Candidate Name	Centre Number	Candidate Number
		2

Merged WJEC Paper 1s with Mark Schemes

January 2009 - June 2016

WJEC CBAC

GCE AS/A level

1091/01 **New AS**

CHEMISTRY CH1

P.M. FRIDAY, 9 January 2009

1½ hours

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-4	
B	5	
	6	
	7	
	8	
	9	
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

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.

SECTION A

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

1. An isotope of magnesium, ^{27}Mg, is used to detect leaks in water pipes.

(a) It decays by β–emission with a half life of 9·5 minutes.

(i) Give the symbol and mass number of the atom formed by the loss of one β particle from an atom of ^{27}Mg. [1]

....

(ii) Calculate how long it will take for the activity of the isotope to decay to $\frac{1}{16}^{th}$ of its original activity. [1]

.... minutes

(b) Complete the boxes below, by inserting arrows to represent electrons, to show the electronic configuration of an atom of magnesium. [1]

1s	2s	2p			3s	3p		

2. Calcium oxide is made by heating calcium carbonate in air.

$$\underset{\text{1 mole}}{CaCO_3} \longrightarrow \underset{\text{1 mole}}{CaO} + CO_2$$

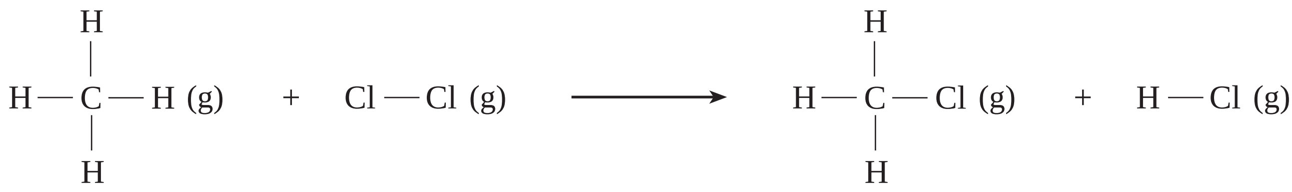
Calculate the maximum mass of calcium oxide formed when 0·500 mole of pure calcium carbonate is heated. [2]

....

....

....

3. Chloromethane, CH_3Cl, is made by reacting methane, CH_4, with chlorine.



(i) The total enthalpy changes of formation from gaseous atoms (calculated from bond energies) of the species involved are shown in the table below.

Species	*Total enthalpy change of formation from gaseous atoms* / kJ mol^{-1}
CH_4	1652
Cl_2	243
CH_3Cl	1585
HCl	432

Use the values in the table to calculate the enthalpy change for the reaction above. [1]

....

....

.... kJ mol^{-1}

(ii) The atom economy of a reaction is given by the formula

$$\text{atom economy} = \frac{\text{theoretical mass of required product} \times 100}{\text{total mass of reactants used}} \ \%$$

Calculate the atom economy of the reaction above, where chloromethane, CH_3Cl, is the required product. [1]

....

....

Examiner only

4. The values for some standard molar ionisation energies are given in the table.

Element	*Standard molar ionisation energies* / kJ mol^{-1}	
	First	*Second*
Argon	1521	2666
Potassium	419	3051

(i) Give **two** reasons why the **first** standard molar ionisation energy for potassium is much less than that of argon. [2]

1. ....

....

2. ....

....

(ii) Give a reason why the value for the **second** standard molar ionisation energy of potassium is larger than that of argon. [1]

....

....

Section A Total [10]

SECTION B

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

5. *(a)* Polluting gases such as sulfur dioxide, SO_2, produced from power stations, can cause the acidification of lakes far from the source of the pollution. At a lake-water pH of 6·0, water snails start to die and when the pH reaches 5·5, fish also begin to die.

State how you would explain to the general public how the pH scale is used to describe levels of acidity. [2]

....

....

....

(b) An equation for the reaction of sulfur dioxide with water is shown below.

$$SO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HSO_3^-(aq)$$

(i) Use the equation to explain why sulfur dioxide is described as an acidic oxide. [1]

....

....

(ii) A solution of sulfur dioxide in water reaches a position of *dynamic equilibrium*. Explain what is meant by the term ***dynamic equilibrium***. [1]

....

....

(iii) Use Le Chatelier's principle to explain how the concentration of hydrogen ions, $H^+(aq)$, would change if more sulfur dioxide were dissolved in a solution that had reached dynamic equilibrium. [2]

....

....

....

Examiner only

(c) One method of removing sulfur dioxide from power station emissions is to react the flue gases with moist calcium carbonate (limestone), giving hydrated calcium sulfate (gypsum) and carbon dioxide.

$$2SO_2 + 2CaCO_3 + 4H_2O + O_2 \longrightarrow 2CaSO_4.2H_2O + 2CO_2$$

One **advantage** of this process is that the gypsum can be used for the production of plaster.
State two **disadvantages** of this method of sulfur dioxide removal, apart from cost. [2]

Disadvantage 1 ....

....

Disadvantage 2 ....

....

(d) Some students measured the concentration of sulfur dioxide in the air.
They pumped air at a rate of 20 dm^3 per hour for 5 days through a suitable solution that absorbed the sulfur dioxide present.
The resulting solution was then treated to give 0·0047 g of barium sulfate, $BaSO_4$.
You should assume that 1 mole of sulfur dioxide gives 1 mole of barium sulfate.

(i) Calculate the total volume of air passed through the solution in 5 days. [1]

....

.... dm^3

(ii) Calculate the relative molecular mass of barium sulfate. [1]

....

....

(iii) Use your answer to (ii) to calculate the number of moles of barium sulfate present. [1]

....

....

....

(iv) State the number of moles of sulfur dioxide present in the sampled air. [1]

....

Examiner only

(v) Calculate the volume of sulfur dioxide present in the sampled air. [1]
[One mole of sulfur dioxide has a volume of 24·0 dm^3 under these conditions.]

....

.... dm^3

(vi) Calculate the percentage by volume of sulfur dioxide in the sampled air. [1]

....

....

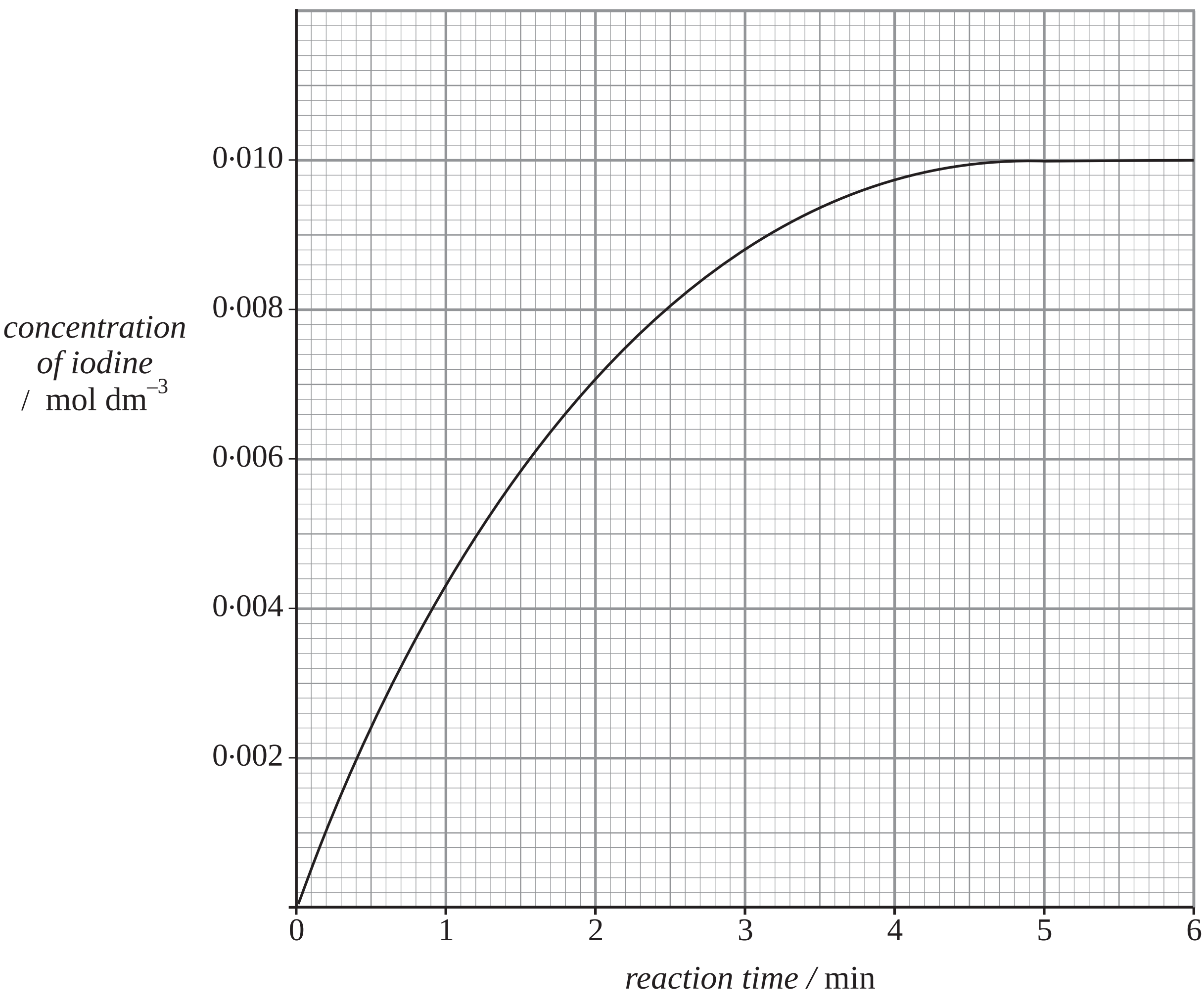
Total [14]

Examiner only

6. *(a)* Iodine is slowly produced, as a red-brown solution, by the reaction of aqueous peroxodisulfate ions, $S_2O_8^{2-}$, with a large excess of aqueous iodide ions, $I^-(aq)$.

$$\underset{\text{colourless}}{S_2O_8^{2-}(aq)} + \underset{\text{colourless}}{2I^-(aq)} \longrightarrow \underset{\text{colourless}}{2SO_4^{2-}(aq)} + \underset{\text{red-brown}}{I_2(aq)}$$

The graph below was produced from one set of experimental results.



(i) State the time taken for all the peroxodisulfate ions to react. [1]

.... minutes

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

....

....

....

(iii) I. Sketch on the graph the line that would be obtained when the reaction is carried out at an increased temperature but keeping the other factors constant. [2]

II. Explain your answer to I. [2]

....

....

....

(iv) State the concentration of the peroxodisulfate ions at the start of the reaction, explaining your answer. [2]

....

....

(v) Use the graph to calculate the initial rate of the reaction. [2]

....

.... mol dm^{-3} min^{-1}

Examiner only

(b) A diluted solution of ethane-1,2-diol is used as an antifreeze.
This compound is made from epoxyethane and water in two different ways, either in neutral solution or in acidic solution using dilute sulfuric acid as a homogeneous catalyst.

Conditions	*Pressure* / atm	*Temperature* / °C	*Relative volume of water used*	*Catalyst*
neutral	14	200	smaller	none
acidic	1	60	larger	sulfuric acid (aq)

(i) Use the information in the table to suggest two reasons why the acid catalysed system is the preferred method. [2]

1. ....

2. ....

(ii) The acid catalysed system does, however, have some disadvantages.
Use the information given to suggest and explain one disadvantage of this system. [1]

....

....

(iii) The acid method uses a homogeneous catalyst.
Give an example of a process that uses a **heterogeneous** catalyst, stating the process and the name of the catalyst. [2]

Process ....

Catalyst ....

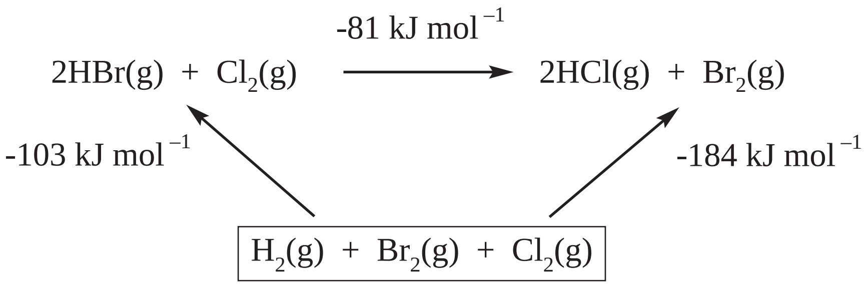
Total [15]

Examiner only

7. *(a)* The enthalpy change of formation of a compound is usually quoted per mole, at standard conditions. Define the term ***standard conditions***. [1]

....

(b) The energy cycle below shows the enthalpy changes that occur when hydrogen bromide reacts with chlorine.



(i) State Hess's Law. [1]

....

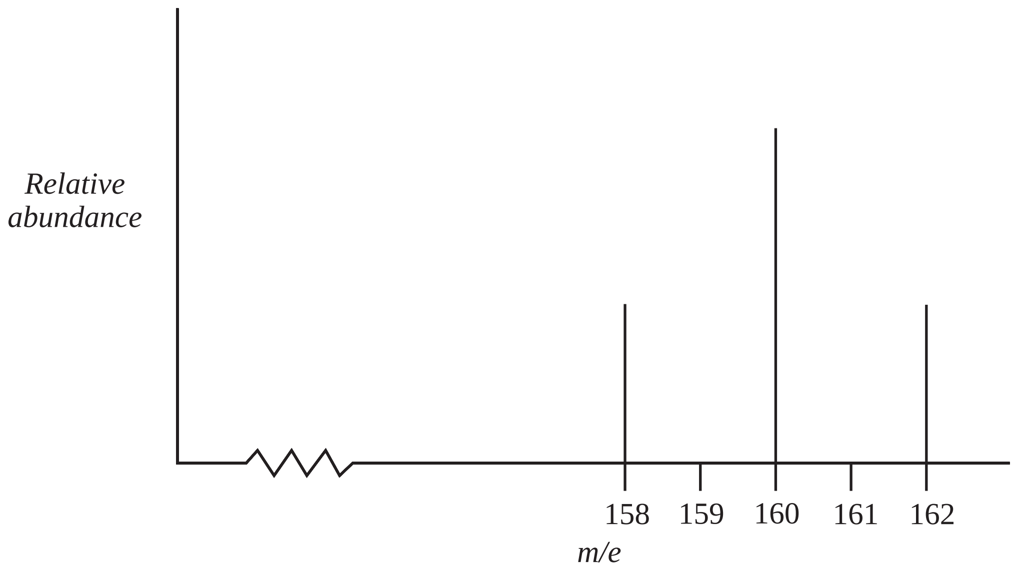
....

(ii) Show that the values in the energy cycle above obey the principle of the conservation of energy. [1]

....

....

(iii) The products of the reaction were examined using a mass spectrometer. The molecular ion peaks for Br_2^+ are shown in the diagram.



Use this information to

I. state the relative isotopic masses of the two bromine atoms, ^{x}Br, [1]

....

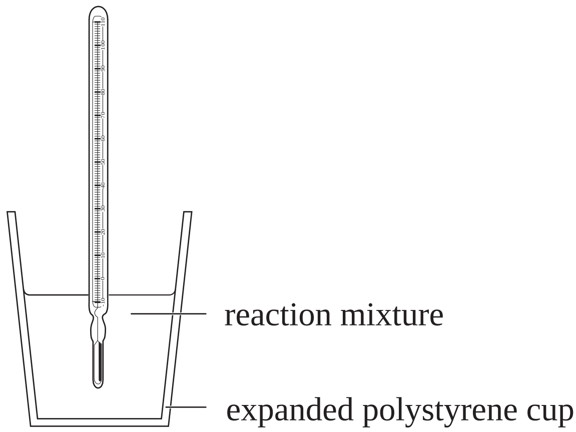
II. find the relative abundance of the two bromine isotopes, giving a reason for your answer. [2]

....

....

(c) Elfed carried out an experiment, using the simple apparatus shown below, to find the enthalpy change for the reaction between hydrobromic acid, HBr(aq), and aqueous sodium hydroxide.

$$HBr(aq) + NaOH(aq) \longrightarrow NaBr(aq) + H_2O(l)$$



Examiner only

He used 50·0 cm^3 of hydrobromic acid of concentration 2·00 mol dm^{-3} and 75·0 cm^3 of sodium hydroxide solution of concentration 2·00 mol dm^{-3}.

He measured the temperature before and after mixing.

Temperature of the solutions before mixing = 21·5 °C
Maximum temperature of the mixture = 32·1°C

He used the equation

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

where m is the total mass of the solutions used, n is the number of moles of hydrobromic acid used and ΔT is the temperature rise.

He assumed that c, the specific heat capacity of the mixture, had the value 4·2 J g^{-1} K^{-1}, and that 1cm^3 of each solution had a mass of 1g.

(i) Calculate the number of moles of hydrobromic acid used. [1]

....

....

(ii) Use your answer to (i) to calculate ΔH, the enthalpy change of reaction, in kJ mol^{-1}. [4]

....

....

.... kJ mol^{-1}

(iii) The accepted value for this reaction is –57·6 kJ mol^{-1}.
State why values obtained are often smaller than this value. [1]

....

....

(iv) Explain why the calculation used the number of moles of hydrobromic acid rather than the number of moles of sodium hydroxide. [1]

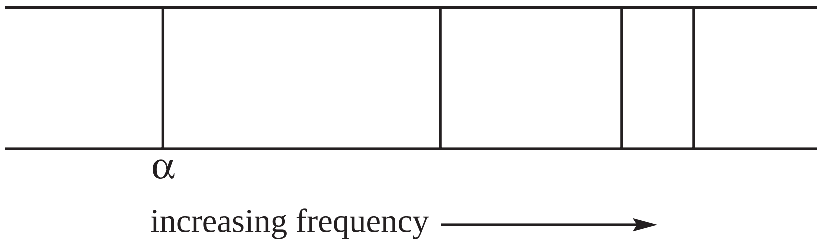
....

....

Total [13]

Examiner only

8. *(a)* The diagram below shows the first four lines of the visible atomic emission spectrum for hydrogen (part of the Balmer series).



(i) Explain why the spectrum is seen as a series of sharp lines and not as a continuous spectrum. [2]
QWC [1]

....

....

....

....

(ii) The line labelled α, the first line of the Balmer series, has a wavelength of 657 nm.
The visible emission spectrum of neon shows a prominent line at 585 nm.
State the relationship between energy, frequency and wavelength and use this to complete the table below, using the words *higher* or *lower*. [4]

....

....

Wavelength / nm	*Frequency* / Hz	*Energy* / J
585		
657		

Examiner only

(b) Neon, discovered in 1898, has three naturally occurring isotopes, of which ^{20}Ne is the most abundant. It is unreactive and forms no compounds.
Use this information to help you answer the questions below.

(i) One reason that neon does not react with other elements is because its first standard molar ionisation energy is very high, having a value of 2081 kJ mol^{-1}. Write an equation that represents the first standard molar ionisation energy of neon. [2]

....

(ii) Explain the meaning of the term ***relative isotopic mass***. [2]

....

....

(iii) Explain, how the ***relative atomic mass*** differs from the ***relative isotopic mass***. [1]

....

....

(iv) At a certain temperature and pressure, 0·890 g of ^{20}Ne occupies a volume of 1 dm^3. Use this value to find the volume occupied by 1 mole of neon at this temperature and pressure. [2]

....

....

.... dm^3

Total [14]

9. Sodium hydroxide and chlorine are important industrial chemicals.
Two methods for making them from sodium chloride solution (brine) are the mercury cell and the diaphragm cell.

Process	*Operation*	*Quality of product*
Diaphragm cell	Needs diaphragm replacing regularly. High electrical current needed.	Contains unreacted sodium chloride. Concentration varies and is relatively low.
Mercury cell	No diaphragm used. High electrical current.	Pure sodium hydroxide solution produced at high concentration.

(a) (i) Use the table to suggest **one** important consideration when choosing which process to use. [1]

....

(ii) If a new process is to be developed as an **alternative** to the two processes outlined above, suggest **two** environmental or technical factors that should be considered when developing this new process. [2]

1. ....

....

2. ....

....

(b) Some students obtained a sample of the sodium hydroxide solution from the diaphragm cell process.

(i) This solution was too concentrated for a normal titration and they needed to dilute it **exactly** ten times using water.
Describe, stating the apparatus used and any essential details, how this dilution was done.
You should assume that you need 250 cm^3 of the diluted solution. [4]
QWC [2]

....

....

....

....

....

....

Examiner only

(ii) 20·0 cm^3 of the diluted sodium hydroxide solution reacted with 0·00500 mole of hydrochloric acid.

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

I. State the number of moles of sodium hydroxide present in the 20·0 cm^3 sample. [1]

II. Calculate the concentration of the **diluted** sodium hydroxide solution. [2]

.... mol dm^{-3}

III. State the concentration of the **original** sodium hydroxide solution. [1]

.... mol dm^{-3}

IV. State how you would identify the end-point of this titration. [1]

Total [14]

Section B Total [70]

Examiner only

Rough Work

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GENERAL CERTIFICATE OF EDUCATION
TYSTYSGRIF ADDYSG GYFFREDINOL

MARKING SCHEME

CHEMISTRY (NEW)
AS/Advanced

JANUARY 2009

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2009 examination in GCE CHEMISTRY (NEW). 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.

CHEMISTRY CH1 (new spec)

January 2009

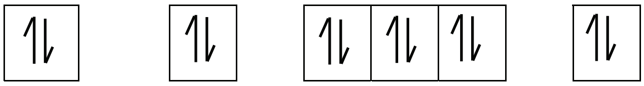
Mark Scheme

Section A

1. (a) (i) ^{27}Al [1]

(ii) 38 (minutes) [1]

(b) 1s 2s 2p 3s [1]



2. M_r CaO 56.1 (1) 0.5×56.1 (1) = 28.1 g [2]

3. (i) $(1652 + 243) - (1585 + 432) = -122$ (kJ mol^{-1}) [1]

(ii) atom economy = 58 [1]

4. (i) (the electron is being removed) from an energy level further from the nucleus [1]

there is increased shielding for potassium [1]

(ii) the nuclear charge is greater for potassium [1]

Section A Total [10]

Section B

5. (a) Acidic solutions have a pH of less than 7 (1)
The lower the figure the 'higher' the degree of acidity (1) [2]

(b) (i) (When sulfur dioxide reacts with water) hydrogen ions / $H^+(aq)$ are produced [1]

(ii) The rate of the forward and reverse reactions are equal. [1]

(iii) The concentration of hydrogen ions / $[H^+]$ would increase (1)
as an increase in the concentration of the reactants moves
the position of equilibrium to the right. (1) [2]

(c) Disadvantage 1 - calcium carbonate is needed, problems of quarrying etc. (1)
Disadvantage 2 - carbon dioxide is produced, contributes to global warming. (1) [2]

(d) (i) $20 \times 24 \times 5 = 2400$ (dm^3) [1]

(ii) $137 + 32.1 + 64 = 233.1$ [1]

(iii) $0.0047 / 233.1 = 2.0(2) \times 10^{-5}$ / 0.0000202 [1]

(iv) $2.0(2) \times 10^{-5}$ / 0.0000202 [1]

(v) 0.00048(5) [1]

(vi) $2.0(2) \times 10^{-5}$ [1]

Total [14]

6. (a) (i) 4.6 to 4.8 inclusive (minutes) [1]

(ii) Measuring the intensity of iodine by colorimetry / taking samples and measuring the concentration of iodine at intervals / taking tangents at the appropriate place [1]

(iii) I. Steeper line (1) finishing at a concentration of 0.010 mol dm^{-3} (1) [2]

II. Higher temperature ≡ higher energy (1)
More reactant molecules / ions have the activation energy (1) [2]

(iv) 0.010 mol dm^{-3} (1) since the reaction is in a 1: 1 ratio and all the peroxodisulfate ions are used up (1) [2]

(v) e.g., $\dfrac{0.002}{0.40}$ (1) = 0.005 (1) (mol dm^{-3} min^{-1}) accept up to 1.00 on the x axis [2]
accept an appropriate gradient

(b) (i) Low(er) temperature (1) low(er) pressure (1) [2]

(ii) Uses dilute sulfuric acid / difficult to separate products, catalyst [1]

(iii) e.g., Haber process (1) iron (1) / Contact process (1) vanadium(V) oxide (1) [2]

Total [15]

7. (a) 298 K / 25 ^{o}C and 1 atmosphere pressure / atmospheric pressure [1]

(b) (i) The enthalpy change in a reaction is independent of the pathway taken [1]

(ii) $-103 + (-81) = -184$ (kJ) [1]

(iii) I. 79 and 81 [1]

II. 50% of each (1)
158 and 162 are the same height (1) [2]

(c) (i) 0.100 [1]

(ii) $\Delta H = -\dfrac{mc\Delta T}{n}$

$m = 125$ (1) $\Delta T = 10.6$ (1)

$\Delta H = -\dfrac{125 \times 4.2 \times 10.6}{0.100} = -55650$ J (1)

$\therefore \Delta H = -55.7$ kJ mol^{-1} (1) must have negative sign [4]

(iii) Loss of heat etc. [1]

(iv) The sodium hydroxide is in excess [1]

Total [13]

8. (a) (i) The energy levels are quantised / only certain energy levels are possible (1)
therefore only certain frequencies are allowed (1) [2]

QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate (1) [1]

(ii) $E = hf$ (1) $f \propto \frac{1}{\lambda}$ / $c = f\lambda$ (1)

Wavelength / nm	*Frequency* / Hz	*Energy* / J
585	higher	higher
657	lower	lower

One mark for each correct row (1) (1) [4]

(b) (i) $Ne(g) \longrightarrow Ne^{+}(g) + e^{-}$ (1) (1) [2]

One mark for correct state and one mark for the equation

(ii) Relative isotopic mass is a term that describes the number of times one atom of ^{20}Ne is as heavy (1) as one-twelfth of a ^{12}C atom (1) [2]

(iii) Relative isotopic mass only considers one isotope, but the relative atomic mass considers a weighted average of the isotopes present. [1]

(iv) 1 mole of Ne has a mass of 20 g (1)
0.890 g has a volume of 1 dm^3

$\therefore$ 20 g has a volume of $\frac{20}{0.890} = 22.5$ (dm^3) (1) [2]

OR

moles of neon $= \frac{0.890}{20} = 0.0445$ (1)

$\therefore$ 1 mole of neon has a volume of $1/0.0445 = 22.5$ (dm^3) (1)

Total [14]

9. (a) (i) Whether pure sodium hydroxide is needed / whether less pure sodium hydroxide is acceptable to the customer / whether high concentration sodium hydroxide is needed / whether lower concentration sodium hydroxide is acceptable to the customer / whether the cost of replacement diaphragms is an important economic consideration [1]

(ii) e.g., can it operate at a lower current / energy considerations
does it give a pure product, (thereby avoiding purification)
does it use or produce (other) toxic materials
do parts need replacing regularly

any two for (1) each (1) [2]

(b) (i) Measure out exactly 25.0 cm^3 (1) using a pipette / burette (1) for the first two marks then any **two** from the following:

Add this to a (250 cm^3) volumetric flask (1), dilute with (distilled) water and make up to the mark (1)
Use of a funnel (1)
Use of a dropping pipette (for making up to the mark) (1)
Now shake the mixture a number of times to ensure thorough mixing. (1) [4]

QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning. (1)
Selection of a form and style of writing appropriate to purpose and to complexity of subject matter. (1) [2]

(ii) I. 0.005(0) [1]

II. number of moles $= \dfrac{\text{concentration} \times \text{volume}}{1000}$ (1)

concentration $= \dfrac{1000 \times 0.005}{20.00} = 0.25(0)$ (mol dm^{-3}) (1) [2]

III. Original concentration = 2.5(0) (mol dm^{-3}) (1) [1]

IV. By using an indicator or named indicator eg. methyl orange / methyl red / phenolphthalein [1]

accept use of a pH meter

Total [14]

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Candidate Name	Centre Number	Candidate Number
		2

GCE AS/A level

1091/01

CHEMISTRY CH1

A.M. THURSDAY, 14 January 2010

1½ hours

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

W10 1091 01 1

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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.

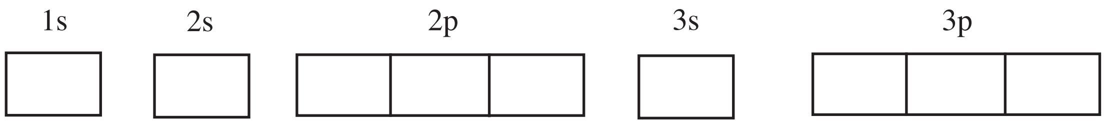
JD*(W10-1091-01)

Examiner only

SECTION A

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

1. Complete the boxes below, by inserting arrows to represent electrons, to show the electron configuration of an atom of aluminium, Al. [1]



2. State which **one** of the following letters represents the first five ionisation energies of aluminium, Al. Give a reason for your choice. [2]

Ionisation energy / kJ mol^{-1}

	1st	2nd	3rd	4th	5th
A	496	4563	6913	9544	13352
B	578	1817	2745	11578	14831
C	1402	2856	4578	7475	9445
D	789	1577	3232	4356	16091

Letter ....

Reason ....

....

....

Examiner only

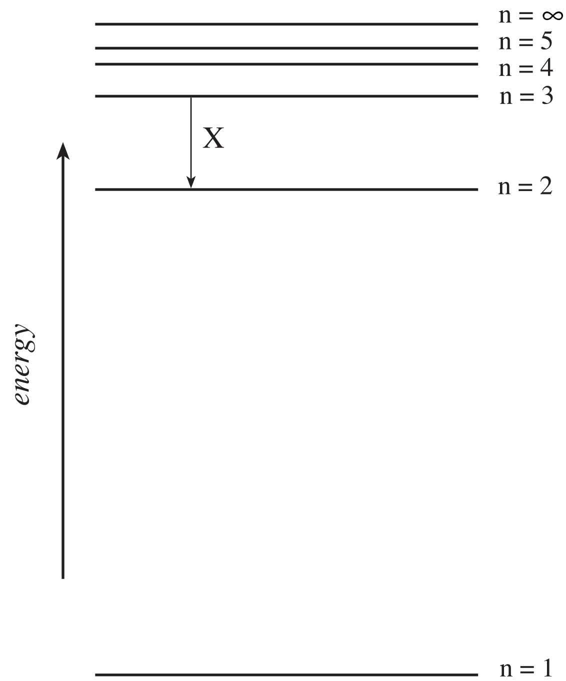
3. *(a)* Complete the following definition of the ***mole***: [1]

A mole is the amount of material containing the same number of particles as there are atoms in ....

(b) State the number of moles of sulfur atoms, S, in 0.3 mol iron(III) sulfate, $Fe_2(SO_4)_3$. [1]

....

4. The diagram below shows the electron energy levels for a hydrogen atom.



(a) State which one of the following correctly describes the transition represented by arrow X: [1]

A The first line in the Lyman series
B The second line in the Lyman series
C The first line in the Balmer series
D The second line in the Balmer series

....

(b) Draw on the energy level diagram an arrow to represent the transition which occurs when a hydrogen atom is ionised. [1]

W10 1091 01 3

Examiner only

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

6. *(a)* Explain the term *dynamic equilibrium* for a chemical system. [1]

....

....

(b) Explain how you would tell, from the properties of the system, that equilibrium has been reached. [1]

....

....

Section A Total [10]

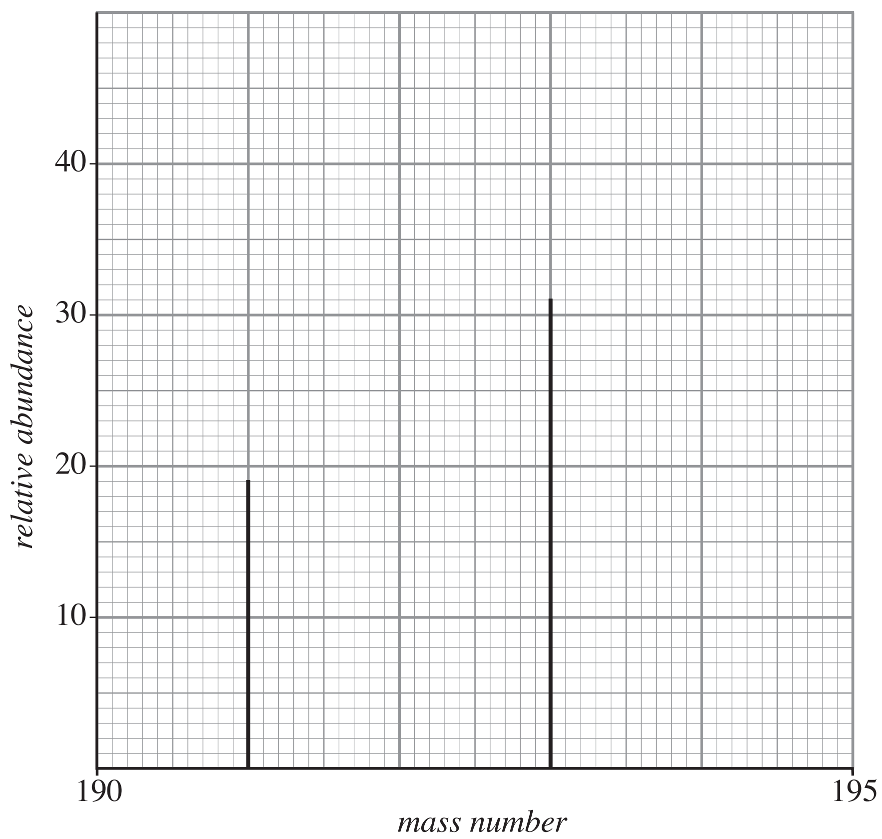
Examiner only

SECTION B

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

7. Iridium, Ir, is the element with atomic number 77.

(a) Its mass spectrum shows that iridium has two naturally-occurring isotopes.



(i) Explain the term *isotopes*. [1]

....

....

(ii) State the numbers of electrons, neutrons and protons present in **each** of the two isotopes. [2]

....

....

....

(iii) Measure the height of each peak and hence calculate the percentage abundance of each isotope in naturally-occurring iridium. [2]

....

....

Examiner only

(b) A further man-made, radioactive isotope of iridium, ^{192}Ir, is manufactured by bombarding naturally-occurring iridium with neutrons in a nuclear reactor. ^{192}Ir is used in the radiotherapy of certain cancers.

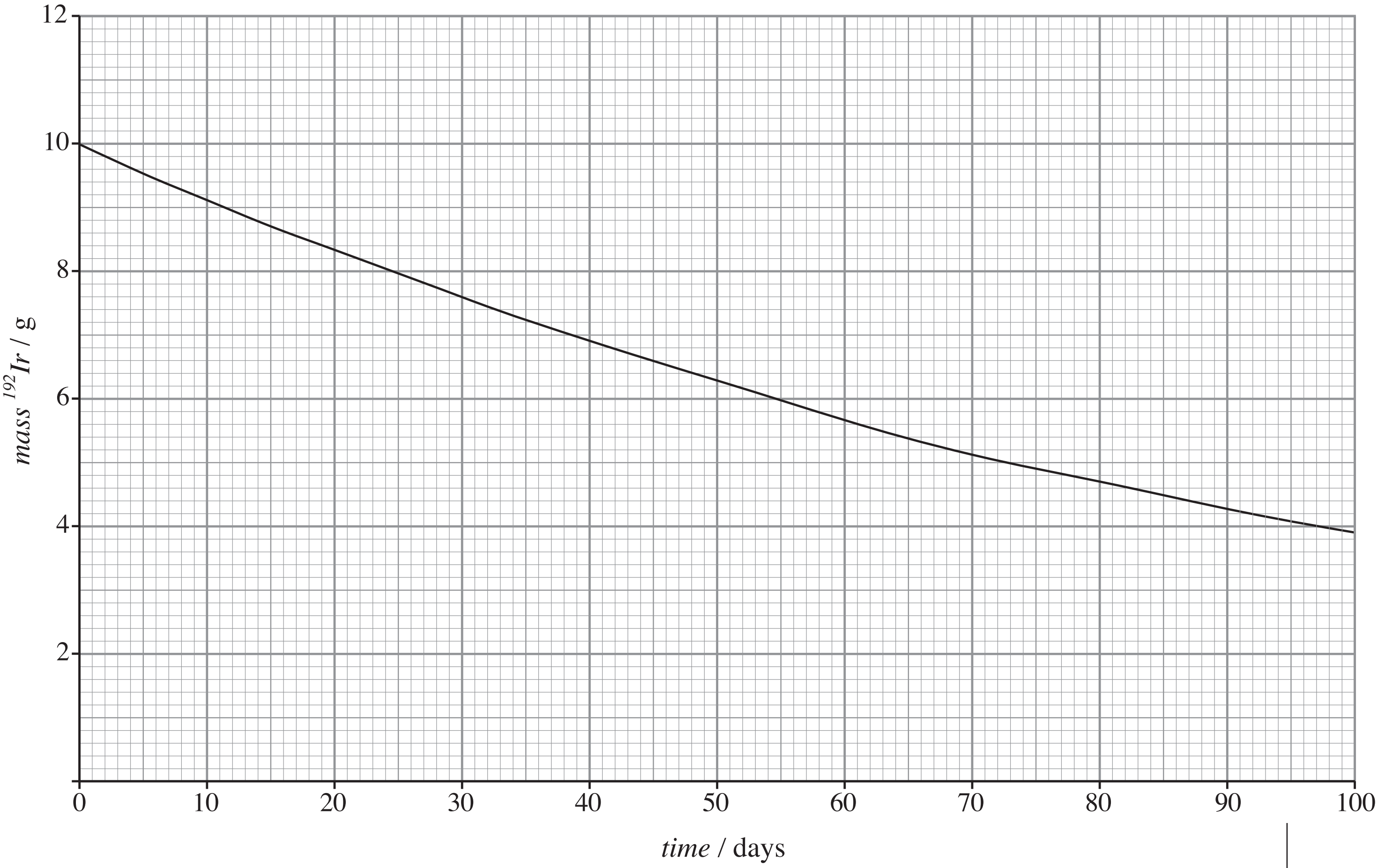
(i) ^{192}Ir decays by β–emission. Explain what is meant by β–emission. [1]

....

(ii) Give the mass number and symbol of the product atom in *(b)*(i). [2]

Mass number .... *Symbol* ....

(c) The decay of a 10g sample of ^{192}Ir with time is shown in the graph.



(i) Explain the term *half-life*. [1]

....

....

(ii) Determine the half-life of ^{192}Ir from the graph. [1]

....

(iii) Determine the total time required for the 10 g mass of ^{192}Ir to decay to 1.25 g. [2]

....

....

