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.

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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]

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

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

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

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.

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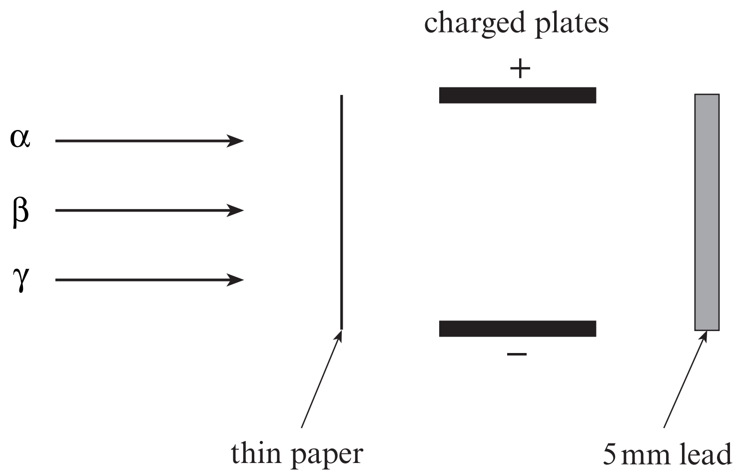
4. Complete the diagram below to show how radiation is affected by an electric field and by materials of different thickness. [3]



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%.

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

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

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Section A Total [10]

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SECTION B

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

6. Potassium metal was discovered in 1807 by the British chemist Sir Humphrey Davy. Its name derives from the word 'potash' since potassium was isolated by the electrolysis of molten caustic potash, KOH.

(a) The mass spectrum of a naturally occurring sample of potassium gave the following results.

Isotope	% abundance
^{39}K	93.26
^{40}K	0.012
^{41}K	6.730

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

(i) Explain the term *relative atomic mass*. [2]

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

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(b) The mass spectrum which provided these results was produced by potassium ions in a mass spectrometer.

(i) State how potassium ions are formed in a mass spectrometer. [1]

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

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

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(ii) Calculate how long it will take for the activity of the isotope to decay to ⅛th of its original activity. [1]

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(d) The first and second ionisation energies of potassium and sodium are shown in the table below.

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

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

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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]

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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}.

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

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

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

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(c) Suggest a method, other than measuring the amount of carbon dioxide produced at set time intervals, that Eurig could have used to follow the rate of this reaction. [1]

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

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(ii) Calculate the **minimum** mass of calcium carbonate needed to react **completely** with this amount of acid. [2]

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(iii) Calculate the volume of carbon dioxide gas that would be produced at 25 °C. [2]
(1 mole of carbon dioxide occupies 24 dm^3 at 25 °C.)

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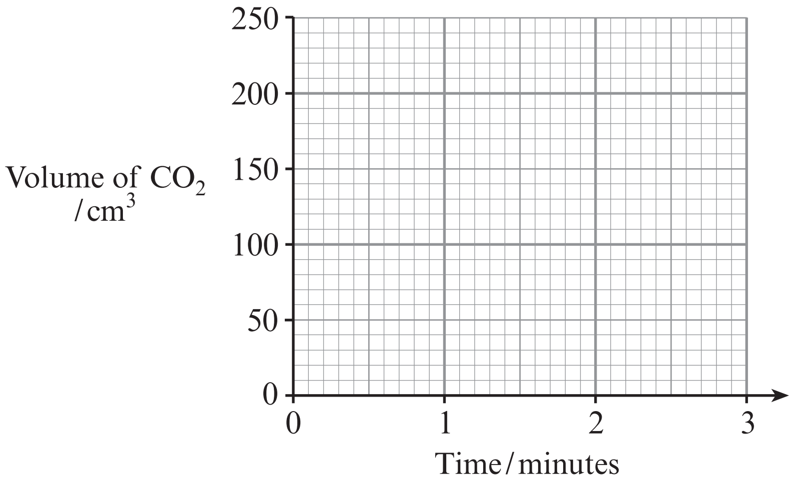
(e) Eurig repeats the experiment starting with a greater mass of calcium carbonate. He follows the rate of the reaction for 3 minutes.

He takes a number of measurements which include 150 cm^3 of carbon dioxide at 1 minute and 200 cm^3 at 2 minutes, when the reaction finishes.

