Surname		Other Names	
Centre Number			Candidate Number					
Candidate Signature								

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General Certificate of Education
January 2005
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY CHM1
Unit 1 Atomic Structure, Bonding and Periodicity

Tuesday 11 January 2005 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 $R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
- 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			

SECTION A

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

1 (a) Define the terms

(i) *mass number* of an atom,

.....

(ii) *relative molecular mass*.

.....

.....

(3 marks)

(b) (i) Complete the electron arrangement for a copper atom.

$1s^2$ .....

(ii) Identify the block in the Periodic Table to which copper belongs.

.....

(iii) Deduce the number of neutrons in one atom of ^{65}Cu

.....

(3 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
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

(c) A sample of copper contains the two isotopes ^{63}Cu and ^{65}Cu only. It has a relative atomic mass, A_r, less than 64. The mass spectrum of this sample shows major peaks with *m/z* values of 63 and 65, respectively.

(i) Explain why the A_r of this sample is less than 64.

.....

(ii) Explain how Cu atoms are converted into Cu^+ ions in a mass spectrometer.

.....

.....

(iii) In addition to the major peaks at *m/z* = 63 and 65, much smaller peaks at *m/z* = 31.5 and 32.5 are also present in the mass spectrum. Identify the ion responsible for the peak at *m/z* = 31.5 in the mass spectrum. Explain why your chosen ion has this *m/z* value and suggest **one** reason why this peak is very small.

Identity of the ion .....

Explanation for m/z value .....

.....

Reason why this peak is very small .....

.....

(6 marks)

12

TURN OVER FOR THE NEXT QUESTION

2 (a) Ammonium sulphate reacts with aqueous sodium hydroxide as shown by the equation below.

$$(NH_4)_2SO_4 + 2NaOH \longrightarrow 2NH_3 + Na_2SO_4 + 2H_2O$$

A sample of ammonium sulphate was heated with 100 cm^3 of 0.500 mol dm^{-3} aqueous sodium hydroxide. To ensure that all the ammonium sulphate reacted, an excess of sodium hydroxide was used.
Heating was continued until all of the ammonia had been driven off as a gas.
The unreacted sodium hydroxide remaining in the solution required 27.3 cm^3 of 0.600 mol dm^{-3} hydrochloric acid for neutralisation.

(i) Calculate the original number of moles of NaOH in 100 cm^3 of 0.500 mol dm^{-3} aqueous sodium hydroxide.

.....

.....

(ii) Calculate the number of moles of HCl in 27.3 cm^3 of 0.600 mol dm^{-3} hydrochloric acid.

.....

.....

(iii) Deduce the number of moles of the unreacted NaOH neutralised by the hydrochloric acid.

.....

(iv) Use your answers from parts (a)(i) and (a)(iii) to calculate the number of moles of NaOH which reacted with the ammonium sulphate.

.....

.....

(v) Use your answer in part (a)(iv) to calculate the number of moles and the mass of ammonium sulphate in the sample.
(If you have been unable to obtain an answer to part (a)(iv), you may assume that the number of moles of NaOH which reacted with ammonium sulphate equals 2.78×10^{-2} mol. This is not the correct answer.)

Moles of ammonium sulphate .....

.....

Mass of ammonium sulphate .....

.....

(7 marks)

(b) A 0.143 g gaseous sample of ammonia occupied a volume of 2.86×10^{-4} m^3 at a temperature ***T*** and a pressure of 100 kPa.

State the ideal gas equation, calculate the number of moles of ammonia present and deduce the value of the temperature ***T***.
(The gas constant $R = 8.31$ J K^{-1} mol^{-1})

Ideal gas equation .....

Moles of ammonia .....

.....

*Value of **T*** .....

.....

.....

.....

.....

(4 marks)

11

TURN OVER FOR THE NEXT QUESTION

3 (a) Magnesium and chlorine react together to form the ionic compound magnesium chloride, $MgCl_2$.

(i) Explain how each of the ions in this compound is formed.

.....

.....

(ii) Explain why compounds with ionic bonding tend to have high melting points.

.....

.....

(4 marks)

(b) (i) Define the term *electronegativity*.

.....

.....

(ii) Explain why electronegativity increases across a period in the Periodic Table.

.....

.....

.....

(4 marks)

(c) Chloride ions are polarised more by aluminium ions than they are by magnesium ions.

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

.....

.....

(ii) Why is a chloride ion polarised more by an aluminium ion than by a magnesium ion?

.....

.....

(iii) Predict the type of bonding in aluminium chloride.

.....

(5 marks)

4 (a) Ammonia, NH_3, reacts with sodium to form sodium amide, $NaNH_2$, and hydrogen.

(i) Write an equation for the reaction between ammonia and sodium.

.....

(ii) Draw the shape of an ammonia molecule and that of an amide ion, NH_2^-
In each case show any lone pairs of electrons.

NH_3 NH_2^-

(iii) State the bond angle found in an ammonia molecule.

.....

(iv) Explain why the bond angle in an amide ion is smaller than that in an ammonia molecule.

.....

.....

.....

(6 marks)

(b) A salt, **X**, contains 16.2 % by mass of magnesium, 18.9 % by mass of nitrogen and 64.9 % by mass of oxygen.

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

.....

.....

(ii) Determine the empirical formula of **X**.

.....

.....

.....

.....

(3 marks)

Turn over ▶

SECTION B

Answer the question below in the space provided on pages 10 to 12 of this booklet.

5 (a) Iodine and diamond are both crystalline solids at room temperature. Identify one similarity in the bonding, and one difference in the structures, of these two solids. Explain why these two solids have very different melting points.

(6 marks)

(b) (i) For the elements Mg–Ba, state how the solubilities of the hydroxides and the solubilities of the sulphates change down Group II.

(ii) Describe a test to show the presence of sulphate ions in an aqueous solution. Give the results of this test when performed on separate aqueous solutions of magnesium chloride and magnesium sulphate. Write equations for any reactions occurring.

(iii) State the trend in the reactivity of the Group II elements Mg–Ba with water. Write an equation for the reaction of barium with water.

(9 marks)

END OF QUESTIONS

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