(iv) Calculate, from the graph, the rate of decay of ^{192}Ir (g day^{-1}) during the first 20 days. [2]

....

....

....

(d) Compound **P**, one of the most important compounds of iridium, is a black solid containing 10.2 % sodium, Na, 42.6 % iridium, Ir, and 47.2 % chlorine, Cl, by mass.

(i) Calculate the empirical formula (which is also the molecular formula) of compound **P**.

A_r(Na) = 23.0; A_r(Cl) = 35.5; A_r(Ir) = 192. [2]

....

....

....

(ii) Compound **P** is made by reacting a mixture of sodium chloride, NaCl, and an iridium chloride, $IrCl_x$. There is only one product of the reaction. By constructing a balanced equation, or otherwise, determine the value of **x** in the iridium chloride formula, $IrCl_x$. [1]

....

....

Total [17]

W10 1091 01 7

8. Because of the link to global warming, much effort is being devoted to investigating how emissions of carbon dioxide, CO_2, into the atmosphere by power stations burning fossil fuels can be reduced or eliminated.

(a) One area of investigation is the removal of CO_2 by sodium carbonate. Three possible reactions are:

$$Na_2CO_3(s) + CO_2(g) + H_2O(g) \rightleftharpoons 2NaHCO_3(s) \quad \textbf{Reaction 1}$$

$$3Na_2CO_3(s) + CO_2(g) + 5H_2O(g) \rightleftharpoons 2Na_2CO_3.NaHCO_3.2H_2O(s) \quad \textbf{Reaction 2}$$

$$5Na_2CO_3(s) + 3CO_2(g) + 3H_2O(g) \rightleftharpoons 2Na_2CO_3.3NaHCO_3(s)$$
(Wegscheider's Salt) **Reaction 3**

(i) Giving a reason, determine from the equations which of the three reactions uses sodium carbonate, $Na_2CO_3(s)$, most effectively to absorb $CO_2(g)$. [2]
QWC [1]

....

....

....

(ii) State Le Chatelier's Principle. [1]

....

....

....

(iii) Giving your reasons, use Le Chatelier's Principle to determine whether $CO_2(g)$ removal will be more efficient at high gas pressure or low gas pressure. [2]

....

....

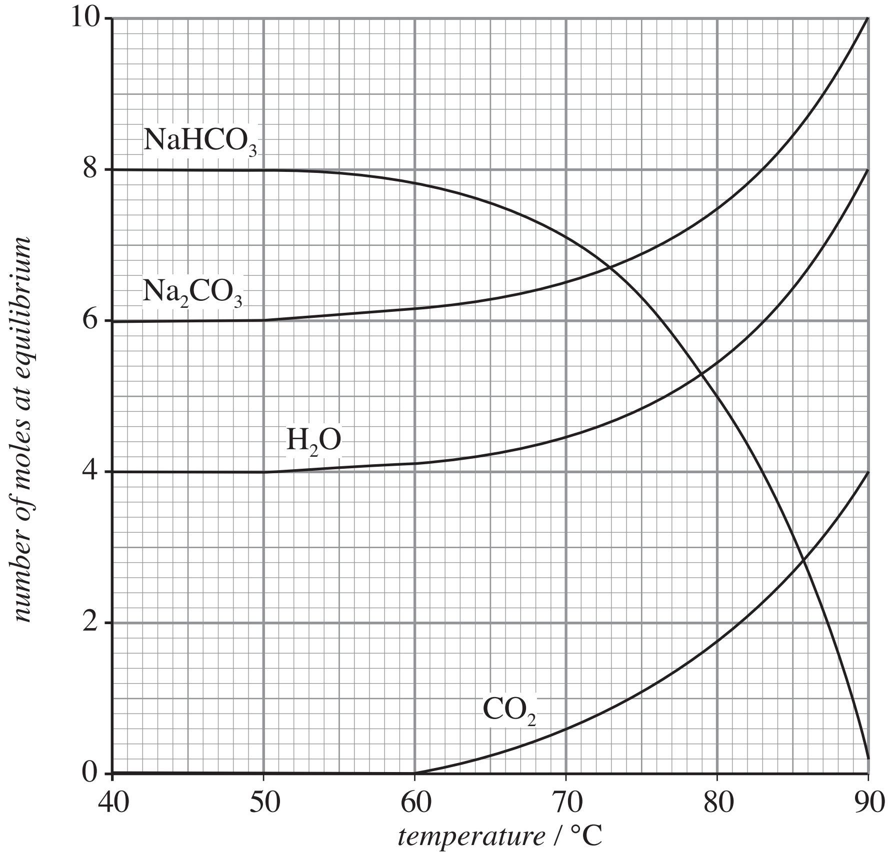
....

Examiner only

(b) For one industrial system using **Reaction 1**

$$Na_2CO_3(s) + CO_2(g) + H_2O(g) \rightleftharpoons 2NaHCO_3(s)$$

the amount of each species present at equilibrium was measured over a range of temperatures. The graph below shows the results.



(i) Giving your reasoning, determine from the graph whether the forward reaction in **Reaction 1** is exothermic or endothermic. [2]

....

....

....

(ii) After the removal of CO_2(g), the solid $NaHCO_3$ residue is taken away and recycled to regenerate sodium carbonate, Na_2CO_3(s).

I By using the graph, or otherwise, determine how sodium carbonate, Na_2CO_3(s), can be regenerated from the $NaHCO_3$ residue. [1]

....

II State **one** problem associated with the regeneration of sodium carbonate, Na_2CO_3(s), by the method you have given. [1]

....

....

W10 1091 01 9

Turn over.

(c) Another area of investigation is the use of a new type of plastic membrane, structured by means of nanotechnology, to catch carbon dioxide gas whilst allowing other waste gases to pass freely through.

If 1000 dm^3 of waste gas at 25 °C yielded 275 g of carbon dioxide, separated by a plastic membrane, calculate:

(i) the number of moles of carbon dioxide in the 275 g separated by the membrane; [2]

....

....

(ii) the volume of carbon dioxide separated at 25 °C; [1]

....

....

[One mole of gas has a volume of 24.0 dm^3 at 25 °C and 1 atm pressure]

(iii) the percentage by volume of carbon dioxide in the waste gas. [1]

....

....

(d) Carbon dioxide, CO_2 is an *acid gas*.

(i) Define the term *acid*. [1]

....

(ii) By considering its interaction with water, explain how carbon dioxide can behave as an acid. [1]

....

....

(iii) Though the pH of pure water is 7, explain why naturally-occurring water in contact with air has a pH of less than 7. [1]

....

....

Total [17]

9. *(a)* (i) Given the bond enthalpy values

Bond	*Bond enthalpy value* / kJ mol^{-1}
Cl – Cl	243
H – Cl	432
H – H	436

calculate the standard enthalpy change, $\Delta H^{\ominus}$, for the gaseous reaction

$$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$$ [2]

....

....

....

(ii) Using your answer to *(a)*(i) calculate the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, for gaseous hydrogen chloride, HCl(g). [1]

....

....

(iii) State the standard conditions which apply to *standard* enthalpy changes. [2]

....

....

(iv) By reference to the bond enthalpy values in *(a)*(i), state which bond will break first in the reaction. [1]

....

....

Examiner only

(v) Typical energies associated with visible light are

Colour of light	*Typical energy* / kJ mol^{-1}
red	171
yellow	200
green	226
blue	254
violet	285

State and explain which colours of light will cause a mixture of hydrogen and chlorine to react. [3]

....

....

(vi) Explain why shining visible light has very little effect on the reverse reaction

$$2HCl(g) \longrightarrow H_2(g) + Cl_2(g)$$ [1]

....

....

(b) The corresponding reaction between hydrogen, $H_2(g)$, and iodine, $I_2(g)$,

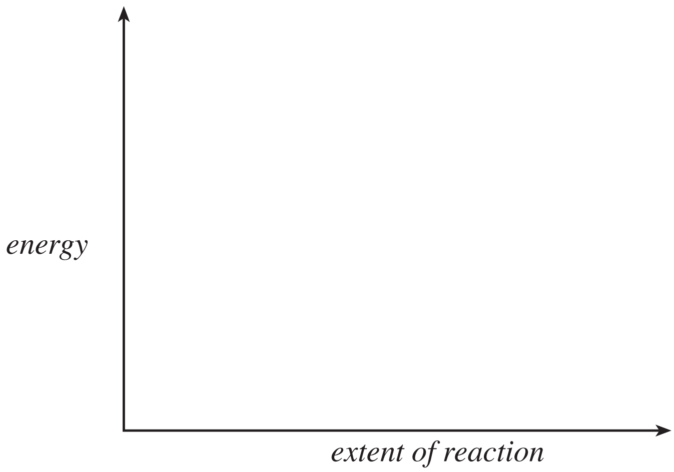
$$H_2(g) \;+\; I_2(g) \rightleftharpoons 2HI(g)$$

for which the standard enthalpy change of reaction, $\Delta H^{\ominus}$, = –9.6 kJ mol^{-1}, is a system unaffected by light.

Sketch on the axes below the energy profile (*energy* v *extent of reaction*) for the reaction between hydrogen and iodine and use it to explain:

- the concept of *activation energy*;
- the effect of increasing temperature on the rate of reaction;
- the effect of adding a catalyst to a reaction mixture. [6]

QWC [2]



Total [18]

10. Ammonia, NH_3, and hydrochloric acid, HCl, undergo an acid-base reaction in aqueous solution.

$$NH_3(aq) + HCl(aq) \longrightarrow NH_4^+(aq) + Cl^-(aq)$$

(a) Explain why this is an acid-base reaction, clearly identifying **both** the acidic and basic reactants. [2]

....

....

....

....

(b) A $25\,cm^3$ sample taken from a stock aqueous solution of ammonia was mixed with $25\,cm^3$ of a solution containing excess hydrochloric acid. The temperature of the mixture rose by 0.7 °C.

(i) Given that the enthalpy change for the reaction, ΔH, is $-53.4\,kJ\,mol^{-1}$, use the equation below to calculate n, the number of moles of ammonia, NH_3, which has reacted.

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

where v is the **total** volume of solution (cm^3)
c is the specific heat capacity ($4.2\,J\,cm^{-3}\,°C^{-1}$)
ΔT is the temperature change (°C)
n is the number of moles of ammonia reacted [3]

....

....

....

(ii) Calculate the concentration ($mol\,dm^{-3}$) of the original ammonia stock solution. [1]

....

....

Examiner only

(c) The concentration of the same stock aqueous solution of ammonia used in part *(b)* was also determined by an acid-base titration. Three separate 25.00 cm^3 samples of the ammonia solution were titrated against hydrochloric acid of concentration 0.1000 mol dm^{-3} from a burette, using an appropriate indicator.

The three titre volumes were 31.25 cm^3, 31.25 cm^3 and 31.20 cm^3 respectively.

(i) Calculate the mean titre volume and use this to find the concentration (mol dm^{-3}) of the ammonia solution. [2]

....

....

....

(ii) Compare the concentration values for the stock ammonia solution obtained by the two experimental methods, *(b)*(ii) and *(c)*(i). State which experiment will give the more precise value, giving **two** reasons for your choice. [3]

....

....

....

....

Examiner only

(d) During World War II, ammonia was used as a fuel for running buses in Belgium. With the current problems associated with fossil fuels, interest in the use of ammonia as a fuel is being revived.
Some relevant standard enthalpy changes of formation, $\Delta H_f^{\ominus}$, are given in the table below.

Species	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CH_4(g)$	–74.8
$CO_2(g)$	–393.5
$H_2O(g)$	–241.8
$N_2(g)$	0
$NH_3(g)$	–46.1
$O_2(g)$	0

(i) Explain why $N_2(g)$ and $O_2(g)$ each have a value of zero for their standard enthalpy change of formation, $\Delta H_f^{\ominus}$. [1]

....

....

(ii) Use the $\Delta H_f^{\ominus}$ values given to calculate:

I the standard enthalpy change, $\Delta H^{\ominus}$, for the combustion of ammonia;

$$4NH_3(g) + 3O_2(g) \longrightarrow 2N_2(g) + 6H_2O(g)$$ [2]

....

....

....

II the standard enthalpy change, $\Delta H^{\ominus}$, for the combustion of methane (as an example of a fossil fuel).

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$$ [2]

....

....

....

Examiner only

(iii) State **one** advantage and **one** disadvantage of using ammonia as a fuel compared to using methane. [2]

Advantage of using ammonia ....

....

Disadvantage of using ammonia ....

....

Total [18]

Section B Total [70]

Examiner only

Rough Work

WJEC
CBAC

GCE MARKING SCHEME

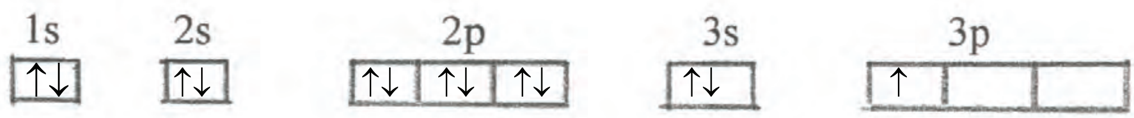
CHEMISTRY (NEW)
AS/Advanced

JANUARY 2010

CH1

SECTION A

1.



1 mark [1]

2. Letter: B 1 mark

Reason: Three electrons in outer shell, so largest jump between 3rd and 4th Ionisation Energies. 1 mark

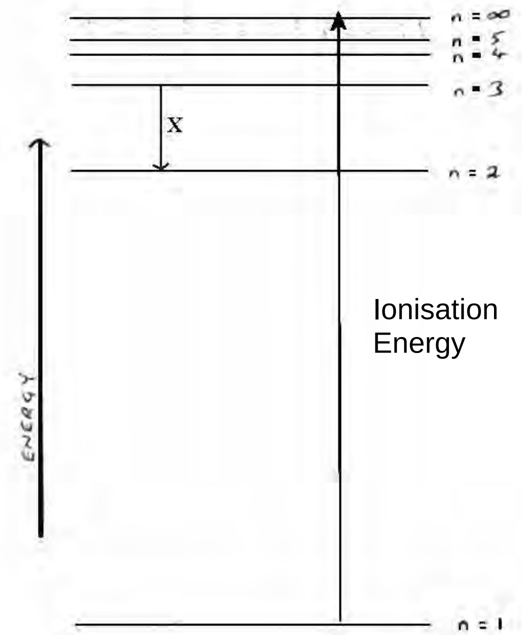
[2]

3 (a) *A mole is the amount of material containing the same number of particles as there are atoms in* 12 g of the ^{12}C isotope. 1 mark [1]

(b) 0.9 mol sulfur atoms. 1 mark [1]

4. (a) C The first line in the Balmer series. 1 mark [1]

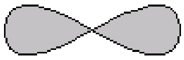
(b) Draw on the energy levels diagram an arrow to represent the transition which occurs when a hydrogen atom is ionised. [1]



(Arrow must be directed upwards for mark).

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

Dumbbell shape or appropriate diagram 1 mark



6. (a) *Dynamic equilibrium* is when the rate of the forward reaction is equal (and opposite) to the rate of the reverse reaction. 1 mark [1]

(b) A chemical system is in *equilibrium* when:
there is no change in the amount of each species present /
there is no change in the concentrations present /
the physical properties are constant. 1 mark [1]

Section A Total [10]

SECTION B

7. (a) (i) *Isotopes* are atoms with the
same atomic number but different mass number /
same number of protons but different numbers of neutrons.
1 mark [1]

(ii) (^{191}Ir) 77 protons 114 neutrons 77 electrons 1 mark

(^{193}Ir) 77 protons 116 neutrons 77 electrons 1 mark
[2]

(iii) *Height of each peak*: [2]

	(^{191}Ir)	19 units	(^{193}Ir)	31 units	1 mark
or (by ruler)		38 mm		62 mm	

% abundance

(^{191}Ir) $\frac{19 \times 100}{50} = 38\%$ (^{193}Ir) $\frac{31 \times 100}{50} = 62\%$ 1 mark

(b) (i) Loss of an electron (from the nucleus). 1 mark [1]

(ii) Mass number 192 Symbol Pt 1 mark for each [2]

(c) (i) *Half-life* is the time taken for half the amount of material to decay.
1 mark [1]

(ii) Half-life of ^{192}Ir = 73 (± 1) days 1 mark [1]

(iii) 1.25 g left (10 $\rightarrow$ 5 $\rightarrow$ 2.5 $\rightarrow$ 1.25 g)
/ 3 half lives elapsed 1 mark

3 x 73 days = 219 days 1 mark
(2 marks for correct answer with no working. Mark consequentially on the half life obtained in (c) (ii)) [2]

(iv) Rate of decay of ^{192}Ir (g day^{-1}) during the first 20 days.

Mass decayed in 20 days = 10 – 8.3 = 1.7 g 1 mark

(Since for the first 20 days the line is indistinguishable from linear)
rate = 1.7 / 20 = 0.085 g day^{-1} 1 mark [2]
(No penalty if units omitted, but do not allow if wrong units given)

(d) (i)

	Sodium	Iridium	Chlorine
Moles	10.2 / 23 = 0.443	42.6 / 192 = 0.222	47.2 / 35.5 = 1.330
			1 mark
Ratio	0.443 / 0.222	0.222 / 0.222	1.330 / 0.222
Hence	Na_2IrCl_6		1 mark

[2]

(ii) **P** is Na_2IrCl_6

So for $2NaCl + IrCl_x \rightarrow Na_2IrCl_6$

x must be 4 / $IrCl_4$ 1 mark [1]
(Mark consequentially if formula of P is incorrect)

Total [17]

8. (a) (i) **Reaction 1** is the most effective. 1 mark
Lowest number moles Na_2CO_3 needed per mole CO_2 /
Highest number moles CO_2 absorbed per mole Na_2CO_3 /
or equivalent statement 1 mark [2]

QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate.
1 mark awarded if candidate has clearly explained their reasoning with appropriate use of words such as *mole* or *ratio*. [1]

(ii) Le Chatelier's Principle:
When a system in equilibrium is subjected to a change, the processes which occur are such as to oppose the effect of the change. 1 mark [1]
(or equivalent statement)

(iii) More efficient at high gas pressure. 1 mark
(Whichever reaction is used gases only occur amongst the reactants, so by Le Chatelier's Principle) high pressure will favour the forward reaction because of the reduction in the number of moles of gas.
1 mark [2]

(b) (i) Exothermic. 1 mark
As the temperature increases, less product ($NaHCO_3$) / more reactants (Na_2CO_3, CO_2 and H_2O) are present so reverse reaction is favoured and forward reaction must be exothermic
(or any equivalent statement) 1 mark [2]

(ii) I (NaHCO$_3$ can be used to regenerate sodium carbonate) by heating (to 90˚C) 1 mark [1]

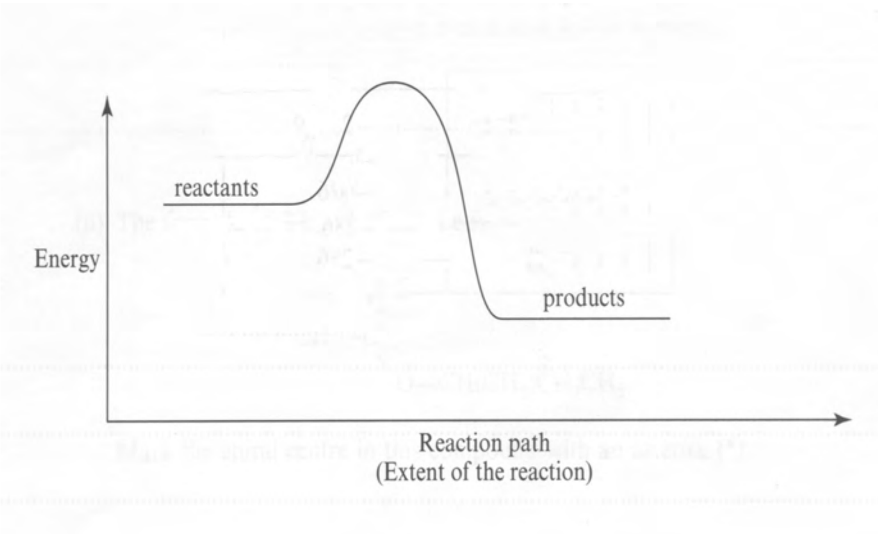
II *Either*
Energy must be supplied for heating (with cost implications)
or
CO_2(g) would be released into the environment (unless prevention measures taken, negating the point of using sodium carbonate to absorb CO_2(g)). 1 mark [1]

(c)	(i)	Relative molecular mass CO_2 = 44	1 mark	
		No moles CO_2 = 275 / 44 = 6.25	1 mark	[2]
	(ii)	6.25 x 24.0 = 150 dm^3	1 mark	[1]
	(iii)	150 x 100 / 1000 = 15%	1 mark	[1]
(d)	(i)	An acid is an H^+ / proton donor.	1 mark	[1]
	(ii)	(Although CO_2 does not contain any hydrogen) it reacts with water to produce H^+ ions / to form carbonic acid / to form H_2CO_3.	1 mark	[1]
	(iii)	Carbon dioxide from air will produce H^+ ions / make the water acidic and acids have pH less than 7.	1 mark	[1]

Total [17]

9.	*(a)*	(i)	1 mark for setting up correctly $\Delta H^{\ominus} = 243 + 436 - (2 \times 432)$ 1 mark for calculation $\Delta H^{\ominus} = -185 \text{ kJ mol}^{-1}$		[2]
		(ii)	$\Delta H_f^{\ominus}$ HCl (g) = $-185 / 2 = -92.5 \text{ kJ mol}^{-1}$ (Mark consequentially if $\Delta H^{\ominus}$ value incorrect)	1 mark	[1]
		(iii)	2 x 1 mark for: Temperature 25˚C / 298 K Pressure 1 atm		[2]
		(iv)	Chlorine – chlorine bond (as it is the weakest).	1 mark	[1]
		(v)	Blue and violet light provide sufficient energy to break the Cl_2 covalent bond	2 x 1 mark 1 mark.	[3]
		(vi)	No visible light has sufficient energy to break the H-Cl bond.	1 mark	[1]

(b)



6 x 1 mark:

- Correct drawing of profile (must be exothermic and show reactants / products)
- Activation Energy is the minimum energy necessary for a reaction to occur
- Increasing temperature increases the (kinetic) energy of molecules
- so more molecules have greater than the activation energy (and reaction speeds up)
- A catalyst lowers the activation energy
- so speeds up the reaction.
  (the points may be made in conjunction with the profile diagram). [6]

QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning. 1 mark

Selection of a form and style of writing appropriate to purpose and to complexity of subject matter. In particular, relating text to the profile diagram. 1 mark [2]

Total [18]

10. *(a)* Transfer of H^+ (from HCl to NH_3) 1 mark
HCl acid, NH_3 base 1 mark [2]

(b) (i) $$\Delta H = \frac{- v\ c\ \Delta T}{n}$$

1 mark for total volume = $50cm^3$

1 mark for converting kJ to J (or vice versa)

1 mark for calculating n (*mark consequentially if set up wrongly above*)

$$-53.4 \times 1000 = \frac{- 50 \times 4.2 \times 0.7}{n}$$

n, no moles NH_3 = 2.75×10^{-3} [3]

(ii) 2.75×10^{-3} mol NH_3 in 25 cm^3

so concentration = 2.75×10^{-3} x 1000/25 = 0.11 mol dm^{-3}
1 mark [1]

(c) (i) Mean titre = 31.23 cm^3 1 mark

Concentration NH_3 = 31.23 x 0.100 / 25 = 0.125 cm^3
1 mark [2]

(ii) Titration will give the more precise value for concentration 1 mark

2 marks for two of the following:

Temperature change only read to one significant figure, titre to three significant figures / titration is a more precise technique than thermometry. 1 mark

The titration is repeated three times (to obtain consistent results), but only one measurement of temperature change. 1 mark

Thermometric method susceptible to heat loss (but no corresponding problem in titrations). 1 mark [3] *(d)* (i) Both already elements in their standard states / no change needed to form them. 1 mark [1]

(ii) I the standard enthalpy change, $\Delta H^{\ominus}$, for the combustion of ammonia

$4NH_3\,(g) + 3O_2\,(g) \rightarrow 2N_2\,(g) + 6H_2O\,(g)$

1 mark for setting up

$\Delta H^{\ominus} = (2 \times 0) + (6 \times -241.8) - (4 \times -46.1) - (3 \times 0)$

1 mark for calculation

$\Delta H^{\ominus} = -1450.8 + 184.4 = -1266.4\ \text{kJ mol}^{-1}$ [2]

II the standard enthalpy change, $\Delta H^{\ominus}$, for the combustion of methane

$CH_4\,(g) + O_2\,(g) \rightarrow CO_2\,(g) + 2H_2O\,(g)$

1 mark for setting up

$\Delta H^{\ominus} = (1 \times -393.5) + (2 \times -241.8) - (1 \times -74.8) - (1 \times 0)$

1 mark for calculation

$\Delta H^{\ominus} = -393.5 - 483.6 + 74.8 = -802.3\ \text{kJ mol}^{-1}$ [2]

(iii) Advantage of using ammonia:
No CO_2 / greenhouse gases emitted 1 mark

Disadvantage of using ammonia:
Much less energy produced per mole on combustion (318.6 v $802.3\ \text{kJ mol}^{-1}$) /more ammonia needed than methane to produce the same amount of energy /sharp smell of ammonia/ ammonia more corrosive. 1 mark [2]

Total [18]

Section B Total [70]

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		

1091 010001

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.

Examiner only

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, $CaSO_4.2H_2O$. [1]

....

....

(b) Calculate the percentage of water, by mass, in calcium sulfate dihydrate. [1]

....

....

3. Ions of two isotopes of the metal lithium are shown below.

$^{6}_{3}Li^{+}$ $\qquad$ $^{7}_{3}Li^{+}$

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

A The electron arrangement of both these Li^+ ions is $1s^22s^1$.

B The $^7Li^+$ ion will have more protons in its nucleus than the $^6Li^+$ ion.

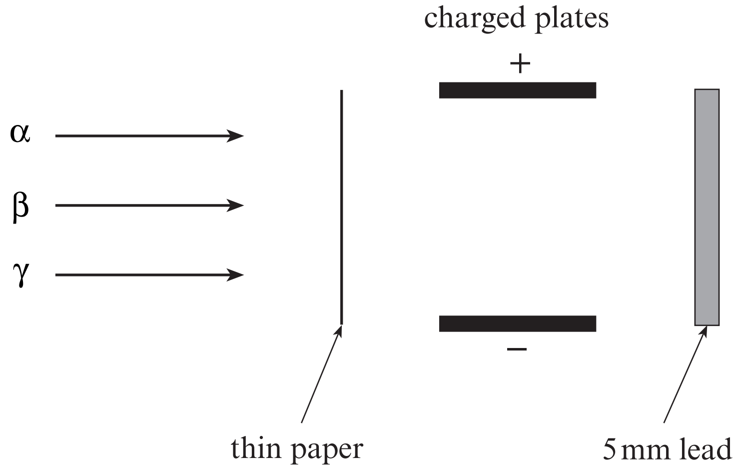
C The $^7Li^+$ ion will be deflected more than the $^6Li^+$ ion in a mass spectrometer.

D Both of these Li^+ ions have the same number of electrons.

....

Examiner only

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]

....

....

....

....

....

....

(b) Determine the molecular formula of this compound. [1]

....

....

....

....

Section A Total [10]

1091 010003

Examiner only

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]

....

....

....

(ii) Calculate the relative atomic mass of the potassium sample, giving your answer to **four** significant figures. [2]

....

....

....

(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]

....

....

(ii) State how potassium ions are separated in a mass spectrometer. [1]

....

....

(c) Potassium-40, $^{40}_{19}K$, 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.

	1st ionisation energy / $kJ\,mol^{-1}$	2nd ionisation energy / $kJ\,mol^{-1}$
potassium	419	3051
sodium	496	4562

(i) Explain the term *molar first ionisation energy*. [2]

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....

....

(ii) Explain why

I potassium has a lower first ionisation energy than sodium, [2]

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II there is a large difference between the first and second ionisation energies of potassium. [2]

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Total [15]

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 cm^3 of acid of concentration 2.00 mol dm^{-3}.

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

(a) Give an observation that Eurig makes during this reaction. [1]

....

....

(b) Name a piece of apparatus that he could use to collect and measure the volume of carbon dioxide produced. [1]

....

(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]

....

....

(d) (i) Calculate the number of moles of hydrochloric acid used in this reaction. [1]

....

....

(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 dm^3 at 25 °C.)

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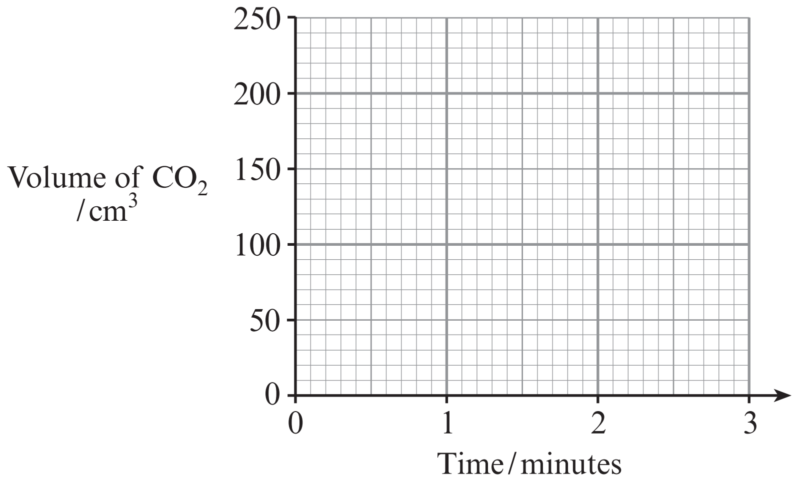
Examiner only

(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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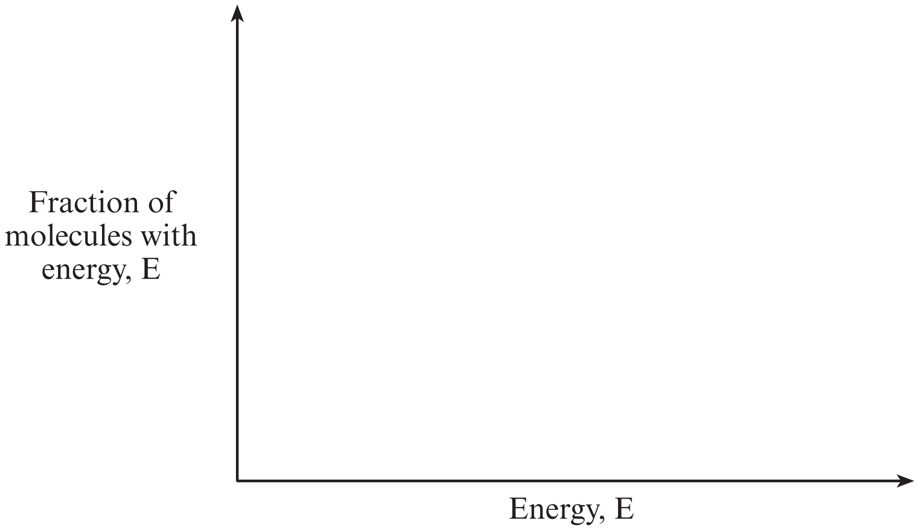
1091
010007

Turn over.

Examiner only

(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]

1091
010009

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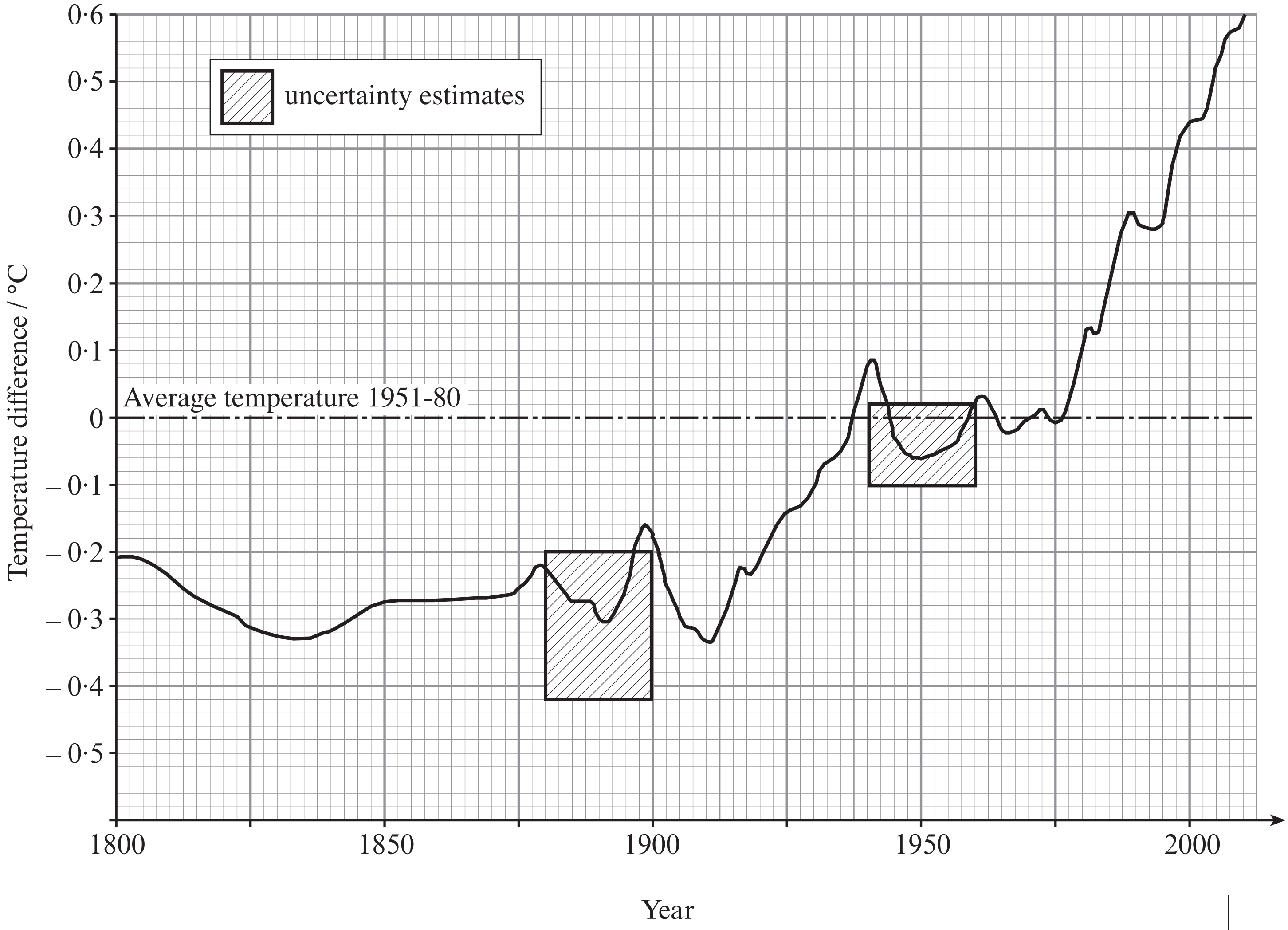
8. *(a)* During the last 200 years, the average temperature of the Earth has risen. One hypothesis put forward by many scientists is that this is due to increased concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

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.

Global Temperature



Examiner only

(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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Examiner only

(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:

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

(i) Chemical equilibria are often described as dynamic equilibria.
Explain the term *dynamic equilibrium.* [1]

....

....

(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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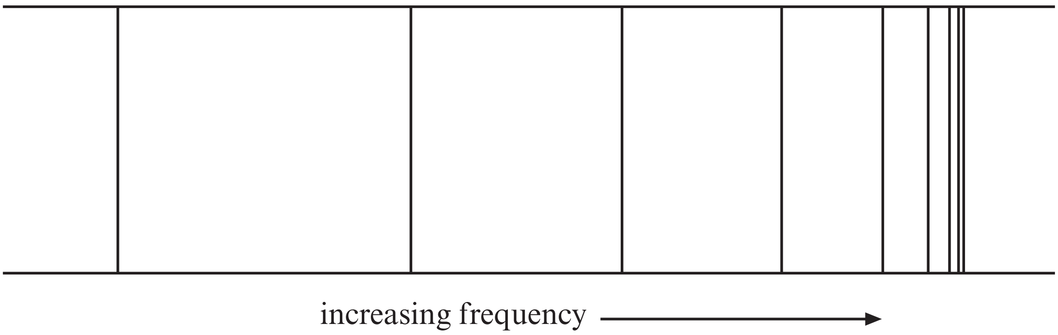
Total [12]

Examiner only

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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....

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Examiner only

(b) Recently hydrogen has been receiving interest as a 'source of energy'. It can be prepared by the steam reforming of methane.

$$CH_4(g) \quad + \quad H_2O(g) \quad \rightleftharpoons \quad CO(g) \quad + \quad 3H_2(g) \qquad \Delta H = 206\,kJ\,mol^{-1}$$

(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]

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....

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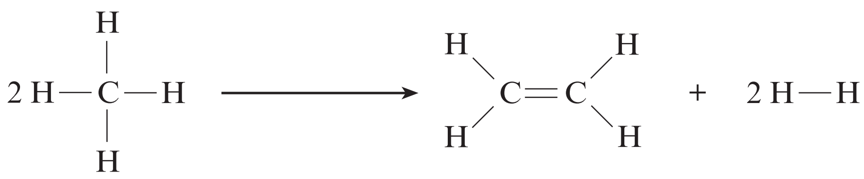
Examiner only

(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}
C$=$C	612
C — H	412
H — H	436

....

....

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Total [11]

Turn over.

