

WJEC A-LEVEL CHEMISTRY

CHEMISTRY



EXAM QUESTION PACK

UNIT CH1 OLD SPECIFICATION PAPERS

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Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1091/01 – **LEGACY**



CHEMISTRY – CH1

A.M. FRIDAY, 27 May 2016

1 hour 30 minutes

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
- copy of the **Periodic Table** supplied by WJEC.
Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

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

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

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The **QWC** label alongside particular part-questions indicates those where the Quality of Written Communication is assessed.

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

Section A

Section B

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1. to 6.	10	
7.	14	
8.	16	
9.	13	
10.	15	
11.	12	
Total	80	

1091
010001

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

1. Using the convention of arrows to represent electrons, complete the electronic structure of an atom of chromium. [1]

1s	2s	2p	3s	3p	3d	4s
↑↓	↑↓	↑↓ ↑↓ ↑↓				

2. State which **one** of the following statements is true. [1]

- A** The first ionisation energy of neon is greater than the first ionisation energy of helium.
- B** The first ionisation energy of sodium is less than the first ionisation energy of neon.
- C** The first ionisation energy values increase down Group 1.
- D** The second ionisation energy of sodium is less than the first ionisation energy of sodium.
-

3. The half-life of a radioactive isotope ${}^{24}_{\text{x}}\text{Z}$ is 15.0 hours. It decays by beta emission to a stable isotope of magnesium, ${}_{12}\text{Mg}$.

- (a) Give the atomic number and symbol of this radioactive isotope. [1]
-

- (b) After a period of 45.0 hours from the start of the decay, only 0.15 g of ${}^{24}_{\text{x}}\text{Z}$ remains.

Calculate the starting mass of the radioactive isotope ${}^{24}_{\text{x}}\text{Z}$. [2]

Starting mass = ... g

4. The mass spectrum of bromine trifluoride, Br^{19}F_3 , shows two molecular ion peaks of equal intensity at m/z 136 and 138.

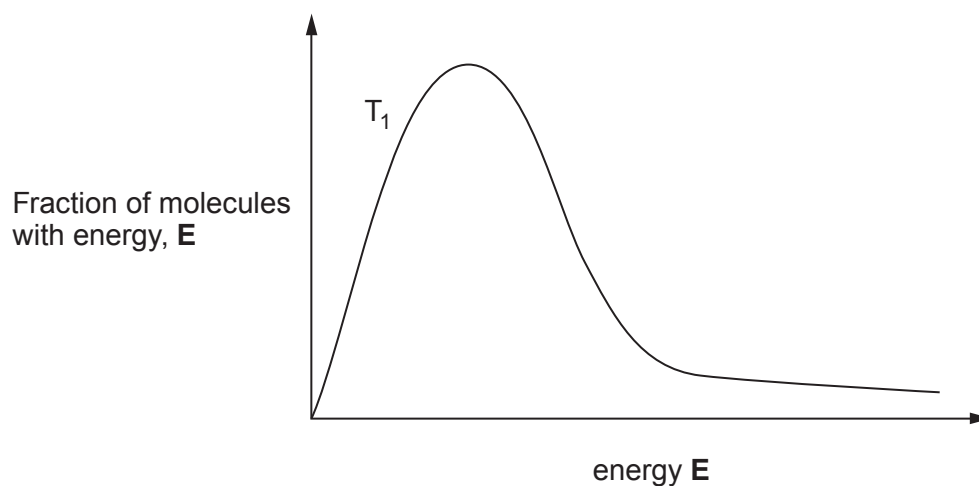
State what can be deduced about the relative isotopic masses of the bromine atoms present and their percentage abundances. [2]

.....

.....

.....

5. The graph shows the distribution of energies in a sample of gas at a certain temperature, T_1 .



Sketch on the graph the curve obtained at a higher temperature, T_2 .

[1]

6. The standard enthalpy change of formation, ΔH_f^θ , of phosphorus(V) chloride is -463 kJ mol^{-1} .

(a) State the standard conditions of temperature and pressure used, showing the units. [1]

Temperature

Pressure

(b) Calculate the heat evolved when 45.2 g of phosphorus(V) chloride (M_r 209) is produced from phosphorus and chlorine under standard conditions. [1]

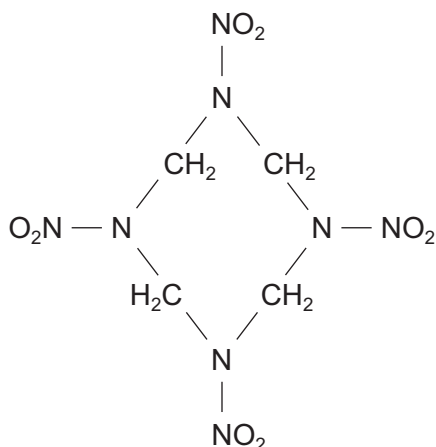
Heat evolved = ... kJ

Total Section A [10]

SECTION B

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

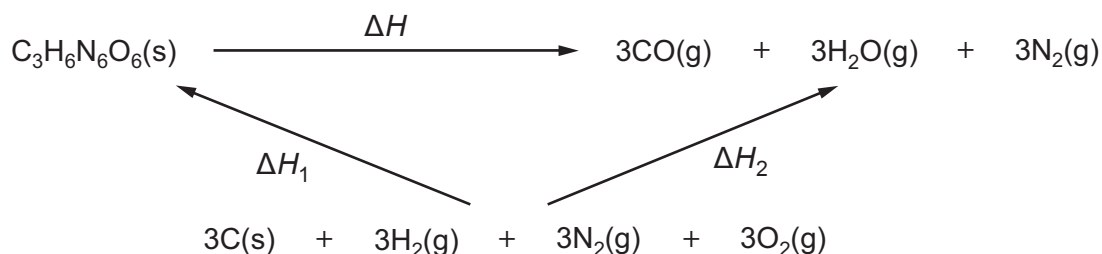
7. (a) The explosive HMX has the following structural formula. State its empirical formula. [1]



Empirical formula

- (b) Another explosive, RDX, has the formula $C_3H_6N_6O_6$.

- (i) Use the data table and the Hess cycle below to calculate the enthalpy of detonation, ΔH , of RDX. [3]



Compound	Enthalpy of formation $\Delta H_f / \text{kJ mol}^{-1}$
RDX(s)	+62
CO(g)	-111
H ₂ O(g)	-242

$\Delta H = \dots\dots\dots \text{kJ mol}^{-1}$

- (ii) The result from (b)(i) can be used to help you sketch the reaction profile for the explosive detonation of RDX.

Draw this profile using the axes given below. Label your profile with reactants, products and the activation energy. [2]



- (iii) The activation energy for the explosive detonation of RDX is 199 kJ mol^{-1} whereas the activation energy for the explosive detonation of mercury fulminate is 105 kJ mol^{-1} .

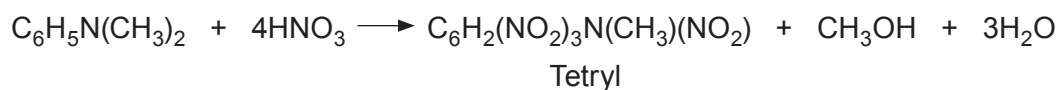
Define the term *activation energy* and hence comment on the relative stability of these two explosives. [2]

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- (c) The explosive Tetryl is made by adding concentrated nitric acid to N,N-dimethylphenylamine under suitable conditions. An equation for this is shown below.



- (i) State why the atom economy for this reaction is not 100 %. [1]

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- (ii) Tetryl produced in this reaction needs further treatment. It can be purified by dissolving it in propanone and then adding water, or by recrystallisation using benzene as the solvent.

State any factor in the purification of Tetryl that **does not** fit with the principles of Green Chemistry. [1]

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- (d) Many fireworks contain metal compounds that emit visible light. The colours given by barium and calcium compounds and their wavelengths are given in the table.

Metal	Colour	Wavelength / nm
barium	green	554
calcium	orange-red	616

- (i) State which of these two colours has the higher energy, giving a reason for your answer. [1]

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- (ii) The colours seen are as a result of the emission of visible light. State how these colours are produced. [3]

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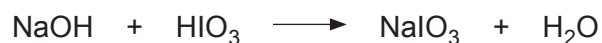
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Total [14]

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8. (a) A student was given an aqueous solution of iodic(V) acid, HIO_3 , and was asked to find its concentration by titration with sodium hydroxide solution.



He rinsed the burette with water and then filled it with the iodic(V) acid solution. 25.0 cm^3 of sodium hydroxide solution of concentration $0.125 \text{ mol dm}^{-3}$ were used for each titration against the aqueous iodic(V) acid. The following results were obtained.

Titration	1	2	3	4	5
Volume of iodic(V) acid solution used / cm^3	19.20	18.60	18.70	18.55	18.55

- (i) Sodium hydroxide is described as a base. State what is meant by the term *base*.

[1]

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- (ii) The teacher said that the result of titration 1 was too high. State **one** reason why a fault in the practical method could explain this result.

[1]

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.....

- (iii) Use the results from titrations 2 to 5 to calculate the mean volume of iodic(V) acid solution and hence the concentration of the acid in mol dm^{-3} .

[3]

Concentration of iodic(V) acid = ... mol dm^{-3}

- (iv) Iodic(V) acid is an expensive material to use and a student suggested that it would be more economical if only 10.00 cm^3 of sodium hydroxide solution were used for each titration.

Suggest **one** reason why this was not done in this experiment.

[1]

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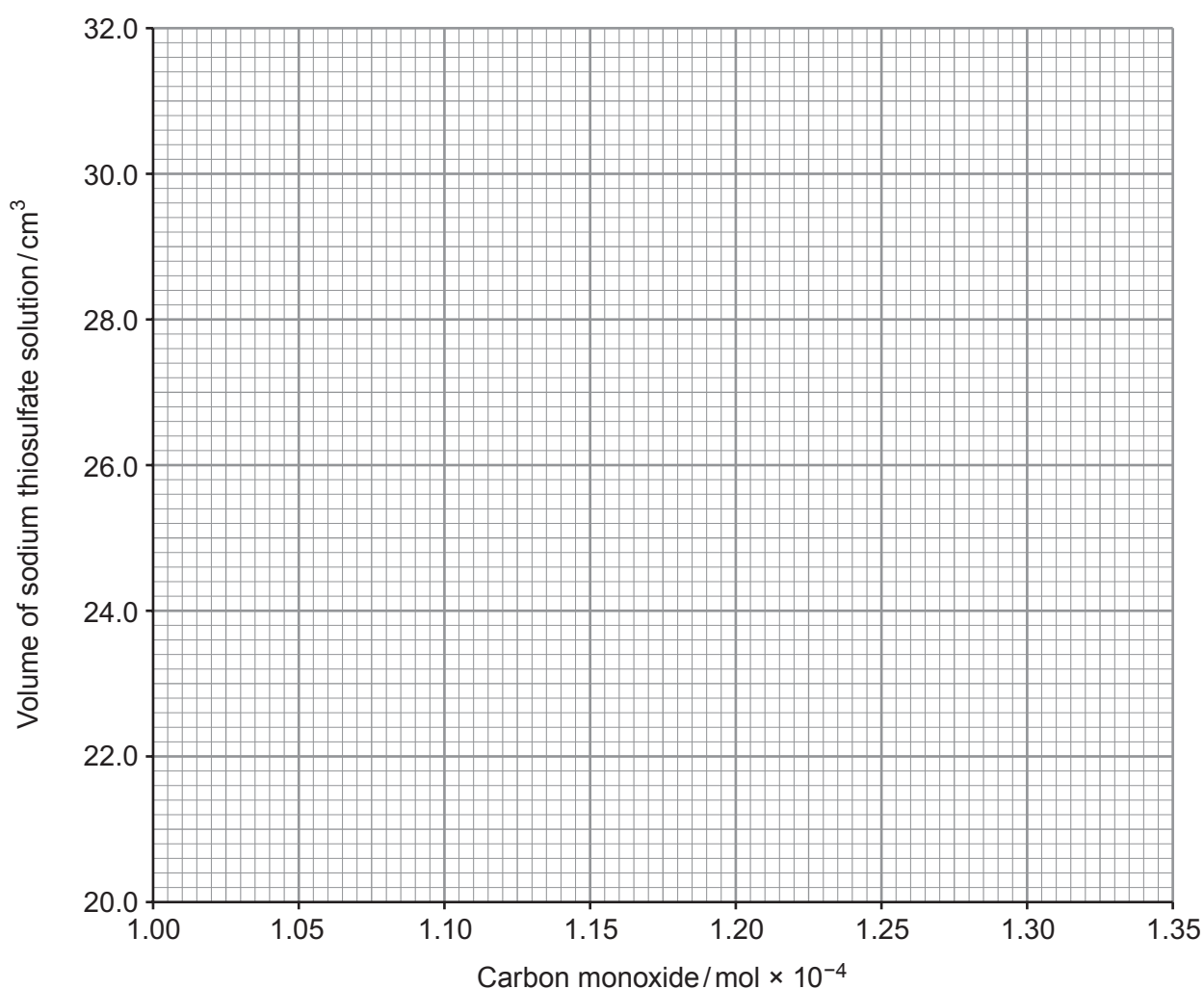
- (b) The percentage by volume of carbon monoxide in a gas mixture can be found by reacting it with an iodine compound, and titrating with sodium thiosulfate solution, from which the number of moles of carbon monoxide present can be found.

Two results obtained by this method are shown below.

Volume of sodium thiosulfate solution / cm ³	23.5	30.2
Carbon monoxide / mol $\times 10^{-4}$	1.05	1.30

- (i) Plot these two points on the grid provided and then join them with a straight line.

[1]



- (ii) In an experiment the carbon monoxide in a gas mixture of volume 300 cm^3 gave a reading of 28.40 cm^3 of sodium thiosulfate solution.

Use your graph to find the number of moles of carbon monoxide present in the gas mixture and hence calculate the percentage by volume of carbon monoxide in the gas mixture. Give your answer to **three** significant figures. [3]
[1 mol of any gas has a volume of $24\,000\text{ cm}^3$ at the conditions used]

Percentage of carbon monoxide by volume = ... %

- (c) Harmful gases from vehicle exhausts include carbon monoxide and nitrogen(II) oxide, NO. In a catalytic converter these two gases are converted to nitrogen and carbon dioxide by passing them over a mixture of platinum and rhodium metals.

Give the equation for this reaction.

[1]

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(d) Catalysts are very important in many industrial processes.

Discuss how catalysts

- increase the rate of a reaction
- affect equilibrium reactions

[4]
QWC [1]

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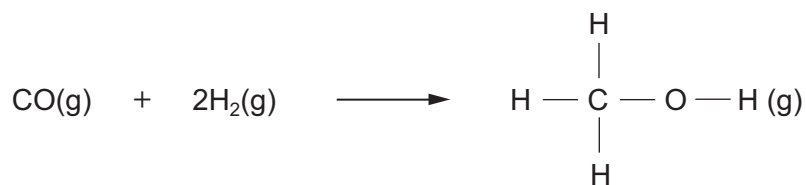
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Total [16]

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9. (a) Methanol, CH₃OH, is made from a mixture that contains carbon monoxide and hydrogen.



- (i) Use the table of average bond enthalpies to calculate the enthalpy change for this reaction. [2]

Bond	Bond enthalpy / kJ mol ⁻¹
C — O	336
C — H	413
H — H	436
O — H	464
C = O in carbon monoxide	1077

Enthalpy change = ... kJ mol⁻¹

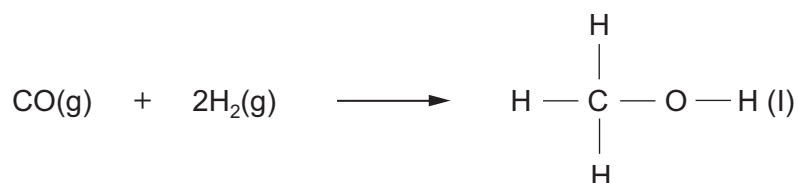
- (ii) State why the calculated value for the enthalpy change of reaction may not be the same as the literature value. [1]

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- (iii) The literature value of the enthalpy change for the reaction

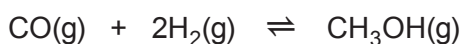


is more exothermic than the literature value for the reaction shown opposite.

State why these two values are different, explaining your answer.

[1]

- (iv) The reaction to make methanol is in dynamic equilibrium.



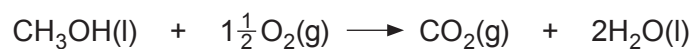
- I. State what is meant by the term *dynamic equilibrium*.

[1]

- II. Use the equation above and your answer to (i) to suggest and explain the conditions of temperature and pressure that will give the greatest yield of methanol.

[2]

- (b) The equation for the reaction that represents the enthalpy change of combustion of methanol, ΔH_c , is shown below.



- (i) Estimate the enthalpy change of combustion of methanol by using the following table, explaining how you obtained your answer. [2]

Name of alcohol	Number of carbon atoms in the alcohol	Enthalpy change of combustion / kJ mol^{-1}
butan-1-ol	4	-2678
pentan-1-ol	5	-3331
hexan-1-ol	6	-3984

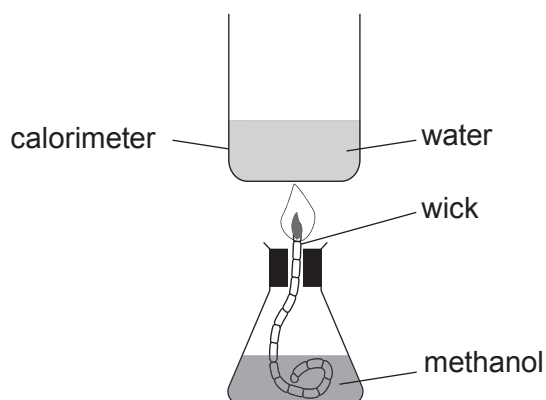
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Enthalpy change of combustion = ... kJ mol^{-1}

- (ii) Enthalpy changes of combustion can be measured directly. A student used the apparatus below to obtain the value for methanol.



The result obtained by this method is often lower than the accepted value.

Suggest **one** way in which the apparatus could be modified in order to obtain a result closer to the expected value, giving a reason for your answer. [2]

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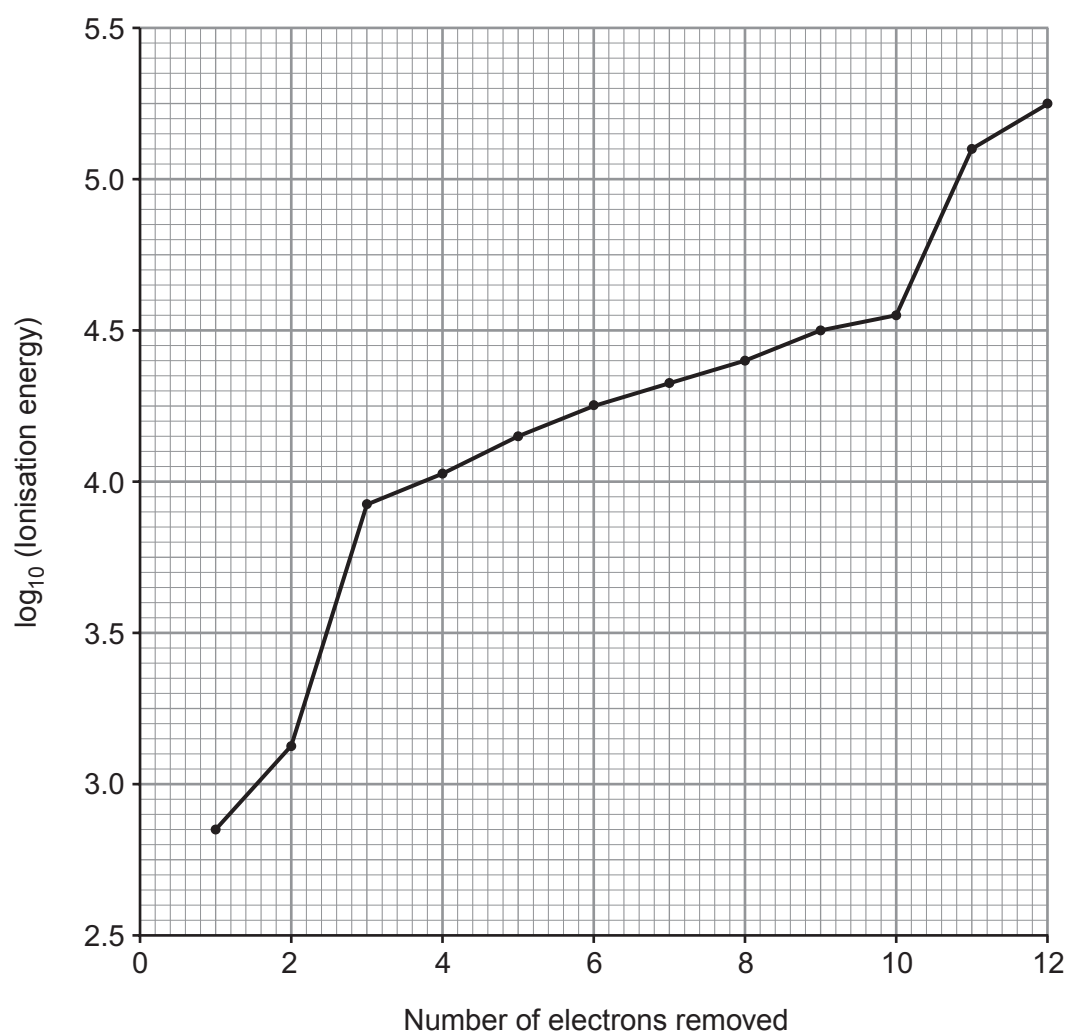
- (iii) In another experiment the enthalpy change of combustion of methanol was measured and found to be -680 kJ mol^{-1} .

Calculate the mass of methanol burned in this experiment if the energy released by burning the methanol was 18.7 kJ. [2]

Mass of methanol = ... g

Total [13]

10. (a) The graph below shows the log of the successive ionisation energies for magnesium.



Using the electron configuration for magnesium discuss how and why the values for the ionisation energies change according to the number of electrons removed.

[4]

QWC [1]

Examiner
only

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- (b) Strontium, Sr, is another metal found in Group 2 of the Periodic Table. It reacts rapidly with cold water to produce a solution of the strong base strontium hydroxide, $\text{Sr}(\text{OH})_2$, and hydrogen.



In an experiment 1.260 g of strontium gave 0.0140 mol of hydrogen gas.

- (i) Use this information to calculate the relative atomic mass of strontium in this sample. [2]

Relative atomic mass of strontium = ...

- (ii) A solution of strontium hydroxide can be used to obtain crystals of hydrated strontium hydroxide, $\text{Sr}(\text{OH})_2 \cdot x\text{H}_2\text{O}$. On heating to 100°C the water is lost giving anhydrous strontium hydroxide.



A sample of hydrated strontium hydroxide of mass 11.95 g was heated and produced 5.47 g of anhydrous strontium hydroxide (M_r 121.62).

Calculate the value of x in $\text{Sr}(\text{OH})_2 \cdot x\text{H}_2\text{O}$. [3]

$x = \dots\dots\dots$

- (iii) Use the information in the question to suggest another method that could be used to find the value of x in $\text{Sr}(\text{OH})_2 \cdot x\text{H}_2\text{O}$ and how this method could be used to produce the value of x . [3]

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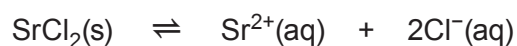
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- (c) A solution that cannot dissolve any more solute is called a saturated solution. A saturated solution of strontium chloride can be represented as an equilibrium mixture between the solid and its solution.



When hydrochloric acid is added, the clear solution of strontium chloride becomes cloudy.

Use Le Chatelier's Principle to explain the appearance of this cloudiness. [2]

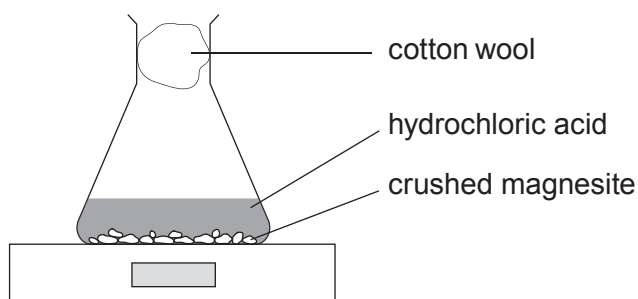
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Total [15]

11. Magnesite is a mineral that consists largely of magnesium carbonate. A sample of crushed magnesite of mass 6.72 g and an excess of dilute hydrochloric acid of concentration 2 mol dm^{-3} were placed in a conical flask on a balance.



Carbon dioxide was given off during the reaction and the loss in mass was recorded at set intervals.

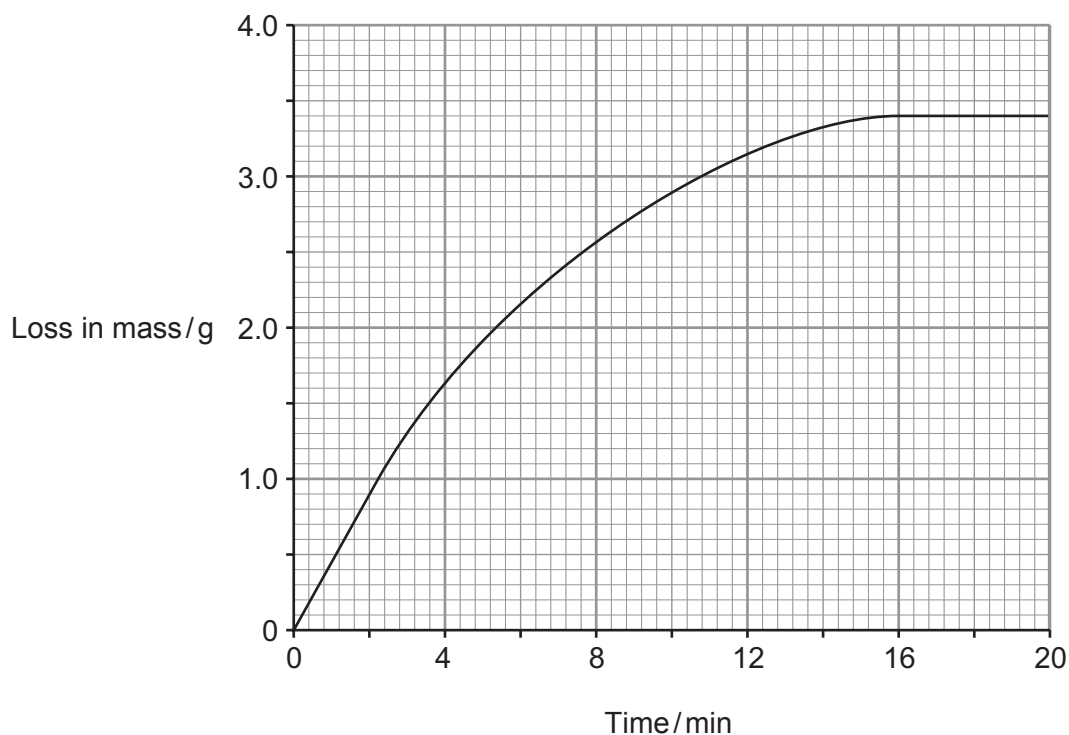
- (a) Suggest why cotton wool was placed in the neck of the flask.

[1]

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.....

(b) The results from the experiment were plotted in a graph.



- (i) Use the graph to find the time taken for half of the original mass of magnesite to react. [1]

Time = ... min

- (ii) Use the graph to calculate the initial rate of the reaction, giving its unit. [2]

Rate = ...

Unit

- (iii) Use collision theory to explain how the rate of the reaction changes during the reaction. You should consider **both** reactants in your answer. [3]

QWC [1]

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- (iv) The experiment was repeated using the same mass of magnesite but in a lump form.

Sketch on the graph (previous page) the resulting line for this experiment. [2]

- (c) In a further experiment an excess of magnesite was added to some hydrochloric acid. At the end of the reaction a neutral solution of magnesium chloride and some unreacted magnesite remained.

Outline how the pH of the mixture would change during this reaction, suggesting pH values where appropriate. [2]

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Total [12]

Section B Total [70]**END OF PAPER**



GCE AS/A level

1091/01-A – **LEGACY**



S16-1091-01A

**CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1**

A.M. FRIDAY, 27 May 2016

THE PERIODIC TABLE

Period **1** **2** **3** **4** **5** **6** **7** **0**

Group

← s Block →

1.01 H Hydrogen 1

6.94 Li Lithium 3	9.01 Be Beryllium 4
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23.0 Na Sodium 11	24.3 Mg Magnesium 12
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39.1 K Potassium 19	40.1 Ca Calcium 20
-------------------------------------	------------------------------------

85.5 Rb Rubidium 37	87.6 Sr Strontium 38
-------------------------------------	--------------------------------------

133 Cs Caesium 55	137 Ba Barium 56
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(223) Fr Francium 87	(226) Ra Radium 88
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Key	
A_r	relative atomic mass
Symbol	
Name	
Z	atomic number

d Block

45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30
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88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48
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139 La Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80
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(227) Ac Actinium 89

f Block

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
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► Lanthanoid elements

232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103
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►► Actinoid elements



GCE MARKING SCHEME

SUMMER 2016

**CHEMISTRY-CH1 (LEGACY)
1091/01**

INTRODUCTION

This marking scheme was used by WJEC for the 2016 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

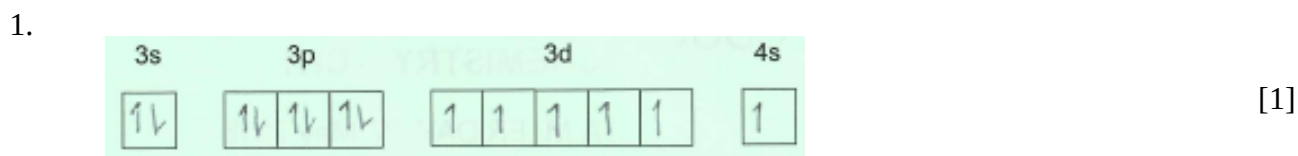
It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

GCE CHEMISTRY-CH1 (LEGACY)

SUMMER 2016 MARK SCHEME

SECTION A



2. B [1]

3. (a) ${}_{11}\text{Na}$ [1]

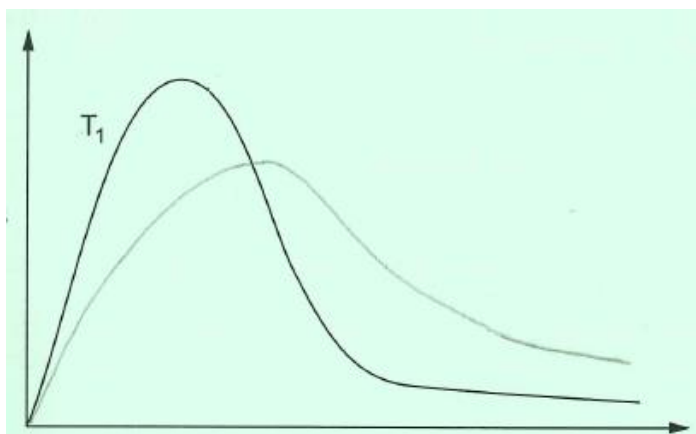
(b) 45 hours is the time of 3 half-lives and therefore $1/8$ of the mass of the radioactive isotope mass is left (1)

$$\therefore \text{original mass} = 0.15 \times 8 = 1.2 \text{ (g)} \quad (1) \quad [2]$$

4. The relative isotopic masses of the bromine atoms are
 $136 - (3 \times 19) = 79$ and $138 - (3 \times 19) = 81$ (1)

(As they have equal intensities) each is 50% of the bromine atoms present (1) [2]

5. Sketch shows a lower peak to the right of the peak for T_1 and a higher percentage of higher energy molecules.



6. (a) Temperature 298 K / 25°C
 Pressure 101.3 kPa / 1.013×10^5 Pa / 1 atmosphere [1]

(b) 100 (kJ) [1]

Total Section A [10]

SECTION B

7. (a) $\text{CH}_2\text{N}_2\text{O}_2$ [1]

(b) (i) $\Delta H_1 + \Delta H_d = \Delta H_2$

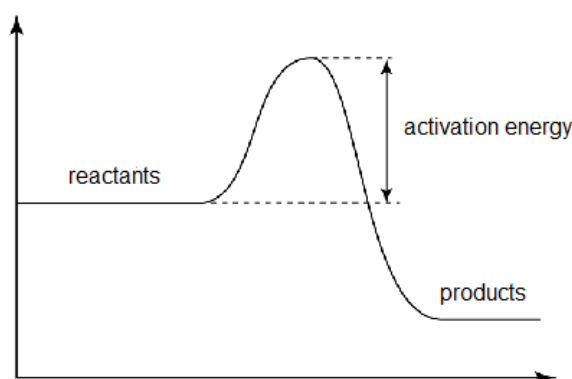
$$\therefore \Delta H_d = \Delta H_2 - \Delta H_1 \quad (1)$$

$$\Delta H_1 = +62$$

$$\Delta H_2 = (3 \times -111) + (3 \times -242) = -333 + (-726) = -1059 \quad (1)$$

$$\Delta H_d = -1059 - (+62) = -1121 \text{ (kJ mol}^{-1}\text{)} \quad (1) \quad [3]$$

(ii)



reactants / products / activation energy correctly labelled (1)

profile shown as exothermic (1)

[2]

(iii) The activation energy is the minimum energy required by molecules for them to react (1)

The lower figure for mercury fulminate suggests that it is less stable than RDX as it is easier for molecules to attain the activation energy and react (1) [2]

(c) (i) Other unwanted products / methanol / water are produced [1]

(ii) Unsafe / toxic solvent propanone / benzene used / non-renewable solvent used [1]

(d) (i) Green has the higher energy as energy is inversely proportional to wavelength / as it has the shorter wavelength [1]

(ii) Electrons are excited and absorb energy as they move to a higher energy level (1)

When they relax / return to a lower level (1)

This energy is given out as energy in the visible part of the (electromagnetic) spectrum (1) [3]

Total [14]

8. (a) (i) An acceptor of hydrogen ions / $\text{H}^+(\text{aq})$ [1]
- (ii) He overshot the endpoint / the burette was not rinsed out with the acid solution / some water remained in the burette [1]
- (iii) Mean volume of iodic(V) acid = 18.60 (1)
- Number of mol of NaOH used = $\frac{25.00 \times 0.125}{1000} = 0.003125$ (1)
- Mole ratio is 1:1
- $\therefore$ 18.60 cm^3 of the iodic(V) acid solution contain 0.003125
- $\therefore$ 1.00 dm^3 of the iodic(V) acid solution contains $\frac{0.003125 \times 1000}{18.60} = 0.168$
- Concentration of iodic(V) acid = 0.168 (mol dm^{-3}) (1) [3]
- (iv) Using only 10.00 cm^3 would lead to a titre of $\sim 7.50 \text{ cm}^3$, this is too small and likely to lead to errors in accuracy [1]
- (b) (i) Correct plots and straight line joining them [1]
- (ii) Moles of carbon monoxide from the graph = 1.235×10^{-4} (1)
- $\therefore$ Volume of carbon monoxide = $1.235 \times 10^{-4} \times 24000$
- = 2.964 / 2.97 (1)
- % of carbon monoxide in the mixture = $\frac{2.964 \times 100}{300} = 0.988$ (1) [3]
- Accept a range from the graph of 1.230 to 1.240×10^{-4} moles of CO giving a % of CO in the mixture from 0.984 to 0.992
- (c) $2\text{NO} + 2\text{CO} \rightarrow 2\text{CO}_2 + \text{N}_2$ [1]

- (d) Catalysts increase the rate of the reaction by providing an alternative pathway of lower activation energy (1)

This results in more molecules having enough energy to react / more successful collisions in a given time (1)

Although catalysts reduce the amount of time taken for a reaction to reach the position of equilibrium (1) they do not affect the position of equilibrium (1)

This is because they increase the rate of the forward and reverse reactions equally (1)

Any 4 from 5 points [4]

QWC Organisation of information clearly and coherently; use of specialist vocabulary where appropriate [1]

Total [16]

9. (a) (i) Bonds broken = 1949 Bonds made = 2039 (1)
- Enthalpy change = ΔH bonds broken – ΔH bonds made
= 1949 – 2039
= –90 (kJ mol⁻¹) (1) do not accept 90 [2]
- (ii) Bond enthalpies are an average value (and the actual value for each bond depends on its environment) / they refer to standard conditions [1]
- (iii) In this reaction methanol is produced as a liquid – it is more exothermic because **heat is given out** when a gas becomes a liquid [1]
- (iv) I A reaction where the rate of the forward reaction is equal to the rate of the reverse reaction [1]
- II High pressure is needed as there are more (gaseous) moles on the left hand side than on the right hand side – using a higher pressure will move the position of equilibrium to the right creating more methanol (1)
- The answer to (i) indicates that the reaction is exothermic – if the temperature is increased this will favour the endothermic / reverse reaction therefore a lower temperature will give a higher equilibrium yield of methanol (1)
- accept appropriate explanation if *endothermic* given in (i) [2]
- (b) (i) Each carbon (or CH₂) being oxidised gives an extra 653 (kJ mol⁻¹) evolved
∴ a loss of 3 C / CH₂ will reduce the figure by 3 × 653 = 1959 (kJ mol⁻¹) (1)
- ∴ Answer is ~ –719 (kJ mol⁻¹) (1) [2]
- (ii) Heat losses are occurring (1)
- Use a lid / conical flask / insulate the beaker / provide shielding around the burner (1) [2]
- One mark for mentioning heat loss and the other mark for a method that reduces the loss of heat
- (iii) *M_r* methanol 32.04
- 680 kJ from 32.04 g methanol (mass of 1 mol) (1)
- 1 kJ from $\frac{32.04}{680}$
- ∴ 18.7 kJ from $\frac{32.04 \times 18.7}{680} = 0.88$ (g) (1) [2]

Total [13]

10. (a) $1s^2 2s^2 2p^6 3s^2$ (1)

As successive electrons are removed the value of the ionisation energy increases due to electrons being removed from an increasingly positive charged ion / greater effective nuclear charge (1)

The large increase in value between 2 and 3 is due to removal of an electron from the 2p subshell which is closer to the nucleus (1)

There is also a large difference in the figures between electrons 10 and 11 where an electron is being removed from the 1s energy level, which is closest to the nucleus (1)

Credit correct reference to changes in 'shielding' for (1)

Any 4 from 5 points [4]

QWC *Selection of a form and style of writing appropriate to purpose and to complex subject matter* [1]

- (b) (i) Mole ratio 1 : 1
1 mol H_2 from 1 mol Sr (1)

$$\therefore 0.0140 \text{ mol } H_2 \text{ from } 0.0140 \text{ mol Sr}$$

$$\therefore A_r \text{ of strontium} = \frac{1.26}{0.0140} = 90.0 \text{ (1)}$$

[2]

- (ii) Mass of water must be $11.95 - 5.47 = 6.48$ (1)

$$\text{Moles of water} = \frac{6.48}{18.02} = 0.360$$

$$\text{Moles of } Sr(OH)_2 = \frac{5.47}{121.62} = 0.045 \text{ (1)}$$

Ratio 8 : 1

$$\therefore x = 8 \text{ (1)}$$

[3]

- (iii) Titration of a known mass of strontium hydroxide with a standard solution of hydrochloric acid (1) accept 'acid'

Hence finding the M_r of $Sr(OH)_2 \cdot xH_2O$ (1) and then the value of x by subtraction of the M_r of $Sr(OH)_2$ from the M_r of $Sr(OH)_2 \cdot xH_2O$ (1)

[3]

- (c) Addition of chloride ions from the acid causes the position of equilibrium to move to the left as solid strontium chloride is precipitated from solution (1)

This occurs because of the need to restore the position of equilibrium (according to Le Chatelier's principle) (1)

[2]

Total [15]

11. (a) To stop mass loss due to solution / acid spray / to only let carbon dioxide out [1]
- (b) (i) 4.4 (minutes) [1]
- (ii) Accept values from 0.44 to 0.46 inclusive (1)
- g min⁻¹ (1) [2]
- (iii) As the reaction proceeds the concentration of hydrogen ions decreases (1)
- As a result the rate of successful collisions between H⁺ / MgCO₃ becomes less (1)
- In addition the surface area of the MgCO₃ reduces (as it reacts to become aqueous Mg²⁺ ions) (1)
- [3]
- QWC Legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning* [1]
- (iv) New line shows a shallower curve (1)
- Finishes with the same loss in mass at time > 16 minutes
or
Loss in mass still rising but less than 3.4 at 20 minutes (1) [2]
- (c) pH value increases from ~ 1-2 to 7 (2)
- pH value increases (1) [2]
- Total [12]
- Total Section B [70]**

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1091/01



S15-1091-01

CHEMISTRY – CH1

A.M. FRIDAY, 22 May 2015

1 hour 30 minutes

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
- copy of the **Periodic Table** supplied by WJEC.
Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

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

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

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The **QWC** label alongside particular part-questions indicates those where the Quality of Written Communication is assessed.