(i) Sketch a curve on the grid below to show these results. Label this graph **A**. [1]



(ii) On the same grid sketch the graph that would be obtained if the experiment were repeated using hydrochloric acid of half the original concentration, keeping all other factors the same. Label this graph **B**. [2]

(iii) Explain, using simple collision theory, why the rates of these two reactions are different. [2]

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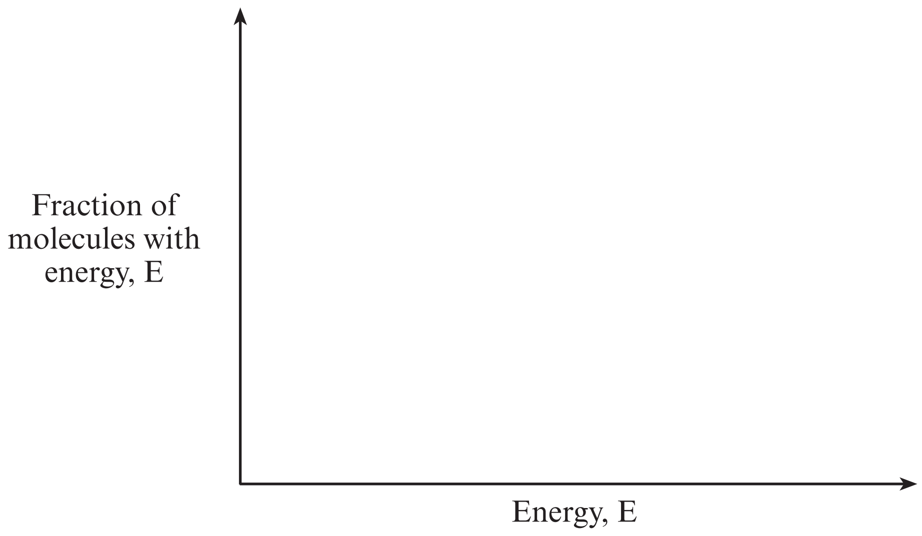
(f) With the aid of an energy distribution curve diagram, explain why raising the temperature by a small amount causes the rate of a chemical reaction to increase by a large amount. [3]
QWC [1]



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Total [17]

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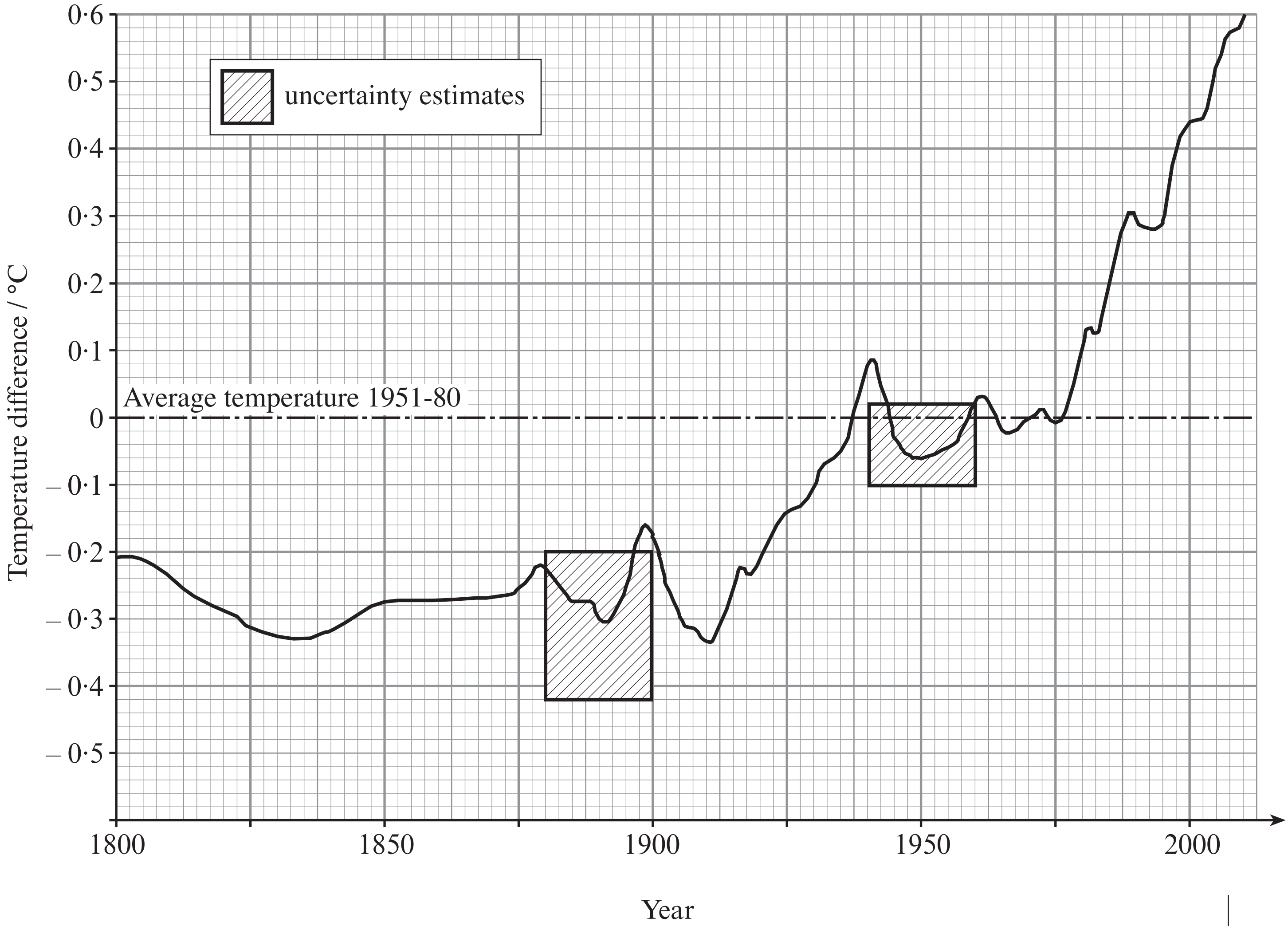
8. *(a)* During the last 200 years, the average temperature of the Earth has risen. One hypothesis put forward by many scientists is that this is due to increased concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