Examiner only

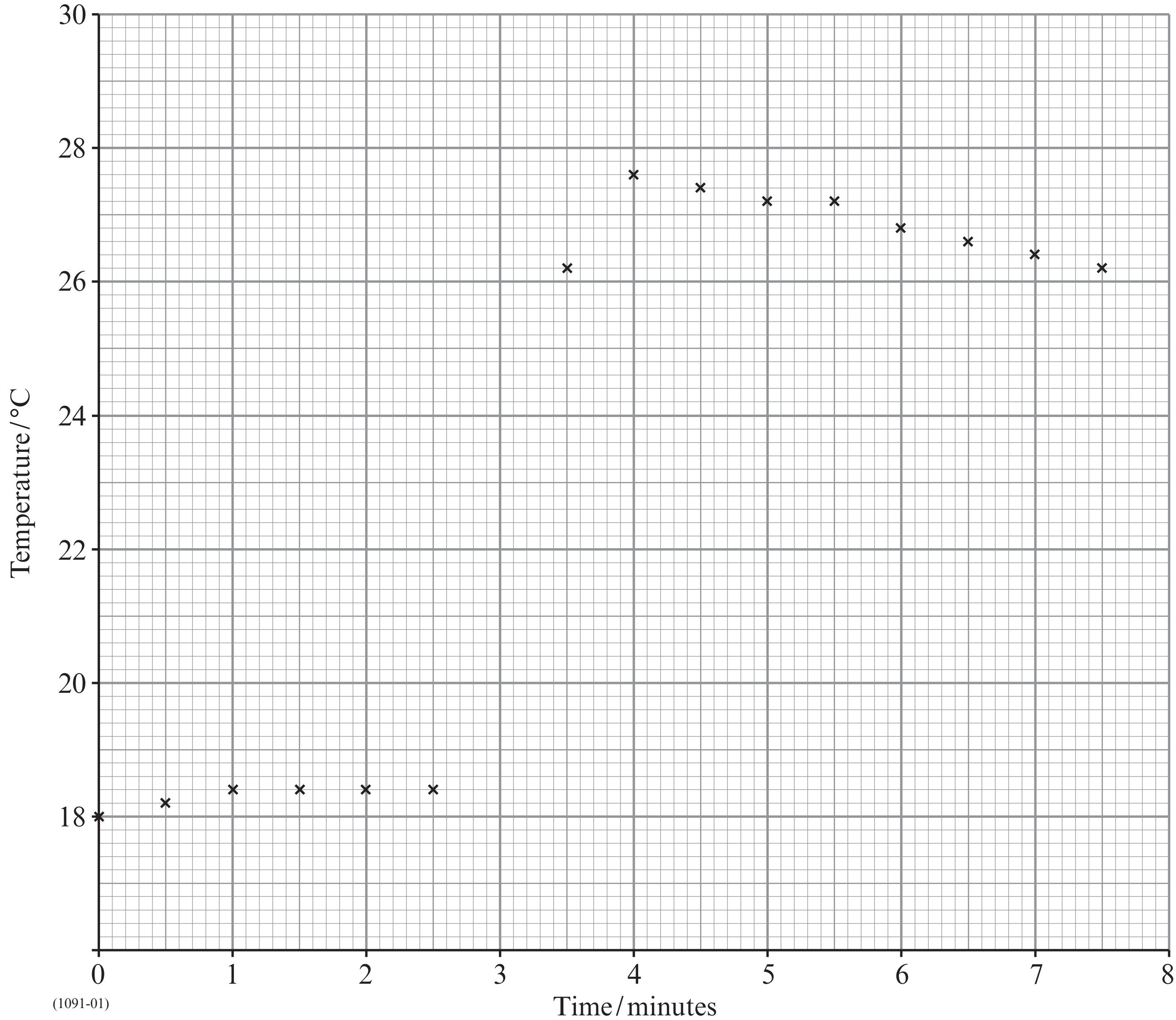
10. Lisa was asked to measure the molar enthalpy change for the reaction between magnesium and copper(II) sulfate solution.

$$Mg(s) \quad + \quad CuSO_4(aq) \longrightarrow MgSO_4(aq) \quad + \quad Cu(s)$$

She was told to use the following method.

- Weigh out about 0.90 g of powdered magnesium.
- Accurately measure 50.0 cm^3 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.



Examiner only

(a) Explain why the temperature of the copper(II) sulfate solution was measured for three minutes before adding the magnesium. [1]

....

....

(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]

....

....

....

(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 $4.18\,J\,K^{-1}\,g^{-1}$) [1]

....

....

(d) (i) Calculate the number of moles of magnesium in 0.90 g. [1]

....

....

(ii) Calculate the number of moles of copper(II) sulfate in $50.0\,cm^3$ of a $0.500\,mol\,dm^{-3}$ solution. [1]

....

....

(e) Calculate the molar enthalpy change for the reaction between magnesium and copper(II) sulfate solution. [2]

....

....

(f) Name a piece of apparatus that Lisa could use to accurately measure $50.0\,cm^3$ of the solution. [1]

....

Examiner only

(g) State why she did not need to accurately weigh the powdered magnesium. [1]

(h) Explain why it is better to use powdered magnesium rather than a strip of magnesium ribbon. [1]

(i) The data book value for this molar enthalpy change is $-93.1\,kJ\,mol^{-1}$.
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.)

(j) State the **main** reason for Lisa's low value in this experiment and suggest **one** change that would improve her result. [2]

Total [15]

Section B Total [70]

Examiner only

Rough Work

WJEC CBAC

GCE AS/A level

1091/01-A

CHEMISTRY CH1
PERIODIC TABLE

A.M. THURSDAY, 13 January 2011

THE PERIODIC TABLE

Key: A_r (relative atomic mass) / Symbol / Name / Z (atomic number)

Period	1	2											3	4	5	6	7	0
	s Block		d Block										p Block					
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	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
6	133 Cs Caesium 55	137 Ba Barium 56	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	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) ▶▶ Ac Actinium 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

JANUARY 2011

CH1

Section A

1.

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

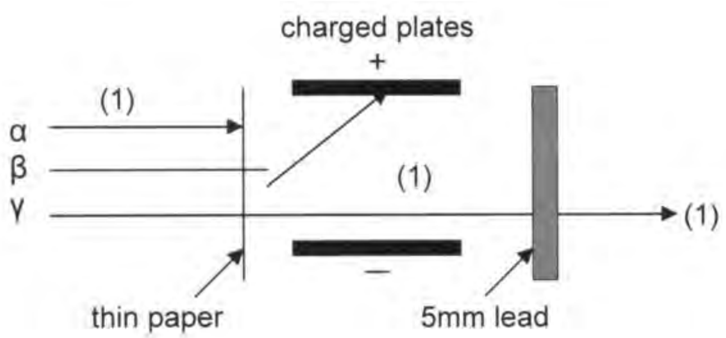
[1]

2. (a) M_r = 172.24 [1]

(b) % = 20.9 [1]

3. D [1]

4.



[3]

5. (a)

C	H	O	
40	6.7	53.3	
12	1.01	16	
3.33	6.63	3.33	(1)
1	2	1	

Empirical Formula = CH_2O (1) [2]

(b) $\frac{180}{30.02} = 6$

Molecular Formula = $C_6H_{12}O_6$ [1]

Total [10]

Section B

6. (a) (i) Average mass of one atom of the element (1) relative to 1/12th mass of one atom of carbon-12. (1) [2]

(ii) $A_r = \dfrac{(39 \times 93.26) + (40 \times 0.012) + (41 \times 6.73)}{100}$ (1)

$= 39.14$ (1) [2]

(b) (i) (Gaseous potassium) atoms bombarded by electrons. [1]

(ii) Deflected through a magnetic field. [1]

(c) (i) $^{40}_{19}K \longrightarrow {}^{40}_{20}Ca + {}^{0}_{-1}\beta$ (accept $^{0}_{-1}e$)

(1 mark for $^{40}_{20}Ca$, 1 mark for balanced equation) [2]

(ii) 3.75×10^9 years. [1]

(d) (i) Energy required to remove one mole of electrons from 1 mole of atoms / an electron from each atom in 1 mole (1) in the gaseous state. (1) [2]
(Accept equation)

(ii) I In K greater shielding of outer electron (1) outweighs larger nuclear charge (1) / Na has greater effective nuclear charge (1) / Na outer electron closer to nucleus (1).
(Maximum 2 marks) [2]

II Shielding effect on outer electron is less (1) / 2nd electron is removed from inner shell / closer to nucleus (1) / after 1st electron is removed effective nuclear charge is greater. (1) [2]

(Maximum 2 marks)

Total [15]

7. (a) Bubbles (of gas) / fizzing / $CaCO_3$ disappears / apparatus gets warmer [1]

(b) Gas syringe / burette / graduated tube/measuring cylinder [1]

(c) (Use scales to) weigh aqueous product / sampling and titration / change in pH at set times [1]

(d) (i) Moles HCl = 0.020 [1]

(ii) Moles $CaCO_3$ = 0.01 (1)
Mass = 1.00 g (1) [2]

(iii) Moles CO_2 = 0.010 (1)
Volume = 0.240 dm^3 (1) [2]

(e) (i) Smooth curve passing through 150 cm^3 ending at 200 cm^3 [1]

(ii) Curve less steep (1) ending at 100 cm^3 (1) [2]

(iii) When the acid is less concentrated it has fewer (acid) particles (1) therefore there is less chance of (successful) collisions (between the acid and carbonate) / fewer collisions per unit time. (1) [2]

(f) Diagram with two reasonable curves. (1 mark) Activation energy labelled (1)
The fraction of molecules that have the required activation energy is much greater at a higher temperature. (1) [3]

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

Total [17]

8. (a) (i) Between 1800 and 1900 the global temperature was fairly constant as was the concentration of CO_2 in the atmosphere. (1)
Since 1900 the global temperature has risen steadily as has the concentration of CO_2 in the atmosphere. (1)

As concentration of CO_2 increases, global temperature increases. (1 mark only). [2]

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

(ii) There is an uncertainty in the results / temperature dropped between 1900 and 1910 / between 1940 and 1950 / at some points. [1]

(iii) Before 1900 the instruments were less accurate (1) and there were fewer records (1)
Temperatures are estimates. (1)
Any 2 from 3 [2]

(iv) More burning of fossil fuels / more industries / more transportation / deforestation. (Any two) [2]

(b) (i) Rate of forward reaction = rate of back reaction. [1]

(ii) (Molecules can escape from the bottle) so concentration amount of CO_2(g) falls / pressure falls (1) and position of equilibrium moves to the left (so concentration of CO_2(aq) falls) / rate of molecules entering solution is less than rate leaving solution. (1) [2]

QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

Total [12]

9. (a) (i) Furthest line on left hand side. [1]

(ii) The (electron) energy levels of a hydrogen atom become closer. [1]

(b) (i) If a system at equilibrium is subject to a change the equilibrium tends to shift so as to minimize the effect of the change. [1]

(ii) I Yield increases. (1)
Forward reaction is endothermic. (1) [2]

II Yield decreases. (1)
More (gaseous) molecules on the right hand side. (1) [2]

(iii) Atom economy = $\dfrac{\text{mass hydrogen}}{\text{mass reactants}} \times 100$ (1)

= 17.8% (1) [2]

(c) Bonds broken = 3296 kJ   Bonds formed = 3132 kJ (1)

$\Delta H = 3296 - 3132 = 164 \text{ kJ mol}^{-1}$ (1) [2]

Total [11]

10. (a) To ensure that the (initial) temperature is constant / temperature difference is required between initial and maximum temperature. [1]

(b) (i) Best fit lines (1)
Temperature rise = 9.6°C (1) [2]
(Accept ±0.2°C)

(ii) Extrapolation gives the temperature that would have been reached if the reaction occurred instantly / to allow for heat loss during the experiment [1]

(c) Heat = $50 \times 4.18 \times 9.6$
$= 2006$ J [1]

(d) (i) Moles Mg = 0.037 [1]

(ii) Moles $CuSO_4$ = 0.025 [1]

(e) $\Delta H = \dfrac{2006}{0.025}$ (1)

$= -80.2\ \text{kJ mol}^{-1}$ (1) [2]

(f) Burette / pipette [1]

(g) Magnesium was in excess. [1]

(h) Rate of reaction is quicker. Allow greater surface area if qualified. [1]

(i) $\dfrac{12.9}{93.1} \times 100 = 13.9\%$ [1]

(j) Energy/Heat is lost to the environment. (1)
States how insulation could be improved e.g. place a lid on the polystyrene cup (1) [2]

Total [15]

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

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

1091 010001

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.

JAN121091010101

Examiner only

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 ....

....

....

Examiner only

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]

....

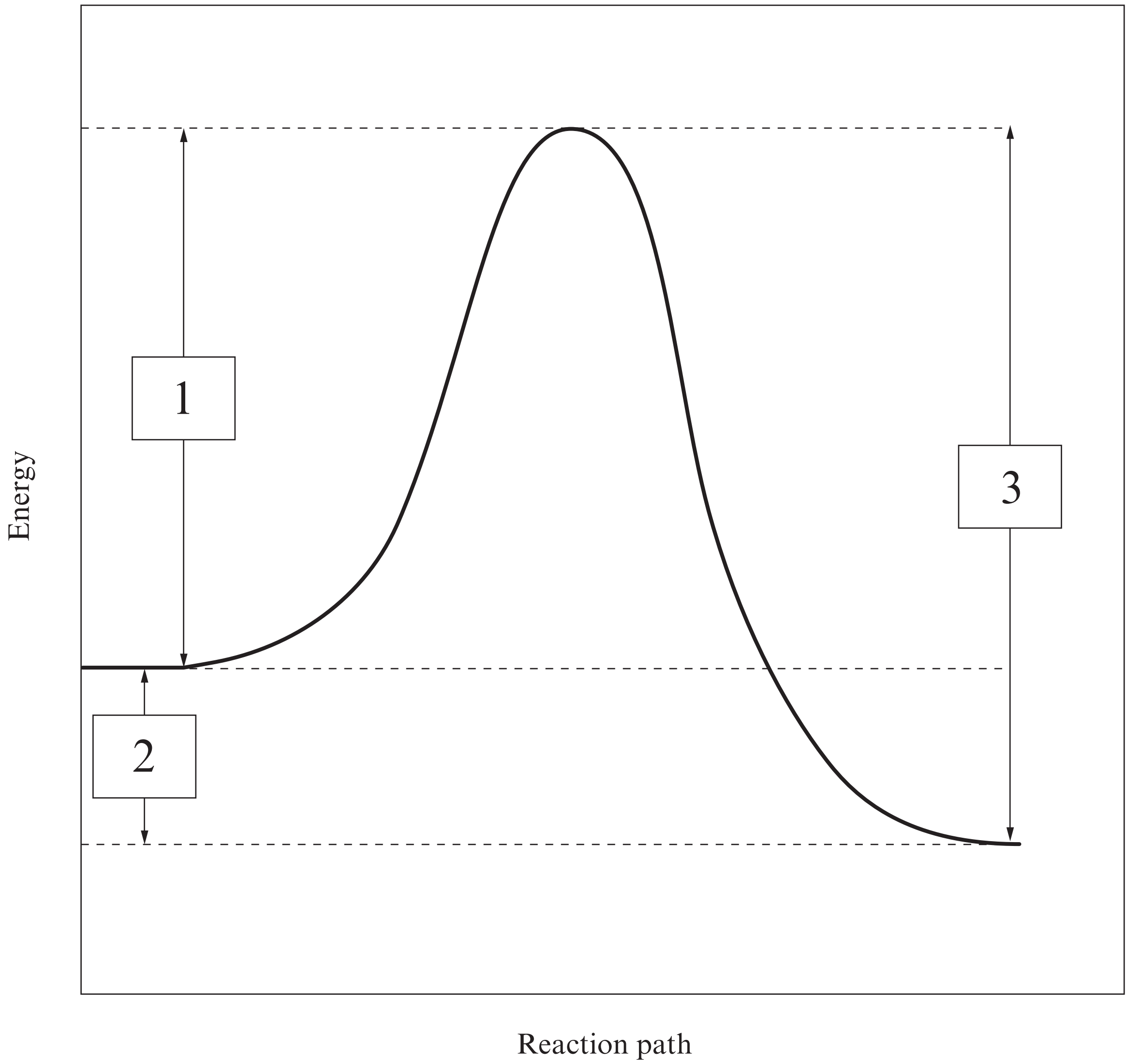
....

.... cm^3

1091 010003

Examiner only

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]

Examiner only

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]

....

....

....

(b) The relative molecular mass of mesitylene is 120.1. Give the **molecular** formula of this compound. [1]

....

....

Total Section A [10]

1091 010005

Examiner only

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.

$$11H_2(g) \ + \ 5CO(g) \longrightarrow C_5H_{12}(l) \ + \ 5H_2O(l) \qquad \Delta H^{\ominus} = -1049\,kJ\,mol^{-1}$$

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, $H_2(g)$	0
Carbon monoxide, CO(g)	–111
Water, $H_2O(l)$	–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, $C_5H_{12}(l)$, in $kJ\,mol^{-1}$. [3]

....

....

....

....

06

Examiner only

(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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1091 010007

Examiner only

(c) One method of producing the hydrogen gas required for the Fischer-Tropsch process is to use the reversible reaction below.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \qquad \Delta H = -42\,kJ\,mol^{-1}$$

(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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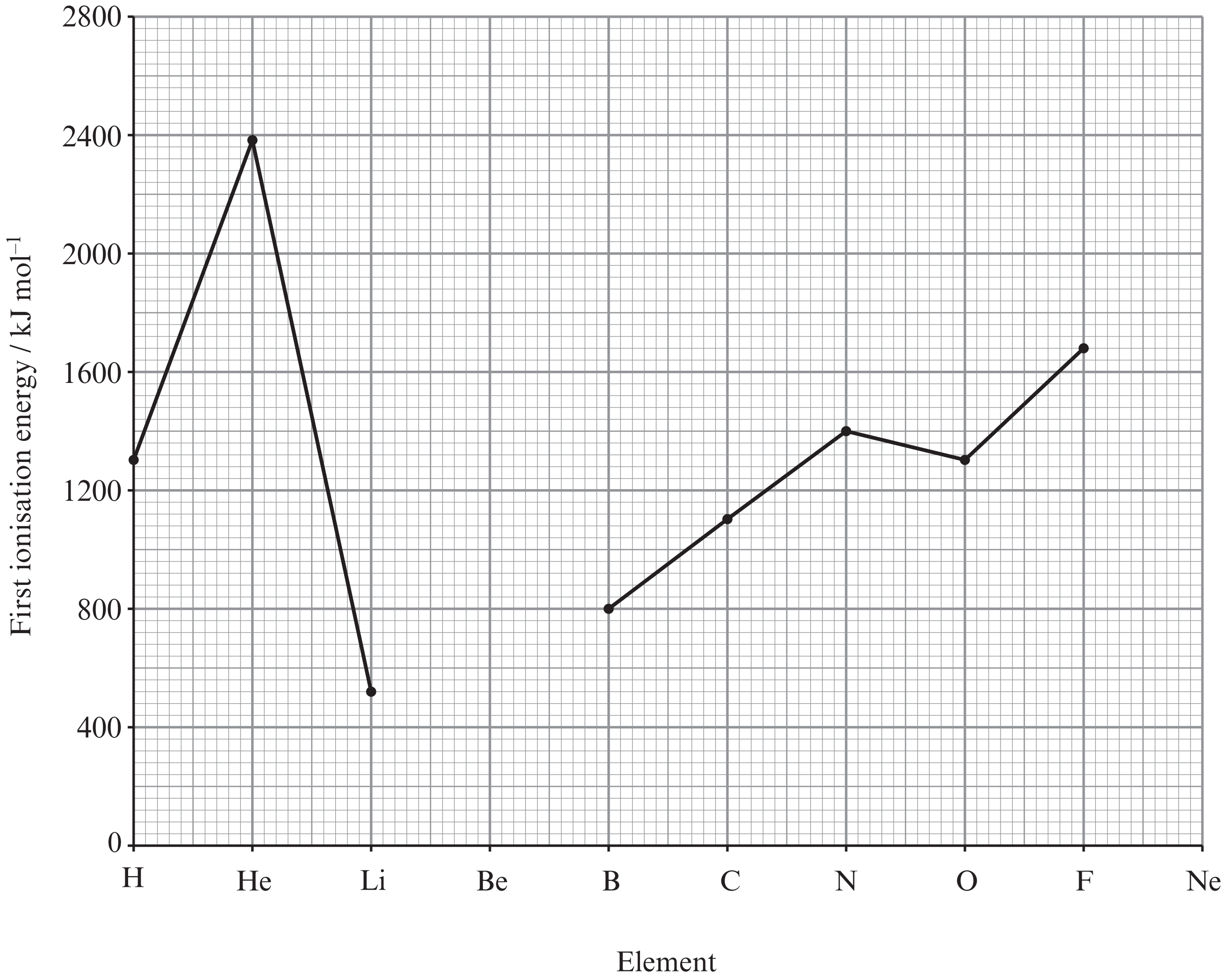
Examiner only

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]

....

Examiner only

(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]

Examiner only

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, SO_2.

$$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$$

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

$$2PbO + PbS \longrightarrow 3Pb + SO_2$$

Method 2: Reduction by carbon monoxide in a blast furnace

$$PbO + CO \longrightarrow Pb + CO_2$$

(i) Both methods for producing lead release waste gases. Give an environmental problem associated with each of these gases. [2]

Sulfur dioxide, SO_2 ....

....

Carbon dioxide, CO_2 ....

....

(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]

....

....

....

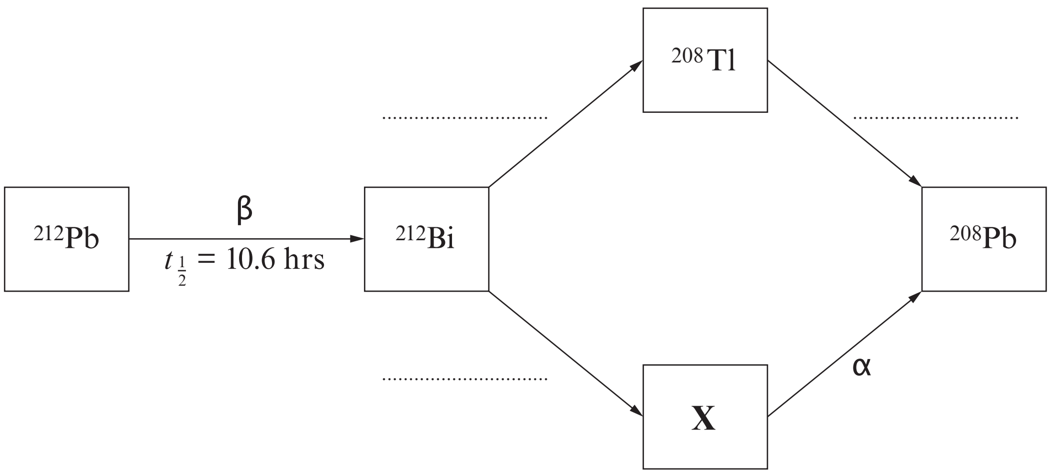
Examiner only

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]

Turn over.

Examiner only

(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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Examiner only

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:

$$CuSO_4(aq) + Zn(s) \longrightarrow ZnSO_4(aq) + Cu(s)$$

(a) Callum prepares copper(II) sulfate solution from hydrated copper(II) sulfate, $CuSO_4.5H_2O$.

(i) Calculate the relative molecular mass of hydrated copper(II) sulfate, $CuSO_4.5H_2O$. [1]

....

....

(ii) Callum measures a mass of hydrated copper(II) sulfate and uses this to make exactly 250.0 cm³ of copper(II) sulfate solution of concentration 0.250 mol 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 250.0 cm³ of copper(II) sulfate solution. [5]

QWC [1]

....

....

....

....

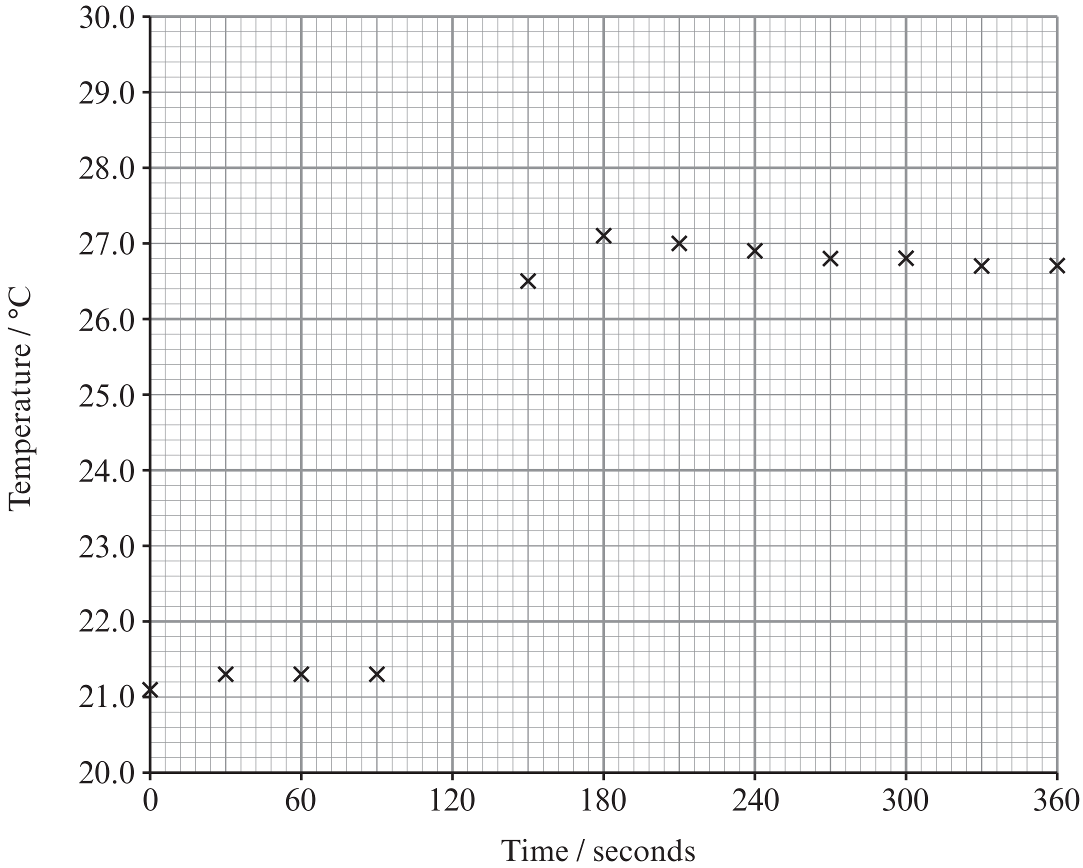
....

....

....

Examiner only

(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.



Examiner only

(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 cm^3 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 J g^{-1} °C^{-1}

Calculate the enthalpy change for the reaction in kJ mol^{-1}. [2]

....

....

....

....

Examiner only

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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WJEC CBAC

GCE AS/A level

1091/01-A

CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1

P.M. FRIDAY, 13 January 2012

THE PERIODIC TABLE

Key

A_r (relative atomic mass) Symbol Name Z (atomic number)

Group

s Block · d Block · p Block

Period	1	2											3	4	5	6	7	0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	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
6	133 Cs Caesium 55	137 Ba Barium 56	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	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 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

JANUARY 2012

GCE Chemistry – CH1

SECTION A

Q.1

1s	2s	2p			3s	3p		
↓↑	↓↑	↓↑	↓↑	↓↑	↓↑	↓↑	↑	↑

[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 cm^3 [1]

Q.5 A [1]

Q.6 (a) Ratio of C:H is 1:1.33 (1)
Emp. Formula = C_3H_4 (1) [2]

(b) Molecular formula = C_9H_{12} [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) $\Delta H = \Delta H_f\ (C_5H_{12}) + 5\ \Delta H_f\ (H_2O) - 5\ \Delta H_f\ (CO) - 11\Delta H_f\ (H_2)$ (1)

$\Delta H_f\ (C_5H_{12}) = -1049 - 5\ (-286) + 5\ (-111)$ (1)

$\Delta H_f\ (C_5H_{12}) = -174\ kJ\ mol^{-1}$ (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 (PbS) = 239.1 M_r (PbO) = 223 (1)

Moles of PbS = 20,000 ÷ 239.1 = 83.65 moles (1)

Mass of PbO = 83.65 x 223 ÷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)

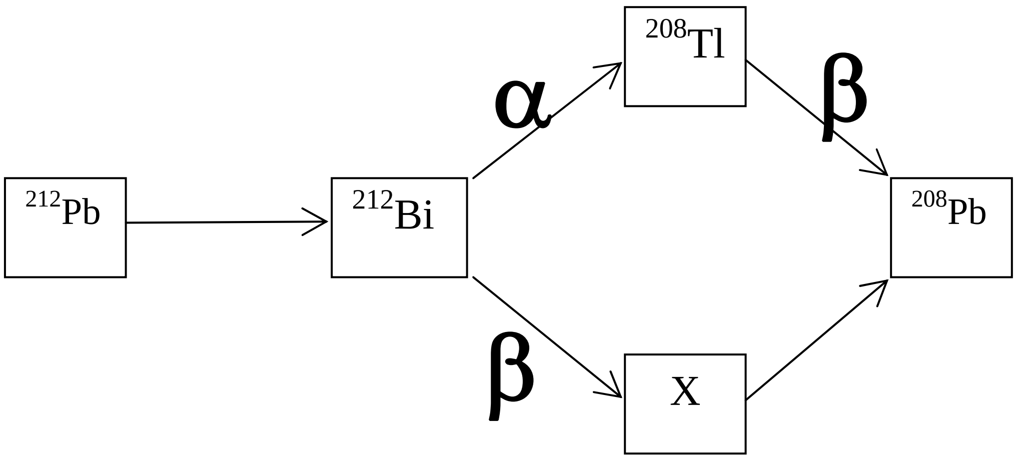
Atom economy = (207 ÷ 251) x 100 = 82.5% (1) [2]

(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 x 25.48) + (207.0 x 22.12) + (208.0 x 52.40)] ÷ 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 ($CuSO_4.5H_2O$) = 249.7 [1]

(ii) I. Moles of copper(II) sulfate

= 0.250 x 250/1000 = 6.25 x 10^{-2} moles (1)

Mass = 6.25 x 10^{-2} x 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°C (Range 5.8-6.2°C) (1) [2]

(iii) I. Moles = 0.250 x 0.05 = 1.25 x 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)

$\Delta H = -204902\ J\ mol^{-1}$

$\Delta H = -205\ kJ\ mol^{-1}$ (1) [2]

IV. Enthalpy measures chemical energy, and as heat energy increases, chemical energy must decrease [1]

Total [18]

SECTION B TOTAL [70]

Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1091/01

CHEMISTRY – CH1

A.M. THURSDAY, 10 January 2013

1½ hours

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

1091 010001

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.

JAN131091010101

Examiner only

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]

A $Ga(g) + 2e^- \longrightarrow Ga^{2-}(g)$

B $Ga(g) \longrightarrow Ga^{2-}(g) + 2e^-$

C $Ga^+(g) \longrightarrow Ga^{2+}(g) + e^-$

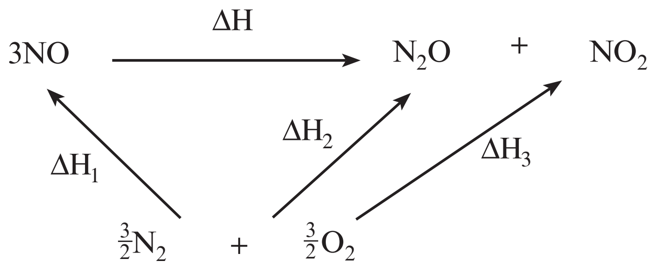
D $Ga^{2+}(g) + 2e^- \longrightarrow Ga(g)$

$\boxed{}$

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]

ΔH = ...

(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.

$$2CO(g) \quad + \quad S_2(g) \quad \rightleftharpoons \quad 2COS(g)$$

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

....

....

....

....

....

....

1091 010003

Examiner only

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

[A_r (Ti) = 48]

Empirical formula ....

Section A Total [10]

Examiner only

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, ^{b}X.

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.

1091
010005

Examiner only

(c) Trona is a naturally-occurring 'sodium carbonate' mineral. It has the formula $Na_2CO_3.NaHCO_3.2H_2O$.

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

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

$$2[Na_2CO_3.NaHCO_3.2H_2O](s) \longrightarrow 3Na_2CO_3(s) + CO_2(g) + 5H_2O(l)$$

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]

....

....

....

....

Examiner only

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

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

(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]

....

....

....

....

....

....

Total [15]

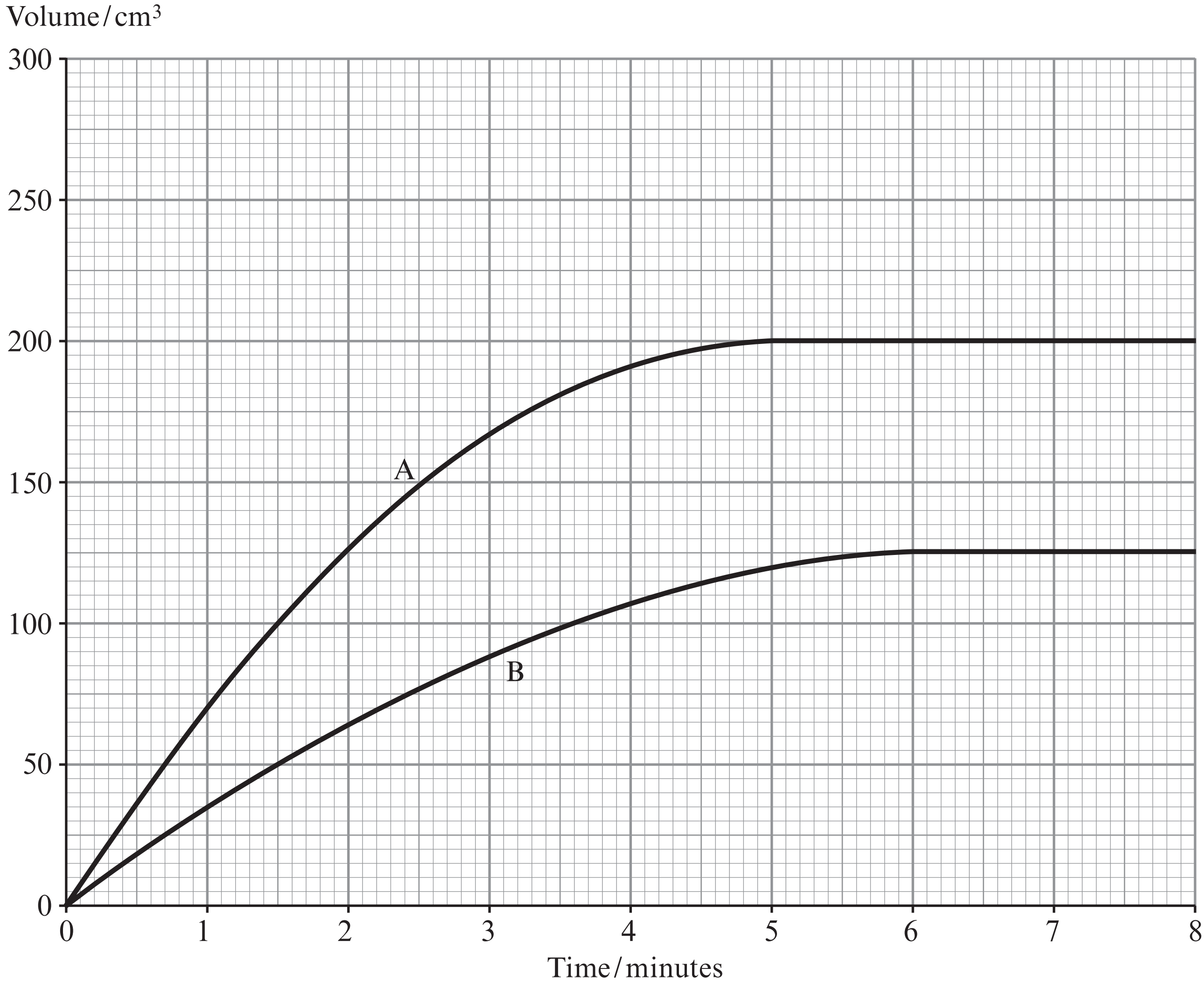
1091
010007

Examiner only

8. Dolomite, $MgCO_3.CaCO_3$, 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. ....

....

Examiner only

(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

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

The volume of carbon dioxide evolved at 298 K is 130 cm^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

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010009

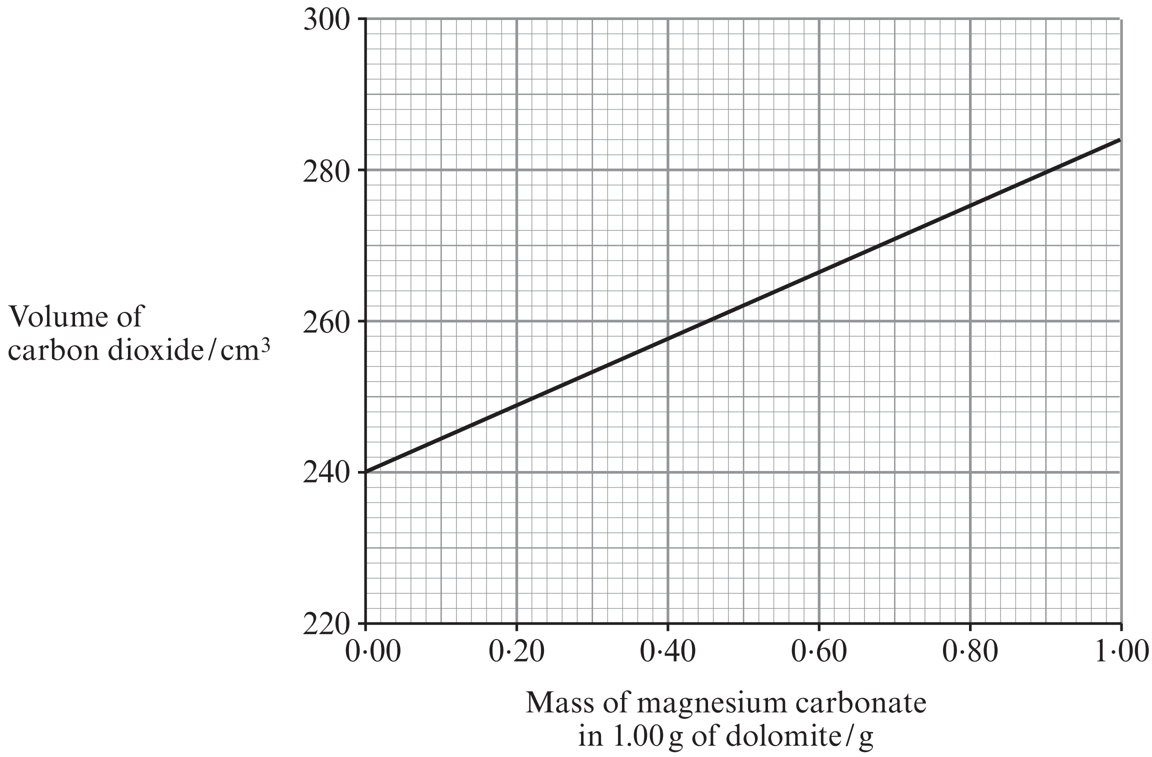
Examiner only

(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 cm^3.