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

Section A

Section B

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1. to 4.	10	
5.	11	
6.	12	
7.	14	
8.	19	
9.	14	
Total	80	

1091
010001



MAY1510910101

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

1. Complete the table below to show the composition of the following species. [2]

Species	Protons	Neutrons	Electrons
$^{20}_{10}\text{Ne}$			
$^{18}_8\text{O}^{2-}$			

2. The isotope ^{226}Ra is radioactive. It decays by α -emission and has a half-life of 1 600 years.

- (a) Give the mass number and symbol of the species formed by the loss of one α -particle from an atom of ^{226}Ra . [1]

.....

- (b) State what is meant by the term *half-life*. [1]

.....

.....

- (c) A sample of ^{226}Ra , of initial mass 1.00 g, decays for 3 200 years. Calculate the number of **moles** of ^{226}Ra left after this period. [2]

Number of moles = ... mol



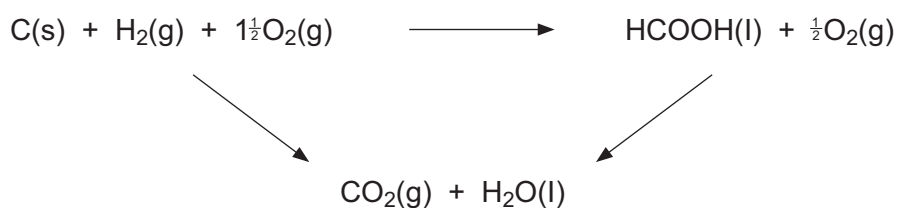
3. Methanoic acid is the simplest carboxylic acid and occurs naturally, most notably in ant venom. It has a molar mass of 46.02 g mol^{-1} .

(a) State what is meant by *molar mass*.

[1]

- (b) Use the values in the table below to calculate the enthalpy change of formation for methanoic acid.

[1]



Substance	Enthalpy change of combustion, $\Delta H_c^\theta / \text{kJ mol}^{-1}$
C	-394
H ₂	-286
HCOOH	-263

$\Delta H_f^\theta = \dots\dots\dots \text{kJ mol}^{-1}$



4. A sample of 0.50g of calcium carbonate completely reacts with 50 cm³ of hydrochloric acid solution of concentration 2.0 mol dm⁻³ to give calcium chloride, carbon dioxide and water.

(a) Suggest a method for measuring the rate of this reaction. [1]

.....

.....

(b) State, giving a reason, what effect using 100 cm³ of hydrochloric acid solution of concentration 2.0 mol dm⁻³ would have on the initial rate of this reaction. [1]

.....

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Section A Total [10]



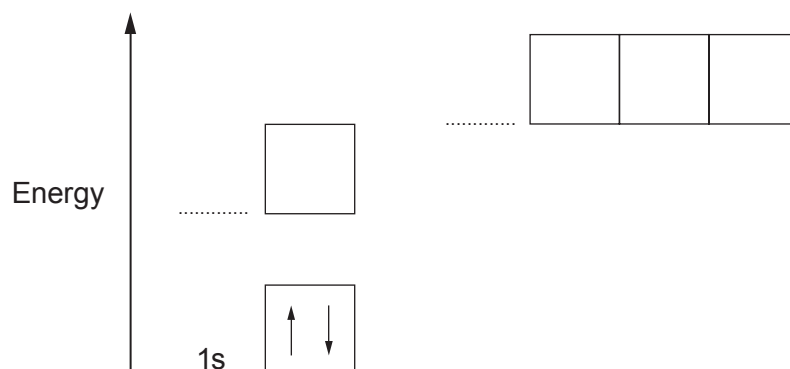
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SECTION B*Answer all questions in the spaces provided.*

5. (a) Electrons are arranged in energy levels. The diagram below shows two electrons in the 1s level in a nitrogen atom.



Complete the diagram for the electrons in a nitrogen atom by labelling the sub-shell levels and showing how the electrons are arranged. [2]

- (b) Nitrogen forms several oxides.

- (i) An oxide of nitrogen contains 25.9% by mass of nitrogen. Calculate the empirical formula of this oxide. [2]

Empirical formula

- (ii) Dinitrogen oxide is formed when ammonia is oxidised.



Balance the equation above.

[1]



- (iii) Nitrogen dioxide is formed when calcium nitrate decomposes.



Calculate the total volume of gas, measured at room temperature and pressure, which would be produced when 0.886 g of calcium nitrate decomposes. [3]

[1 mol of gas occupies 24.0 dm³ at room temperature and pressure]

Volume = ... dm³

- (c) Hydrated calcium nitrate can be represented by the formula $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$.

A 6.04 g sample of $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$ contains 1.84 g of water of crystallisation.

Calculate the value of x in $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$. You **must** show your working. [3]

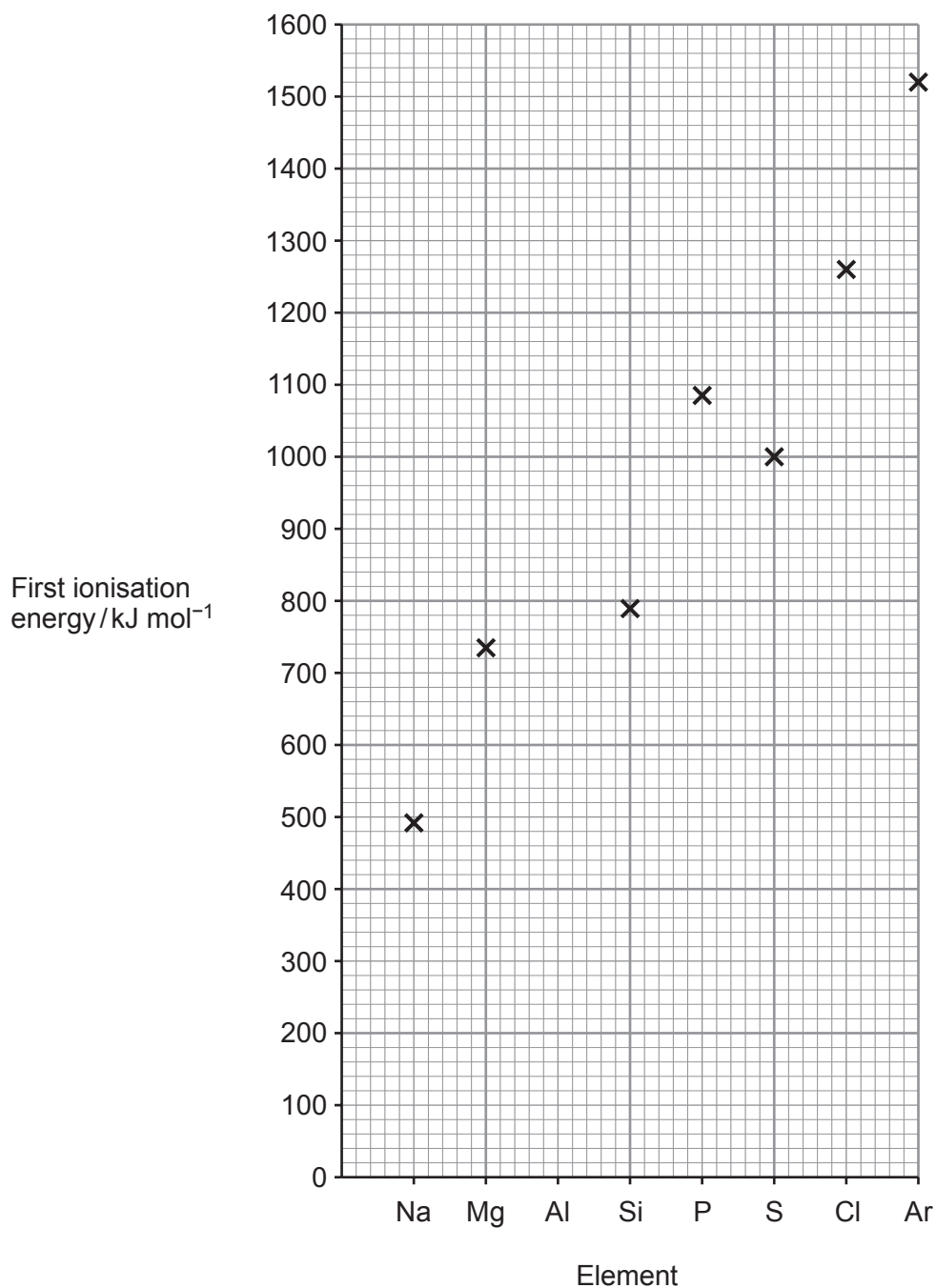
$x =$

Total [11]



6. Ionisation energies and atomic spectra provide evidence for the arrangement of electrons in atoms.

(a) The following diagram shows the first ionisation energies of the Period 3 elements.



- (i) State the meaning of the term *molar first ionisation energy*. [2]

.....

.....

.....

- (ii) Draw a cross on the diagram to suggest the first ionisation energy of aluminium. [1]

- (iii) Explain why the value of the first ionisation energy of sulfur is less than that of phosphorus. [2]

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- (b) The table below gives some ionisation energies for magnesium.

	1st	2nd	3rd	4th	5th
Ionisation energy / kJ mol ⁻¹	736	1450		10 500	13 629

- (i) Explain why the second ionisation energy is greater than the first. [1]

.....

.....

.....

- (ii) Complete the table by suggesting a value for the third ionisation energy of magnesium. [1]



- (c) Explain briefly how the lines in the visible atomic emission spectrum of hydrogen are formed and why the lines become closer together at the high frequency end of the spectrum.

[4]

QWC [1]

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Total [12]



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7. (a) Lithium was discovered in 1817 by the Swedish chemist Johan August Arfwedson. Its name derives from the Greek word *lithos*, meaning 'stone', to reflect its discovery in a solid mineral, as opposed to potassium, which had been isolated from plant ashes 10 years earlier. Naturally occurring lithium is composed of two stable isotopes – ${}^6\text{Li}$ and ${}^7\text{Li}$.

In a mass spectrometer, a sample of lithium must be ionised before it can be analysed.

- (i) Describe how vaporised atoms of Li are converted into Li^+ ions in a mass spectrometer. [2]

.....

.....

.....

- (ii) Suggest why no more than the minimum energy is used to ionise the sample of lithium. [1]

.....

.....

- (iii) State the difference, if any, between the chemical properties of the isotopes ${}^6\text{Li}$ and ${}^7\text{Li}$, giving a reason for your answer. [2]

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- (b) The mass spectrum of a naturally occurring sample of lithium gave the following results.

Isotope	% abundance
${}^6\text{Li}$	7.25
${}^7\text{Li}$	92.75

These results can be used to determine the relative atomic mass of the lithium sample.

- (i) Calculate the relative atomic mass of the sample. [2]

Relative atomic mass = ...



- (ii) State and explain which of the Li^+ ions formed from the isotopes of Li will be deflected more in a mass spectrometer. [1]

.....

.....

- (c) Lithium hydroxide reacts with ammonium sulfate to form ammonia, lithium sulfate and water as shown in the equation below.



A 2.06 g sample of ammonium sulfate reacted exactly with 29.80 cm^3 of a lithium hydroxide solution.

- (i) Calculate the amount, in moles, of $(\text{NH}_4)_2\text{SO}_4$ in 2.06 g of ammonium sulfate. Give your answer to **three** significant figures. [2]

Number of moles = ... mol

- (ii) Calculate the concentration, in mol dm^{-3} , of the lithium hydroxide solution used. [2]

Concentration = ... mol dm^{-3}

- (iii) Calculate the percentage atom economy for the production of ammonia in the reaction between ammonium sulfate and lithium hydroxide. [2]

Atom economy = ... %

Total [14]



8. (a) Planners have to ensure a secure supply of energy in the future. It has been suggested that the use of fossil fuels should be reduced, the use of renewable energy increased and that energy efficiency should be greatly improved.

By considering both the benefits and the difficulties involved, discuss whether you think that these suggestions are realistic.

[4]
QWC [1]

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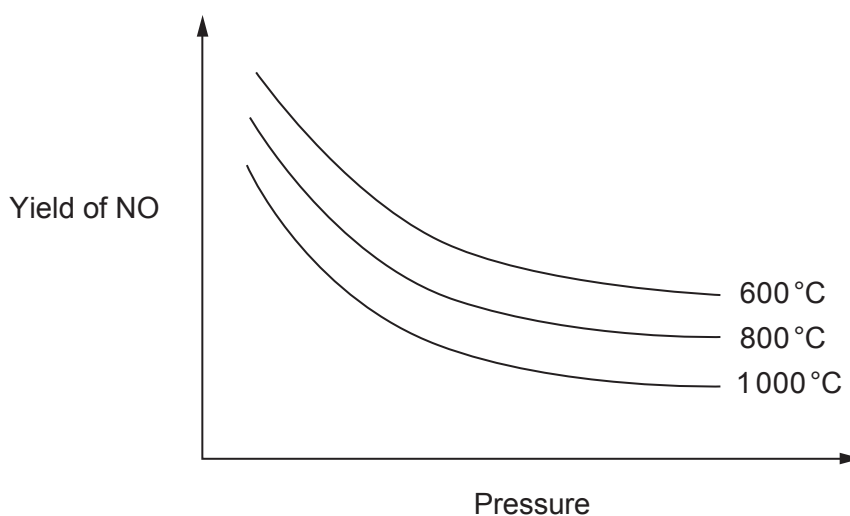
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- (b) Nitric acid is produced by the Ostwald process.

The first stage involves the oxidation of ammonia over a platinum/rhodium catalyst.



The graph below shows how the yield of nitric oxide, NO, depends on the temperature and pressure used in its production.



- (i) I. State the general variations in this yield with temperature and pressure. [1]

.....

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- II. Use the graphs to explain whether the reaction is endothermic or exothermic and whether there are more moles of gaseous products than reactants. [4]
QWC [1]

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- (ii) Normally the process is carried out at a temperature of around 900 °C. Suggest why this temperature is used. [2]

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- (iii) State the **type** of catalyst used. [1]

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- (iv) Explain why there has been much research to find a better catalyst. [2]

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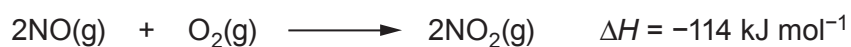
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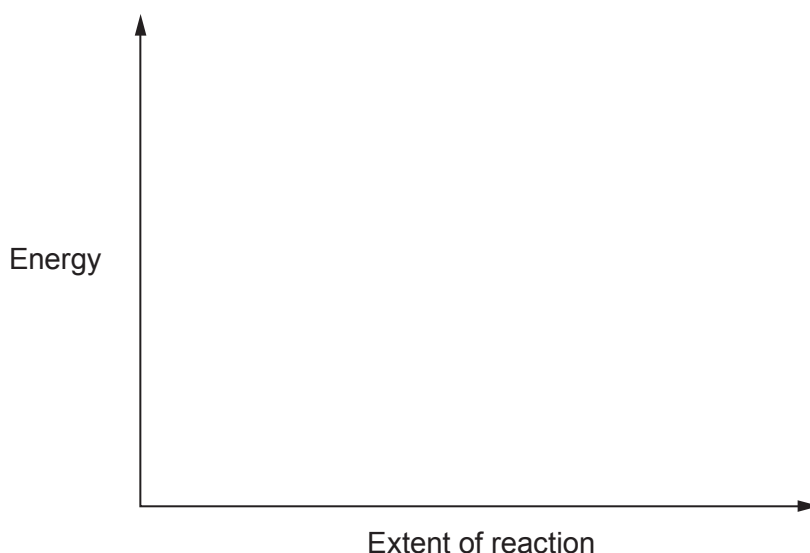
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- (v) The next stage in the Ostwald process is to convert the nitric oxide to nitrogen dioxide.



Sketch on the axes below the energy profile for this reaction, clearly labelling the enthalpy change of reaction, ΔH . [2]



- (vi) Write an expression that connects the enthalpy change of a reaction, ΔH , with the activation energies of the forward (E_f) and reverse (E_b) reactions. [1]

.....

Total [19]

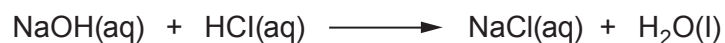


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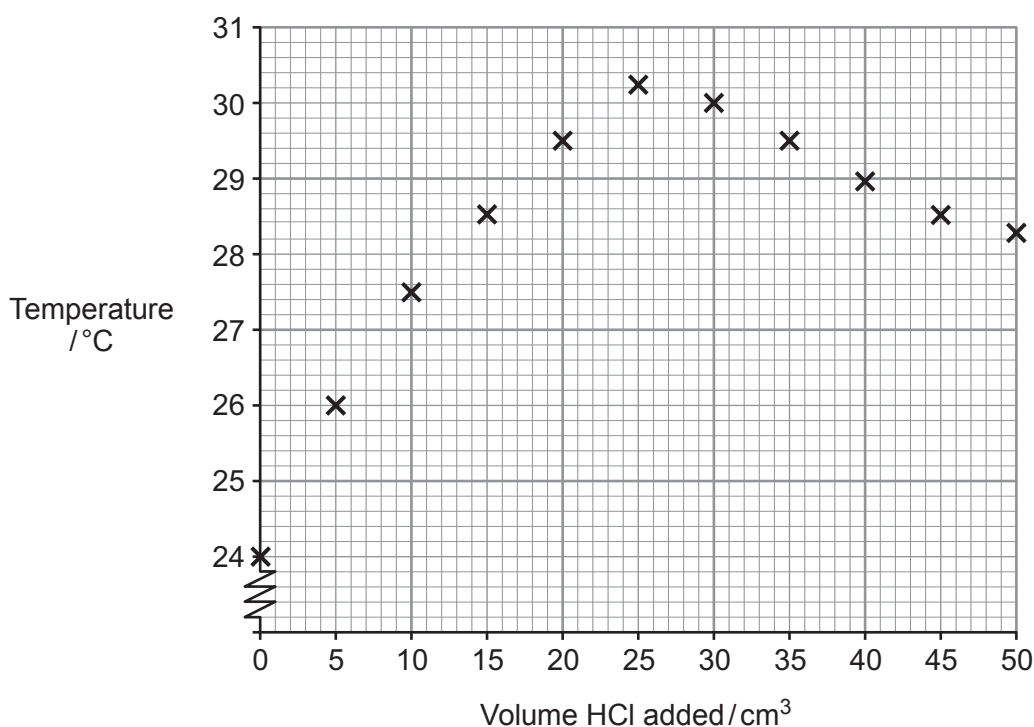
9. Zac was asked to measure the molar enthalpy change of neutralisation of sodium hydroxide by hydrochloric acid.



He was told to use the following method:

- Measure 25.0 cm^3 of sodium hydroxide solution of concentration 0.970 mol dm^{-3} into a polystyrene cup.
- Measure the temperature of the solution.
- Place the hydrochloric acid solution into a suitable container and measure the temperature of the solution.
- When the temperatures of both solutions are equal add 5.00 cm^3 of hydrochloric acid to the sodium hydroxide and stir.
- Measure the temperature of the mixture.
- Keep adding 5.00 cm^3 portions of hydrochloric acid, until 50.0 cm^3 have been added, stirring and measuring the temperature each time.

Zac's results are shown on the graph below.



- (a) Suggest why it is important that the hydrochloric acid and the sodium hydroxide are at the same temperature. [1]

.....

.....

- (b) By drawing lines of best fit for both sets of points determine:

- (i) the maximum temperature **change** [2]

Maximum temperature rise from the graph = ... °C

- (ii) the volume of acid required to neutralise the sodium hydroxide. [1]

Volume of acid = ... cm³

- (c) Use your value from part (b)(ii) to calculate the concentration, in mol dm⁻³, of the hydrochloric acid solution. [2]

Concentration = ... mol dm⁻³

- (d) Use **both** values from part (b) to calculate the heat given out during **this** experiment.

[Assume that the density of the solution is 1.00 g cm⁻³ and that its specific heat capacity is 4.18 J K⁻¹ g⁻¹] [1]

Heat given out = ... J

- (e) Calculate the molar enthalpy change, ΔH , for the reaction between sodium hydroxide and hydrochloric acid. [2]

ΔH = ... kJ mol⁻¹



- (f) Name a piece of apparatus that Zac could use to measure exactly 25.0 cm^3 of the sodium hydroxide solution. [1]

.....

- (g) Explain why the temperature falls on continuing to add hydrochloric acid **after** the maximum temperature has been reached. [2]

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.....

.....

- (h) The data book value for this molar enthalpy change of neutralisation is more exothermic than Zac's value.

State the **main** reason for the difference between the values and suggest **one** change that would improve his result. [2]

.....

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.....

.....

Total [14]

Section B Total [70]

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GCE AS/A level

1091/01-A



S15-1091-01A

**CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1**

A.M. FRIDAY, 22 May 2015

THE PERIODIC TABLE

1

2

3

4

5

6

7

0

Group

Period
← s Block

1.01 H Hydrogen 1

1

6.94 Li Lithium 3	9.01 Be Beryllium 4
----------------------------	------------------------------

2

23.0 Na Sodium 11	24.3 Mg Magnesium 12
----------------------------	-------------------------------

3

39.1 K Potassium 19	40.1 Ca Calcium 20
------------------------------	-----------------------------

4

85.5 Rb Rubidium 37	87.6 Sr Strontium 38
------------------------------	-------------------------------

5

133 Cs Caesium 55	137 Ba Barium 56
----------------------------	---------------------------

6

(223) Fr Francium 87	(226) Ra Radium 88
-------------------------------	-----------------------------

7

Key			
A_r	Symbol	Name	Z
relative atomic mass		atomic number	

p Block

10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86

d Block

47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30
47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30
91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48
179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80

f Block

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
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► Lanthanoid elements

232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103
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►► Actinoid elements



GCE MARKING SCHEME

CHEMISTRY
AS/Advanced

SUMMER 2015

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2015 examination in GCE CHEMISTRY. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

	Page
CH1	1
CH2	7
CH4	13
CH5	20

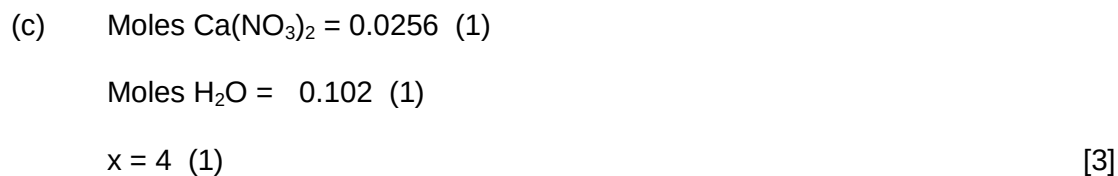
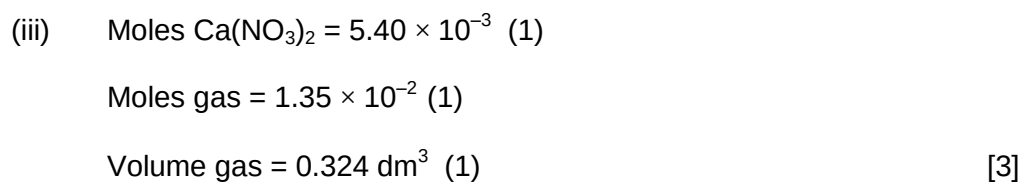
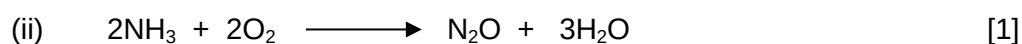
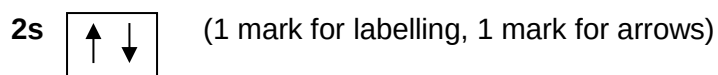
CH1

SECTION A

1. Ne 10p, 10n, 10e (1)
O²⁻ 8p, 10n, 10e (1) [2]
2. (a) ²²²Rn [1]
(b) Time taken for half of the atoms in a radioisotope to decay (or similar) [1]
(c) Mass = 0.25 g (1)
Moles = 1.11×10^{-3} (1) do not accept 1×10^{-3} [2]
3. (a) The mass of one mole of compound [1]
(b) $\Delta H_f = -417 \text{ kJ mol}^{-1}$ [1]
4. (a) Measure the volume of CO₂ produced / mass of CO₂ lost at constant time intervals [1]
(b) No effect since concentration of acid has not changed [1]

Total Section A [10]

SECTION B



Total [11]

6. (a) (i) Energy required to remove one mole of electrons from one mole of atoms / to form one mole of positive ions from one mole of atoms (1)
in the gaseous state (to form 1 mol of gaseous ions) (1)
(Accept correct equation) [2]
- (ii) Cross between Na and Mg crosses [1]
- (iii) P only has unpaired electrons, S has a pair of electrons in 3p orbital (1)
Repulsion between the paired electrons makes it easier to remove one of the electrons (1) [2]
- (b) (i) Effective nuclear charge is greater / electron being removed from a positive ion [1]
- (ii) Accept from 6000 to 9000 [1]
- (c) Lines are formed from electron being excited and jumping up to a higher energy level (1)
Falling back down to the $n = 2$ level (1)
Emitting energy / photon of light (1)
Lines become closer since the electron energy levels of a hydrogen atom become closer (1) [4]
- QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter [1]

Total [12]

7. (a) (i) Sample is bombarded by high energy electrons / electron gun used on sample (1)
Electron knocked out (to form ions) (1) [2]
- (ii) So no more than / only 1 electron is knocked out [1]
- (iii) No difference (1)
Same number of electrons (in the outer shell) (1) [2]
- (b) (i) $\frac{(7.25 \times 6) + (92.75 \times 7)}{100}$ (1)
6.928 (1) (accept 6.93) [2]
- (ii) ${}^6\text{Li}^+$ since lower mass / lower m/z / lighter
do not accept 'smaller' [1]
- (c) (i) $M_r(\text{NH}_4)_2\text{SO}_4 = 132.18$ (1)
Moles = 0.0156 (1) [2]
- (ii) Moles LiOH = 0.0312 (1)
Concentration = $\frac{0.0312}{0.0298} = 1.05 \text{ mol dm}^{-3}$ (1) [2]
- (iii) Atom economy = $\frac{34.06}{180.08} \times 100$ (1)
= 18.9 % (1) [2]

Total [14]

8. (a) Benefits:
 Stops fossil fuels from running out
 Reduces CO₂ emissions / greenhouse emissions / global warming / effect of global warming
 Reduces SO₂ emissions / acid rain
 There will be an investment in new technology

Difficulties:

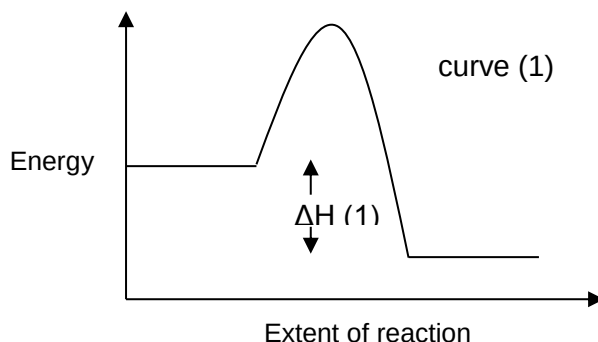
Dependence on fossil fuel/Unlikely to meet current demand
 Renewable energy currently more expensive
 Reliability of supply from renewables
 Major development in energy efficiency technologies required
 Opposition by vested interests
 (Maximum 3 marks from list, but need examples of both) (3)

Consideration and discussion of benefits/difficulties (1) [4]

QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning [1]

- (b) (i) I As temperature increases yield decreases
 As pressure increases yield decreases [1]
- II As temperature is increased, equilibrium moves to the left (1)
 Therefore forward reaction is exothermic (1)
 As pressure is increased, equilibrium moves to the left (1)
 Therefore more gas moles in products (1) [4]
 QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]
- (ii) If temperature is too low, then reaction is too slow (1)
 If temperature is too high, yield is too low (1)
 Compromise temperature – acceptable rate and yield (1)
 (Accept any two points) [2]
- (iii) Heterogenous catalyst [1]
- (iv) Lower temperatures could be used (1)
 Less energy consumption / increased yield (1)
 Equilibrium could be reached more quickly (1)
 (Accept any two points) [2]

(v)



[2]

- (vi) $\Delta H = E_f - E_b$ [1]

Total [19]

9. (a) Otherwise a temperature change would occur on adding the acid which had nothing to do with the reaction [1]
- (b) (i) Best fit lines (1)
 Temperature rise = 6.4°C (1)
 (Take value from candidate's best fit lines) [2]
- (ii) Volume of acid = 26.0 cm^3 [1]
 [If no best fit lines award 0 in (i) and accept 25 cm^3 in (ii)]
- (c) Moles acid = 0.02425 (1)
 Conc acid = $\frac{0.02425}{0.026} = 0.933\text{ mol dm}^{-3}$ (1) [2]
- (d) Heat = $51 \times 4.18 \times 6.4$
 = 1364 J [1]
- (e) $\Delta H = \frac{-1364}{0.02425}$ (1)
 = -56.2 kJ mol^{-1} (1) [2]
- (f) Pipette / burette [1]
- (g) No further reaction occurs (1)
 The excess acid cools the solution (1) [2]
- (h) Heat / energy is lost to the environment (1)
 Insulation is improved e.g. lid on the polystyrene cup (1) [2]

Total [14]

Section B Total [70]

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1091/01

CHEMISTRY – CH1

A.M. FRIDAY, 23 May 2014

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
Section A 1. to 7.	10	
Section B 8.	14	
9.	11	
10.	14	
11.	17	
12.	14	
Total	80	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
- copy of the **Periodic Table** supplied by WJEC.
Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

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

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

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The **QWC** label alongside particular part-questions indicates those where the Quality of Written Communication is assessed.

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.



M A Y 1 4 1 0 9 1 0 1 0 1

STEMUP.CO.UK

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

1. Complete the electronic structure for the sulfide ion present in Na_2S . [1]

$1s^2$

2. Which isotope is the standard used in defining relative atomic masses? [1]

.....

3. State **one** example of an industrially or environmentally important heterogeneous catalyst. You should identify the reaction catalysed and name the catalyst. [1]

.....

.....

4. Hydrated sodium carbonate has the formula $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$.

- (a) Calculate the relative molecular mass (M_r) of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$. [1]

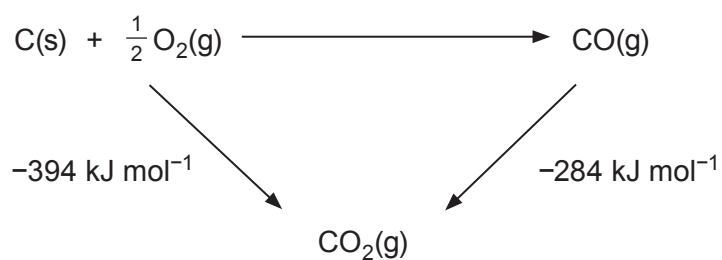
$M_r =$

- (b) Calculate the mass of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ needed to make 250cm^3 of a 0.10 mol dm^{-3} solution. [1]

Mass = ... g

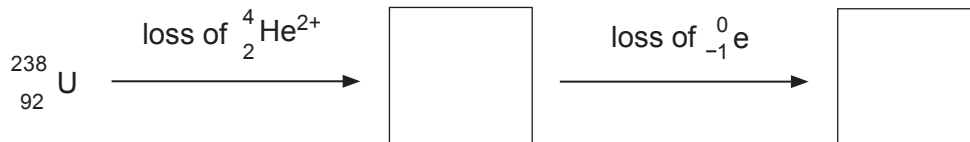


5. Use the energy cycle to calculate the enthalpy change of formation of carbon monoxide. [1]



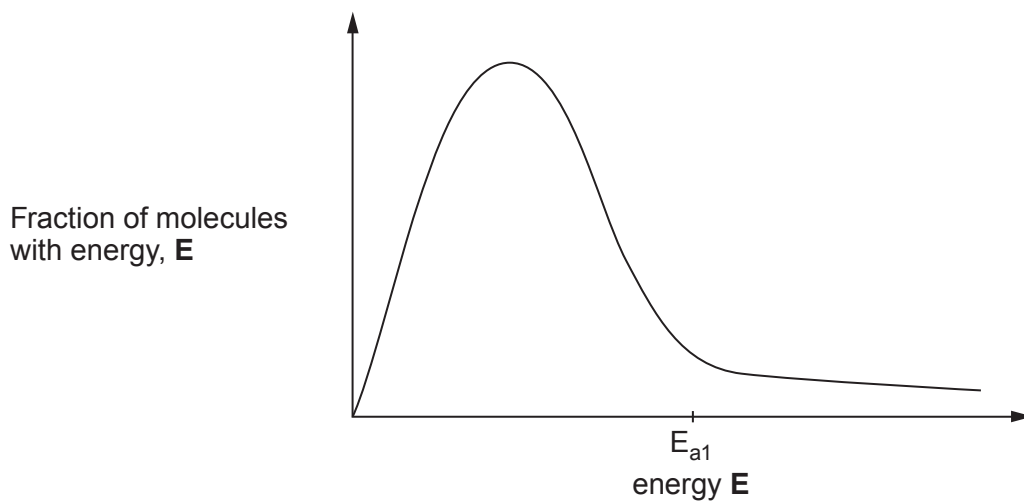
Enthalpy change of formation = ... kJ mol⁻¹

6. Complete the equation to show the two-stage process by which a radioactive isotope of uranium decays. [2]

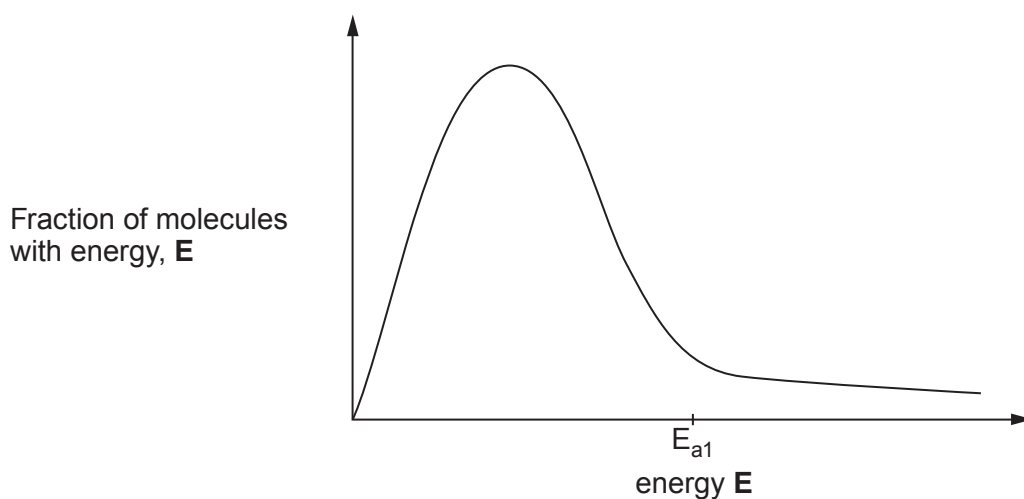


7. The diagrams show the energy distribution curve for gaseous molecules at a fixed temperature.

- (a) On the diagram below, E_{a1} shows the activation energy of a particular reaction without a catalyst. Indicate on the diagram the fraction of molecules that react. [1]



- (b) Indicate on the diagram below the activation energy, E_{a2} , and the fraction of molecules that react when the reaction proceeds with a catalyst. [1]



Section A Total [10]



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SECTION B

Answer all questions in the spaces provided.

