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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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

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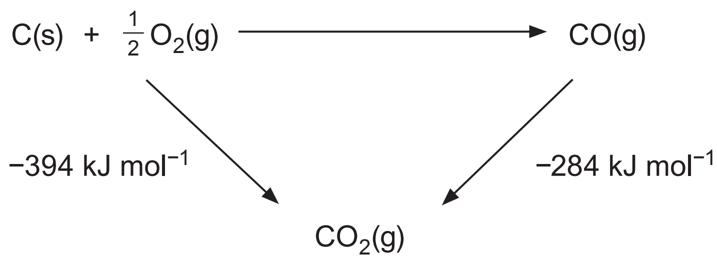
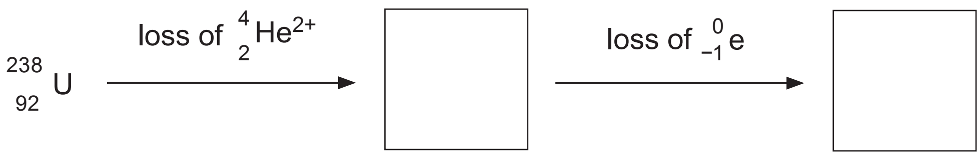
5. Use the energy cycle to calculate the enthalpy change of formation of carbon monoxide. [1]



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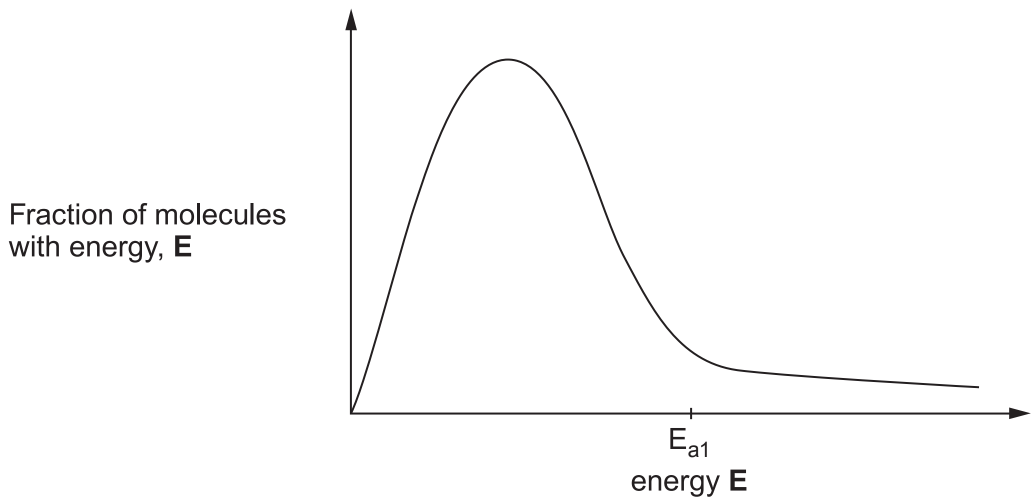
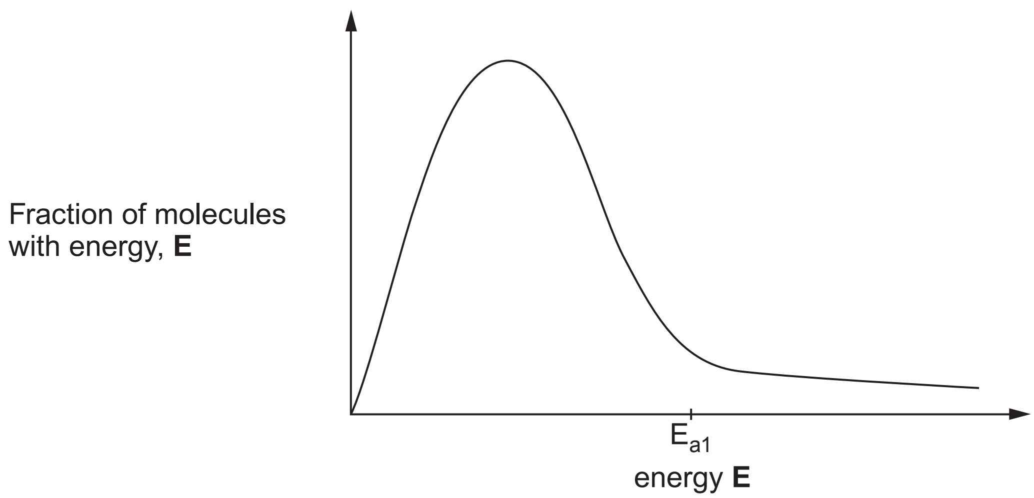
7. The diagrams show the energy distribution curve for gaseous molecules at a fixed temperature.

