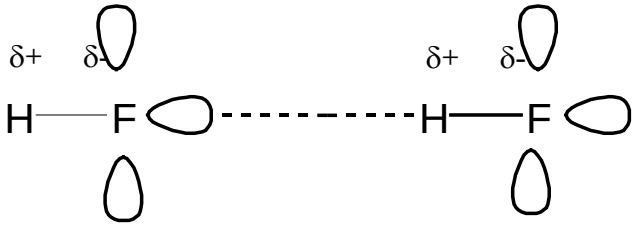
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Question	Marking Guidance	Mark	Comments
1(a)	Covalent	1	If not covalent CE = 0/2 If dative covalent CE = 0/2 If blank mark on Ignore polar If number of pairs of electrons specified, must be 3
	Shared pair(s) of electrons / one electron from Br and one electron from F	1	Not 2 electrons from 1 atom Not shared pair between ions/molecules
1(b)(i)	 or 	1	BrF_3 should have 3 bp and 2 lp and correct atoms for the mark Penalise Fl
	BrF_3 if trigonal planar shown = 120° or if T shape shown 84 - 90°	1	Allow 84 - 90° or 120° and ignore 180° Irrespective of shape drawn

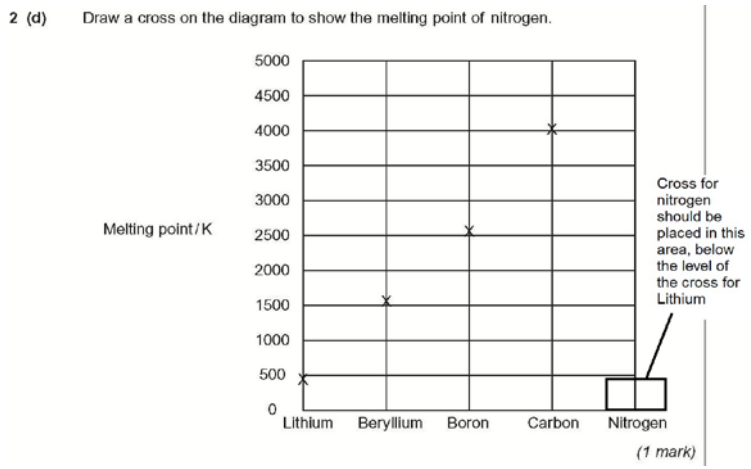
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1(b)(ii)	 BrF_4^- 90°	1 1	BrF_4^- should have 4 bp and 2 lp and all atoms for the mark (ignore sign) Allow Fl Only Ignore 180°
1(c)	Ionic or (forces of) attraction between ions / bonds between ions Strong (electrostatic) attraction / strong bonds / lots of energy needed to break bonds Between K^+ and BrF_4^- ions/oppositely charged ions / + and - ions	1 1 1	If molecules, IMF, metallic, CE =0 If covalent bonds mentioned, 0/3, unless specified <u>within</u> the BrF_4^- ion and not broken Ignore atoms If ions mentioned they must be correct Strong bonds between + and – ions =3/3
1(d)(i)	Hydrogen <u>bonds</u>/hydrogen <u>bonding</u>/H <u>bonds</u>/H <u>bonding</u>	1	Not just hydrogen
1(d)(ii)		3	One mark for 4 partial charges One mark for 6 lone pairs One mark for H bond from the <u>lone pair to the Hδ+</u> Allow Fl If more than 2 molecules are shown they must all be correct. Treat any errors as contradictions within each marking point. CE = 0/3 if incorrect molecules shown.

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1(e)	vdw / van der Waals forces between molecules	1	QoL Not vdw between HF molecules, CE = 0/2 vdw between atoms, CE = 0/2 If covalent, ionic, metallic, CE=0/2
	IMF are weak / need little energy to break IMF / easy to overcome IMF	1	

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Question	Marking Guidance	Mark	Comments
2(a)	Lithium / Li	1	Penalise obvious capital I (second letter).
2(b)(i)	Increase / gets bigger	1	Ignore exceptions to trend here even if wrong
2(b)(ii)	Boron / B Electron removed from (2)p orbital /sub-shell / (2)p electrons removed Which is higher in energy (so more easily lost) / more shielded (so more easily lost) / further from nucleus	1 1 1	If not Boron, CE = 0/3 If p orbital specified it must be 2p
2(c)	C / carbon	1	
2(d)	Below Li 	1	The cross should be placed on the diagram, on the column for nitrogen, below the level of the cross printed on the diagram for Lithium.

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2(e)	Macromolecular / giant molecular / giant atomic Covalent bonds in the structure Strong (covalent) bonds must be broken or overcome / (covalent) bonds need a lot of energy to break	1 1 1	Allow giant covalent (molecule) = 2 Ignore weakening / loosening bonds If ionic / metallic/molecular/ dipole dipole/ H bonds/ bonds between molecules, CE = 0/3 Ignore van der Waals forces Ignore hard to break

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Question	Marking Guidance	Mark	Comments
3(a)(i)	Crude oil / oil / petroleum	1	Do not allow ‘petrol’
3(a)(ii)	Fractional distillation / fractionation / fractionating	1	Not distillation alone
3(b)(i)	5	1	Allow five / V
3(b)(ii)	Chain (isomerism)	1	Allow branched chain / chain branched / side chain (isomerism) Ignore position (isomerism) Do not allow straight chain **/** geometric / branched / function
3(c)(i)	$C_{12}H_{26}$ / $H_{26}C_{12}$	1	Only
3(c)(ii)	Thermal cracking High temperature (400°C ≤ T ≤ 900°C) or (650 K ≤ T ≤ 1200 K) **and** High pressure (≥ 10 atm, ≥ 1 MPa, ≥1000 kPa)	1 1	If not thermal cracking, CE = 0/2 If blank mark on Allow ‘high heat’ for ‘high temperature’ Not ‘heat’ alone If no T, units must be 650 - 900
3(c)(iii)	To produce substances which are (more) in demand / produce products with a high value / products worth more	1	Ignore ‘to make more useful substances’

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3(d)(i)	Corrosive or diagram to show this hazard symbol	1	Ignore irritant, acidic, toxic, harmful
3(d)(ii)	($\frac{120.5}{86 + 71}$ × 100) =76.75(%) or 76.8(%)	 1	 Allow answers > 3 sig figs
3(e)	2,2-dichloro-3-methylpentane C_3H_6Cl	1 1	Ignore punctuation Any order

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Question	Marking Guidance	Mark	Comments
4(a)(i)	$C_8H_{18} + 8\frac{1}{2} O_2 \rightarrow 8CO + 9H_2O$	1	Accept multiples
4(a)(ii)	Not enough oxygen or air (available for complete combustion) /lack of oxygen or air / too much octane	1	Ignore poor ventilation, low temp, poor mixing, incomplete combustion
4(b)(i)	$2CO + 2NO \rightarrow 2CO_2 + N_2$	1	Allow multiples
4(b)(ii)	Pt / Pd / Rh / Ir or names Big(ger) surface area / increased reaction rate / removes more of the gases / ensures complete reaction	1 1	Apply list principle Allow (ceramic) withstands high temperatures
4(c)(i)	Acid rain	1	Allow consequence of acid rain Ignore greenhouse gas / global warming / ozone
4(c)(ii)	CaO/ lime / $CaCO_3$ /limestone Neutralises the gas or words to that effect/it is basic/ SO_2 is acidic	1 1	Allow chemical names Allow ‘reacts with it’ or ‘it is alkaline’ Ignore ‘absorb’

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Question	Marking Guidance	Mark	Comments
5(a)	N^{3-} / N^{-3}	1	
5(b)	F^-/ fluoride	1	Ignore fluorine/F Penalise Fl
5(c)	Li_3N / NLi_3	1	
5(d)	$\frac{81.1}{40.1}$ $\frac{18.9}{14}$ (=2.02 = 1.35) 1.5 1 or 3 : 2 Ca_3N_2	1 1 1	M1 for correct fractions M2 for correct ratio If Ca_3N_2 shown and with no working award 3 marks If Ca_3N_2 obtained by using atomic numbers then lose M1
5(e)	3 Si + 2 N_2 → Si_3N_4	1	Accept multiples

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Question	Marking Guidance	Mark	Comments
6(a)	Mol Pb = 8.14 / 207(.2) (= 0.0393 mol) Mol HNO_3 = 0.0393 x 8 / 3 =0.105 mol Vol HNO_3 = 0.105 / 2 = 0.0524 (dm^3)	1 1 1	M1 and M2 are process marks Allow mark for M1 x 8/3 or M1 x 2.67 Accept range 0.0520 to 0.0530 No consequential marking for M3 Answer to 3 sig figs required
6(b)	101000 (Pa) and 638 x 10^{-6} (m^3) n = pV/RT (= $\frac{101000 \times 638 \times 10^{-6}}{8.31 \times 298}$) 0.026(0) (mol)	1 1 1	 Can score M2 with incorrect conversion of p and V If T incorrect lose M1 and M3 If answer correct then award 3 marks Allow answers to 2 sig figs or more 26.02 = 1 If transcription error lose M3 only
6(c)(i)	$2Pb(NO_3)_2(s) \rightarrow 2 PbO(s) + 4NO_2(g) + (1)O_2(g)$	1	Allow multiples Allow fractions
6(c)(ii)	Decomposition not complete / side reactions / by-products / some (NO_2) escapes / not all reacts / impure $Pb(NO_3)_2$	1	Ignore reversible / not heated enough / slow
6(c)(iii)	Hard to separate O_2 from NO_2 / hard to separate the 2 gases	1	Allow mixture of gases Not 'all products are gases'

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Question	Marking Guidance	Mark	Comments
7(a)	$\frac{(82 \times 2) + (83 \times 2) + (84 \times 10) + (86 \times 3)}{17}$ $\left(\frac{1428}{17}\right)$	1 1	M1 for the top line M2 is for division by 17
	= 84.0	1	Not 84 No consequential marking from M1 or M2 Ignore units
	The A_r in the Periodic table takes account of the other isotopes / different amounts of isotopes (or words to that effect regarding isotopes)	1	Award independently Comparison implied Isotope(s) alone, M4 = 0
7(b)	(Beam of electrons from) an electron gun / high speed / high energy electrons	1	
	Knocks out electron(s) (to form a positive ion)	1	
	$Kr(g) + e^- \rightarrow Kr^+(g) + 2e(^-)$	1	State symbols must clearly be (g)
	OR		
	$Kr(g) \rightarrow Kr^+(g) + e(^-)$ / $Kr(g) - e(^-) \rightarrow Kr^+(g)$		
	The ^{84}Kr isotope	1	One mark for identifying the 84 isotope
	Has 2 electrons knocked out / gets a 2+ charge	1	One mark for the idea of losing 2 electrons (from this isotope)

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General principles applied to marking CHEM1 papers by CMI+ (January 2012)

It is important to note that the guidance given here is generic and specific variations may be made in the mark scheme.

Basic principles

- **Examiners should note that throughout the mark scheme, items that are underlined are required information to gain credit.**
- **Occasionally a response involves incorrect chemistry and the mark scheme records CE = 0, which means a chemical error has occurred and no credit is given for that section of the clip or for the whole clip.**

A. The "List principle" and the use of "ignore" in the mark scheme

If a question requires **one** answer and a candidate gives two answers, no mark is scored if one answer is correct and one answer is incorrect. There is no penalty if both answers are correct.

N.B. Certain answers are designated in the mark scheme as those that the examiner should "Ignore". These answers are not counted as part of the list and should be ignored and will not be penalised.

B. Incorrect case for element symbol

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip.
For example, penalise the use of "h" for hydrogen, "CL" for chlorine or "br" for bromine.

C. Spelling

In general

- The names of organic chemical compounds and functional groups **must be spelled correctly,** when specifically asked for, to gain credit.
- Phonetic spelling may be acceptable for some chemical compounds (eg amonia would be phonetically acceptable. However, ammoniam would be unacceptable since it is ambiguous).

N.B. Some terms may be required to be spelled correctly or an idea needs to be articulated with clarity, as part of the "Quality of Language" (**QoL**) marking. These will be identified in the mark scheme and marks are awarded only if the QoL criterion is satisfied.

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D. Equations

In general

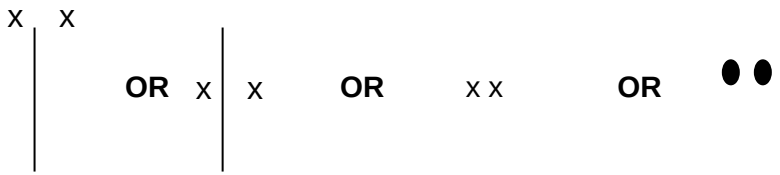
- Equations **must** be balanced.
- State symbols are generally ignored, unless specifically required in the mark scheme.

E. Lone Pairs

The following representations of lone pairs in structures are acceptable.



with or without the 2 electrons shown **OR**



F. Reagents

The command word "Identify", allows the candidate to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when the name and formula contradict. Specific details will be given in mark schemes.