(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 = ... cm^3

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

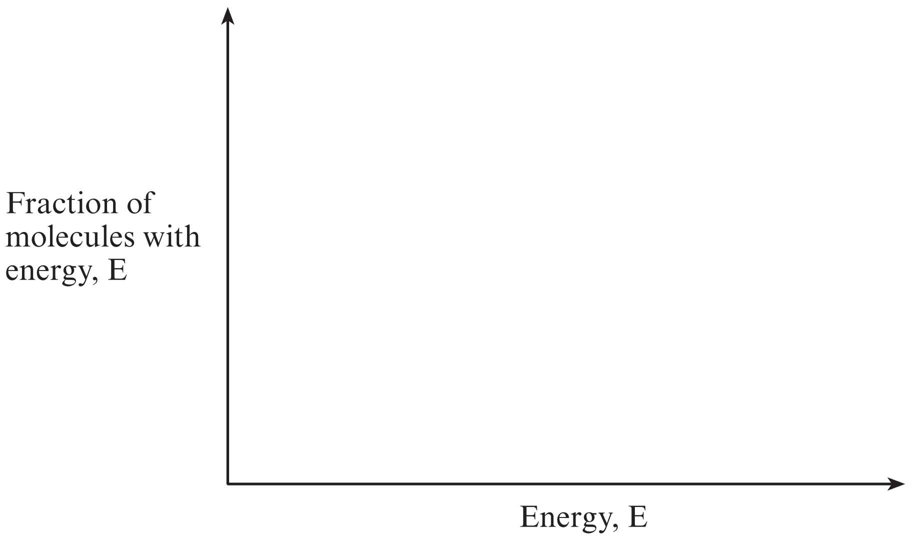


Mass of magnesium carbonate = ... g

Examiner only

(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]



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(d) Briefly outline a different method of following the rate of the reaction between dolomite and hydrochloric acid. [2]

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....

Total [14]

1091 010011

Examiner only

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

$$N_2O(g) \ + \ H_2(g) \longrightarrow N_2(g) \ + \ H_2O(l) \qquad \Delta H = -368\,kJ\,mol^{-1}$$

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

....

....

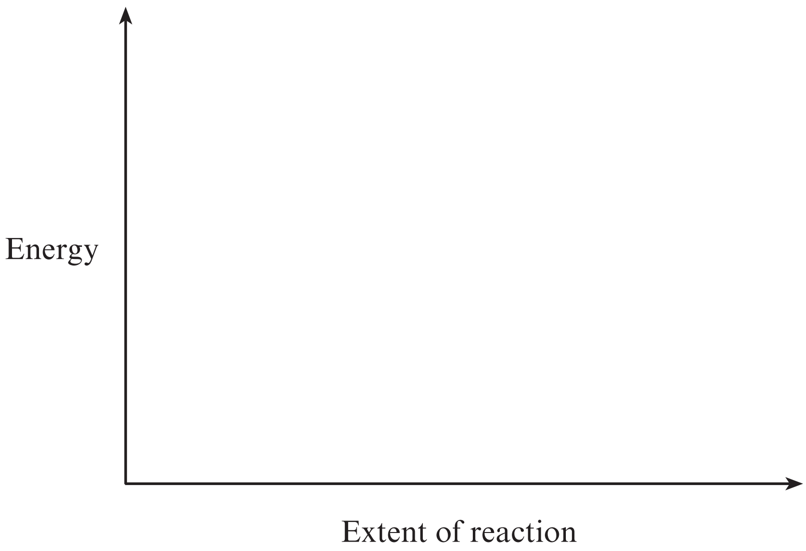
(ii) Calculate the standard enthalpy of formation of nitrogen(I) oxide in $kJ\,mol^{-1}$.
(You should assume that the standard enthalpy of formation of water is $-286\,kJ\,mol^{-1}$) [2]

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

(b) A new method for producing phenol, C_6H_5OH, is by reacting benzene, C_6H_6, with nitrogen(I) oxide at 400 °C in the presence of a suitable catalyst.

$$C_6H_6 + N_2O \longrightarrow C_6H_5OH + N_2 \qquad \Delta H = -286\,kJ\,mol^{-1}$$

(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]

$$C_6H_6 + N_2O \longrightarrow C_6H_5OH + N_2$$

Mass of phenol = ... kg

Examiner only

(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.

$$C_6H_6 \; + \; N_2O \longrightarrow C_6H_5OH \; + \; N_2 \qquad \Delta H = -286\,kJ\,mol^{-1}$$

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]

Examiner only

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 $J\,g^{-1}\,°C^{-1}$
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]

ΔH = ...

(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. ....

....

Examiner only

(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.

$$2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$$

$2.0\,m^3$ 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 $24.0\,dm^3$ under these conditions]

Volume of carbon dioxide = ... dm^3

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

$$[1\,dm^3 = 0.001\,m^3]$$

Percentage of carbon dioxide = ... %

Examiner only

(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’.

$$CO_2(aq) + H_2O(l) + CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + 2HCO_3^{-}(aq)$$

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]

Examiner only

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]

....

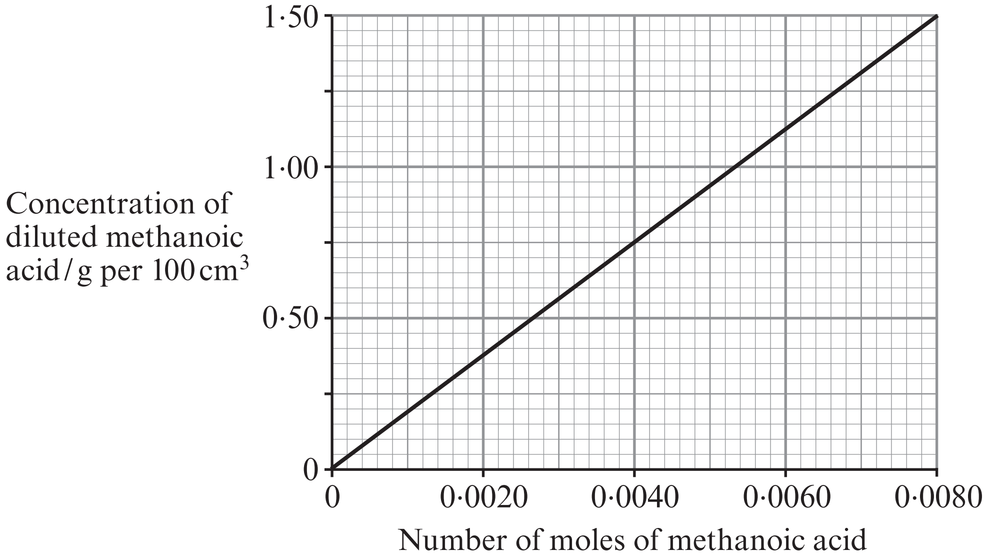
(ii) A 25.0 cm^3 sample of the diluted methanoic acid was titrated with sodium hydroxide solution of concentration 0.200 mol dm^{-3}. A volume of 32.00 cm^3 was needed to react with all the methanoic acid present.

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

Moles of sodium hydroxide = ... mol

Examiner only

(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 cm^3 of solution. [1]



Concentration = ... g per 100 cm^3

(iv) State the concentration of the original methanoic acid in g per 100 cm^3 solution. [1]

Original concentration = ... g per 100 cm^3

Examiner only

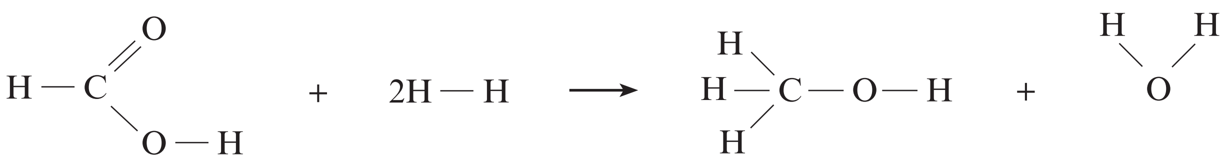
(b) Methanoic acid, HCOOH, can be reduced to methanol, CH_3OH, in a gas phase reaction, by using hydrogen in the presence of a solid ruthenium metal catalyst.

(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 / $kJ\,mol^{-1}$
C—H	412
C—O	360
C═O	743
H—H	436
O—H	463

Enthalpy change = ... $kJ\,mol^{-1}$

Examiner only

(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.

$$HCOOH + CH_3CH_2CH_2OH \rightleftharpoons HCOOCH_2CH_2CH_3 + H_2O$$

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

Question number	**Additional page, if required. Write the question numbers in the left-hand margin.**

Examiner only

Question number	Additional page, if required. Write the question numbers in the left-hand margin.

Examiner only

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Examiner only

GCE AS/A level

1091/01-A

CHEMISTRY – PERIODIC TABLE FOR USE WITH CH1

A.M. THURSDAY, 10 January 2013

THE PERIODIC TABLE

Key: A_r (relative atomic mass) / Symbol / Name / Z (atomic number)

Period	1	2											3	4	5	6	7	0
	s Block		d Block										p Block					
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	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
6	133 Cs Caesium 55	137 Ba Barium 56	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	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 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

JANUARY 2013

GCE CHEMISTRY - CH1

JANUARY 2013 MARK SCHEME

SECTION A

Q.1 39 [1]

Q.2 C [1]

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

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

(b) $½N_2(g) + ½O_2(g) \rightarrow NO(g)$ 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 $\dfrac{60}{48}$ O $\dfrac{40}{16}$ (1)

$= 1.25$ $= 2.5$ $\therefore$ 1 : 2

$\therefore$ TiO_2 (1) [2]

Section A Total [10]

SECTION B

Q.7 (a) (i) A helium (atom) nucleus / 2 protons and 2 neutrons / $^{4}He^{2+}$ [1]

(ii) b………22 (1) X……………Ne (1) [2]

(iii) (4 × 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)

$$\begin{array}{ccccccc} Na_2CO_3 & & NaHCO_3 & & 2H_2O & & \\ \downarrow & & \downarrow & & \downarrow & & \\ 106 & + & 84 & + & 36 & (1) \rightarrow & 226 \end{array}$$ [1]

(or by other appropriate method – note mark is for the working)

(ii) Atom economy $= \dfrac{\text{‘}M_r\text{ required product} \times 100}{\text{Total ‘}M_r\text{’ of the reactants}}$ (1)

$= \dfrac{318 \times 100}{452} = 70.4 / 70.35$ (%) (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

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

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

(b) (i) 260 (cm^3) [1]

(ii) 0.45 (g) (0.43–0.48) [1]

(c) The diagram shows two reasonable distribution curves with T_2 flatter and 'more to the right' than T_1. (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]

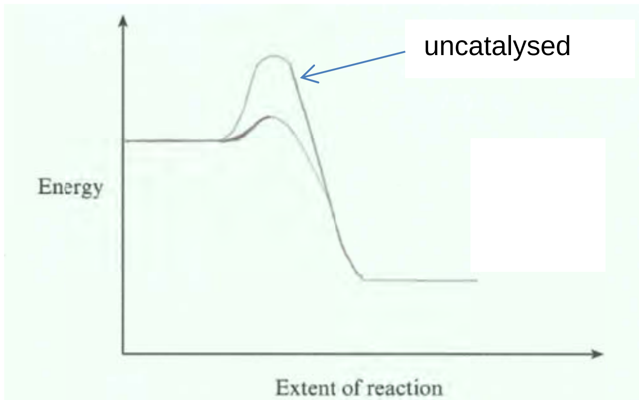
(ii) $\Delta H = \sum \Delta H_f$ products - $\sum \Delta H_f$ reactants (1)

$= (-286 + 0) - (-368 + 0)$

$= -286 + 368 = (+)82$ (kJ mol^{-1}) (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)

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

mass = M_r × number of moles = 94 × 1900 = 178.6 / 179 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 × 156/78 (kg) of phenol = 188 (kg) (1)
but 95% yield $\therefore$ $\dfrac{188 \times 95}{100}$ = 178.6 / 179 (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) $\Delta T = 4.8\ ^oC$ (1)

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

✓ 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 × 24.0) = 1.20 (dm^3) [1]

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

Q.11	(a)	(i)	I burette / (graduated) pipette	[1]
			II volumetric / graduated / standard flask	[1]
		(ii)	0.0064	[1]
		(iii)	1.20 g / 100 cm^3 solution	[1]
		(iv)	12.0 g / 100 cm^3 solution	[1]
	(b)	(i)	The catalyst is in a different physical state to the reactants.	[1]

(ii) Bonds broken

2 H-H $\rightarrow$ 872   1 C-O $\rightarrow$ 360
1 C-H $\rightarrow$ 412   1 O-H $\rightarrow$ 463
1 C=O $\rightarrow$ 743

Total +2850 kJ (1)

Bonds made

3 C-H $\rightarrow$ 1236
1 C-O $\rightarrow$ 360
3 O-H $\rightarrow$ 1389

Total -2985 kJ (1)

$\Delta H = 2850 - 2985 = -135 \text{ kJ mol}^{-1}$ (1) [3]

(c) Relative molecular mass is a relative quantity (based on $^1/_{12}$th of the ^{12}C atom as one unit). [1]

(d) (i) The rate of the forward reaction is equal to the rate of the backward reaction. [1]

(ii) C_2H_4O [1]

Total [12]

Total Section B [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
Section A	1.5.	10	
Section B	6.	8	
	7.	15	
	8.	19	
	9.	18	
	10.	10	
	Total	80	

1091 010001

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.

Examiner only

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]

....

....

(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.

$$2C(s) + 3H_2(g) + 3\tfrac{1}{2}O_2(g) \xrightarrow{\Delta H^{\ominus}} C_2H_6(g) + 3\tfrac{1}{2}O_2(g)$$

$$\searrow \qquad \swarrow$$

$$2CO_2(g) + 3H_2O(l)$$

Use the values in the table below to calculate the enthalpy change of reaction, $\Delta H^{\ominus}$. [2]

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

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

1091
010003

Examiner only

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 ....

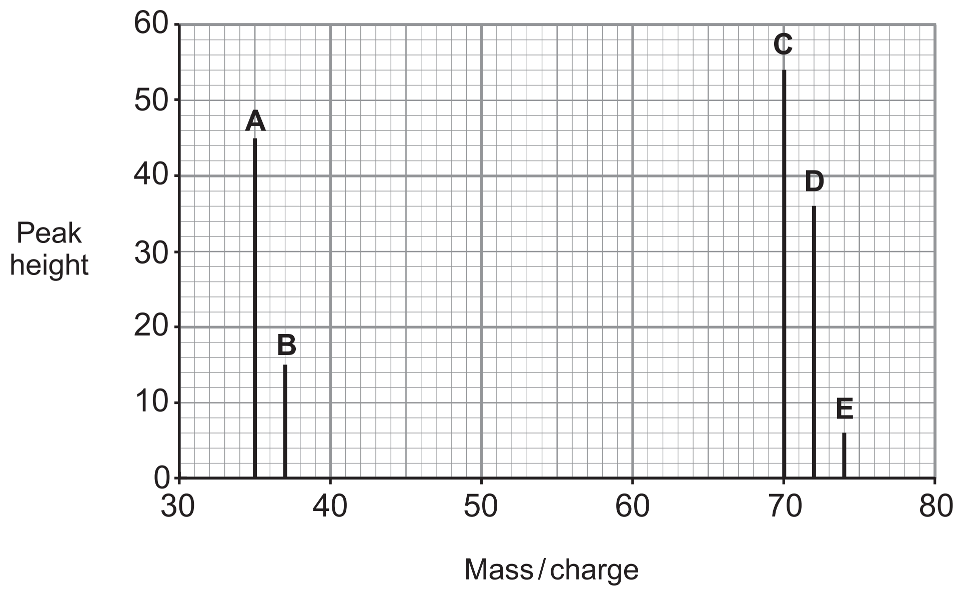
Section A Total [10]

Examiner only

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]

....

....

....

....

....

Examiner only

(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]

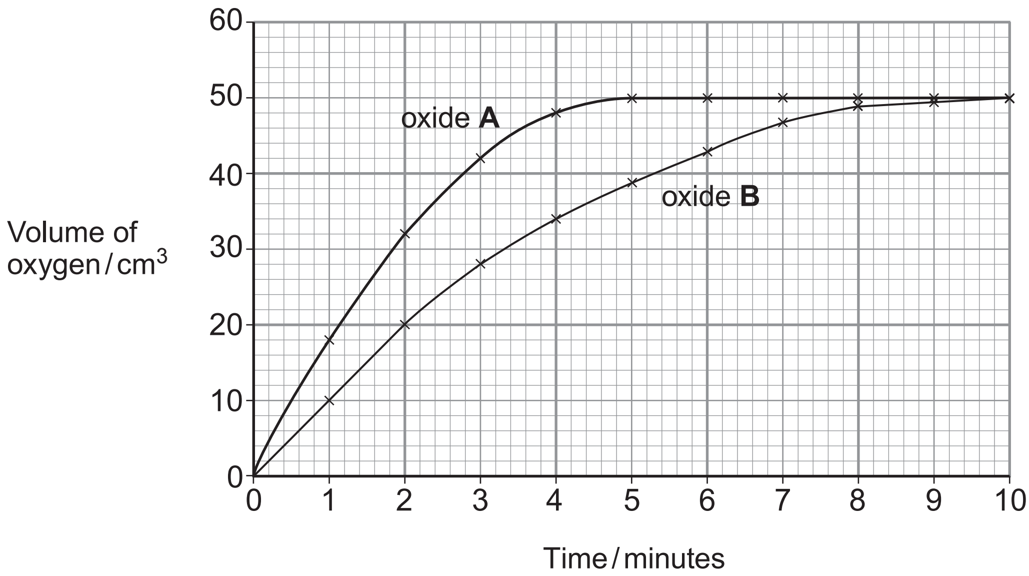
Examiner only

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

$$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$$

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 cm^3 of a hydrogen peroxide solution with 90 cm^3 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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010007

Examiner only

(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]

....

Examiner only

(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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Examiner only

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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Examiner only

(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]

Examiner only

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 $H_2O(g)$. [1]

....

(ii) The standard molar enthalpy change of formation, $\Delta H_f^{\ominus}$, of $H_2O(g)$ 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]

....

....

Examiner only

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

$$MgH_2(s) \quad + \quad 2H_2O(l) \longrightarrow Mg(OH)_2(s) \quad + \quad 2H_2(g)$$

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 dm^3 at room temperature and pressure]

Volume of hydrogen gas = ... dm^3

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

$$CO(g) \quad + \quad 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -91 \text{ kJ mol}^{-1}$$

(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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Examiner only

(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]

Examiner only

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

$$NaCl + NH_3 + CO_2 + H_2O \longrightarrow NaHCO_3 + NH_4Cl$$

$$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$$

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, $Na_2CO_3.xH_2O$.

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 $Na_2CO_3.xH_2O$. [2]

x = ...

QUESTION 10 CONTINUES ON PAGE 16

Examiner only

(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.

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$$

(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

Examiner only

For continuation only.

Examiner only

For continuation only.

Examiner only

For continuation only.

GCE AS/A level

1091/01-A

CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1

A.M. THURSDAY, 9 January 2014

SM*(W14-1091-01A)

THE PERIODIC TABLE

Group

s Block | d Block | p Block

Period	1	2											3	4	5	6	7	0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	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
6	133 Cs Caesium 55	137 Ba Barium 56	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	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 89															

Key

A_r Symbol Name Z

relative atomic mass

atomic number

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

WJEC
CBAC

GCE MARKING SCHEME

CHEMISTRY
AS/Advanced

JANUARY 2014

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 H_2 = $(2 \times -394) + (3 \times -286)$ $= -1646$ kJ mol^{-1}	(1)	
		$\Delta H = -1646 - (-1560) = -86$ kJ mol^{-1}	(1)	[2]

Q.5

	Ag	S		
Mass	1.08	0.16		
A_r	108	32		
Moles	0.01	0.005	(1)	
	2	1		
Formula = Ag_2S			(1)	[2]

Total Section A [10]

Section B

Q.6	(a)	(i)	**B** is $^{37}Cl^{+}$	(1)	
			C is $(^{35}Cl—^{35}Cl)^{+}$	(1)	[2]
		(ii)	**C** = 54, **E** = 6	(1)	
			Ratio of **C**:**E** is 9:1	(1)	[2]
		(iii)	Ratio of ^{35}Cl:^{37}Cl is 3:1	(1)	
			Ratio of $^{35}Cl—^{35}Cl$: $^{37}Cl—^{37}Cl$ is 3:1 × 3:1 = 9:1	(1)	
			or		
			Probability of atom being ^{35}Cl is ¾ and that of ^{37}Cl is ¼	(1)	
			Probability of $^{35}Cl—^{35}Cl$ is ¾ × ¾ = 9/16 and $^{37}Cl—^{37}Cl$ is ¼ × ¼ = 1/16	(1)	[2]
	(b)		$A_r = \dfrac{(79 \times 50.69) + (81 \times 49.31)}{100}$	(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 cm^3		[1]
		(ii)	10 cm^3		[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 cm^3		[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)	$H_2 + ½O_2 \rightarrow H_2O$		[1]
		(ii)	$-242 = 436 + 248 - 2(O—H)$ $2(O—H) = 926$ $O—H = 463\ kJ\ mol^{-1}$	(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 $MgH_2 = \frac{70000}{26.32} = 2659.6\ (2660)$	(1)	
			Moles $H_2 = 5319.2\ (5320)$	(1)	
			Volume $H_2 = 1.28 \times 10^5\ dm^3$	(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 $Na_2CO_3 = 7.69$	(1)	
			Mass $Na_2CO_3 = 7.69 \times 106 = 815(.4)$ g	(1)	[3]
	(b)	(i)	2.52 g		[1]
		(ii)	Moles $Na_2CO_3 = 0.02$ Moles $H_2O = 0.14$ (1) $x = 7$	(1) (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]

Candidate Name	Centre Number	Candidate Number
		2

GCE AS/A level

1091/01 **New AS**

CHEMISTRY CH1

A.M. WEDNESDAY, 3 June 2009

1½ hours

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-4	
B	5	
	6	
	7	
	8	
	9	
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

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 20 may be used for rough work.

SECTION A

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

1. The symbols $^{35}_{17}Cl$, $^{37}_{17}Cl$ and $^{39}_{19}K$, represent chlorine atoms and potassium atoms respectively.

(a) Use these symbols to explain the meaning of the terms

(i) atomic number, [1]

....

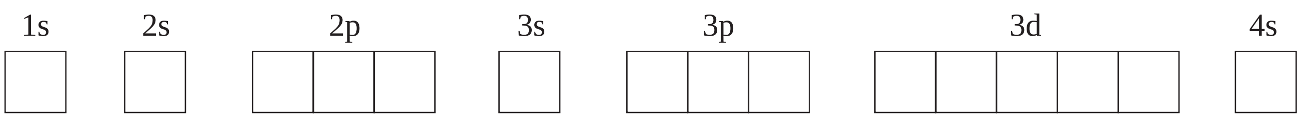
....

(ii) isotope. [1]

....

....

(b) By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of a potassium atom. [1]



2. *(a)* Cobalt reacts with hydrochloric acid to give cobalt chloride and hydrogen.

$$Co(s) + 2HCl(aq) \longrightarrow CoCl_2(aq) + H_2(g)$$

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

....

....

(ii) State what could be done to the cobalt to increase the rate of this reaction. [1]

....

....

(b) A radioactive isotope of cobalt has a half-life of 71 days. Starting with 16 g, calculate the mass of this isotope remaining after 213 days. [1]

....

....

3. State the mass of carbon that contains the same number of atoms as there are molecules in 16 g sulfur dioxide, SO_2. [1]

A 3 g

B 6 g

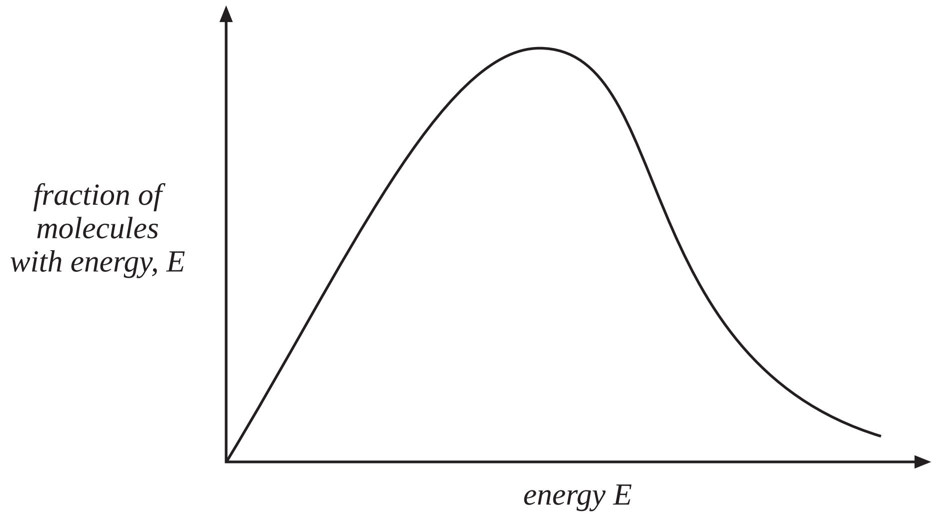
C 12 g

D 64 g ....

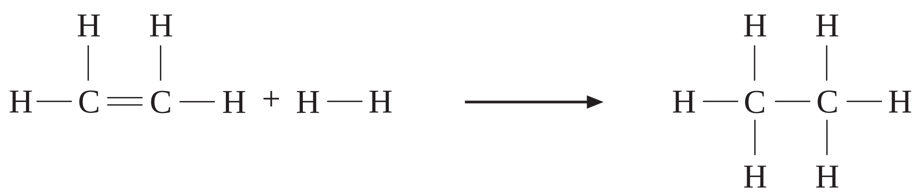
Examiner only

4. *(a)* The diagram below shows the distribution of molecular energies for a sample of ethene.

On the diagram, draw the distribution curve of molecular energies for the same sample of ethene at a higher temperature. [1]



(b) Ethene can be converted to ethane. The equation for the reaction is shown below.



Using the average bond enthalpy values listed below, calculate the enthalpy change, in kJ mol^{-1}, for the reaction. [2]

Bond	*Average bond enthalpy* / kJ mol^{-1}
C — C	348
C ═ C	612
C — H	412
H — H	436

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Section A Total [10]

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Examiner only

SECTION B

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

5. *(a)* The table below shows the molar first ionisation energy values, IE, for the first ten elements of the Periodic Table.

Element	H	He	Li	Be	B	C	N	O	F	Ne
IE / kJ mol^{-1}	1310	2370	520	900	800	1090	1400	1310	1680	2080

(i) Complete the graph shown on the next page, to show how first ionisation energy varies for the first ten elements.

Four of the points have been plotted for you. [3]

(ii) Explain why

I. helium has a higher first ionisation energy than neon, [2]

....

....

....

II. neon has a higher first ionisation energy than nitrogen, [1]

....

....

III. nitrogen has a higher first ionisation energy than oxygen. [2]

....

....

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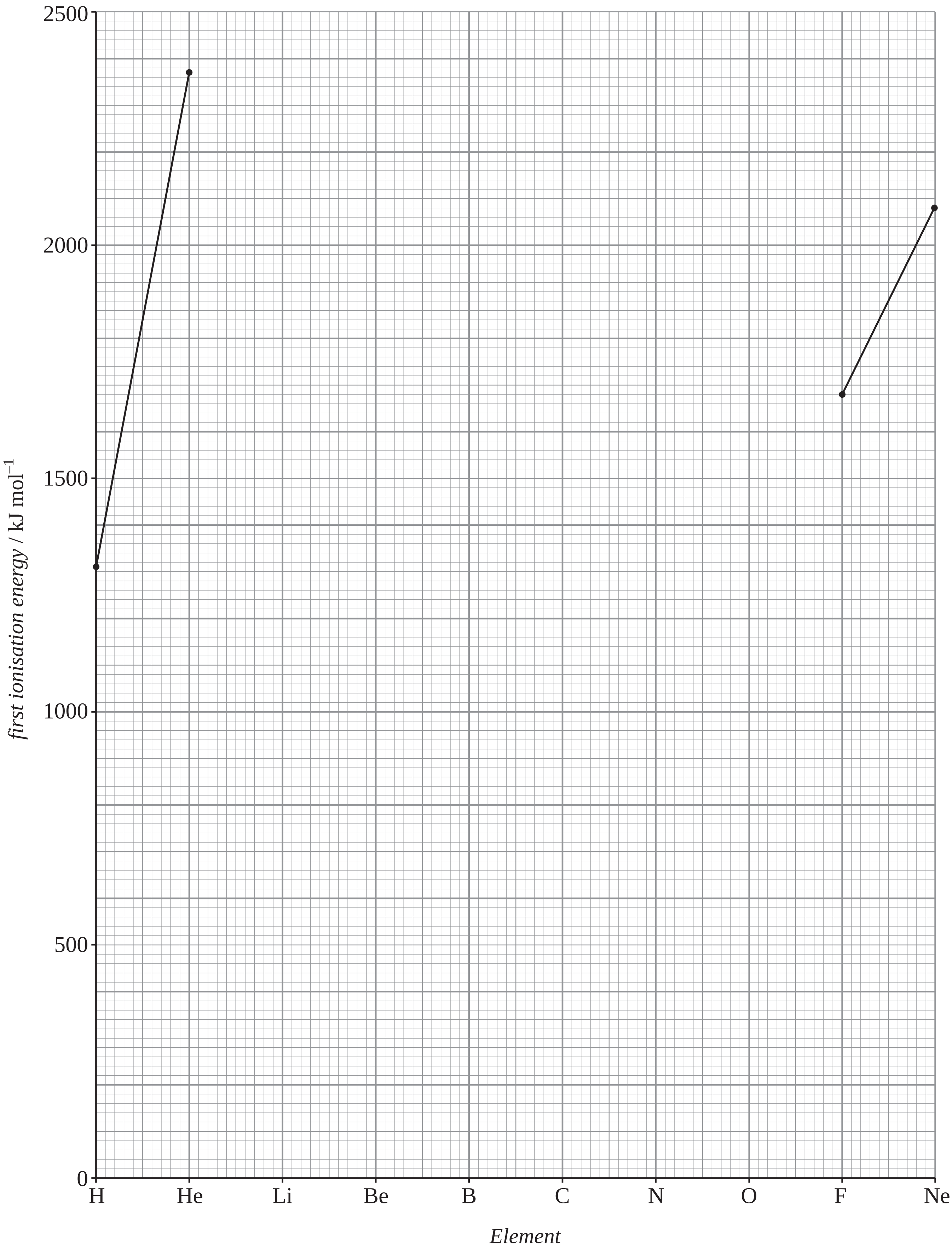
2500
2000
1500
1000
500
0
first ionisation energy / kJ mol^{-1}
H
He
Li
Be
B
C
N
O
F
Ne
Element

Turn over.

(b) The use of lead compounds in paints and pigments has been common for many centuries, although, due to its toxicity, this is now rare.

(i) 'White lead', which is based on lead carbonate, was used as a skin whitening cosmetic by Queen Elizabeth I in the 16th century.

Analysis of lead carbonate shows that it has the following percentage composition by mass: Pb 77.5%; C 4.50%; O 18.0%.

Calculate the empirical formula of lead carbonate.
Show your working. [2]

....

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....

(ii) 'Red lead', which is based on lead oxide, Pb_3O_4, is used in anti-corrosive paint. It is formed by oxidising lead(II) oxide with oxygen.

$$6PbO \quad + \quad O_2 \longrightarrow 2Pb_3O_4$$

I. Calculate the molar mass of Pb_3O_4. [1]

....

II. Calculate the mass of Pb_3O_4 that could be formed from 134 g of PbO. [3]

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Total [14]

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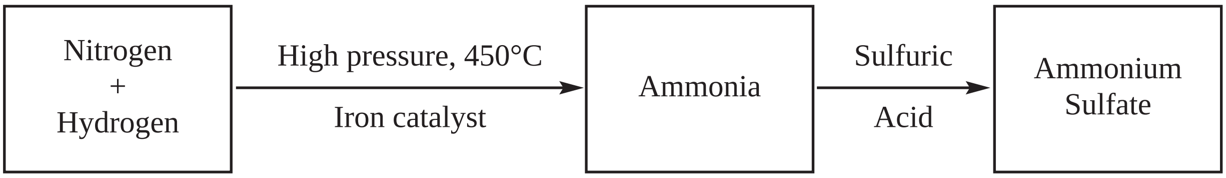
Examiner only

6. *(a)* Ammonia, a very important industrial product, is produced by the Haber process. Ammonia can be converted to ammonium sulfate, $(NH_4)_2SO_4$, a common fertiliser, by reacting it with sulfuric acid, H_2SO_4.



The Haber process can be represented by the following equation.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^{\ominus} = -92 \text{ kJ mol}^{-1}$$

(i) Explain how a catalyst speeds up a reaction. [2]

(ii) What **type** of catalyst is iron in the above process? [1]

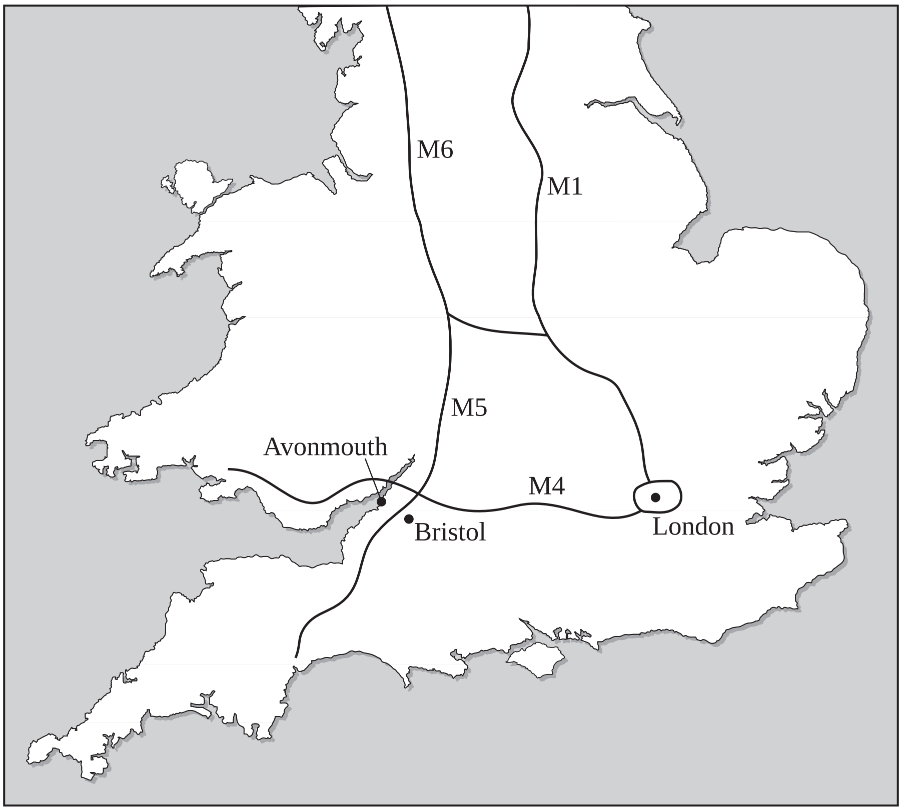
(iii) For the equilibrium reaction, explain why

I. there has been much research to find a better catalyst, [2]

II. a high pressure is used, [2]

III. ammonia is removed from the equilibrium mixture as it forms. [2]

(iv) In Britain, an ammonia factory is sited at Avonmouth on the banks of the River Severn near Bristol.



Give **two** reasons why this site was chosen. [2]

....

....

(b) (i) Write an equation for the acid-base reaction of ammonia with sulfuric acid. [1]

....

(ii) Explain why ammonia behaves as a base in this reaction. [1]

....

....

(iii) Farmers use ammonium sulfate as a fertiliser.

Calculate the percentage by mass of nitrogen in ammonium sulfate, $(NH_4)_2SO_4$. [2]

....

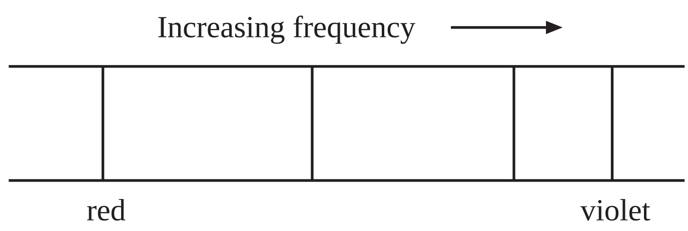
....

....

Total [15]

Examiner only

7. *(a)* The diagram below shows the emission spectrum of the hydrogen atom in the visible region.



(i) Explain why hydrogen emits only certain definite frequencies of visible light. [2]

....

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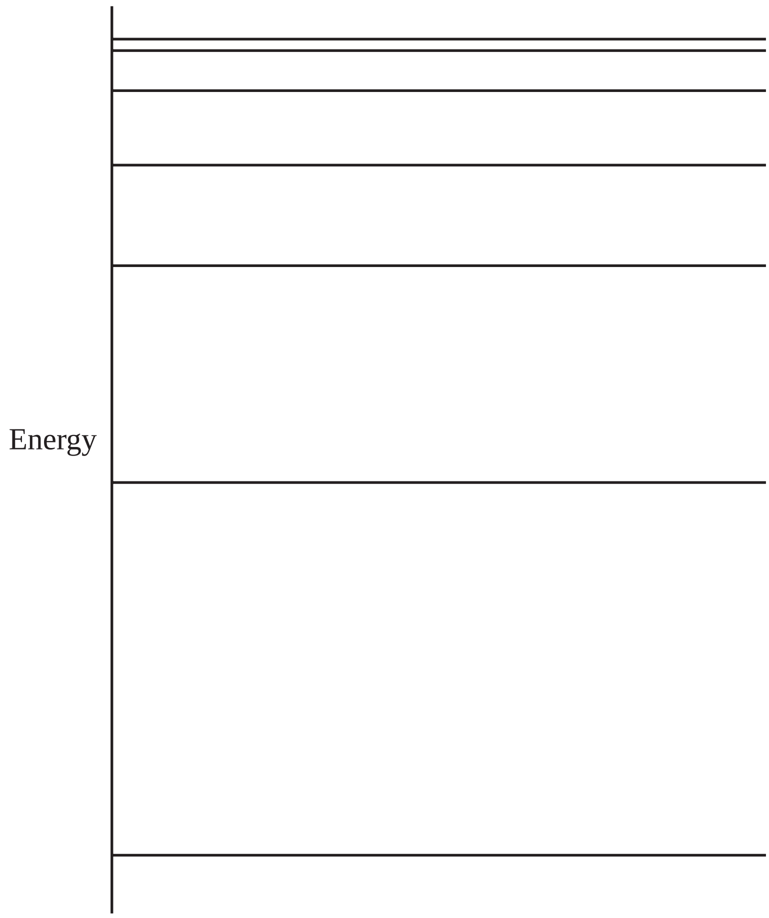
(ii) The horizontal lines below show the electron energy levels of a hydrogen atom.