(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.

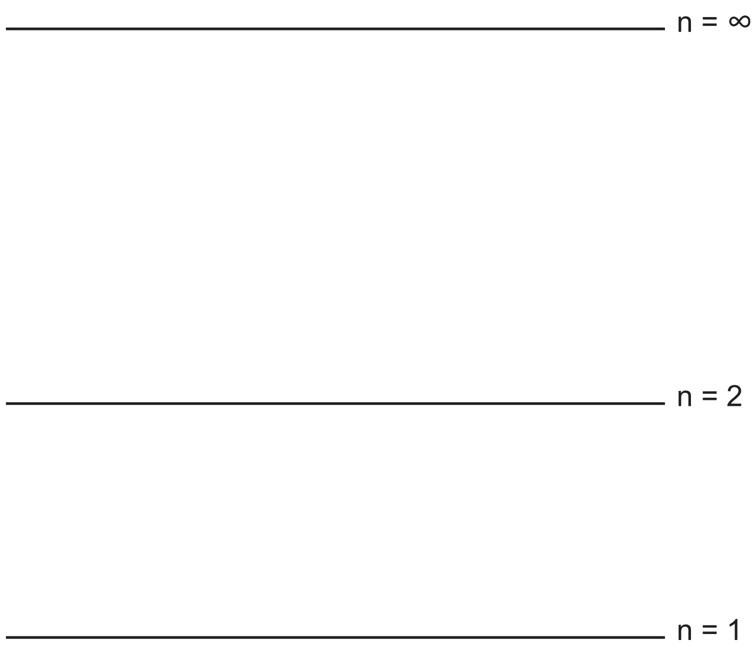
State the similarities and differences in the composition of these specific isotopes. [2]

....

....

....

(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]

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(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]

....

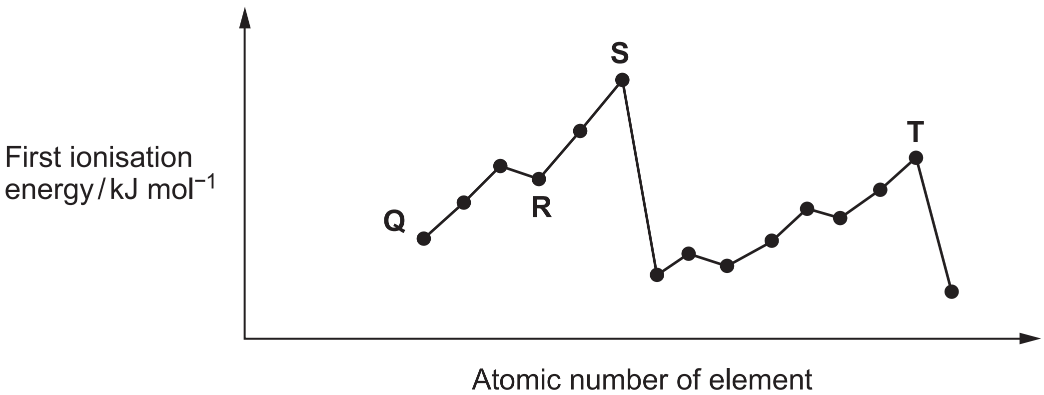
(ii) Explain whether or not this student was correct. [2]

....

....

....