G. Marking calculations

In general

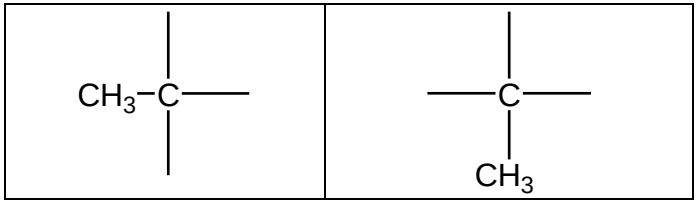
- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- If a candidate has made an arithmetic error or a transcription error deduct one mark, but continue marking (error carried forward).

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H. Organic structures

In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Bonds should be drawn correctly between the relevant atoms.
- Latitude should be given to the representation of C ─ C bonds in structures, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- The following representations are allowed:-



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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2011

Chemistry CHEM1

Unit 1 Foundation Chemistry

Monday 23 May 2011 1.30 pm to 2.45 pm

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a calculator.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- The Periodic Table/Data Sheet is provided as an insert.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use accurate scientific terminology.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

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Do not write outside the box

Section A

Answer **all** questions in the spaces provided.

1 Mass spectrometry can be used to identify isotopes of elements.

1 (a) (i) In terms of fundamental particles, state the difference between isotopes of an element.

.....

.....

(1 mark)

1 (a) (ii) State why isotopes of an element have the same chemical properties.

.....

.....

(1 mark)

1 (b) Give the meaning of the term *relative atomic mass.*

.....

.....

.....

(2 marks)

(Extra space).....

.....

Do not write outside the box

1 (c) The mass spectrum of element **X** has four peaks. The table below gives the relative abundance of each isotope in a sample of element **X**.

m/*z*	64	66	67	68
Relative abundance	12	8	1	6

1 (c) (i) Calculate the relative atomic mass of element **X**.
Give your answer to one decimal place.

.....

.....

.....

.....

.....

(3 marks)

1 (c) (ii) Use the Periodic Table to identify the species responsible for the peak at *m*/*z* = 64

.....

(2 marks)

1 (d) Suggest **one** reason why particles with the same mass and velocity can be deflected by different amounts in the same magnetic field.

.....

.....

(1 mark)

1 (e) Explain how the detector in a mass spectrometer enables the abundance of an isotope to be measured.

.....

.....

.....

(2 marks)

(Extra space) .....

.....

12

Do not write outside the box

2 Norgessaltpeter was the first nitrogen fertiliser to be manufactured in Norway. It has the formula $Ca(NO_3)_2$

2 (a) Norgessaltpeter can be made by the reaction of calcium carbonate with dilute nitric acid as shown by the following equation.

$$CaCO_3(s) + 2HNO_3(aq) \longrightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

In an experiment, an excess of powdered calcium carbonate was added to 36.2 cm^3 of 0.586 mol dm^{-3} nitric acid.

2 (a) (i) Calculate the amount, in moles, of HNO_3 in 36.2 cm^3 of 0.586 mol dm^{-3} nitric acid. Give your answer to 3 significant figures.

.....

.....

(1 mark)

2 (a) (ii) Calculate the amount, in moles, of $CaCO_3$ that reacted with the nitric acid. Give your answer to 3 significant figures.

.....

.....

(1 mark)

2 (a) (iii) Calculate the minimum mass of powdered $CaCO_3$ that should be added to react with all of the nitric acid. Give your answer to 3 significant figures.

.....

.....

.....

(2 marks)

2 (a) (iv) State the type of reaction that occurs when calcium carbonate reacts with nitric acid.

.....

(1 mark)

Do not write outside the box

2 (b) Norgessaltpeter decomposes on heating as shown by the following equation.

$$2Ca(NO_3)_2(s) \longrightarrow 2CaO(s) + 4NO_2(g) + O_2(g)$$

A sample of Norgessaltpeter was decomposed completely.

The gases produced occupied a volume of $3.50 \times 10^{-3}\,m^3$ at a pressure of 100 kPa and a temperature of 31 °C.
(The gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

2 (b) (i) Calculate the total amount, in moles, of gases produced.

.....

.....

.....

.....

(3 marks)

2 (b) (ii) Hence calculate the amount, in moles, of oxygen produced.

.....

.....

(1 mark)

2 (c) Hydrated calcium nitrate can be represented by the formula $Ca(NO_3)_2.xH_2O$ where x is an integer.

A 6.04 g sample of $Ca(NO_3)_2.xH_2O$ contains 1.84 g of water of crystallisation.

Use this information to calculate a value for x.
Show your working.

.....

.....

.....

.....

.....

.....

(3 marks)

12

Turn over ▶

Do not write outside the box

3 Fluorine and iodine are elements in Group 7 of the Periodic Table.

3 (a) Explain why iodine has a higher melting point than fluorine.

.....

.....

.....

(2 marks)

(Extra space).....

.....

3 (b) (i) Draw the shape of the NHF_2 molecule and the shape of the BF_3 molecule.
Include any lone pairs of electrons that influence the shape.
In each case name the shape.

Shape of NHF_2 Shape of BF_3

Name of shape of NHF_2 .....

Name of shape of BF_3 .....

(4 marks)

3 (b) (ii) Suggest a value for the F—N—F bond angle in NHF_2

.....

(1 mark)

3 (c) State the strongest type of intermolecular force in a sample of NHF_2

.....

(1 mark)

Do not write outside the box

3 (d) A molecule of NHF_2 reacts with a molecule of BF_3 as shown in the following equation.

$$NHF_2 + BF_3 \longrightarrow F_2HNBF_3$$

State the type of bond formed between the N atom and the B atom in F_2HNBF_3
Explain how this bond is formed.

Name of type of bond .....

How bond is formed .....

.....

.....

(2 marks)

10

Turn over for the next question

Do not write outside the box

4 There are several types of crystal structure and bonding shown by elements and compounds.

4 (a) (i) Name the type of bonding in the element sodium.

.....

(1 mark)

4 (a) (ii) Use your knowledge of structure and bonding to draw a diagram that shows how the particles are arranged in a crystal of sodium.
You should identify the particles and show a minimum of six particles in a two-dimensional diagram.

(2 marks)

4 (b) Sodium reacts with chlorine to form sodium chloride.

4 (b) (i) Name the type of bonding in sodium chloride.

.....

(1 mark)

4 (b) (ii) Explain why the melting point of sodium chloride is high.

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

Do not write outside the box

4 (c) The table below shows the melting points of some sodium halides.

	NaCl	NaBr	NaI
Melting point / K	1074	1020	920

Suggest why the melting point of sodium iodide is lower than the melting point of sodium bromide.

.....

.....

(1 mark)

7

Turn over for the next question

Do not write outside the box

5 This question is about the first ionisation energies of some elements in the Periodic Table.

5 (a) Write an equation, including state symbols, to show the reaction that occurs when the first ionisation energy of lithium is measured.

.....

(1 mark)

5 (b) State and explain the general trend in first ionisation energies for the Period 3 elements aluminium to argon.

Trend .....

Explanation .....

.....

.....

(3 marks)

(Extra space).....

.....

5 (c) There is a similar general trend in first ionisation energies for the Period 4 elements gallium to krypton.
State how selenium deviates from this general trend and explain your answer.

How selenium deviates from this trend .....

Explanation .....

.....

.....

(3 marks)

(Extra space).....

.....

5 (d) Suggest why the first ionisation energy of krypton is lower than the first ionisation energy of argon.

.....

.....

.....

(1 mark)

Do not write outside the box

5 (e) The table below gives the successive ionisation energies of an element.

	First	Second	Third	Fourth	Fifth
Ionisation energy / kJ mol^{-1}	590	1150	4940	6480	8120

Deduce the group in the Periodic Table that contains this element.

.....

(1 mark)

5 (f) Identify the element that has a 5+ ion with an electron configuration of $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$

.....

(1 mark)

10

Turn over for the next question

Do not write outside the box

Section B

Answer **all** questions in the spaces provided.

6 (a) There is a risk of gas explosions in coal mines. This risk is mainly due to the presence of methane. If the percentage of coal-mine methane (CMM) in the air in the mine is greater than 15%, the explosion risk is much lower. CMM slowly escapes from the mine into the atmosphere.

Write an equation to show the complete combustion of methane.

Suggest **one** reason why there is a much lower risk of an explosion if the percentage of CMM is greater than 15%.

State why it is beneficial to the environment to collect the CMM rather than allowing it to escape into the atmosphere.

.....

.....

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.....

.....

(3 marks)

(Extra space) .....

.....

.....

Do not write outside the box

6 (b) Methane can be obtained from crude oil. Some of this crude oil contains an impurity called methanethiol (CH_3SH). This impurity causes environmental problems when burned.

Write an equation to show the complete combustion of methanethiol.

State why calcium oxide can be used to remove the sulfur-containing product of this combustion reaction.

State **one** pollution problem that is caused by the release of this sulfur-containing product into the atmosphere.

.....

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.....

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(3 marks)

(Extra space).....

.....

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6

Turn over for the next question

Do not write outside the box

7 Pentane is a member of the alkane homologous series.

7 (a) Give the general formula for the homologous series of alkanes.

.....

(1 mark)

7 (b) One of the structural isomers of pentane is 2,2-dimethylpropane.

Draw the displayed formula of 2,2-dimethylpropane.

State the type of structural isomerism shown.

.....

(2 marks)

Do not write outside the box

7 (c) A molecule of hydrocarbon **Y** can be thermally cracked to form one molecule of pentane and two molecules of ethene only.

Deduce the molecular formula of **Y**.

State why high temperatures are necessary for cracking reactions to occur.

Give **one** reason why thermal cracking reactions are carried out in industry.

.....

.....

.....

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.....

(3 marks)

(Extra space) .....

.....

.....

7 (d) Write an equation for the incomplete combustion of pentane to form a solid pollutant.

Suggest why this solid pollutant is an environmental problem.

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

Question 7 continues on the next page

Do not write outside the box

7 (e) Pentane can react with chlorine as shown in the following equation.

$$C_5H_{12} + Cl_2 \longrightarrow C_5H_{11}Cl + HCl$$

Calculate the percentage atom economy for the formation of $C_5H_{11}Cl$

Deduce how many straight-chain isomers of $C_5H_{11}Cl$ could be formed.

.....

.....

.....

.....

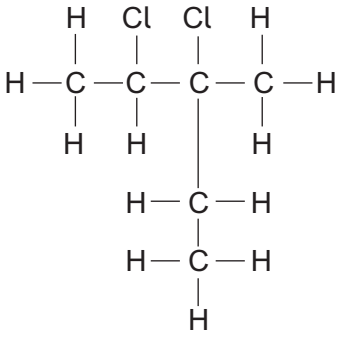
.....

(3 marks)

(Extra space).....

.....

7 (f) Consider the following compound.



Name this compound.

Deduce the empirical formula of this compound.

.....

.....

.....

.....

(2 marks)

13

END OF QUESTIONS

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Version 1.3

General Certificate of Education
June 2011

Chemistry CHEM1

Foundation Chemistry

Final

Mark Scheme

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Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Question	Marking Guidance	Mark	Comments
1(a)(i)	Different number / amount of neutrons	1	Not different neutrons Ignore same protons and/or electrons CE incorrect statement relating to protons / electrons
1(a)(ii)	Same electron configuration / same number of electrons (in the outer shell)	1	Ignore same no of protons Ignore electrons determine chemical properties CE if wrong statement relating to protons / neutrons
1(b)	<u>Average mass of 1 atom (of an element)</u> 1/12 mass atom of ^{12}C OR <u>Average/mean mass of atoms of an element</u> 1/12 mass of one atom of ^{12}C OR <u>(Average) mass of one mole of atoms</u> 1/12 mass of one mole of ^{12}C OR <u>(Weighted) average mass of all the isotopes</u> 1/12 mass of one atom of ^{12}C OR Average mass of an atom/isotope compared to C-12 on a scale in which an atom of C-12 has a mass of 12	1 1	If moles and atoms mixes Max = 1 Mark top and bottom line independently 1/12 on bottom line can be represented as x 12 on top line This expression = 2 marks

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1 (c) (i)	$\frac{(64 \times 12) + (66 \times 8) + (67 \times 1) + (68 \times 6)}{27}$ (= $\frac{1771}{27}$) = $\underline{65.6}$	1 1 1	If not 27 max 1 mark (for top line) Mark is for dividing by 27 or string If **evidence** of arithmetic or transcription error seen in M1 or M2 allow consequential M3 and consequential 1(c)(ii) 65.6 = 3 marks
1(c)(ii)	$^{64}Zn^{+}$	1 1	M1 for identifying Zn / zinc M2 is for the + sign and the 64 M2 is dependent on M1
1(d)	Size of the charge (on the ion) / different charges / different *m/z*	1	Allow forms 2+ ions QWC
1(e)	(ions hit detector and) cause current/(ions) accept electrons/cause electron flow/electric pulse caused bigger current = more of that isotope/current proportional to abundance	1 1	 Implication that current depends on the number of ions M2 dependent on M1

