Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education
January 2006
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY CHM1
Unit 1 Atomic Structure, Bonding and Periodicity

Wednesday 11 January 2006 9.00 am to 10.00 am

For this paper you must have
- a calculator

Time allowed: 1 hour

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in **Section A** and **Section B** in the spaces provided.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.
- The Periodic Table/Data Sheet is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

Information
- The maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- The following data may be required.
  Gas constant $R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
- Your answers to the question in **Section B** should be written in continuous prose, where appropriate.
- You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate.

Advice
- You are advised to spend about 45 minutes on **Section A** and about 15 minutes on **Section B**.

For Examiner's Use			
Number	Mark	Number	Mark
1			
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Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

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SECTION A

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

1 (a) Complete the following table.

	Relative mass	Relative charge
Neutron		
Electron		

(2 marks)

(b) An atom has twice as many protons as, and four more neutrons than, an atom of ^{9}Be. Deduce the symbol, including the mass number, of this atom.

....

(2 marks)

(c) Draw the shape of a molecule of $BeCl_2$ and the shape of a molecule of Cl_2O. Show any lone pairs of electrons on the central atom. Name the shape of each molecule.

$BeCl_2$ *Cl_2O*

Name of shape .... *Name of shape* ....

(4 marks)

(d) The equation for the reaction between magnesium hydroxide and hydrochloric acid is shown below.

$$Mg(OH)_2(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + 2H_2O(l)$$

Calculate the volume, in cm^3, of 1.00 $mol\,dm^{-3}$ hydrochloric acid required to react completely with 1.00 g of magnesium hydroxide.

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(4 marks)

12

The Periodic Table of the Elements

■ The atomic numbers and approximate relative atomic masses shown in the table are for use in the examination unless stated otherwise in an individual question.

Key

relative atomic mass	6.9
	Li Lithium
atomic number	3

I	II											III	IV	V	VI	VII	0
1.0 **H** Hydrogen 1																	4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **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
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** Sulphur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
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
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	101.1 **Ru** Ruthenium 44	102.9 **Rh** Rhodium 45	106.4 **Pd** Palladium 46	107.9 **Ag** Silver 47	112.4 **Cd** Cadmium 48	114.8 **In** Indium 49	118.7 **Sn** Tin 50	121.8 **Sb** Antimony 51	127.6 **Te** Tellurium 52	126.9 **I** Iodine 53	131.3 **Xe** Xenon 54
132.9 **Cs** Caesium 55	137.3 **Ba** Barium 56	138.9 **La** Lanthanum 57 *	178.5 **Hf** Hafnium 72	180.9 **Ta** Tantalum 73	183.9 **W** Tungsten 74	186.2 **Re** Rhenium 75	190.2 **Os** Osmium 76	192.2 **Ir** Iridium 77	195.1 **Pt** Platinum 78	197.0 **Au** Gold 79	200.6 **Hg** Mercury 80	204.4 **Tl** Thallium 81	207.2 **Pb** Lead 82	209.0 **Bi** Bismuth 83	210.0 **Po** Polonium 84	210.0 **At** Astatine 85	222.0 **Rn** Radon 86
223.0 **Fr** Francium 87	226.0 **Ra** Radium 88	227 **Ac** Actinium 89 †															

* 58 – 71 Lanthanides	140.1 **Ce** Cerium 58	140.9 **Pr** Praseodymium 59	144.2 **Nd** Neodymium 60	144.9 **Pm** Promethium 61	150.4 **Sm** Samarium 62	152.0 **Eu** Europium 63	157.3 **Gd** Gadolinium 64	158.9 **Tb** Terbium 65	162.5 **Dy** Dysprosium 66	164.9 **Ho** Holmium 67	167.3 **Er** Erbium 68	168.9 **Tm** Thulium 69	173.0 **Yb** Ytterbium 70	175.0 **Lu** Lutetium 71
† 90 – 103 Actinides	232.0 **Th** Thorium 90	231.0 **Pa** Protactinium 91	238.0 **U** Uranium 92	237.0 **Np** Neptunium 93	239.1 **Pu** Plutonium 94	243.1 **Am** Americium 95	247.1 **Cm** Curium 96	247.1 **Bk** Berkelium 97	252.1 **Cf** Californium 98	(252) **Es** Einsteinium 99	(257) **Fm** Fermium 100	(258) **Md** Mendelevium 101	(259) **No** Nobelium 102	(260) **Lr** Lawrencium 103

Table 1
Proton n.m.r chemical shift data

Type of proton	**δ/ppm**
RCH_3	0.7–1.2
R_2CH_2	1.2–1.4
R_3CH	1.4–1.6
$RCOCH_3$	2.1–2.6
$ROCH_3$	3.1–3.9
$RCOOCH_3$	3.7–4.1
ROH	0.5–5.0

Table 2
Infra-red absorption data

Bond	**Wavenumber/cm^{-1}**
C—H	2850–3300
C—C	750–1100
C═C	1620–1680
C═O	1680–1750
C—O	1000–1300
O—H (alcohols)	3230–3550
O—H (acids)	2500–3000

2 Potassium nitrate, KNO_3, decomposes on strong heating, forming oxygen and solid **Y** as the only products.

(a) A 1.00 g sample of KNO_3 (M_r = 101.1) was heated strongly until fully decomposed into **Y**.

