Surname		Other Names	
Centre Number			Candidate Number					
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General Certificate of Education
June 2004
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY CHM1
Unit 1 Atomic Structure, Bonding and Periodicity

Thursday 10 June 2004 Morning Session

In addition to this paper you will require:
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 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.
- Mark allocations are shown in brackets.
- This paper carries 30 per cent of the total marks for AS. For Advanced Level this paper carries 15 per cent of the total marks.
- You are expected to use a calculator where appropriate.
- The following data may be required.
  Gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$
- 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			
2			
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Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

SECTION A

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

1 (a) Complete the following table.

	Relative mass	Relative charge
Proton		
Electron		

(2 marks)

(b) An atom of element **Q** contains the same number of neutrons as are found in an atom of ^{27}Al. An atom of **Q** also contains 14 protons.

(i) Give the number of protons in an atom of ^{27}Al.

.....

(ii) Deduce the symbol, including mass number and atomic number, for this atom of element **Q**.

.....

(3 marks)

(c) Define the term *relative atomic mass* of an element.

.....

.....

(2 marks)

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.

I	II										III	IV	V	VI	VII	0
																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 †															

Key

relative atomic mass — 6.9 **Li** Lithium

atomic number — 3

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
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

* **58 – 71** Lanthanides

† **90 – 103** Actinides

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

(d) The table below gives the relative abundance of each isotope in a mass spectrum of a sample of magnesium.

m/z	24	25	26
Relative abundance (%)	73.5	10.1	16.4

Use the data above to calculate the relative atomic mass of this sample of magnesium. Give your answer to one decimal place.

.....

.....

.....

(2 marks)

(e) State how the relative molecular mass of a covalent compound is obtained from its mass spectrum.

.....

.....

(1 mark)

10

TURN OVER FOR THE NEXT QUESTION

2 (a) Sodium carbonate forms a number of hydrates of general formula $Na_2CO_3.xH_2O$
A 3.01 g sample of one of these hydrates was dissolved in water and the solution made up to 250 cm^3.
In a titration, a 25.0 cm^3 portion of this solution required 24.3 cm^3 of 0.200 mol dm^{-3} hydrochloric acid for complete reaction.
The equation for this reaction is shown below.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

(i) Calculate the number of moles of HCl in 24.3 cm^3 of 0.200 mol dm^{-3} hydrochloric acid.

.....

(ii) Deduce the number of moles of Na_2CO_3 in 25.0 cm^3 of the Na_2CO_3 solution.

.....

(iii) Hence deduce the number of moles of Na_2CO_3 in the original 250 cm^3 of solution.

.....

(iv) Calculate the M_r of the hydrated sodium carbonate.

.....

.....

(5 marks)

(b) In an experiment, the M_r of a different hydrated sodium carbonate was found to be 250. Use this value to calculate the number of molecules of water of crystallisation, x, in this hydrated sodium carbonate, $Na_2CO_3.xH_2O$

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.....

(3 marks)

(c) A gas cylinder, of volume $5.00 \times 10^{-3}\,m^3$, contains 325 g of argon gas.

(i) Give the ideal gas equation.

.....

(ii) Use the ideal gas equation to calculate the pressure of the argon gas in the cylinder at a temperature of 298 K.
(The gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

.....

.....

.....

.....

(4 marks)

12

TURN OVER FOR THE NEXT QUESTION

3 The values of the first ionisation energies of neon, sodium and magnesium are 2080, 494 and 736 kJ mol^{-1}, respectively.

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

.....

.....

.....

(2 marks)

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

.....

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(2 marks)

(c) Explain why the value of the first ionisation energy of magnesium is higher than that of sodium.

.....

.....

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(2 marks)

(d) Explain why the value of the first ionisation energy of neon is higher than that of sodium.

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.....

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(2 marks)

8

4 Lithium hydride, LiH, is an ionic compound containing the hydride ion, H^-
The reaction between LiH and aluminium chloride, $AlCl_3$, produces the ionic compound $LiAlH_4$

(a) Balance the equation below which represents the reaction between LiH and $AlCl_3$

$$\_\,LiH + \_\,AlCl_3 \rightarrow \_\,LiAlH_4 + \_\,LiCl$$

(1 mark)

(b) Give the electronic configuration of the hydride ion, H^-

.....

(1 mark)

(c) Predict the shape of the AlH_4^- ion. Explain why it has this shape.

Shape .....

Explanation .....

.....

.....

(3 marks)

(d) A bond in AlH_4^- can be represented by H→Al
Name this type of bond and explain how it is formed.

Type of bond .....

Explanation .....

.....

.....

(3 marks)

8

TURN OVER FOR THE NEXT QUESTION

5 (a) There is a trend in the reactivity of the Group II metals, Be–Ba, with water. State this trend and give the conditions under which magnesium reacts rapidly with water. Write an equation to represent this reaction.

Trend Be to Ba .....

Conditions .....

Equation .....

(3 marks)

(b) Describe what you would observe when a few drops of aqueous sodium hydroxide are added to aqueous beryllium chloride, followed by a large excess of aqueous sodium hydroxide. Write equations for the two reactions which occur.

Observation when a few drops are added .....

.....

Equation .....

Observation with excess .....

.....

Equation .....

(4 marks)

7

SECTION B

Answer the question below in the space provided on pages 11 to 16 of this booklet.

6 (a) Define the term *electronegativity* and explain why the electronegativity values of the Group II elements Be–Ba decrease down the group. *(4 marks)*

(b) Name the strongest type of intermolecular force between hydrogen fluoride molecules and draw a diagram to illustrate how two molecules of HF are attracted to each other. In your diagram show all lone pairs of electrons and any partial charges. Explain the origin of these charges.
Suggest why this strong intermolecular force is not present between HI molecules.
(7 marks)

(c) Crystals of sodium chloride and of diamond both have giant structures. Their melting points are 1074 K and 3827 K, respectively. State the type of structure present in each case and explain why the melting point of diamond is so high. *(4 marks)*

END OF QUESTIONS

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