Label these horizontal lines and draw the transitions corresponding to the four spectral lines in *(a)* above, clearly indicating which transition represents the red spectral line. [3]



Examiner only

(iii) On the diagram, draw and label the transition corresponding to the ionisation of the atom. [1]

(b) Hydrogen exists as two naturally occurring isotopes, ^{1}H and ^{2}H.

(i) A mass spectrum of a sample of hydrogen showed that it contained ^{1}H 99.20% and ^{2}H 0.8000%.

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

....

....

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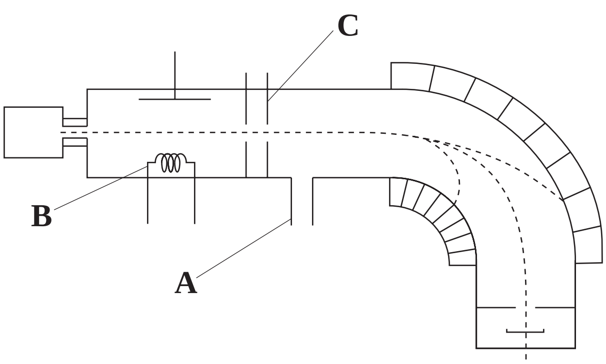
(ii) In the mass spectrum, explain why peaks due to hydrogen atoms are present, although hydrogen gas contains only H_2 molecules. [1]

....

....

(c) Below is a diagram of a mass spectrometer.



(i) Name part **B**. [1]

....

(ii) Name part **C**. [1]

....

(iii) State the function of part **A**. [1]

....

....

Turn over.

(d) Hydrogen also has an artificial isotope which is radioactive by β decay.

Complete the table below which shows the nature and effect of radioactive emission. [4]

Type	*Nature*	*Effect on atomic number*
α particle		
β particle		
γ radiation	Electromagnetic radiation of high energy	No effect

Total [16]

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8. *(a)* In 1987, the United Nations published a report on sustainable development, which included the following statement:

"Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs."

(i) In the UK, most electricity is generated in gas-fired power stations.
Give **two** reasons why the use of gas to generate electricity does not match the definition of sustainability. [2]

QWC [1]

....

....

....

....

(ii) Suggest **one** method of generating electricity which would be sustainable and outline how it works. [2]

....

....

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Examiner only

(b) In some countries, ethanol is replacing petrol (octane) as a car fuel.

(i) When ethanol, C_2H_5OH, is burnt in air, the only products are carbon dioxide and water.

Balance the following equation for this reaction. [1]

C_2H_5OH + ... O_2 $\longrightarrow$ .... CO_2 + ... H_2O

(ii) Use the standard enthalpy change of formation values given in the table to calculate the standard enthalpy change, $\Delta H^{\ominus}$, for the combustion of ethanol. [2]

Compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$C_2H_5OH(l)$	–278
$CO_2(g)$	–394
$H_2O(l)$	–286
$O_2(g)$	0

....

....

....

....

(iii) The standard enthalpy change of combustion for octane $\Delta H_c^{\ominus}(C_8H_{18})$ is –5512 kJ mol^{-1}.

Using this value and your answer to *(b)*(ii), show that octane gives more energy per gram of fuel burned than ethanol. [2]

....

....

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....

(iv) Suggest a reason why ethanol is being used rather than petrol. [1]

....

....

Total [11]

Turn over.

9. Elinor is given a mixture containing sodium carbonate and she carries out a two-part experiment to determine the percentage of sodium carbonate in the mixture.

In part 1, she accurately weighs 2.05 g of the mixture, transfers all of it to an appropriate container, adds 100 cm^3 of distilled water to ensure that it all dissolves and accurately makes up the solution to 250 cm^3 with distilled water.

In part 2, she pipettes 25.0 cm^3 of the solution into a container, adds 3 drops of an appropriate indicator and titrates this solution with hydrochloric acid of concentration 0.100 mol dm^{-3}. She repeats this procedure three times and obtains the following results.

Titration	1	2	3	4
Final reading (cm^3)	23.50	24.10	24.10	23.40
Initial reading (cm^3)	0.40	0.15	0.90	0.25
Titre (cm^3)				

(a) Name a suitable container to make up the solution that could be used in part 1. [1]

....

(b) Complete the table to show the values of the titres. [1]

(c) Identify clearly any anomalous results and calculate a mean value. [1]

....

....

(d) The equation for the reaction between sodium carbonate and hydrochloric acid is given below.

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$$

(i) Use your answer to part *(c)* to calculate the number of moles of HCl used in the titration. [1]

....

....

(ii) Deduce the number of moles of Na_2CO_3 in 25.0 cm^3 of the solution. [1]

....

(iii) Calculate the total number of moles of Na_2CO_3 in the original 250 cm^3 solution. [1]

....

....

(iv) Calculate the mass of Na_2CO_3 in the original solution. [1]

....

....

(v) Calculate the percentage of Na_2CO_3 in the mixture. [1]

....

....

(e) Elinor's percentage for sodium carbonate was slightly lower than the actual value. When asked why, she stated 'I did not add the acid drop by drop at the end and so overshot the end-point'.

State **two** other common sources of error in such experiments and explain why Elinor's statement cannot be correct.
(Assume that all the equipment is clean and all chemicals are pure.) [4]

QWC [2]

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Total [14]

Section B Total [70]

Examiner only

Rough Work

MS4
£4.00

GCE MARKING SCHEME

CHEMISTRY (NEW)
AS/Advanced

SUMMER 2009

CH1

Section A

1. *(a)* (i) Atomic number is the number of protons in the nucleus / in an element (e.g. 19 for potassium) [1]

(ii) Isotopes of elements have the same number of protons but different number of neutrons (e.g. chlorine has two isotopes ^{35}Cl and ^{37}Cl) / same atomic number but different mass number [1]

(b)

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

[1]

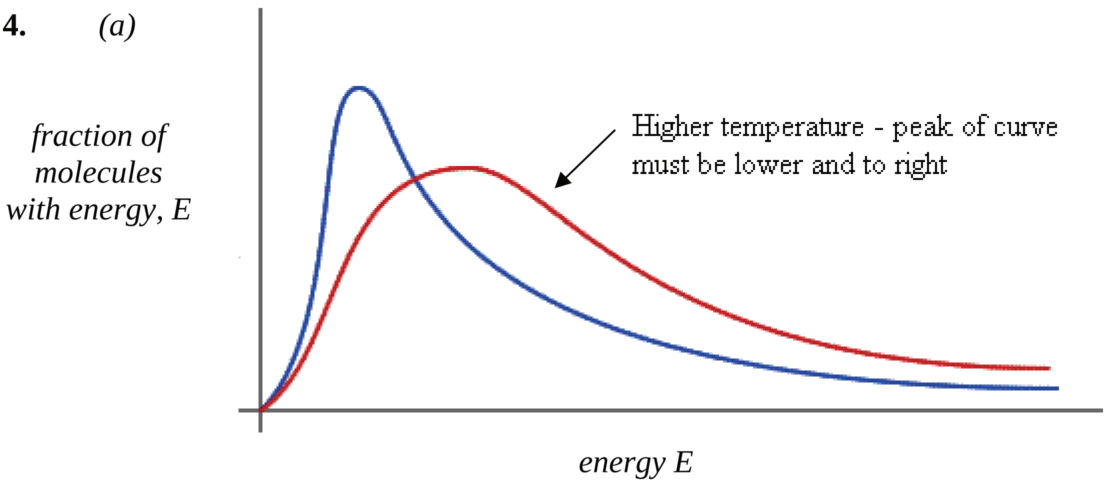
2. *(a)* (i) Measure (the volume of) hydrogen produced (using a gas syringe) / (mass of) hydrogen lost at constant time intervals [1]

(ii) Crush it into a powder / increase its surface area / heat it / stir it [1]

(b) 2 g [1]

3. 3 g / A [1]

4. *(a)*



(b) ΔH = (4 x 412) + 612 + 436 – ((6 x 412) + 348) [1]

= – 124 kJ mol^{-1} [1]

Total [10]

Section B

5. *(a)* (i) Correct plotting of 6 points (Allow ± ½ square) [3]

(ii) In He less shielding of outer electron (1)
outweighs smaller nuclear charge (1) /
He has greater effective nuclear charge (1) /
He outer electron closer to nucleus (1)

(Accept any two points) [2]

(iii) Ne has greater nuclear charge /
greater number of protons (in same orbital) [1]

(iv) N only has unpaired 2p electrons, O has two unpaired and two paired 2p electrons / N $1s^2\ 2s^2\ 2p^3$, O $1s^2\ 2s^2\ 2p^4$ (1), repulsion between the paired electrons makes it easier to remove one of the electrons / takes more energy to remove unpaired electron (1) [2]

(b) (i)

Pb	C	O	
$\frac{77.5}{207}$	$\frac{4.50}{12}$	$\frac{18.0}{16}$	
0.374	0.375	1.125	(1)
1	1	3	

Formula = $PbCO_3$ (1) [2]

(ii) I M_r Pb_3O_4 = (3 x 207) + (4 x 16) = 685 [1]

II Moles PbO = $\frac{134}{223}$ = 0.601 (1)

Moles Pb_3O_4 = 0.200 (1)

Mass Pb_3O_4 = 137 g (1) [3]

or alternative

1338 g PbO gives 1370 g Pb_3O_4 (1)

1 g PbO gives $\frac{1370}{1388}$ g Pb_3O_4 (1)

134 g PbO gives 137(.2) g Pb_3O_4 (1)

Total [14]

6. *(a)* (i) It provides a new route (1)

of lower activation energy (1) [2]

(ii) Heterogenous [1]

(iii) I Lower temperatures could be used (1)
(which would mean) increased yield (1) /
less energy consumption (1) / lower pressure used (1) /
equilibrium could be reached faster (1)
(Accept any two points) [2]

II More ammonia formed / equilibrium moves to right (1)
since more (gas) molecules on l.h.s. (1)
(Increases rate of reaction 1 mark) [2]

III Equilibrium moves to right / more ammonia formed (1)
since removing ammonia decreases its concentration in the mixture (1)
(Stops ammonia from returning to nitrogen and hydrogen 1 mark) [2]

(iv) Near a port / on the coast for exporting products (1),
good transport links for product (1), nearby workforce (1)

(Two valid reasons without one qualification 1 mark only) [2]

(b) (i) $2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$ [1]

(ii) Ammonia accepts a proton (from the acid) / ammonia has a lone pair of electrons / ammonia neutralises the acid [1]

(iii) % N = 28/132 × 100 (1)

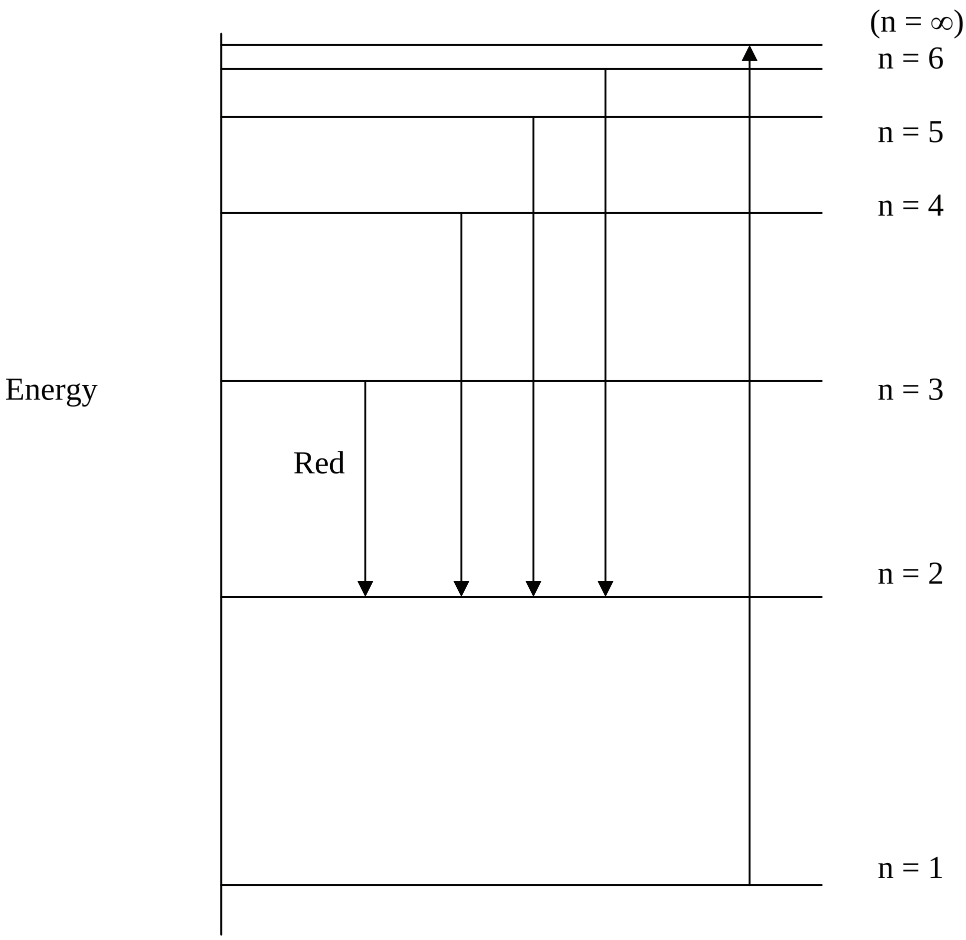
= 21.2% (1) [2]

Total [15]

7. *(a)* (i) Only changes between energy levels allowed / electron falls from higher energy levels to lower energy levels (1)

Energy emitted related to frequency / E = hf / the difference between any two energy levels are fixed / energy levels are quantised (1) [2]

(ii)



Labelling of any 3 horizontal lines (1)

Transitions going to n = 2 (1)

Red line from n = 3 to n = 2 (1)

(If all lines go to n = 1, accept red line from n = 2 to n = 1) [3]

(iii) Transition from n = 1 to n = ∞ [1]

(b) (i) A_r H = $\frac{(1 \times 99.2) + (2 \times 0.8)}{100}$ (1)

= 1.008 (1) [2]

(ii) Some of the hydrogen molecules are split into atoms [1]

(c) (i) Electron gun / source of electrons / heated filament [1]

(ii) Electric field / charged plates / accelerator / collimator [1]

(iii) To ensure a vacuum /
prevents collisions between sample and air molecules [1]

(d)

Type	*Nature*	*Effect on atomic number*
α particle	**Cluster of 2 protons and 2 neutrons** (1) / **$^{4}_{2}$He <u>nucleus</u>**	**Decrease by 2** (1)
β particle	**Electron (1)**	**Increase by 1 (1)**
γ radiation	Electromagnetic radiation of high energy	No effect

(Accept '*decrease*' and '*increase*' in 'atomic number' for 1 mark only)
[4]

Total [16]

8. *(a)* (i) Increases CO_2 levels / causes global warming (1)

Gas is a non renewable energy source / will run out (1) [2]

(QWC) The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

(ii) Wind / hydro / biomass / solar / geothermal (1)

Rotation of blades turns turbine / falling water turns turbine / combustion steam turns turbine / sunlight on photovoltaic cell produces electricity (1)

(Accept answers in terms of energy changes) [2]

(b) (i) $C_2H_5OH + \mathbf{3}O_2 \longrightarrow \mathbf{2}CO_2 + \mathbf{3}H_2O$ [1]

(ii) $\Delta H = (2 \times -394) + (3 \times -286) - (-278)$ (1)

$\Delta H = -1368 \text{ kJ mol}^{-1}$ (1) [2]

(iii) Energy for ethanol $= \frac{1368}{46} = 29.7 \text{ kJ g}^{-1}$ (1)

Energy for octane $= \frac{5512}{11\ 4} = 48.4 \text{ kJ g}^{-1}$ (1) [2]

(iv) Ethanol is a renewable fuel (if obtained by fermentation) / ethanol is cheaper in countries with plentiful sugar cane growth / ethanol is more carbon neutral / ethanol burns more cleanly [1]

Total [11]

9. *(a)* Volumetric / graduated / standard flask [1]

(b) 23.10 23.95 23.20 23.15 [1]

(c) Anomalous result = 23.95 cm^3

Mean = 23.15 cm^3 [1]

(d) (i) Moles HCl $= \frac{0.1 \times 23.15}{1000} = 2.315\times10^{-3}$ [1]

(ii) Moles $Na_2CO_3 = 1.158\times10^{-3}$ [1]

(iii) Moles in original solution = 1.158×10^{-2} [1]

(iv) Mass Na_2CO_3 = 1.227 g [1]

(v) % Na_2CO_3 = 59.9 % [1]

(Consequential marking applies)

(e) e.g. funnel left in burette (1) / air in pipette (1) /

not reading meniscus (1) / solution in flask not mixed thoroughly (1) /all of solid not used to make solution (1)

(Maximum 2 marks for sources of error)

If end-point overshot, too much acid would have been added (1),

so moles (mass) carbonate calculated would have been more than actual moles (mass) present (1)

[4]

(QWC) Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning (1)

Selection of a form and style of writing appropriate to purpose and to complexity of subject matter (1) [2]

Total [14]

Section B Total [70]

Candidate Name	Centre Number	Candidate Number
		2

WJEC CBAC

GCE AS/A level

1091/01

CHEMISTRY CH1

P.M. FRIDAY, 21 May 2010

1½ hours

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

1091 01 01

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

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.

Examiner only

SECTION A

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

1. A gaseous isotope of hydrogen, tritium, $^{3}_{1}H$, is produced in the upper atmosphere.

(i) State which of the following correctly describes an atom of tritium. [1]

	Number of protons	Number of neutrons	Number of electrons
A	1	1	1
B	1	1	2
C	1	2	1
D	1	2	0

....

(ii) Tritium is a radioactive gas with a half-life of 12.5 years. A sample of tritium has a mass of 0.960 g.
Calculate the mass of tritium remaining after 37.5 years. [1]

....

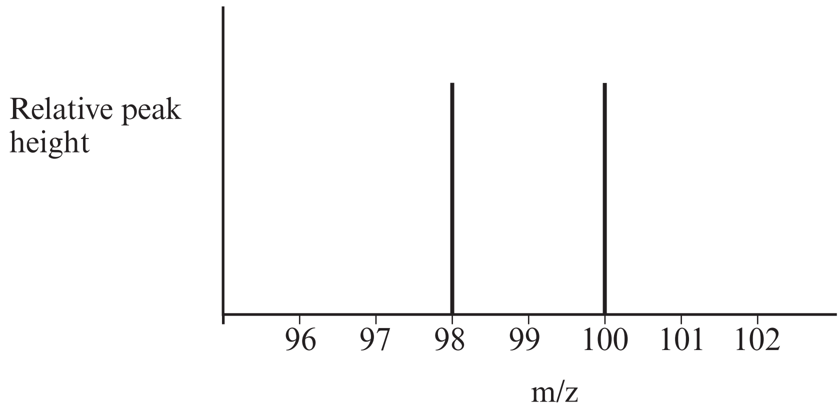
....

2. Cyanogen is a compound containing only carbon and nitrogen.
It has a relative molecular mass of 52.

(i) State the molecular formula of cyanogen. .... [1]

(ii) State the empirical formula of cyanogen. .... [1]

3. The mass spectrum of the colourless gas bromine fluoride, $Br^{19}F$, shows two molecular ions.



(i) State the mass numbers of the two bromine isotopes present in bromine fluoride. [1]

.... and ....

(ii) Bromine fluoride is unstable and readily gives $Br^{19}F_3$.
State the mass/charge (m/z) value for the molecular ion $Br^{19}F_3^+$, when all the bromine is present as the isotope ^{85}Br. [1]

....

4. The first two standard molar ionisation energies for magnesium are shown in the table.

Electron removed	Standard molar ionisation energy / kJ mol^{-1}
first	736
second	1450

State which of the following is the value for the third molar standard ionisation energy, in kJ mol^{-1}, of magnesium. [1]

A 457

B 923

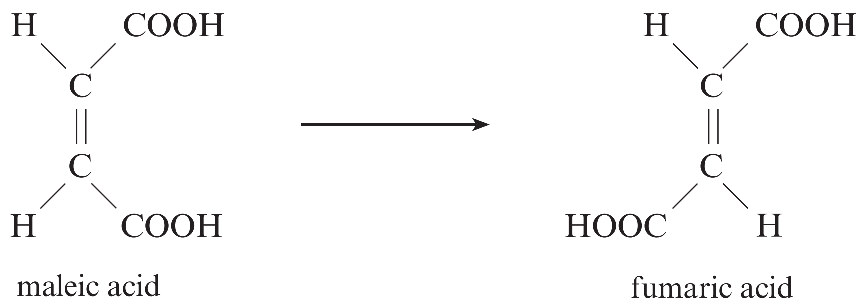
C 2170

D 7740

....

Examiner only

5. One industrial method of preparing fumaric acid is to heat maleic acid in the presence of a catalyst.



(i) Deduce the atom economy of this reaction. [1]

.... %

(ii) Data from a manufacturer states that the percentage yield of fumaric acid is 95% using a 150 kg batch of maleic acid.

Calculate the mass of fumaric acid formed. [1]

.... kg

6. Choose the mass of methane, CH_4, that contains the same number of molecules as there are molecules in 96 g of silane, SiH_4. [1]

A 36 g

B 48 g

C 96 g

D 144 g

....

Total Section A [10]

SECTION B

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

7. Ammonia, NH_3, is produced from nitrogen and hydrogen.

$$N_2(g) \quad + \quad 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) Typically, this process is carried out at a temperature of 450 °C, at a pressure of 250 atmospheres and in the presence of an iron catalyst. The yield is around 15%.

(i) If this reaction were carried out using a reduced pressure of 50 atmospheres, the process would be safer because of the lower pressure used.

State **one** disadvantage of using this lower pressure. [1]

....

(ii) In the actual process some of the ammonia is removed as the reaction proceeds.

State and explain what effect this removal has on the position of equilibrium. [2]

....

....

....

(iii) How would the equilibrium yield be affected if the reaction were run without using the catalyst? [1]

....

(b) Some of the ammonia is reacted with sulfuric acid to produce the fertiliser ammonium sulfate.

$$2NH_3 \quad + \quad H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

(i) State the molar masses of

ammonia .... g ammonium sulfate .... g [1]

(ii) Calculate the maximum mass of ammonium sulfate, in tonnes, that can be made from 17.03 tonnes of ammonia. [3]

....

....

....

....

Examiner only

(c) A member of the public read in an article that the pH of an ammonium sulfate solution was 6. He asked you to explain what was meant by the pH scale.
What would be your reply? [2]

....

....

....

....

(d) Ammonium nitrate, NH_4NO_3, is also used as a fertiliser. However, in the presence of certain impurities, it can explode very violently. This explosive reaction gives nitrogen, oxygen and steam.

$$NH_4NO_3(s) \longrightarrow N_2(g) + 2H_2O(g) + \tfrac{1}{2}O_2(g) \qquad \Delta H = -296\ \text{kJ mol}^{-1}$$

M_r 80

Some years ago 400 tonnes (4×10^8 g) of ammonium nitrate, stored in a ship in a harbour, exploded, causing extensive damage.

Calculate the energy produced in this explosion, in kJ. [2]

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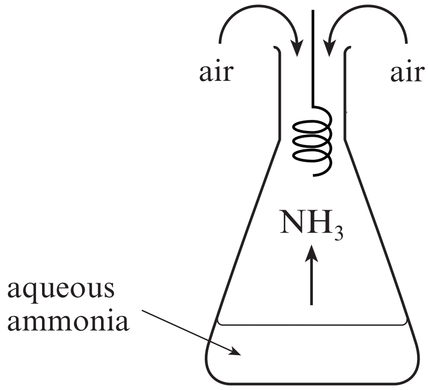
Examiner only

(e) Ammonia gas can be oxidised in air in the presence of a platinum catalyst. One method of showing this is to suspend a red-hot spiral of platinum wire in the neck of a flask containing ammonia gas and air. The platinum wire continues to glow red-hot as the ammonia is oxidised.



(i) Use the information given to explain how this experiment shows that the oxidation of ammonia is an exothermic reaction. [1]

....

....

....

(ii) The platinum wire is acting as a heterogeneous catalyst in this reaction.
Explain what is meant by the term 'heterogenous'. [1]

....

....

Total [14]

1091 01 07

Examiner only

8. *(a)* Sodium street lights, with their familiar orange-yellow light, have been used for many years. When these lights are first switched on, a red glow is seen as neon is used as the starter gas. The wavelength of the colour produced by each of these elements is shown in the table.

Element	Colour	Wavelength / nm
sodium	orange-yellow	590
neon	red	640

(i) State which one of these two colours has the higher frequency, explaining your answer. [1]

....

....

(ii) State the equation linking energy and frequency. [1]

....

(b) The atomic emission spectrum of hydrogen consists of several series of lines.

(i) Explain how these lines are formed. [3]

....

....

....

....

....

(ii) State the significance of the frequency of the convergence limit in the Lyman series. [1]

....

....

(iii) Explain why there is more than one series of lines. [1]

....

....

(c) (i) An atom of ^{23}Na absorbs a neutron to give ^{24}Na.
Complete the table to show any **changes** (if any) in the atomic number and mass number. [1]

	Change
Atomic number	
Mass number	

(ii) The isotope ^{24}Na decays by β-emission.
State the mass number and symbol of the species formed by the emission of one β-particle from an atom of ^{24}Na. [1]

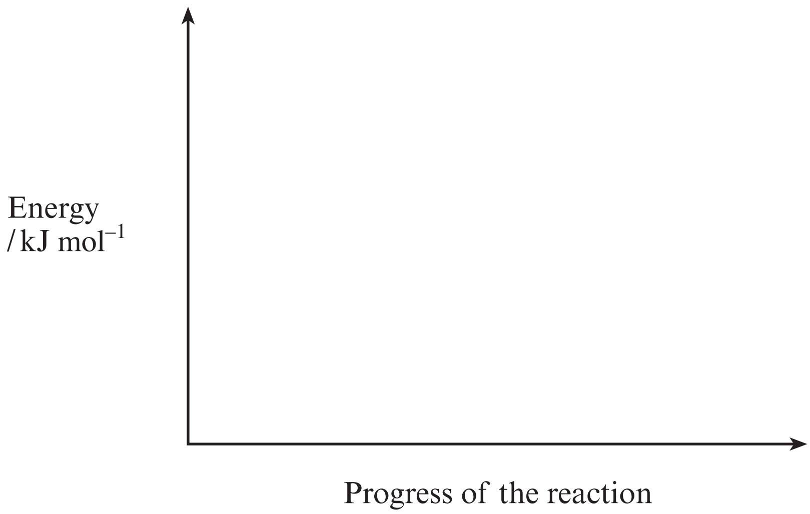
....

(d) Using the 'arrows in boxes' notation give the electronic configuration of a magnesium atom. [1]

1s	2s	2p	3s	3p
☐	☐	☐☐☐	☐	☐☐☐

(e) Magnesium burns in air with a brilliant white light, forming magnesium oxide.

(i) Sketch a reaction profile for this reaction, using the axes provided. [1]

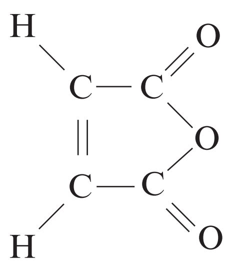


(ii) Indicate, on your profile in (i), the activation energy for the reaction. [1]

Total [12]

Examiner only

9. *(a)* The compound maleic anhydride (Z-butenedioic anhydride) is an important compound that is used in the production of polyester resins.



maleic anhydride

(i) Three compounds, **L**, **M** and **N**, can be used to produce maleic anhydride in the presence of oxygen. The same conditions are used in each method.

Compound	% Yield of maleic anhydride	Other product(s)
L	75	H_2O and CO_2
M	65	H_2O
N	75	H_2O

I Using the **information in the table only** suggest which compound, **L**, **M** or **N**, should be used to produce maleic anhydride. Explain your reasoning. [2]

....

....

....

II Chemical manufacturers are interested in methods of production that have a minimum effect on the environment – 'Green Chemistry'.
Suggest **two** factors (not from information given in the table) that manufacturers should take into account when considering the production of maleic anhydride. [2]

1. ....

....

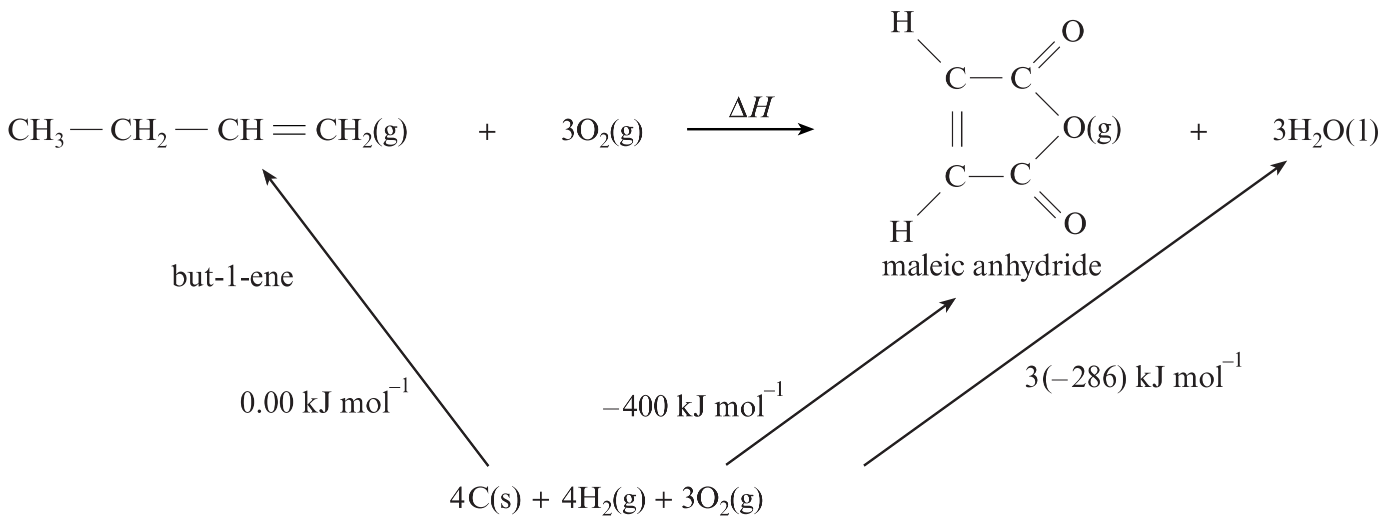
2. ....

....

Examiner only

(ii) One method of preparation of maleic anhydride is the oxidation of but-1-ene.

Use the energy cycle to calculate the enthalpy change, ΔH, for the production of maleic anhydride from but-1-ene. [2]



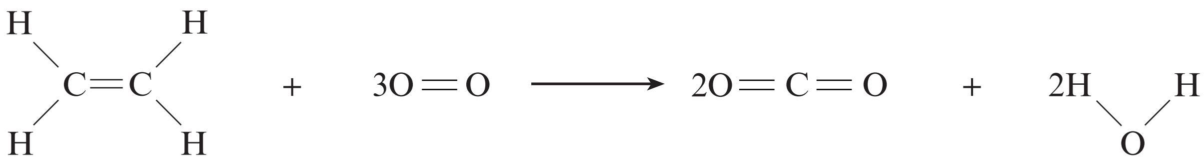
....

....

(b) In the complete oxidation of ethene, carbon dioxide and water are formed.

Use the bond energy values in the table to calculate the enthalpy change in the reaction given. [4]

Bond	Average bond energy / kJ mol^{-1}
C—H	412
C=C	612
O=O	496
C=O	743
O—H	463



ethene

....

....

....

Examiner only

(c) In sea water there are equilibria between carbon dioxide, hydrogencarbonate (HCO_3^-) ions and carbonate (CO_3^{2-}) ions.

$$CO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

$$H^+(aq) + CO_3^{2-}(aq) \rightleftharpoons HCO_3^-(aq)$$

(i) Use Le Chatelier's Principle to predict the effect on the first equilibrium and the change in pH when more carbon dioxide is dissolved. [2]

....

....

....

(ii) State what would be the effect on the concentration of carbonate (CO_3^{2-}) ions of increasing the concentration of hydrogen (H^+) ions in the second equilibrium. [1]

....

(d) The solubility of carbon dioxide, M_r 44, in water at 25 °C and atmospheric pressure is 0.145 g / 100 g H_2O.

Calculate its concentration in mol dm^{-3}. [2]

....

....

....

Total [15]

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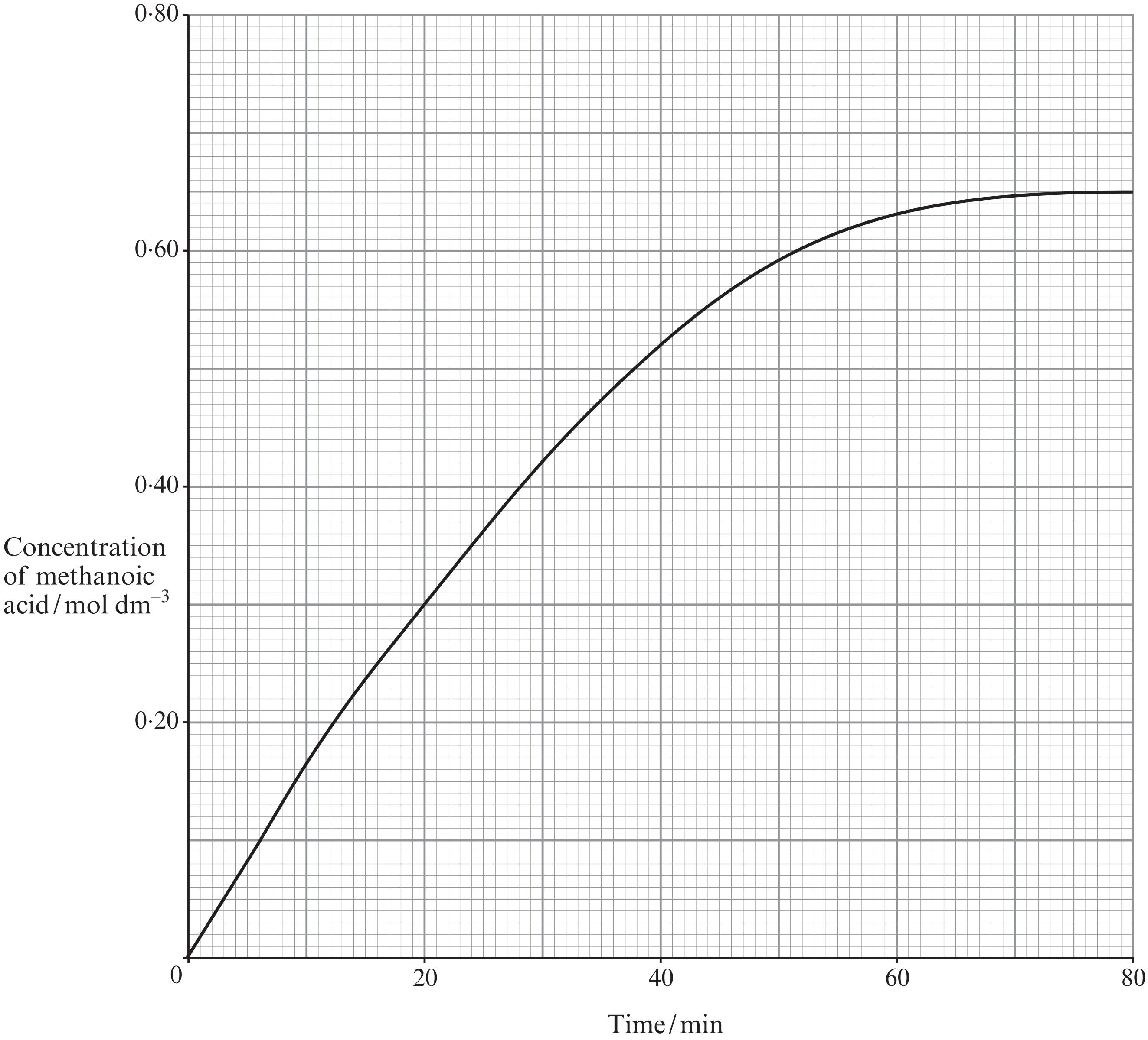
Examiner only

10. An organic solvent, **A**, can be slowly decomposed at room temperature, using water in the presence of catalyst **X**. Methanoic acid is one of the products and its concentration is measured at various times during the reaction. The results are shown in the following graph.



$$\text{A} \longrightarrow \text{methanoic acid} + \text{other products}$$

1 mole   1 mole

Examiner only

Use the graph to

(i) calculate the initial rate of the reaction, giving its units, [2]

....

.... *Units* ....

(ii) describe how the rate changes during the reaction. Explain the reason for this change in terms of simple collision theory. [4]

QWC [2]

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....

(iii) A more effective catalyst, **Y**, has been found for this reaction. The decomposition of solvent **A** is repeated under the same conditions using catalyst **Y**.

I Use the graph to suggest a possible concentration of methanoic acid after 20 minutes when catalyst **Y** is used in place of catalyst **X**. [1]

.... mol dm^{-3}

II Using catalyst **X** the concentration of methanoic acid at the end of the reaction is 0.65 mol dm^{-3}.
State and explain if this final concentration would change when catalyst **Y** replaces catalyst **X**. [2]

....

....

(iv) At the start of the reaction using catalyst **X** the concentration of solvent **A** was 48.1 g dm^{-3}.
If the concentration of methanoic acid at the end of the reaction was 0.65 mol dm^{-3}, use the word equation under the graph to calculate the relative molecular mass of solvent **A**. [2]

....

....

....

Total [13]

Examiner only

11. Potash is a common name for potassium carbonate. Originally, potash was obtained by adding water to the ash produced from the burning of wood, filtering and evaporating the filtrate.

(a) Meirion was asked to find the percentage of potash that could be obtained from some wood ash. He added water to a known mass of wood ash, stirred the mixture and then filtered the product. The filtrate was then made up to a volume of $250\,cm^3$.

(i) State why the mixture was stirred. [1]

....

....

(ii) Describe, giving full practical details, how the volume was made up to **exactly** $250\,cm^3$. [4]

....

....

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....

....

(iii) The filtrate was an alkaline solution of potassium carbonate. This was titrated against a standard hydrochloric acid solution to find the concentration of the potassium carbonate.

$$K_2CO_3 + 2HCl \longrightarrow 2KCl + CO_2 + H_2O$$

Methyl orange was used as an indicator; this turns from yellow in the potassium carbonate solution to pink when the potassium carbonate is neutralised by the hydrochloric acid. The following results were obtained using $25.00\,cm^3$ samples of the potassium carbonate solution.

