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.

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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]

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4. Sketch the shape of **one** *p*-orbital. [1]

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5. Name an element that has a half-filled set of *p*-orbitals. [1]

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6. Vinegar is a dilute solution of a weak acid.

(a) State what is meant by an *acid*. [1]

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(b) Suggest a pH value for vinegar. [1]

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Section A Total [10]

1091
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Turn over.

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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]

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....

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(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]

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(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]

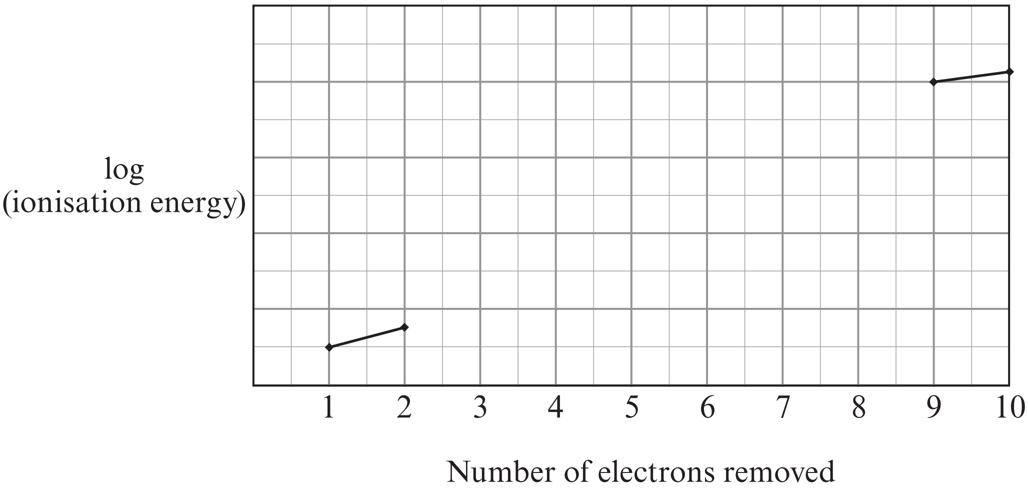
Turn over.

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]

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(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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(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]

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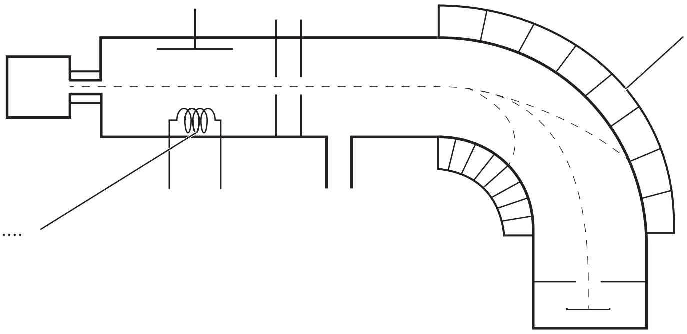
9. Selenium is a Group 6 element that is needed in the human body in trace amounts for the correct functioning of some enzymes. Only small amounts are required as large doses are harmful.

(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]

B ....



A ....

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(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 = ...

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(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. ....

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2. ....

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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}

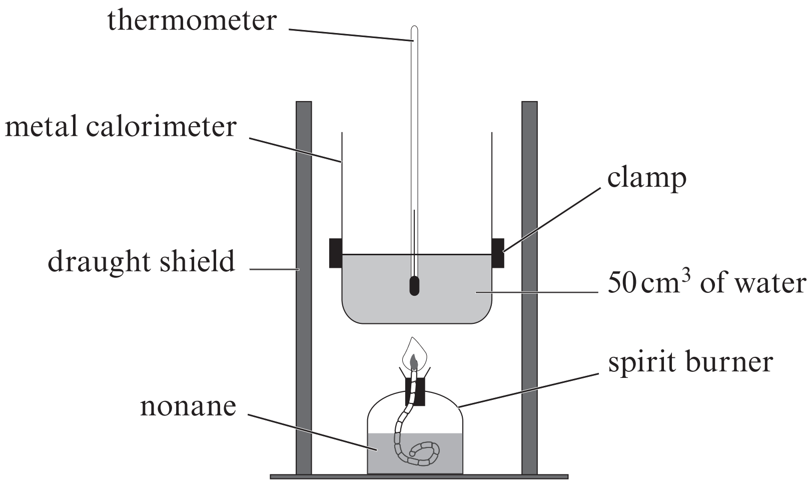
(ii) Standard enthalpy changes are measured under standard conditions. Give the standard conditions of temperature and pressure, including units for each. [2]

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

Turn over.

Examiner only

(iii) Give **one** reason why the experimental value that Iwan obtained differs from the theoretical value calculated in part *(a)*. [1]

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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]

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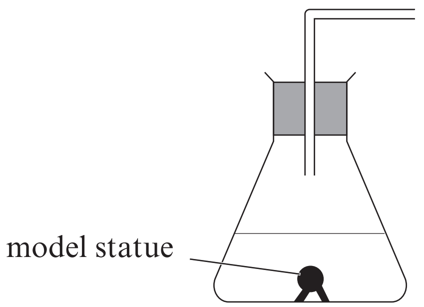
(b) A chemist is developing coatings for marble that will slow down the rate of their erosion by acid rain. To compare different coatings he uses small model statues, all of which are the same size and shape as each other. He proposes to measure the rate of reaction by adding acid and measuring the volume 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]

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(iii) State **two** other factors he will need to keep constant if he is to collect valid data. [2]

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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]

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(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]

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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]

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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. ....

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(iii) Route **B** uses a homogeneous catalyst. State what effect the catalyst will have on the position of this equilibrium. [1]

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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

CJ*(S13-1091-01A)

THE PERIODIC TABLE

Group

s Block · d Block · p 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															

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