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	

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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.

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.

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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

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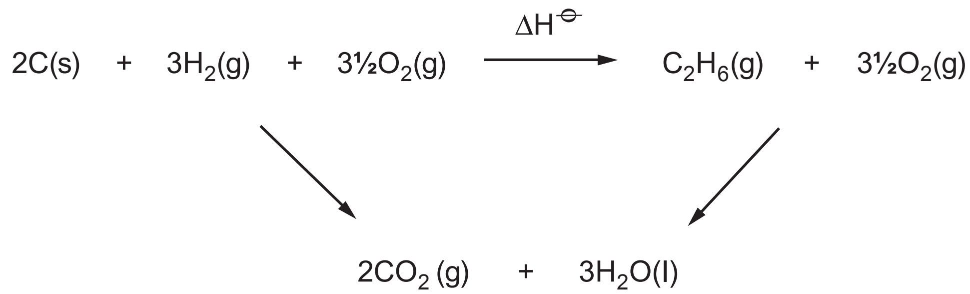
4. Study the following energy cycle.



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

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

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

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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]

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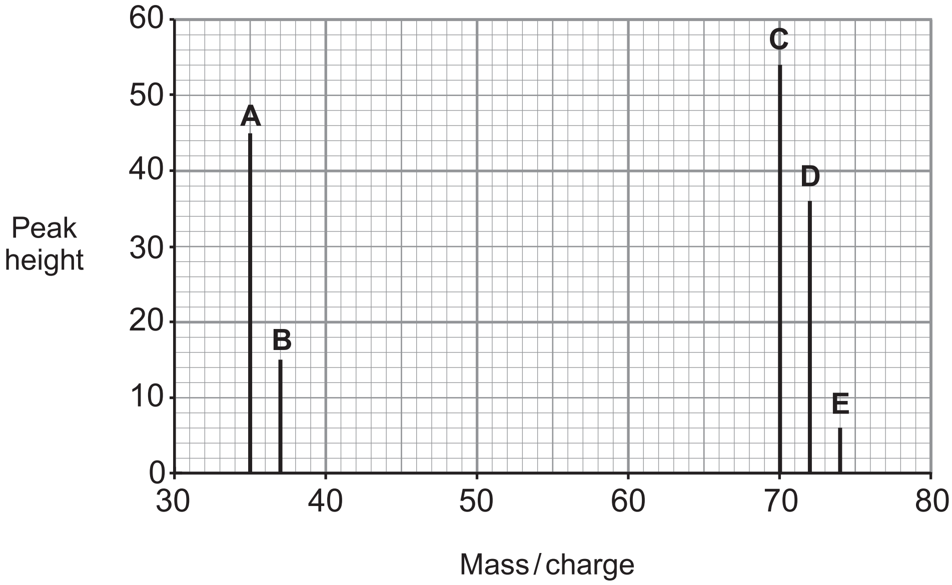
SECTION B

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

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



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

Peak **B** ....

Peak **C** ....

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

Ratio ....

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

....

....

....

....

....

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

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

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

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

Relative atomic mass = ...

Total [8]

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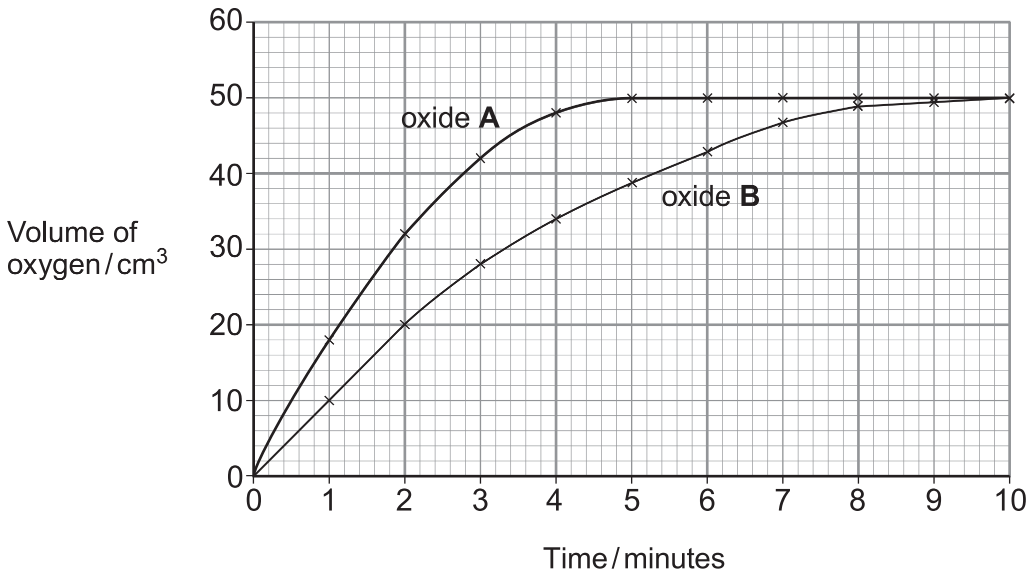
7. Oxygen can be produced in the laboratory by the decomposition of hydrogen peroxide.

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

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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(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]

....

....

....

....

....

....

Total [15]

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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]

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

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

....

....

....

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

....

....

....

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

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

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

....

....

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

....

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

....

....

....

Total [19]

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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.

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

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.

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

(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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(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]

....

....

....

....

....

....

....

....

Total [18]

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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

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(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

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CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1

A.M. THURSDAY, 9 January 2014

THE PERIODIC TABLE

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

Period	Group 1 (s Block)	Group 2 (s Block)	d Block										Group 3 (p Block)	Group 4	Group 5	Group 6	Group 7	Group 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