The table below shows the concentration of carbon dioxide in the atmosphere at 50 year intervals since 1800.

	Year				
	1800	1850	1900	1950	2000
Concentration of carbon dioxide in the atmosphere / % by volume	0.0282	0.0288	0.0297	0.0310	0.0368

The following graph based on data from NASA research, shows the annual global temperature relative to the average temperature between 1951 and 1980.

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]

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(ii) When the top is removed from a bottle of fizzy drink it goes 'flat' because much of the dissolved carbon dioxide comes out of solution.
Explain why this happens in terms of chemical equilibria. [2]
QWC [1]

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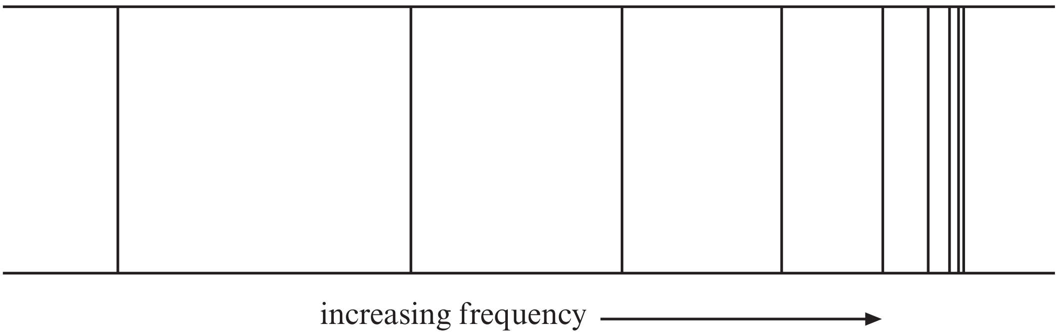
Total [12]

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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Turn over.

Examiner only

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

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

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

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(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]

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II increasing the pressure at constant temperature. [2]

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(iii) Calculate the atom economy of hydrogen production in the above reaction. [2]

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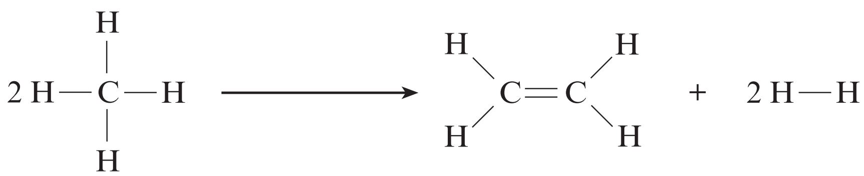
Examiner only