(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]

....

....

....

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....

Total [14]

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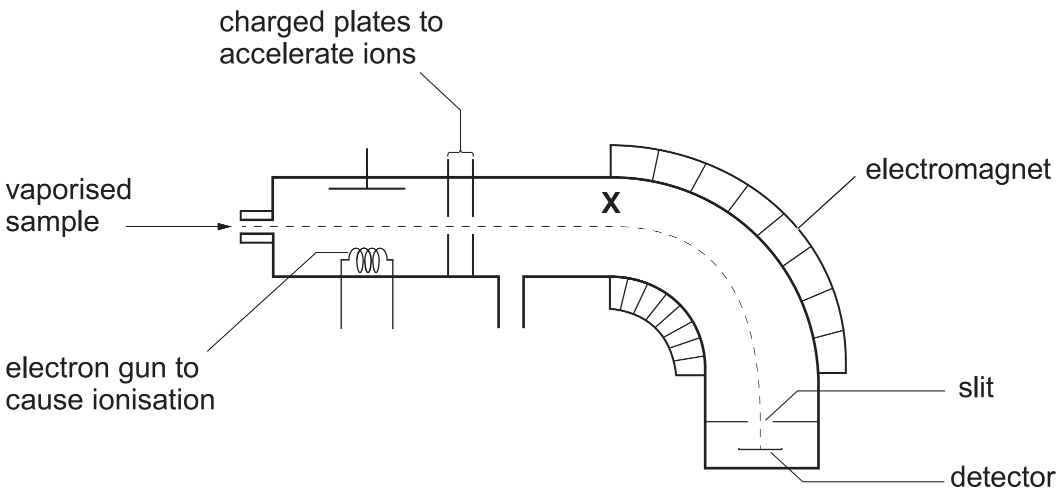
9. The diagram shows the principal parts in one type of mass spectrometer.



(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]

....

....

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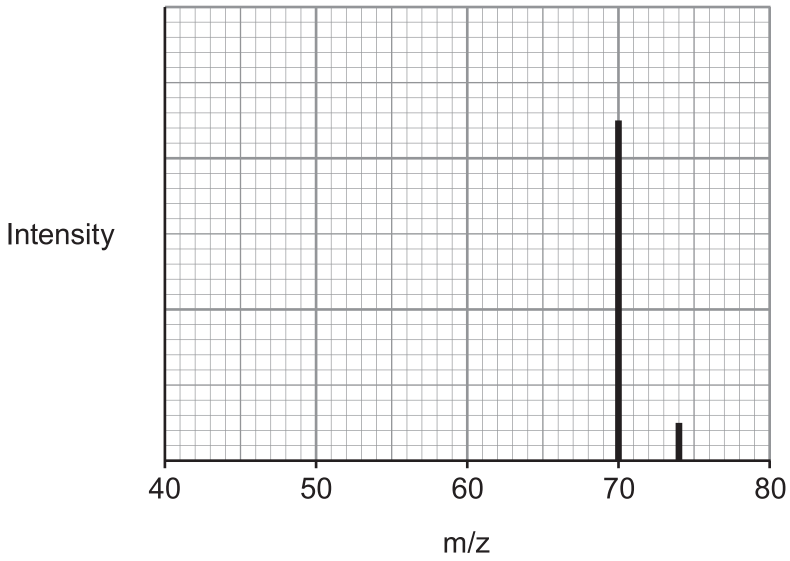
(b) The diagram shows an incomplete mass spectrum for a sample of chlorine, Cl_2.



(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]

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

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = +57 \text{ kJ mol}^{-1}$$

pale yellow — dark brown

(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]

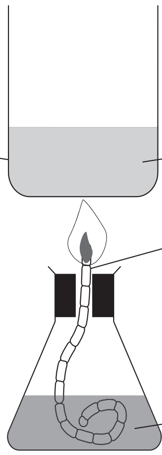
....

....

(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]

....

....

....

