Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1091/01

CHEMISTRY CH1

P.M. FRIDAY, 13 January 2012

1½ hours

1091
010001

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

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- copy of the **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. 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.

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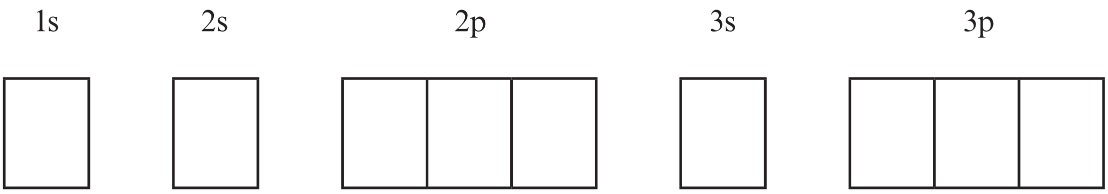
SECTION A

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 sulfur atom. [1]



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 ....

....

....

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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

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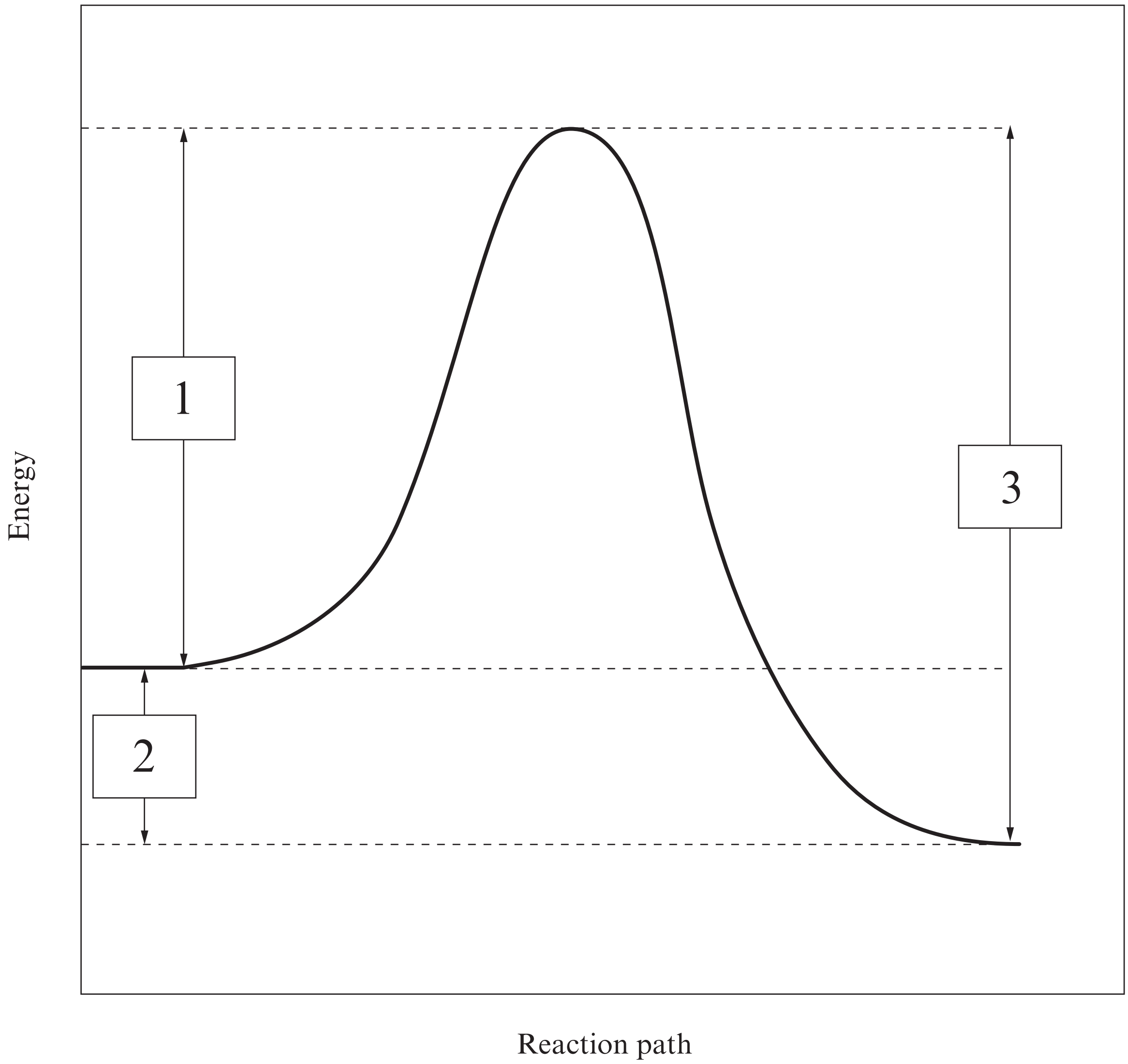
5. The diagram below shows the reaction profile for a chemical reaction. Three energy differences are marked on it with arrows labelled 1, 2 and 3.