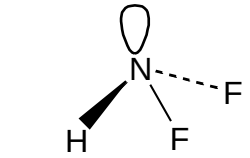
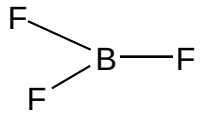
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Question	Marking Guidance	Mark	Comments
2(a)(i)	0.0212	1	Need 3 sig figs Allow correct answer to 3 sig figs eg 2.12×10^{-2}
2(a)(ii)	0.0106	1	Mark is for 2(a)(i) divided by 2 leading to correct answer ≥ 2 sig figs
2(a)(iii)	M_r = 100.1 1.06 g	1 1	Allow 100.1 as 'string' Need 3 sig figs or more Consequential on 2(a)(ii) x 100(.1)
2(a)(iv)	Neutralisation or acid / base reaction	1	Allow acid / alkali reaction Apply list principle
2(b)(i)	T = 304(K) and P = 100 000 (Pa) $\frac{100\,000 \times 3.50 \times 10^{-3}}{8.31 \times 304}$ OR $n = \frac{PV}{RT}$ 0.139 (mol)	1 1 1	Only T and P correctly converted Allow 0.138 – 0.139
2(b)(ii)	0.0276 – 0.0278(mol)	1	Allow answer to 2(b)(i) divided by 5 leading to a correct answer Allow 0.028

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2(c)	4.20 g $Ca(NO_3)_2$ $Ca(NO_3)_2$ H_2O 4.20 1.84 164(.1) 18 0.0256 0.102 1 : 3.98 x = 4	1 1 1	 Mark is for dividing by the correct M_r values M2 and M3 dependent on correct M1 M2 can be awarded here instead If $Ca(NO_3)_2.4H_2O$ seen with working then award 3 marks Credit alternative method which gives x = 4

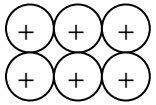
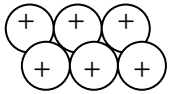
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Question	Marking Guidance	Mark	Comments
3(a)	Iodine has more electrons / iodine is bigger (atom or molecule) / iodine has bigger M_r / bigger surface area	1	
	<u>Stronger / more</u> van der Waals forces / vdw / London / temporarily induced dipole / dispersion forces <u>between molecules</u>	1	Stronger VdW intermolecular forces = M2 If stated VdW between atoms lose M2
3(b)(i)		1	Mark is for 3 bp and 1 lp attached to N (irrespective of shape)
		1	Mark is for 3 bp and 0 lp attached to B (irrespective of shape)
	NHF_2 shape - pyramidal / trigonal pyramid	1	Accept tetrahedral / triangular pyramid
	BF_3 shape - <u>trigonal planar</u>	1	Not triangular or triangular planar
3(b)(ii)	107°	1	Allow 106-108°
3(c)	Hydrogen bonds	1	Allow H-Bonds Not just Hydrogen Apply list principle eg Hydrogen bonding and dipole-dipole = 0

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3(d)	Coordinate / dative covalent / dative	1	If covalent mark on If ionic / metallic CE = 0
	Lone pair / both electrons/ 2 electrons <u>on N(HF_2)</u> donated (to BF_3)	1	Direction of donation needed here

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Question	Marking Guidance	Mark	Comments
4(a)(i)	Metallic	1	Allow body centred cubic
4(a)(ii)	 OR  Na^+ Na^+ Na^+ Na^+ Na^+ Na^+	1 1	One mark for regular arrangement of particles. Can have a space between them Do not allow hexagonal arrangement One mark for + in each Ignore electrons If it looks like ionic bonding then CE = 0/2
4(b)(i)	<u>Ionic</u>	1	CE = 0 for 4(b)(i) and 4(b)(ii) if not ionic
4(b)(ii)	Strong (electrostatic) attraction Between <u>oppositely</u> charged ions / particles	1 1	Any mention of IMF or molecules / metallic / covalent in 4(b)(ii) then CE 0/2 Or + and – ions
4(c)	Iodide / I^- bigger (ion) (so less attraction to the Na+ ion)	1	Need comparison Do not allow iodine is a bigger atom Ignore I^- has one more e- shell CE = 0 if IMF / covalent / metallic mentioned

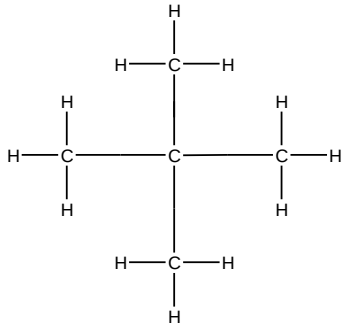
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Question	Marking Guidance	Mark	Comments
5(a)	$Li(g) \rightarrow Li^+(g) + e^-(g)$ $Li(g) - e^-(g) \rightarrow Li^+(g)$ $Li(g) + e^-(g) \rightarrow Li^+(g) + 2e^-$	1	One mark for balanced equation with state symbols Charge and state on electron need not be shown
5(b)	Increases Increasing nuclear charge / increasing no of protons Same or similar shielding / same no of shells / electron (taken) from same (sub)shell / electron closer to the nucleus / smaller atomic radius	1 1 1	If trend wrong then CE = 0/3 for 5(b). If blank mark on. Ignore effective with regard to nuclear charge
5(c)	Lower Paired electrons in a (4) p orbital (Paired electrons) repel	1 1 1	If not lower then CE = 0/3 If incorrect p orbital then M2 = 0 If shared pair of electrons M2 + M3 = 0
5(d)	Kr is a bigger atom / has more shells / more shielding in Kr / electron removed further from nucleus/ electron removed from a higher (principal or main) energy level	1	CE if molecule mentioned Must be comparative answer QWC
5(e)	2 / two / II	1	
5(f)	Arsenic / As	1	

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Question	Marking Guidance	Mark	Comments
6(a)	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	1	Accept multiples Ignore state symbols even if incorrect
	Not enough oxygen / air	1	
	CMM / methane is a greenhouse gas / contributes to global warming	1	Do not allow formation of CO_2 / CO_2 is a greenhouse gas Apply list principle, eg CH_4 is a greenhouse gas and toxic = 0 CH_4 is a greenhouse gas and damages ozone = 0 Allow CH_4 and CO_2 are greenhouses gases Allow collect to use as a fuel so fossil fuels do not run out (as quickly)
6(b)	$CH_3SH + 3O_2 \rightarrow CO_2 + 2H_2O + SO_2$	1	Accept multiples Ignore state symbols even if incorrect
	Calcium oxide is basic (and SO_2 is acidic) / CaO neutralises SO_2 / CaO reacts with SO_2 to form gypsum / salt / solid / $CaSO_4$ / $CaSO_3$ Allow $CaO + SO_2 \rightarrow CaSO_3$	1	**M2 and M3 can only be scored if SO_2 seen somewhere in the answer**
	Acid rain	1	Allow consequence of acid rain eg increased rusting of iron / fish in lakes die / problems for asthmatics Apply list principle Ignore air pollution

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Question	Marking Guidance	Mark	Comments
7(a)	$C_n H_{2n+2}$	1	Allow x in place of n
7(b)		1	Must show every bond
	Chain	1	Allow branched chain
7(c)	C_9H_{20}	1	Only
	To break the (C-C and/or C-H) bonds	1	M2=0 if break C=C
	To make products which are in greater demand / higher value / make alkenes	1	Not more useful products Allow specific answers relating to question
7(d)	$C_5H_{12} + 3O_2 \rightarrow 5C + 6H_2O$	1	Allow other balanced equations which give C and CO/CO_2
	Causes global dimming / exacerbates asthma / causes breathing problems / makes visibility poor / smog	1	Apply list principle Ignore causes cancer / toxic

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7(e)	106.5 (x 100) 143 74.48% 3	1 1 1	 Allow 74.5% Only
7(f)	2,3-dichloro-3-methylpentane C_3H_6Cl	1 1	Ignore punctuation Only

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General principles applied to marking CHEM1 papers by CMI+ June 2011

It is important to note that the guidance given here is generic and specific variations may be made in the mark scheme.

Basic principles

- **Examiners should note that throughout the mark scheme, items that are underlined are required information to gain credit.**
- **Occasionally a response involves incorrect chemistry and the mark scheme records CE = 0, which means a chemical error has occurred and no credit is given for that section of the clip or for the whole clip.**

A. The "List principle" and the use of "ignore" in the mark scheme

If a question requires **one** answer and a candidate gives two answers, no mark is scored if one answer is correct and one answer is incorrect. There is no penalty if both answers are correct.

N.B. Certain answers are designated in the mark scheme as those which the examiner should "Ignore". These answers are not counted as part of the list and should be ignored and will not be penalised.

B. Incorrect case for element symbol

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip.
For example, penalise the use of "h" for hydrogen, "CL" for chlorine or "br" for bromine.

C. Spelling

In general

- The names of organic chemical compounds and functional groups **must be spelled correctly,** when specifically asked for, to gain credit.
- Phonetic spelling may be acceptable for some chemical compounds (eg amonia would be phonetically acceptable. However, ammoniam would be unacceptable since it is ambiguous).

N.B. Some terms may be required to be spelled correctly or an idea needs to be articulated with clarity, as part of the "Quality of Language" (**QoL**) marking. These will be identified in the mark scheme and marks are awarded only if the QoL criterion is satisfied.

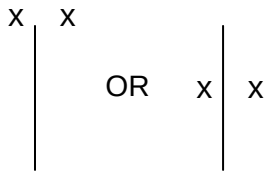
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D. Equations

In general
- Equations **must** be balanced.
- State symbols are generally ignored, unless specifically required in the mark scheme.

E. Lone Pairs

The following representations of lone pairs in structures are acceptable.

 with or without the 2 electrons shown OR  OR OR x x OR 

F. Reagents

The command word "Identify", allows the candidate to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when the name and formula contradict. Specific details will be given in mark schemes.

G. Marking calculations

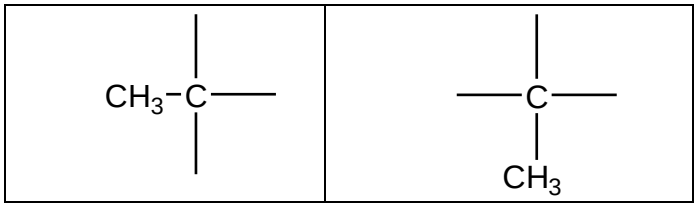
In general
- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- If a candidate has made an arithmetic error or a transcription error deduct one mark, but continue marking (error carried forward).

H. Organic structures

In general
- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Bonds should be drawn correctly between the relevant atoms.

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- Latitude should be given to the representation of C ─ C bonds in structures, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- The following representations are allowed:-



I. Additional sheets and blank clips

- Markers should **mark all that is seen** and carry on marking as normal. Clips which refer to the use of additional sheets should **not** be referred to the senior team.
- Clips which refer to other parts of the script must be referred to the senior team.
- When considering crossed out work, **mark it** as if it were not crossed out **unless** it has been replaced by a later version; this later version then takes priority.
- Mark a blank section with a dash (─) and **not with a score of zero**.

UMS conversion calculator www.aqa.org.uk/umsconversion

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2011

Chemistry CHEM1

Unit 1 Foundation Chemistry

Thursday 13 January 2011 9.00 am to 10.15 am

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a calculator.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- The Periodic Table/Data Sheet is provided as an insert.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use accurate scientific terminology.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

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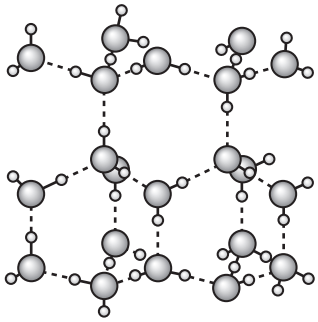
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Section A

Answer **all** questions in the spaces provided.

1 Water can be found as ice, water and steam.

1 (a) The following diagram shows the arrangement of some of the water molecules in a crystal of ice.



With reference to the structure shown above give **one** reason why ice is less dense than water.

.....

.....

.....

(1 mark)

1 (b) Water and methane have similar relative molecular masses and both contain the element hydrogen.
The table below gives some information about water and methane.

	H_2O	CH_4
M_r	18.0	16.0
Melting point / K	273	91

1 (b) (i) State the strongest type of intermolecular force holding the water molecules together in the ice crystal.

.....

(1 mark)

1 (b) (ii) State the strongest type of intermolecular force in methane.

.....

(1 mark)

Do not write outside the box

1 (b) (iii) Give **one** reason why the melting point of ice is higher than the melting point of methane.

.....

.....

.....

(1 mark)

1 (c) A molecule of H_2O can react with an H^+ ion to form an H_3O^+ ion.

1 (c) (i) Draw and name the shape of the H_3O^+ ion. Include any lone pairs of electrons.