Burette finish / cm^3	24.80	26.20	26.55
Burette start / cm^3	0.00	1.60	2.00

I Calculate the mean volume of hydrochloric acid added, using all three sets of results. [1]

....

....

II Describe the practical steps used to obtain a titration value. You should start by measuring 25.00 cm^3 of the potassium carbonate solution from the 250 cm^3 stock solution, with the acid already in the burette. [5]

QWC [1]

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....

....

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....

(b) In another experiment Penny obtained white crystals of potassium carbonate, K_2CO_3, from the wood ash.

(i) Show that the percentage by mass of potassium in K_2CO_3 is 56.6. [2]

....

....

(ii) Some of Penny's crystals were analysed for potassium by flame emission spectroscopy. The results showed that the percentage of potassium present was 44.9%.
Penny suggested that the crystals of potassium carbonate might be a hydrate, $K_2CO_3.2H_2O$.

Explain why the percentage of potassium in the hydrate is lower than the value stated in (i). [1]

....

....

(c) Potassium compounds are usually obtained from mineral deposits of potassium chloride rather than from wood ash.

Suggest **one** environmental disadvantage of using wood ash to obtain potassium compounds. [1]

....

....

Total [16]

Section B Total [70]

Rough Work

WJEC
CBAC

GCE MARKING SCHEME

CHEMISTRY
AS/Advanced

SUMMER 2010

CH1

SECTION A

1.	(i)	C	[1]
	(ii)	0.120 g	[1]
2.	(i)	C_2N_2	[1]
	(ii)	CN	[1]
3.	(i)	79 and 81	[1]
	(ii)	142	[1]
4.	D		[1]
5.	(i)	100	[1]
	(ii)	142.5 / 143 kg	[1]
6.	B		[1]

Total [10]

SECTION B

7. (a) (i) A lower pressure gives a reduced equilibrium yield / less ammonia (accept – the reaction rate is slower) [1]

(ii) The position of equilibrium will shift to the right (1) as more nitrogen and hydrogen react to restore the position of equilibrium. (1) [2]

(iii) Unchanged [1]

(b) (i) ammonia 17.03 (g) ammonium sulfate 132.2 (g) [1]

(ii) molar ratio 2 : 1 (1)

2×17.03 tonnes ammonia give 132.2 tonnes of ammonium sulfate (1)

66.1 (tonnes) (1) [3]

(c) The pH scale is a measure of acidity/alkalinity (1)

values below 7 are acidic / above 7 are alkaline / pH 7 is neutral / pH 6 is a weak acid (1) [2]

(d) Number of moles of ammonium nitrate $= \dfrac{4 \times 10^8}{80} = 5 \times 10^6$ / 5 000 000 (1)

Energy produced $= 296 \times 5 \times 10^6 = 1.48 \times 10^9$ (kJ) (1) [2]

(e) (i) It is exothermic because the heat evolved maintains the temperature of the platinum wire, keeping it red-hot (and maintaining the reaction) [1]

(ii) A reaction where the catalyst is in a different (physical) state to the reactants / products [1]

Total [14]

8. (a) (i) orange-yellow (accept sodium/590 mm)

frequency $\propto \dfrac{1}{\text{wavelength}}$

shorter wavelength/shorter wavelength, higher frequency) [1]

(ii) energy = h × frequency (accept energy ∝ frequency)
E = hf [1]

(b) (i) Lines represent the energy emitted (1) when an excited electron drops back (1) from one energy level to another (1) [3]

(ii) This represents the energy needed to remove the electron from the hydrogen atom / ionise the atom [1]

(iii) In each series the excited electron drops back to a different energy level [1]

(c) (i)

	Change
Atomic number	No change/0
Mass number	Increases by one/+1

[1]

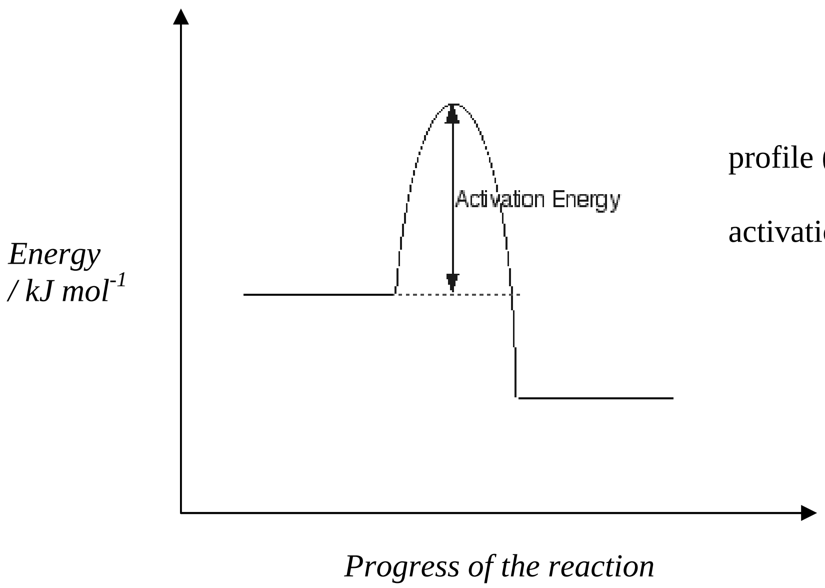
(ii) ^{24}Mg [1]

(d)

↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	
1s	2s	2p	3s	3p

[1]

(e) (i)



profile (1)

activation energy (1)

[2]

Total [12]

9. (a) (i) I **N** (1) the yield is 75%, as for **L**, but only water is formed (1) [2]

II e.g. use renewable energy resources
keep energy use to a minimum/low temperature/low pressure
use the most effective catalyst
use non-toxic materials wherever possible
the co-products should be non-toxic / or capable of being converted to non-toxic materials
use renewable feedstocks/sustainable feedstocks
re-use / recycle waste product
'high atom economy'

any two (1) (1) [2]

(ii) $0.0 + \Delta H = -400 + (-858)$ (1)
$\Delta H = -1258 \text{ kJ mol}^{-1}$ (1) [2]

(b) Bonds broken = 3748 kJ (1) Bonds made = 4824 kJ (1)

$\Delta H = \Sigma$ bonds broken $-$ Σ bonds made (1)

$= 3748 - 4824 = -1076 \text{ kJ mol}^{-1}$ (1) [4]

(c) (i) When more carbon dioxide dissolves in sea water the position of equilibrium for the first equation is moved to the right producing more H^+ (and more HCO_3^-) ions (1) making the water more acidic / pH decreases (1) [2]

(ii) The concentration of carbonate ions / CO_3^{2-} will decrease [1]

(d) Solubility is 1.45 g dm^{-3} (1)
Concentration of carbon dioxide $= \dfrac{1.45}{M_r} = \dfrac{1.45}{44} = 0.033\ (\text{mol dm}^{-3})$ (1)
[2]

Total [15]

10. (i) $\frac{0.20}{12.5}$ = 0.016 (1) mol dm^{-3} min^{-1} (1) [2]

(ii) As the reaction proceeds the rate becomes less / reaction slows down (1)
As the concentration of the reactant becomes smaller (1)
At the beginning of the reaction there is more chance of a successful collision (hence rate is faster) (1)
The collision rate becomes slower as the reactant is used up (1)

Text is legible; spelling is accurate and its meaning is clear, and punctuation and grammar are correct. QWC (1)
The candidate has selected a form and style of writing that is appropriate to purpose and complexity of the subject matter. QWC (1)

[6]

(iii) I Accept values between 0.30 and 0.65 (mol dm^{-3}) [1]

II The final concentration would be the same (1) as a catalyst does not affect the overall yield (1) [2]

(iv) 1 mole of the solvent gives 1 mole of the acid
∴ Number of moles of the solvent **A** is also 0.650 (1)

$M_r = \frac{\text{mass}}{\text{number of moles}} = \frac{48.1}{0.650} = 74$ (1) [2]

Total [13]

11. (a) (i) To make sure that the potassium carbonate/soluble substances had dissolved [1]

(ii) Filtrate added to a 250 cm^3 volumetric flask (1)
Use of a funnel (1)
Mention of washing out original vessel etc. (1)
Made up to the mark (with distilled water) (1)
Shaken/inverted (1)
Any 4 points [4]

(iii) I 24.65 (cm^3) [1]

II Any 5 from
25.00 cm^3 of the potassium carbonate solution **pipetted** into a conical flask (1)
(A few drops of) indicator added (1)
Titrate (with the acid) until the indicator just (1) turns pink (1)
Shake/swirl/mix (1)
Reads burette before and after (1)
Wash sides with distilled/deionised water (1)

Organisation of information clearly and coherently; using specialist vocabulary where appropriate QWC (1)
[6]

(b) (i) M_r of potassium carbonate 138.2 (1)

% potassium $= \dfrac{78.2 \times 100}{138.2}$ (1) = 56.6 (1) [2]

(ii) The relative (molecular) mass of the hydrate is higher (than the anhydrous salt) but a ‘molecule’ still only contains two potassium ‘atoms’ [1]

(c) e.g. wood needs to be burnt, forming carbon dioxide (a greenhouse gas)/ deforestation [1]

Total [16]

Candidate Name	Centre Number	Candidate Number
		2

GCE AS/A level

1091/01

CHEMISTRY CH1

P.M. MONDAY, 23 May 2011

$1\frac{1}{2}$ hours

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

1091 010001

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.

Examiner only

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			
$^{24}Mg^{2+}$			

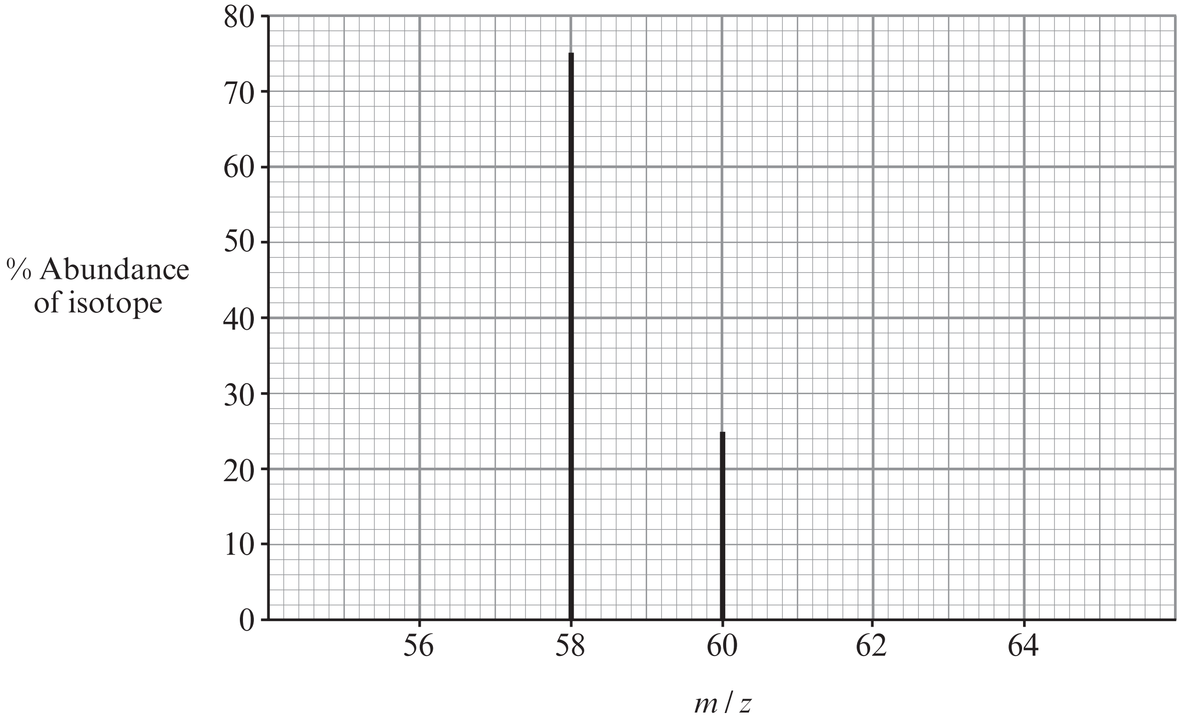
[3]

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.

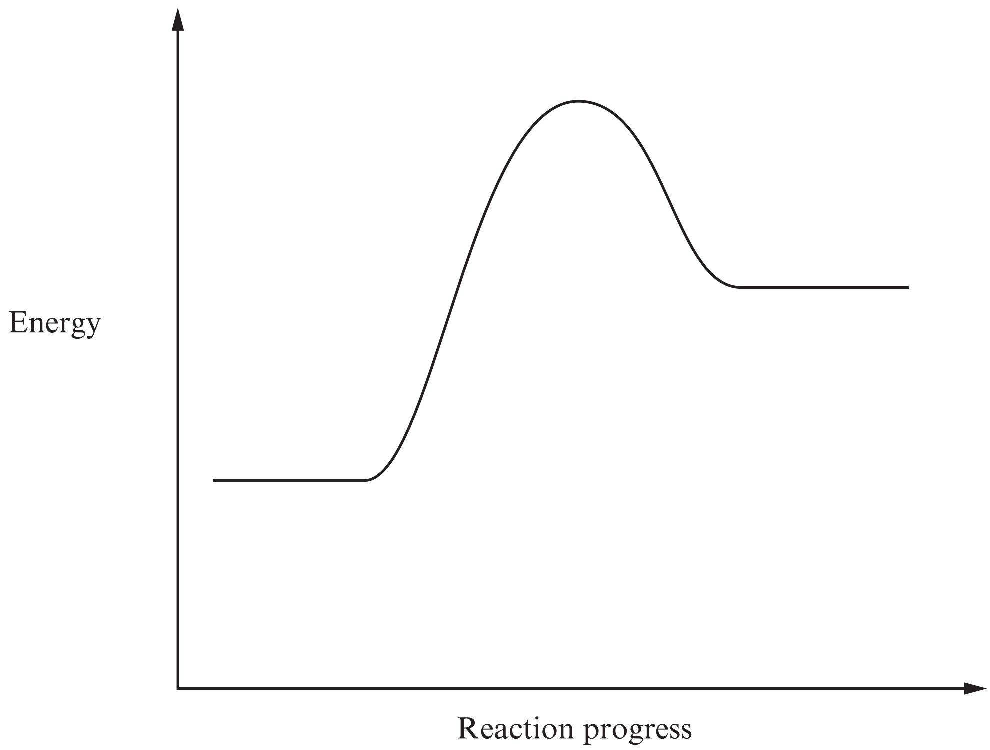
	Na	C	O
A	0.5	0.5	0.5
B	1	0.5	3
C	1	0.5	1.5
D	2	1	3

[1]

Letter ....

Examiner only

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]

1091
010005

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Examiner only

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]

....

....

....

....

Examiner only

(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]

....

....

....

(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		

1091 010007

(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]

....

....

....

(ii) Give **two other** uses of radioactive materials in analysis, industry or medicine. [2]

....

....

Total [17]

Examiner only

8. *(a)* Chloroethane, C_2H_5Cl, can be made from ethene by the addition of hydrogen chloride, HCl.

$$C_2H_4 + HCl \longrightarrow C_2H_5Cl \qquad \text{Reaction } \mathbf{A}$$

	C_2H_4	HCl	C_2H_5Cl
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]

....

....

....

(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]

....

....

....

(b) Chloroethane can be formed by another reaction as in the following equation.

$$C_2H_5OH + NaCl + H_2SO_4 \longrightarrow C_2H_5Cl + NaHSO_4 + H_2O \qquad \text{Reaction } \mathbf{B}$$

	C_2H_5OH	NaCl	H_2SO_4	C_2H_5Cl	$NaHSO_4$	H_2O
M_r values	46.0	58.5	98.0	64.5	120	18.0

(i) Describe what is meant by *atom economy*. [1]

....

....

(ii) Calculate the % atom economy for reactions **A** and **B**. [2]

....

....

....

(iii) State which of reactions **A** and **B** is preferred, giving your reason. [1]

....

....

Examiner only

(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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....

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Total [12]

Examiner only

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]

....

....

(b) Describe in simple terms what is meant by pH. [1]

....

....

(c) About half of the carbon dioxide formed by burning fossil fuels dissolves in the oceans. The equilibrium may be written simply as:

$$CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$$

(i) State, giving a reason in both cases, the effect that increasing carbon dioxide concentrations have on

I the ocean's acidity, [1]

....

....

II the pH of seawater. [1]

....

....

(ii) Another important equilibrium in the ocean is that between hydrogencarbonate and carbonate ions.

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

State, giving a reason, the effect of increasing acidity on the amount of carbonate present. [1]

....

....

(iii) Many animals in the ocean make shells of calcium carbonate using the equilibrium:

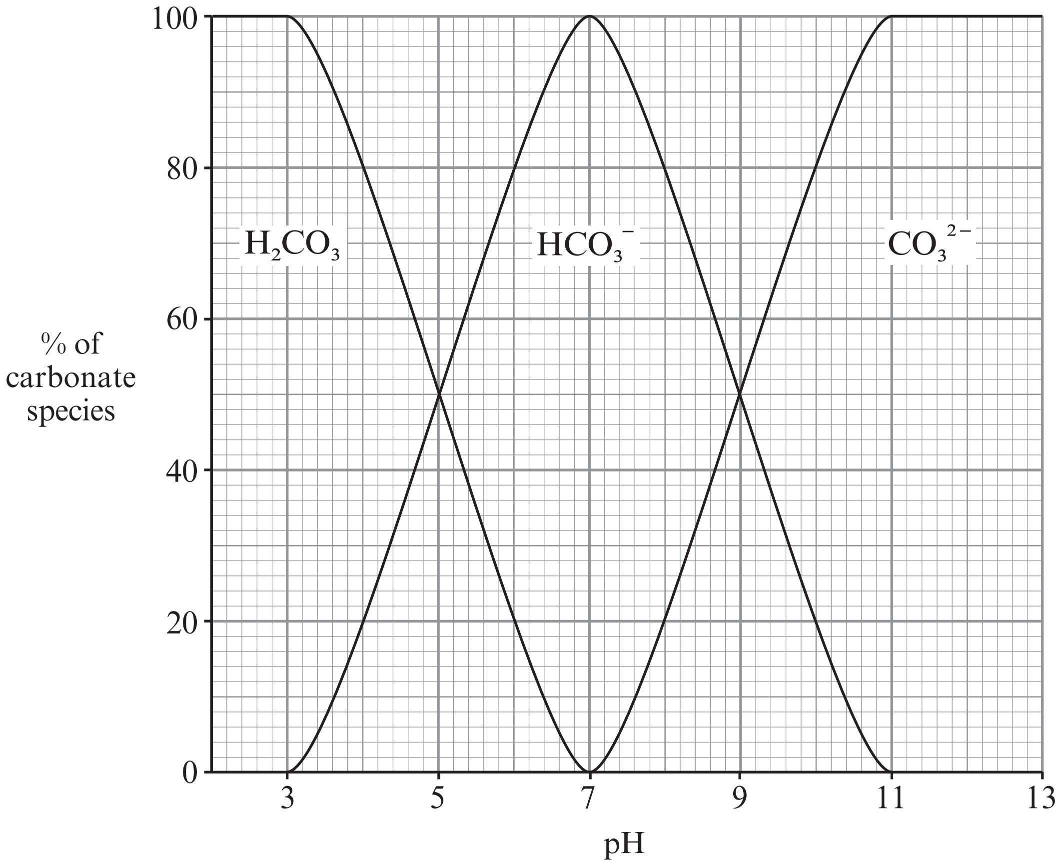
$$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightleftharpoons CaCO_3(s)$$

Using your answer to parts (i) and (ii), state and explain the effect of increasing acidity on their ability to make shells. [1]

....

....

(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 cm^3 of hydrogencarbonate solution was neutralised by 19.60 cm^3 of hydrochloric acid of concentration 0.095 mol dm^{-3}, the equation being:

$$HCO_3^- + H^+ \longrightarrow H_2CO_3$$

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]

....

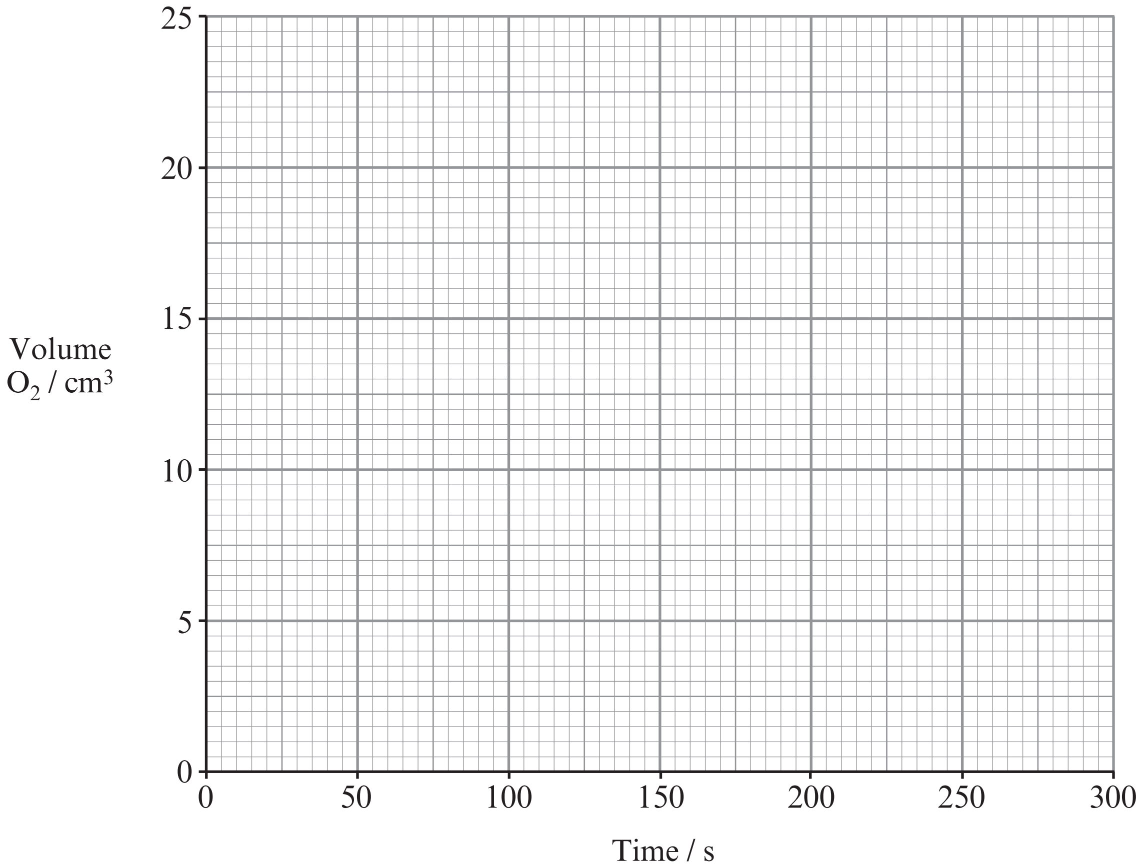
....

(b) The following results were obtained in an experiment to find the rate of decomposition of hydrogen peroxide.

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

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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Examiner only

(ii) State how the rate of reaction changes over time and give a reason for any difference. [2]

....

....

(iii) Describe briefly how this experiment could be carried out. [2]

....

....

....

(c) Using collision theory for a reaction such as

$$A(g) + B(g) \longrightarrow C(g)$$

explain why the rate of reaction depends on both the pressure of the reactants and the temperature. [4]

QWC [1]

....

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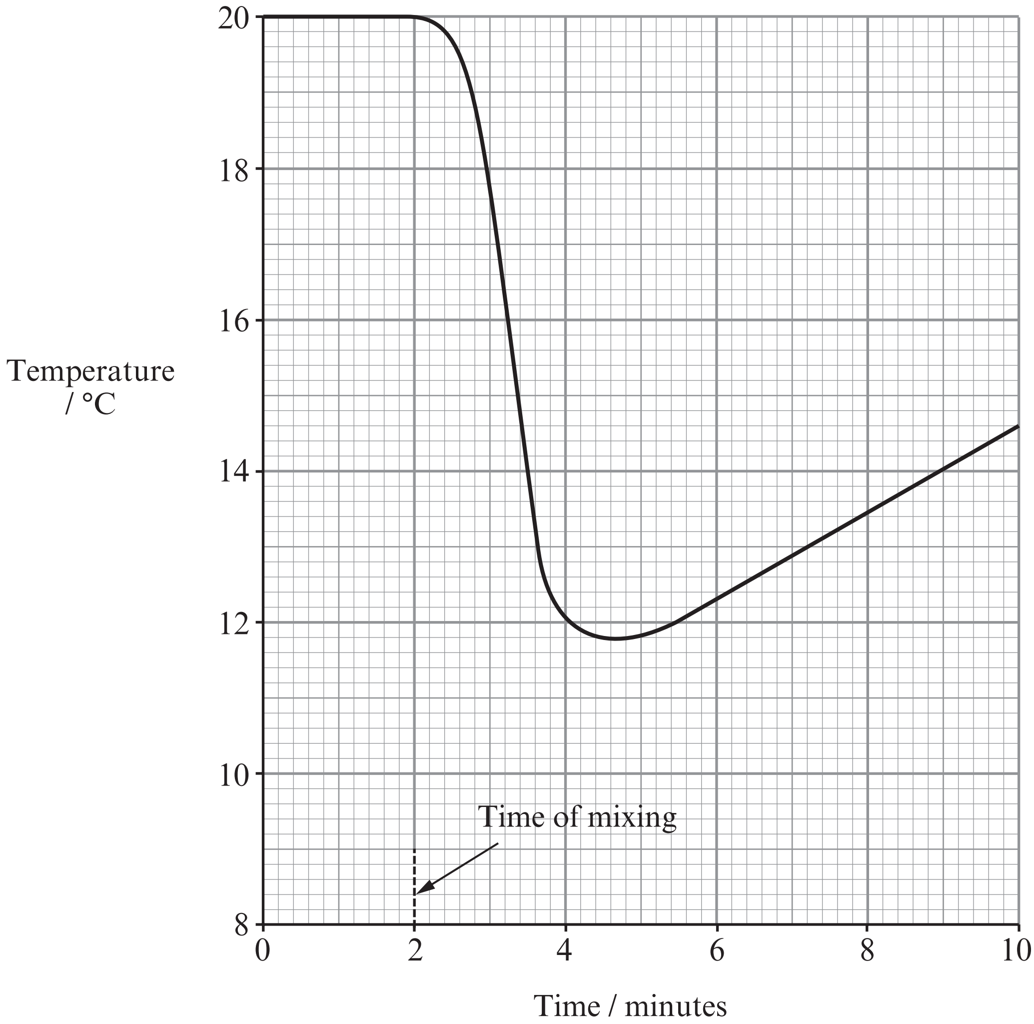
....

Total [17]

Examiner only

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.



Examiner only

(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

$$\Delta H = \frac{-mc\Delta T}{n}\ \text{Jmol}^{-1}$$

where the mass of water (m) was 50 g, the heat capacity (c) was 4.2 J g^{-1} K^{-1} and the amount of nitrate used (n) was 0.10 mol. [4]

....

....

ΔH = ... kJ mol^{-1}

Examiner only

(b) (i) State *Hess's Law*. [1]

....

....

(ii) Use this law to calculate the enthalpy change when sulfur trioxide and water react to form sulfuric acid.

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

The standard enthalpy changes of formation of the compounds ($\Delta H_f^{\ominus}$) are given in the following table.

Compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
H_2O	–286
SO_3	–395
H_2SO_4	–811

[2]

....

....

....

....

....

(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]

....

....

....

....

Examiner only

(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]

....

....

....

....

Total [15]

Section B Total [70]

Rough Work

GCE AS/A level

1091/01-A

CHEMISTRY
PERIODIC TABLE FOR USE WITH CH1

P.M. MONDAY, 23 May 2011

THE PERIODIC TABLE

Key: A_r (relative atomic mass) / Symbol / Name / Z (atomic number)

s Block — d Block — p Block

Period	1	2											3	4	5	6	7	0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	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
6	133 Cs Caesium 55	137 Ba Barium 56	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	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▶▶ Actinium 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

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GCE MARKING SCHEME

CHEMISTRY
AS/Advanced

SUMMER 2011

CHEMISTRY - CH1

SECTION A

Q.1

Atom/ion	No. of protons	No. of neutrons	No.of electrons
^{24}Mg	12	12	12
^{26}Mg	12	14	12
$^{24}Mg^{2+}$	12	12	10

One mark for each correct line [3]

Q.2 An iron atom, Fe

3s	3p			3d					4s
↑↓	↑↓	↑↓	↑↓	↑↓	↑	↑	↑	↑	↑↓

[1]

Q.3 58.5 - working must be shown [1]

Q.4 **C** [1]

Q.5 ΔH (1), **both** activation energies (1) [2]

Q.6 (a) NO_2

(b) N_2O_4 [2]

Total [10]

SECTION B

Q.7 (a) The electrons absorb energy from the radiation (1) and are excited up to a higher energy level (1)leaving dark lines or bands in the spectrum (1)
- 2 max. [2]

(b) A **series** (four) of sharp (bright) **lines** (on a dark background) (converging towards the violet end). (1)
The atom's electron energy levels have fixed values/ are quantized (1), the lines arise when electrons fall between these levels (1) and thus have fixed energies and wavelengths. (1)
Any two in this sentence for two marks. [3]

QWC: Information organized clearly and coherently, using specialist vocabulary where appropriate. [1]

(c) (i) IEs increase (1) due to increasing nuclear charge / more protons and same orbitals being filled. (1)

(ii) IEs decrease (1) since increase in nuclear charge is outweighed by increased shielding by electrons in inner orbitals (or similar sense). (1)
[4]

(d)

Radiation	**Effect on atomic number**	**Effect on mass number**
alpha particle	-2	-4
beta particle	+1	0
gamma radiation	0	0

One mark per correct line. [3]

(e) (i) The time taken for one half of a (radioactive) isotope to decay. (1)
By measuring how much of the isotope has decayed the period of time over which it has been decaying can be calculated and the age of the rock or organic material found. (1)
[2]

(ii) Accept any two realistic examples - not x-ray / MRI. [2]

Total [17]

Q.8	(a)	(i)	96.8 g	(1) for 1.5 mol if answer incorrect	[2]
		(ii)	81.7 %	(1) for 1.22 mol if answer incorrect	[2]
	(b)	(i)	The amount or % by mass of all the reactants that ends up in the desired product.		[1]
		(ii)	**A** 100 % (1); **B** 31.9 % (1)		[2]
		(iii)	**A** is preferred giving complete use of materials and no waste or co-products to be removed.		[1]
	(c)	General statement of meaning of the term (1) and examples of individual aims such as to maximise yield, prevent waste, avoid materials toxic to health and damaging to the environment, minimise energy use, work at lower temperatures and pressures, increase safety, avoid the use of organic solvents, etc., etc., Any three of above or similar points. Mark flexibly!			[3]
		QWC: Selection of form and style of writing appropriate to purpose and to complexity of subject matter.			[1]
					Total [12]

Q.9	(a)	If the temperature, pressure or concentration of a system in equilibrium is changed the position of equilibrium shifts in the direction to oppose the change (or similar).			[1]
	(b)	This is a measure of the acidity or alkalinity of an (aqueous) solution (and relates to the hydrogen ion concentration.) pH 7 is neutral, lower values are acidic and higher values alkaline and the further the values are from 7 the more acidic or alkaline the solution is. Accept $pH = -\log_{10}[H^+]$			[1]
	(c)	(i)	I	Acidity will increase since, from Le Chatelier, increased CO_2 pushes the equilibrium to the right.	[1]
			II	pH will fall since $[H^+]$ increases	[1]
		(ii)	This will decrease since the increase in H^+ moves the equil. to the left, (reducing carbonate and increasing hydrogencarbonate).		[1]
		(iii)	It will be more difficult to make shells since the reduction in carbonate will displace the equil. to the left and the solid shell will tend to dissolve rather than form. Accept error carried forward from (ii).		[1]
	(d)	7.6 ± 0.1			[1]
	(e)	moles H^+ = 0.095 x 19.6/1000 = 0.00186 (1) concn HCO_3^- = 0.00186 x 1000/25 = 0.0744 (1) (mol dm^{-3})			[2]
					Total [9]

Q.10 (a) Temperature, pressure/concentration, catalyst, light, particle size.
- any three for 1 mark each [3]

(b) (i) Results correctly plotted (2), one error (1), more than one (0).
Good curve (and tangent) (1).
Correct rate 0.1 (1), cm^3/s (1) [5]

(ii) The rate is lower at 250 s (1) since the concentration of peroxide has fallen through decomposition (1) (and there are fewer collisions/the rate depends on concentration) [2]

(iii) A gas syringe or gas volume-measuring device is attached to the reaction flask, a stopwatch/timer is started and the volume of gas in the syringe measured at (50 s) time intervals. [2]

(c) Rate increases with increasing pressure and temperature (1).
Increasing pressure increases concentration (1).
Increasing temperature increases number of molecules with E_a. (1)
Rate increases with rate of successful collisions. (1) [4]

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

Total [17]

Q.11 (a) (i) A known mass / volume of water is placed into an insulated vessel (calorimeter)(1) and the temperature measured every 30s. When the temperature is constant (1) a known mass of $NaNO_3$ is rapidly added (and stirred to dissolve) (1). The temperature continues to be measured every 30 s for some minutes (1), a temperature/time plot is made from the results, ΔT (max) is found from the graph(1) – extrapolation (1)- and ΔH calculated from the equation below.
- 4 max. [4]

(ii) Extrapolate (1)
$\Delta T = -10.0 \pm 0.4^{o}$ (1)

$\Delta H = +21$ kJ mol^{-1} (2); -1 if wrong sign, consequential [4]
[21 000 kJ mol^{-1} (1)]

(b) (i) The overall enthalpy change for a reaction is independent of the reaction route taken (or equivalent). [1]

(ii) $\Delta H = \Delta H^{o}_{f}(H_2SO_4) – [\Delta H^{o}_{f}(SO_3) + \Delta H^{o}_{f}(H_2O)$ (1)

= (-811)-[(-395) + (-286)] = -130 kJ mol^{-1} (1) [2]
- 1 max. for +130 kJ mol^{-1}

(c) The (average) energy needed to break the O-H bond. (1)
O-H bonds in different molecules will have slightly different bond energies and so a mean or average value is useful. (1) [2]

(d) These are fossil fuels, that are non-renewable and finite in amount so will eventually run out. (1)
Turn to renewable sources of energy (such as solar, wind, biofuels and nuclear.) (1)
OR
Combustion of carbon compounds gives CO_2 in the atmosphere that is causing global warming. (1)
Reduce the use of these fuels / capture / store the CO_2. (1)
OR
Sulfur in fuels producing sulfuric acid in atmosphere –acid rain-(1).
Remove sulfur dioxide from flues (FGD), use low sulfur fuels, etc. (1) [2]

Total [15]

Section B Total [70]

Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1091/01

CHEMISTRY CH1

P.M. TUESDAY, 15 May 2012

1½ hours

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

1091
010001

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.

MAY121091 0101

Examiner only

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]

....

0 2

Examiner only

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]

1091 010003

Turn over.

Examiner only

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]

....

....

(c) In order to obtain a mass spectrum of a gaseous sample of magnesium, the sample must be ionised.

(i) State how the magnesium atoms are ionised in the sample. [1]

....

....

(ii) Give a reason why it is necessary to ionise the magnesium atoms in the sample. [1]

....

....

(iii) State how the ions of magnesium are separated. [1]

....

....

(d) Magnesium reacts with nitrogen forming magnesium nitride, which is an ionic compound.

By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of a nitride ion, N^{3-}. [1]

1s	2s	2p			3s	3p		

(e) Magnesium nitride reacts with water to form magnesium hydroxide and ammonia.

$$\square\ Mg_3N_2 + \square\ H_2O \longrightarrow \square\ Mg(OH)_2 + \square\ NH_3$$

(i) Balance the equation above. [1]

(ii) Calculate the minimum mass of magnesium nitride required to form 1.75 g of magnesium hydroxide, giving your answer to **three** significant figures. [3]

....

....

....

....

Total [14]

Examiner only

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.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

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

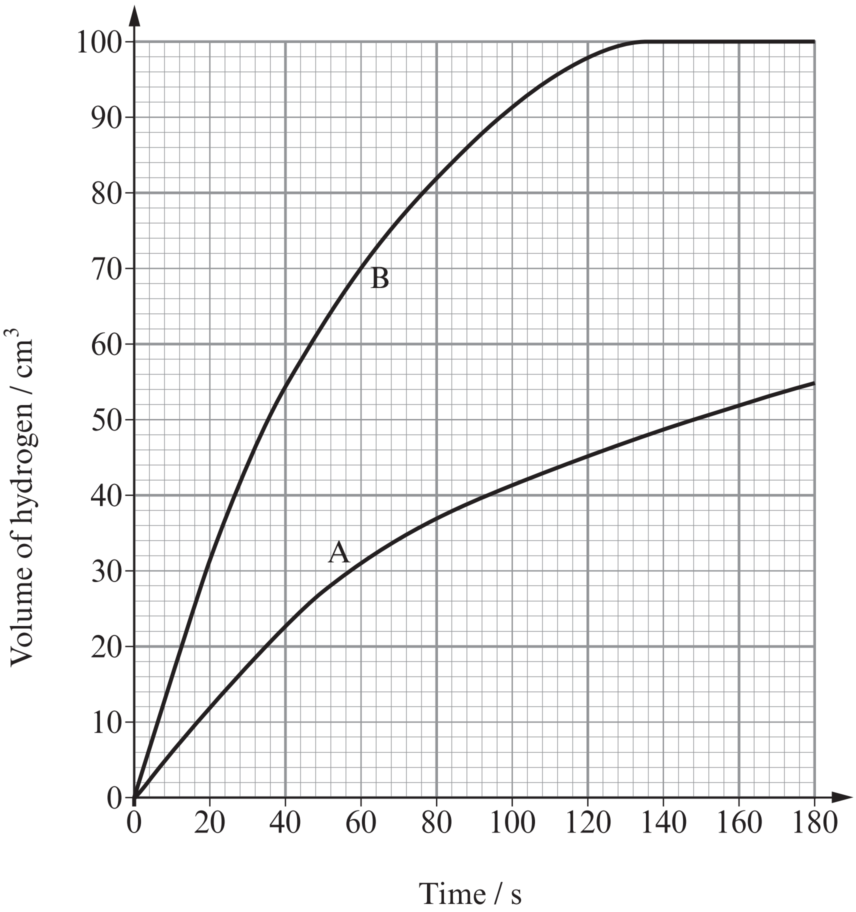
The results obtained in experiment **C** are shown in Table 2 below.

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]

....