8. (a) Hydrogen exists as three isotopes with relative masses of 1, 2 and 3.

State the similarities and differences in the composition of these specific isotopes. [2]

.....

.....

.....

- (b) The first two electronic energy levels in a hydrogen atom are shown on the diagram.

_____ $n = \infty$

_____ $n = 2$

_____ $n = 1$

- (i) Complete the diagram to show energy levels $n = 3$, $n = 4$ and $n = 5$. [1]
- (ii) Mark with an arrow the energy change corresponding to the ionisation energy of hydrogen. [2]



- (c) A student said that the ionisation energy of hydrogen could be calculated using the Balmer Series of lines.

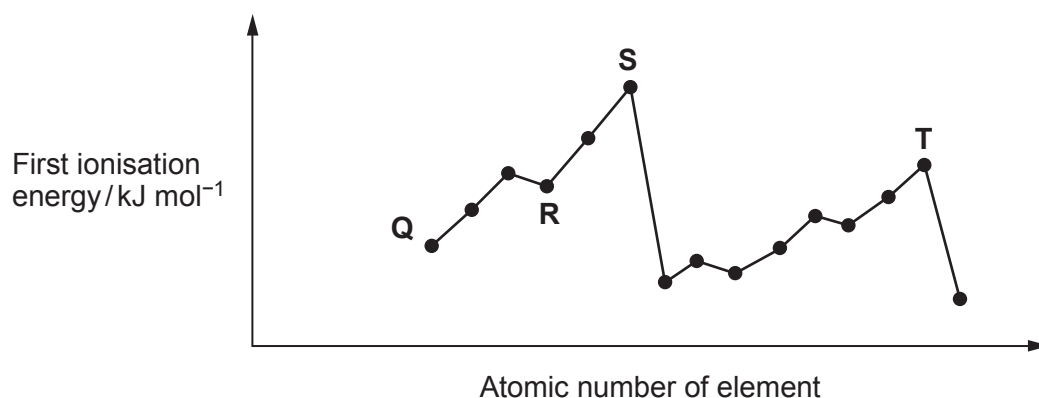
(i) In which part of the electromagnetic spectrum does the Balmer Series appear? [1]

.....

(ii) Explain whether or not this student was correct. [2]

.....

- (d) The diagram shows part of a plot of the first ionisation energy of elements against their atomic numbers. Letters **Q–T** do **not** represent the symbols of the elements.



(i) Write the equation for the change occurring for the first ionisation energy of element **Q**. [1]

.....

(ii) In which group of the Periodic Table is element **R** found? [1]

.....

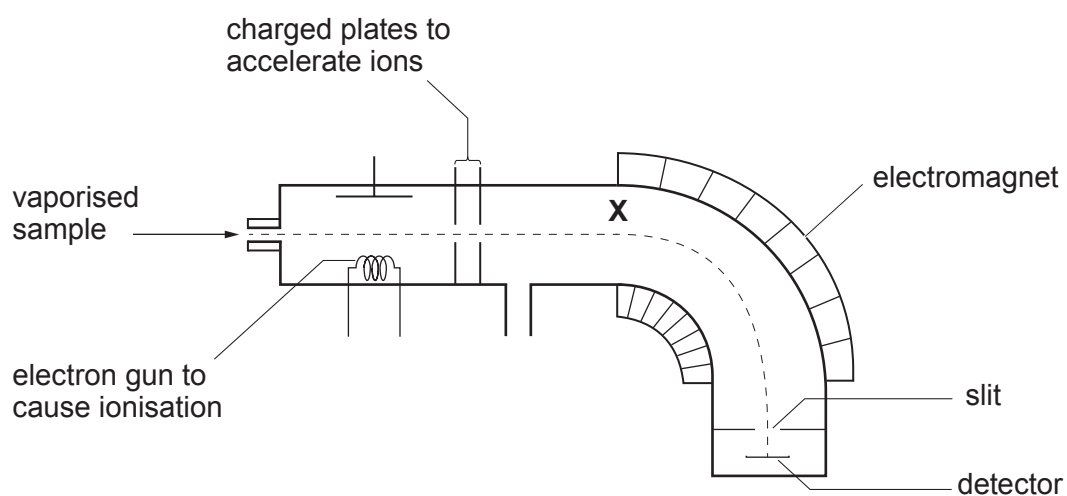
(iii) Explain why the first ionisation energy of **S** is greater than that of **T**. [3]
 QWC [1]

.....

Total [14]



9. The diagram shows the principal parts in one type of mass spectrometer.



- (a) (i) The line labelled **X** shows the path of ion **X** passing through the slit and being detected.

Ion **Y** has a higher mass to charge ratio than ion **X**. Draw a line on the diagram to show the path of ion **Y**. [1]

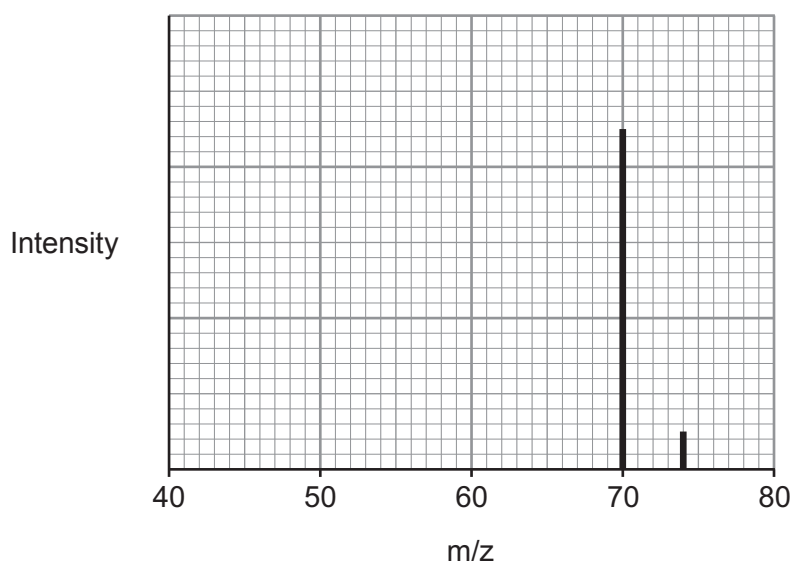
- (ii) Without altering the shape of the mass spectrometer, what change could be made to allow ion **Y**, with its higher mass to charge ratio, to pass through the slit and be detected? [1]

.....

.....



- (b) The diagram shows an incomplete mass spectrum for a sample of chlorine, Cl_2 .



- (i) What ion is responsible for the peak at $m/z = 74$? [2]
- (ii) Draw on the spectrum another peak that you would expect to see. You should show the mass to charge ratio at which you would see the peak **and** the height of the peak. [2]
- (c) A compound **Z** contains only carbon, hydrogen and chlorine. It is analysed and found to contain 10.04 % carbon and 89.12 % chlorine by mass.
- (i) Find the empirical formula of compound **Z**. [3]

Empirical formula

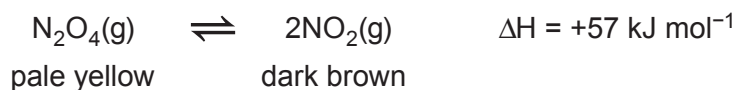
- (ii) What other information would you need to decide whether this empirical formula is also the molecular formula of **Z**? [1]

- (iii) What feature of a mass spectrum gives the information needed in part (ii)? [1]

Total [11]



10. The decomposition of dinitrogen(IV) oxide into nitrogen(IV) oxide is a reversible reaction that establishes a dynamic equilibrium.



- (a) State the meaning of the term *dynamic equilibrium*. [1]

.....

.....

- (b) The conditions applied to an equilibrium mixture of dinitrogen(IV) oxide and nitrogen(IV) oxide were changed. For each of the following, state what was **seen** and explain any change that occurred. [5]

Temperature increased

.....

.....

.....

Pressure increased

.....

.....

.....

A catalyst was added

.....

.....



- (c) Hydrazine, N_2H_4 , is an unstable liquid that decomposes according to the following equation.



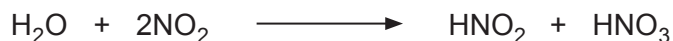
- (i) Calculate the volume of gas that could be obtained from 14 kg of hydrazine. Assume that the volume of 1 mol of gas is 24.0 dm^3 . [3]

Volume of gas = ... dm^3

- (ii) One use of hydrazine is as a fuel in rockets. Apart from any energy changes, state **one** feature of this reaction that suggests it would be useful in rocket propulsion. [1]

.....

- (d) Nitrogen (IV) oxide reacts with water.



Both nitric(III) acid, HNO_2 , and nitric(V) acid, HNO_3 , are described as being acids.

- (i) Define an *acid*. [1]

- (ii) Complete the equation to show nitric(III) acid behaving as an acid. [1]



- (iii) When concentrated nitric(V) acid is mixed with concentrated sulfuric acid the reaction shown below occurs.



- Explain this reaction in terms of acid-base behaviour. [2]

.....

Total [14]

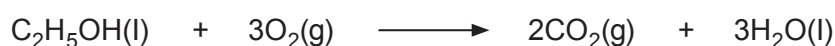


11. (a) Ethanol, $\text{C}_2\text{H}_5\text{OH}$, is a liquid at room temperature. It is being increasingly used as a fuel.

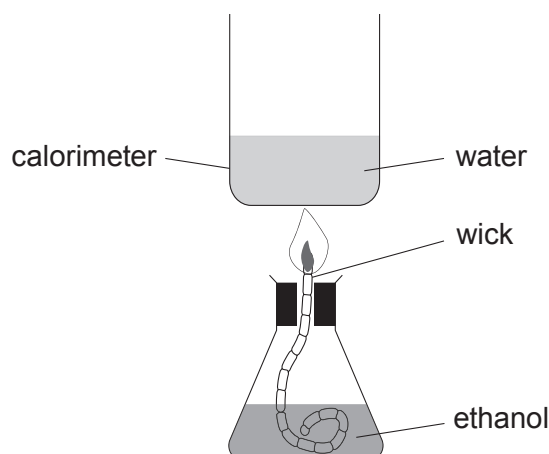
(i) Write the equation that represents the standard molar enthalpy change of formation (ΔH_f) of ethanol. [1]

(ii) Suggest why this enthalpy change cannot be measured directly. [1]

(b) Enthalpy changes of combustion can often be measured directly. The equation for the reaction which represents the enthalpy change of combustion (ΔH_c) of ethanol is as follows.



A student used the apparatus below to determine the enthalpy change of combustion of ethanol.



The student obtained the following results.

Mass of spirit burner + ethanol at start	= 72.27 g
Mass of spirit burner + ethanol after combustion	= 71.46 g
Temperature of water at start	= 21.5 °C
Temperature of water after combustion	= 75.5 °C
Volume of water in calorimeter	= 100 cm ³

The energy released in the experiment can be calculated using the formula

$$\text{energy released} = mc\Delta T$$

where m = mass of the water in grams (assume 1 cm³ has a mass of 1 g)
 c = 4.2 Jg⁻¹°C⁻¹
 ΔT = change in temperature of the water



- (i) Calculate the energy released in the experiment.

[1]

Energy released = ... J

- (ii) The enthalpy change of combustion of ethanol is defined as the energy change per mol of ethanol burned.

Use your answer to (i) to calculate the enthalpy change of combustion of ethanol. Give your answer in kJ mol^{-1} and correct to **3 significant figures**. Include the sign. [3]

ΔH_c of ethanol = ... kJ mol^{-1}
sign value

- (c) Another student did not carry out an experiment to find ΔH_c of ethanol. He looked up the literature value on a respected internet site.

How would you expect the numerical values obtained by the two students to differ? Explain your answer.

You may assume that both values were found under the same conditions of temperature and pressure. [2]

.....

.....

.....



(d) The students then used the apparatus from (b) to find the enthalpy change of combustion of higher relative molecular mass alcohols. They found that as the number of carbon atoms increased the value of the enthalpy change of combustion became more negative.

(i) Write the equation for the reaction which represents the enthalpy change of combustion of propanol, $\text{C}_3\text{H}_7\text{OH}$. [1]

(ii) In terms of bond strengths, explain why enthalpy changes of combustion are negative. [1]

(iii) Explain why the enthalpy change of combustion of propanol is more negative than that of ethanol. [1]

(e) Recent research has been carried out to find economic and environmentally friendly uses for waste straw and wood chippings.

The process of gasification involves the material being partly combusted at a temperature of about 700°C to give a mixture consisting mainly of hydrogen and carbon monoxide but also some carbon dioxide.

Another approach has been to use enzyme catalysed reactions to change the waste material into glucose and then to ethanol.

Comment on the economic and environmental factors involved in both of these processes. [4]

QWC [2]

Total [17]



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12. Hydromagnesite is a mixture of magnesium carbonate and soluble impurities. A student crushed some hydromagnesite and added a sample of mass 0.889 g to excess dilute hydrochloric acid so that the magnesium carbonate component reacted fully.

(a) Explain why the rock was crushed before being added to the acid. [1]

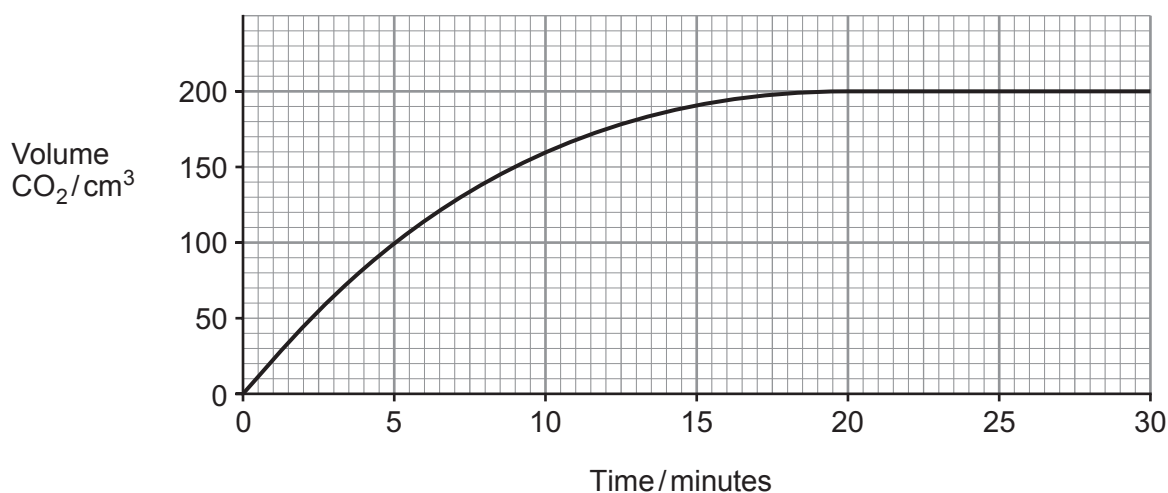
.....

.....

(b) Write the equation for the reaction between magnesium carbonate and dilute hydrochloric acid. [1]

.....

(c) The gas formed was collected in a gas syringe and its volume was measured over a period of time. The volumes and times were plotted. The volume of 1 mol of gas under these conditions is 24.0 dm^3 .



Describe what happened to the rate of the reaction over the 30 minute period.
Explain why any changes in the rate occurred. [3]

.....

.....

.....

.....

.....

.....



- (d) Other than by using an indicator, how would the student know that hydrochloric acid was in excess? [1]

.....

.....

- (e) (i) Use the graph to calculate how many moles of magnesium carbonate reacted with the hydrochloric acid. [2]

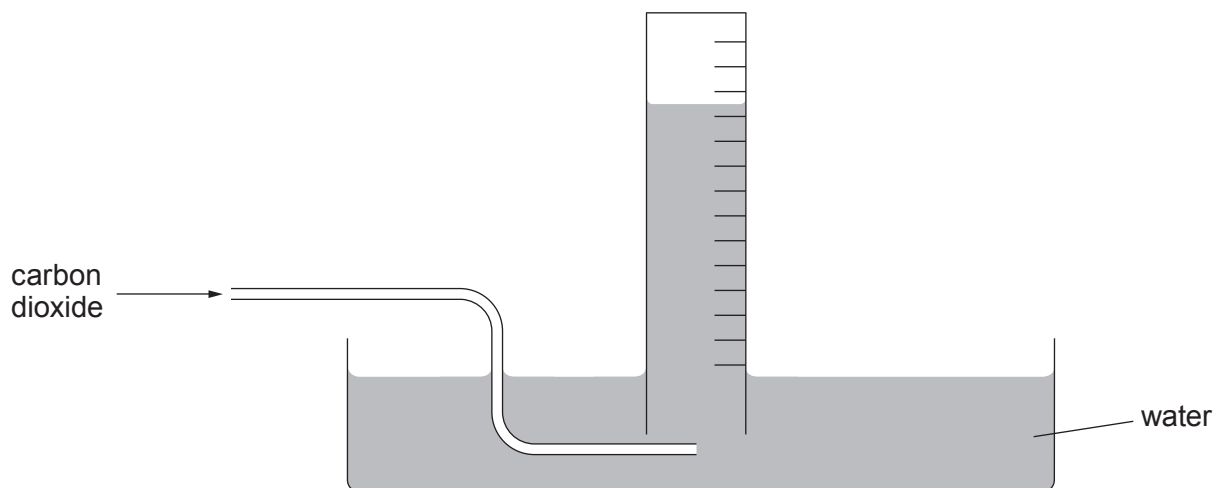
Number of moles MgCO_3 = ... mol

- (ii) Find the mass of magnesium carbonate that reacted and hence the percentage of magnesium carbonate present in hydromagnesite. [2]

Percentage of magnesium carbonate = ... %



- (f) A student wanted to carry out this experiment on another sample of hydromagnesite. He did not have a gas syringe and therefore he decided to collect the carbon dioxide over water in a measuring cylinder.



Explain what effect this would have on the results of the experiment. You should assume that the gas syringe and the measuring cylinder can both be read to the same precision. [2]

.....

.....

.....

.....

- (g) When magnesium carbonate is heated it decomposes to make magnesium oxide and carbon dioxide.



Magnesium oxide has a very high melting temperature and so can be used to line furnaces.

What is the atom economy for the production of magnesium oxide from magnesium carbonate? [2]

Atom economy = ... %

Total [14]

Section B Total [70]

END OF PAPER



[illegible]

[illegible]



GCE AS/A level

1091/01-A

**CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1**

A.M. FRIDAY, 23 May 2014

THE PERIODIC TABLE

Period **1** **2** **3** **4** **5** **6** **7** **0**

Group

s Block

1.01 H Hydrogen 1

6.94 Li Lithium 3	9.01 Be Beryllium 4
23.0 Na Sodium 11	24.3 Mg Magnesium 12

39.1 K Potassium 19	40.1 Ca Calcium 20
85.5 Rb Rubidium 37	87.6 Sr Strontium 38
133 Cs Caesium 55	137 Ba Barium 56
(223) Fr Francium 87	(226) Ra Radium 88

(227) La Lanthanum 57	(227) Ac Actinium 89
--------------------------------	-------------------------------

Key

Ar

Symbol

Name

Z

relative atomic mass

atomic number

p Block

10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86

d Block

45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30
88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48
139 La Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80

f Block

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
---------------------------	---------------------------------	------------------------------	-------------------------------	-----------------------------	-------------------------------	-------------------------------	----------------------------	-------------------------------	----------------------------	---------------------------	----------------------------	------------------------------	-----------------------------

► Lanthanoid elements

232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103
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►► Actinoid elements



GCE MARKING SCHEME

CHEMISTRY
AS/Advanced

SUMMER 2014

INTRODUCTION

The marking schemes which follow were those used by WJEC for the SUMMER 2014 examination in GCE CHEMISTRY. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

	Page
CH1	1
CH2	7
CH4	13
CH5	21

GCE CHEMISTRY - CH1
SUMMER 2014 MARK SCHEME

SECTION A

- Q.1** $1s^2 2s^2 2p^6 3s^2 3p^6$ [1]
- Q.2** carbon-12 / ^{12}C [1]
- Q.3** any example e.g. [1]
iron for Haber process / manufacture of ammonia
vanadium(V) oxide in Contact process / manufacture of sulfuric acid
platinum / palladium / rhodium in catalytic converters / to remove toxic gases from exhaust fumes
nickel in hydrogenation of alkenes / unsaturated oils
- Q.4** (a) $M_r = 286.2$ allow 286 [1]
(b) $\text{mass} = \frac{286.2 \times 0.1}{4} = 7.155 / 7.16$ allow 7.15 / 7.2 based on 286 [1]
- Q.5** enthalpy changes = -110 [1]
- Q.6** $^{234}_{90}\text{Th}$ (1) $^{234}_{91}\text{Pa}$ (1) (award 1 mark for 2 correct symbols) [2]
- Q.7** portion to right of E_{a1} labelled as molecules that react / shaded [1]

 E_{a2} marked, at lower energy than E_{a1} , and portion to right labelled as molecules that react / shaded [1]

Section A Total [10]

SECTION B

- Q.8** (a) same number of protons and electrons (1)
- 0, 1 and 2 neutrons (1) [2]
- (b) (i) 3 energy levels between $n = 2$ and $n = \infty$
becoming closer together
first gap must be $<$ that between $n = 1$ and $n = 2$ [1]
- (ii) any arrow pointing upwards (1)
- from $n = 1$ to $n = \infty$ (1) [2]
- (c) (i) visible [1]
- (ii) (not correct because) Balmer series corresponds to energy transitions involving $n = 2$ (1)
- for ionisation energy need Lyman series / energy transitions involving $n = 1$ (1) [2]
- (d) (i) $Q(g) \rightarrow Q^+(g) + e^-$ / accept any symbol [1]
- (ii) Group 6 [1]
- (iii) In T there is more shielding (1)
- The outer electron is further from the nucleus (1)
- The increase in shielding outweighs the increase in nuclear charge / there is less effective nuclear charge (1) [3]
- Legibility of text; accuracy of spelling, punctuation and grammar; clarity of meaning QWC* [1]
- Total [14]**

- Q.9**
- (a) (i) line drawn that is deflected less by magnetic field [1]
- (ii) increase strength of the magnetic field [1]
allow decrease charge on charged plates
- (b) (i) $1+$ (1)
- $^{37}\text{Cl} - ^{37}\text{Cl}$ (1) $^{37}\text{Cl}_2^+$ (2) [2]
- (ii) line drawn as m/z 72 (1)
- ratio height 6 (1) allow $\frac{1}{2}$ square tolerance [2]
- (c) (i) % H = 0.84 (1)
- C : H : Cl = $10.04 / 12 : 0.84 / 1.01 : 89.12 / 35.5$ (1)
- = 0.84 : 0.83 : 2.51 = 1 : 1 : 3 empirical formula = CHCl_3 (1) [3]
- (ii) the relative molecular mass / M_r / molar mass [1]
- (iii) right hand / largest / heaviest m/z peak from mass spectrum [1]

Total [11]

- Q.10** (a) (a reaction in which) the rate of the forward reaction is equal to the rate of the backward reaction [1]
- (b) goes darker / more brown (1)
 because the (forward) reaction has a +ve ΔH / is endothermic (1)
 goes paler / less brown (1)
 because there are more moles / molecules on RHS (1)
 no change (because catalysts do not affect the position of an equilibrium) (1) [5]
- (c) (i) moles $\text{N}_2\text{H}_4 = 14000/32.04 = 437.0$ (1)
 this produces $437.0 \times 3 = 1311$ moles of gas (1)
 volume = $1311 \times 24 = 3.15 \times 10^4 \text{ dm}^3$ (1) [minimum 2 sf] [3]
- (ii) (large volume of) gas produced [1]
- (d) (i) an acid is a proton / H^+ donor [1]
- (ii) $\rightarrow \text{NO}_2^- + \text{H}_3\text{O}^+$ [1]
- (iii) sulfuric acid is behaving as the acid / nitric acid is behaving as a base (1)
 as it donates a proton / as it accepts a proton (1) [2]

Total [14]

- Q.11** (a) (i) $2\text{C(s)} + 3\text{H}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{C}_2\text{H}_5\text{OH(l)}$ (state symbols needed) [1]
 C(s) allowed as C(gr) or C(graphite) [1]
- (ii) (if these elements were reacted together) other products would form/
 carbon does not react with hydrogen **and** oxygen under standard conditions [1]
- (b) (i) energy = $100 \times 4.2 \times 54 = 22680$ [1]
- (ii) moles ethanol = $0.81/46 = 0.0176$ (1)
 energy change = $\frac{22.68}{0.0176}$ $\Delta H = -1290$ (1)
 –ve sign and correct to 3 sf (1) [3]
- (c) internet value numerically larger (1)
 heat losses / incomplete combustion / thermal capacity of calorimeter ignored (1) no credit for energy loss [2]
- (d) (i) $\text{C}_3\text{H}_7\text{OH} + 4\frac{1}{2}\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$ (ignore state symbols) [1]
- (ii) negative enthalpy change means energy in bonds broken is less than that in bonds made [1]
- (iii) more bonds broken and made in propanol and therefore more energy released [1]
- (e) any 4 from:
 both conserve carbon / non-renewable fuel sources / fossil fuels / use renewable sources
 (these gas / liquid) suitable for different uses e.g. ethanol to fuel cars
 atom economy gasification is less (some C lost as CO_2) / CO_2 produced in gasification is a greenhouse gas
 CO is toxic
 gasification at high temperature / enzymes need low temperature
 enzyme approach therefore saves fuel / gasification needs more energy [4]
 3 max if any reference to destruction of ozone layer
 QWC [2]
 The candidate has selected a form and style of writing that is appropriate to purpose and complexity of the subject matter (1)
 Answer has suitable structure (1)

Total [17]

- Q.12** (a) to increase rate of reaction / to increase surface area [1]
- (b) $\text{MgCO}_3 + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$ (ignore state symbols) [1]
- (c) rate starts fast and gradually slows (1)
 because concentration becomes less so fewer collisions (per unit time) /
 less frequent collisions / lower probability of collisions (1)
 at time = 17/18 min rate = 0 (1) [3]
- (d) all the solid would all have disappeared / if more carbonate is added further
 effervescence is seen [1]
- (e) (i) volume $\text{CO}_2 = 200 \text{ cm}^3$ (1)
 moles $\text{CO}_2 = 200 / 24000 = 0.008333 = \text{moles MgCO}_3$ (1)
 [minimum 2 sf] [2]
- (ii) mass $\text{MgCO}_3 = 0.008333 \times 84.3 = 0.702 \text{ g}$ (1)
 $\% \text{MgCO}_3 = \frac{0.702}{0.889} \times 100 = 79.0\% / 79\%$ [2]
- (e) carbon dioxide is soluble in water / reacts with water (1)
 volume collected less therefore % / moles of MgCO_3 less (1) [2]
- (f) use of 40.3 and 84.3 (1)
 atom economy = $40.3 / 84.3 \times 100 = 47.8\%$ (1) [2]

Total [14]

Section B Total [70]

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1091/01

CHEMISTRY – CH1

A.M. THURSDAY, 9 January 2014

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.5.	10	
6.	8	
7.	15	
8.	19	
9.	18	
10.	10	
Total	80	

Section A

Section B

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
- copy of the **Periodic Table** supplied by WJEC.
Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

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

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

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The **QWC** label alongside particular part-questions indicates those where the Quality of Written Communication is assessed.

If you run out of space, use the continuation page(s) at the back of the booklet, taking care to number the question(s) correctly.

1091
010001

SECTION A

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

1. An element, X, has an atomic number of 9 and forms an ion X^- . State which **one** of the following shows the numbers of protons and electrons in this **ion**. [1]

	protons	electrons
A	8	9
B	9	8
C	9	9
D	9	10

2. State which **one** of the following shows the mass of aluminium that contains the same number of atoms as there are molecules in 11.0 g of carbon dioxide, CO_2 . [1]

A	6.75 g
B	13.5 g
C	27.0 g
D	54.0 g

3. The isotope ^{32}P is radioactive. It decays by β -emission and has a half-life of 14 days.

(a) State what is meant by β -emission. [1]

.....

.....

(b) Give the mass number **and** symbol of the atom formed by the loss of one β -particle from an atom of ^{32}P . [1]

.....

(c) State what is meant by the term *half-life*. [1]

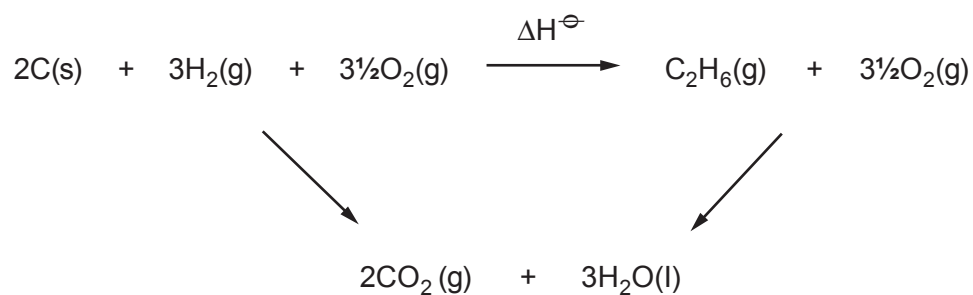
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(d) Calculate how long it will take a sample of ^{32}P to decay from 8 g to 1 g. [1]

Time taken = ... days

4. Study the following energy cycle.



Use the values in the table below to calculate the enthalpy change of reaction, $\Delta H^\ominus$.

[2]

Substance	Enthalpy change of combustion, $\Delta H_c^\ominus / \text{kJ mol}^{-1}$
carbon	-394
hydrogen	-286
ethane	-1560

$\Delta H^\ominus = \dots\dots\dots \text{kJ mol}^{-1}$

5. Silver tarnishes because it reacts with hydrogen sulfide in the air to form silver sulfide.

A 1.24 g sample of silver sulfide contains 0.16 g of sulfur. Calculate the empirical formula of this compound. **Show your working.** [2]

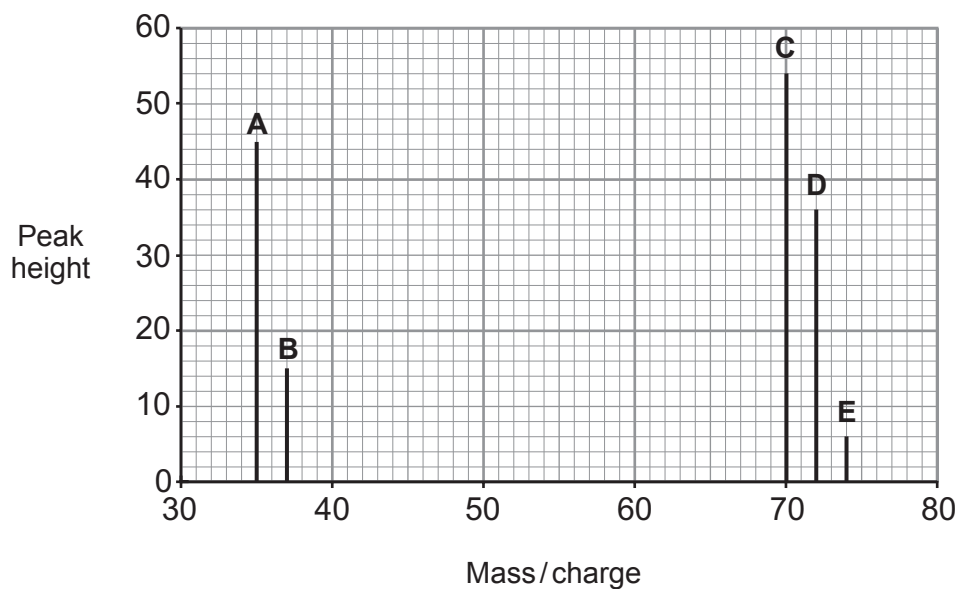
Empirical formula

Section A Total [10]

SECTION B

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

6. (a) The mass spectrum of chlorine, Cl_2 , is shown below.



- (i) Identify the positive ions that are responsible for the peaks **B** and **C**. [2]

Peak **B**

Peak **C**

- (ii) Use the mass spectrum to calculate the ratio of peak height **C** : peak height **E**. [2]

Ratio

- (iii) Explain why the peak heights of **C** and **E** are in this ratio. [2]

.....

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(b) Another element in Group 7 is bromine, Br.

Its mass spectrum shows that bromine has two naturally-occurring isotopes. The abundance of each isotope is given below.

Isotope	Percentage abundance/%
^{79}Br	50.69
^{81}Br	49.31

Calculate the relative atomic mass of bromine, giving your answer to **four** significant figures. [2]

Relative atomic mass = ...

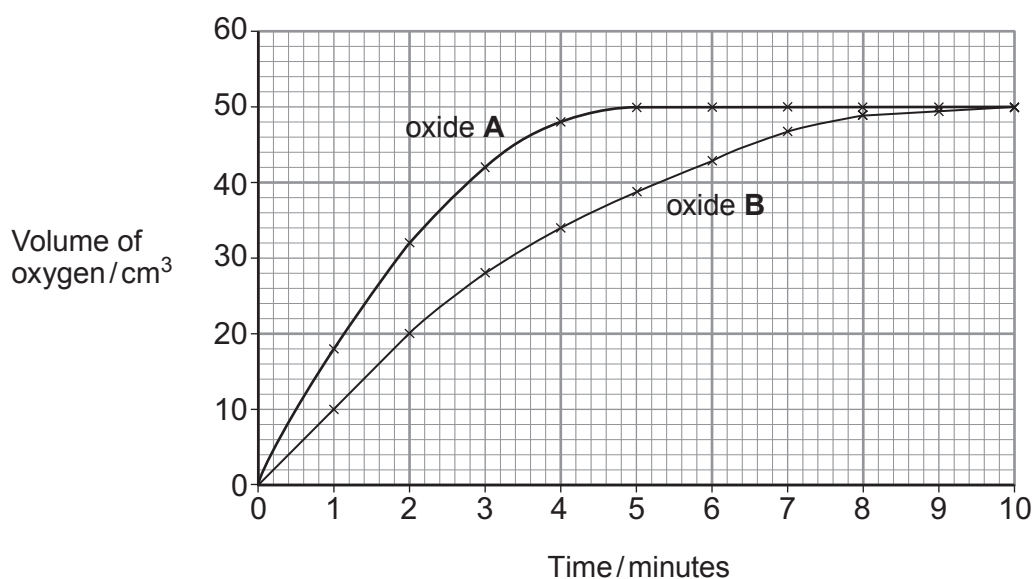
Total [8]

7. Oxygen can be produced in the laboratory by the decomposition of hydrogen peroxide.



Trystan carried out experiments to study the effect of using two metal oxides, **A** and **B**, to catalyse the reaction. He used 0.5 g of each metal oxide and diluted 10 cm³ of a hydrogen peroxide solution with 90 cm³ of water in each case. Following dilution the solutions were kept at a constant temperature of 35 °C throughout the experiment.