Shape of the H_3O^+ ion

Name of shape.....

(2 marks)

1 (c) (ii) Suggest a value for the bond angle in the H_3O^+ ion.

.....

(1 mark)

1 (c) (iii) Identify **one** molecule with the same number of atoms, the same number of electrons and the same shape as the H_3O^+ ion.

.....

(1 mark)

1 (d) Water can also form the hydroxide ion.
State the number of lone pairs of electrons in the hydroxide ion.

.....

(1 mark)

9

Turn over ▶

Do not write outside the box

2 Indium is in Group 3 in the Periodic Table and exists as a mixture of the isotopes ^{113}In and ^{115}In.

2 (a) Use your understanding of the Periodic Table to complete the electron configuration of indium.

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$ .....

(1 mark)

2 (b) A sample of indium must be ionised before it can be analysed in a mass spectrometer.

2 (b) (i) State what is used to ionise a sample of indium in a mass spectrometer.

.....

.....

(1 mark)

2 (b) (ii) Write an equation, including state symbols, for the ionisation of indium that requires the minimum energy.

.....

(1 mark)

2 (b) (iii) State why more than the minimum energy is **not** used to ionise the sample of indium.

.....

.....

(1 mark)

2 (b) (iv) Give two reasons why the sample of indium must be ionised.

Reason 1 .....

Reason 2 .....

(2 marks)

Do not write outside the box

2 (c) A mass spectrum of a sample of indium showed two peaks at m/z = 113 and m/z = 115. The relative atomic mass of this sample of indium is 114.5

2 (c) (i) Give the meaning of the term *relative atomic mass*.

.....

.....

.....

.....

(2 marks)

2 (c) (ii) Use these data to calculate the ratio of the relative abundances of the two isotopes.

.....

.....

.....

(2 marks)

(Extra space) .....

.....

2 (d) State and explain the difference, if any, between the chemical properties of the isotopes ^{113}In and ^{115}In

Difference in chemical properties.....

Explanation.....

.....

(2 marks)

2 (e) Indium forms a compound **X** with hydrogen and oxygen. Compound **X** contains 69.2% indium and 1.8% hydrogen by mass.
Calculate the empirical formula of compound **X**.

.....

.....

.....

.....

.....

(3 marks)

15

Do not write outside the box

3 (a) An unknown metal carbonate reacts with hydrochloric acid according to the following equation.

$$M_2CO_3(aq) + 2HCl(aq) \longrightarrow 2MCl(aq) + CO_2(g) + H_2O(l)$$

A 3.44 g sample of M_2CO_3 was dissolved in distilled water to make 250 cm^3 of solution. A 25.0 cm^3 portion of this solution required 33.2 cm^3 of 0.150 mol dm^{-3} hydrochloric acid for complete reaction.

3 (a) (i) Calculate the amount, in moles, of HCl in 33.2 cm^3 of 0.150 mol dm^{-3} hydrochloric acid. Give your answer to 3 significant figures.

.....

.....

(1 mark)

3 (a) (ii) Calculate the amount, in moles, of M_2CO_3 that reacted with this amount of HCl. Give your answer to 3 significant figures.

.....

.....

(1 mark)

3 (a) (iii) Calculate the amount, in moles, of M_2CO_3 in the 3.44 g sample. Give your answer to 3 significant figures.

.....

.....

(1 mark)

3 (a) (iv) Calculate the relative formula mass, M_r, of M_2CO_3
Give your answer to 1 decimal place.

.....

.....

(1 mark)

3 (a) (v) Hence determine the relative atomic mass, A_r, of the metal M and deduce its identity.

A_r of M .....

Identity of M .....

(2 marks)

Do not write outside the box

3 (b) In another experiment, 0.658 mol of CO_2 was produced. This gas occupied a volume of 0.0220 m^3 at a pressure of 100 kPa.
Calculate the temperature of this CO_2 and state the units.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

.....

.....

.....

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(3 marks)

3 (c) Suggest **one** possible danger when a metal carbonate is reacted with an acid in a sealed flask.

.....

.....

(1 mark)

3 (d) In a different experiment, 6.27 g of magnesium carbonate were added to an excess of sulfuric acid. The following reaction occurred.

$$MgCO_3 + H_2SO_4 \longrightarrow MgSO_4 + CO_2 + H_2O$$

3 (d) (i) Calculate the amount, in moles, of $MgCO_3$ in 6.27 g of magnesium carbonate.

.....

.....

(2 marks)

3 (d) (ii) Calculate the mass of $MgSO_4$ produced in this reaction assuming a 95% yield.

.....

.....

.....

.....

(3 marks)

15

Turn over ▶

Do not write outside the box

4 Cetane ($C_{16}H_{34}$) is a major component of diesel fuel.

4 (a) Write an equation to show the complete combustion of cetane.

.....

(1 mark)

4 (b) Cetane has a melting point of 18 °C and a boiling point of 287 °C.
In polar regions vehicles that use diesel fuel may have ignition problems.
Suggest **one** possible cause of this problem with the diesel fuel.

.....

.....

(1 mark)

4 (c) The pollutant gases NO and NO_2 are sometimes present in the exhaust gases of vehicles that use petrol fuel.

4 (c) (i) Write an equation to show how NO is formed and give a condition needed for its formation.

Equation .....

Condition .....

(2 marks)

4 (c) (ii) Write an equation to show how NO is removed from the exhaust gases in a catalytic converter. Identify a catalyst used in the converter.

Equation .....

Catalyst .....

(2 marks)

4 (c) (iii) Deduce an equation to show how NO_2 reacts with water and oxygen to form nitric acid (HNO_3).

.....

(1 mark)

Do not write outside the box

4 (d) Cetane ($C_{16}H_{34}$) can be cracked to produce hexane, butene and ethene.

4 (d) (i) State **one** condition that is used in this cracking reaction.

.....

(1 mark)

4 (d) (ii) Write an equation to show how one molecule of cetane can be cracked to form hexane, butene and ethene.

.....

(1 mark)

4 (d) (iii) State **one** type of useful solid material that could be formed from alkenes.

.....

(1 mark)

10

Turn over for the next question

Do not write outside the box

Section B

Answer **all** questions in the spaces provided.

5 The following table gives the melting points of some elements in Period 3.

Element	Na	Al	Si	P	S
Melting point / K	371	933	1680	317	392

5 (a) State the type of structure shown by a crystal of silicon.
Explain why the melting point of silicon is very high.

.....

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

5 (b) State the type of structure shown by crystals of sulfur and phosphorus.
Explain why the melting point of sulfur is higher than the melting point of phosphorus.

.....

.....

.....

.....

.....

(3 marks)

(Extra space) .....

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Do not write outside the box

5 (c) Draw a diagram to show how the particles are arranged in aluminium and explain why aluminium is malleable.
(You should show a minimum of six aluminium particles arranged in two dimensions.)

.....

.....

.....

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.....

(3 marks)

(Extra space) .....

.....

.....

5 (d) Explain why the melting point of aluminium is higher than the melting point of sodium.

.....

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.....

.....

(3 marks)

(Extra space) .....

.....

.....

12

Do not write outside the box

6 Octane is the eighth member of the alkane homologous series.

6 (a) State **two** characteristics of a homologous series.

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

6 (b) Name a process used to separate octane from a mixture containing several different alkanes.

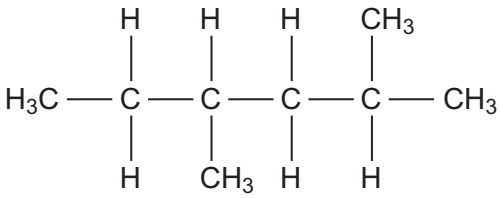
.....

.....

(1 mark)

Do not write outside the box

6 (c) The structure shown below is one of several structural isomers of octane.



Give the meaning of the term structural isomerism.
Name this isomer and state its empirical formula.

.....

.....

.....

.....

.....

.....

(4 marks)

(Extra space) .....

.....

6 (d) Suggest why the branched chain isomer shown above has a lower boiling point than octane.

.....

.....

.....

.....

(2 marks)

9

END OF QUESTIONS

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Version 2



General Certificate of Education (A-level)
January 2011

Chemistry CHEM1

(Specification 2420)

Unit 1: Foundation Chemistry

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Question	Marking Guidance	Mark	Comments
1(a)	Water or H_2O or molecules (in ice) are held further apart (than in liquid water)/(more) space/gaps/holes in structure/ Water or H_2O or molecules (in ice) are more spread out	1	Allow water (liquid) is more compact / less space/gaps/holes CE if holes filled with air, O_2 etc CE if macromolecule CE if atoms further apart (since ambiguous) Ignore spaces filled with H_2O Ignore reference to H bonds Allow better tessellation in liquid water
1(b)(i)	Hydrogen bonding	1	Allow H bonds Do not allow 'hydrogen' only but mark on
1(b)(ii)	Van der Waals' / VdW	1	Allow London forces, dispersion forces, temporary induced dipole forces
1(b)(iii)	Hydrogen bonding is stronger (than van der Waals forces) / IMF in ice stronger (than IMF in methane)/ H bonds take more energy to break	1	Not H Bonds are strong (needs comparison) If (b)(i) OR (ii) is incorrect, cannot award (b)(iii) If (b)(i) and /or (ii) is blank, can score (b)(iii)

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1(c)(i)	Structure showing 3 bonds to H and 1 lone pair (trigonal) pyramid(al) /(distorted) tetrahedral	1 1	do not insist on the + sign Allow triangular pyramid Not square pyramid Ignore bond angles in structure M2 independent of M1
1(c)(ii)	107°	1	Allow range106 - 108° Ignore ° (C)
1(c)(iii)	NH_3 /ammonia	1	Contradictions (eg NH_4 ammonia) CE = 0
1(d)	3	1	Allow three/ III/ 3 lone pairs/ 3lp/ 3 lone pairs of electrons

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Question	Marking Guidance	Mark	Comments
2(a)	$\underline{4d^{10}\,5s^2\,5p^1}$ in any order	1	Allow subscripts for numbers Allow capitals
2(b)(i)	Using an electron gun / (beam of) high energy/fast moving electrons	1	Ignore 'knocks out an electron'
2(b)(ii)	$In(g) + e^- \rightarrow In^+(g) + 2e^-$ ***OR*** $In(g) \rightarrow In^+(g) + e^-$ $In(g) - e^- \rightarrow In^+(g)$	1	The state symbols need not be present for the electron- but if they are they must be (g) No need to show charge on electron If I CE = 0 Ignore any equations using M
2(b)(iii)	So no more than 1 electron is knocked out/ so only one electron is knocked out/ prevent further ionisation	1	Allow stop 2+ and 3+/other ions being formed Not to get wrong m/z
2(b)(iv)	Any two processes from • Accelerate (owtte) • Deflect (owtte) • Detect (owtte)	2 max	Ignore wrong causes of process

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2(c)(i)	Average/mean mass of (1) atom(s) (of an element) 1/12 mass of one atom of ^{12}C ***OR*** (Average) mass of one mole of atoms 1/12 mass of one mole of ^{12}C ***OR*** (Weighted) average mass of all the isotopes 1/12 mass of one atom of ^{12}C ***OR*** Average mass of an atom/isotope compared to C-12 on a scale in which an atom of C-12 has a mass of 12	1 1	Not average mass of 1 molecule Allow the wording Average mass of 1 atom of an element compared to 1/12 mass atom of ^{12}C (or mass 1/12 atom of ^{12}C) Allow if moles of atoms on both lines Accept answer in words Can have top line x 12 instead of bottom line ÷12 If atoms/moles mixed, max = 1
2(c)(ii)	$\frac{113x + 115y}{x + y} = 114.5$ ratio (113:115) = 1:3 **OR** 25:75 **OR** 0.5:1.5 etc	1 1	Allow idea that there are 4 x 0.5 divisions between 113 and 115 Correct answer scores M1 and M2 If 1:3 for In(115): In(113), max = 1
2(d)	None Same no of electrons (in the outer shell)/same electron configuration	1 1	 Ignore electrons determine chemical properties/ ignore protons M2 dependent on M1 being correct

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2(e)	29.0% /29% O $\frac{69.2}{114.8/114.5}$ $\frac{1.8}{1}$ $\frac{29.0}{16}$ or 0.603 1.8 1.81 1 3 3 EF = In H_3O_3	1 1 1	If no O calculated, allow M2 if In and H divided by the correct A_r Allow $In(OH)_3$ Do not allow last mark just for ratio 1:3:3 If InO_3H_3 given with no working then allow 3 marks If I not In, lose M3