(i) Calculate the number of moles of KNO_3 in the 1.00 g sample.

....

....

(ii) At 298 K and 100 kPa, the oxygen gas produced in this decomposition occupied a volume of 1.22×10^{-4} m^3.
State the ideal gas equation and use it to calculate the number of moles of oxygen produced in this decomposition.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

Ideal gas equation ....

Moles of oxygen ....

....

....

....

....

(5 marks)

(b) Compound **Y** contains 45.9 % of potassium and 16.5 % of nitrogen by mass, the remainder being oxygen.

(i) State what is meant by the term *empirical formula*.

....

....

(ii) Use the data above to calculate the empirical formula of **Y**.

....

....

....

(4 marks)

(c) Deduce an equation for the decomposition of KNO_3 into **Y** and oxygen.

....

(1 mark)

10

Turn over ▶

3 The table below shows the electronegativity values of some elements.

	Fluorine	Chlorine	Bromine	Iodine	Carbon	Hydrogen
Electronegativity	4.0	3.0	2.8	2.5	2.5	2.1

(a) Define the term *electronegativity*.

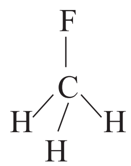
....

....

....

(2 marks)

(b) The table below shows the boiling points of fluorine, fluoromethane (CH_3F) and hydrogen fluoride.

	F—F		H—F
Boiling point / K	85	194	293

(i) Name the strongest type of intermolecular force present in:

Liquid F_2 ....

Liquid CH_3F ....

Liquid HF ....

(ii) Explain how the strongest type of intermolecular force in liquid HF arises.

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(6 marks)

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(c) The table below shows the boiling points of some other hydrogen halides.

	HCl	HBr	HI
Boiling point / K	188	206	238

(i) Explain the trend in the boiling points of the hydrogen halides from HCl to HI.

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....

....

(ii) Give **one** reason why the boiling point of HF is higher than that of all the other hydrogen halides.

....

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(3 marks)

11

Turn over for the next question

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4 (a) State the meaning of the term *first ionisation energy* of an atom.

....

....

....

(2 marks)

(b) Complete the electron arrangement for the Mg^{2+} ion.

$1s^2$ ....

(1 mark)

(c) Identify the block in the Periodic Table to which magnesium belongs.

....

(1 mark)

(d) Write an equation to illustrate the process occurring when the **second** ionisation energy of magnesium is measured.

....

(1 mark)

(e) The Ne atom and the Mg^{2+} ion have the same number of electrons. Give **two** reasons why the first ionisation energy of neon is lower than the third ionisation energy of magnesium.

Reason 1 ....

Reason 2 ....

(2 marks)

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(f) There is a general trend in the first ionisation energies of the Period 3 elements, Na – Ar

(i) State and explain this general trend.

Trend ....

Explanation ....

....

....

(ii) Explain why the first ionisation energy of sulphur is lower than would be predicted from the general trend.

....

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(5 marks)

12

Turn over for the next question

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SECTION B

Answer both questions in the space provided on pages 10–12 of this booklet.

5 A sample of element **Q** was extracted from a meteorite. The table below shows the relative abundance of each isotope in a mass spectrum of this sample of **Q**.

m/z	64	66	67	68
Relative abundance (%)	38.9	27.8	14.7	18.6

(a) Define the term *relative atomic mass* of an element. *(2 marks)*

(b) Use the data above to calculate the relative atomic mass of this sample of **Q**. Give your answer to one decimal place. Suggest the identity of **Q**. *(3 marks)*

(c) In order to obtain a mass spectrum of **Q**, a gaseous sample is first ionised. Describe how ionisation is achieved in a mass spectrometer. Give **three** reasons why ionisation is necessary. *(5 marks)*

6 Phosphorus exists in several different forms, two of which are white phosphorus and red phosphorus. White phosphorus consists of P_4 molecules, and melts at 44 °C. Red phosphorus is macromolecular, and has a melting point above 550 °C.

Explain what is meant by the term *macromolecular*. By considering the structure and bonding present in these two forms of phosphorus, explain why their melting points are so different. *(5 marks)*

END OF QUESTIONS

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