He plotted his results on the graph shown below.



- (a) Outline a suitable method, including essential apparatus, for carrying out an experiment to obtain these results. You may include a diagram if you consider it helpful. [4]

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(b) State, giving a reason, which oxide is the more efficient catalyst. [1]

.....

.....

(c) In the experiment with oxide **A**, calculate the volume of oxygen evolved

(i) during the first minute, [1]

.....

(ii) during the third minute. [1]

.....

(d) Explain the difference between the answers in (c)(i) and (c)(ii). [2]

.....

.....

.....

(e) Give a reason why the total volume of oxygen obtained in the two experiments is the same. [1]

.....

.....

(f) If Trystan repeated the experiment using 5 cm^3 of the original hydrogen peroxide solution diluted with 95 cm^3 of water, state the final volume of oxygen that would be evolved. [1]

.....

- (g) If he carried out the experiments at 45 °C instead of 35 °C, state what effect this would have on the time required to obtain the final volume of oxygen. Use collision theory to explain your answer.

[3]

QWC [1]

.....

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.....

Total [15]

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010009

8. This question is about atomic structure.

- (a) Give the full electronic configuration of a nitrogen atom and use this to describe the way in which electrons are arranged in atoms. [4]

QWC [1]

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- (b) Describe the main features of the atomic emission spectrum of hydrogen in the visible region. Explain how these features arise and how their interpretation provides evidence for energy levels in the atom. [6]

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- (c) (i) Hydrogen has a first ionisation energy of 1312 kJ mol^{-1} .
Explain why helium has a higher first ionisation energy than hydrogen. [2]

.....

.....

.....

- (ii) Beryllium and magnesium are both in Group 2 of the Periodic Table.
Explain why beryllium has a higher first ionisation energy than magnesium. [2]

.....

.....

.....

- (iii) The table below gives the first three ionisation energies for boron and potassium.

Element	Ionisation energy / kJ mol^{-1}		
	1st	2nd	3rd
B	800	2420	3660
K	419	3051	4412

- I Suggest why compounds containing B^{3+} ions are unlikely to exist. [1]

.....

.....

- II Write an equation to represent the **second** ionisation energy of potassium. [1]

.....

- III State how the first three ionisation energies of calcium would differ from those of potassium. [2]

.....

.....

.....

Total [19]

9. (a) State what is meant by the term *standard molar enthalpy change of formation*. [2]

.....

.....

.....

- (b) (i) Write an equation to represent the standard molar enthalpy change of formation, $\Delta H_f^\ominus$, of $\text{H}_2\text{O}(\text{g})$. [1]

.....

- (ii) The standard molar enthalpy change of formation, $\Delta H_f^\ominus$, of $\text{H}_2\text{O}(\text{g})$ is -242 kJ mol^{-1} . Using this value and the average bond enthalpies given in the table below, calculate the average bond enthalpy of the O — H bond in H_2O . [2]

Bond	Average bond enthalpy / kJ mol^{-1}
H — H	436
O = O	496

Average bond enthalpy of O — H bond = ... kJ mol^{-1}

- (c) Hydrogen has been proposed as a possible alternative to petrol as a fuel for cars. One suggestion is to store the hydrogen in the car as solid magnesium hydride, MgH_2 , and generate it as required by heating.

- (i) I Give **one** advantage of using hydrogen in place of petrol as a fuel for cars. [1]

.....

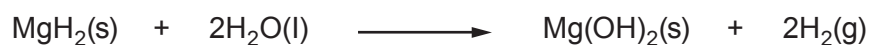
.....

- II Give **one** advantage of storing the fuel in the car in the form of magnesium hydride rather than hydrogen gas. [1]

.....

.....

- (ii) One possible disadvantage of using magnesium hydride arises from its reaction with water.



Suggest why magnesium hydride's reaction with water could be a problem. [1]

.....

.....

- (iii) The fuel tank of one type of hydrogen-powered car holds 70 kg of magnesium hydride.

Calculate the volume of hydrogen gas, measured at room temperature and pressure, which would be produced if this amount of magnesium hydride reacted with water. [3]

[1 mol of gas molecules occupies 24 dm³ at room temperature and pressure]

Volume of hydrogen gas = ... dm³

- (d) Methanol can be produced industrially by passing carbon monoxide and hydrogen over a catalyst at high temperatures and pressures.



- (i) State how the equilibrium yield of methanol is affected by an increase in temperature and in pressure. [1]

.....

.....

- (ii) Explain your answer to part (i). [2]

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- (e) Many catalysts are very expensive but their use does allow the chemical industry to operate more profitably. Explain why the use of catalysts provides economic and environmental benefits.

[3]

QWC [1]

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Total [18]

10. (a) Sodium carbonate can be manufactured in a two-stage process as shown by the following equations.



Calculate the maximum mass of sodium carbonate which could be obtained from 900 g of sodium chloride. [3]

Maximum mass of sodium carbonate = ... g

- (b) Sodium carbonate can form a hydrate, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$.

When 4.64 g of this hydrate was heated, 2.12 g of anhydrous Na_2CO_3 remained.

- (i) State the mass of water in 4.64 g of the hydrate. [1]

- (ii) Calculate the number of moles of sodium carbonate and the number of moles of water in 4.64 g of the original hydrate. Use these values to calculate the value of x in $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$. [2]

$x = \dots\dots\dots$

QUESTION 10 CONTINUES ON PAGE 16

- (c) Hannah is given an impure sample of anhydrous sodium carbonate and she carries out an experiment to determine the percentage of sodium carbonate in the sample. She finds that she needs 18.0 cm^3 of hydrochloric acid of concentration 0.50 mol dm^{-3} to react completely with 0.55 g of the impure sample. The impurity does not react with hydrochloric acid. The equation for the reaction is given below.



- (i) Calculate the number of moles of HCl used in the titration. [1]

Number of moles of HCl = ... mol

- (ii) Deduce the number of moles of Na_2CO_3 that reacted with the HCl. [1]

.....

- (iii) Calculate the mass of Na_2CO_3 in the sample. [1]

Mass of Na_2CO_3 in sample = ... g

- (iv) Calculate the percentage by mass of Na_2CO_3 in the sample. [1]

Percentage by mass = ... %

Total [10]

Section B Total [70]

END OF PAPER

This image shows a full page of a document template designed for handwriting practice or general writing. It consists of approximately 20 evenly spaced, horizontal dashed lines running across the entire width of the page. The background is plain white, and there are no margins, headers, footers, or other markings present.



GCE AS/A level

1091/01-A

**CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1**

A.M. THURSDAY, 9 January 2014

THE PERIODIC TABLE

Period **1** **2** **3** **4** **5** **6** **7** **0**

Group

s Block

4.00 He Helium 2

Key	
A_r	relative atomic mass
Symbol	atomic number
Name	
Z	

p Block

10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86

d Block

47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30
91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48
179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80
(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac Actinium 89						

f Block

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103

► Lanthanoid elements

► Actinoid elements



GCE MARKING SCHEME

**CHEMISTRY
AS/Advanced**

JANUARY 2014

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2014 examination in GCE CHEMISTRY. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

	Page
CH1	1
CH2	8
CH4	14

CH1

Section A

Q.1 D [1]

Q.2	A	[1]
-----	----------	------------

Q.3 (a) An electron formed when a neutron changes into a proton /
an electron emitted by the nucleus [1]

(b) ^{32}S [1]

(c) Time taken for half of the atoms in a radioisotope to decay (or similar) [1]

(d) 42 days [1]

Q.4 Combustion of C and H₂ = (2 × -394) + (3 × -286)
= -1646 kJ mol⁻¹ (1)

$$\Delta H = -1646 - (-1560) = -86 \text{ kJ mol}^{-1} \quad (1) \quad [2]$$

Q.5		Ag	S	
	Mass	1.08	0.16	
	A_r	108	32	
	Moles	0.01	0.005	(1)

$$\text{Formula} = \text{Ag}_2\text{S} \quad (1) \quad [2]$$

Total Section A [10]

Section B

- Q.6 (a) (i) **B** is $^{37}\text{Cl}^+$ (1)
C is $(^{35}\text{Cl} - ^{35}\text{Cl})^+$ (1) [2]
- (ii) **C** = 54, **E** = 6 (1)
 Ratio of **C:E** is 9:1 (1) [2]
- (iii) Ratio of $^{35}\text{Cl} : ^{37}\text{Cl}$ is 3:1 (1)
 Ratio of $^{35}\text{Cl} - ^{35}\text{Cl} : ^{37}\text{Cl} - ^{37}\text{Cl}$ is $3:1 \times 3:1 = 9:1$ (1)
- or
- Probability of atom being
 ^{35}Cl is $\frac{3}{4}$ and that of ^{37}Cl is $\frac{1}{4}$ (1)
- Probability of
 $^{35}\text{Cl} - ^{35}\text{Cl}$ is $\frac{3}{4} \times \frac{3}{4} = \frac{9}{16}$
 and $^{37}\text{Cl} - ^{37}\text{Cl}$ is $\frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$ (1) [2]
- (b) $A_r = \frac{(79 \times 50.69) + (81 \times 49.31)}{100}$ (1)
- $A_r = 79.99$ (1) [2]

Total [8]

- Q.7 (a) Use weighing scales to weigh the metal oxide (1)
 Use measuring cylinder to pour hydrogen peroxide solution and water into a conical flask (1)
 Immerse flask in water bath at 35 °C (1)
 Add oxide to flask and connect flask to gas syringe (1)
 Measure volume of oxygen every minute for 10 minutes / at regular time intervals (1)
- (any 4 of above, credit possible from labelled diagram) [4]
- (b) Oxide **A** because reaction is faster [1]
- (c) (i) 18 cm³ [1]
 (ii) 10 cm³ [1]
- (d) Concentration of hydrogen peroxide has decreased (1)
 reaction rate decreases / fewer successful collisions (1) [2]
- (e) All the hydrogen peroxide has decomposed / the same quantity of hydrogen peroxide was used [1]
- (f) 25 cm³ [1]
- (g) Reaction will take less time (1)
 Reactants collide with more (kinetic) energy (1)
 More molecules have the required activation energy (1) [3]
- QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter* [1]

Total [15]

- Q.8 (a) Electrons within atoms occupy fixed energy levels or shells of increasing energy / nitrogen has electrons in two shells (1)
 $1s^2 2s^2 2p^3$ (1)
- Electrons occupy atomic orbitals within these shells /
 The first shell in nitrogen has s orbitals and the second shell s and p orbitals (1)
- A maximum of two electrons can occupy any orbital /
 Each s orbital in nitrogen contains two electrons (1)
- Each with opposite spins (1)
- Orbitals of the same type are grouped together as a sub-shell /
 There are three p orbitals in nitrogen's p sub-shell (1)
- Each orbital in a sub-shell will fill with one electron before pairing starts / In nitrogen's p sub-shell each orbital contains one electron (1)
- (configuration mark + any 3 of above) [4]
- QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate* [1]
- (b) Atomic spectrum of hydrogen is a series of lines (1)
 that get closer as their frequency increases (1)
 (credit possible from labelled diagram)
- Lines arise from atom / electrons being excited by absorbing energy (1)
 electron jumping up to a higher energy level (1)
 falling back down and emitting energy (in the form of electromagnetic radiation) (1)
 to the $n = 2$ level (1)
 (any **three** points for maximum 3 marks)
- Since lines are discrete energy levels must have fixed values /
 Since energy emitted is equal to the difference between two energy levels, ΔE is a fixed quantity or quantum (1) [6]

- (c) (i) It has greater nuclear charge (1)
but little / no extra shielding (1) [2]
- (ii) In Be less shielding of outer electron (1)
outweighs smaller nuclear charge (1)
- or
- Be outer electron closer to nucleus (1)
Be has greater effective nuclear charge (1) [2]
- (iii) I. Too much energy required to form B^{3+} ion [1]
- II. $K^+(g) \rightarrow K^{2+}(g) + e^-$ [1]
- III. Value of 1st and 3rd I.E. will be higher (1)
Value of 2nd I.E. will be smaller (1)
(accept large jump in I.E. value would be between 2nd and 3rd electrons for 1 mark) [2]

Total [19]

- Q.9 (a) Enthalpy change when one mole of a compound is formed from its (constituent) elements (1)
in their standard states / under standard conditions (1) [2]
- (b) (i) $\text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{H}_2\text{O}$ [1]
- (ii) $-242 = 436 + 248 - 2(\text{O}-\text{H})$ (1)
 $2(\text{O}-\text{H}) = 926$
 $\text{O}-\text{H} = 463 \text{ kJ mol}^{-1}$ (1) [2]
- (c) (i) I. Burning hydrogen will not produce CO_2 (or SO_2) as pollutants [1]
 II. Hydrogen is very flammable, storing as MgH_2 is safer / MgH_2 is solid therefore volume occupied by given amount of hydrogen is less [1]
- (ii) If the MgH_2 is not kept dry, hydrogen will be formed and there could be a potential explosion [1]
- (iii) Moles $\text{MgH}_2 = \frac{70000}{26.32} = 2659.6$ (2660) (1)
 Moles $\text{H}_2 = 5319.2$ (5320) (1)
 Volume $\text{H}_2 = 1.28 \times 10^5 \text{ dm}^3$ (1) [3]
- (d) (i) An increase in temperature would decrease the yield and an increase in pressure would increase the yield [1]
- (ii) Forward reaction is exothermic so equilibrium shifts to the left as temperature is increased (1)
 More gaseous moles on the l.h.s. so equilibrium shifts to the right as pressure is increased (1) [2]
- (e) Lower temperatures can be used (1)
 Energy costs saved (1)
 More product can be made in a given time (so more can be sold) (1)
 Enable reactions to take place that would be impossible otherwise (1)
 Less fossil fuels burned to provide energy (so less CO_2 formed) (1)
 (any 3 of above) [3]
- QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning* [1]

Total [18]

- Q.10 (a) Moles NaCl = $\frac{900}{58.5} = 15.38$ (1)
- Moles Na₂CO₃ = 7.69 (1)
- Mass Na₂CO₃ = $7.69 \times 106 = 815(.4)$ g (1) [3]
- (b) (i) 2.52 g [1]
- (ii) Moles Na₂CO₃ = 0.02 (1)
Moles H₂O = 0.14 (1) $\times 7$ (1) [2]
- (c) (i) Moles = $0.5 \times 0.018 = 0.009$ [1]
- (ii) 0.0045 [1]
- (iii) $0.0045 \times 106 = 0.477$ [1]
- (iv) $\% = 0.477/0.55 = 86.7 \%$ [1]

Total [10]

Total Section B [70]

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1091/01

CHEMISTRY – CH1

A.M. THURSDAY, 23 May 2013

1½ hours

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-6	
B	7	
	8	
	9	
	10	
	11	
	12	
TOTAL MARK		

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
 - copy of the **Periodic Table** supplied by WJEC.
- Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

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

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

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The *QWC* label alongside particular part-questions indicates those where the Quality of Written Communication is assessed.

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.



M A Y 1 3 1 0 9 1 0 1 0 1

SECTION A

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

1. Carbon-14 is a radioactive isotope of carbon. Give the numbers of protons, neutrons and electrons present in an atom of carbon-14. [2]

Number of protons

Number of neutrons

Number of electrons

2. Circle **all** of the following that carry a negative charge. [2]

electron α -particle γ -ray proton neutron β -particle

3. Many industrial processes use catalysts.

Explain how a catalyst increases the rate of a chemical reaction. [2]

.....

.....

.....

4. Sketch the shape of **one** *p*-orbital. [1]



5. Name an element that has a half-filled set of p -orbitals. [1]

.....

6. Vinegar is a dilute solution of a weak acid.

(a) State what is meant by an *acid*. [1]

.....

.....

(b) Suggest a pH value for vinegar. [1]

.....

Section A Total [10]



SECTION B

Answer all questions in the spaces provided.

7. Jewels such as diamonds, rubies and emeralds are highly valued but are all closely related to much less precious materials.

- (a) Emeralds are a form of the mineral beryl, with their green colour due to the impurities present.

A sample of beryl contains 10.04% aluminium, 53.58% oxygen and 31.35% silicon by mass, with beryllium making up the remainder. Its molecular formula is $\text{Al}_2\text{Be}_x\text{Si}_6\text{O}_{18}$. Find the percentage by mass of beryllium in the compound and hence calculate the value of x in this formula. [3]

$x = \dots\dots\dots$

- (b) The most common form of carbon is graphite, however the element also exists in the form of diamond.

We can calculate the standard enthalpy change of reaction for making diamond from graphite using Hess' Law.

Reaction	Standard enthalpy change of reaction / kJ mol^{-1}
$\text{C}(\text{diamond}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$	-395.4
$\text{C}(\text{graphite}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$	-393.5

- (i) State Hess' Law.

[1]

.....



- (ii) Use Hess' Law and the data in the table on page 4 to calculate the enthalpy change of the reaction below. [2]



Enthalpy change of reaction = ... kJ mol⁻¹

- (iii) Kyran states that because diamond is an element, its enthalpy of formation under standard conditions must be zero.

State whether Kyran is correct and give a reason to support your answer. [1]

.....

.....

.....

- (iv) Most diamonds used in jewellery come from natural sources, but it is possible to produce diamonds artificially although these are rarely of gemstone quality.

- I One proposed use of artificial diamond is to protect medical implants. To cover a particular implant, a volume of 2.08 cm³ of diamond is needed. Calculate the mass of diamond required. [1]

[Density of diamond under standard conditions = 3.51 g cm⁻³]

Mass of diamond = ... g

- II The process of producing diamond from graphite has a yield of 93%. Calculate the mass of graphite needed to make the diamond required. [2]

Mass of graphite = ... g

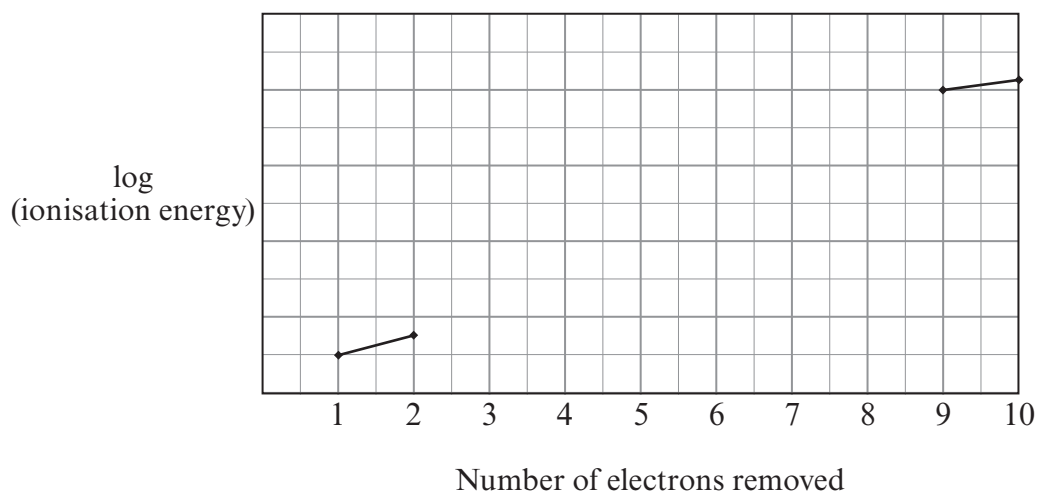
Total [10]



8. The noble gases (Group 0) are a group of very unreactive elements. The first members of the group (helium, neon and argon) do not form any compounds, however it is possible to form a few compounds of krypton and xenon.

(a) Neon has ten electrons in each atom. The sketch below shows the first two and the final two ionisation energies for a neon atom.

(i) Sketch the pattern you would expect to see for the remaining six ionisation energies of neon. [2]



(ii) Explain any significant changes in slope on the graph you have sketched. [2]

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- (b) The first compound of a noble gas was formed from Xe atoms and PtF_6 . It was the ionic compound $\text{Xe}^+ \text{PtF}_6^-$.

Explain why it is not possible to form a similar ionic compound of argon, $\text{Ar}^+ \text{PtF}_6^-$.

[2]

.....

.....

.....

- (c) Helium was identified in the Sun before it was discovered on Earth. When light from the Sun is split into its different colours by a prism, dark lines are observed against a coloured background which show the atomic absorption spectrum of helium. Explain how an atomic absorption spectrum forms.

[2]

.....

.....

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.....

- (d) Xenon trioxide, XeO_3 , is a compound which decomposes explosively at 25°C according to the following equation.



Calculate the volume of gas, in dm^3 , released by the decomposition of 1 mol of XeO_3 under these conditions.

[2]

[1 mol of any gas at 25°C occupies a volume of 24.0dm^3]

Volume = ... dm^3

Total [10]

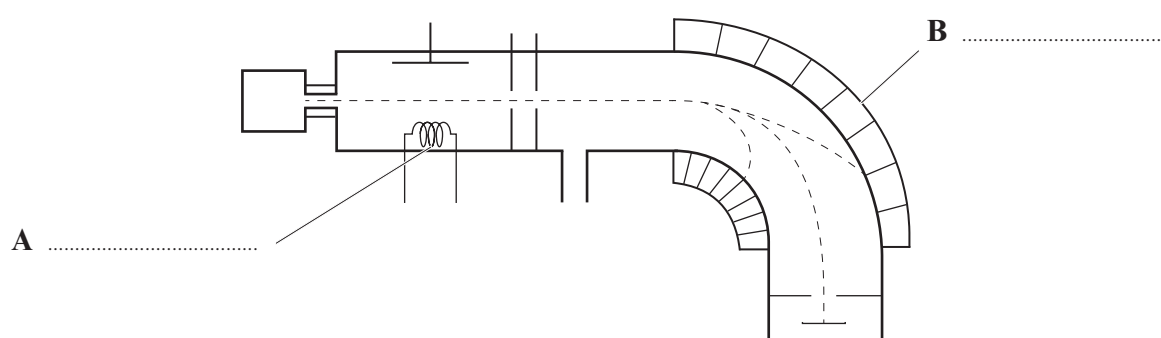


9. Selenium is a Group 6 element that is needed in the human body in trace amounts for the correct functioning of some enzymes. Only small amounts are required as large doses are harmful.

(a) A mass spectrometer can be used to find the relative atomic mass of a sample of selenium. The following diagram shows a typical mass spectrometer.

(i) Label parts **A** and **B**. [1]

(ii) Describe what happens to a sample introduced into the mass spectrometer. [4]
QWC [2]



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- (b) Some selenium is found amongst the decay products in a nuclear reactor. The mass spectrum found for this sample of selenium had the isotopic composition below.

Isotope	Abundance
^{78}Se	12.2%
^{79}Se	26.4%
^{80}Se	61.4%

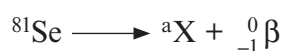
Calculate the relative atomic mass of this sample of selenium.
Give your answer to **3 significant figures**.

[3]

Relative atomic mass = ...

- (c) ^{81}Se is a radioactive isotope of the element selenium, which decays by β -emission with a half life of 18.75 minutes.

- (i) The decay of ^{81}Se is shown by the equation below.



Identify a and X in this equation.

[1]

a X

- (ii) 2.72 g of ^{81}Se is used by a scientist for an experiment. Calculate the mass of ^{81}Se that would remain after 75 minutes.

[2]

Mass = ... g

Total [13]



10. Hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$, is a crystalline solid that can be used to prepare a standard solution for titration.

- (a) The relative molecular mass of this hydrated sodium carbonate is 286.2. Calculate the value of x in this formula. [1]

$x = \dots\dots\dots$

- (b) Emily wants to prepare 250cm^3 of a solution of sodium carbonate of concentration 0.200 mol dm^{-3} using this hydrated sodium carbonate.

- (i) Calculate the mass of hydrated sodium carbonate needed to prepare this solution. [2]

Mass of hydrated sodium carbonate = $\dots\dots\dots$ g

- (ii) Emily proposes to make the solution by the following method.

- Weigh the required mass of hydrated sodium carbonate.
- Place the hydrated sodium carbonate in a beaker and add 250cm^3 of distilled water.
- Stir the mixture until all the sodium carbonate dissolves.
- Transfer the solution to the volumetric flask and shake.

Her teacher said that the method was not correct. Suggest **two** changes that Emily should make to her method. [2]

1. $\dots\dots\dots$

$\dots\dots\dots$

$\dots\dots\dots$

2. $\dots\dots\dots$

$\dots\dots\dots$

$\dots\dots\dots$



- (c) Emily then prepared 250cm^3 of sodium carbonate solution of concentration 0.200mol dm^{-3} using a correct method. She took 25.0cm^3 samples of the sodium carbonate solution and titrated these using a solution of sulfuric acid, H_2SO_4 , of unknown concentration. The acid was placed in the burette.

Describe how Emily should perform one titration to find the volume of sulfuric acid needed for complete reaction.

[4]
QWC [1]

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Total [10]



11. The combustion of fossil fuels provides much of the energy we use today. Nonane, C_9H_{20} , is one of the compounds present in the fuel kerosene.

(a) (i) The equation for the combustion of nonane is given below.



Use the values given in the table to calculate the standard enthalpy of combustion of nonane. [3]

Substance	Standard enthalpy of formation, $\Delta H_f^\ominus / \text{kJ mol}^{-1}$
$\text{C}_9\text{H}_{20}(\text{l})$	-275
$\text{O}_2(\text{g})$	0
$\text{CO}_2(\text{g})$	-394
$\text{H}_2\text{O}(\text{l})$	-286

Standard enthalpy of combustion = ... kJ mol^{-1}

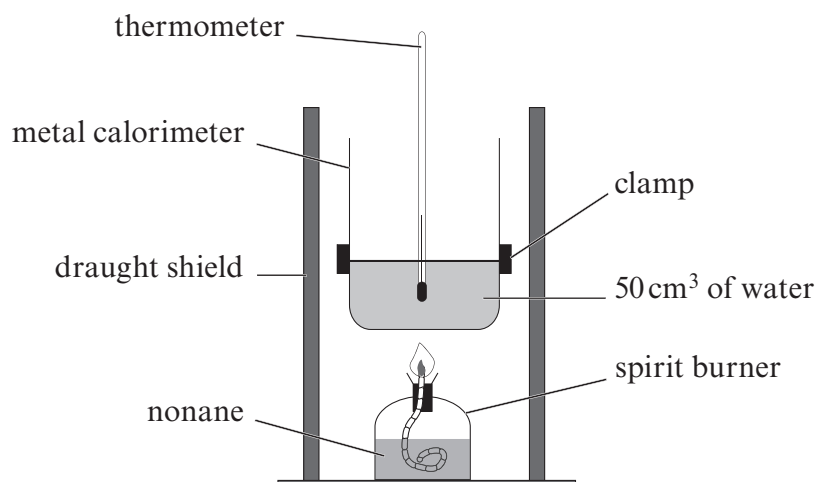
- (ii) Standard enthalpy changes are measured under standard conditions. Give the standard conditions of temperature and pressure, including units for each. [2]

Temperature

Pressure



- (b) Iwan wished to confirm the value he had calculated for the enthalpy of combustion of nonane, and he used the apparatus below.



- (i) Iwan measured the mass of the spirit burner at the start and end of the experiment and found that 0.20 g of nonane had been burned. Calculate the number of moles of nonane present in 0.20 g. [2]

Number of moles = ... mol

- (ii) During this experiment, the temperature of the water increased by 42.0 °C. Use the formula below to calculate the enthalpy change of combustion of nonane, in kJ mol⁻¹. [2]

$$\Delta H = \frac{-mc\Delta T}{n}$$

m is the mass of water

c is the specific heat capacity of water which is 4.18 J °C⁻¹ g⁻¹

ΔT is the temperature change in °C

n is the number of moles of nonane

ΔH = ... kJ mol⁻¹

QUESTION 11 CONTINUES ON PAGE 14



- (iii) Give **one** reason why the experimental value that Iwan obtained differs from the theoretical value calculated in part (a). [1]

.....

.....

Total [10]



12. (a) The combustion of fossil fuels containing sulfur impurities is known to cause acid rain. This acid rain can cause the erosion of marble statues as the calcium carbonate in them reacts with the acid in the rain.

Give **one** other problem caused by acid rain.

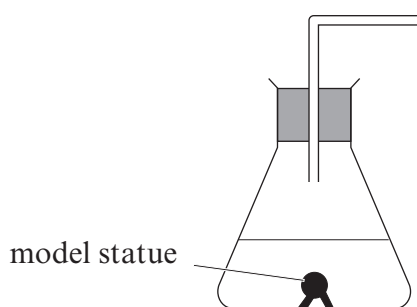
[1]

.....

.....

- (b) A chemist is developing coatings for marble that will slow down the rate of their erosion by acid rain. To compare different coatings he uses small model statues, all of which are the same size and shape as each other. He proposes to measure the rate of reaction by adding acid and measuring the volume of gas given off at set time intervals.

- (i) Complete the diagram to show the apparatus that could be used to perform this experiment. [1]



- (ii) Explain why it is important that the model statues are the same size and shape as each other. [1]

.....

.....

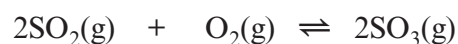
- (iii) State **two** other factors he will need to keep constant if he is to collect valid data. [2]

.....

.....



- (c) One gas that causes acid rain is sulfur dioxide. This gas is used to produce sulfur trioxide in the Contact Process. The reaction occurring is shown in the following equation.



- (i) State and explain the effect of increasing pressure on the equilibrium yield of sulfur trioxide. [2]

.....

.....

.....

.....

- (ii) When the temperature is increased the rate at which equilibrium is reached is increased and the yield of sulfur trioxide is decreased.

- I State whether this reaction is endothermic, exothermic or neither, giving a reason for your answer. [2]

.....

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.....



- II Explain why increasing the temperature leads to an increase in the rate of reaction. [3]

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.....

- III To increase the rate of a reaction, a catalyst can be used. Give a **different** catalysed reaction and name the catalyst for this reaction. [1]

.....

.....



- (d) Ethanoic acid, CH_3COOH , is one of the most familiar compounds used as a flavouring and preservative for food. Originally ethanoic acid was produced by oxidation of ethanol by bacteria in the presence of air (route **A** below). Today there are many other possible routes and three of these are shown as routes **B**, **C** and **D** below.

Route	Carbon-containing starting materials	Conditions	Overall equation	Atom economy
A	ethanol		$\text{C}_2\text{H}_5\text{OH} + \text{O}_2 \rightarrow \text{CH}_3\text{COOH} + \text{H}_2\text{O}$	76.9%
B	methanol, carbon monoxide	150 °C, 30 atm	$\text{CH}_3\text{OH} + \text{CO} \rightleftharpoons \text{CH}_3\text{COOH}$	100.0%
C	butane	150 °C, 55 atm	$2\text{C}_4\text{H}_{10} + 5\text{O}_2 \rightarrow 4\text{CH}_3\text{COOH} + 2\text{H}_2\text{O}$	87.0%
D	sugars		$\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 3\text{CH}_3\text{COOH}$	

- (i) State the atom economy of route **D** for production of ethanoic acid. [1]

.....

- (ii) Route **B** is the route most commonly used for producing ethanoic acid today for both financial and *Green Chemistry* reasons. Apply the principles of *Green Chemistry* to the information above to give **two** reasons why route **B** is favoured over route **C**. [2]

1.

.....

2.

.....

- (iii) Route **B** uses a homogeneous catalyst. State what effect the catalyst will have on the position of this equilibrium. [1]

.....

.....

Total [17]

Section B Total [70]



[illegible]

[illegible]



GCE AS/A level

1091/01-A

**CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1**

A.M. THURSDAY, 23 May 2013

Group	
1	2
1	2
3	4
3	4
5	6
6	7
7	0

STEMUP.CO.UK

88	89	f Block													
▶ Lanthanoid elements		140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
▶▶ Actinoid elements		232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103



GCE MARKING SCHEME

**CHEMISTRY
AS/Advanced**

SUMMER 2013

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2013 examination in GCE CHEMISTRY. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

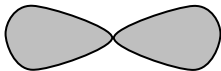
It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

	Page
CH1	1
CH2	8
CH4	14
CH5	22

GCE CHEMISTRY - CH1
SUMMER 2013 MARK SCHEME

SECTION A

- Q.1** number of protons 6
 number of neutrons 8
 number of electrons 6 (all correct 2 marks, 2 correct 1 mark) **[2]**
- Q.2** electron (1)
 β -particle (1) (max 1 if three circled, 0 if four or more) **[2]**
- Q.3** Provides an alternative pathway (1)
 with lower activation energy / more particles have energy above E_A (1) **[2]**
- Q.4**  **[1]**
- Q.5** nitrogen / phosphorus (or any other Group 5 element) **[1]**
- Q.6** (a) (dissociates to) release H^+ ions **[1]**
 (b) 2.5-6.0 **[1]**

Total [10]

SECTION B

Q.7 (a) percentage Be by mass = 5.03% (1)

division of percentage by A_r for Be and at least one other element as shown below (1)

$$\text{Al} \quad 10.04 \div 27 = 0.3719 \rightarrow 1.00$$

$$\text{Be} \quad 5.03 \div 9.01 = 0.5583 \rightarrow 1.50$$

$$\text{O} \quad 53.58 \div 16 = 3.3488 \rightarrow 9.00$$

$$\text{Si} \quad 31.35 \div 28.1 = 1.1566 \rightarrow 3.10$$

molecular formula = $\text{Al}_2\text{Be}_3\text{O}_{18}\text{Si}_6$ or $x=3$ (1) [3]

(b) (i) Hess' Law states that where a reaction can occur by more than one route the total enthalpy **change** for each route will be the same [1]

$$(ii) \quad \Delta H = -393.5 - (-395.4) (1) \quad = +1.9 \text{ kJ mol}^{-1} (1) \quad [2]$$

(iii) Kyran is **incorrect** as diamond is not the **standard state** of carbon [1]

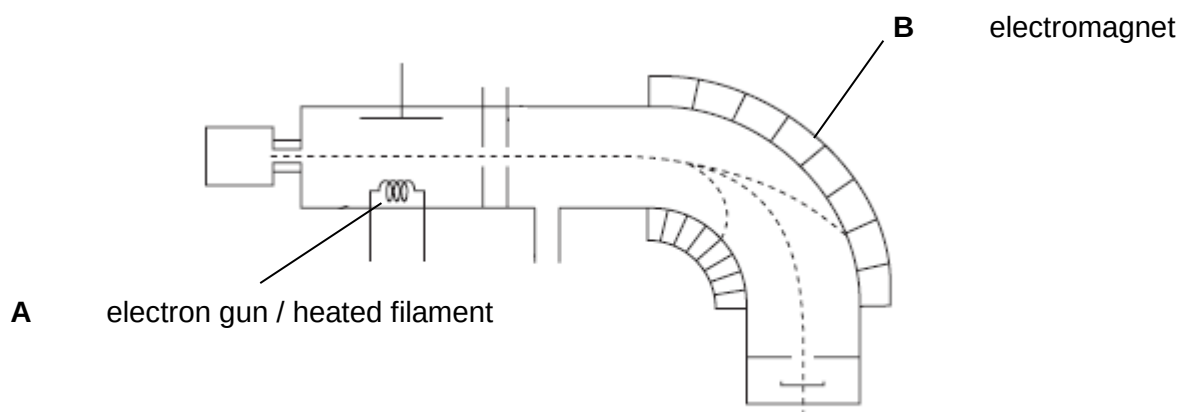
(iv) I mass of diamond = 7.30 g [1]

$$II \quad \text{mass of graphite} = 7.30 \div (93/100) (1) = 7.85 \text{ g} (1) \quad [2]$$

Total [10]

- Q.8**
- (a) (i) all ionisation energies showing gradual increase and one large jump (1)
 large jump after 8 electrons (1) [2]
- (ii) eighth and ninth electrons come from different shells (1)
 ninth electron is closer to nucleus / has less or no shielding / has greater effective nuclear charge (1) [2]
- (b) the compound formation has the noble gas atom being ionised (1)
 ionisation energy of argon is much higher than that of xenon (1)
 because the outer electron in argon is closer to the nucleus / has greater effective nuclear charge / shielding (1) - 2 max [2]
- (c) electrons move from lower energy levels to higher energy levels (1)
 by absorbing **specific frequencies** of light (1) [2]
- (d) 1 mol of XeO_3 released 2.5 mol gas products (1)
 2.5 mol of gas occupies $24.0 \times 2.5 = 60.0 \text{ dm}^3$ (1) – follow through error (ft)
 if candidates calculate the volumes of the two gases separately, then (1) for one gas volume correct and (1) for total volume correct [2]
- Total [10]**

Q.9 (a) (i) both needed



[1]

- (ii) electron gun bombards sample and **ionises** atoms/molecules (1)
 negatively charged plates / electric field **accelerates** (positive ions in) sample (1)
 electromagnet **deflects** ions according to mass and charge / m/z (1)
 current in electromagnet / electromagnetic field is varied so different mass ions hit detector (1)

[4]

QWC: selection of a form and style of writing appropriate to purpose and to complexity of subject matter (1)

QWC: legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning (1)

QWC [2]

(b) $A_r = (78 \times 12.2) + (79 \times 26.4) + (80 \times 61.4) \div 100$ (1) [for method] = 79.5 (1)

(1) for 3 sig figs for sensible answer (above 79.0 and below 80.0) (1)

[3]

(c) (i) a 81

X Br /bromine both needed

[1]

(ii) 75 minutes = 4 half-lives (1)

2.72g $\rightarrow$ 1.36g $\rightarrow$ 0.68g $\rightarrow$ 0.34g $\rightarrow$ 0.17g (1) – no ft

[2]

Total [13]

- Q.10** (a) $x = 10$ [1]
- (b) (i) number of moles = $250 \times 0.200 \div 1000 = 0.05 \text{ mol}$ (1) – ft
 mass of sodium carbonate = $0.05 \times M_r(\text{Na}_2\text{CO}_3) = 0.05 \times 286.2$
 $= 14.31\text{g}$ (1) [2]
- (ii) any two points from:
 weigh by difference (1)
 add less water initially (1)
 wash out beaker / glass rod / funnel and put water into volumetric flask (1)
 add water up to mark in volumetric flask (1)
 - 2 max [2]
- (c) add few drops of indicator (1) do not accept 'universal indicator'
 take initial and final reading on burette (1)
 swirl the conical flask (1)
 add acid until the indicator changes colour (1) [4]
- QWC: organisation of information clearly and coherently; use of specialist vocabulary where appropriate.* QWC [1]
- Total [10]**

- Q.11** (a) (i) $\Delta H = 9 \times (-394) + 10 \times (-286) - (-275)$ (1)
 $= -6131 \text{ kJ mol}^{-1}$ (1) for correct value and (1) for correct sign [3]
- (ii) temperature 298K, 25°C (1) pressure 1 atm, 101 kPa (1) [2]
- (b) (i) $M_r = (9 \times 12) + (20 \times 1.01) = 128.2$ (1)
 number of moles = $1.56 \times 10^{-3} \text{ mol}$ (1) [2]
- (ii) $\Delta H = -50 \times 4.18 \times 42 \div 1.56 \times 10^{-3}$ (1)
 $= -5626698 \text{ J mol}^{-1} = -5627 \text{ kJ mol}^{-1}$ (1) [2]
- (iii) heat loss to environment / incomplete combustion / not standard conditions [1]
- Total [10]**

Q.12	(a)	killing marine life / killing trees	[1]
	(b)	(i) either gas syringe or inverted burette attached to sealed vessel	[1]
		(ii) different surface area would affect rate of reaction	[1]
		(iii) concentration / volume / nature of acid (1)	
		temperature (1)	[2]
	(c)	(i) increasing pressure will shift the reaction to side with fewer gas molecules (1)	
		increasing yield of SO ₃ (1) – reason must be given	[2]
		(ii) I increasing temperature shifts equilibrium in endothermic direction (1)	
		as SO ₃ yield is decreased forward reaction must be exothermic (1)	[2]
		II increasing temperature increases energy of particles (1)	
		more collisions have energy above activation energy (1)	
		successful collisions occur more frequently (1)	
		<i>can gain first two points from labelled Boltzmann distribution curve</i>	[3]
		III e.g. iron in production of ammonia or any valid example	[1]
	(d)	(i) atom economy = 100%	[1]
		(ii) any two points from:	
		lower pressure used in B (1)	
		methanol is a renewable starting material (1)	
		higher atom economy in B or less waste in B (1)	
		[ignore reference to cost]	
		2 max	[2]
		(iii) no effect on position of equilibrium	[1]
			Total [17]

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1091/01

CHEMISTRY – CH1

A.M. THURSDAY, 10 January 2013

1½ hours

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
- copy of the **Periodic Table** supplied by WJEC.
Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

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

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

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The *QWC* label alongside particular part-questions indicates those where the Quality of Written Communication is assessed.