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Question	Marking Guidance	Mark	Comments
3(a)(i)	$\underline{4.98 \times 10^{-3}}$	1	Only
3(a)(ii)	2.49×10^{-3}	1	Allow answer to 3(a)(i) ÷ 2 Allow answers to 2 or more significant figures
3(a)(iii)	2.49×10^{-2}	1	Allow 3(a)(ii) x 10 Allow answers to 2 or more significant figures
3(a)(iv)	138.2	1	3.44 divided by the candidate's answer to 3(a)(iii) 138.2 or 138.1 (i.e. to 1 d.p.)
3(a)(v)	(138 - 60) ÷ 2 = 39.1 K/ potassium	1 1	Allow 39 – 39.1 Allow ((a)(iv) – 60) ÷ 2 Allow consequential on candidate's answer to a(iv) and a(v) if a group 1 metal Ignore + sign

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3(b)	PV = n RT or rearranged $T = \frac{0.022 \times 100000}{0.658 \times 8.31}$ 402(.3) K (or 129 ^{0}C)	1 1 1	If incorrectly rearranged CE = 0 Correct M2 also scores M1 allow 402- 403K or 129- 130^{0}C do not penalise ^{0}K M3 must include units for mark
3(c)	Pressure build up from gas/ may explode/ stopper fly out/glass shatters/breaks	1	Penalise incorrect gas
3(d)(i)	M_r =84.3 $\frac{6.27}{}$ = 0.074(4) 84.3	1 1	If 84 used, max 1 CE if not 84 or 84.3 Allow answers to 2 or more significant figures M2 = 0.074-0.075
3(d)(ii)	M1 M_r $MgSO_4$ = 120(.4) M2 Expected mass $MgSO_4$ =0.074(4) x120(.4)= 8.96 g M3 95% yield = $\frac{8.96 \times 95}{100}$ = 8.51 g Alternative method M2 0.074(4) x 95/100 = 0.0707 M3 0.0707 x 120(.4) = 8.51 g	1 1 1	allow 120.3 and 120.1 CE if wrong *Mr* Allow 8.8 – 9.0 or candidate's answer to 3(d)(i) x 120(.4) Allow 8.3 – 8.6 M3 dependent on M2 Allow 3d(i) x 95/100 Allow 8.3 – 8.6 M3 dependent on M2

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Question	Marking Guidance	Mark	Comments
4(a)	$C_{16}H_{34}$ + 24.5O_2 → 16CO_2 + 17H_2O	1	Allow multiples Ignore state symbols in equation
4(b)	Solidifies/freezes/goes viscous/waxing occurs	1	Allow does not vapourise/ less volatile Lack of Oxygen = 0 Apply list principle
4(c)(i)	N_2 + O_2 → 2NO Spark/ (very) high temp/ 2500 ^{o}C – 4000 ^{o} C	1 1	Allow multiples/ Ignore state symbols in equation Ignore pressure/catalyst/low % of oxygen Not just heat/hot Apply list principle eg if high temp 150°C = 0
4(c)(ii)	2CO + 2NO → 2CO_2 + N_2 **OR** C_8H_{18} + 25NO → 8CO_2 + 12.5 N_2 + 9H_2O **OR** C + 2NO → CO_2 + N_2 **OR** 2NO → N_2 + O_2 Pt/ Pd/ Rh/ Ir	1 1	Allow multiples/ Ignore state symbols in equation Allow other alkane reacting with NO in correctly balanced equation Penalise contradiction of name and symbol
4(c)(iii)	4NO_2 +2H_2O + O_2 → 4HNO_3	1	Allow multiples/ Ignore state symbols in equation

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4(d)(i)	High temp/ anywhere in range 400 ^{o}C – 900 ^{o} C/ anywhere in range 670-1200K / high pressure/ anywhere in range 5000 kPa up to 8000 kPa/	1	Not catalyst/heat
4(d)(ii)	$C_{16}H_{34} \rightarrow C_6H_{14} + 2C_4H_8 + C_2H_4$ Or $C_{16}H_{34} \rightarrow C_6H_{14} + C_4H_8 + 3C_2H_4$	1	Do not allow multiples Ignore state symbols in equation
4(d)(iii)	Polymers/plastics/ named polymer	1	Allow polyesters or polyamides Ignore object made from polymer

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Question	Marking Guidance	Mark	Comments
5(a)	Macromolecular/giant covalent/ giant molecular / giant atomic	1	If IMF/H-bonds/Ionic/metallic CE =0/3 covalent bond between molecules CE = 0/3 If giant unqualified M1 = 0 but mark on
	Many/strong covalent bonds	1	M2 and M3 can only be scored if covalent mentioned in answer Ignore metalloid and carbon Ignore bp
	Bonds must be broken/overcome	1	Ignore numbers of bonds and references to energy
5(b)	(Simple) <u>molecular</u>	1	QoL Do not allow simple covalent for M1 Giant covalent/ionic/metallic, CE = 0 If breaking covalent bonds CE= 0/3
	S bigger <u>molecule</u> (than P) or S_8 and P_4 references	1	QoL Allow more electrons in sulfur <u>molecule</u> or S_8 Do not allow S is bigger then P Allow S <u>molecule</u> has a bigger M_r Do not allow contradictions
	So more/ stronger <u>van der Waals</u>' forces (to be broken or overcome)	1	Not just more energy to break

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5(c)	Regular arrangement of minimum of 6 particles in minimum of 2 rows + charge in each one (of 6) <u>Rows/planes/sheets/layers</u> (of atoms/ions) can slide (owtte) over one another	1 1 1	Ignore e- Do not allow ring arrangements OR structures bonded with electrons Allow +, (1+, 2+ or 3+) in ions/or in words M3 independent If ionic bonding/molecules/IMF/vdw/covalent, penalise M3 Ignore layers of electrons sliding

5(d)	Bigger charge (3+ compared to 1+) ***OR*** smaller atom/ion in Al / more protons/bigger nuclear charge More free /<u>delocalised</u> electrons (in Al)/bigger sea of electrons in Al Stronger metallic bonding/ stronger (electrostatic) attraction between the (+) ions or nuclei and the (delocalised) electrons (or implied)	1 1 1	CE = 0 if molecules, ionic, covalent, IMF (Allow Al^{2+}) Accept 2 or 3 delocalised electrons compared to 1 in Na Must be implied that the electrons are the delocalised ones not the electrons in the shells. Accept converse arguments

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Question	Marking Guidance	Mark	Comments
6(a)	• (Same) General formula /allow a named homologous series with its general formula • Chemically similar/same (chemical) reactions • Same functional group • Trend in physical properties/ eg inc bp as M_r increases • (Molecules) increase by CH_2/M_r = *14*	2	Any two points
6(b)	Fractional distillation/ fractionation/ chromatography	1	Allow GLC
6(c)	(Molecules/compounds/substances) with the same molecular formula / same number and type of atoms but different structural formula/ different displayed formula/ different arrangement of atoms/different structures 2,4-dimethylhexane C_4H_9	1 1 1 1	Allow alkanes with same molecular formula Allow same chemical formula in M1 = 0 but can allow M2 Not different positions in space M2 dependent on M1 Ignore the absence of dash and/or commas

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6(d)	less surface contact / less surface area/ less polarisable molecule	1	Allow more spherical or fewer ponts of contact Not smaller molecule/ not more compact molecule/ not shorter chain Allow converse arguments
	so fewer/weaker/less Van der Waals'/vdw forces	1	Must be comparative answer ie not just few VDW forces QoL Assume 'it' refers to the branched isomer

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General principles applied to marking CHEM1 papers by CMI+ (January 2011)

It is important to note that the guidance given here is generic and specific variations may be made in the mark scheme.

Basic principles

- **Examiners should note that throughout the mark scheme, items that are underlined are required information to gain credit.**
- **Occasionally a response involves incorrect chemistry and the mark scheme records CE = 0, which means a chemical error has occurred and no credit is given for that section of the clip or for the whole clip.**

A. The "List principle" and the use of "ignore" in the mark scheme

If a question requires **one** answer and a candidate gives two answers, no mark is scored if one answer is correct and one answer is incorrect. There is no penalty if both answers are correct.

N.B. Certain answers are designated in the mark scheme as those that the examiner should "Ignore". These answers are not counted as part of the list and should be ignored and will not be penalised.

B. Incorrect case for element symbol

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip.
For example, penalise the use of "h" for hydrogen, "CL" for chlorine or "br" for bromine.

C. Spelling

In general

- The names of organic chemical compounds and functional groups **must be spelled correctly,** when specifically asked for, to gain credit.
- Phonetic spelling may be acceptable for some chemical compounds (eg amonia would be phonetically acceptable. However, ammoniam would be unacceptable since it is ambiguous).

N.B. Some terms may be required to be spelled correctly or an idea needs to be articulated with clarity, as part of the "Quality of Language" (**QoL**) marking. These will be identified in the mark scheme and marks are awarded only if the QoL criterion is satisfied.

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D. Equations

In general

- Equations **must** be balanced.
- State symbols are generally ignored, unless specifically required in the mark scheme.

E. Lone Pairs

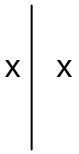
The following representations of lone pairs in structures are acceptable.



with or without the 2 electrons shown **OR**



OR



OR x x **OR** x x **OR**



F. Reagents

The command word "Identify", allows the candidate to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when the name and formula contradict. Specific details will be given in mark schemes.

G. Marking calculations

In general

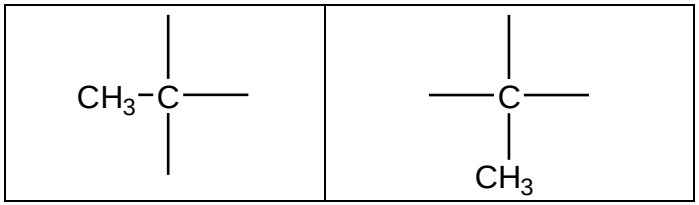
- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- If a candidate has made an arithmetic error or a transcription error deduct one mark, but continue marking (error carried forward).

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H. Organic structures

In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Bonds should be drawn correctly between the relevant atoms.
- Latitude should be given to the representation of C ─ C bonds in structures, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- The following representations are allowed:-



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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	



General Certificate of Education
Advanced Subsidiary Examination
June 2010

Chemistry CHEM1

Unit 1 Foundation Chemistry

Friday 21 May 2010 1.30 pm to 2.45 pm

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a calculator.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- The Periodic Table/Data Sheet is provided as an insert.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use accurate scientific terminology.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.



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Do not write outside the box

Section A

Answer **all** questions in the spaces provided.

1 Fluorine forms many compounds that contain covalent bonds.

1 (a) (i) State the meaning of the term *covalent bond*.

.....

.....

(1 mark)

1 (a) (ii) Write an equation to show the formation of one molecule of ClF_3 from chlorine and fluorine molecules.

.....

(1 mark)

1 (b) Draw the shape of a dichlorodifluoromethane molecule (CCl_2F_2) and the shape of a chlorine trifluoride molecule (ClF_3). Include any lone pairs of electrons that influence the shape.

Shape of CCl_2F_2 Shape of ClF_3

(2 marks)

1 (c) Suggest the strongest type of intermolecular force between CCl_2F_2 molecules.

.....

(1 mark)

Do not write outside the box

1 (d) BF_3 is a covalent molecule that reacts with an F^- ion to form a BF_4^- ion.

1 (d) (i) Name the type of bond formed when a molecule of BF_3 reacts with an F^- ion. Explain how this bond is formed.

Type of bond .....

Explanation .....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

1 (d) (ii) State the bond angle in the BF_4^- ion.

.....

(1 mark)

1 (e) An ultrasound imaging agent has the formula C_4F_{10}
It can be made by the reaction of butane and fluorine as shown in the following equation.

$$C_4H_{10} + 10F_2 \longrightarrow C_4F_{10} + 10HF$$

Calculate the percentage atom economy for the formation of C_4F_{10} in this reaction.
Give your answer to three significant figures.

.....

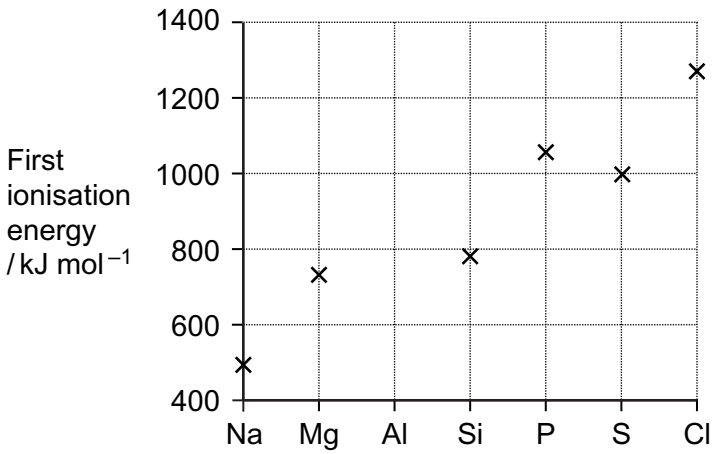
.....

(2 marks)

11

Do not write outside the box

2 The following diagram shows the first ionisation energies of some Period 3 elements.



2 (a) Draw a cross on the diagram to show the first ionisation energy of aluminium.

(1 mark)

2 (b) Write an equation to show the process that occurs when the first ionisation energy of aluminium is measured.