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Examiner only

(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 cm^3 of hydrogen. If 0.122 g of magnesium were used, under the same conditions, then 120 cm^3 would be produced. Explain why using 0.610 g would not produce 600 cm^3 of hydrogen. [1]

....

....

(ii) Calculate the volume of hydrogen produced using 0.610 g of magnesium. [2]

(1 mole of gas molecules occupies 24 dm^3 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]

Examiner only

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]

....

....

Turn over.

Examiner only

(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]

Examiner only

9. Ethanol is an important industrial chemical and can be made by the direct hydration of ethene using a phosphoric acid catalyst.

$$CH_2{=}CH_2(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g) \quad \Delta H = -46\,kJ\,mol^{-1}$$

(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	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CH_2{=}CH_2(g)$	52.3
$H_2O(g)$	–242

....

....

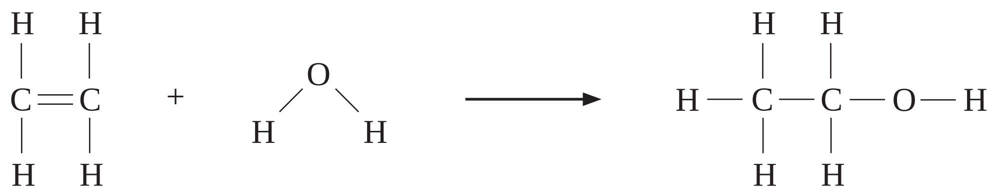
....

....

Turn over.

Examiner only

(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}
C—C	348
C=C	612
C—H	412
C—O	360
O—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]

....

....

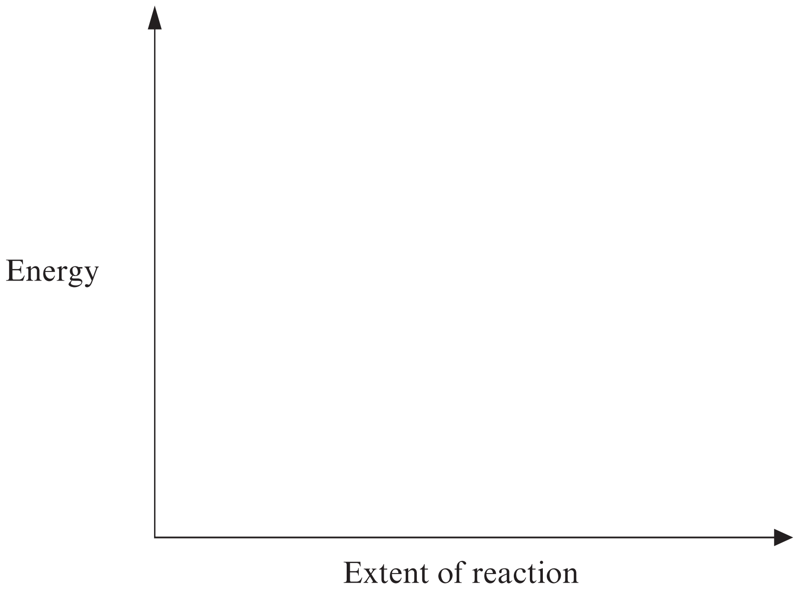
Examiner only

(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]

Examiner only

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]

....

....

Examiner only

(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.

$$MOH + HCl \longrightarrow MCl + H_2O$$

(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]

Question number	Write the question numbers in the left-hand margin

Examiner only

WJEC CBAC

GCE AS/A level

1091/01-A

CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1

P.M. TUESDAY, 15 May 2012

THE PERIODIC TABLE

Key

A_r — relative atomic mass Symbol Name Z — atomic number

Period	1	2						Group					3	4	5	6	7	0
	s Block							d Block							p Block			
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	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
6	133 Cs Caesium 55	137 Ba Barium 56	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	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 89															

f Block

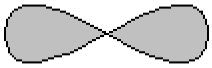
▸ Lanthanoid elements	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
▸▸ Actinoid 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 2012

CH1
Section A

1. 

[1]

2. 1/12th mass of one atom of carbon-12. [1]

3. C [1]

4. (a)

	C	O	Cl		
	$\frac{12.1}{12}$	$\frac{16.2}{16}$	$\frac{71.7}{35.5}$	(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		
↓↑	↓↑	↓↑	↓↑	↓↑				

[1]

(e) (i) $Mg_3N_2 + \mathbf{6}H_2O \longrightarrow \mathbf{3}Mg(OH)_2 + \mathbf{2}NH_3$ [1]

(ii) moles $Mg(OH)_2$ = 1.75/58.32 = 0.0300 (1)

moles Mg_3N_2 = 0.0100 (1)

mass Mg_3N_2 = 0.01 x 100.9 = 1.01 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)	$44\ cm^3$ ($\pm 1\ cm^3$)			[1]
	(d)	Moles Mg = 0.101/24.3 = 0.00416		(1)	
		Moles HCl = 2 x 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 x 0.04 = 0.02	(1)	
			Volume H_2 = 0.01 x 24 = 0.24 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 CO_2 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 H_2 (1)

Resulting in CO_2 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) ^{218}Po [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) ΔHreaction = ΔH_f products – ΔH_f reactants (1)

-46 = ΔH_f ethanol – (52.3 – 242)

ΔH_f ethanol = -46 – 189.7 (1)

ΔH_f ethanol = -235.7 kJ mol^{-1} (1) [3]

(c) Bonds broken = 1648 + 612 + 926 = 3186 kJ mol^{-1} (1)

Bonds formed = 2060 + 348 + 360 + 463 = 3231 kJ mol^{-1} (1)

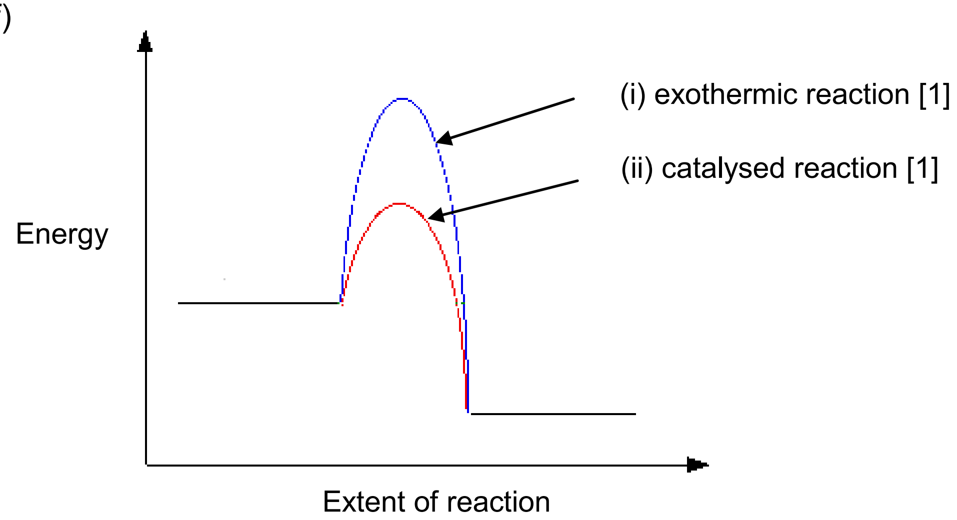
ΔH reaction = 3186 – 3231 = -45 kJ mol^{-1} (1)
[3]

(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]

(f)



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 cm^3			[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 mol dm^{-3}	(1)	[2]
		(ii)	Moles = 0.2 x 0.0238 = 0.00476		[1]
		(iii)	0.00476		[1]
		(iv)	0.00476 x 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

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		

1091
010001

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.

MAY131091O101

Examiner only

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]

Examiner only

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]

1091 010003

Examiner only

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 $Al_2Be_xSi_6O_{18}$. Find the percentage by mass of beryllium in the compound and hence calculate the value of x in this formula. [3]

x = ...

(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}
$C(diamond) + O_2(g) \longrightarrow CO_2(g)$	–395.4
$C(graphite) + O_2(g) \longrightarrow CO_2(g)$	–393.5

(i) State Hess' Law. [1]

....

....

Examiner only

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

$$C(graphite) \rightarrow C(diamond)$$

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]

....

....

....

1091 010005

(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 cm^3 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

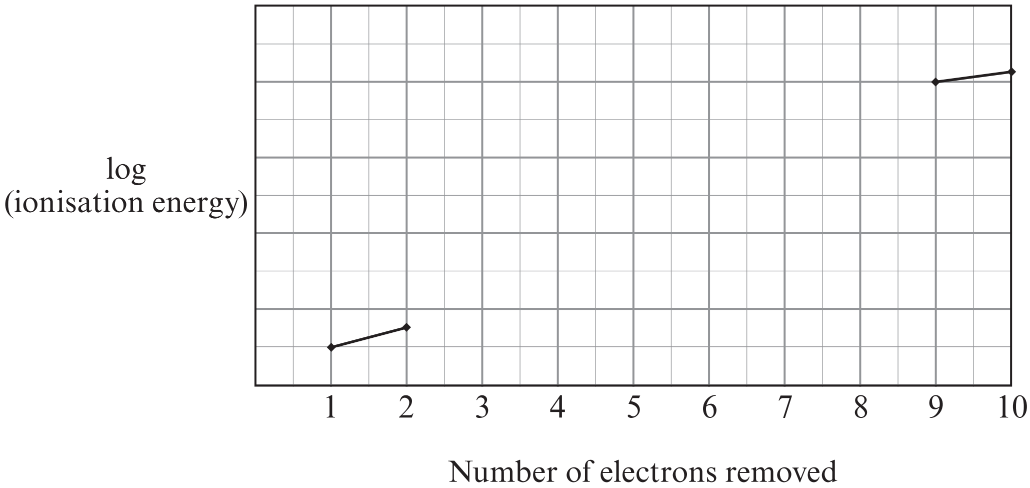
Total [10]

Examiner only

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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Examiner only

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

Explain why it is not possible to form a similar ionic compound of argon, $Ar^+ PtF_6^-$. [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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1091 010007

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

$$2XeO_3(s) \longrightarrow 2Xe(g) + 3O_2(g)$$

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 24.0 dm^3]

Volume = ... dm^3

Total [10]

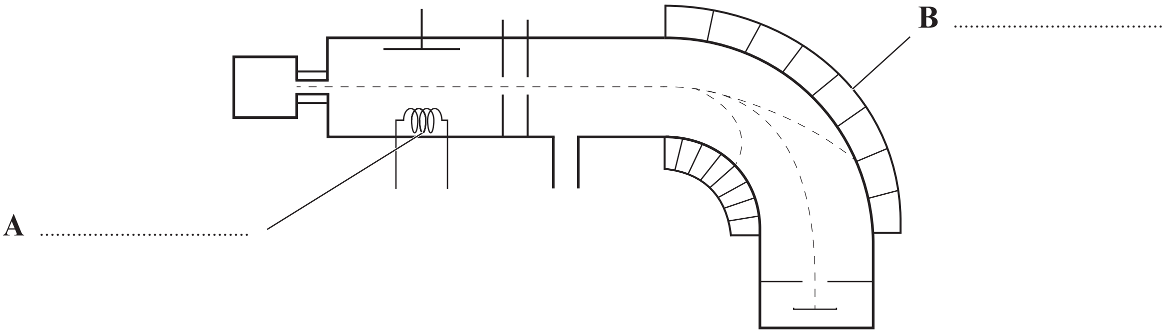
Examiner only

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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Examiner only

(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 = ...

1091 010009

(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.

$$^{81}Se \longrightarrow {}^{a}X + {}^{0}_{-1}\beta$$

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]

Examiner only

10. Hydrated sodium carbonate, $Na_2CO_3.xH_2O$, 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 = ...

(b) Emily wants to prepare $250\,cm^3$ 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 = ... 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 $250\,cm^3$ 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. ....

....

....

2. ....

....

....

Examiner only

(c) Emily then prepared $250\,cm^3$ of sodium carbonate solution of concentration $0.200\,mol\,dm^{-3}$ using a correct method. She took $25.0\,cm^3$ 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]

Examiner only

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.

$$C_9H_{20}(l) \quad + \quad 14\,O_2(g) \longrightarrow 9\,CO_2(g) \quad + \quad 10H_2O(l)$$

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

Substance	Standard enthalpy of formation, $\Delta H_f^{\ominus}$ / kJ mol^{-1}
$C_9H_{20}(l)$	–275
$O_2(g)$	0
$CO_2(g)$	–394
$H_2O(l)$	–286

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

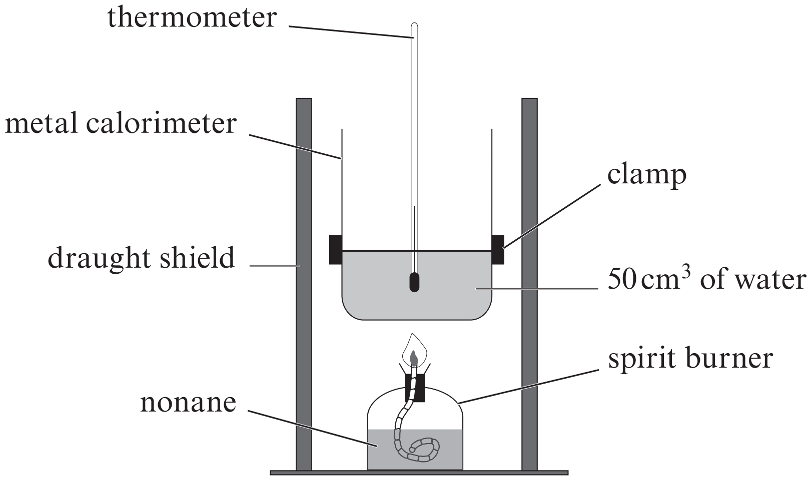
(ii) Standard enthalpy changes are measured under standard conditions. Give the standard conditions of temperature and pressure, including units for each. [2]

Temperature ....

Pressure ....

Examiner only

(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

Examiner only

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

....

....

Total [10]

Examiner only

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.

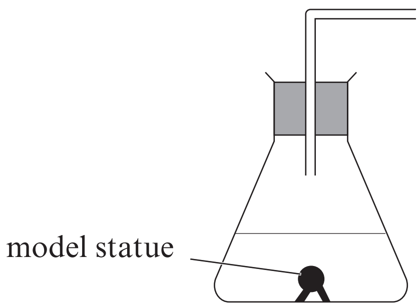
Give **one** other problem caused by acid rain. [1]

....

....

(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]

....

....

Examiner only

(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.

$$2SO_2(g) \quad + \quad O_2(g) \rightleftharpoons 2SO_3(g)$$

(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]

....

....

....

....

Examiner only

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]

....

....

Examiner only

(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		$C_2H_5OH + O_2 \rightarrow CH_3COOH + H_2O$	76.9%
B	methanol, carbon monoxide	150 °C, 30 atm	$CH_3OH + CO \rightleftharpoons CH_3COOH$	100.0%
C	butane	150 °C, 55 atm	$2C_4H_{10} + 5O_2 \rightarrow 4CH_3COOH + 2H_2O$	87.0%
D	sugars		$C_6H_{12}O_6 \rightarrow 3CH_3COOH$	

(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]

Question number	**Additional page, if required. Write the question numbers in the left-hand margin.**

Examiner only

Question number	Additional page, if required. Write the question numbers in the left-hand margin.

Examiner only

GCE AS/A level

1091/01-A

CHEMISTRY – PERIODIC TABLE FOR USE WITH CH1

A.M. THURSDAY, 23 May 2013

THE PERIODIC TABLE

Group

Key: A_r (relative atomic mass) / Symbol / Name / Z (atomic number)

s Block; d Block; p Block

Period	1	2											3	4	5	6	7	0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	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
6	133 Cs Caesium 55	137 Ba Barium 56	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	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 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

GCE CHEMISTRY - CH1

SUMMER 2013 MARK SCHEME

SECTION A

Q.1 number of protons 6

number of neutrons 8

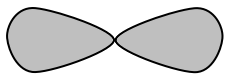
number of electrons 6 (all correct 2 marks, 2 correct 1 mark) **[2]**

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)

Al 10.04 ÷ 27 = 0.3719 → 1.00

Be 5.03 ÷ 9.01 = 0.5583 → 1.50

O 53.58 ÷ 16 = 3.3488 → 9.00

Si 31.35 ÷ 28.1 = 1.1566 → 3.10

molecular formula = $Al_2Be_3O_{18}Si_6$ 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) $\Delta H = -393.5 - (-395.4)$ (1) = +1.9 kJ mol^{-1} (1) **[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 mass of graphite = 7.30 ÷ (93/100) (1) = 7.85 g (1) **[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)

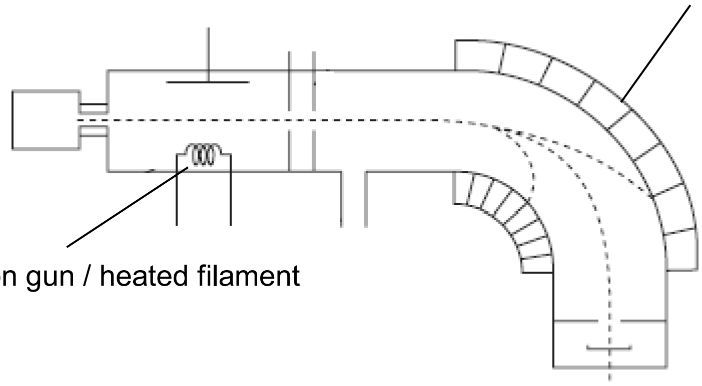
2.5 mol of gas occupies 24.0 x 2.5 = 60.0 dm^3 (1) – follow through error (ft)

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

B electromagnet



A electron gun / heated filament

[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 x 12.2) + (79 x 26.4) + (80 x 61.4) ÷ 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 → 1.36g → 0.68g → 0.34g → 0.17g (1) – no ft **[2]**

Total [13]

Q.10 (a) $x = 10$ **[1]**

(b) (i) number of moles = 250 x 0.200 ÷ 1000 = 0.05 mol (1) – ft

mass of sodium carbonate = 0.05 x $M_r(Na_2CO_3)$ = 0.05 x 286.2
= 14.31g (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)	
			$= -6131$ 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 = 1.56×10^{-3} mol (1)	**[2]**
		(ii)	$\Delta H = –50 \times 4.18 \times 42 \div 1.56 \times 10^{-3}$ (1)	
			$= –5626698$ J mol^{-1} $= –5627$ 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)

can gain first two points from labelled Boltzmann distribution curve **[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. 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**	

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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.

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Examiner only

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 $Na_2CO_3.10H_2O$.

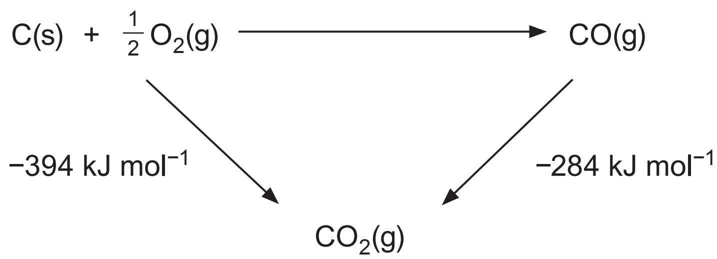
(a) Calculate the relative molecular mass (M_r) of $Na_2CO_3.10H_2O$. [1]

M_r = ...

(b) Calculate the mass of $Na_2CO_3.10H_2O$ needed to make 250 cm^3 of a 0.10 mol dm^{-3} solution. [1]

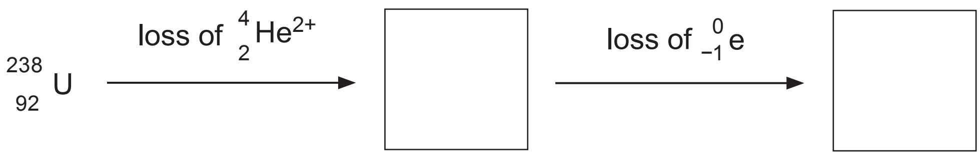
Mass = ... g

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]



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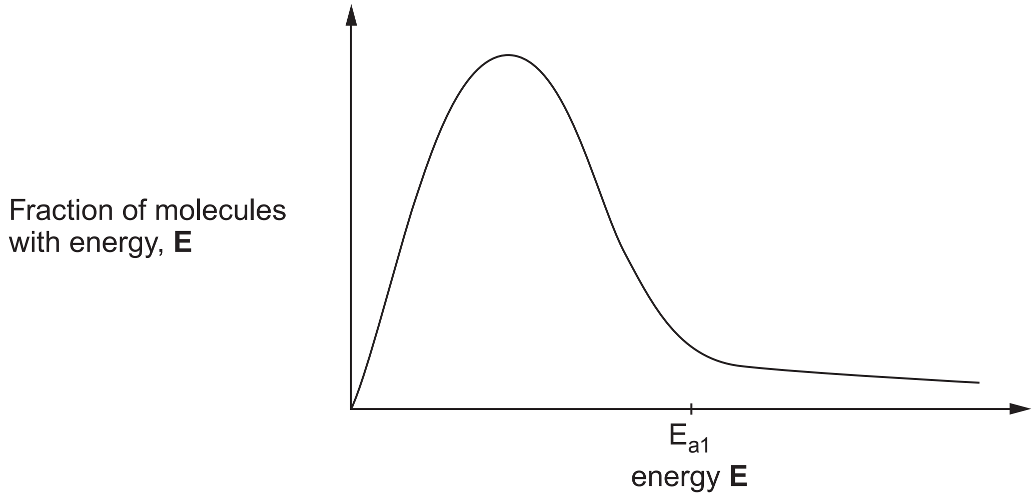
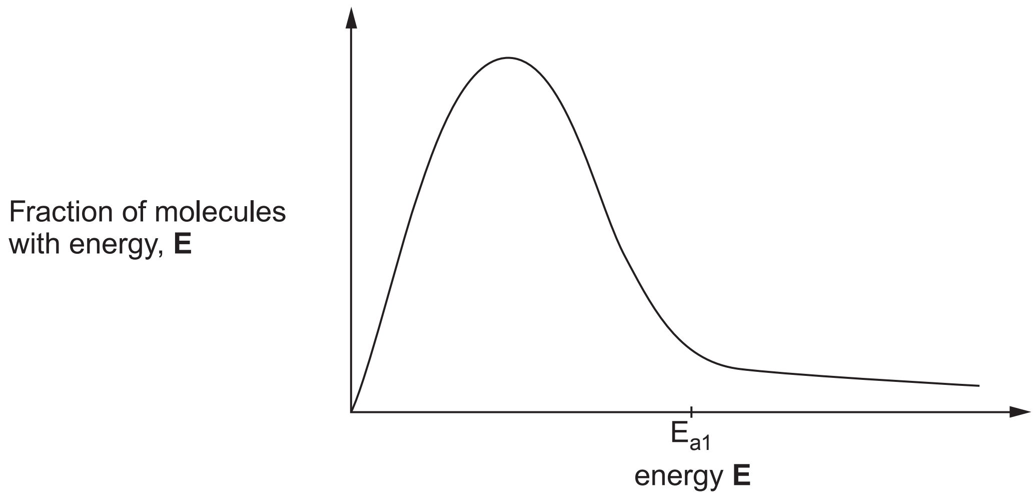
7. The diagrams show the energy distribution curve for gaseous molecules at a fixed temperature.

(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.

(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]

Examiner only

(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]

....

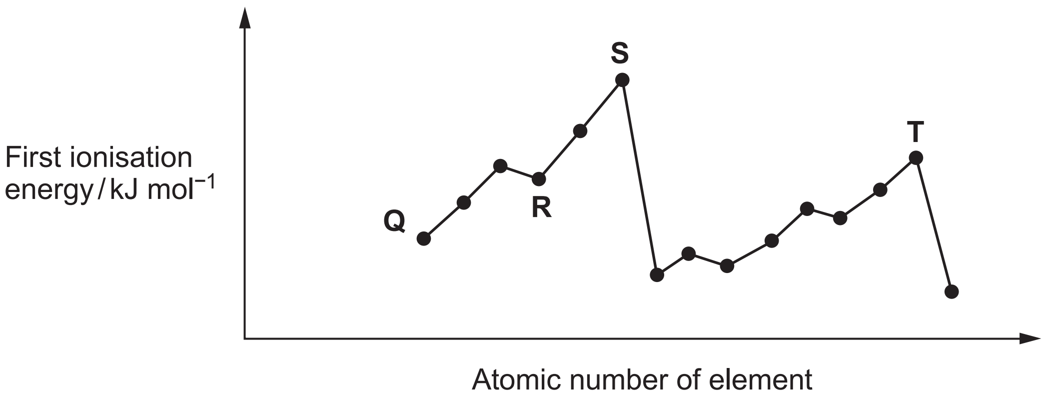
(ii) Explain whether or not this student was correct. [2]

....

....

....

(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]

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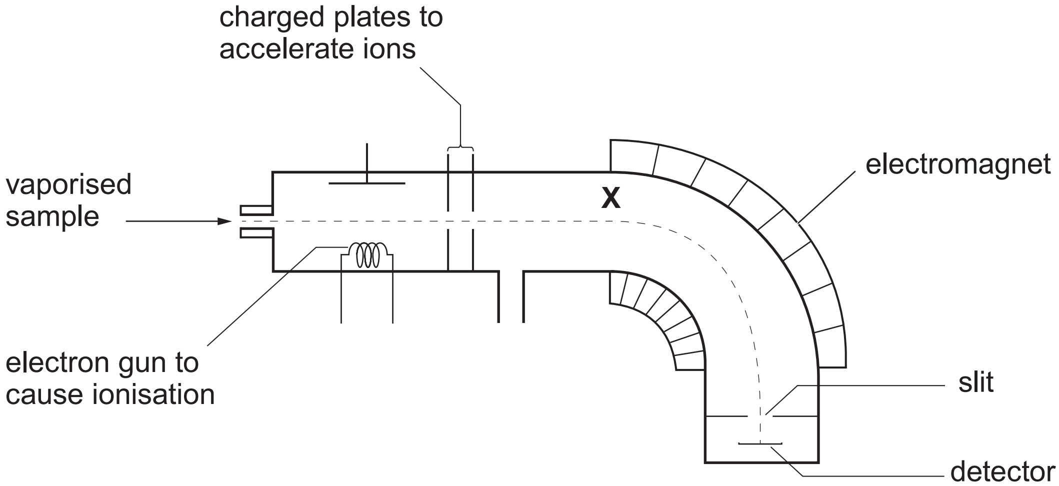
Examiner only

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]

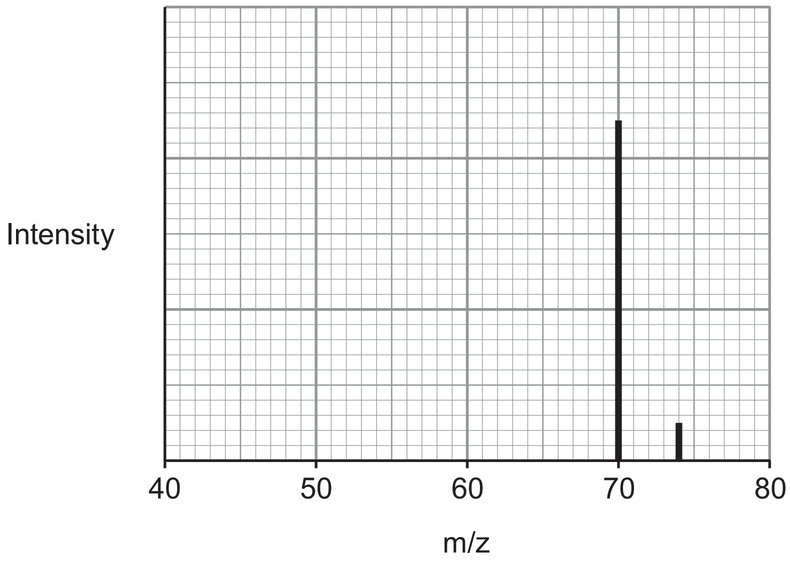
(ii) Without altering the shape of the mass spectrometer, what change could be made to allow ion **Y**, with its higher mass to charge ratio, to pass through the slit and be detected? [1]

....

....

Examiner only

(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]

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(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]

Examiner only

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

$$\underset{\text{pale yellow}}{N_2O_4(g)} \rightleftharpoons \underset{\text{dark brown}}{2NO_2(g)} \qquad \Delta H = +57\ \text{kJ mol}^{-1}$$

(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

....

....

Examiner only

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

$$N_2H_4(l) \longrightarrow N_2(g) + 2H_2(g)$$

(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.

$$H_2O + 2NO_2 \longrightarrow HNO_2 + HNO_3$$

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]

$$HNO_2 + H_2O \longrightarrow$$

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

$$HNO_3 + H_2SO_4 \longrightarrow H_2NO_3^{+} + HSO_4^{-}$$

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

....

....

Total [14]

Examiner only

11. *(a)* Ethanol, C_2H_5OH, 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]

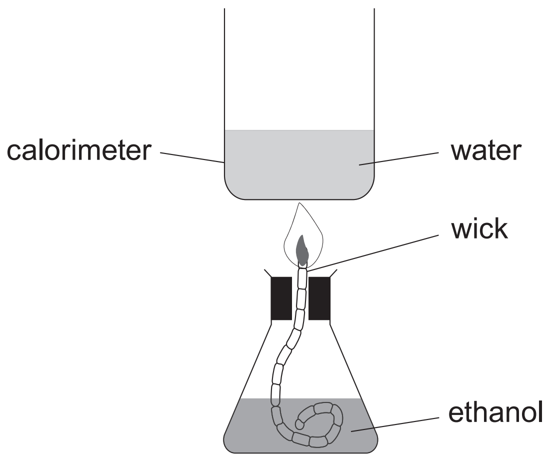
....

....

(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.

$$C_2H_5OH(l) \quad + \quad 3O_2(g) \longrightarrow 2CO_2(g) \quad + \quad 3H_2O(l)$$

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

energy released = $mc\Delta T$

where m = mass of the water in grams (assume 1 cm^3 has a mass of 1 g)
c = 4.2 J g^{-1}°C^{-1}
ΔT = change in temperature of the water

Examiner only

(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]

....

....

....

Examiner only

(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, C_3H_7OH. [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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Examiner only

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]

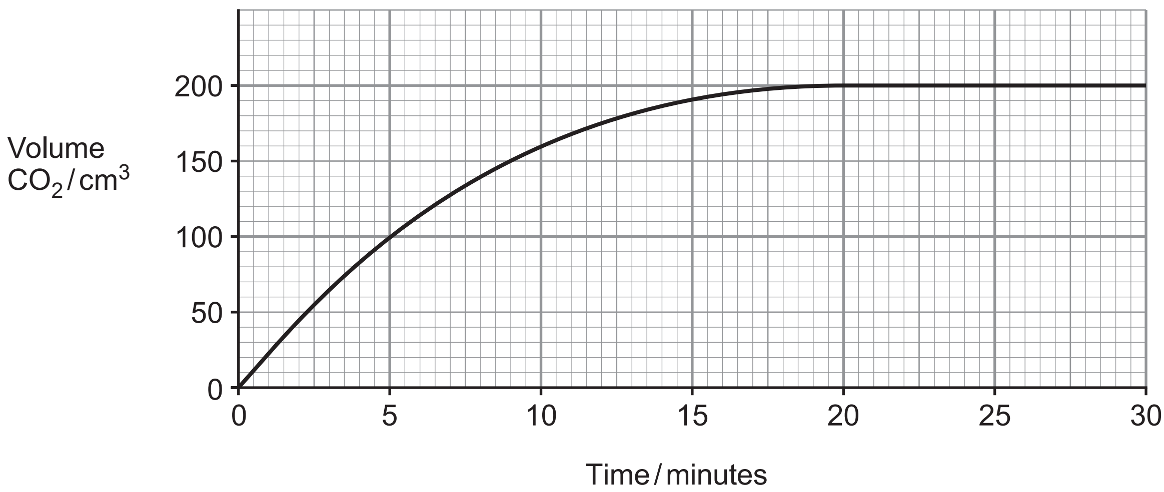
....

....

(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]

....

....

....

....

....

....

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(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]

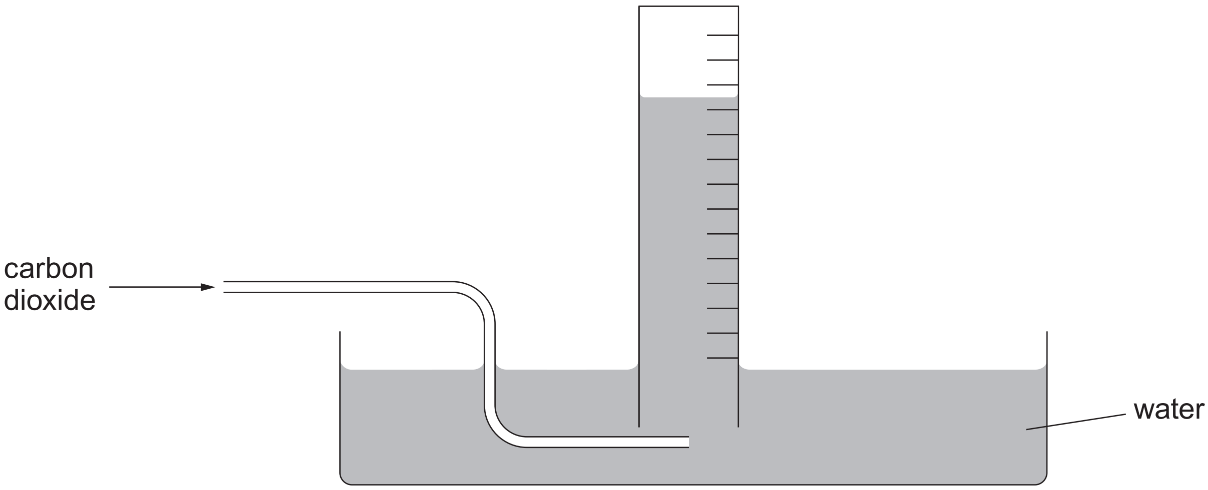
Number of moles $MgCO_3$ = ... mol

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

Percentage of magnesium carbonate = ... %

Examiner only

(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.

$$MgCO_3(s) \longrightarrow MgO(s) + CO_2(g)$$

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

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

Examiner only

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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GCE AS/A level

1091/01-A

CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1

A.M. FRIDAY, 23 May 2014

THE PERIODIC TABLE

Key

A_r — relative atomic mass Symbol Name Z — atomic number

Group

Period	1 (s Block)	2 (s Block)	d Block										3 (p Block)	4 (p Block)	5 (p Block)	6 (p Block)	7 (p Block)	0 (p Block)
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	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
6	133 Cs Caesium 55	137 Ba Barium 56	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	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 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 2014

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) 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 $^{234}_{90}Th$ (1) $^{234}_{91}Pa$ (1) (award 1 mark for 2 correct symbols) [2]

Q.7 portion to right of Ea_1 labelled as molecules that react / shaded [1]

Ea_2 marked, at lower energy than Ea_1, 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 = ∞
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 = ∞ (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 allow decrease charge on charged plates	[1]
	(b)	(i)	1+ (1) ^{37}Cl - ^{37}Cl (1) $^{37}Cl_2^+$ (2)	[2]
		(ii)	line drawn as m/z 72 (1) ratio height 6 (1) allow ½ 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 N_2H_4 = 14000/32.04 = 437.0 (1)

this produces 437.0 × 3 = 1311 moles of gas (1)

volume = 1311 × 24 = 3.15×10^4 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) $\rightarrow NO_2^- + H_3O^+$ [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) $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$ (state symbols needed)

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) $C_3H_7OH + 4\frac{1}{2}O_2 \rightarrow 3CO_2 + 4H_2O$ (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) $MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$ (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 CO_2 = 200 cm^3 (1)

moles CO_2 = 200 / 24000 = 0.008333 = moles $MgCO_3$ (1)
[minimum 2 sf] [2]

(ii) mass $MgCO_3$ = 0.008333 × 84.3 = 0.702 g (1)

% $MgCO_3$ = $\frac{0.702}{0.889} \times 100$ = 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 × 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

S15-1091-01

CHEMISTRY – CH1

A.M. FRIDAY, 22 May 2015

1 hour 30 minutes

1091
010001

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

MAY1510910101

Examiner only

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
$^{20}_{10}Ne$			
$^{18}_{8}O^{2-}$			

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

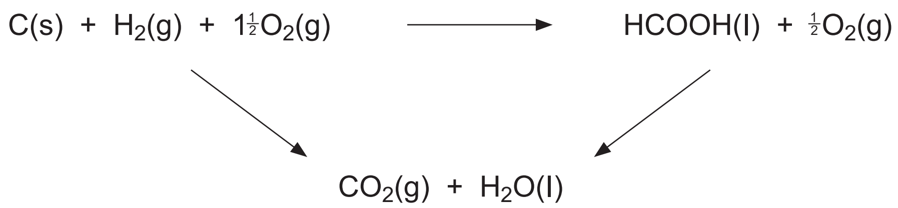
Examiner only

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, ΔH_c^θ / kJ mol^{-1}
C	−394
H_2	−286
HCOOH	−263

ΔH_f^θ = ... kJ mol^{-1}

1091
010003

Examiner only

4. A sample of 0.50 g of calcium carbonate completely reacts with 50 cm^3 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 cm^3 of hydrochloric acid solution of concentration 2.0 mol dm^{-3} would have on the initial rate of this reaction. [1]

....

....

Section A Total [10]

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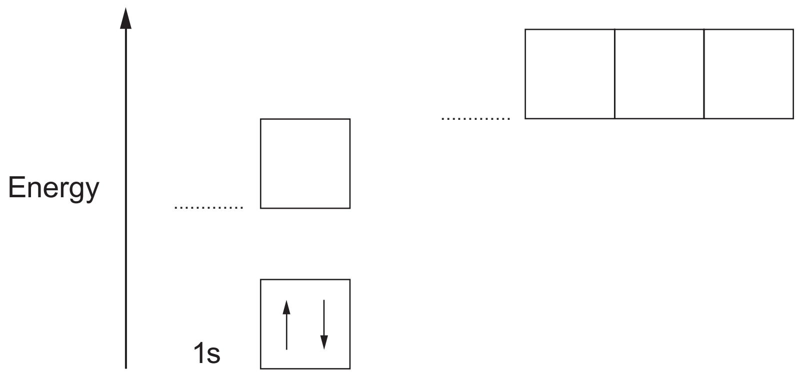
SECTION B

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.

$$\ldots\ldots\ NH_3 + \ldots\ldots\ O_2 \longrightarrow \ldots\ldots\ N_2O + \ldots\ldots\ H_2O$$

Balance the equation above. [1]

Examiner only

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

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

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 dm^3 at room temperature and pressure]

Volume = ... dm^3

(c) Hydrated calcium nitrate can be represented by the formula $Ca(NO_3)_2.xH_2O$.