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-6	
B	7	
	8	
	9	
	10	
	11	
TOTAL MARK		

1091
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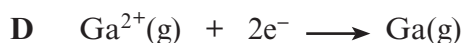
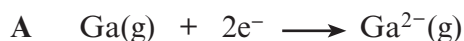
SECTION A

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

1. The mass number of an isotope of gallium is 70.

State the number of neutrons in an atom of this isotope. [1]

2. Write the letter which represents the correct equation for the **second** ionisation energy of gallium in the box below. [1]

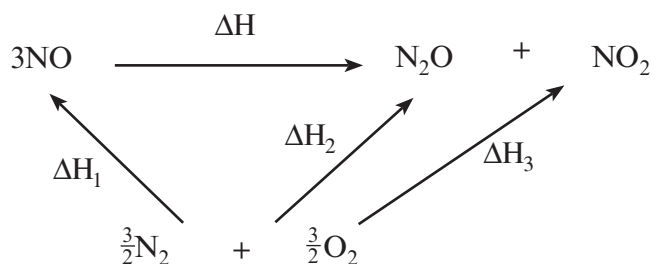


3. An enriched isotopic mixture of lithium contains ^6Li 12.0% and ^7Li 88.0% by mass. Showing your working, calculate the relative atomic mass of this sample of lithium. Give your answer to **three** significant figures. [2]

Relative atomic mass = ...



4. The energy cycle for a decomposition of nitrogen(II) oxide is shown below.



- (a) Complete the equation to show ΔH in terms of ΔH_1 , ΔH_2 and ΔH_3 . [1]

$\Delta H = \dots\dots\dots$

- (b) Write the chemical equation for the standard molar enthalpy change of formation of gaseous nitrogen(II) oxide, NO. [1]

.....

5. Carbon oxide sulfide, COS, is obtained by heating together carbon monoxide and gaseous sulfur.



State and explain any change that occurs when more carbon monoxide is added to the equilibrium mixture. [2]

.....

.....

.....

.....

.....

.....



6. An oxide of titanium contains 60% of titanium by mass. Calculate the empirical formula of this oxide of titanium. [2]

$$[A_r(\text{Ti}) = 48]$$

Empirical formula

Section A Total [10]



SECTION B

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

7. (a) In 2011 a man was detained at Moscow Airport when he tried to smuggle samples containing a radioactive isotope of sodium, ^{22}Na , onto an aircraft.

- (i) This isotope is made from an aluminium isotope by loss of an α -particle.

State what is meant by an α -particle. [1]

- (ii) ^{22}Na decays by the loss of a positron. This may occur by the breakdown of a proton into a neutron and a positron, giving the product, ^bX .

Deduce the mass number (b) and the chemical symbol (X) of this product. [2]

b

X

- (iii) The half-life of the isotope ^{22}Na is 2.6 years. The mass of a sample of this isotope is 48 mg.

Calculate the time taken for the mass of ^{22}Na to fall to 3 mg. [1]

Time taken = ... years

- (b) The visible emission spectrum of sodium shows a strong yellow-orange line at a wavelength of 589 nm and a weaker green line at 569 nm.

Complete the sentences below by using the words **higher** or **lower** as appropriate. [1]

The frequency of the green line at 569 nm is than the frequency of the yellow-orange line at 589 nm. Another line is seen at 424 nm. This is caused by an electronic transition of energy than the line at 569 nm.



- (c) Trona is a naturally-occurring 'sodium carbonate' mineral. It has the formula $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$.

(i) Show that the relative molecular mass of trona is 226. [1]

(ii) On heating, trona loses water and carbon dioxide giving sodium carbonate.



Calculate the atom economy of this reaction, assuming that sodium carbonate is the only required product. [2]

Atom economy = ... %

(iii) The above reaction is used commercially to obtain sodium carbonate.

Suggest **one** environmental disadvantage of this reaction as indicated by the equation, and state what could be done to overcome this problem. [2]

.....

.....

.....

.....



- (d) When sodium carbonate is added to water, some of the carbonate ions react with the water to give an alkaline solution.



- (i) Explain why this reaction is considered to be an acid-base reaction. [2]

.....

.....

.....

.....

- (ii) The pH of a sodium carbonate solution is 11.4.
How would you explain the meaning of the pH scale to a member of the public? [3]

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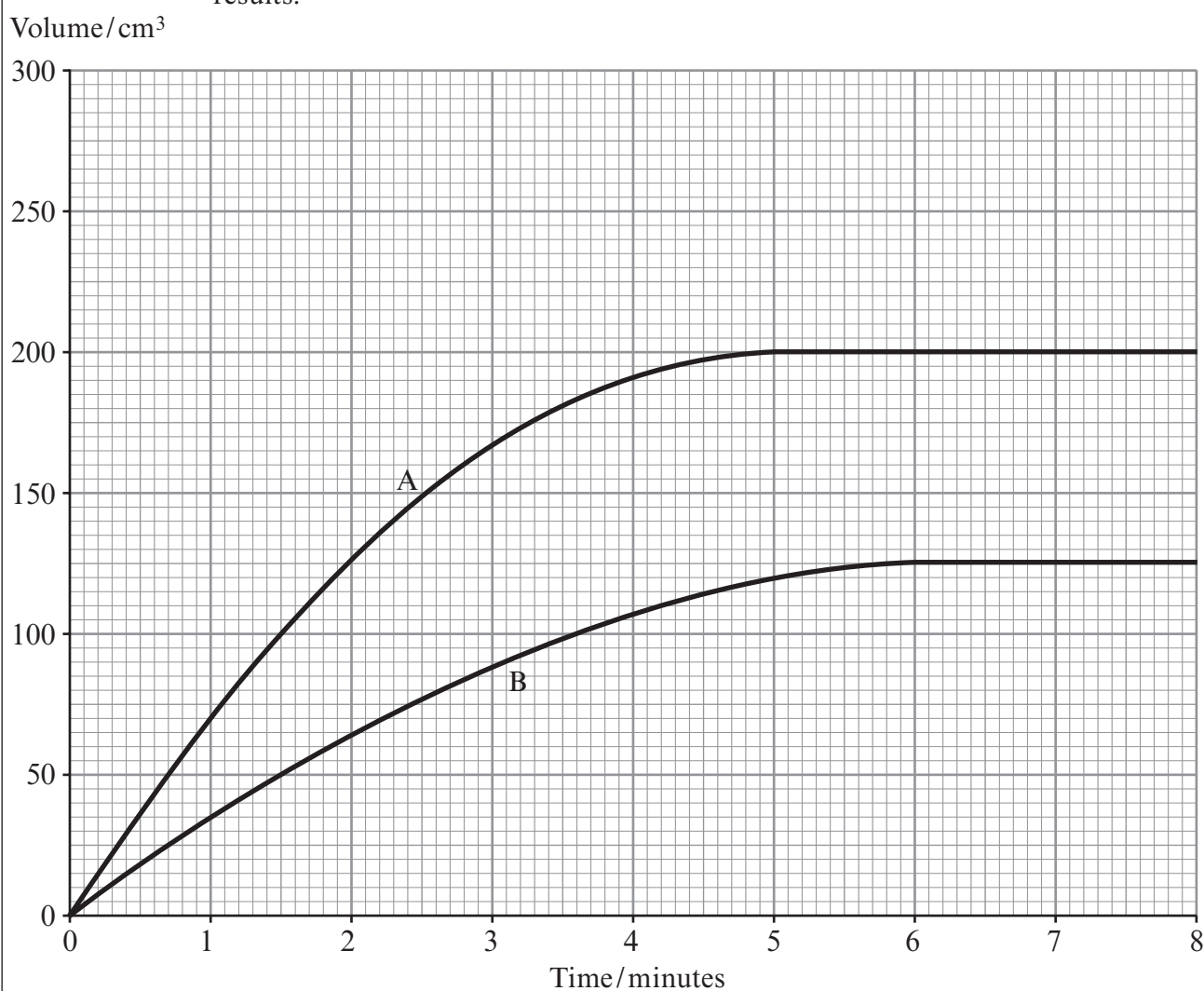
Total [15]



8. Dolomite, $\text{MgCO}_3 \cdot \text{CaCO}_3$, is a mineral containing magnesium carbonate and calcium carbonate.

(a) Some students were asked to react samples of dolomite, each of mass 0.50 g, with an excess of dilute hydrochloric acid and to follow the rate of the reaction by measuring the volume of carbon dioxide evolved at suitable time intervals.

(i) Line **A** on the graph shows Natalie's results. Her teacher said that this was correct. David's line is labelled **B**. Although his line represents his results, the teacher said that he must have done something wrong during the experiment to obtain these results.



Suggest and explain **two** things that he might have done wrongly to obtain these results. [2]

1.

.....

2.

.....



- (ii) Explain why, in Natalie's experiment, 0.25 g of the dolomite has reacted in 1.5 minutes but the remaining 0.25 g has taken a further 3.5 minutes to react. [2]

.....

.....

.....

- (iii) Emma asked what the volume of carbon dioxide collected from the samples would be if the temperature rose from 298 K to 323 K.
The teacher explained that, if the pressure remained the same, volume V (in cm^3) and temperature T (in Kelvin) were linked by the equation

$$V = k \times T \quad \text{where } k \text{ is constant.}$$

The volume of carbon dioxide evolved at 298 K is 130cm^3 . By finding the value of k , or by other means, calculate the volume of this carbon dioxide when its temperature is raised to 323 K. [2]

Volume of carbon dioxide = ... cm^3

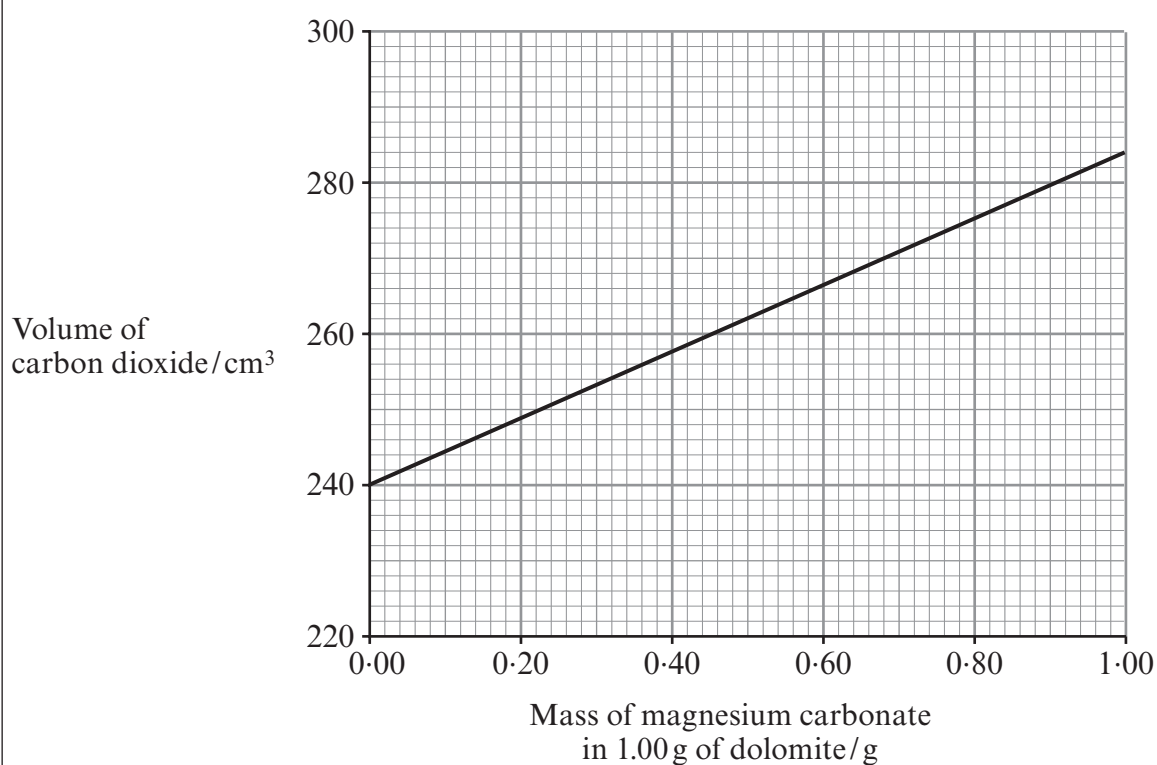


(b) In another experiment 0.623 g of dolomite reacted with an excess of dilute hydrochloric acid. The total volume of carbon dioxide evolved was 162 cm³.

- (i) Calculate the total volume of carbon dioxide that would be evolved if a sample of dolomite of mass 1.00 g was used under the same conditions. [1]

Volume of carbon dioxide = ... cm³

- (ii) Use the graph below to find the mass of magnesium carbonate present in this 1.00 g sample of dolomite. [1]



Mass of magnesium carbonate = ... g



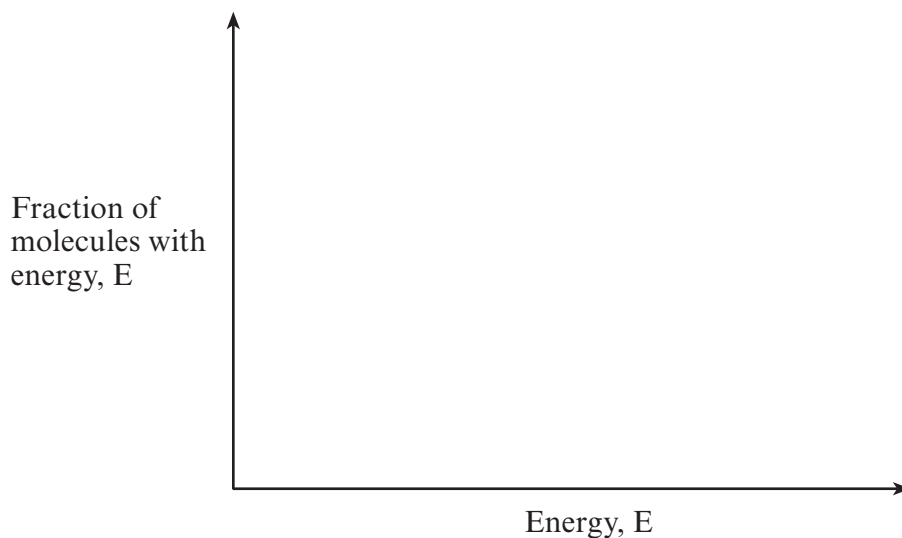
- (c) The rate of the reaction between dolomite and hydrochloric acid increases by a large amount if the temperature is increased.

Complete the following energy distribution curve diagram by drawing two lines that show the distribution of energies at two different temperatures.

Label the line at lower temperature T_1 and the line at higher temperature T_2 . Use the diagram to help you explain why the rate increases as the temperature increases.

[3]

QWC [1]



- (d) Briefly outline a different method of following the rate of the reaction between dolomite and hydrochloric acid.

[2]

.....

.....

.....

.....

Total [14]



9. (a) Nitrogen(I) oxide is a colourless gas that reacts with hydrogen to give nitrogen and water.



- (i) State why the standard enthalpy of formation of both hydrogen and nitrogen gases is 0 kJ mol^{-1} . [1]

.....

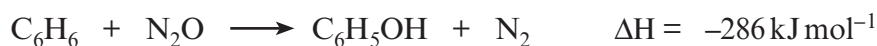
.....

- (ii) Calculate the standard enthalpy of formation of nitrogen(I) oxide in kJ mol^{-1} . (You should assume that the standard enthalpy of formation of water is -286 kJ mol^{-1}) [2]

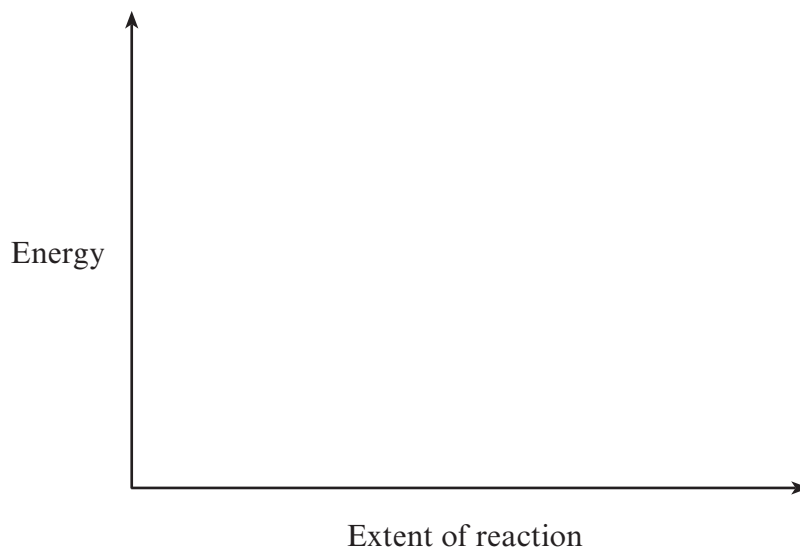
Standard enthalpy of formation = ... kJ mol^{-1}



- (b) A new method for producing phenol, $\text{C}_6\text{H}_5\text{OH}$, is by reacting benzene, C_6H_6 , with nitrogen(I) oxide at 400°C in the presence of a suitable catalyst.



- (i) Sketch the energy profiles for the catalysed and uncatalysed reactions using the axes shown below.
Label your profiles as *catalysed* and *uncatalysed*. [2]



- (ii) A pilot-scale plant used 156 kg of benzene ($M_r = 78$) to produce phenol ($M_r = 94$).

I Calculate the number of moles of benzene used. [1]

Moles of benzene = ... mol

- II The yield of phenol was 95%. Using your answer to I and the equation below (or another suitable method), calculate the mass of phenol obtained. Show your working. [3]



Mass of phenol = ... kg



- (iii) Study the short account below, which gives more detail about this process.

The process to make phenol is carried out in the gas phase and uses a solid zeolite catalyst. The operating temperature is around 400 °C.



The reactants are the hydrocarbon benzene and nitrogen(I) oxide, which is a potent greenhouse gas. The nitrogen(I) oxide is obtained from another process, where it is produced as an undesirable side product.

Use the account and the equation to comment on the environmental and *Green Chemistry* advantages of this process. A reference to the yield is not required. [4]
QWC [1]

.....

.....

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.....

Total [14]



10. (a) Potassium hydroxide contains potassium ions, K^+ .
Give the electron configuration of a potassium **atom** and use this to explain why most potassium compounds contain the potassium ion. [2]

.....

.....

.....

- (b) Michael was asked to make 250 cm^3 of a solution of potassium hydroxide and to record the maximum rise in temperature that occurred as it dissolved.
He measured 250 cm^3 of water in a glass beaker and then added 7.01 g (0.125 mol) of solid potassium hydroxide to this, with stirring.
He noticed that the temperature rose from 20.2°C to a maximum of 25.0°C .

- (i) Calculate the molar enthalpy change of solution of potassium hydroxide by use of the formula

$$\Delta H = - \frac{mc\Delta T}{n}$$

where m = mass of the solvent in grams (assume 1 cm^3 has a mass of 1 g)
 c = $4.2\text{ J g}^{-1}\text{ }^\circ\text{C}^{-1}$
 ΔT = change in temperature of the solution
 n = number of moles of the solute
 ΔH = molar enthalpy change of solution

You should show the **units** in your answer.

[3]

$\Delta H =$

- (ii) Michael's measurements produced a value for the enthalpy of solution of potassium hydroxide that was different to the literature value.

Use the information given to suggest and explain **two** factors that might produce a different result. [2]

1.

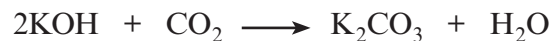
.....

2.

.....



- (c) Solid potassium hydroxide can be used in analysis to find the percentage of carbon dioxide present in a mixture of gases. The equation for the reaction that occurs is given below.



2.0 m³ of a gas mixture was passed through potassium hydroxide. Analysis showed that 0.050 mol of potassium carbonate had been formed.

- (i) State the number of moles of carbon dioxide necessary to produce 0.050 mol of potassium carbonate. [1]

.....

- (ii) Calculate the volume of carbon dioxide that produced 0.050 mol of potassium carbonate. [1]

[1 mol of carbon dioxide has a volume of 24.0 dm³ under these conditions]

Volume of carbon dioxide = ... dm³

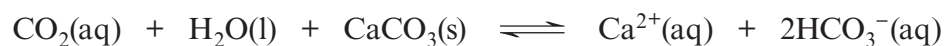
- (iii) Calculate the percentage of carbon dioxide in the gas mixture, in terms of volume. [2]

[1 dm³ = 0.001 m³]

Percentage of carbon dioxide = ... %



- (d) Scientists have commented that ‘an increase in the amount of carbon dioxide dissolved in sea water will cause problems for animals whose shells are composed of calcium carbonate’.



Use the equation above to help you discuss the problem that is caused for these animals by this increase in carbon dioxide concentration.

[3]

QWC [1]

.....

.....

.....

.....

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.....

.....

.....

Total [15]



11. (a) An aqueous solution of methanoic acid can be used to dissolve 'lime scale' in kettles. The concentration of a methanoic acid solution used for this purpose can be found by a titration using sodium hydroxide solution. For this purpose a 25.0 cm^3 sample of aqueous methanoic acid was diluted to 250 cm^3 .

(i) State the name of the piece of apparatus used to

I measure out 25.0 cm^3 of aqueous methanoic acid, [1]

.....

II contain exactly 250 cm^3 of the diluted solution. [1]

.....

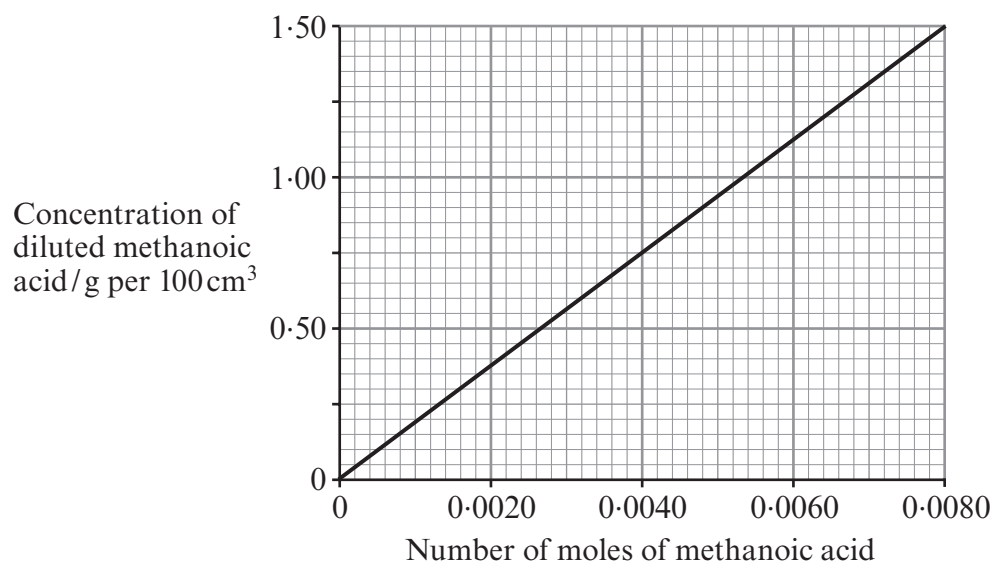
(ii) A 25.0 cm^3 sample of the diluted methanoic acid was titrated with sodium hydroxide solution of concentration 0.200 mol dm^{-3} . A volume of 32.00 cm^3 was needed to react with all the methanoic acid present.

Calculate the number of moles of sodium hydroxide used. [1]

Moles of sodium hydroxide = ... mol



- (iii) Methanoic acid and sodium hydroxide react together in a 1:1 molar ratio. Use the graph below and your result from (ii) to find the concentration of methanoic acid present in the diluted solution in g per 100 cm³ of solution. [1]



Concentration = ... g per 100 cm³

- (iv) State the concentration of the original methanoic acid in g per 100 cm³ solution. [1]

Original concentration = ... g per 100 cm³



(b) Methanoic acid, HCOOH , can be reduced to methanol, CH_3OH , in a gas phase reaction, by using hydrogen in the presence of a solid ruthenium metal catalyst.

(i) Ruthenium is acting as a heterogeneous catalyst.

State the meaning of the word *heterogeneous*.

[1]

.....

.....

(ii) The equation for the reduction of methanoic acid is shown below.



Use the table of bond enthalpies to find the enthalpy change for this reaction. [3]

Bond	Average bond enthalpy / kJ mol^{-1}
$\text{C}-\text{H}$	412
$\text{C}-\text{O}$	360
$\text{C}=\text{O}$	743
$\text{H}-\text{H}$	436
$\text{O}-\text{H}$	463

Enthalpy change = ... kJ mol^{-1}

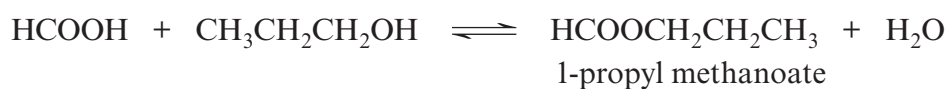


- (c) The relative molecular mass of methanoic acid is 46.02.

State why this quantity does not have units.

[1]

- (d) Methanoic acid reacts with propan-1-ol to give 1-propyl methanoate.



- (i) This reaction eventually reaches dynamic equilibrium.
State what is meant by *dynamic equilibrium*.

[1]

- (ii) Give the empirical formula of 1-propyl methanoate.

[1]

Empirical formula

Total [12]

Section B Total [70]

END OF PAPER



[illegible]

[illegible]

[illegible]



GCE AS/A level

1091/01-A

**CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1**

A.M. THURSDAY, 10 January 2013

Group	1	2	3	4	5	6	7	0
1								
2								
3								
4								
5								
6								
7								
0								

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88	89															
▶ Lanthanoid elements		f Block <table><tr><td>140 Ce Cerium 58</td><td>141 Pr Praseodymium 59</td><td>144 Nd Neodymium 60</td><td>(147) Pm Promethium 61</td><td>150 Sm Samarium 62</td><td>(153) Eu Europium 63</td><td>157 Gd Gadolinium 64</td><td>159 Tb Terbium 65</td><td>163 Dy Dysprosium 66</td><td>165 Ho Holmium 67</td><td>167 Er Erbium 68</td><td>169 Tm Thulium 69</td><td>173 Yb Ytterbium 70</td><td>175 Lu Lutetium 71</td></tr></table>	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71			
▶▶ Actinoid elements		<table><tr><td>232 Th Thorium 90</td><td>(231) Pa Protactinium 91</td><td>238 U Uranium 92</td><td>(237) Np Neptunium 93</td><td>(242) Pu Plutonium 94</td><td>(243) Am Americium 95</td><td>(247) Cm Curium 96</td><td>(245) Bk Berkelium 97</td><td>(251) Cf Californium 98</td><td>(254) Es Einsteinium 99</td><td>(253) Fm Fermium 100</td><td>(256) Md Mendelevium 101</td><td>(254) No Nobelium 102</td><td>(257) Lr Lawrencium 103</td></tr></table>	232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103
232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103			



GCE MARKING SCHEME

**CHEMISTRY
AS/Advanced**

JANUARY 2013

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2013 examination in GCE CHEMISTRY. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

Unit	Page
CH1	1
CH2	9
CH4	15

GCE CHEMISTRY - CH1
JANUARY 2013 MARK SCHEME

SECTION A

Q.1 39 [1]

Q.2 C [1]

Q.3 $A_r = \frac{(12.0 \times 6) + (88.0 \times 7)}{100} (1) = \frac{72.0 + 616.0}{100} = 6.88 (1)$ [2]

Q.4 (a) $\Delta H = \Delta H_2 + \Delta H_3 - \Delta H_1$ [1]

(b) $\frac{1}{2}\text{N}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{NO}(\text{g})$ state symbols requires [1]

Q.5 The position of equilibrium moves to the right / more COS is formed (1)
 (By Le Chatelier's principle) the system 'removes' added 'material' to restore the position of equilibrium / accept explanation in terms of pressure (1) [2]

Q.6 Ti $\frac{60}{48}$ O $\frac{40}{16}$ (1)
 $= 1.25$ $= 2.5$ $\therefore 1 : 2$
 $\therefore \text{TiO}_2$ (1) [2]

Section A Total [10]

SECTION B

- Q.7 (a) (i) A helium (atom) nucleus / 2 protons and 2 neutrons / ${}^4\text{He}^{2+}$ [1]
- (ii) b.....22 (1) X.....Ne (1) [2]
- (iii) $(4 \times 2.6) = 10.4$ [1]
- (b) The frequency of the green line at 569 nm is HIGHER. than the frequency of the yellow-orange line at 589 nm. Another line is seen at 424 nm, this is caused by an electronic transition of HIGHER. energy than the line at 569 nm. [1]
- (c) (i)
- | | | | | | | |
|--------------------------|---|------------------|---|-----------------------|-----|-----------|
| Na_2CO_3 | | NaHCO_3 | | $2\text{H}_2\text{O}$ | | |
| ↓ | | ↓ | | ↓ | | |
| 106 | + | 84 | + | 36 | (1) | → 226 [1] |
- (or by other appropriate method – note mark is for the working)
- (ii) Atom economy = $\frac{\text{'M}_r \text{ required product} \times 100}{\text{Total 'M}_r \text{ of the reactants}}$ (1)
- $= \frac{318 \times 100}{452} = 70.4 / 70.35 (\%)$ (1) [2]
- (iii) Carbon dioxide is produced (and released into the air) and this contributes to the greenhouse effect / increases acidity of sea (1)
It should be trapped / a use found for it. (1) [2]
- (d) (i) Water is acting as a proton donor (1) and this combines with the carbonate ion / CO_3^{2-} , giving the hydrogencarbonate ion / HCO_3^- (1) [2]
- (ii) The pH scale runs from 0-14 / measure of acidity / alkalinity (1)
pH <7 acid / >7 alkali (1)
acid stronger as pH value decreases / alkali stronger as pH value increases / 11.4 is strong alkali (1) [3]

Total [15]

Q.8 (a) (i) He may have lost carbon dioxide through leaks, this would have given a lower volume than expected. (1)
He used lower concentration of acid / diluted the acid with water and the rate of carbon dioxide evolution was slower than expected. (1) [2]

(ii) The concentration of acid is higher in the first half (1) the collision rate is higher (1) [2]

(iii) eg $k = \frac{V}{T}$ (1) $\therefore k = \frac{130}{298}$ / 0.436

$\therefore V = 0.436 \times 323 = 141 \text{ (cm}^3\text{)}$ (1)

or $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ (1) $\therefore V_1 = \frac{323 \times 130}{298} = 141 \text{ (cm}^3\text{)}$ (1) [2]

(b) (i) 260 (cm³) [1]

(ii) 0.45 (g) (0.43–0.48) [1]

(c) The diagram shows two reasonable distribution curves with T₂ flatter and 'more to the right' than T₁. (1)
Activation energy correctly labelled, or mentioned in the writing (1)
Fraction of molecules having the required activation energy is much greater at a higher temperature (thus increasing the frequency of successful collisions) (in words) (1) [3]

The candidate has selected a form and style of writing that is appropriate to purpose and complexity of the subject matter QWC [1]

(d) Place the mixture on a balance and measure the (loss in) mass (1)
at appropriate time intervals (1)

OR BY OTHER SUITABLE METHOD

eg. sample at intervals / quench (1) titration (1) [2]

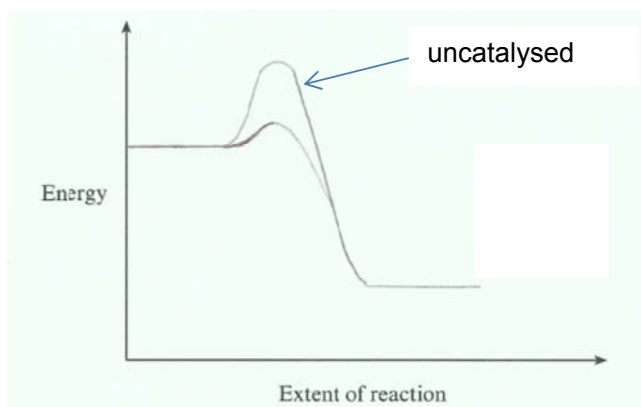
Total [14]

Q.9 (a) (i) They are both elements in their standard states. [1]

(ii) $\Delta H = \sum \Delta H_f \text{ products} - \sum \Delta H_f \text{ reactants}$ (1)
 $= (-286 + 0) - (-368 + 0)$
 $= -286 + 368 = (+)82 \text{ (kJ mol}^{-1}\text{)}$ (1) [2]

or by a cycle where correct cycle drawn (1) correct answer (1)

(b) (i)



exothermic profile drawn (1)
uncatalysed / catalysed line labelled (1) [2]

(ii) I number of moles of benzene = 2000 [1]

II mole ratio is 1 : 1 (1)

$$\therefore \text{moles of phenol produced} = \frac{2000 \times 95}{100} = 1900 \text{ (1)}$$

$$\text{mass} = M_r \times \text{number of moles} = 94 \times 1900 = 178.6 / 179 \text{ kg (1)}$$

alternatively

78 (g / kg) of benzene gives 94 (g / kg) of phenol (1)

$\therefore$ 1 (g / kg) of benzene gives $94/78$ (g / kg) of phenol

$\therefore$ 156 (kg) of benzene gives $94 \times 156/78$ (kg) of phenol = 188 (kg) (1)

but 95% yield $\therefore \frac{188 \times 95}{100} = 178.6 / 179 \text{ (kg)}$ (1) [3]

(iii) Look for at least four relevant positive points [4]

- e.g.
- the process uses a (heterogeneous) catalyst, which can easily be separated from the gaseous products (thus saving energy)
 - the only other product of the reaction is gaseous nitrogen, which is non-toxic / safe / not a harmful product
 - the process uses nitrogen(I) oxide which is used up, rather than being released into the atmosphere from the other process (and causing global warming)
 - the process is exothermic and the heat produced can be used elsewhere
 - a relatively moderate operating temperature reduces overall costs
 - high atom economy

*Legibility of text; accuracy of spelling, punctuation and grammar;
clarity of meaning* QWC [1]

Total [14]

Q.10 (a) $K \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ (1)
 There is one outer electron and the loss of this electron gives a stable potassium ion with a full outer shell/ ion more stable than the atom (1) [2]

(b) (i) $\Delta T = 4.8^\circ C$ (1)

$$\Delta H = - \frac{250 \times 4.2 \times 4.8}{0.125} = - 40320 \text{ J mol}^{-1} / - 40.3 \text{ kJ mol}^{-1} \text{ (2) [3]}$$

✓ for negative sign

✓ correct value with relevant units

(ii) e.g. The volume used was not precise in measurement as the readings on a beaker are only approximate (1)
 The experiment was performed in a beaker and this was not insulated and heat was lost to the surroundings (1) [2]

there may be other acceptable answers here, for example based on slow dissolving

(c) (i) 0.050 [1]

(ii) $(0.050 \times 24.0) = 1.20 \text{ (dm}^3\text{)}$ [1]

(iii) $\% \text{ v/v} = \frac{1.20 \times 0.001 \times 100}{2} \text{ (1)} = 0.06 \text{ (1)} \text{ [2]}$

(d) An increase in the concentration of (aqueous) carbon dioxide causes the position of equilibrium to move to the right. (1)
 This causes calcium carbonate to become aqueous calcium (and hydrogencarbonate) ions / dissolve (1)
 weakening shells / causing difficulty in formation of shells (1) [3]

Organisation of information clearly and coherently; using specialist vocabulary where appropriate QWC [1]

Total [15]

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1091/01

CHEMISTRY CH1

P.M. TUESDAY, 15 May 2012

1½ hours

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
- copy of the **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

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

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

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The *QWC* label alongside particular part-questions indicates those where the Quality of Written Communication is assessed.