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]

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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]

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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]

....

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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]

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(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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....

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Turn over.

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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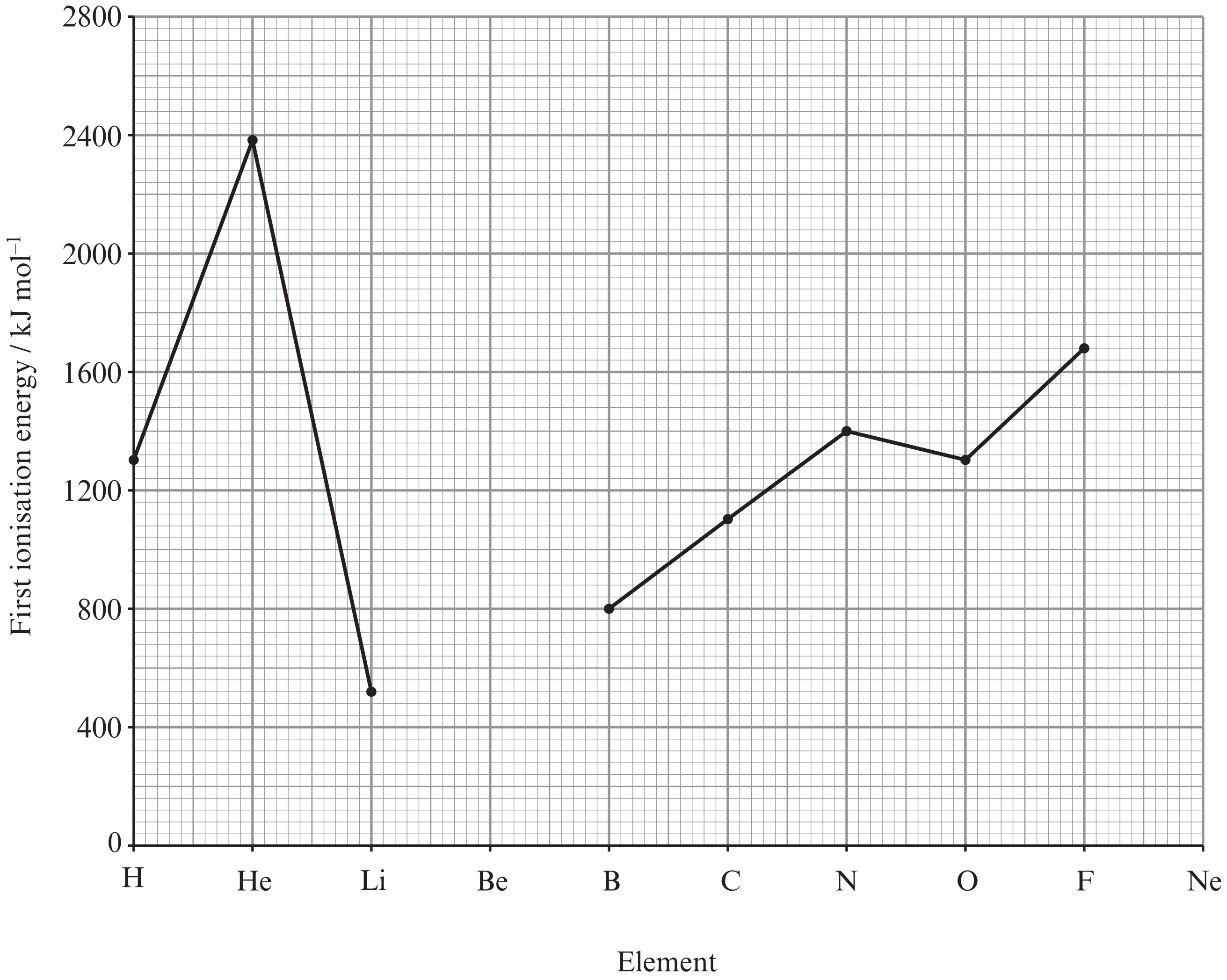
8. The graph below shows the first molar ionisation energies for a selection of the first 10 elements.



