Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
June 2007
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY **CHM1**
Unit 1 Atomic Structure, Bonding and Periodicity

Wednesday 6 June 2007 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 to be 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.
- Your answers to the questions 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			
Question	Mark	Question	Mark
1			
2			
3			
4			
5			
6			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

SECTION A

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

1 (a) State and explain the trend in the atomic radius of the elements Na to Cl in Period 3.

Trend .....

Explanation .....

.....

.....

(3 marks)

(b) The table below gives the values of the first three ionisation energies of magnesium.

	First ionisation energy	Second ionisation energy	Third ionisation energy
Ionisation energy / kJ mol^{-1}	738	1451	7733

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

.....

(ii) Explain why the third ionisation energy of magnesium is very much larger than the second ionisation energy of magnesium.

.....

.....

.....

(iii) State and explain the trend in the first ionisation energy of the elements Mg to Ba in Group II.

Trend .....

Explanation .....

.....

.....

(6 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

Gas constant $R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$

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) There is a trend in the reactivity of the Group II metals with H_2O. State the conditions needed for Mg and Ca to react rapidly with H_2O. Write an equation for each of these reactions.

Conditions for Mg .....

Equation .....

Conditions for Ca .....

Equation .....

(4 marks)

13

Turn over for the next question

2 (a) Ammonium carbamate contains 15.38 % of carbon, 7.69 % of hydrogen, 35.90 % of nitrogen and 41.03 % of oxygen by mass.

Use these data to confirm that the empirical formula of ammonium carbamate is $CH_6N_2O_2$

.....

.....

.....

.....

(2 marks)

(b) When heated, ammonium carbamate, $H_2NCOONH_4$, decomposes as shown below.

$$H_2NCOONH_4(s) \longrightarrow 2NH_3(g) + CO_2(g)$$

In a closed container, a 7.50 g sample of ammonium carbamate was heated. The solid decomposed completely into ammonia and carbon dioxide at 473 K and 98.7 kPa.

(i) Calculate the number of moles of ammonium carbamate used and the total number of moles of gas produced.

Moles of ammonium carbamate used .....

.....

Total moles of gas produced .....

.....

(ii) State the ideal gas equation and use it, together with your answer from part (b)(i), to calculate the total volume of gas produced at 473 K and 98.7 kPa. Include units in your final answer.
(The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$)

(If you have been unable to obtain an answer to part (b)(i), you should assume that the total number of moles of gas produced is 0.253 mol. This is not the correct answer.)

Ideal gas equation .....

Calculation .....

.....

.....

.....

(7 marks)

9

3 (a) Balance the equation below, in which nitric acid is formed by the reaction between dinitrogen tetroxide and water.

$$\ldots\ldots N_2O_4 + \ldots\ldots H_2O \longrightarrow \ldots\ldots HNO_3 + \ldots\ldots NO$$

(1 mark)

(b) A 150 cm^3 sample of 1.65 mol dm^{-3} aqueous nitric acid was completely reacted with copper. The equation for the reaction which occurred is shown below.

$$3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

(i) Calculate the number of moles of nitric acid in 150 cm^3 of 1.65 mol dm^{-3} aqueous nitric acid.

.....

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(ii) Calculate the number of moles, and hence the mass, of copper that would react completely with this amount of nitric acid.

(If you have been unable to obtain an answer to part (b)(i), you should assume that the total number of moles of nitric acid is 0.172. This is not the correct answer.)

Moles of copper .....

.....

.....

Mass of copper .....

.....

(5 marks)

6

Turn over for the next question

4 Molecules of NH_3, H_2O and HF contain covalent bonds. The bonds in these molecules are polar.

(a) State what is meant by a *covalent bond* and by a *polar bond*.

Covalent bond .....

.....

Polar bond .....

.....

(2 marks)

(b) (i) Explain why the H–F bond is polar.

.....

.....

.....

(ii) State which one of the molecules NH_3, H_2O or HF contains the least polar bond.

.....

(iii) Explain why the bond in your chosen molecule from part (b)(ii) is less polar than the bonds found in the other two molecules.

.....

.....

(4 marks)

(c) The boiling points of NH_3, H_2O and HF are all high for molecules of their size. This is due to the type of intermolecular force present in each case.

(i) Identify the type of intermolecular force responsible.

.....

(ii) Draw a diagram to show how two molecules of ammonia are attracted to each other by this type of intermolecular force. Include partial charges and all lone pairs of electrons in your diagram.

(4 marks)

(d) When an H^+ ion reacts with an NH_3 molecule, an NH_4^+ ion is formed.

(i) Give the name of the type of bond formed when an H^+ ion reacts with an NH_3 molecule. Describe how this bond is formed in the NH_4^+ ion.

Type of bond .....

Description .....

.....

.....

(ii) Draw the shape, including any lone pairs of electrons, of an NH_3 molecule and of an NH_4^+ ion.

NH_3 *NH_4^+*

(iii) Name the shape produced by the arrangement of the **atoms** in the NH_3 molecule.

.....

(iv) Give the bond angle in the NH_4^+ ion.

.....

(7 marks)

17

SECTION B

Answer questions 5 and 6 in the space provided on pages 11 and 12.

5 (a) The two isotopes normally found in a sample of nitrogen are ^{14}N and ^{15}N. Compare these two isotopes in terms of their fundamental particles. State and explain the difference, if any, in the chemical properties of these two isotopes.

(4 marks)

(b) State the block in the Periodic Table to which nitrogen belongs and explain your answer.

Give the electron arrangement of the N^{3-} ion.

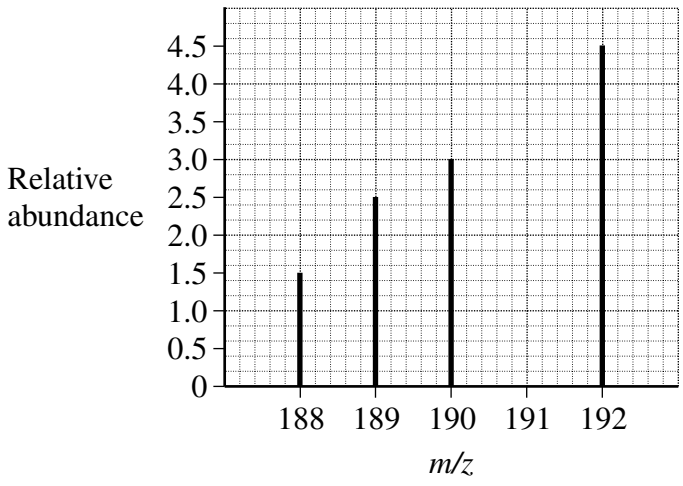
(3 marks)

6 (a) Acceleration and detection are two processes involved in obtaining the mass spectrum of a vaporised sample of a metal.

Name the other two main processes involved. In each case, identify the part of the mass spectrometer responsible for that process.

(4 marks)

(b) The diagram below shows the mass spectrum of a gaseous sample of a metal **Z**.



Use the spectrum to calculate the relative atomic mass of **Z**. Give your answer to one decimal place.

Deduce the identity of **Z**.

(4 marks)

END OF QUESTIONS