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

Calculate the value of x in $Ca(NO_3)_2.xH_2O$. You **must** show your working. [3]

x = ...

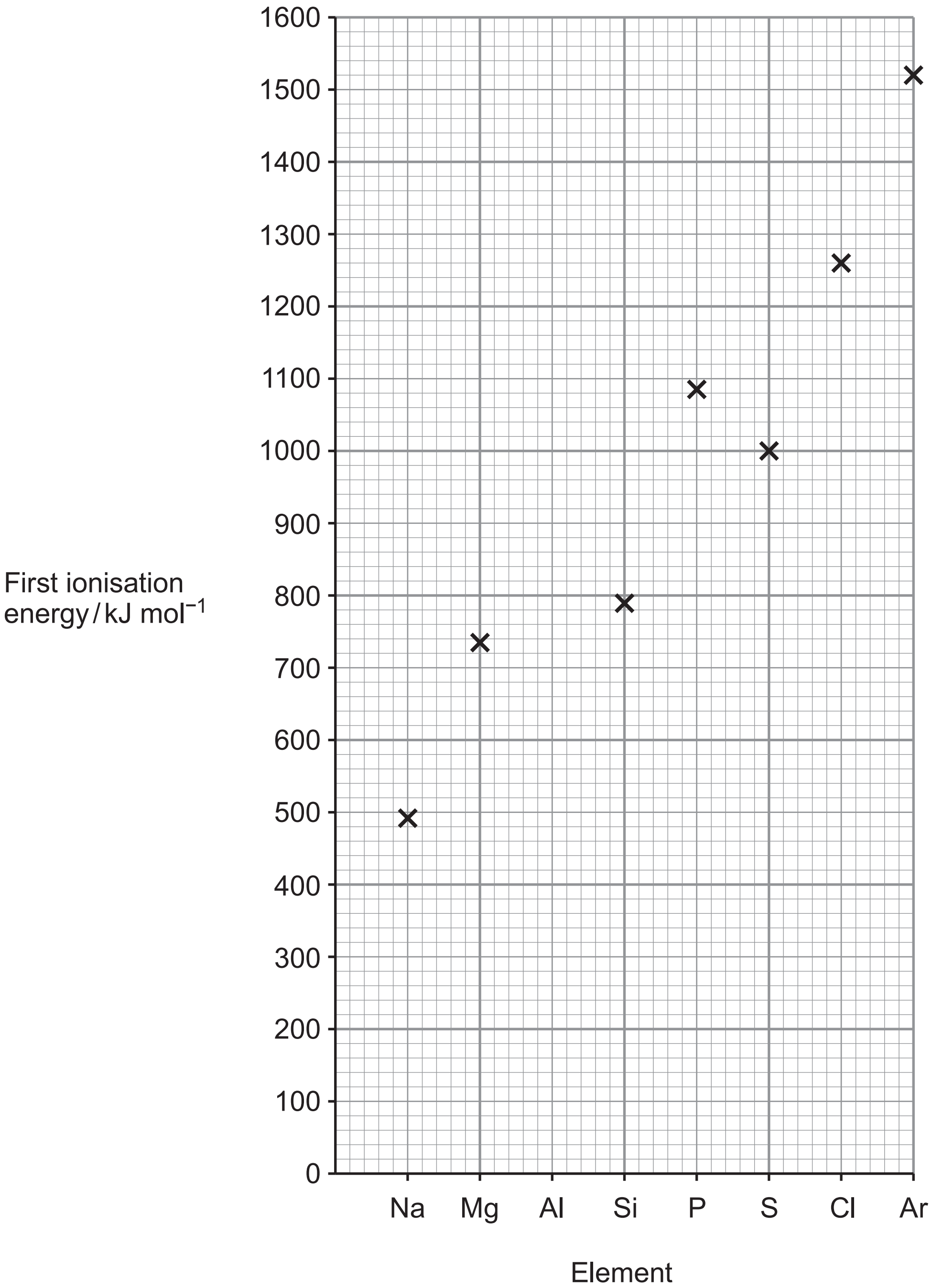
Total [11]

1091 010007

Examiner only

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.



Examiner only

(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]

....

....

....

....

....

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

	1st	2nd	3rd	4th	5th
Ionisation energy / kJ mol^{-1}	736	1450		10500	13629

(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]

1091 010009

Examiner only

(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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Examiner only

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}Li and ^{7}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}Li and ^{7}Li, giving a reason for your answer. [2]

....

....

....

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

Isotope	% abundance
^{6}Li	7.25
^{7}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 = ...

Examiner only

(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.

$$(NH_4)_2SO_4 \quad + \quad 2LiOH \longrightarrow 2NH_3 \quad + \quad Li_2SO_4 \quad + \quad 2H_2O$$

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 $(NH_4)_2SO_4$ 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]

Examiner only

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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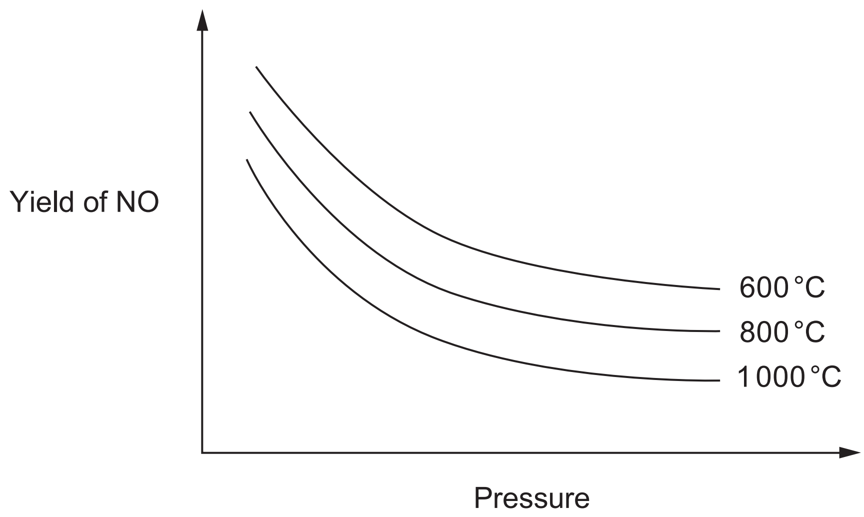
....

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

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

ammonia + oxygen $\rightleftharpoons$ nitric oxide + water

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



Examiner only

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

....

....

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]

....

....

....

....

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

....

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

....

....

....

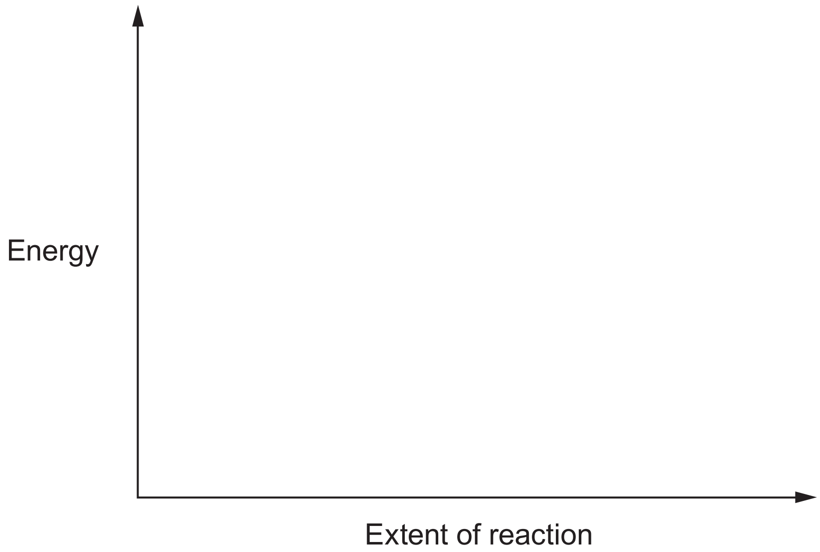
....

Examiner only

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

$$2NO(g) \quad + \quad O_2(g) \longrightarrow 2NO_2(g) \qquad \Delta H = -114 \text{ kJ mol}^{-1}$$

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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Examiner only

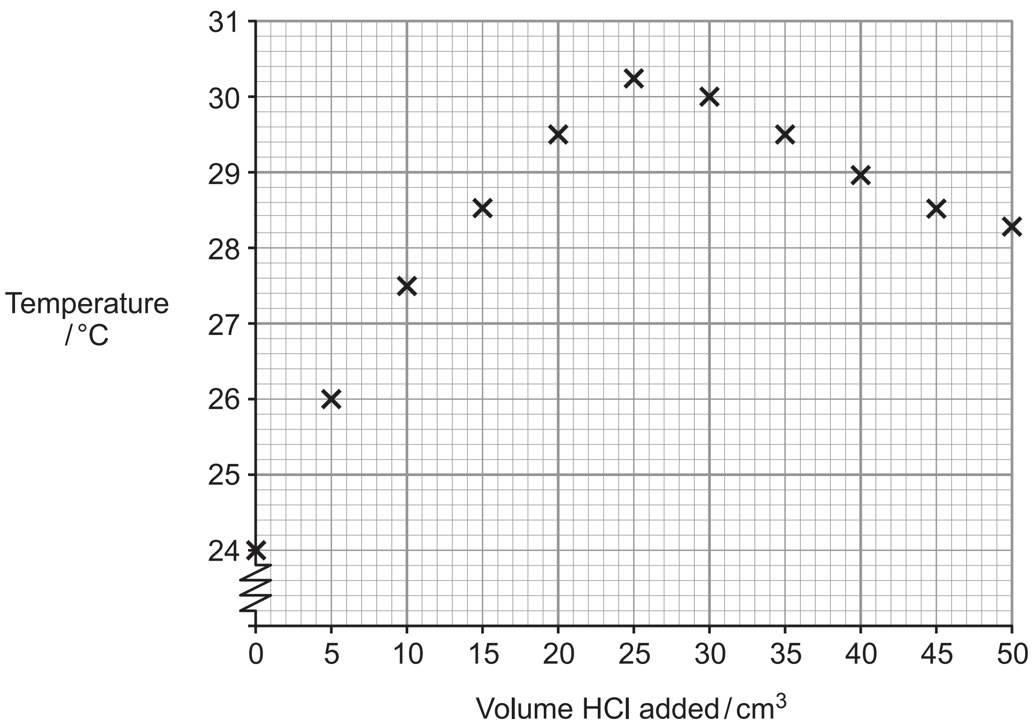
9. Zac was asked to measure the molar enthalpy change of neutralisation of sodium hydroxide by hydrochloric acid.

$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

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.



Examiner only

(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 = ... cm^3

(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}

Examiner only

(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]

....

....

....

....

(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]

....

....

....

....

Total [14]

Section B Total [70]

END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

Examiner only

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

Examiner only

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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

Group

s Block | d Block | p Block | f Block

Key

A_r (relative atomic mass) Symbol Name Z (atomic number)

Period	1	2											3	4	5	6	7	0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	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
6	133 Cs Caesium 55	137 Ba Barium 56	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	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 89															

▸ 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 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.

CH1

SECTION A

1.	Ne	10p, 10n, 10e (1)		
	O^{2-}	8p, 10n, 10e (1)		[2]
2.	(a)	^{222}Rn		[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)	$\Delta H_f = -417$ kJ mol^{-1}		[1]
4.	(a)	Measure the volume of CO_2 produced / mass of CO_2 lost at constant time intervals		[1]
	(b)	No effect since concentration of acid has not changed		[1]

Total Section A [10]

SECTION B

5. (a) **2p** | ↑ | ↑ | ↑ | [2]

2s | ↑↓ | (1 mark for labelling, 1 mark for arrows)

(b) (i)

N	O
$\frac{25.9}{14}$	$\frac{74.1}{16}$
1.85	4.63 (1)
1	2.5

N_2O_5 (1) [2]

(ii) $2NH_3 + 2O_2 \longrightarrow N_2O + 3H_2O$ [1]

(iii) Moles $Ca(NO_3)_2 = 5.40 \times 10^{-3}$ (1)

Moles gas = 1.35×10^{-2} (1)

Volume gas = 0.324 dm^3 (1) [3]

(c) Moles $Ca(NO_3)_2$ = 0.0256 (1)

Moles H_2O = 0.102 (1)

x = 4 (1) [3]

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) $^{6}Li^{+}$ since lower mass / lower m/z / lighter
do not accept 'smaller' [1]

(c) (i) $M_r(NH_4)_2SO_4$ = 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 CO_2 emissions / greenhouse emissions / global warming / effect of global warming
Reduces SO_2 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]

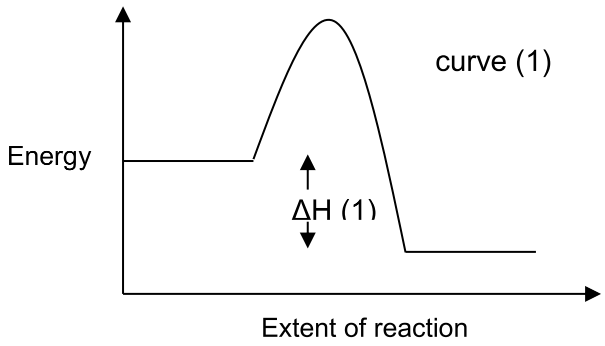
II As temperature is increased, equilibrium moves to the left (1)
Therefore forward reaction is exothermic (1)
As pressure is increased, equilibrium moves to the left (1)
Therefore more gas moles in products (1) [4]
QWC The information is organised clearly and coherently, using specialist vocabulary 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 mol dm^{-3} (1) [2]

(d) Heat = 51 × 4.18 x 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 – **LEGACY**

S16-1091-01

CHEMISTRY – CH1

A.M. FRIDAY, 27 May 2016

1 hour 30 minutes

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

1091 010001

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.

Examiner only

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 ${}^{24}_{x}Z$ is 15.0 hours. It decays by beta emission to a stable isotope of magnesium, ${}_{12}Mg$.

(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 ${}^{24}_{x}Z$ remains.

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

Starting mass = ... g

Examiner only

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]

....

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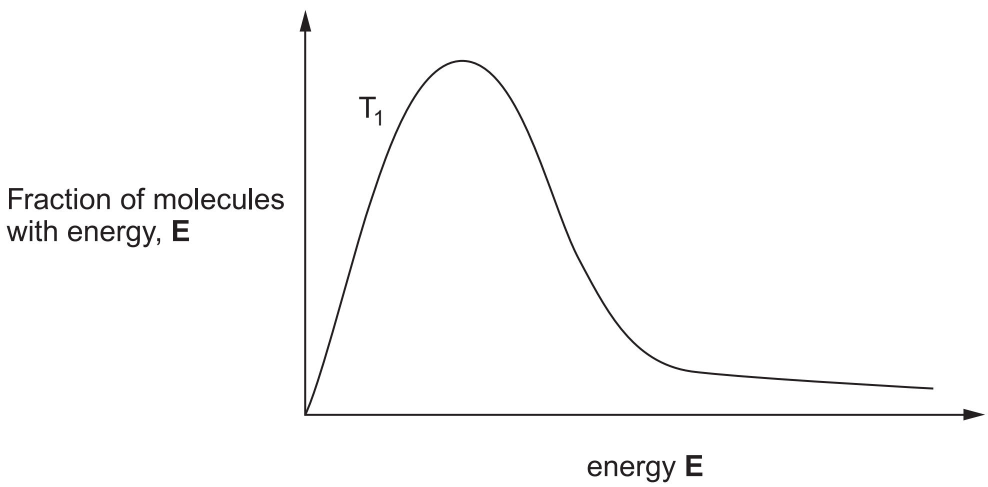
....

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]

1091
010003

Examiner only

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

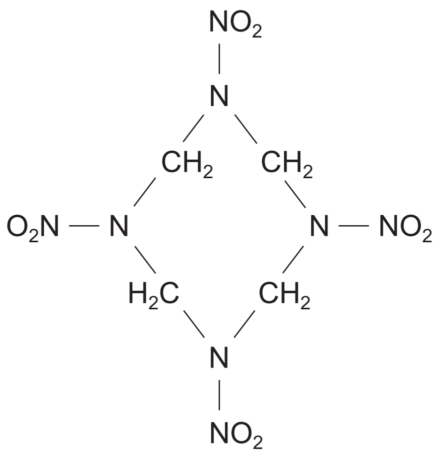
Total Section A [10]

Examiner only

SECTION B

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

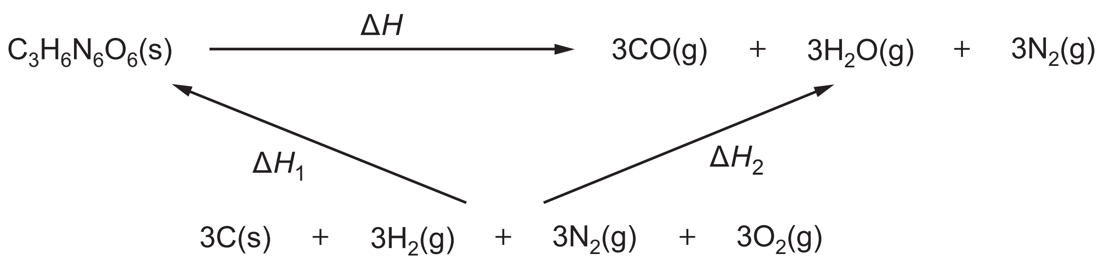
7. *(a)* The explosive HMX has the following structural formula. State its empirical formula. [1]



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 ΔH_f / kJ mol^{-1}
RDX(s)	+62
CO(g)	−111
$H_2O(g)$	−242

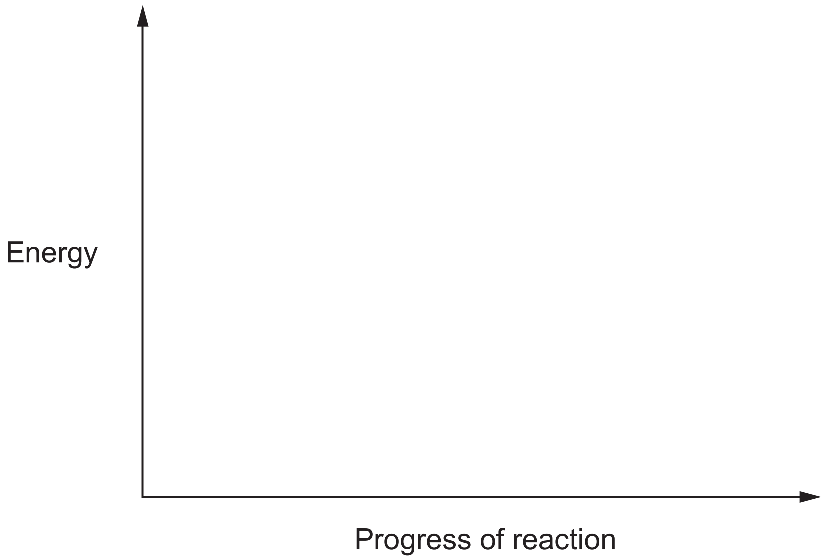
ΔH = ... kJ mol^{-1}

Turn over.

Examiner only

(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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Examiner only

(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.

$$C_6H_5N(CH_3)_2 \;+\; 4HNO_3 \longrightarrow \underset{\text{Tetryl}}{C_6H_2(NO_2)_3N(CH_3)(NO_2)} \;+\; CH_3OH \;+\; 3H_2O$$

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

....

....

(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]

....

....

1091
010007

Examiner only

(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]

....

....

(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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Total [14]

1091
010009

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Turn over.

Examiner only

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.

$$NaOH \quad + \quad HIO_3 \longrightarrow NaIO_3 \quad + \quad H_2O$$

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 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]

....

....

(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]

....

....

(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}

Examiner only

(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]

....

....

....

1091 010011

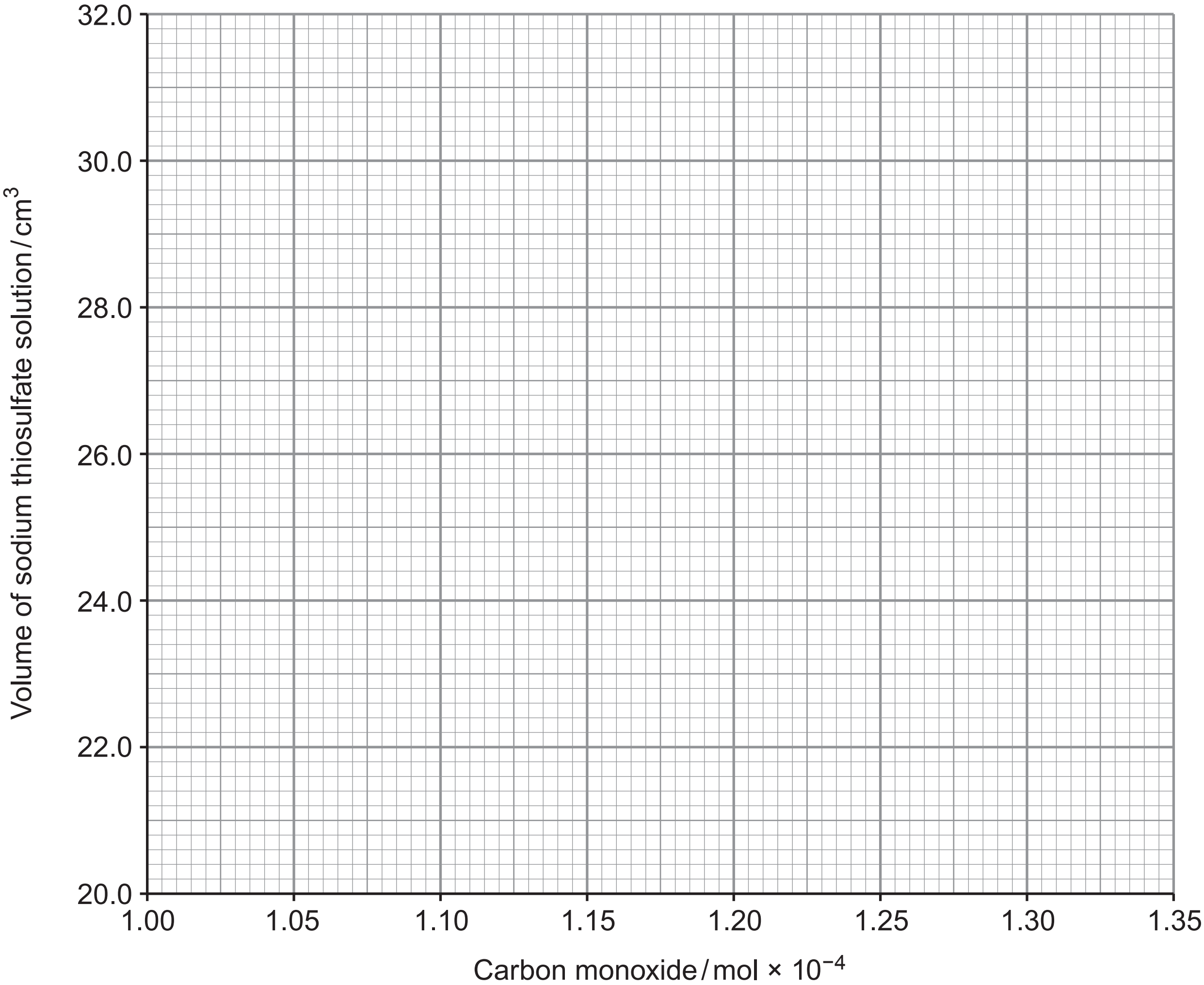
Examiner only

(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 × 10^{-4}	1.05	1.30

(i) Plot these two points on the grid provided and then join them with a straight line. [1]



Examiner only

(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 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]

....

1091
010013

Examiner only

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

Discuss how catalysts

- increase the rate of a reaction
- affect equilibrium reactions

[4]
QWC [1]

Total [16]

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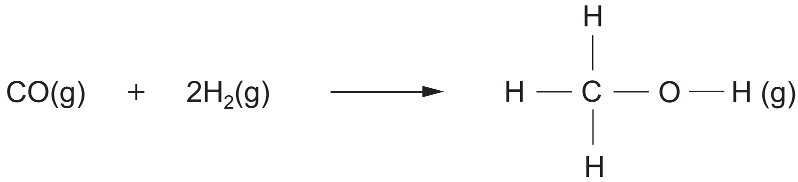
Examiner only

9. *(a)* Methanol, CH_3OH, 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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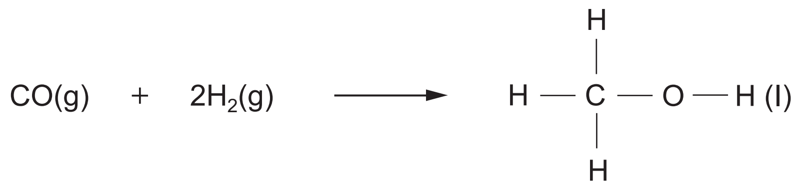
Examiner only

(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.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

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]

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Examiner only

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

$$CH_3OH(l) \quad + \quad 1\tfrac{1}{2}O_2(g) \longrightarrow CO_2(g) \quad + \quad 2H_2O(l)$$

(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

....

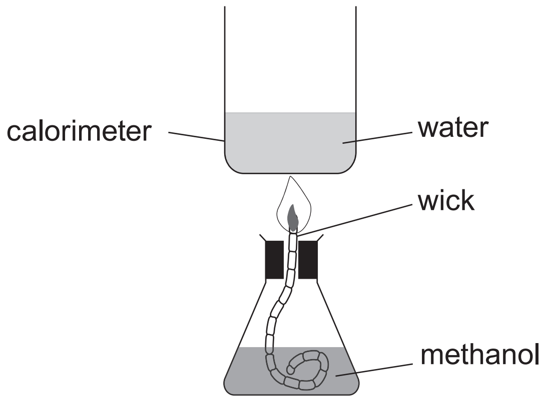
....

....

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

Examiner only

(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]

....

....

....

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

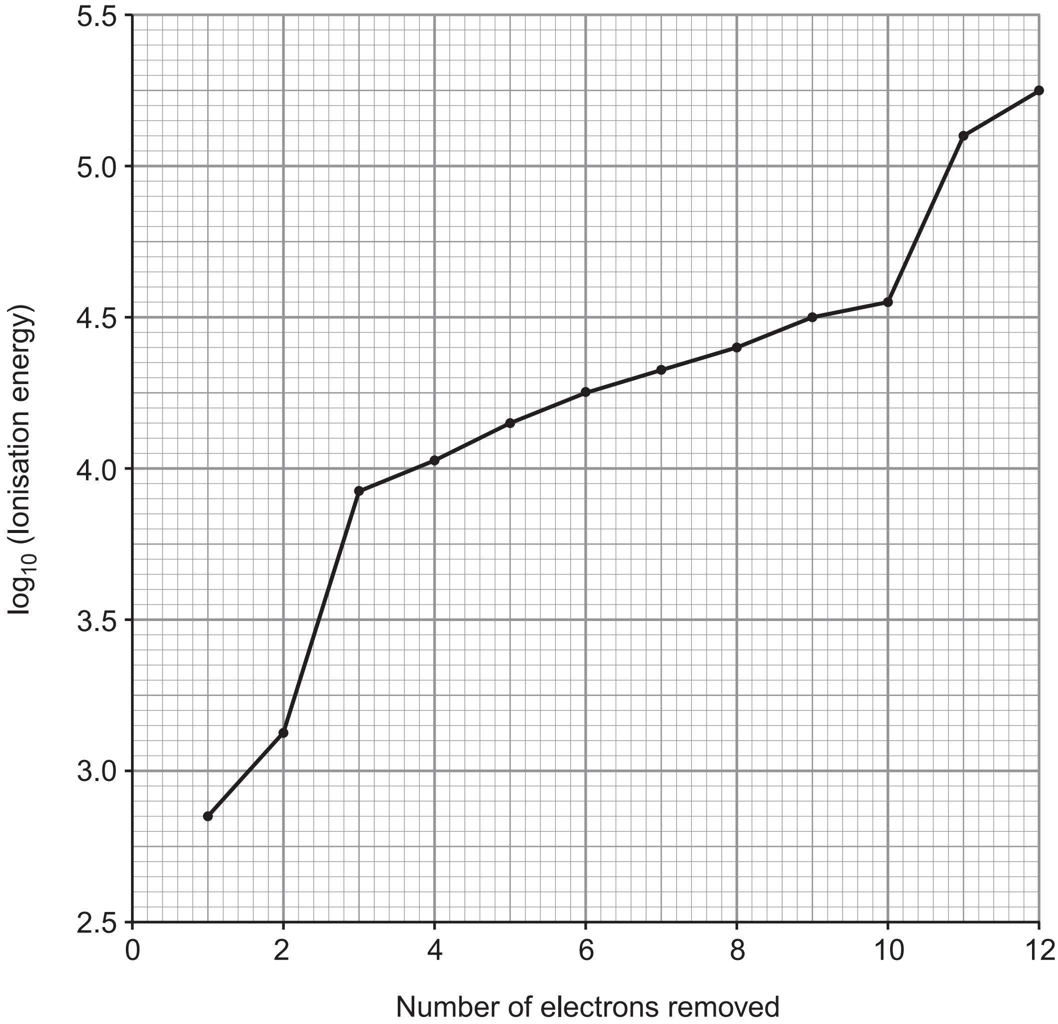
Calculate the mass of methanol burned in this experiment if the energy released by burning the methanol was 18.7 kJ. [2]

Mass of methanol = ... g

Total [13]

Examiner only

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



Examiner only

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]

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Examiner only

(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, $Sr(OH)_2$, and hydrogen.

$$Sr + 2H_2O \longrightarrow Sr(OH)_2 + H_2$$

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, $Sr(OH)_2.xH_2O$. On heating to 100 °C the water is lost giving anhydrous strontium hydroxide.

$$Sr(OH)_2.xH_2O(s) \longrightarrow Sr(OH)_2(s) + xH_2O(g)$$

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 $Sr(OH)_2.xH_2O$. [3]

x = ...

Examiner only

(iii) Use the information in the question to suggest another method that could be used to find the value of x in $Sr(OH)_2.xH_2O$ and how this method could be used to produce the value of x. [3]

....

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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.

$$SrCl_2(s) \rightleftharpoons Sr^{2+}(aq) + 2Cl^-(aq)$$

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]

....

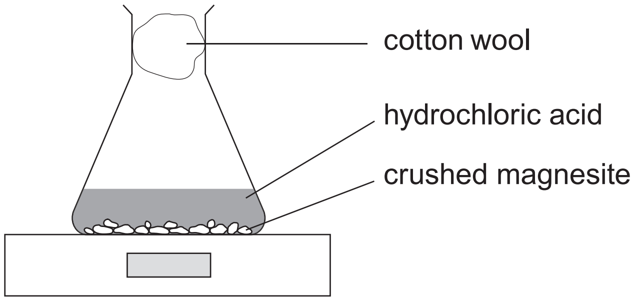
....

....

Total [15]

Examiner only

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.

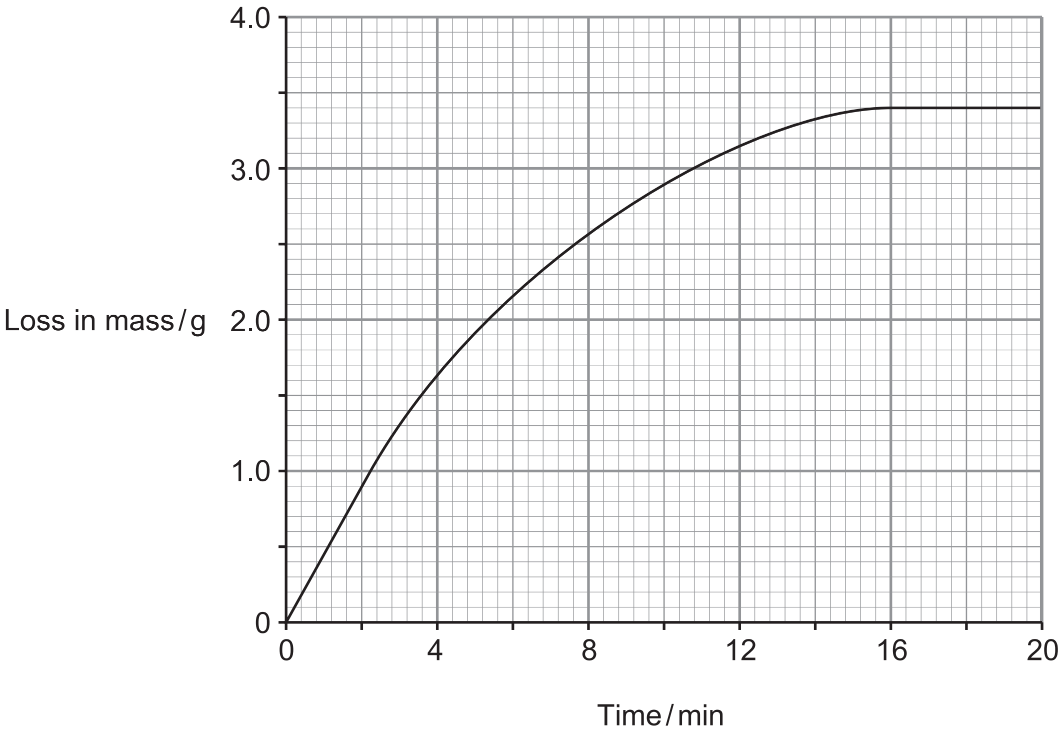
(a) Suggest why cotton wool was placed in the neck of the flask. [1]

....

....

Examiner only

(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 ....

Examiner only

(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]

....

....

....

Total [12]

Section B Total [70]

END OF PAPER

Examiner only

For continuation only.

Examiner only

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

Key: A_r (relative atomic mass) / Symbol / Name / Z (atomic number)

s Block: Groups 1–2; d Block; p Block: Groups 3–0; f Block

Period	1	2											3	4	5	6	7	0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	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
6	133 Cs Caesium 55	137 Ba Barium 56	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	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 89															

▸ 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

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.

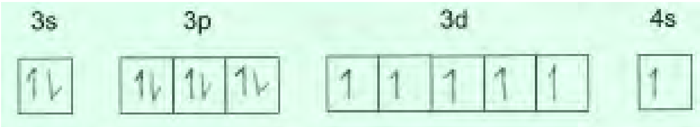
WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

GCE CHEMISTRY-CH1 (LEGACY)

SUMMER 2016 MARK SCHEME

SECTION A

1.



[1]

2. B [1]

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

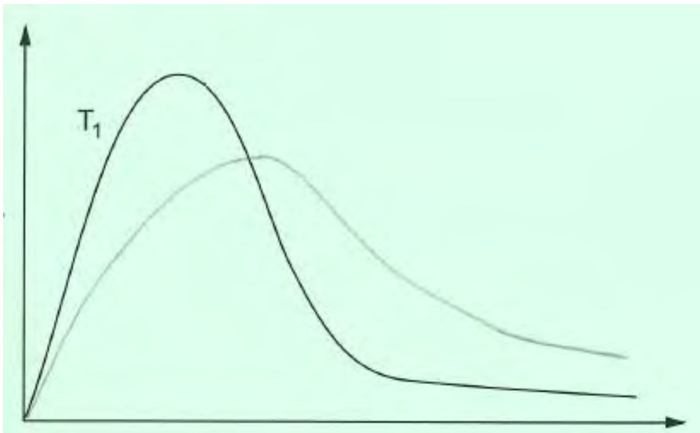
(b) 45 hours is the time of 3 half-lives and therefore 1/8 of the mass of the radioactive isotope mass is left (1)

$\therefore$ original mass = 0.15 × 8 = 1.2 (g) (1) [2]

4. The relative isotopic masses of the bromine atoms are
136 – (3 × 19) = 79 and 138 – (3 × 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.



[1]

6. (a) Temperature 298 K / 25°C

Pressure 101.3 kPa / 1.013 x 10^5 Pa / 1 atmosphere [1]

(b) 100 (kJ) [1]

Total Section A [10]

SECTION B

7. (a) $CH_2N_2O_2$ [1]

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

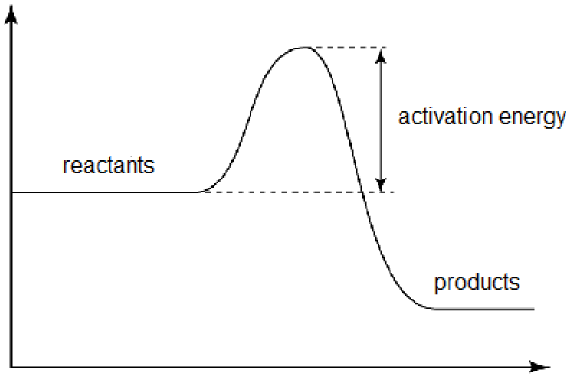
$\therefore \Delta H_d = \Delta H_2 - \Delta H_1$ (1)

$\Delta H_1 = +62$

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

$\Delta H_d = -1059 - (+62) = -1121$ (kJ mol^{-1}) (1) [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 / $H^+(aq)$ [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 $= \dfrac{25.00 \times 0.125}{1000} = 0.003125$ (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 ~7.50 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 $= 1.235 \times 10^{-4}$ (1)

$\therefore$ Volume of carbon monoxide $= 1.235 \times 10^{-4} \times 24000$

$= 2.964 / 2.97$ (1)

% of carbon monoxide in the mixture $= \dfrac{2.964 \times 100}{300} = 0.988$ (1) [3]

Accept a range from the graph of 1.230 to 1.240 $\times 10^{-4}$ moles of CO giving a % of CO in the mixture from 0.984 to 0.992

(c) $2NO + 2CO \rightarrow 2CO_2 + N_2$ [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 reacion 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 CH_2) being oxidised gives an extra 653 (kJ mol^{-1}) evolved
$\therefore$ a loss of 3 C / CH_2 will reduce the figure by 3 × 653 = 1959 (kJ mol^{-1}) (1)

$\therefore$ 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 $\frac{32.04}{680}$

$\therefore$ 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 mol H_2 from 0.0140 mol Sr
$\therefore$ A_r of strontium $= \dfrac{1.26}{0.0140} = 90.(0)$ (1) [2]

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

Moles of water $= \dfrac{6.48}{18.02} = 0.360$
Moles of $Sr(OH)_2$ $= \dfrac{5.47}{121.62} = 0.045$ (1)

Ratio 8 : 1

$\therefore x = 8$ (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 $Sr(OH)_2.\,xH_2O$ (1) and then the value of x by subtraction of the M_r of $Sr(OH)_2$ from the M_r of $Sr(OH)_2.\,xH_2O$ (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^+ / $MgCO_3$ becomes less (1)

In addition the surface area of the $MgCO_3$ reduces (as it reacts to become aqueous Mg^{2+} 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]