(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]

....

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(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]

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(ii) Explain how the ionisation energy of a hydrogen atom can be calculated from a feature in the atomic emission spectrum. [3]

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Total [14]

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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]

....

....

....

1 2

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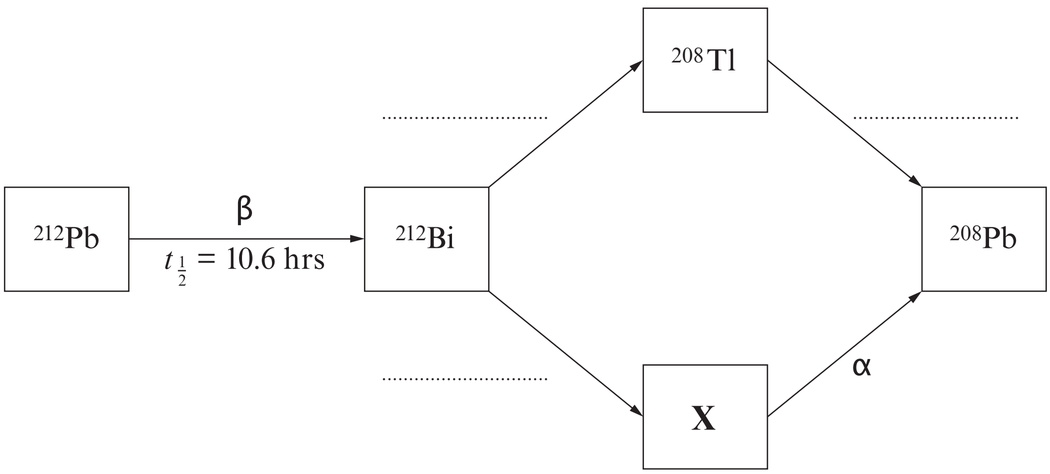
II. Atom economy is one factor used in 'Green Chemistry' to assess the advantages and disadvantages of different routes to produce the same product. State, giving a reason, which of the two alternative methods would be considered to have the more advantageous atom economy. [1]

....

....

(c) Lead has a wide range of isotopes, some of which are stable and others that are radioactive. Radioactive lead-212 decays to eventually form the stable isotope ^{208}Pb. This process involves the decay of ^{212}Pb into ^{212}Bi followed by two alternative routes that both lead to ^{208}Pb, as shown in the scheme below.



(i) Give the correct symbol and mass number of the isotope indicated by **X** on the scheme above. [2]

Symbol .... *Mass Number* ....

(ii) Two arrows have been labelled with α and β.
Label the remaining **three** arrows to indicate the nature of the radioactive decay occurring in each step. [2]

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]

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(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]

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....