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(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]

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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]

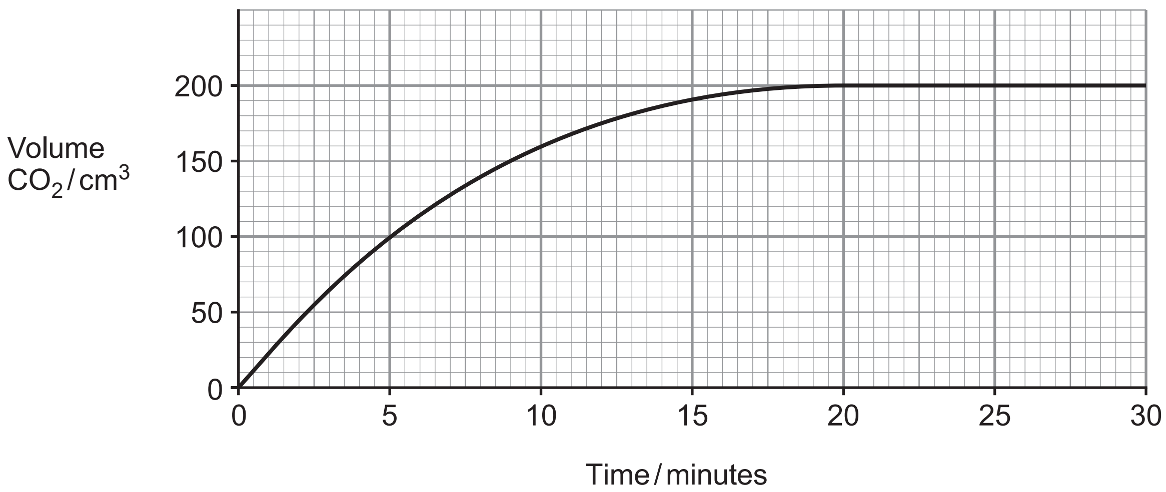
....

....

(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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....

Examiner only

(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]

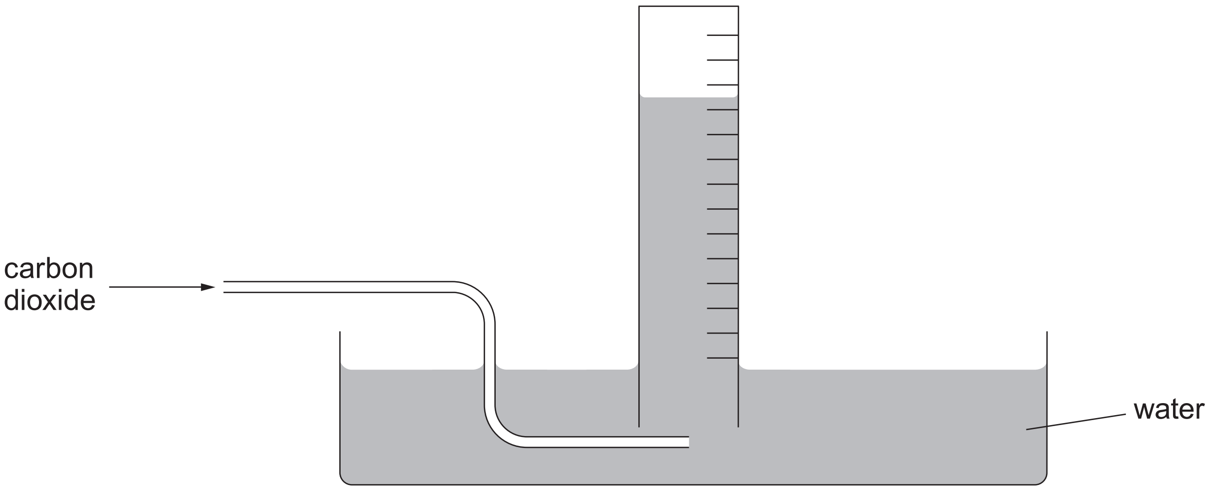
Number of moles $MgCO_3$ = ... mol

(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.

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Turn over.

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

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 (relative atomic mass) Symbol Name Z (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