If you run out of space, use the continuation page at the back of the booklet, taking care to number the question(s) correctly.

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-5	
B	6	
	7	
	8	
	9	
	10	
TOTAL MARK		

1091
010001



M A Y 1 2 1 0 9 1 0 1 0 1

SECTION A

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

1. Sketch a diagram to show the shape of a *p* orbital. [1]

2. Complete the following definition of *relative atomic mass*: [1]

The relative atomic mass of an element is the average mass of one atom of the element relative to

.....
.....

3. State which **one** of the following contains the greatest number of molecules. [1]

A 3 g of hydrogen

B 32 g of oxygen

C 36 g of water

D 66 g of carbon dioxide

.....

4. Phosgene is a compound of carbon, oxygen and chlorine. It is used to make polyurethanes and polycarbonates. Its percentage composition, by mass, is as follows.

C 12.1% O 16.2% Cl 71.7%

- (a) Calculate the **empirical** formula of this compound. [2]

.....
.....
.....
.....

- (b) What other information would you need to know to be able to deduce the **molecular** formula of this compound? [1]

.....



5. (a) The electronic structures of five atoms, **A** to **E**, are listed below. Arrange these atoms in order of increasing molar first ionisation energy. [2]

Atom	A	B	C	D	E
Electronic structure	$1s^2$	$1s^2 2s^2$	$1s^2 2s^2 2p^1$	$1s^2 2s^2 2p^3$	$1s^2 2s^2 2p^6$

lowest *highest*

- (b) State, giving a reason for your choice, which **one** of the following gives the first four ionisation energies for silicon, Si. [2]

	Ionisation energy / kJ mol^{-1}			
	1st	2nd	3rd	4th
W	496	4563	6913	9544
X	578	1817	2745	11578
Y	738	1451	7733	10541
Z	789	1577	3232	4356

Letter

Reason

.....
.....

Section A Total [10]



SECTION B

Answer all questions in the spaces provided.

6. Magnesium is best known for burning with a characteristic brilliant white light, however in industry it is the third most commonly used structural metal. The metal itself was first produced by Sir Humphry Davy in 1808 by the electrolysis of a mixture of magnesia and mercury oxide.

(a) Magnesium has three stable isotopes ^{24}Mg , ^{25}Mg and ^{26}Mg .

(i) State the number of protons present in an atom of ^{24}Mg . [1]

.....

(ii) Deduce the number of neutrons present in an atom of ^{26}Mg . [1]

.....

(iii) In order to calculate the relative atomic mass of magnesium, what would you need to know in addition to the relative mass of each isotope? [1]

.....

(b) Magnesium also has a radioactive isotope ^{28}Mg which has a half-life of 21 hours.

(i) If you started with 2.0 g of ^{28}Mg , calculate the mass of this isotope remaining after 84 hours. [1]

.....

.....

(ii) Name **one** useful radioactive isotope and briefly describe how it is used in medicine, industry or analysis. [2]

.....

.....



091
010005

By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of a nitride ion, N^{3-} . [1]

Diagram illustrating the arrangement of atomic orbitals for the first three principal energy levels (n=1, 2, 3). The orbitals are arranged in rows corresponding to the principal quantum number n.

- n=1:** 1s orbital (1 box).
- n=2:** 2s orbital (1 box) and 2p orbitals (3 boxes).
- n=3:** 3s orbital (1 box) and 3p orbitals (3 boxes).

$$\boxed{} \text{Mg}_3\text{N}_2 + \boxed{} \text{H}_2\text{O} \longrightarrow \boxed{} \text{Mg}(\text{OH})_2 + \boxed{} \text{NH}_3$$


7. Judith carried out three experiments to study the reaction between powdered magnesium and hydrochloric acid.

She used a gas syringe to measure the volume of hydrogen evolved, at room temperature and pressure, at set intervals. In each case, the amount of acid used was sufficient to react with all the magnesium.



The details of each experiment are shown in Table 1 below.

Experiment	Mass of magnesium / g	Volume of HCl / cm ³	Concentration of HCl / mol dm ⁻³
A	0.061	40.0	0.50
B	0.101	40.0	1.00
C	0.101	20.0	2.00

Table 1

The results obtained in experiment **C** are shown in Table 2 below.

Time / s	Volume of hydrogen / cm ³
0	0
20	50
40	75
60	88
80	92
100	100
120	100

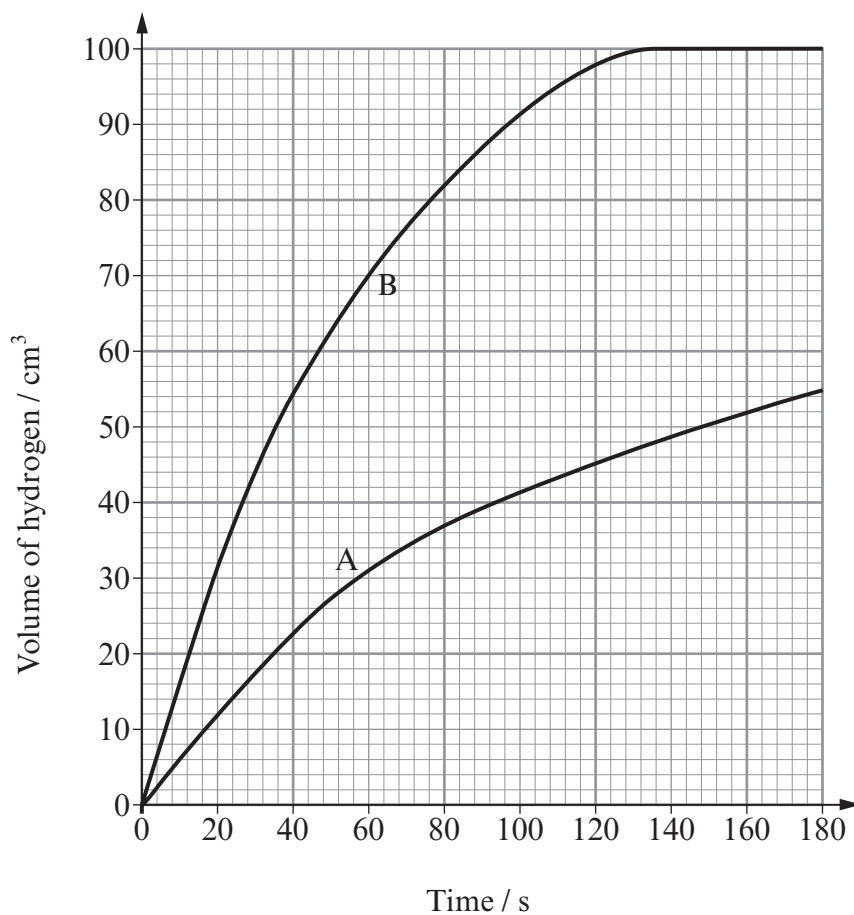
Table 2



(a) The results for experiments **A** and **B** have already been plotted on the grid below.

On the same grid, plot the results for experiment **C** and draw a line of best fit.

[3]



(b) (i) State in which experiment the reaction begins most rapidly and **use the graph** to explain your choice. [2]

.....

.....

(ii) By referring to Table 1 give an explanation of your answer in part (i). [1]

.....

.....

(c) State the volume of hydrogen evolved after 30 seconds in experiment **B**. [1]

.....



- (d) Using **only** the values in Table 1, show that the acid is in excess in experiment C. [2]

.....

.....

.....

- (e) (i) In experiment A, 0.061 g of magnesium produces 60 cm³ of hydrogen. If 0.122 g of magnesium were used, under the same conditions, then 120 cm³ would be produced. Explain why using 0.610 g would not produce 600 cm³ of hydrogen. [1]

.....

.....

- (ii) Calculate the volume of hydrogen produced using 0.610 g of magnesium. [2]

(1 mole of gas molecules occupies 24 dm³ at 25 °C)

.....

.....

.....

- (f) State one method of slowing down the reaction in experiment C and use collision theory to explain your choice. Assume that the quantities of magnesium and hydrochloric acid are the same as those in Table 1. [3]

QWC [1]

.....

.....

.....

.....

Total [16]



8. (a) The vast majority of motor vehicles worldwide are powered by petrol or diesel which come from crude oil. Give **two** reasons why we cannot rely indefinitely on oil as a source of transport fuel. [2]

.....

.....

.....

.....

- (b) Many vehicle manufacturers around the world have made the development of alternative fuels a priority. One such fuel being studied is hydrogen.

Its main advantage is that the only waste product is water, however hydrogen does not occur naturally on Earth. It is produced by passing an electric current through water.

- (i) A leading car manufacturer said,
“Cars powered by hydrogen will be pollution-free”.
Give **two** reasons why this is not necessarily true.

[2]
QWC [1]

.....

.....

.....

.....

- (ii) A spokesperson for a safety group said,
“Hydrogen can burn explosively. It must not be used in cars unless it is 100% safe”.
State, giving a reason, whether you agree with this. [1]

.....

.....



- (c) The first line in the visible atomic emission spectrum for hydrogen has a wavelength of 656 nm, while that for helium has a wavelength of 707 nm.
State, giving a reason, which line has

(i) the higher frequency, [1]

.....
.....

(ii) the higher energy. [1]

.....
.....

- (d) The first ionisation energy of helium is 2370 kJ mol^{-1} while that of neon is 2080 kJ mol^{-1} .
Explain why neon has a lower first ionisation energy than helium. [2]

.....
.....
.....

- (e) Another noble gas is radon. Its more stable isotope ^{222}Rn has a half-life of 3.8 days, decays by α -emission and is responsible for the majority of the public exposure to ionising radiation.

(i) Give the symbol and mass number of the atom formed by the loss of one α -particle from an atom of ^{222}Rn . [1]

.....
.....

(ii) Explain why doctors are concerned that an over-exposure to radon may cause lung cancer. [1]

.....
.....

Total [12]



9. Ethanol is an important industrial chemical and can be made by the direct hydration of ethene using a phosphoric acid catalyst.



- (a) State, giving your reasons, the general conditions of temperature and pressure required to give a high equilibrium yield of ethanol in this process. [4]

QWC [1]

.....

.....

.....

.....

.....

.....

- (b) Using the standard enthalpy change for the reaction above and the standard enthalpy changes of formation ($\Delta H_f^\ominus$) given in the table below, calculate the standard enthalpy change of formation of gaseous ethanol. [3]

Compound	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
$\text{CH}_2=\text{CH}_2(\text{g})$	52.3
$\text{H}_2\text{O}(\text{g})$	-242

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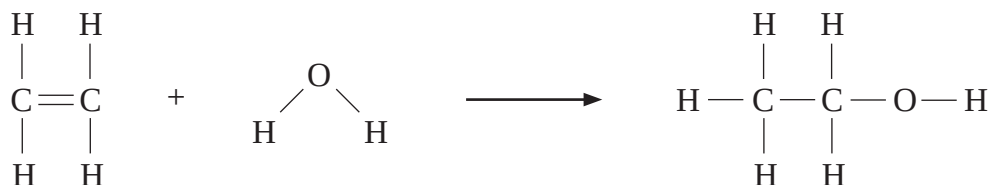
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.....

.....



- (c) Another way of calculating the enthalpy change of a reaction is by using average bond enthalpies. Use the values in the table below to calculate the enthalpy change for the direct hydration of ethene. [3]



Bond	Average bond enthalpy / kJ mol^{-1}
$\text{C} - \text{C}$	348
$\text{C} = \text{C}$	612
$\text{C} - \text{H}$	412
$\text{C} - \text{O}$	360
$\text{O} - \text{H}$	463

.....

.....

.....

.....

- (d) (i) Give a reason why the calculated value in (c) is different to the actual value, -46 kJ mol^{-1} . [1]

.....

.....

- (ii) Explain whether your answer to part (i) supports the use of average bond enthalpies to calculate the energy change for a reaction. [1]

.....

.....

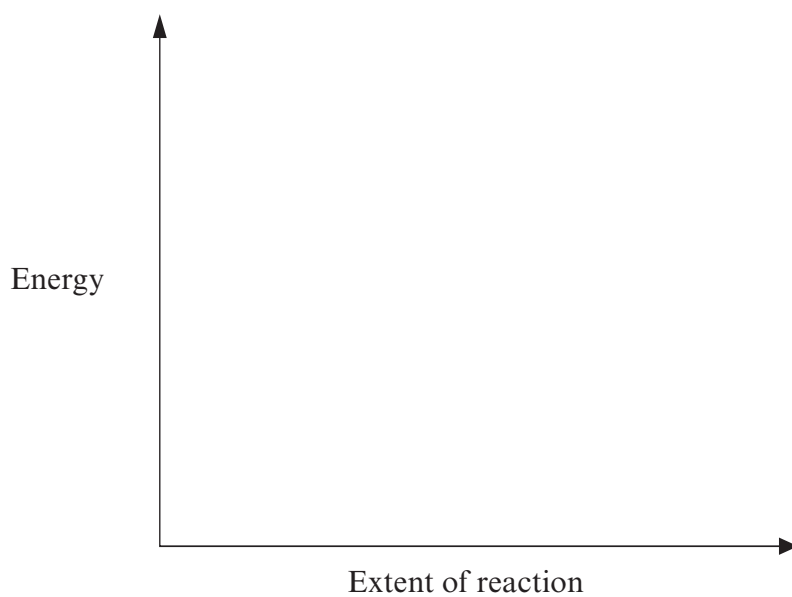


- (e) Phosphoric acid is an example of a heterogeneous catalyst.
Explain the term *heterogeneous* in this context.

[1]

- (f) (i) Sketch on the axes below the energy profile for an exothermic reaction.

[1]



- (ii) On the same axes, sketch and label the energy profile if the same reaction is carried out using a catalyst.

[1]

Total [16]



10. Berian was asked to find the identity of a Group 1 metal hydroxide by titration.

He was told to use the following method.

- Fill a burette with hydrochloric acid solution.
- Accurately weigh about 1.14 g of the metal hydroxide.
- Dissolve all the metal hydroxide in water, transfer the solution to a volumetric flask then add more water to make exactly 250 cm^3 of solution.
- Accurately transfer 25.0 cm^3 of this solution into a conical flask.
- Add 2-3 drops of a suitable indicator to this solution.
- Carry out a rough titration of this solution with the hydrochloric acid.
- Accurately repeat the titration several times and calculate a mean titre.

Berian's results are shown below:

Mass of metal hydroxide = 1.14 g

Concentration of acid solution = 0.730 g HCl in 100 cm^3 of water

Mean titre = 23.80 cm^3

- (a) Give a reason why Berian does not simply add 1.14 g of metal hydroxide to 250 cm^3 of water. [1]

.....
.....

- (b) Name a suitable piece of apparatus for transferring 25.0 cm^3 of the metal hydroxide solution to a conical flask. [1]

-
(c) State why he adds an indicator to this solution. [1]

-
(d) Suggest why Berian was told to carry out a rough titration first. [1]

.....
.....



- (e) Explain why he carried out several titrations and calculated a mean value. [1]

.....

.....

- (f) The equation for the reaction between the metal hydroxide and hydrochloric acid is given below. M represents the symbol of the Group 1 metal.



- (i) Calculate the concentration, in mol dm^{-3} , of the HCl in the burette. [2]

.....

.....

- (ii) Calculate the number of moles of HCl used in the titration. [1]

.....

.....

- (iii) Deduce the number of moles of MOH in 25.0 cm^3 of the solution. [1]

.....

.....

- (iv) Calculate the total number of moles of MOH in the original solution. [1]

.....

.....

- (v) Calculate the relative molecular mass of MOH. [1]

.....

.....

- (vi) Deduce the Group 1 metal in the hydroxide. [1]

.....

.....

Total [12]

Section B Total [70]



[illegible]



GCE AS/A level

1091/01-A

**CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1**

P.M. TUESDAY, 15 May 2012

THE PERIODIC TABLE

Group 1 2 3 4 5 6 7 0

Period 1 2 3 4 5 6 7

s Block

p Block

d Block

f Block

1.01 H Hydrogen 1

6.94 Li Lithium 3

9.01 Be Beryllium 4

23.0 Na Sodium 11

24.3 Mg Magnesium 12

39.1 K Potassium 19

87.6 Sr Strontium 38

137 Ba Barium 56

(223) Fr Francium 87

45.0 Sc Scandium 21

88.9 Y Yttrium 39

139 La Lanthanum 57

(227) Ac Actinium 89

47.9 Ti Titanium 22

91.2 Zr Zirconium 40

179 Hf Hafnium 72

50.9 V Vanadium 23

92.9 Nb Niobium 41

181 Ta Tantalum 73

52.0 Cr Chromium 24

95.9 Mo Molybdenum 42

184 W Tungsten 74

54.9 Mn Manganese 25

98.9 Tc Technetium 43

186 Re Rhenium 75

55.8 Fe Iron 26

101 Ru Ruthenium 44

190 Os Osmium 76

58.7 Ni Nickel 28

106 Pd Palladium 46

195 Pt Platinum 78

58.9 Co Cobalt 27

103 Rh Rhodium 45

192 Ir Iridium 77

63.5 Cu Copper 29

108 Ag Silver 47

197 Au Gold 79

65.4 Zn Zinc 30

112 Cd Cadmium 48

201 Hg Mercury 80

Key		
A_r	Symbol	relative atomic mass
Name		atomic number
Z		

10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
-------------------------	--------------------------	----------------------------	--------------------------	----------------------------	--------------------------

27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
-------------------------------	-----------------------------	-------------------------------	---------------------------	------------------------------	---------------------------

69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
-----------------------------	-------------------------------	-----------------------------	------------------------------	-----------------------------	-----------------------------

115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
---------------------------	------------------------	-----------------------------	------------------------------	--------------------------	--------------------------

204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
-----------------------------	-------------------------	----------------------------	-------------------------------	-------------------------------	----------------------------

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
---------------------------	---------------------------------	------------------------------	---------------------------------	-----------------------------	-------------------------------	-------------------------------	----------------------------	-------------------------------	----------------------------	---------------------------	----------------------------	------------------------------	-----------------------------

► Lanthanoid elements

232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103
----------------------------	-----------------------------------	---------------------------	--------------------------------	--------------------------------	--------------------------------	-----------------------------	--------------------------------	----------------------------------	----------------------------------	-------------------------------	-----------------------------------	--------------------------------	----------------------------------

► Actinoid elements



GCE MARKING SCHEME

**CHEMISTRY
AS/Advanced**

SUMMER 2012

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2012 examination in GCE CHEMISTRY. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

CH1

Section A

1.  [1]

2. $1/12^{\text{th}}$ mass of one atom of carbon-12. [1]

3. C [1]

4. (a)

C	O	Cl	
<u>12.1</u>	<u>16.2</u>	<u>71.7</u>	
12	16	35.5	(1)
1.01	1.01	2.02	
1	1	2	
Formula = COCl_2			(1) [2]

 (b) M_r / molecular mass / number of atoms of any element in compound [1]

5. (a) **C B D E A** [2]
 (1 mark if one mistake e.g. **A** in wrong place)

 (b) **Z** (1)

 Si is in Group 4 therefore large jump in ionisation energy would be after the fourth ionisation, not before it / **W**, **X** and **Y** have a large jump before the fourth ionisation energy so cannot be in Group 4 (1)

[2]

Total [10]

Section B

6. (a) (i) 12 [1]
- (ii) 14 [1]
- (iii) Percentage / abundance / ratio / proportion of each isotope [1]
- (b) (i) 0.125 g [1]
- (ii) e.g. Cobalt-60 (1) in radiotherapy (1) / Carbon-14 (1) in radio carbon dating (1) / Iodine-131 (1) as a tracer in thyroid glands (1) [2]
- (c) (i) Atoms are hit by an electron beam / electrons fired from an electron gun (and lose electrons) [1]
- (ii) To be able to accelerate the ions (to high speed) / so that they can be deflected by a magnetic field
- no credit for 'so that *atoms* can be deflected...'
[1]
- (iii) They are deflected by a magnetic field / according to the m/z ratio [1]
- (d)
- | 1s | 2s | 2p | 3s | 3p |
|---|---|---|--|--|
| <div style="border: 1px solid black; display: inline-block; width: 30px; height: 30px; line-height: 30px;">↓↑</div> | <div style="border: 1px solid black; display: inline-block; width: 30px; height: 30px; line-height: 30px;">↓↑</div> | <div style="display: inline-block; width: 60px; height: 30px; border: 1px solid black; position: relative;"> <div style="position: absolute; left: 0; top: 0; width: 33%; height: 30px; line-height: 30px;">↓↑</div> <div style="position: absolute; left: 33%; top: 0; width: 33%; height: 30px; line-height: 30px;">↓↑</div> <div style="position: absolute; left: 66%; top: 0; width: 33%; height: 30px; line-height: 30px;">↓↑</div> </div> | <div style="border: 1px solid black; display: inline-block; width: 30px; height: 30px;"></div> | <div style="display: inline-block; width: 60px; height: 30px; border: 1px solid black; position: relative;"> <div style="position: absolute; left: 0; top: 0; width: 33%; height: 30px;"></div> <div style="position: absolute; left: 33%; top: 0; width: 33%; height: 30px;"></div> <div style="position: absolute; left: 66%; top: 0; width: 33%; height: 30px;"></div> </div> |
- [1]
- (e) (i) $\text{Mg}_3\text{N}_2 + 6\text{H}_2\text{O} \longrightarrow 3\text{Mg}(\text{OH})_2 + 2\text{NH}_3$ [1]
- (ii) moles $\text{Mg}(\text{OH})_2 = 1.75/58.32 = 0.0300$ (1)
- moles $\text{Mg}_3\text{N}_2 = 0.0100$ (1)
- mass $\text{Mg}_3\text{N}_2 = 0.01 \times 100.9 = 1.01 \text{ g}$ (1) [3]
- must be **3 significant figures** to gain third mark

Total [14]

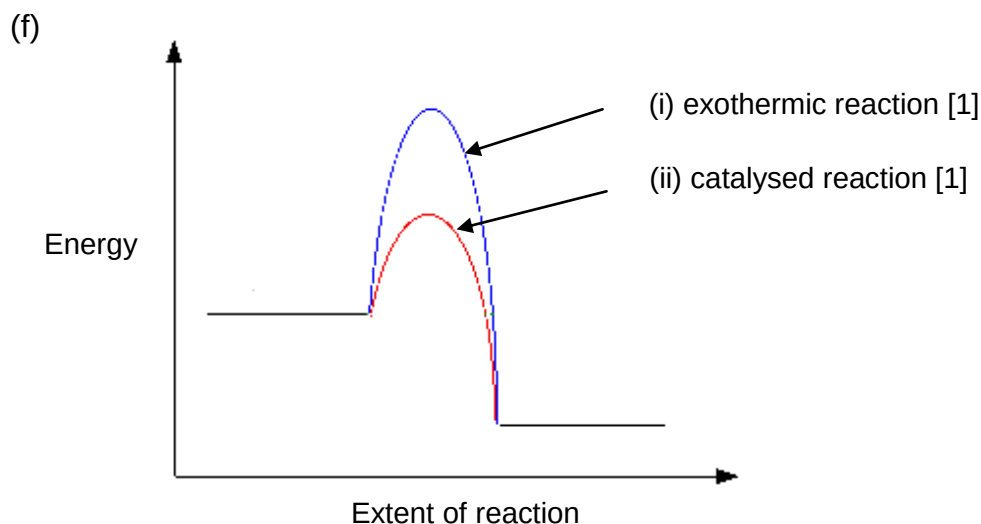
7. (a) Plotting (2)
- Best fit line (1) [3]
- (b) (i) C (1)
- Curve steeper (1) [2]
- (ii) Concentration of acid is greatest [1]
- (c) $44 \text{ cm}^3 (\pm 1 \text{ cm}^3)$ [1]
- (d) Moles Mg = $0.101/24.3 = 0.00416$ (1)
- Moles HCl = $2 \times 0.02 = 0.04$ (1) [2]
- (e) (i) Mg is not the limiting factor /
Mg now in excess / HCl not in excess [1]
- (ii) Moles acid = $0.5 \times 0.04 = 0.02$ (1)
- Volume $\text{H}_2 = 0.01 \times 24 = 0.24 \text{ dm}^3$
- correct unit needed (1) [2]
- (f) Lower the temperature of the acid (1)
- Reactants collide with less energy (1)
- Fewer molecules that have the required activation energy (1) [3]
- or Use pieces of magnesium (1) less surface area (1) less chance
of successful collisions (1)
- QWC Selection of a form and style of writing appropriate to purpose
and to complexity of subject matter. [1]

Total [16]

8. (a) Oil is non-renewable / will run out (1)
 Contribution of CO₂ to global warming (1)
 Oil has other important uses (1) [2]
 (Maximum 2 marks)
- (b) (i) Power stations / fossil fuels used to generate the electricity needed to make H₂ (1)
 Resulting in CO₂ formation (global warming) / acid rain (1)
 Manufacture of car produces pollution (1) [2]
 (Maximum 2 marks)
- QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning [1]
- (ii) Disagree, no fuel is 100% safe / petrol can burn explosively
 (Accept agree if valid reason given e.g. in terms of lives being lost) [1]
- (c) (i) Hydrogen since frequency is inversely proportional to wavelength / smaller wavelength [1]
- (ii) Hydrogen since energy is proportional to frequency / greater frequency / $E = hf$ [1]
- (d) In Ne greater shielding of *outer* electron (1) outweighs larger nuclear charge (1) / He has greater effective nuclear charge (1) / He *outer* electron closer to nucleus (1)
 - max 1 if no reference to *outer* electron [2]
 (Maximum 2 marks)
- (e) (i) ²¹⁸Po [1]
- (ii) Since radon is a gas / inhaled, α particles will be given off in the lungs (which may cause cancer) [1]

Total [12]

9. (a) Low temperature (1)
As temperature is decreased equilibrium moves in exothermic direction. (1)
- High pressure (1)
As pressure is increased equilibrium moves towards side with smaller number of gas moles (1) [4]
- QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]
- (b) $\Delta H_{\text{reaction}} = \Delta H_f \text{ products} - \Delta H_f \text{ reactants}$ (1)
 $-46 = \Delta H_f \text{ ethanol} - (52.3 - 242)$
 $\Delta H_f \text{ ethanol} = -46 - 189.7$ (1)
 $\Delta H_f \text{ ethanol} = -235.7 \text{ kJ mol}^{-1}$ (1) [3]
- (c) Bonds broken = $1648 + 612 + 926 = 3186 \text{ kJ mol}^{-1}$ (1)
 Bonds formed = $2060 + 348 + 360 + 463 = 3231 \text{ kJ mol}^{-1}$ (1)
 $\Delta H_{\text{reaction}} = 3186 - 3231 = -45 \text{ kJ mol}^{-1}$ (1) [3]
- (d) (i) Average bond enthalpies used (not actual ones) [1]
 (ii) Yes, since answers are close to each other [1]
- (e) Catalyst is in different (physical) state to reactants [1]



Total [16]

10. (a) Weighing bottle would not have been washed / difficult to dissolve solid in volumetric flask / final volume would not necessarily be 250 cm³ [1]
- (b) Pipette [1]
- (c) To show the end point / when to stop adding acid / when it's neutralised [1]
- (d) So that a certain volume of acid can be added quickly before adding drop by drop / to save time before doing accurate titrations / to give a rough idea of the end point [1]
- (e) To obtain a more reliable value [1]
- (f) (i) Moles = $0.730/36.5 = 0.0200$ (1)
- Concentration = $0.02/0.1 = 0.200 \text{ mol dm}^{-3}$ (1) [2]
- (ii) Moles = $0.2 \times 0.0238 = 0.00476$ [1]
- (iii) 0.00476 [1]
- (iv) $0.00476 \times 10 = 0.0476$ [1]
- (v) $M_r = 1.14/0.0476 = 23.95$ [1]
- (vi) Lithium [1]

- mark consequentially throughout (f)

Total [12]

Section B Total [70]

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1091/01

CHEMISTRY CH1

P.M. FRIDAY, 13 January 2012

1½ hours

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
- copy of the **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

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

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

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

You are reminded that marking will take into account the Quality of Written Communication used in all written answers.

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-6	
B	7	
	8	
	9	
	10	
TOTAL MARK		

1091
010001



SECTION A

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

1. By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of a sulfur atom. [1]

1s	2s	2p	3s	3p

2. State the number of protons present in an aluminium ion, Al^{3+} . [1]

- A** 10
B 13
C 14
D 16

3. Weak *acids* establish a *dynamic equilibrium* when dissolved in water. Give brief explanations of what is meant by the following terms. [2]

Acid

.....

Dynamic equilibrium

.....

.....



4. In an experiment, Aled titrated 25.00 cm^3 of potassium hydroxide solution with hydrochloric acid, and obtained the following results.

	1	2	3	4
Initial burette reading / cm^3	0.10	0.25	1.20	21.30
Final burette reading / cm^3	20.85	20.45	21.30	41.60
Volume used / cm^3				

- (a) Complete the table to show the volume used in each titration. [1]
- (b) Calculate the mean volume that Aled should use for his further calculations. [1]

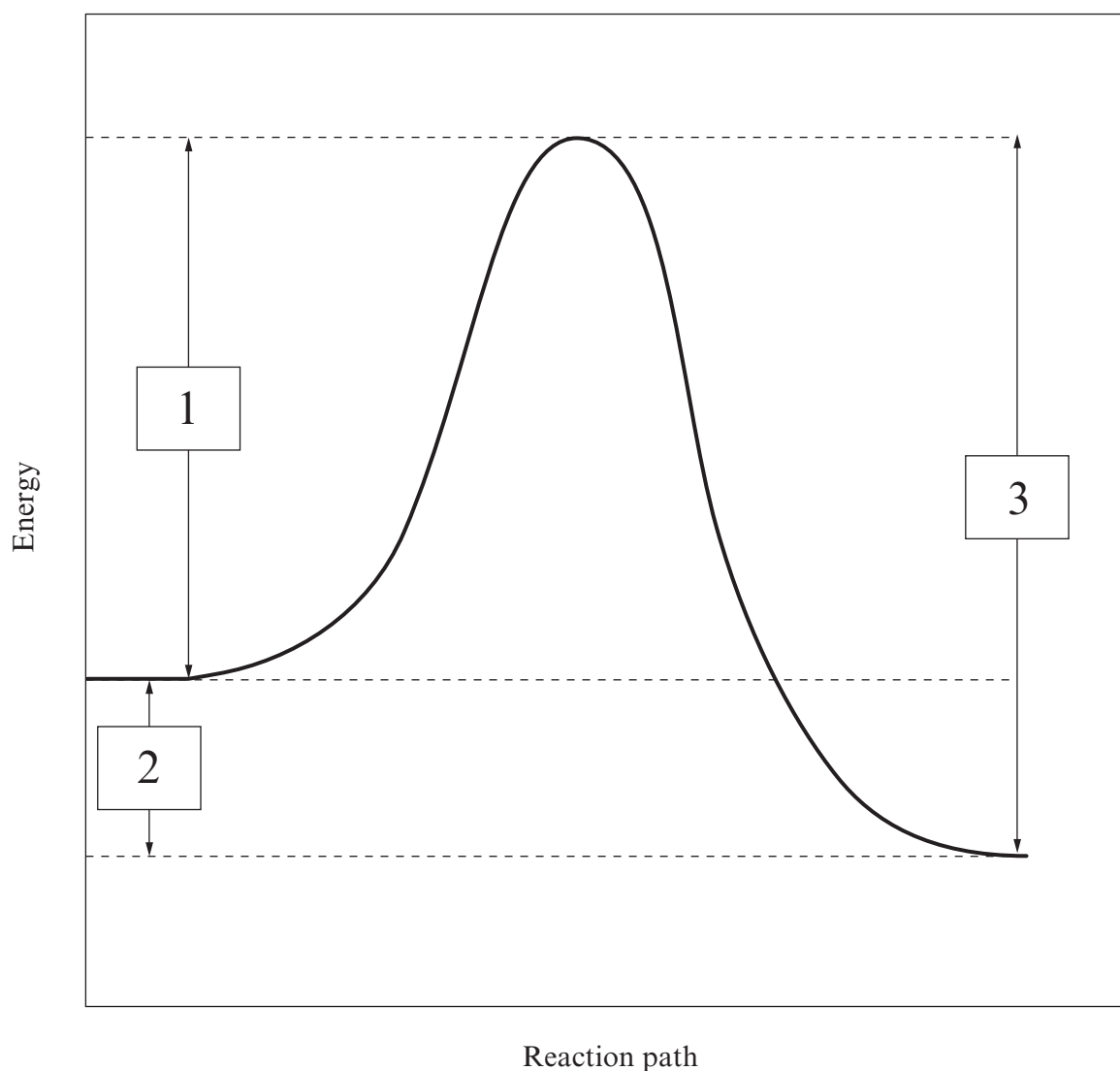
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..... cm^3



5. The diagram below shows the reaction profile for a chemical reaction. Three energy differences are marked on it with arrows labelled 1, 2 and 3.



Select which of the following correctly assigns the three energy differences.

	Activation energy of forward reaction	Activation energy of reverse reaction	Enthalpy change of reaction
A	1	3	2
B	2	1	3
C	2	3	1
D	3	2	1

..... [1]



6. (a) Mesitylene is a hydrocarbon composed of 89.9% carbon and 10.1% hydrogen by mass. Calculate the **empirical** formula of this compound. [2]

.....

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- (b) The relative molecular mass of mesitylene is 120.1. Give the **molecular** formula of this compound. [1]

.....

.....

Total Section A [10]

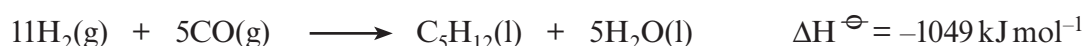


SECTION B

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

7. Hydrocarbons play an important role in our life today, both as fuels and as raw materials for the synthesis of a wide range of materials. Most hydrocarbons are isolated from crude oil, however there is increasing interest in alternative methods of obtaining these molecules.

- (a) One route to the production of hydrocarbons is the Fischer-Tropsch process, which uses hydrogen and carbon monoxide as starting materials to produce a range of molecules. The equation below shows the production of pentane, C_5H_{12} , by this route.



The enthalpies of formation of some of these substances are given in the table below.