Total [19]

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10. Callum and Carys wish to measure the enthalpy change of the reaction of aqueous copper(II) sulfate with zinc powder. The reaction that occurs is:

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

(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 cm^3 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 cm^3 of copper(II) sulfate solution. [5]
QWC [1]

....

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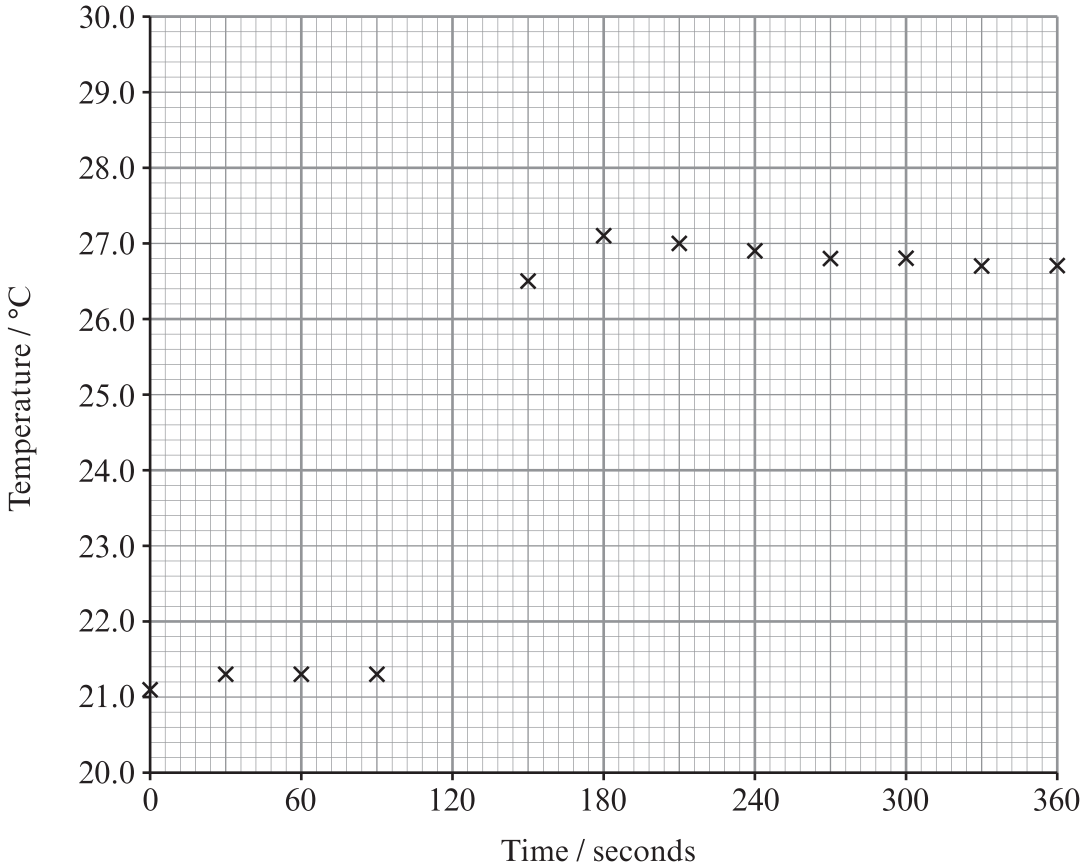
(b) In order to measure the enthalpy change, Carys carried out the reaction between zinc powder and their copper(II) sulfate solution in an insulated vessel. She measured the temperature in the vessel at 30 second intervals, before, during and after the reaction. The zinc powder was added to the copper(II) sulfate solution at 120 seconds. The temperatures recorded were plotted on the graph below.



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(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]

....

....

....

....

18

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IV. Give a reason why the sign of the enthalpy value calculated is different from the sign of the temperature change measured. [1]

....

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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)

s Block: Groups 1–2; d Block: between Group 2 and Group 3; p Block: Groups 3–0; f Block: Lanthanoid and Actinoid elements

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