.....

(2 marks)

2 (c) State which of the first, second or third ionisations of aluminium would produce an ion with the electron configuration $1s^2\ 2s^2\ 2p^6\ 3s^1$

.....

(1 mark)

2 (d) Explain why the value of the first ionisation energy of sulfur is less than the value of the first ionisation energy of phosphorus.

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

Do not write outside the box

2 (e) Identify the element in Period 2 that has the highest first ionisation energy and give its electron configuration.

Element .....

Electron configuration .....

(2 marks)

2 (f) State the trend in first ionisation energies in Group 2 from beryllium to barium. Explain your answer in terms of a suitable model of atomic structure.

Trend.....

Explanation .....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

11

Turn over for the next question

Do not write outside the box

3 In this question give all your answers to three significant figures.

Magnesium nitrate decomposes on heating to form magnesium oxide, nitrogen dioxide and oxygen as shown in the following equation.

$$2Mg(NO_3)_2(s) \longrightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

3 (a) Thermal decomposition of a sample of magnesium nitrate produced 0.741 g of magnesium oxide.

3 (a) (i) Calculate the amount, in moles, of MgO in 0.741 g of magnesium oxide.

.....

.....

(2 marks)

3 (a) (ii) Calculate the total amount, in moles, of gas produced from this sample of magnesium nitrate.

.....

.....

(1 mark)

3 (b) In another experiment, a different sample of magnesium nitrate decomposed to produce 0.402 mol of gas. Calculate the volume, in dm^3, that this gas would occupy at 333 K and 1.00×10^5 Pa.
(The gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

Do not write outside the box

3 (c) A 0.0152 mol sample of magnesium oxide, produced from the decomposition of magnesium nitrate, was reacted with hydrochloric acid.

$$MgO + 2HCl \longrightarrow MgCl_2 + H_2O$$

3 (c) (i) Calculate the amount, in moles, of HCl needed to react completely with the 0.0152 mol sample of magnesium oxide.

.....

(1 mark)

3 (c) (ii) This 0.0152 mol sample of magnesium oxide required 32.4 cm^3 of hydrochloric acid for complete reaction. Use this information and your answer to part **(c) (i)** to calculate the concentration, in mol dm^{-3}, of the hydrochloric acid.

.....

.....

.....

(1 mark)

8

Turn over for the next question

Do not write outside the box

4 There are several oxides of nitrogen.

4 (a) An oxide of nitrogen contains 25.9% by mass of nitrogen. Determine the empirical formula of this oxide.

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

4 (b) Give **one** reason why the oxide NO is a pollutant gas.

.....

.....

(1 mark)

4 (c) The oxide NO reacts with oxygen to form nitrogen dioxide. Write an equation for this reaction.

.....

(1 mark)

4 (d) Explain how NO is produced in the engine of a motor vehicle.

.....

.....

.....

(2 marks)

4 (e) Write an equation to show how NO is removed from the exhaust gases in motor vehicles using a catalytic converter.

.....

(1 mark)

8

Do not write outside the box

5 The alkane butane is used as a fuel.

5 (a) (i) Write an equation for the complete combustion of butane.

.....

(1 mark)

5 (a) (ii) State a condition which may cause carbon to be formed as a product in the combustion of butane.

.....

(1 mark)

5 (b) Butane obtained from crude oil may contain trace amounts of an impurity.
When this impurity burns it produces a toxic gas that can be removed by reacting it with calcium oxide coated on a mesh.

5 (b) (i) Suggest the identity of the toxic gas.

.....

(1 mark)

5 (b) (ii) Suggest why calcium oxide reacts with the toxic gas.

.....

(1 mark)

5 (b) (iii) Suggest why the calcium oxide is coated on a mesh.

.....

(1 mark)

5

Turn over for the next question

Do not write outside the box

6 Pent-1-ene is a member of the alkene homologous series.

6 (a) Pent-1-ene can be separated from other alkenes.

State the physical property of alkenes that allows them to be separated from a mixture by fractional distillation.

.....

(1 mark)

6 (b) (i) State the meaning of the term *structural isomerism*.

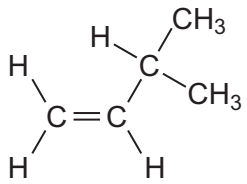
.....

.....

.....

(2 marks)

6 (b) (ii) Name the branched chain isomer of pent-1-ene shown below.



.....

(1 mark)

6 (b) (iii) Draw the structure of a functional group isomer of pent-1-ene.

(1 mark)

Do not write outside the box

6 (c) The cracking of one molecule of compound **X** produces pent-1-ene, ethene and butane in a 1:2:1 mol ratio.
Deduce the molecular formula of **X** and state a use for the ethene formed.

Molecular formula of **X** .....

.....

Use of ethene .....

(2 marks)

7

Turn over for the next question

Do not write outside the box

Section B

Answer **all** questions in the spaces provided.

7 Iodine and graphite are both solids. When iodine is heated gently a purple vapour is seen. Graphite will not melt until the temperature reaches 4000 K. Graphite conducts electricity but iodine is a very poor conductor of electricity.

7 (a) State the type of crystal structure for each of iodine and graphite.

.....

.....

.....

.....

(2 marks)

7 (b) Describe the structure of and bonding in graphite and explain why the melting point of graphite is very high.

.....

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.....

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(4 marks)

(Extra space) .....

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.....

.....

Do not write outside the box

7 (c) Explain why iodine vaporises when heated gently.

.....

.....

.....

.....

(2 marks)

7 (d) State why iodine is a very poor conductor of electricity.

.....

.....

(1 mark)

9

Turn over for the next question

Do not write outside the box

8 (a) Define the term *mass number* of an atom.

The mass number of an isotope of nitrogen is 15. Deduce the number of each of the fundamental particles in an atom of ^{15}N

.....

.....

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

Do not write outside the box

8 (b) Define the term *relative atomic mass*.

An organic fertiliser was analysed using a mass spectrometer. The spectrum showed that the nitrogen in the fertiliser was made up of 95.12% ^{14}N and 4.88% ^{15}N

Calculate the relative atomic mass of the nitrogen found in this organic fertiliser. Give your answer to two decimal places.

.....

.....

.....

.....

.....

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.....

.....

(4 marks)

(Extra space) .....

.....

.....

.....

8 (c) In a mass spectrometer, under the same conditions, $^{14}N^+$ and $^{15}N^+$ ions follow different paths. State the property of these ions that causes them to follow different paths.

State **one** change in the operation of the mass spectrometer that will change the path of an ion.

.....

.....

.....

.....

(2 marks)

Question 8 continues on the next page

Turn over ▶

Do not write outside the box

8 (d) Organic fertilisers contain a higher proportion of ^{15}N atoms than are found in synthetic fertilisers.

State and explain whether or not you would expect the chemical reactions of the nitrogen compounds in the synthetic fertiliser to be different from those in the organic fertiliser. Assume that the nitrogen compounds in each fertiliser are the same.

.....

.....

.....

.....

(2 marks)

11

END OF QUESTIONS

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Version 1.0

General Certificate of Education
June 2010

Chemistry CHEM1

Foundation Chemistry

Mark Scheme

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Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available to download from the AQA Website: www.aqa.org.uk

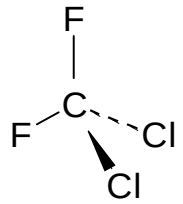
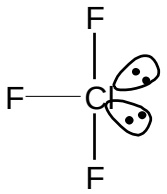
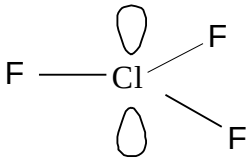
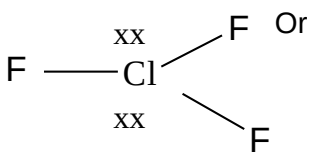
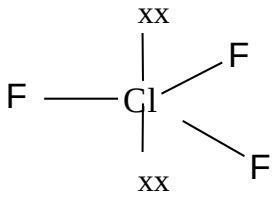
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Qu	Part	Sub Part	Marking Guidance	Mark	Comments
1	a	i	shared <u>pair of electrons</u>	1	Can have one electron from each atom contributes to the bond Not both electrons from one atom
1	a	ii	$\frac{1}{2}Cl_2 + \frac{3}{2}F_2 \rightarrow ClF_3$	1	Only Ignore state symbols even if wrong
1	b		  **OR** 	1 1	Allow any structure with 4 bp Watch for Cl in centre- it must be C Ignore wrong bond angles Representations of lone pairs allowed are the two examples shown with or without the electrons in the lobe. Also they can show the lone pair for either structure by two crosses /dots or a line with two crosses/dots on it e.g.  Or  Or a structure with 3 bp and 2 lp
1	c		Dipole – dipole	1	Allow van der Waals/ vdw/ London/ dispersion/ temporary dipole - induced dipole Not dipole alone

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1	d	i	Coordinate/ dative (covalent) (Lone) pair of electrons/ both electrons (on F^-) Donated from F^- / fluoride or donated to the BF_3	1 1 1	If wrong CE = 0/3 but if 'covalent' or left top line blank, mark on. CE if lone pair is from B Must have the – sign on the F ie F^- Ignore Fl^- M3 dependent on M2
1	d	ii	109° to 109.5°	1	
1	e		$\frac{238 \times 100}{438}$ = 54.3%	1 1	For 1 mark allow 238 as numerator and 438 as denominator or correct strings 2 marks if correct answer to 3 sig figs. 54% or greater than 3 sig figs = 1 mark

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Qu	Part	Sub Part	Marking Guidance	Mark	Comments
2	a		Cross between the Na cross and the Mg cross	1	
2	b		$Al(g) \rightarrow Al^+(g) + e–$ $Al(g) - e– \rightarrow Al^+(g)$ $Al(g) + e– \rightarrow Al^+(g) + 2e–$	2	One mark for state symbols consequential on getting equation correct. Electron does not have to have the – sign on it Ignore (g) if put as state symbol with e^- but penalise state symbol mark if other state symbols on e^-
2	c		2nd / second / 2 / II	1	Only
2	d		Paired electrons <u>in (3)p orbital</u> repel	1 1	Penalise wrong number If paired electrons repel allow M2
2	e		Neon/ Ne $1s^22s^22p^6$ / $[He]2s^22p^6$	1 1	No consequential marking from wrong element Allow capital s and p Allow subscript numbers
2	f		Decreases Atomic radius increases/ electron removed further from nucleus or nuclear charge/ electron in higher energy level/ Atoms get larger/ more shells As group is descended more shielding	1 1 1	CE if wrong Accept more repulsion between more electrons for M2 Mark is for distance from nucleus Must be comparative answers from M2 and M3 CE M2 and M3 if mention molecules Not more sub-shells

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Qu	Part	Sub Part	Marking Guidance	Mark	Comments
3	a	i	M_r MgO = 40.3 0.741/40.3 = 0.0184	1 1	If used 40 then penalise this mark but allow consequential M2 (0.0185) 0.018 with no M_r shown = 0 Penalise if not 3 sig figs in this clip only
3	a	ii	0.0184 x 5/2 = 0.0460	1	Allow 0.0459 to 0.0463 Allow their 3(a)(i) x 5/2 ie allow process mark of x 5/2 but insist on a correct answer being written down Ignore sig figs
3	b		pV=nRT (V= $\frac{0.402 \times 8.31 \times 333}{100\,000}$) 0.0111 11.1 (dm^3)	1 1 1	If rearranged incorrectly then lose M1 If this expression correct then candidate has scored first mark Ignore units 3 marks for 11.1 (dm^3) However if 11.1 m^3 or cm^3 allow 2 (ie penalise wrong units in final answer) Ignore sig figs- but must be 2 sig figs or greater
3	c	i	0.0152 x 2 = 0.0304	1	Allow 0.03
3	c	ii	0.938 mol dm^{-3}	1	Allow range 0.92 – 0.94 Minimum 2 sig figs Allow consequential marking from 3(c)(i) Ignore units even if wrong

