Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
January 2007
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Thursday 11 January 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.
- Write your answers to the questions in **Section B** 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			

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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 has twice as many protons and twice as many neutrons as an atom of ^{19}F Deduce the symbol, including the mass number, of this atom.

.....

(2 marks)

(c) The Al^{3+} ion and the Na^{+} ion have the same electron arrangement.

(i) Give the electron arrangement of these ions.

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(ii) Explain why more energy is needed to remove an electron from the Al^{3+} ion than from the Na^{+} ion.

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(3 marks)

(d) In a mass spectrometer, gaseous atoms are ionised. These ions are then accelerated.

(i) Explain how atoms are ionised in a mass spectrometer.

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.....

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

* **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

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

(ii) State what is used to accelerate ions in a mass spectrometer.

.....

(3 marks)

(e) The table below shows the relative abundance of each isotope in a sample of platinum.

m/z	194	195	196	198
Relative abundance (%)	32.8	30.6	25.4	11.2

Use the data in the table to calculate the relative atomic mass of this sample of platinum.
Give your answer to **one** decimal place.

.....

.....

.....

.....

(2 marks)

12

Turn over for the next question

2 (a) An acid, H_2X, reacts with sodium hydroxide as shown in the equation below.

$$H_2X(aq) + 2NaOH(aq) \longrightarrow 2Na^+(aq) + X^{2-}(aq) + 2H_2O(l)$$

A solution of this acid was prepared by dissolving 1.92 g of H_2X in water and making the volume up to 250 cm^3 in a volumetric flask.

A 25.0 cm^3 sample of this solution required 21.70 cm^3 of 0.150 mol dm^{-3} aqueous NaOH for complete reaction.

(i) Calculate the number of moles of NaOH in 21.70 cm^3 of 0.150 mol dm^{-3} aqueous NaOH

.....

(ii) Calculate the number of moles of H_2X which reacted with this amount of NaOH Hence, deduce the number of moles of H_2X in the 1.92 g sample.

Moles of H_2X in 25.0 cm^3 of solution .....

.....

Moles of H_2X in 1.92 g sample .....

.....

(iii) Calculate the relative molecular mass, M_r, of H_2X

.....

.....

.....

(5 marks)

(b) Analysis of a compound **Y** showed that it contained 49.31 % of carbon, 6.85 % of hydrogen and 43.84 % of oxygen by mass. The M_r of **Y** is 146.0

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

.....

.....

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

Empirical formula of ***Y*** .....

.....

.....

.....

Molecular formula of ***Y*** .....

.....

(4 marks)

(c) Sodium hydrogencarbonate decomposes on heating as shown in the equation below.

$$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

A sample of $NaHCO_3$ was heated until completely decomposed. The CO_2 formed in the reaction occupied a volume of 352 cm^3 at 1.00×10^5 Pa and 298 K.

(i) State the ideal gas equation and use it to calculate the number of moles of CO_2 formed in this decomposition.
(The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$)

Ideal gas equation .....

Moles of CO_2 .....

.....

.....

.....

(ii) Use your answer from part (c)(i) to calculate the mass of the $NaHCO_3$ that has decomposed.
(If you have been unable to calculate the number of moles of CO_2 in part (c)(i), you should assume this to be 0.0230 mol. This is not the correct value.)

.....

.....

.....

.....

(7 marks)

3 (a) (i) State what is meant by the term *polar* when applied to a covalent bond.

.....

.....

(ii) Consider the covalent bonds in molecules of hydrogen and of water. State whether the covalent bonds are polar or non-polar. Explain your answers.

Bonds in hydrogen .....

Bonds in water .....

Explanation .....

.....

.....

.....

(4 marks)

(b) Ammonia is very soluble in water because it is able to form hydrogen bonds with water molecules.

(i) Complete the diagram below to show how an ammonia molecule forms a hydrogen bond with a water molecule. Include partial charges and all the lone pairs of electrons.

(ii) The bond angle in a molecule of water is about 104.5°. State the bond angle in an ammonia molecule and explain why it is different from that in water.

Bond angle in ammonia .....

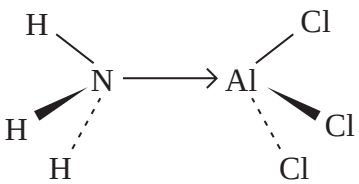
Explanation .....

.....

.....

(6 marks)

(c) Ammonia reacts with aluminium chloride to form the molecule shown below.



Name the type of bond formed between the nitrogen and aluminium atoms. Explain how this bond is formed.

Type of bond .....

Explanation .....

.....

(2 marks)

12

Turn over for the next question

4 (a) Give the formula of the least soluble hydroxide of the Group II elements Mg to Ba.

.....

(1 mark)

(b) An aqueous solution of sodium chloride may be distinguished from an aqueous solution of sodium sulphate using a simple chemical test.

(i) Identify a reagent for this test.

.....

(ii) State the observations you would expect to make if the reagent identified in part (b)(i) is added to a separate sample of each solution. Write an equation for any reaction which occurs.

Observation with sodium chloride .....

Observation with sodium sulphate .....

Equation .....

.....

(4 marks)

5

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SECTION B

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

5 Draw a diagram to show how the ions are arranged in three dimensions in a crystal of sodium chloride. Explain, in terms of bonding, why sodium chloride has a high melting point. State and explain a condition needed for sodium chloride to conduct electricity.

(6 marks)

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

(4 marks)

(b) State the meaning of the term *first ionisation energy* of an atom.
State the general trend in the first ionisation energy of the Period 3 elements Na to Ar.
Identify and explain **one** deviation from this general trend.

(5 marks)

END OF QUESTIONS

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