(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

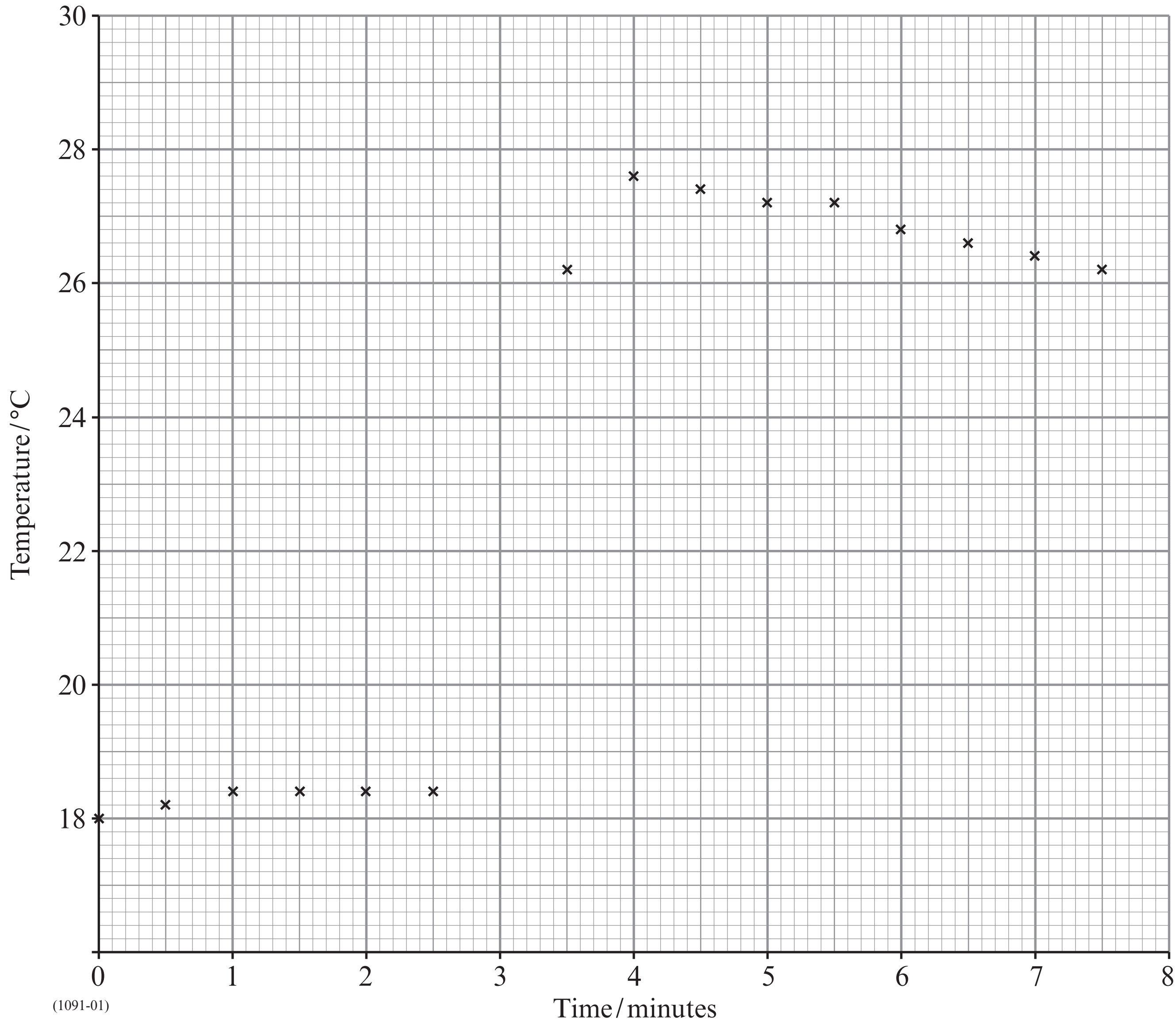
10. Lisa was asked to measure the molar enthalpy change for the reaction between magnesium and copper(II) sulfate solution.

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

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.



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

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(b) (i) Determine the maximum temperature **change** by drawing lines of best fit for both sets of points and extrapolating both lines to the third minute.

Temperature rise from the graph after extrapolation .... °C [2]

(ii) Explain why extrapolation gives a more accurate temperature change than using the maximum temperature recorded in the experiment. [1]

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(c) Use the temperature rise from the graph to calculate the amount of heat given out during **this** experiment.
(Assume that the density of the solution is $1.00\,g\,cm^{-3}$ and that its specific heat capacity is $4.18\,J\,K^{-1}\,g^{-1}$) [1]

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

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

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

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

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

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

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(i) The data book value for this molar enthalpy change is $-93.1\,kJ\,mol^{-1}$.
Express the difference between Lisa's value and this value as a percentage of the data book value. [1]
(If you do not have an answer in *(e)* assume that the molar enthalpy change is $-65\,kJ\,mol^{-1}$, although this is **not** the correct answer.)

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

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Total [15]

Section B Total [70]

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Rough Work

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