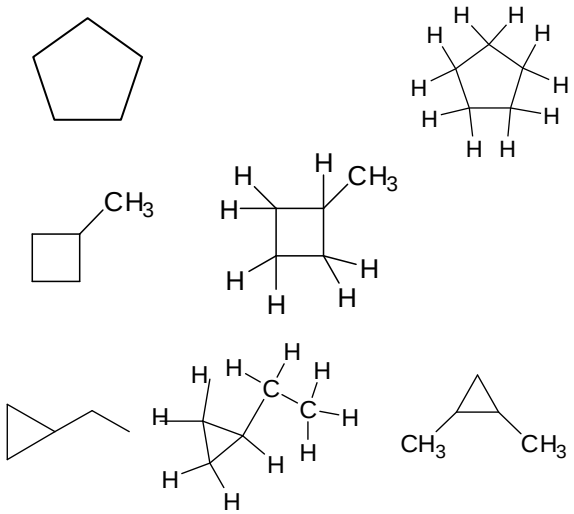
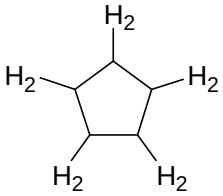
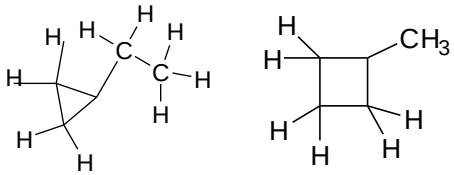
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Qu	Part	Sub Part	Marking Guidance	Mark	Comments
4	a		O = 74.1% 25.9 74.1 14 16 1.85 4.63 1 2.5 N_2O_5	1 1 1	 If atomic numbers or molecular masses are used lose M2 This ratio alone will not score the final mark. (It would get 2) Allow 3 marks for N_2O_5
4	b		Toxic/ poisonous/ forms an acidic gas / forms NO_2 which is acidic/ respiratory irritant/ forms $HNO_3$when NO reacts with water and oxygen/ triggers asthma attacks/ greenhouse gas/ photochemical smog/ contributes to global warming /formation of acid rain	1	ignore NO is an acidic gas or NO is acidic in water Not references to ozone layer
4	c		$2NO + O_2 \rightarrow 2NO_2$	1	Accept multiples or fractions of equation Ignore wrong state symbols
4	d		Nitrogen / N_2 and oxygen / O_2 combine/react spark / high temperature / 2500-4000 °C	1 1	QWC (not N and O combine) Not nitrogen in fuel Allow $N_2 + 0_2 \rightarrow 2NO$ for M1 only
4	e		$2NO + 2CO \rightarrow N_2 + 2CO_2$ ***OR*** $2NO \rightarrow N_2 + O_2$	1	Accept multiples or fractions of equation Ignore wrong state symbols Allow $C_8H_{18} + 25NO \rightarrow 8CO_2 + 12.5\ N_2 + 9H_20$

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Qu	Part	Sub Part	Marking Guidance	Mark	Comments
5	a	i	$C_4H_{10} + 6\frac{1}{2}O_2 \rightarrow 4CO_2 + 5H_2O$	1	Allow multiples
5	a	ii	insufficient oxygen / low temperature / poor mixing of butane and air	1	Allow insufficient air Allow lack or oxygen / air Do not allow no oxygen Not incomplete combustion
5	b	i	Sulfur dioxide / SO_2	1	Allow sulfur trioxide/ SO_3 (allow spelling of sulphur to be sulphur)
5	b	ii	It is basic / the gas (SO_2) is acidic	1	Idea of neutralisation It = calcium oxide
5	b	iii	bigger surface area to react	1	Do not allow cheaper

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Qu	Part	Sub Part	Marking Guidance	Mark	Comments
6	a		(Different) boiling points	1	Ignore mp's, references to imf, different volatilities
6	b	i	Compound which have the same <u>molecular</u> formula but different structures/different structural formulae/different displayed formulae	1 1	Accept same no and type of atom for M1 But If same (chemical) formula M1 = 0 but allow M2 If empirical formula CE = 0/2 M2 dependent on M1
6	b	ii	3-methylbut-1-ene	1	only ignore commas and hyphens
6	b	iii	 Allow any correct structure with a cyclic alkane	1	Do not allow  or  i.e with an H missing on one C

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6	c		$C_{13}H_{28}$ Making plastics/ used to make polymers or polythene/ used to make antifreeze/ make ethanol/ ripening fruit/ any named additional polymer	1 1	only not used **as** a plastic/polymer/antifreeze not just 'polymers' – we need to see that they are being made

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Qu	Part	Sub Part	Marking Guidance	Mark	Comments
7	a		Iodine – molecular Graphite- macromolecular/giant covalent/giant atomic	1 1	Not covalent lattice
7	b		Layers of (C atoms) Connected by covalent bonds within each layer Van der Waals forces/ IMF between layers/ weak forces between layers Many/strong covalent bonds need to be broken	1 1 1 1	If any other element mentioned other than C, CE = 0 Ignore the no of covalent bonds around the C if mentioned The first 3 marks could be scored with a labelled diagram. Need to label or state covalent bonds within the layers. Covalent or ionic or metallic bonds between molecules CE = 0
7	c		Van der Waals forces are weak or easily broken Van der Waals between molecules (or implied)	1 1	Not vdw between atoms Allow weak IMF = 2
7	d		Does not have delocalised/free electrons	1	Only allow answer with respect to iodine Not all electrons used in bonding Ignore free ions

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Qu	Part	Sub Part	Marking Guidance	Mark	Comments
8	a		Mass number = number of protons + neutrons (in the nucleus/atom) 7 protons <u>and</u> 7 electrons 8 neutrons	1 1 1	Not in a substance or compound or element
8	b		<u>Average/mean mass of (1) atom(s) (of an element)</u> 1/12 mass of one atom of ^{12}C ***OR*** <u>(Average) mass of one mole of atoms</u> 1/12 mass of one mole of ^{12}C ***OR*** <u>(Weighted) average mass of all the isotopes</u> 1/12 mass of one atom of ^{12}C ***OR*** Average mass of an atom/isotope compared to C-12 on a scale in which an atom of C-12 has a mass of 12 <u>(95.12 x 14) + (4.88 x 15)</u> 100 = 14.05	1 1 1 1	Accept answer in words Can have top line x 12 instead of bottom line ÷12 Allow 95.12 + 4.88 instead of 100 If not to 2 d.p. then lose last mark Not 14.04

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8	c		^{15}N is heavier / ^{15}N has a bigger m/z / different m/z values Electromagnet/ electric field/ magnet /accelerating potential or voltage / electric current	1 1	Not different no's of neutrons Not ionisation potential
8	d		No difference Same no of electrons (in outer orbital/shell/sub shell)/ same electron configuration	1 1	 M2 dependent on M1 Not just electrons determine chemical properties Ignore protons

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Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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5	
6	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2010

Chemistry CHEM1

Unit 1 Foundation Chemistry

Thursday 14 January 2010 9.00 am to 10.15 am

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a calculator.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. **Answers written in margins or on blank pages will not be marked.**
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- The Periodic Table/Data Sheet is provided as an insert.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use accurate scientific terminology.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

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SECTION A

Answer **all** questions in the spaces provided.

1 Ionisation energies provide evidence for the arrangement of electrons in atoms.

1 (a) Complete the electron configuration of the Mg^+ ion.

$1s^2$ .....

(1 mark)

1 (b) (i) State the meaning of the term *first ionisation energy*.

.....

.....

.....

(2 marks)

1 (b) (ii) Write an equation, including state symbols, to show the reaction that occurs when the **second** ionisation energy of magnesium is measured.

.....

(1 mark)

1 (b) (iii) Explain why the second ionisation energy of magnesium is greater than the first ionisation energy of magnesium.

.....

.....

.....

(1 mark)

1 (b) (iv) Use your understanding of electron arrangement to complete the table by suggesting a value for the third ionisation energy of magnesium.

	First	Second	Third	Fourth	Fifth
Ionisation energies of magnesium / kJ mol^{-1}	736	1450		10 500	13 629

(1 mark)

Areas outside the box will not be scanned for marking

1 (c) State and explain the general trend in the first ionisation energies of the Period 3 elements sodium to chlorine.

Trend .....

Explanation .....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

1 (d) State how the element sulfur deviates from the general trend in first ionisation energies across Period 3. Explain your answer.

How sulfur deviates from the trend .....

.....

Explanation .....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

1 (e) A general trend exists in the first ionisation energies of the Period 2 elements lithium to fluorine. Identify **one** element which deviates from this general trend.

.....

(1 mark)

13

Turn over ▶

Areas outside the box will not be scanned for marking

2 Ammonium sulfate reacts with sodium hydroxide to form ammonia, sodium sulfate and water as shown in the equation below.

$$(NH_4)_2SO_4(s) + 2NaOH(aq) \longrightarrow 2NH_3(g) + Na_2SO_4(aq) + 2H_2O(l)$$

2 (a) A 3.14 g sample of ammonium sulfate reacted completely with 39.30 cm^3 of a sodium hydroxide solution.

2 (a) (i) Calculate the amount, in moles, of $(NH_4)_2SO_4$ in 3.14 g of ammonium sulfate.

.....

.....

.....

(2 marks)

2 (a) (ii) Hence calculate the amount, in moles, of sodium hydroxide which reacted.

.....

(1 mark)

2 (a) (iii) Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide solution used.

.....

.....

(1 mark)

2 (b) Calculate the percentage atom economy for the production of ammonia in the reaction between ammonium sulfate and sodium hydroxide.

.....

.....

.....

(2 marks)

Areas outside the box will not be scanned for marking

2 (c) Ammonia is manufactured by the Haber Process.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Calculate the percentage atom economy for the production of ammonia in this process.

.....

.....

(1 mark)

2 (d) A sample of ammonia gas occupied a volume of 1.53×10^{-2} m^3 at 37 °C and a pressure of 100 kPa.
(The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$)

Calculate the amount, in moles, of ammonia in this sample.

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

2 (e) Glauber's salt is a form of hydrated sodium sulfate that contains 44.1% by mass of sodium sulfate. Hydrated sodium sulfate can be represented by the formula $Na_2SO_4.xH_2O$ where x is an integer. Calculate the value of x.

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

13

Areas outside the box will not be scanned for marking

3 The table below shows the boiling points of some hydrogen compounds formed by Group 6 elements.

	H_2O	H_2S	H_2Se	H_2Te
Boiling point / K	373	212	232	271

3 (a) State the strongest type of intermolecular force in water and in hydrogen sulfide (H_2S).

Water .....

Hydrogen sulfide .....

(2 marks)

3 (b) Draw a diagram to show how two molecules of water are attracted to each other by the type of intermolecular force you stated in part (a). Include partial charges and all lone pairs of electrons in your diagram.

(3 marks)

3 (c) Explain why the boiling point of water is much higher than the boiling point of hydrogen sulfide.

.....

.....

(1 mark)

3 (d) Explain why the boiling points increase from H_2S to H_2Te

.....

.....

(2 marks)

Areas outside the box will not be scanned for marking

3 (e) When H^+ ions react with H_2O molecules, H_3O^+ ions are formed.

Name the type of bond formed when H^+ ions react with H_2O molecules.
Explain how this type of bond is formed in the H_3O^+ ion.

Type of bond .....

Explanation .....

.....

(2 marks)

3 (f) Sodium sulfide (Na_2S) has a melting point of 1223 K.
Predict the type of bonding in sodium sulfide and explain why its melting point is high.

Type of bonding .....

Explanation .....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

13

Turn over for the next question

Areas outside the box will not be scanned for marking

4 Alkanes are saturated hydrocarbons which can be obtained from crude oil.
Pentane is an example of an alkane. A molecule of pentane contains five carbon atoms.

4 (a) (i) State the meaning of the term *saturated* and of the term *hydrocarbon* as applied to alkanes.

Saturated .....

.....

Hydrocarbon .....

.....

(2 marks)

4 (a) (ii) Give the general formula for the alkanes.

.....

(1 mark)

4 (b) Pentane burns completely in oxygen.

4 (b) (i) Write an equation for this reaction.

.....

(1 mark)

4 (b) (ii) State how the products of this reaction may affect the environment.

.....

.....

(1 mark)

4 (c) Give the name of a solid pollutant which may form when pentane burns incompletely in air.

.....

(1 mark)

Areas outside the box will not be scanned for marking

4 (d) One molecule of C_9H_{20} can be cracked to form one molecule of pentane and one other product.

4 (d) (i) Write an equation for this cracking reaction.

.....

(1 mark)

4 (d) (ii) Suggest a type of compound that can be manufactured from the other product of this cracking reaction.

.....

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(1 mark)

4 (d) (iii) State why a high temperature is needed for cracking reactions to occur.

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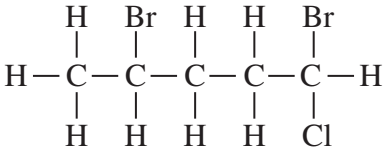
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(1 mark)

Question 4 continues on the next page

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4 (e) Pentane can react to form the following haloalkane **Q**.

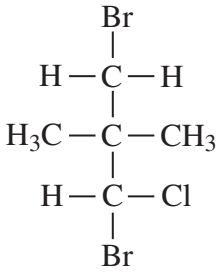


4 (e) (i) Name **Q**.

.....

(1 mark)

4 (e) (ii) State the type of structural isomerism shown by **Q** and the haloalkane shown below.



.....

(1 mark)

11

Areas outside the box will not be scanned for marking

SECTION B

Answer **all** questions in the spaces provided.

5 A mass spectrometer can be used to investigate the isotopes in an element.

5 (a) Define the term *relative atomic mass* of an element.

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

5 (b) Element **X** has a relative atomic mass of 47.9

Identify the block in the Periodic Table to which element **X** belongs and give the electron configuration of an atom of element **X**.