Substance	Standard enthalpy of formation, $\Delta H_f^\ominus$ / kJ mol^{-1}
Hydrogen, $\text{H}_2(\text{g})$	0
Carbon monoxide, $\text{CO}(\text{g})$	-111
Water, $\text{H}_2\text{O}(\text{l})$	-286

- (i) State the temperature and pressure used as standard conditions. Give units for each. [2]

Temperature Pressure

- (ii) State why the standard enthalpy of formation for hydrogen gas is 0 kJ mol^{-1} . [1]

.....

.....

.....

- (iii) Use the values given to calculate the standard enthalpy of formation for pentane, $\text{C}_5\text{H}_{12}(\text{l})$, in kJ mol^{-1} . [3]

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.....



(b) The Fischer-Tropsch process uses a heterogeneous catalyst containing iron.

(i) State what is meant by the term *heterogeneous* in this context. [1]

.....

.....

(ii) Explain how a catalyst increases the rate of a chemical reaction. [2]

.....

.....

(iii) Chemical manufacturers consider catalysts to be a key part of production methods that have the minimum possible effect on the environment ('Green Chemistry'). Give **one** reason why the use of catalysts reduces the effect on the environment.[1]

.....

.....

.....

(iv) An alternative method of increasing the rate of a chemical reaction is to increase the temperature. Explain why temperature affects the rate of a chemical reaction. [3]
QWC [1]

.....

.....

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.....



- (c) One method of producing the hydrogen gas required for the Fischer-Tropsch process is to use the reversible reaction below.



- (i) State and explain the effect, if any, of increasing pressure on the yield of hydrogen gas produced at equilibrium. [2]

.....

.....

.....

- (ii) State and explain the effect, if any, of increasing temperature on the yield of hydrogen gas produced at equilibrium. [2]

.....

.....

- (iii) This reaction uses a catalyst based on iron oxide. State the effect of using a catalyst on the position of equilibrium. [1]

.....

Total [19]



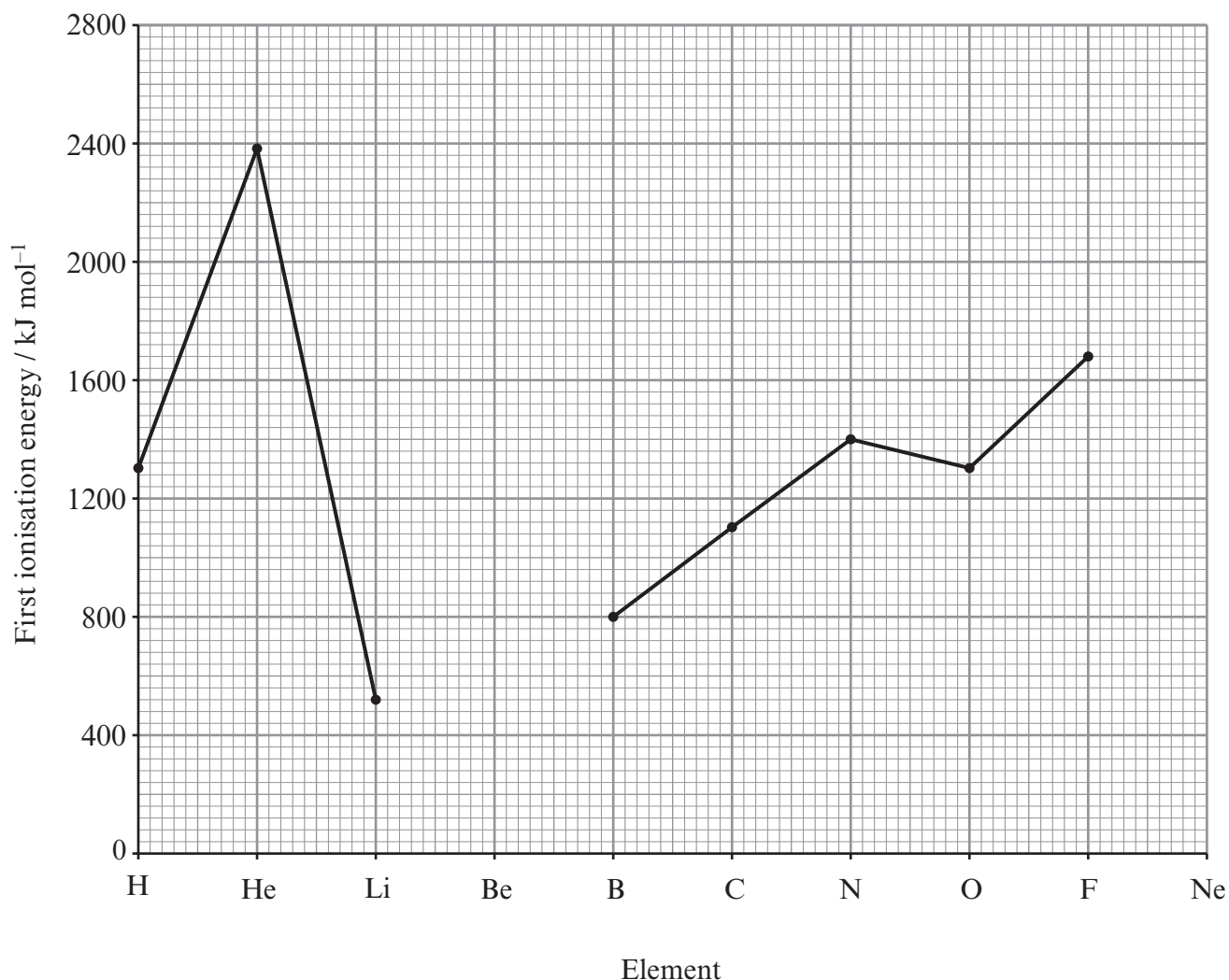
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1091
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8. The graph below shows the first molar ionisation energies for a selection of the first 10 elements.



- (a) Complete the graph above by adding points that represent the first ionisation energies for the elements beryllium and neon. [2]
- (b) Write an equation to represent the first ionisation of a beryllium atom. [1]

.....



(c) Explain why

(i) helium has a higher first ionisation energy than hydrogen, [2]

.....

.....

.....

(ii) nitrogen has a higher first ionisation energy than oxygen. [2]

.....

.....

.....

(d) The atomic emission spectrum can be used to calculate the ionisation energy of hydrogen.

(i) Explain how the lines in the atomic emission spectrum are formed. [3]
QWC [1]

.....

.....

.....

.....

.....

(ii) Explain how the ionisation energy of a hydrogen atom can be calculated from a feature in the atomic emission spectrum. [3]

.....

.....

.....

.....

Total [14]



9. The metal lead was one of the first in common use and even as far back as two thousand years ago, tens of thousands of tonnes of the metal were being produced every year in the Roman Empire. It is still in common use today, although many of its former uses have declined due to the toxic nature of the element.

- (a) Lead is commonly extracted from lead(II) sulfide, PbS. Initially this ore is heated in a limited supply of air to produce lead(II) oxide, PbO, giving off sulfur dioxide gas, SO₂.



If 20 kg of lead(II) sulfide were heated in air, calculate the mass of lead(II) oxide formed.

[3]

.....

.....

.....

.....

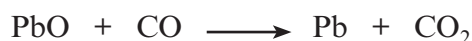
Mass of lead(II) oxide formed = ... kg

- (b) Metallic lead can then be obtained from lead(II) oxide by one of two methods:

Method 1: Reduction with a fresh supply of lead(II) sulfide in the absence of air



Method 2: Reduction by carbon monoxide in a blast furnace



- (i) Both methods for producing lead release waste gases. Give an environmental problem associated with each of these gases. [2]

Sulfur dioxide, SO₂

.....

Carbon dioxide, CO₂

.....

- (ii) The atom economy for producing lead by method 1 is 90.7%.

I. Calculate the atom economy for producing lead by method 2. [2]

.....

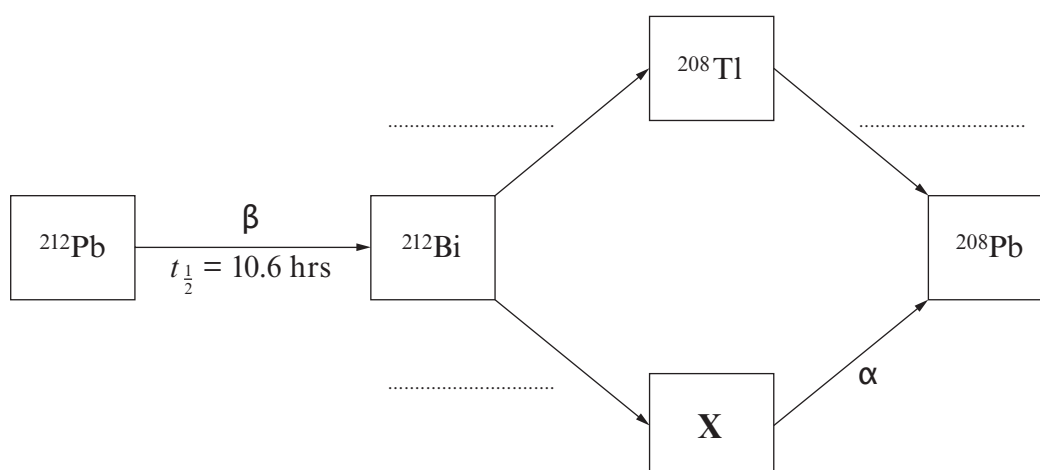
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- II. Atom economy is one factor used in 'Green Chemistry' to assess the advantages and disadvantages of different routes to produce the same product. State, giving a reason, which of the two alternative methods would be considered to have the more advantageous atom economy. [1]
-
-

- (c) Lead has a wide range of isotopes, some of which are stable and others that are radioactive. Radioactive lead-212 decays to eventually form the stable isotope ^{208}Pb . This process involves the decay of ^{212}Pb into ^{212}Bi followed by two alternative routes that both lead to ^{208}Pb , as shown in the scheme below.



- (i) Give the correct symbol and mass number of the isotope indicated by X on the scheme above. [2]

Symbol Mass Number

- (ii) Two arrows have been labelled with α and β . Label the remaining **three** arrows to indicate the nature of the radioactive decay occurring in each step. [2]



- (iii) It is not possible to identify whether γ -radiation is also produced during any of the radioactive decay processes from the information given in the scheme.

State what is meant by γ -radiation and why it cannot be identified from the information given in the scheme. [2]

.....

.....

.....

- (iv) A sample of 24 mg of ^{212}Pb was allowed to stand for 31.8 hours. Calculate the mass of ^{212}Pb that would remain after this time. [2]

.....

.....

..... mg

- (d) Naturally-occurring lead consists of a mixture of stable isotopes which include ^{206}Pb , ^{207}Pb and ^{208}Pb . The relative amounts of these isotopes can vary between different sources. The abundance of each isotope in a sample is given below.

Isotope	Relative isotopic mass	Percentage abundance
^{206}Pb	206.0	25.48%
^{207}Pb	207.0	22.12%
^{208}Pb	208.0	52.40%

Calculate the relative atomic mass (A_r) for this sample of lead. Give your answer to **four significant figures**. [3]

.....

.....

.....

.....

Total [19]



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10. Callum and Carys wish to measure the enthalpy change of the reaction of aqueous copper(II) sulfate with zinc powder. The reaction that occurs is:



- (a) Callum prepares copper(II) sulfate solution from hydrated copper(II) sulfate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$.

- (i) Calculate the relative molecular mass of hydrated copper(II) sulfate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$. [1]

.....

.....

- (ii) Callum measures a mass of hydrated copper(II) sulfate and uses this to make exactly 250.0cm^3 of copper(II) sulfate solution of concentration 0.250mol dm^{-3} .

- I. Calculate the mass of hydrated copper(II) sulfate required to prepare this solution. [2]

.....

.....

.....

Mass of hydrated copper(II) sulfate = ... g

- II. Describe, giving full practical details, how Callum should prepare the 250.0cm^3 of copper(II) sulfate solution. [5]

QWC [1]

.....

.....

.....

.....

.....

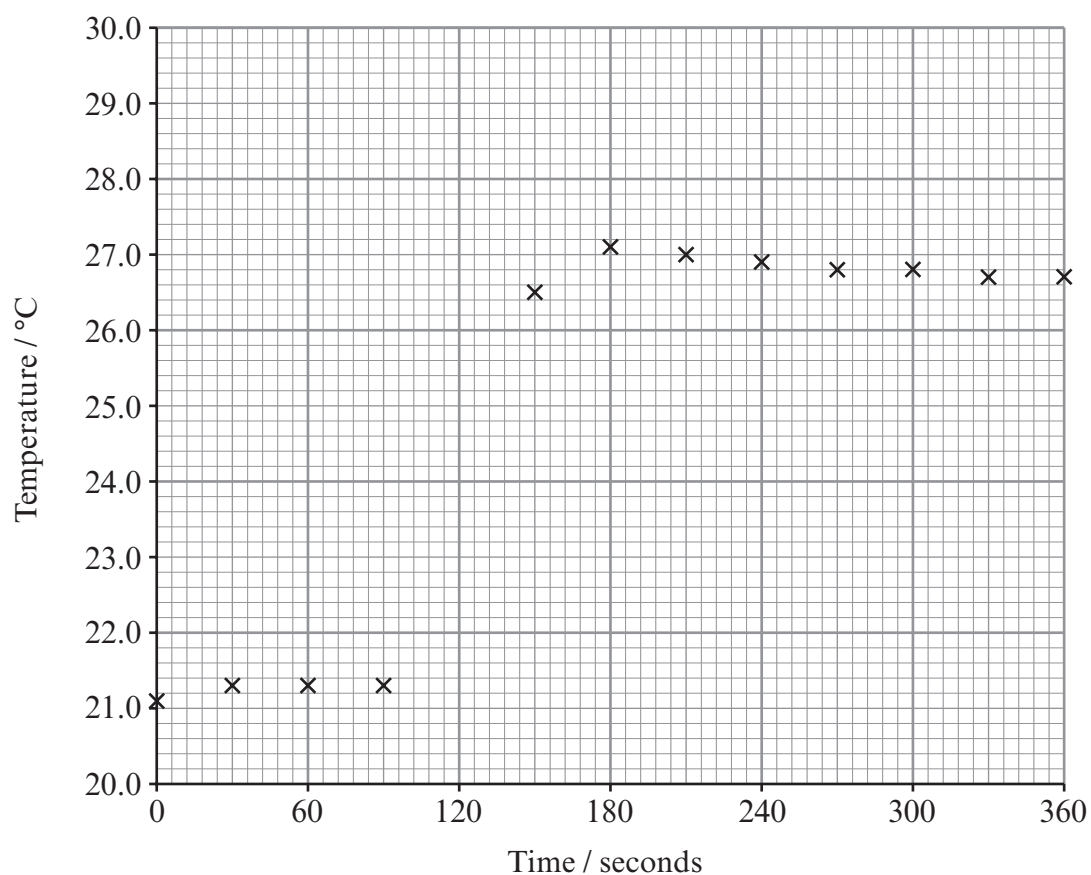
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- (b) In order to measure the enthalpy change, Carys carried out the reaction between zinc powder and their copper(II) sulfate solution in an insulated vessel. She measured the temperature in the vessel at 30 second intervals, before, during and after the reaction. The zinc powder was added to the copper(II) sulfate solution at 120 seconds. The temperatures recorded were plotted on the graph below.



- (i) Explain why zinc powder is used in this experiment rather than pieces of zinc metal. [2]

.....

.....

- (ii) Draw lines to complete the graph, and use these to find the maximum temperature change.

Maximum temperature change °C [2]

- (iii) In this experiment, Carys used 50.00 cm³ of the copper(II) sulfate solution prepared by Callum and added 0.400 g of zinc powder.

- I. Calculate the number of moles of copper(II) sulfate present in this solution. [1]

.....

.....

- II. The sample of zinc metal used contained 6.12×10^{-3} moles. State why this value, rather than the number of moles of copper(II) sulfate, is used to calculate the enthalpy change of the reaction. [1]

.....

.....

- III. The enthalpy change can be calculated using the expression below.

$$\Delta H = - \frac{mc\Delta T}{n}$$

Where: m is the mass of the copper(II) sulfate solution (50 g)

ΔT is the change in temperature in °C

n is the number of moles of zinc

c is the specific heat capacity of the solution which equals $4.18 \text{ J g}^{-1} \text{ °C}^{-1}$

Calculate the enthalpy change for the reaction in kJ mol^{-1} . [2]

.....

.....

.....

.....



- IV. Give a reason why the sign of the enthalpy value calculated is different from the sign of the temperature change measured. [1]

.....

.....

Total [18]

Total Section B [70]



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GCE AS/A level

1091/01-A

**CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1**

P.M. FRIDAY, 13 January 2012

THE PERIODIC TABLE

Period **1** **2** **3** **4** **5** **6** **7** **0**

Group

s Block

1	1.01 H Hydrogen 1	4.00 He Helium 2
---	-----------------------------------	----------------------------------

2	6.94 Li Lithium 3	9.01 Be Beryllium 4
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12
4	39.1 K Potassium 19	40.1 Ca Calcium 20
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38
6	133 Cs Caesium 55	137 Ba Barium 56
7	(223) Fr Francium 87	(226) Ra Radium 88

Key		
A_r	Symbol	relative atomic mass
Name		atomic number
Z		

45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
139 La Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86

p Block

d Block

f Block

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103

► Lanthanoid elements

► Actinoid elements



GCE MARKING SCHEME

CHEMISTRY
AS/Advanced

JANUARY 2012

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2012 examination in GCE CHEMISTRY. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

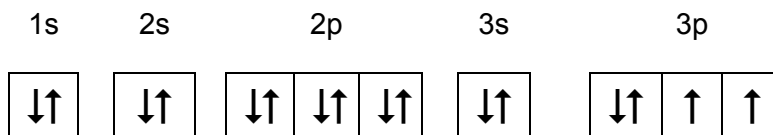
WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

Unit	Page
CH1	1
CH2	6
CH4	11

GCE Chemistry – CH1

SECTION A

Q.1



[1]

Q.2 B / 13

[1]

Q.3 Acid: Proton donor (1)

Dynamic equilibrium: Reversible reaction where the **rate** of forward and reverse reactions is equal (1)

[2]

Q.4 (a)

	1	2	3	4
Volume used / cm ³	20.75	20.20	20.10	20.30

[1]

(b) 20.20 cm³

[1]

Q.5 A

[1]

Q.6 (a) Ratio of C:H is 1:1.33 (1)
Emp. Formula = C₃H₄ (1)

[2]

(b) Molecular formula = C₉H₁₂

[1]

SECTION A TOTAL [10]

SECTION B

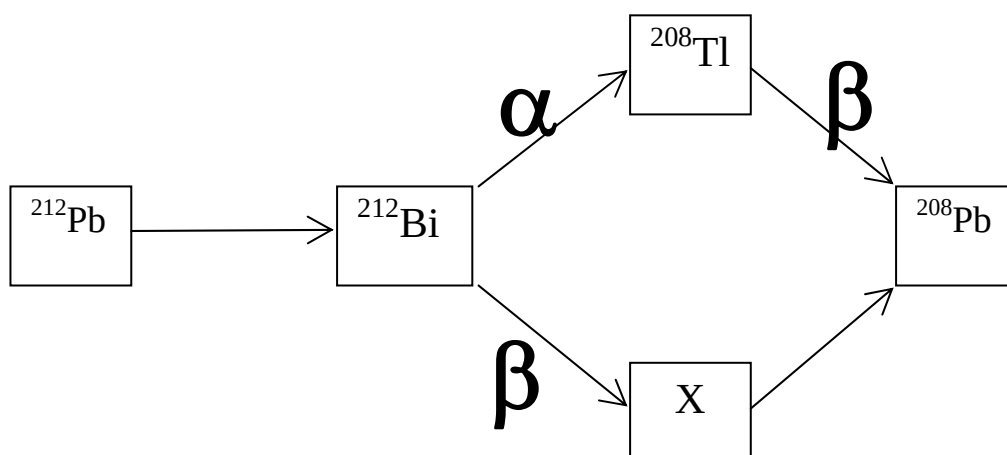
- Q.7**
- (a) (i) Temperature: 298K / 25°C (1) Pressure: 1 atm / 101.325 kPa or 100 kPa (1) [2]
- (ii) Hydrogen gas is an element in its standard state [1]
- (iii) $\Delta H = \Delta H_f (\text{C}_5\text{H}_{12}) + 5 \Delta H_f (\text{H}_2\text{O}) - 5 \Delta H_f (\text{CO}) - 11 \Delta H_f (\text{H}_2)$ (1)
- $\Delta H_f (\text{C}_5\text{H}_{12}) = -1049 - 5 (-286) + 5 (-111)$ (1)
- $\Delta H_f (\text{C}_5\text{H}_{12}) = -174 \text{ kJ mol}^{-1}$ (1) [3]
- (b) (i) Catalyst in different state to reactants [1]
- (ii) Catalysts provide an alternative route (1) with a lower activation energy (1) [2]
- (iii) Lower temperature or less time so less energy needed / Can make alternative production method possible with sustainable starting materials or less waste products [1]
- (iv) At higher temperatures particles have more energy (1)
- More collisions have energy above activation energy (1)
- (Can obtain these two marks from correctly labelled Boltzmann energy distribution plot with two temperature lines (1) and Activation energy (1))*
- Successful collisions occur more frequently (1) – 3 max [3]
- QWC: selection of a form and style of writing appropriate to purpose and to complexity of subject matter* [1]
- (c) (i) No effect (1)
- Same number of (gas) molecules on both sides of reaction (1) [2]
- (ii) Lower yield of hydrogen (1)
- Reaction shifts in endothermic direction to (try to counteract increase in temperature) (1) [2]
- (iii) No effect [1]

Total [19]

- Q.8** (a) Be: 800 - 1000 kJ mol⁻¹ (1)
 Ne: 1700 – 2300 cm⁻¹ (1) [2]
- (b) Be (g) → Be⁺ (g) + e [1]
- (c) (i) Greater nuclear charge on He (1)
 No increase in shielding / Outer electrons same distance from nucleus / Outer electrons in same shell (1) [2]
- (ii) Outer electron in O is paired in orbital / Outer electron for N is unpaired (1)
 Repulsion between paired electrons makes it easier to remove outer electron of oxygen (1) [2]
- (d) (i) Electrons excited to a higher energy level (1)
 Energy levels are quantised (1)
 Electrons drop from higher to lower energy levels (1)
 Energy is emitted as light (1) – 3 max [3]
 Lines represent the energy emitted (1) when an excited electron drops back (1) from one energy level to another (1)
QWC: legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning [1]
- (ii) Find frequency of convergence limit (1) for Lyman series (1)
 Ionisation energy is given by $E=hf$ / Energy $\propto$ frequency (1) [3]

Total [14]

- Q.9** (a) $M_r(\text{PbS}) = 239.1$ $M_r(\text{PbO}) = 223$ (1)
- Moles of PbS = $20,000 \div 239.1 = 83.65$ moles (1)
- Mass of PbO = $83.65 \times 223 \div 1000 = 18.7$ kg (1) [3]
- (b) (i) Sulfur dioxide: Acid rain (1)
- Carbon dioxide: Climate change / global warming / acidification of oceans (1) [2]
- (ii) I. Sum of M_r of reactants = $223 + 28 = 251$ (1)
- Atom economy = $(207 \div 251) \times 100 = 82.5\%$ (1) [2]
- (ii) II. Method 1 as higher atom economy means less waste / more useful product [1]
- (c) (i) Symbol = Po (1) Mass number = 212 (1) [2]
- (ii) All three arrows labelled correctly, as shows below, gives two marks
- Any two arrows labelled correctly gives one mark [2]



- (iii) γ -radiation is high energy / frequency electromagnetic waves (1)
- It affects neither atomic number nor mass number / it changes neither the number of protons nor neutrons (1) [2]
- (iv) 31.8 hours = 3 half lives (1)
- Mass remaining after 3 half lives = 3mg (1) [2]
- (d) $A_r = [(206.0 \times 25.48) + (207.0 \times 22.12) + (208.0 \times 52.40)] \div 100$ (1)
- $A_r = 207.3$ (1)
- 1 mark for correct significant figures (answer must be reasonable) [3]

Total [19]

- Q.10** (a) (i) $M_r(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = 249.7$ [1]
- (ii) I. Moles of copper(II) sulfate
 $= 0.250 \times 250/1000 = 6.25 \times 10^{-2}$ moles (1)
 Mass $= 6.25 \times 10^{-2} \times 249.7 = 15.6$ g (1) [2]
- II. 1 mark each for:
- Weighing method
 - Dissolve copper sulfate in a smaller volume of distilled water
 - Transfer to 250.0 cm^3 volumetric / standard flask
 - Use of funnel
 - Wash funnel / glass rod / beaker with distilled water into volumetric flask
 - Add distilled water up to mark
 - Shake solution / mix thoroughly 5 max [5]
- QWC: organisation of information clearly and coherently; use of specialist vocabulary where appropriate* [1]
- (b) (i) Powder has a greater surface area (1) so gives a higher rate of reaction (1) [2]
- (ii) Extrapolate lines from start (level at 21.3°C) and end (through points at 180-270 seconds) (1)
 Temperature rise $= 6.0^\circ\text{C}$ (Range $5.8\text{--}6.2^\circ\text{C}$) (1) [2]
- (iii) I. Moles $= 0.250 \times 0.05 = 1.25 \times 10^{-2}$ moles [1]
- II. Zinc is the limiting reagent / Copper(II) sulfate is in excess [1]
- III. $\Delta H = -(50) \times 4.18 \times 6.0 \div (6.12 \times 10^{-3})$ (1)
 $\Delta H = -204902 \text{ J mol}^{-1}$
 $\Delta H = -205 \text{ kJ mol}^{-1}$ (1) [2]
- IV. Enthalpy measures chemical energy, and as heat energy increases, chemical energy must decrease [1]
- Total [18]**

SECTION B TOTAL [70]

Candidate Name	Centre Number	Candidate Number
		2



GCE AS/A level

1091/01

CHEMISTRY CH1

P.M. MONDAY, 23 May 2011

1½ hours

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
- copy of the **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

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

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

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

You are reminded that marking will take into account the Quality of Written Communication used in all written answers.

Page 18 may be used for rough work.

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-6	
B	7	
	8	
	9	
	10	
	11	
TOTAL MARK		

1091/01/100001

SECTION A

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

1. Enter the number of protons, neutrons and electrons present in the atoms/ions listed in the table below.

Atom/ion	Number of protons	Number of neutrons	Number of electrons
^{24}Mg			
^{26}Mg			
$^{24}\text{Mg}^{2+}$			

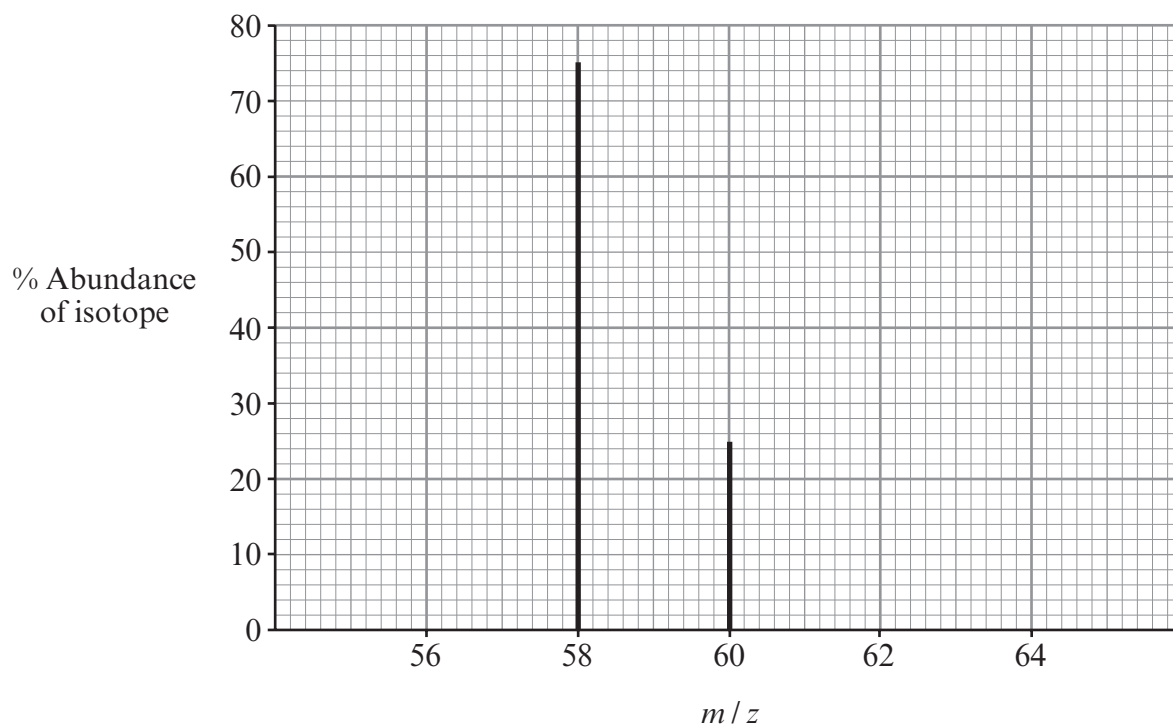
[3]

2. By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of an iron atom, Fe. The 1s, 2s and 2p orbitals are assumed to be already filled.

3s	3p	3d	4s

[1]

3. The mass spectrum of a sample of nickel is shown below.



Use the data to calculate the relative atomic mass of this sample to **three** significant figures.
You must show your working. [1]

.....

.....

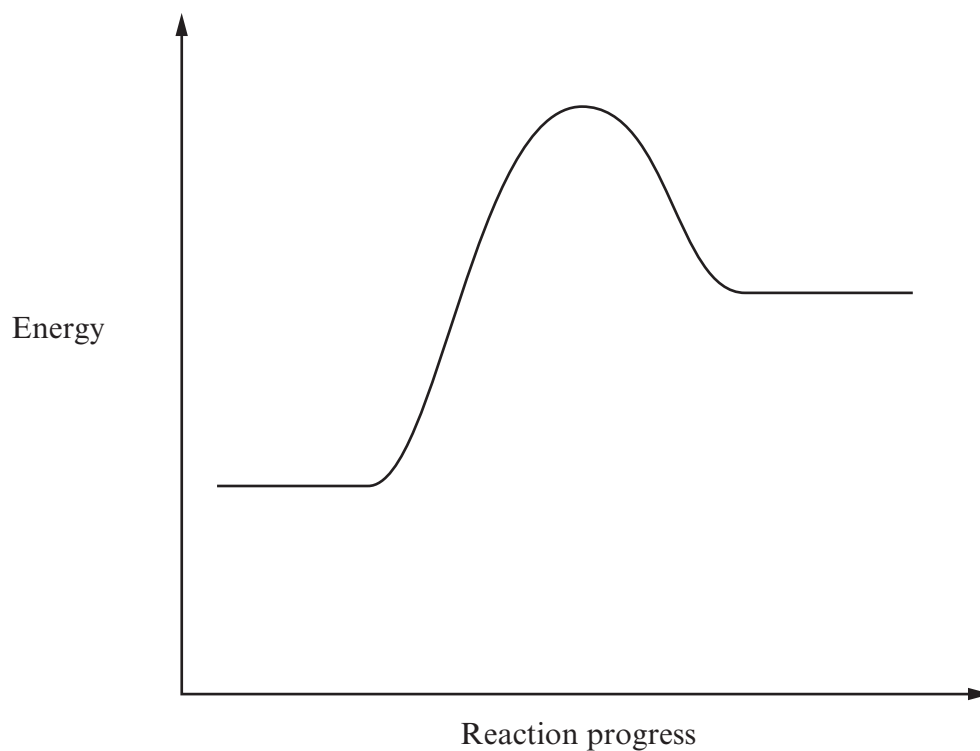
4. State which of the following letters corresponds to the number of moles of each element in 53 g of sodium carbonate, Na_2CO_3 , which has an M_r of 106.

	Na	C	O
A	0.5	0.5	0.5
B	1	0.5	3
C	1	0.5	1.5
D	2	1	3

[1]

Letter

5. Label clearly on the energy profile diagram below the forward (E_f) and reverse (E_b) activation energies and the enthalpy change (ΔH) for the reaction. [2]



6. An oxide of nitrogen has a relative molecular mass of 92 and contains 30.4 % of nitrogen and 69.6 % of oxygen, by mass.

Calculate

- (a) the empirical formula, [1]

.....

.....

.....

- (b) the molecular formula of this oxide. [1]

.....

.....

Section A Total [10]

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SECTION B

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

7. An understanding of atoms is a vital part of chemistry and this is gained by studies of spectra, ionisation energies and radioactivity.

(a) Explain briefly the origin of atomic absorption spectra in terms of electron transitions. [2]

.....

.....

.....

(b) Describe the visible emission spectrum of a hydrogen atom and explain, in terms of the atom's electronic structure, why it does not consist of a continuous, rainbow-like spectrum. [3]

QWC [1]

.....

.....

.....

.....

(c) Describe and explain the **general** change in ionisation energies

(i) across a period e.g. from Na to Ar, [2]

.....

.....

.....

(ii) down a group e.g. from Li to Cs. [2]

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(d) Complete the table below to show the effects that the emission of alpha, beta and gamma radiation have on the atomic number and mass number of a radioactive atom (by inserting e.g. +1, -2, etc). [3]

Radiation	Effect on atomic number	Effect on mass number
alpha particle		
beta particle		
gamma radiation		

(e) (i) The half-life of carbon-14 is 5500 years and that of uranium-238 is 4.5 billion years. State what is meant by the *half-life* of an isotope and explain in principle how knowledge of such half-lives is useful in studies of rocks **or** ancient organic objects. [2]

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(ii) Give **two other** uses of radioactive materials in analysis, industry or medicine. [2]

.....

.....

Total [17]

8. (a) Chloroethane, $\text{C}_2\text{H}_5\text{Cl}$, can be made from ethene by the addition of hydrogen chloride, HCl .



M_r values 28.0 36.5 64.5

- (i) Calculate the maximum possible (theoretical) mass of chloroethane obtainable from 42.0 g of ethene. [2]

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- (ii) The actual mass of chloroethane obtained from 42.0 g of ethene in an experiment was 79.0 g. Calculate the percentage yield in this experiment. [2]

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- (b) Chloroethane can be formed by another reaction as in the following equation.



M_r values 46.0 58.5 98.0 64.5 120 18.0

- (i) Describe what is meant by *atom economy*. [1]

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.....

- (ii) Calculate the % atom economy for reactions A and B. [2]

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- (iii) State which of reactions A and B is preferred, giving your reason. [1]

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(c) Describe how industry is adapting to the challenges of *Green Chemistry*. Your answer should include reference to the

- overall aim of Green Chemistry,
- materials used or produced,
- energy used.

[3]

QWC [1]

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Total [12]

1091
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9. This question is about equilibria in seawater and the effect of carbon dioxide from burning fuels on the acidity of seawater. It involves the use of Le Chatelier's principle.

(a) State *Le Chatelier's principle*. [1]

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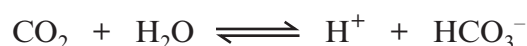
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(b) Describe in simple terms what is meant by pH. [1]

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(c) About half of the carbon dioxide formed by burning fossil fuels dissolves in the oceans. The equilibrium may be written simply as:



- (i) State, giving a reason in both cases, the effect that increasing carbon dioxide concentrations have on

I the ocean's acidity, [1]

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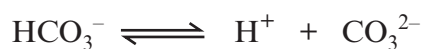
.....

II the pH of seawater. [1]

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- (ii) Another important equilibrium in the ocean is that between hydrogencarbonate and carbonate ions.

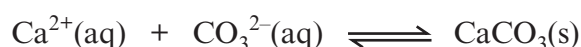


State, giving a reason, the effect of increasing acidity on the amount of carbonate present. [1]

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.....

