Surname		Other Names	
Centre Number			Candidate Number								
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General Certificate of Education
June 2003
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY CHM1
Unit 1 Atomic Structure, Bonding and Periodicity

Wednesday 4 June 2003 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 $R = 8.31\,\text{J}\,\text{K}^{-1}\,\text{mol}^{-1}$
- 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			
2			
3			
4			
5			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

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
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 †															

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

SECTION A

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

1 (a) (i) Complete the electronic configuration of aluminium.

$1s^2$ .....

(ii) State the block in the Periodic Table to which aluminium belongs.

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(2 marks)

(b) Describe the bonding in metals.

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(2 marks)

(c) Explain why the melting point of magnesium is higher than that of sodium.

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(3 marks)

(d) Explain how metals conduct electricity.

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(2 marks)

9

2 (a) Give the relative charge and relative mass of an electron.

Relative charge .....

Relative mass .....

(2 marks)

(b) Isotopes of chromium include ^{54}Cr and ^{52}Cr

(i) Give the number of protons present in an atom of ^{54}Cr

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(ii) Deduce the number of neutrons present in an atom of ^{52}Cr

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(iii) Apart from the relative mass of each isotope, what else would need to be known for the relative atomic mass of chromium to be calculated?

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(3 marks)

(c) In order to obtain a mass spectrum of a gaseous sample of chromium, the sample must first be ionised.

(i) Give **two** reasons why it is necessary to ionise the chromium atoms in the sample.

Reason 1 .....

Reason 2 .....

(ii) State what is adjusted so that each of the isotopes of chromium can be detected in turn.

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(iii) Explain how the adjustment given in part (c)(ii) enables the isotopes of chromium to be separated.

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(4 marks)

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

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(ii) A chromium compound contains 28.4% of sodium and 32.1% of chromium by mass, the remainder being oxygen.
Calculate the empirical formula of this compound.

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(4 marks)

13

TURN OVER FOR THE NEXT QUESTION

3 (a) A sample of ethanol vapour, C_2H_5OH ($M_r = 46.0$), was maintained at a pressure of 100 kPa and at a temperature of 366 K.

(i) State the ideal gas equation.

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(ii) Use the ideal gas equation to calculate the volume, in cm^3, that 1.36 g of ethanol vapour would occupy under these conditions.
(The gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

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(5 marks)

(b) Magnesium nitride reacts with water to form magnesium hydroxide and ammonia.

(i) Balance the equation, given below, for the reaction between magnesium nitride and water.

$$Mg_3N_2 + H_2O \rightarrow Mg(OH)_2 + NH_3$$

(ii) Calculate the number of moles, and hence the number of molecules, of NH_3 in 0.263 g of ammonia gas.
(The Avogadro constant $L = 6.02 \times 10^{23}\ mol^{-1}$)

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(4 marks)

(c) Sodium carbonate is manufactured in a two-stage process as shown by the equations below.

$$NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$$

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

Calculate the maximum mass of sodium carbonate which could be obtained from 800 g of sodium chloride.

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(4 marks)

13

TURN OVER FOR THE NEXT QUESTION

4 (a) Both HF and HCl are molecules having a polar covalent bond. Their boiling points are 293 K and 188 K respectively.

(i) State which property of the atoms involved causes a bond to be polar.

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(ii) Explain, in terms of the intermolecular forces present in each compound, why HF has a higher boiling point than HCl.

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(4 marks)

(b) When aluminium chloride reacts with chloride ions, as shown by the equation below, a co-ordinate bond is formed.

$$AlCl_3 + Cl^- \rightarrow AlCl_4^-$$

Explain how this co-ordinate bond is formed.

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(2 marks)

(c) Draw the shape of the PCl_5 molecule and of the PCl_4^+ ion. State the value(s) of the bond angles.

PCl_5 PCl_4^+

Bond angle(s) ..... *Bond angle(s)* .....

(4 marks)

10

TURN OVER FOR THE NEXT QUESTION

SECTION B

Answer the question below in the space provided on pages 12 to 16 of this booklet.

5 (a) The table below gives the melting point for each of the Period 3 elements Na – Ar.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Melting point / K	371	923	933	1680	317	392	172	84

In terms of structure and bonding, explain why silicon has a high melting point, and why the melting point of sulphur is higher than that of phosphorus. *(7 marks)*

(b) Draw a diagram to show the structure of sodium chloride. Explain, in terms of bonding, why sodium chloride has a high melting point. *(4 marks)*

(c) Give the conditions under which, if at all, beryllium and magnesium react with water. For any reaction that occurs, state **one** observation you would make and write an equation. *(4 marks)*

END OF QUESTIONS

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