Calculate the number of neutrons in the isotope of **X** which has a mass number 49

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(3 marks)

(Extra space) .....

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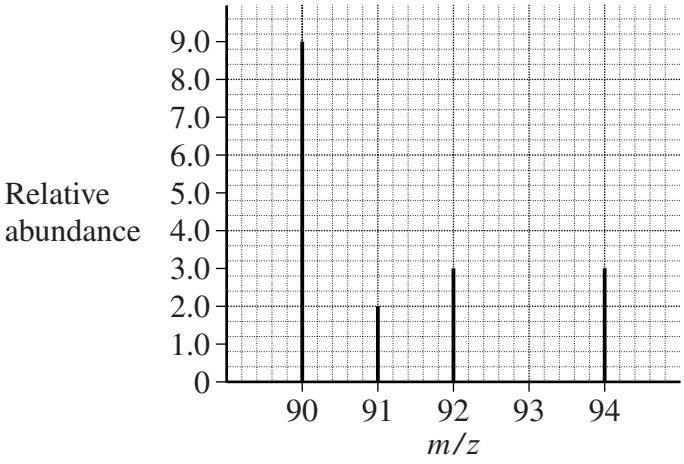
Question 5 continues on the next page

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5 (c) The mass spectrum of element **Z** is shown below.

Use this spectrum to calculate the relative atomic mass of **Z**, giving your answer to one decimal place.

Identify element **Z**.



.....

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(4 marks)

(Extra space) .....

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Areas outside the box will not be scanned for marking

5 (d) State how vaporised atoms of **Z** are converted into $\mathbf{Z}^+$ ions in a mass spectrometer.

State and explain which of the $\mathbf{Z}^+$ ions formed from the isotopes of **Z** in part (c) will be deflected the most in a mass spectrometer.

.....

.....

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(4 marks)

(Extra space) .....

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5 (e) Explain briefly how the relative abundance of an ion is measured in a mass spectrometer.

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

15

Areas outside the box will not be scanned for marking

6 A molecule of ClF_3 reacts with a molecule of AsF_5 as shown in the following equation.

$$ClF_3 + AsF_5 \longrightarrow ClF_2^+ + AsF_6^-$$

Use your understanding of electron pair repulsion to draw the shape of the AsF_5 molecule and the shape of the ClF_2^+ ion. Include any lone pairs of electrons.

Name the shape made by the atoms in the AsF_5 molecule and in the ClF_2^+ ion.

Predict the bond angle in the ClF_2^+ ion.

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(5 marks)

(Extra space) .....

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5

END OF QUESTIONS

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Version 1.1: 21/01

General Certificate of Education

Chemistry 1421

CHEM1 Foundation Chemistry

Mark Scheme

2010 examination - January series

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It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Dr Michael Cresswell Director General

Question	Part	Sub Part	Marking Guidance	Mark	Comments
1	(a)		$2s^2 2p^6 3s^1$	1	$1s^2$ can be rewritten Allow $2s^2 2p_x^2 2p_y^2 2p_z^2 3s^1$ Allow subscripts and capitals
1	(b)	(i)	Energy/enthalpy (needed) to remove one mole of electrons from one mole of atoms/compounds/molecules/elements ***OR*** Energy to form one mole of positive ions from one mole of atoms ***OR*** Energy/enthalpy to remove one electron from one atom In the gaseous state (to form 1 mol of gaseous ions)	1 1	Energy given out loses M1 M2 is dependent on a reasonable attempt at M1 Energy needed for this change $X(g) \rightarrow X^+(g) + e^{(-)}$ = 2 marks This equation alone scores one mark
1	(b)	(ii)	$Mg^+(g) \rightarrow Mg^{2+}(g) + e^{(-)}$ $Mg^+(g) + e^{(-)} \rightarrow Mg^{2+}(g) + 2e^{(-)}$ $Mg^+(g) - e^{(-)} \rightarrow Mg^{2+}(g)$	1	Do not penalise MG Not equation with X
1	(b)	(iii)	Electron being removed from a positive ion (therefore need more energy)/ electron being removed is closer to the nucleus/Mg^+ smaller (than Mg)/Mg^+ more positive than Mg	1	Allow from a + particle/ species Not electron from a higher energy level/or higher sub-level More protons = 0
1	(b)	(iv)	Range from 5000 to 9000 kJ mol^{-1}	1	
1	(c)		Increase Bigger nuclear <u>charge</u> (from Na to Cl)/more <u>protons</u> electron (taken) from same (sub)shell/ similar or same shielding/ electron closer to the nucleus/smaller atomic radius	1 1 1	If decrease CE = 0/3 If blank mark on QWC If no shielding = 0 Smaller ionic radius = 0

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1	(d)		Lower Two/pair of electrons in (3)p orbital or implied repel (each other)	1 1 1	If not lower CE = 0/3 If blank mark on Allow does not increase Not 2p M3 dependent upon a reasonable attempt at M2
1	(e)		Boron/B or oxygen/O/ O_2	1	

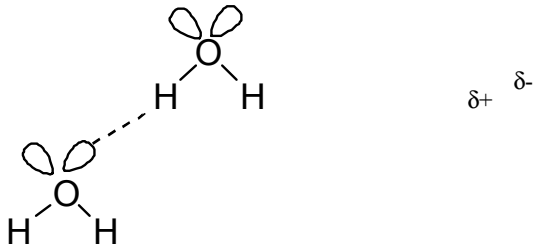
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Question	Part	Sub Part	Marking Guidance	Mark	Comments
2	(a)	(i)	M_r = 132.1 0.0238	1 1	132 Allow 0.024 Allow 0.0237 Penalise less than 2 sig fig once in (a)
2	(a)	(ii)	0.0476	1	0.0474-0.0476 Allow (a) (i) x 2
2	(a)	(iii)	1.21	1	Allow consequential from (a) (ii) ie allow (a) (ii) x 1000 / 39.30 Ignore units even if wrong
2	(b)		$\frac{34 \times 100}{212.1}$ = 16.0(3)%	1 1	Allow mass or Mr of desired product times one hundred divided by total mass or Mr of reactants/products If 34/212.1 seen correctly award M1 Allow 16% 16 scores 2 marks
2	(c)		100(%)	1	Ignore all working
2	(d)		PV = nRT or $n = \frac{PV}{RT}$ $n = \frac{100000 \times 1.53 \times 10^{-2}}{8.31 \times 310}$ = 0.59(4)	1 1 1	If rearranged incorrectly lose M1 and M3 M2 for mark for converting P and T into correct units in any expression Allow 0.593 M3 consequential on transcription error only not on incorrect P and T

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2	(e)		(Na_2SO_4) (44.1%) 44.1/142.1 0.310 =1 *x* = 10	H_2O 55.9% 55.9/18 3.11 =10	 1 1 1	 M1 is for 55.9 Alternative method gives180 for water part =2 marks X = 10 = 3 marks 10.02 = 2 marks

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Question	Part	Sub Part	Marking Guidance	Mark	Comments
3	(a)		Hydrogen/H bonds van der Waals/vdw/ dipole-dipole/London/temporarily induced dipole/dispersion forces	1 1	Not just hydrogen Not just dipole
3	(b)			3	M1 for partial charges as indicated in diagram (correct minimum) M2 for all four lone pairs M3 for H bond from the lp to the H (δ+) on the other molecule Lone pair on hydrogen CE = 0 OHO CE = 0 If only one molecule of water shown CE = 0
3	(c)		Hydrogen bonds/IMF (in water) stronger ***OR*** IMF / VDW / dipole-dipole forces (in H_2S) are weaker ***OR*** H bonding is the strongest IMF	1	Ignore energy references Comparison must be stated or implied
3	(d)		Atoms/molecules get larger/more shells/more electrons/ more surface area therefore increased Van der Waals/IMF forces	1 1	Not heavier/greater Mr Ignore references to dipole-dipole forces

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3	(e)		Dative (covalent)/ coordinate (Lone) pair/both electrons/two electrons on O(H_2) donated (to H^+) OR pair/both electrons come from O(H_2)	1 1	If not dative/coordinate CE = 0/2 If covalent or blank read on Explanation of a coordinate bond specific to oxygen or water required Not just H+ attracted to lone pair since that is nearer to a H bond
3	(f)		ionic oppositely charged <u>ions</u> /+ and – <u>ions or particles</u> ions attract <u>strongly</u> OR strong/many (ionic) bonds must be broken	1 1 1	if not ionic CE = 0 atoms or molecules loses M2 and M3 S^- loses M2 Reference to IMF loses M2 and M3

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Question	Part	Sub Part	Marking Guidance	Mark	Comments
4	(a)	(i)	single (C-C) bonds <u>only</u>/ no double (C=C) bonds C and H (atoms) <u>only/purely/solely/entirely</u>	1 1	Allow all carbon atoms bonded to four other atoms Single C-H bonds only =0 C=H CE Not consists or comprises Not completely filled with hydrogen CH molecules = CE Element containing C and H = CE
4	(a)	(ii)	C_nH_{2n+2}	1	*Formula only* C_xH_{2x+2}
4	(b)	(i)	$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$	1	Accept multiples Ignore state symbols
4	(b)	(ii)	gases produced are greenhouse gases/contribute to Global warming/effect of global warming/climate change	1	Allow CO_2 or water is greenhouse gas/causes global warming Acid rain/ozone CE = 0
4	(c)		carbon	1	Allow C Allow soot
4	(d)	(i)	$C_9H_{20} \rightarrow C_5H_{12} + C_4H_8$ ***OR*** $C_9H_{20} \rightarrow C_5H_{12} + 2C_2H_4$	1	Accept multiples
4	(d)	(ii)	Plastics, polymers	1	Accept any polyalkene / haloalkanes / alcohols
4	(d)	(iii)	so the <u>bonds</u> break ***OR*** because the <u>bonds</u> are strong	1	IMF mentioned = 0
4	(e)	(i)	1,4-dibromo-1-chloropentane / 1-chloro-1,4-dibromopentane	1	Ignore punctuation
4	(e)	(ii)	Chain/position/positional	1	Not structural or branched alone

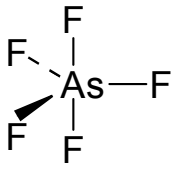
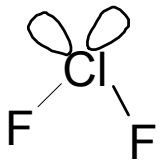
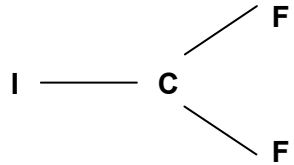
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Question	Part	Sub Part	Marking Guidance	Mark	Comments
5	(a)		<u>Average/mean mass of (1) atom(s) (of an element)</u> 1/12 mass of one atom of ^{12}C ***OR*** <u>(Average) mass of one mole of atoms</u> 1/12 mass of one mole of ^{12}C ***OR*** <u>(Weighted) average mass of all the isotopes</u> 1/12 mass of one atom of ^{12}C ***OR*** Average mass of an atom/isotope compared to C-12 on a scale in which an atom of C-12 has a mass of 12	1 1 This expression = 2 marks	If moles and atoms mixes Max = 1
5	(b)		d block [Ar] $3d^2 4s^2$ 27	1 1 1	Allow 3d/D Other numbers lose M1 Ignore transition metals Can be written in full Allow subscripts $3d^2$ and $4s^2$ can be in either order

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5	(c)		$\frac{(90x9) + (91x2) + (92x3) + (94x3)}{17}$ (= 1550) (or ∑ their abundances) =91.2 Zr/ Zirconium	1 1 1 1	If one graph reading error lose M1 and allow consequential M2 and M3. If 2 GR errors penalise M1 and M2 but allow consequential M3 If not 17 or ∑ their abundances lose M2 and M3 91.2 = 3 marks provided working shown. M4 -allow nearest consequential element from M3 accept Zr in any circumstance
5	(d)		High energy electrons/bombarded or hit with electrons knocks out electron(s) (to form ions) Z^+ = 90 deflected most since lowest mass/lowest m/z	1 1 1 1	accept electron gun If not 90 lose M3 and M4 If charge is wrong on 90 isotope lose M3 only Accept any symbol in place of Z Allow lightest
5	(e)		(ions hit detector and) cause current/(ions) accept electrons/cause electron flow bigger current = more of that isotope/current proportional to abundance	1 1	QWC Implication that current depends on the number of ions

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Question	Part	Sub Part	Marking Guidance	Mark	Comments
6				1	**Mark M1 – M5 independently** M1 for 5 bond pairs around As Do not penalise A for As or Fl for F
			trigonal / triangular bipyramid(al)	1	Allow trigonal dipyramid
				1	M3 for 2 bond pairs to F and 2 lone pairs Lone pairs can be shown as lobes with or without electrons or as xx or x x
			Bent / V shape / non-linear / triangular / angular	1	Bent-linear = contradiction Do not allow trigonal
			104° - 106°	1	
			(For candidates who thought this was ClF_2^+ which contained iodine allow 		
			Trigonal / triangular <u>planar</u>		Not just triangular
			120°		

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