- (iii) Many animals in the ocean make shells of calcium carbonate using the equilibrium:

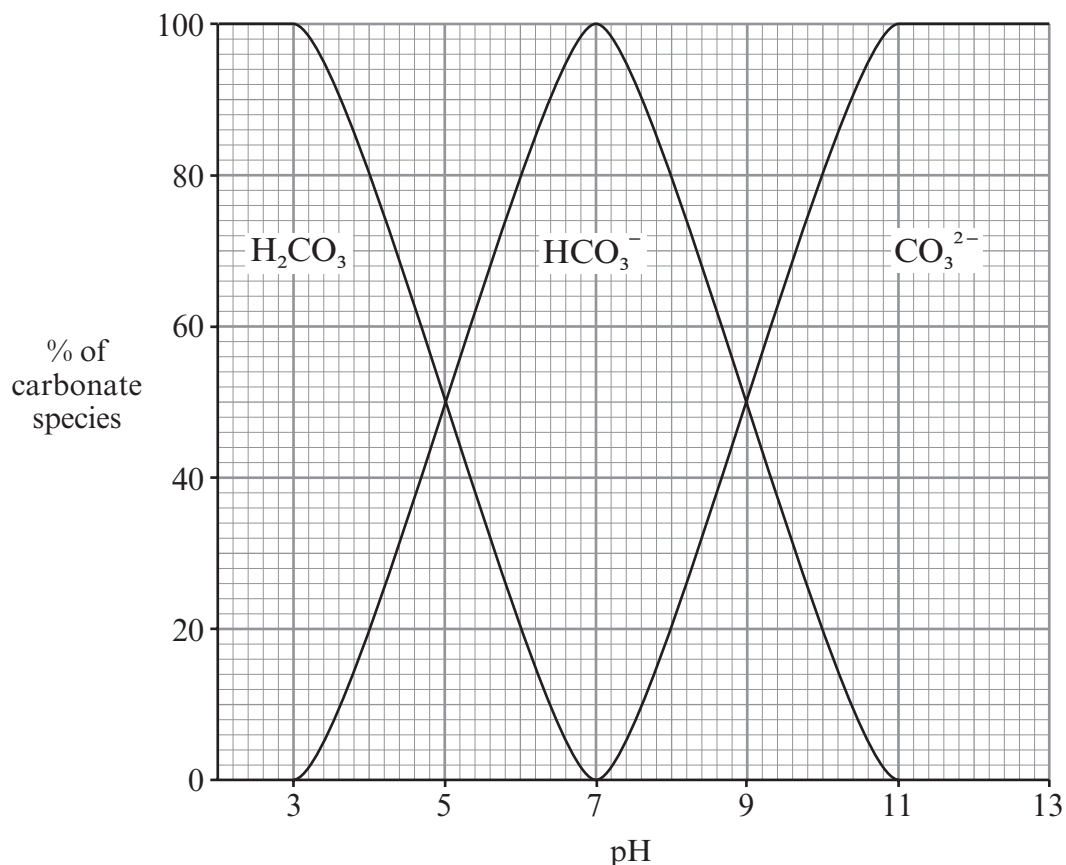


Using your answer to parts (i) and (ii), state and explain the effect of increasing acidity on their ability to make shells. [1]

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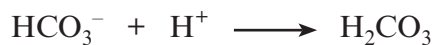
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- (d) The plot below shows how the proportions of the three carbonate species in the ocean change with pH.



Using the graph, find the pH of the ocean if it contains 90% hydrogencarbonate ions and 10% carbonate ions. [1]

- (e) A study of a model ocean included measuring a hydrogencarbonate concentration by titrating with acid.
 25.00 cm³ of hydrogencarbonate solution was neutralised by 19.60 cm³ of hydrochloric acid of concentration 0.095 mol dm⁻³, the equation being:



Calculate the concentration of hydrogencarbonate ions in the solution. [2]

Total [9]

10. Measuring the rates of chemical reactions is very important in industrial processes, environmental studies and medical work.

(a) Name **three** factors that can affect the rate of a chemical reaction. [3]

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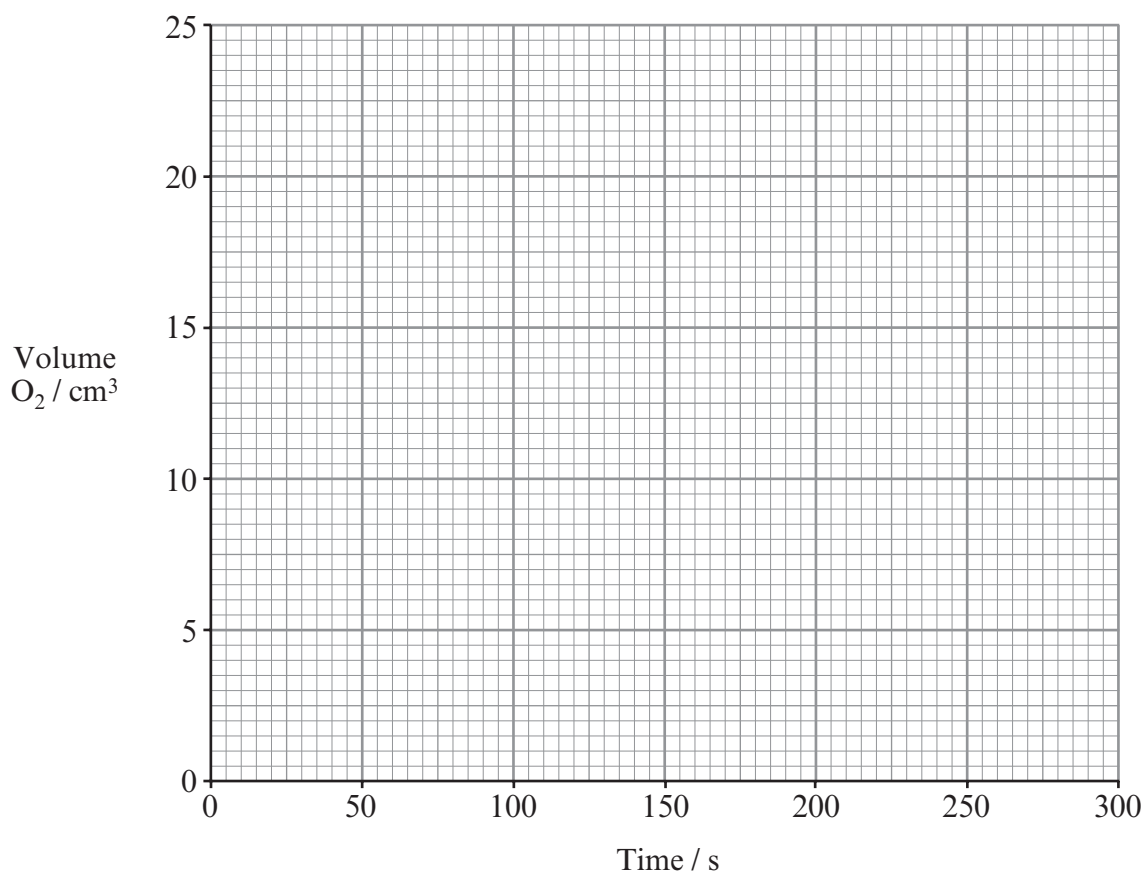
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(b) The following results were obtained in an experiment to find the rate of decomposition of hydrogen peroxide.



Time / s	0	50	100	150	200	250	300
Volume O ₂ / cm ³	0	5.0	10.0	14.8	19.0	22.5	25.0

(i) Plot these results on the grid below and calculate the initial rate of reaction from your plot. **Show your working and state the units for the rate.** [5]



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- (ii) State how the rate of reaction changes over time and give a reason for any difference. [2]

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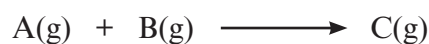
- (iii) Describe briefly how this experiment could be carried out. [2]

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- (c) Using collision theory for a reaction such as



explain why the rate of reaction depends on both the pressure of the reactants and the temperature. [4]

QWC [1]

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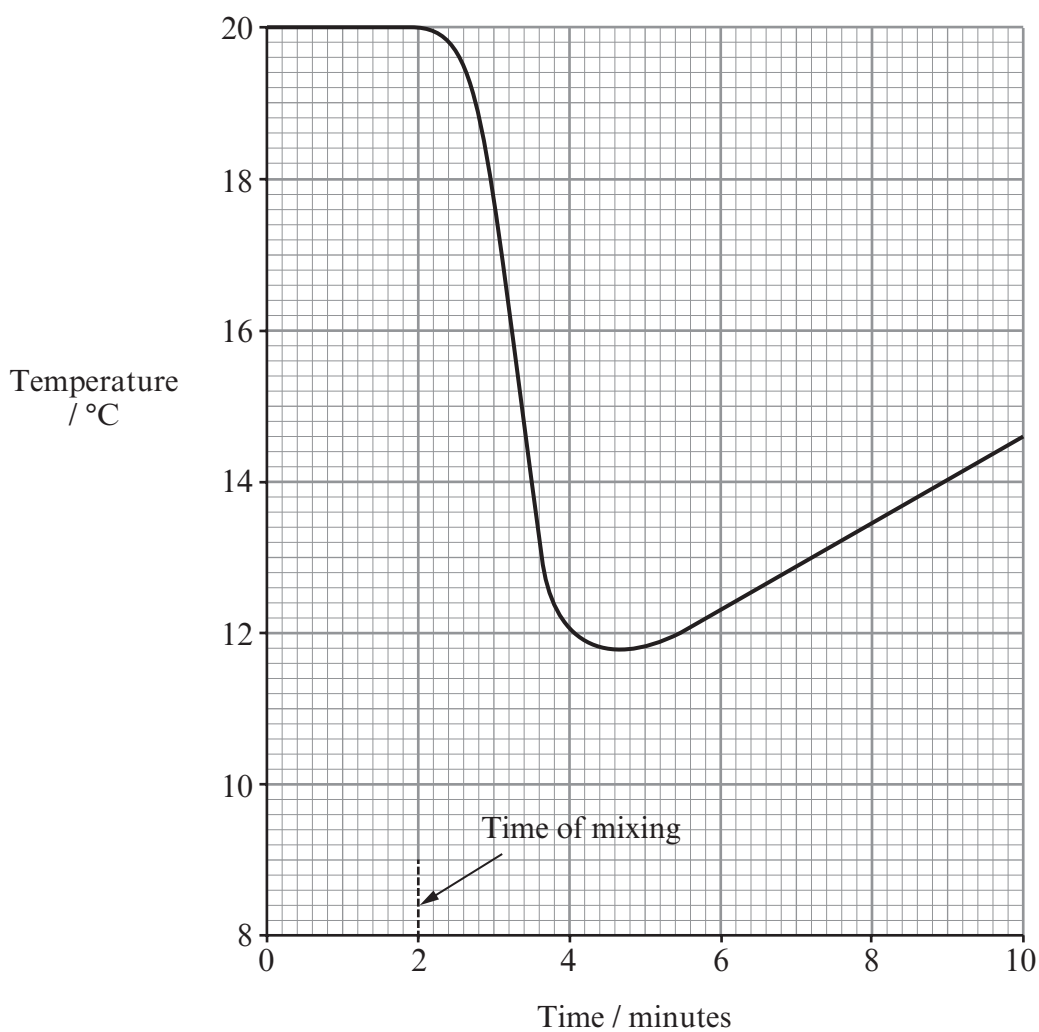
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Total [17]

11. The study of energy changes is important in chemistry and concerns most aspects of modern life such as the efficiency of fuels.

- (a) The plot below resulted from an experiment to find the enthalpy change that occurs when sodium nitrate(V), NaNO_3 , is dissolved in water.



- (i) Describe how you could carry out such an experiment, using a diagram if you wish. [4]

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- (ii) Using the plot and drawing lines where necessary, find ΔT and thus calculate ΔH using the equation

$$\Delta H = \frac{-mc\Delta T}{n} \text{ J mol}^{-1}$$

where the mass of water (m) was 50 g, the heat capacity (c) was $4.2 \text{ J g}^{-1} \text{ K}^{-1}$ and the amount of nitrate used (n) was 0.10 mol. [4]

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$$\Delta H = \dots\dots\dots \text{ kJ mol}^{-1}$$

(b) (i) State *Hess's Law*.

[1]

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.....

(ii) Use this law to calculate the enthalpy change when sulfur trioxide and water react to form sulfuric acid.



The standard enthalpy changes of formation of the compounds ($\Delta H_f^\ominus$) are given in the following table.

Compound	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
H ₂ O	−286
SO ₃	−395
H ₂ SO ₄	−811

[2]

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(c) State what is meant by the *average bond enthalpy* of an O—H bond and explain why the word *average* must be used.

[2]

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- (d) The most important chemical reactions in terms of tonnage used are the combustion of coal and hydrocarbons to produce energy. There are major problems arising from these combustion reactions. Describe **one** such problem and discuss what can be done about it. [2]

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Total [15]

Section B Total [70]

Rough Work

[illegible]



GCE AS/A level

1091/01-A

CHEMISTRY

PERIODIC TABLE FOR USE WITH CH1

P.M. MONDAY, 23 May 2011

THE PERIODIC TABLE

Period 1 2 3 4 5 6 7 0

s Block

Group

p Block

d Block

f Block

1		2		3		4		5		6		7			
1.01 H Hydrogen 1		6.94 Li Lithium 3		9.01 Be Beryllium 4		23.0 Na Sodium 11		39.1 K Potassium 19		85.5 Rb Rubidium 37		133 Cs Caesium 55		(223) Fr Francium 87	
		24.3 Mg Magnesium 12				40.1 Ca Calcium 20		87.6 Sr Strontium 38		137 Ba Barium 56		(226) Ra Radium 88			
						45.0 Sc Scandium 21		88.9 Y Yttrium 39		139 La Lanthanum 57		(227)▶▶ Ac Actinium 89			
						47.9 Ti Titanium 22		91.2 Zr Zirconium 40		179 Hf Hafnium 72					
						50.9 V Vanadium 23		92.9 Nb Niobium 41		181 Ta Tantalum 73					
						52.0 Cr Chromium 24		95.9 Mo Molybdenum 42		184 W Tungsten 74					
						54.9 Mn Manganese 25		98.9 Tc Technetium 43		186 Re Rhenium 75					
						55.8 Fe Iron 26		101 Ru Ruthenium 44		190 Os Osmium 76					
						58.9 Co Cobalt 27		103 Rh Rhodium 45		192 Ir Iridium 77					
						58.7 Ni Nickel 28		106 Pd Palladium 46		195 Pt Platinum 78					
						63.5 Cu Copper 29		108 Ag Silver 47		197 Au Gold 79					
						65.4 Zn Zinc 30		112 Cd Cadmium 48		201 Hg Mercury 80					

Key

A_r

Symbol

Name

Z

relative
atomic
mass

atomic
number

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103

► Lanthanoid elements

► Actinoid elements

Candidate Name	Centre Number	Candidate Number
		2



GCE AS/A level

1091/01

CHEMISTRY CH1

A.M. THURSDAY, 13 January 2011

1½ hours

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-5	
B	6	
	7	
	8	
	9	
	10	
TOTAL MARK		

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
- copy of the **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

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

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

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

You are reminded that marking will take into account the Quality of Written Communication used in all written answers.

Page 19 may be used for rough work.

SECTION A

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

1. By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of a calcium atom. [1]

1s	2s	2p	3s	3p	3d	4s

2. (a) Calculate the molar mass, in g mol^{-1} , of calcium sulfate dihydrate, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. [1]

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- (b) Calculate the percentage of water, by mass, in calcium sulfate dihydrate. [1]

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3. Ions of two isotopes of the metal lithium are shown below.

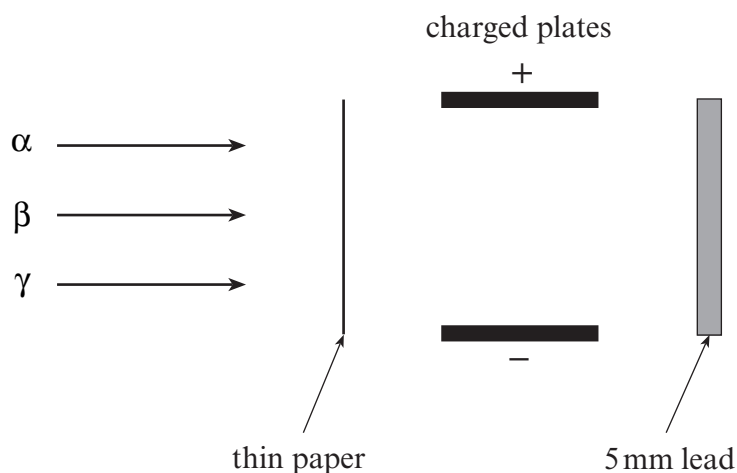


State which **one** of the following statements is **correct**. [1]

- A** The electron arrangement of both these Li^+ ions is $1s^2 2s^1$.
- B** The ${}^7\text{Li}^+$ ion will have more protons in its nucleus than the ${}^6\text{Li}^+$ ion.
- C** The ${}^7\text{Li}^+$ ion will be deflected more than the ${}^6\text{Li}^+$ ion in a mass spectrometer.
- D** Both of these Li^+ ions have the same number of electrons.

.....

4. Complete the diagram below to show how radiation is affected by an electric field and by materials of different thickness. [3]



5. A compound of carbon, hydrogen and oxygen has a relative molecular mass of 180. The percentage composition by mass is C 40.0%; H 6.70%; O 53.3%.

(a) Calculate the empirical formula of this compound. [2]

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(b) Determine the molecular formula of this compound. [1]

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Section A Total [10]

SECTION B

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

6. Potassium metal was discovered in 1807 by the British chemist Sir Humphrey Davy. Its name derives from the word ‘potash’ since potassium was isolated by the electrolysis of molten caustic potash, KOH.

- (a) The mass spectrum of a naturally occurring sample of potassium gave the following results.

Isotope	% abundance
^{39}K	93.26
^{40}K	0.012
^{41}K	6.730

These results can be used to determine the relative atomic mass of the potassium sample.

- (i) Explain the term *relative atomic mass*. [2]

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- (ii) Calculate the relative atomic mass of the potassium sample, giving your answer to **four** significant figures. [2]

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- (b) The mass spectrum which provided these results was produced by potassium ions in a mass spectrometer.

- (i) State how potassium ions are formed in a mass spectrometer. [1]

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- (ii) State how potassium ions are separated in a mass spectrometer. [1]

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(c) Potassium-40, $^{40}_{19}\text{K}$, is a radioactive isotope that decays by β -emission and has a half-life of 1.25×10^9 years.

(i) Write an equation for the process by which a potassium-40 isotope emits a β -particle. [2]

(ii) Calculate how long it will take for the activity of the isotope to decay to $\frac{1}{8}$ th of its original activity. [1]

(d) The first and second ionisation energies of potassium and sodium are shown in the table below.

	1 st ionisation energy / kJ mol^{-1}	2 nd ionisation energy / kJ mol^{-1}
potassium	419	3051
sodium	496	4562

(i) Explain the term *molar first ionisation energy*. [2]

(ii) Explain why

I potassium has a lower first ionisation energy than sodium, [2]

II there is a large difference between the first and second ionisation energies of potassium. [2]

7. Eurig is asked to measure the rate of reaction of calcium carbonate with dilute hydrochloric acid. He is given 1.50 g of the carbonate and 10.0 cm³ of acid of concentration 2.00 mol dm⁻³.



- (a) Give an observation that Eurig makes during this reaction. [1]

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- (b) Name a piece of apparatus that he could use to collect and measure the volume of carbon dioxide produced. [1]

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- (c) Suggest a method, other than measuring the amount of carbon dioxide produced at set time intervals, that Eurig could have used to follow the rate of this reaction. [1]

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- (d) (i) Calculate the number of moles of hydrochloric acid used in this reaction. [1]

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- (ii) Calculate the **minimum** mass of calcium carbonate needed to react **completely** with this amount of acid. [2]

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- (iii) Calculate the volume of carbon dioxide gas that would be produced at 25 °C. [2]
(1 mole of carbon dioxide occupies 24 dm³ at 25 °C.)

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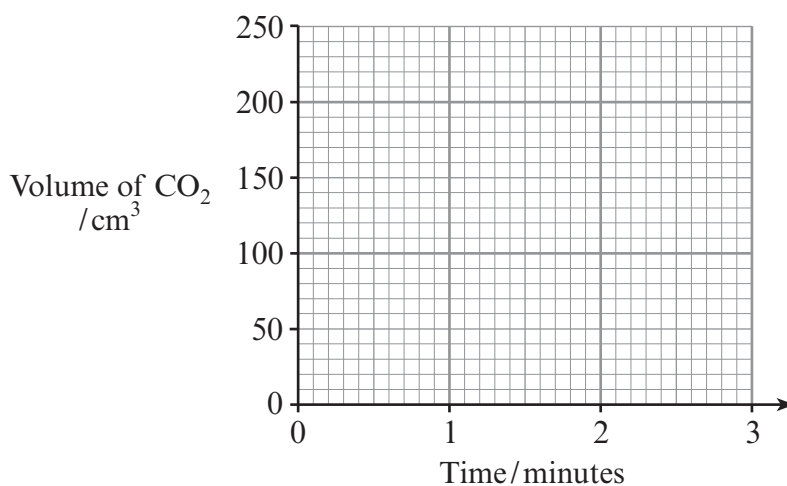
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- (e) Eurig repeats the experiment starting with a greater mass of calcium carbonate. He follows the rate of the reaction for 3 minutes.

He takes a number of measurements which include 150 cm^3 of carbon dioxide at 1 minute and 200 cm^3 at 2 minutes, when the reaction finishes.

- (i) Sketch a curve on the grid below to show these results. Label this graph **A**. [1]



- (ii) On the same grid sketch the graph that would be obtained if the experiment were repeated using hydrochloric acid of half the original concentration, keeping all other factors the same. Label this graph **B**. [2]
- (iii) Explain, using simple collision theory, why the rates of these two reactions are different. [2]

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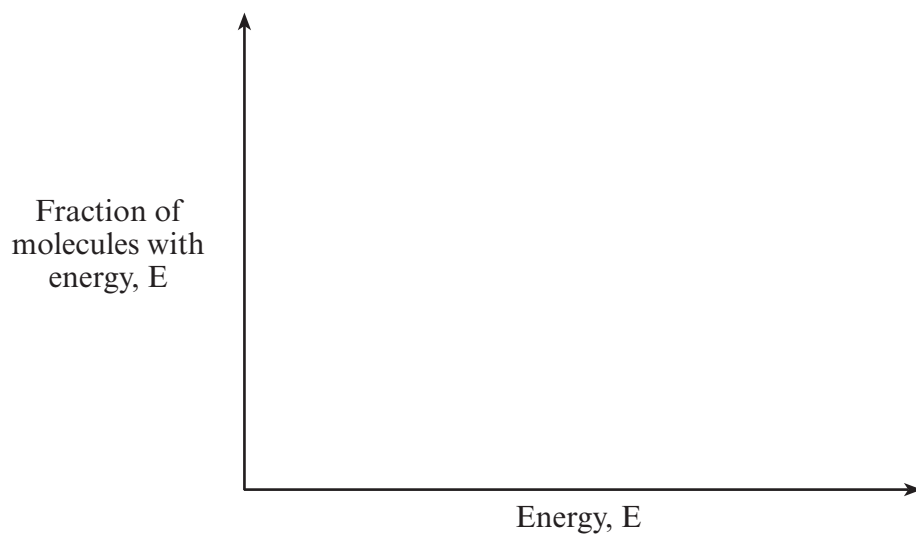
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- (f) With the aid of an energy distribution curve diagram, explain why raising the temperature by a small amount causes the rate of a chemical reaction to increase by a large amount.

[3]

QWC [1]



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Total [17]

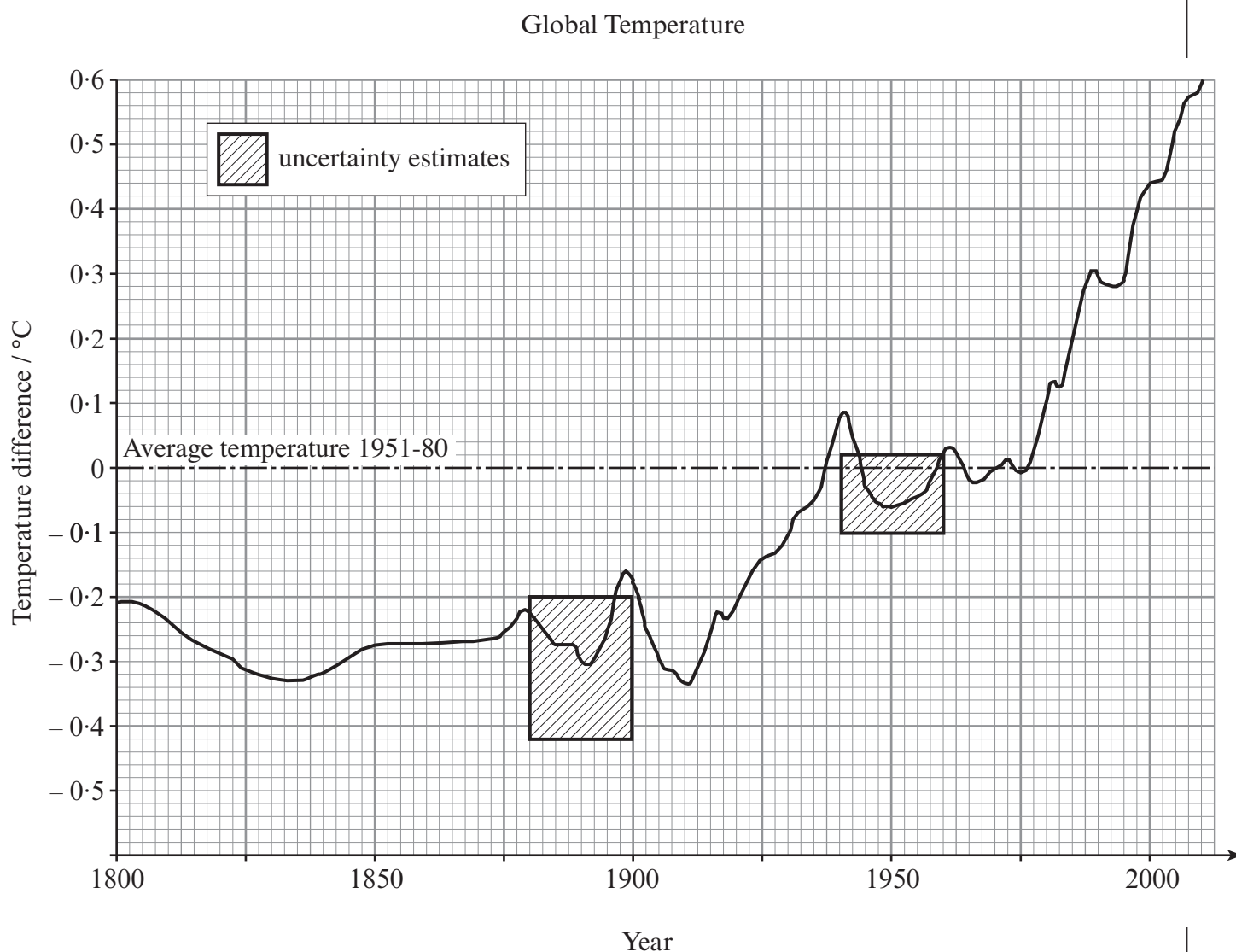
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8. (a) During the last 200 years, the average temperature of the Earth has risen. One hypothesis put forward by many scientists is that this is due to increased concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

The table below shows the concentration of carbon dioxide in the atmosphere at 50 year intervals since 1800.

	Year				
	1800	1850	1900	1950	2000
Concentration of carbon dioxide in the atmosphere / % by volume	0.0282	0.0288	0.0297	0.0310	0.0368

The following graph based on data from NASA research, shows the annual global temperature relative to the average temperature between 1951 and 1980.



- (i) Explain how these two sets of data led many scientists to this hypothesis. [2]
QWC [1]

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- (ii) Suggest why the data does not convince all scientists that this hypothesis is true. [1]

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- (iii) Suggest **two** reasons why the uncertainty is greater in the period 1880-1900 than the period 1940-1960. [2]

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- (iv) Give **two** reasons for the changing amounts of carbon dioxide in the atmosphere after 1900. [2]

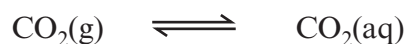
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- (b) In fizzy drinks, carbon dioxide is dissolved in water under pressure and when the pressure is released the 'fizz' appears.

In a bottle of fizzy drink, the following chemical equilibrium exists:



- (i) Chemical equilibria are often described as dynamic equilibria.
Explain the term *dynamic equilibrium*.

[1]

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.....

- (ii) When the top is removed from a bottle of fizzy drink it goes 'flat' because much of the dissolved carbon dioxide comes out of solution.
Explain why this happens in terms of chemical equilibria.

[2]

QWC [1]

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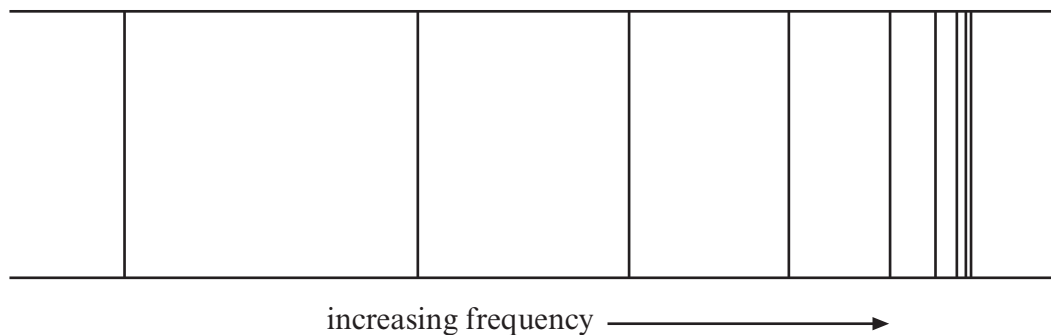
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Total [12]

9. (a) The diagram below includes the visible atomic emission spectrum of hydrogen (the Balmer series).



- (i) Label the line of **lowest** energy on the diagram. [1]
- (ii) Explain why the lines become closer together at the high frequency end of the spectrum. [1]

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- (b) Recently hydrogen has been receiving interest as a 'source of energy'. It can be prepared by the steam reforming of methane.



- (i) State Le Chatelier's Principle. [1]

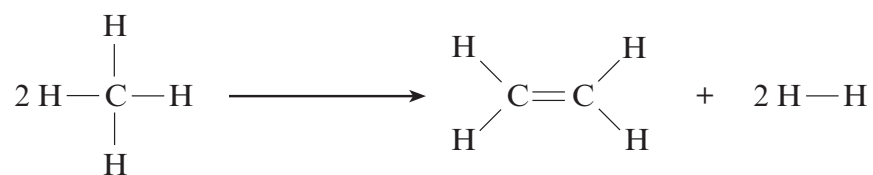
- (ii) Giving your reasons, state how the equilibrium yield of hydrogen is affected, if at all, by

- I increasing the temperature at constant pressure, [2]

- II increasing the pressure at constant temperature. [2]

- (iii) Calculate the atom economy of hydrogen production in the above reaction. [2]

(c) Another way of producing hydrogen is from reforming natural gas.



Use the values in the table below to calculate the enthalpy change for the above reaction. [2]

Bond	Average bond enthalpy / kJ mol^{-1}
$\text{C}=\text{C}$	612
$\text{C}-\text{H}$	412
$\text{H}-\text{H}$	436

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Total [11]

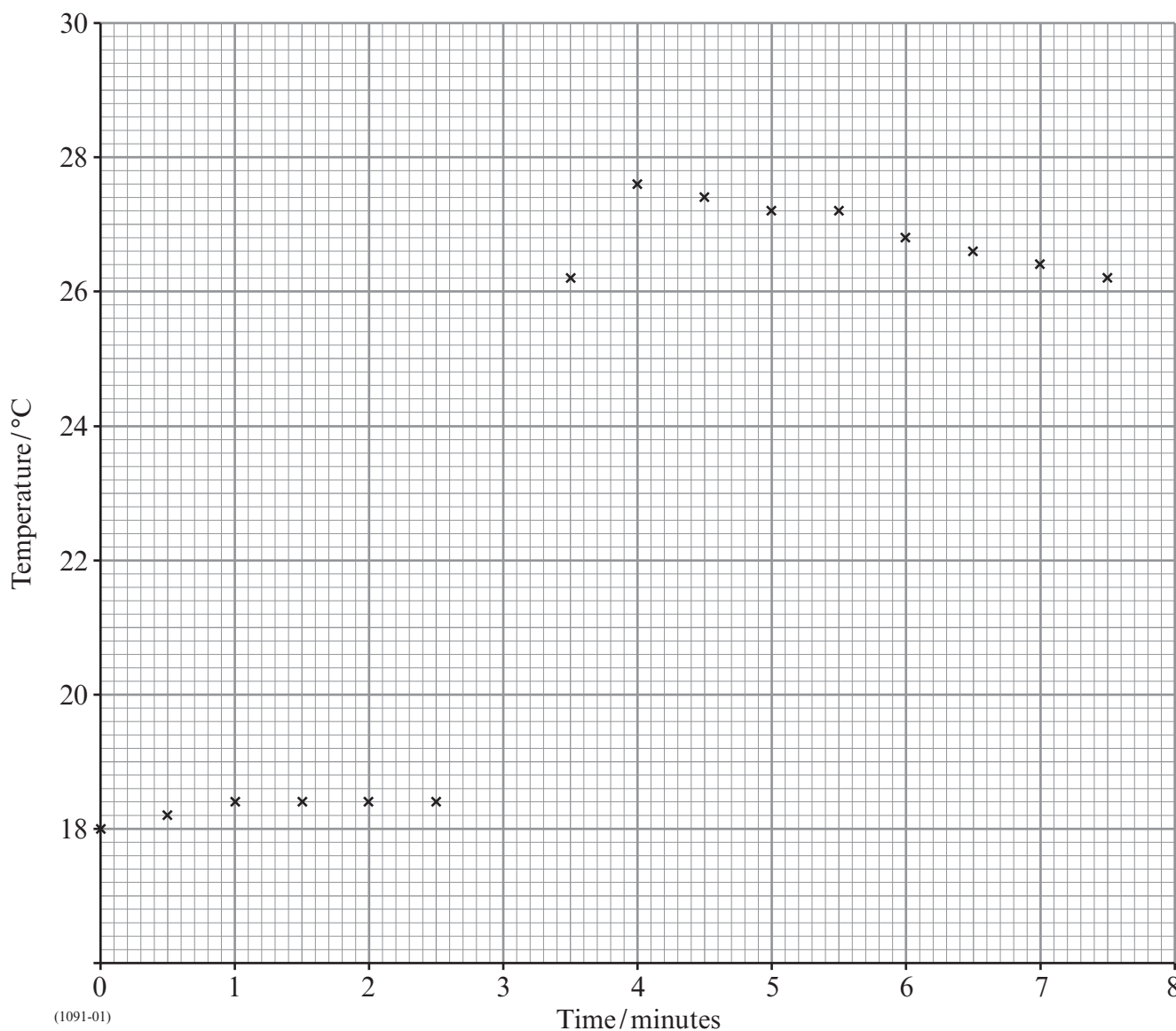
10. Lisa was asked to measure the molar enthalpy change for the reaction between magnesium and copper(II) sulfate solution.



She was told to use the following method.

- Weigh out about 0.90 g of powdered magnesium.
- Accurately measure 50.0 cm³ of copper(II) sulfate solution of concentration 0.500 mol dm⁻³ into a polystyrene cup (placed in another polystyrene cup to provide insulation).
- Place a 0.2 °C graduated thermometer in the solution and measure its temperature every half-minute, stirring the solution before reading the temperature.
- At the third minute add 0.90 g of powdered magnesium, but do not record the temperature.
- Stir the mixture thoroughly, then record the temperature after three and a half minutes.
- Continue stirring and record the temperature at half-minute intervals for a further four minutes.

Lisa's results are shown on the graph below.



- (a) Explain why the temperature of the copper(II) sulfate solution was measured for three minutes before adding the magnesium. [1]

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- (b) (i) Determine the maximum temperature **change** by drawing lines of best fit for both sets of points and extrapolating both lines to the third minute.

Temperature rise from the graph after extrapolation °C [2]

- (ii) Explain why extrapolation gives a more accurate temperature change than using the maximum temperature recorded in the experiment. [1]

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.....

- (c) Use the temperature rise from the graph to calculate the amount of heat given out during **this** experiment.
(Assume that the density of the solution is 1.00 g cm^{-3} and that its specific heat capacity is $4.18 \text{ J K}^{-1} \text{ g}^{-1}$) [1]

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- (d) (i) Calculate the number of moles of magnesium in 0.90 g. [1]

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- (ii) Calculate the number of moles of copper(II) sulfate in 50.0 cm^3 of a $0.500 \text{ mol dm}^{-3}$ solution. [1]

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.....

- (e) Calculate the molar enthalpy change for the reaction between magnesium and copper(II) sulfate solution. [2]

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- (f) Name a piece of apparatus that Lisa could use to accurately measure 50.0 cm^3 of the solution. [1]

.....

- (g) State why she did not need to accurately weigh the powdered magnesium. [1]

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- (h) Explain why it is better to use powdered magnesium rather than a strip of magnesium ribbon. [1]

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- (i) The data book value for this molar enthalpy change is $-93.1 \text{ kJ mol}^{-1}$.
Express the difference between Lisa's value and this value as a percentage of the data book value. [1]
(If you do not have an answer in (e) assume that the molar enthalpy change is -65 kJ mol^{-1} , although this is **not** the correct answer.)

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- (j) State the **main** reason for Lisa's low value in this experiment and suggest **one** change that would improve her result. [2]

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Total [15]

Section B Total [70]



GCE AS/A level

1091/01-A

**CHEMISTRY CH1
PERIODIC TABLE**

A.M. THURSDAY, 13 January 2011

Group	3	4	5	6	7	0
1						
2						

2