Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
January 2008
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Thursday 10 January 2008 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			

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SECTION A

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

1 Relative atomic mass can be determined using a mass spectrometer.

(a) Define the term *relative atomic mass*.

.....

.....

(2 marks)

(b) To obtain the mass spectrum of an element, a gaseous sample of the element must first be ionised. The ions produced are then accelerated, deflected and detected.

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

.....

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

.....

(iii) Explain how the ions are detected in a mass spectrometer.

.....

(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

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

Table 1
Proton n.m.r chemical shift data

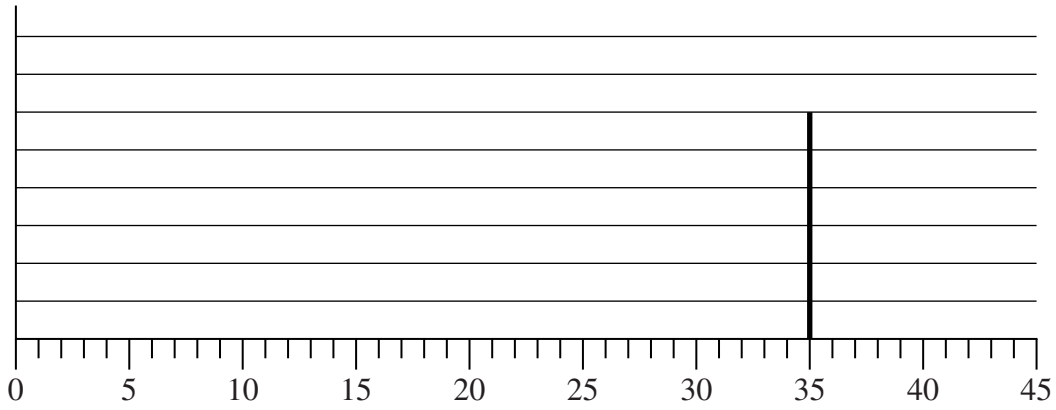
Type of proton	**δ/ppm**
RCH_3	0.7–1.2
R_2CH_2	1.2–1.4
R_3CH	1.4–1.6
$RCOCH_3$	2.1–2.6
$ROCH_3$	3.1–3.9
$RCOOCH_3$	3.7–4.1
ROH	0.5–5.0

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) A sample of chlorine was placed in a mass spectrometer. In this sample of chlorine, 75 % of the atoms were ^{35}Cl atoms and 25 % were ^{37}Cl atoms.

The mass spectrometer detected only Cl^+ ions and Cl^{2+} ions. The spectrum obtained contained four peaks. The diagram below is an incomplete spectrum, showing only the peak produced by the $^{35}Cl^+$ ions.



(i) Label both axes on the diagram.

(ii) Complete this diagram to show the remaining three peaks in the mass spectrum of the chlorine sample.

(5 marks)

10

Turn over for the next question

2 Sodium carbonate neutralises hydrochloric acid as shown in the equation below.

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

(a) Sodium carbonate is used to neutralise a 100 cm^3 sample of 1.75 mol dm^{-3} hydrochloric acid.

(i) Calculate the number of moles of HCl in the 100 cm^3 sample of 1.75 mol dm^{-3} hydrochloric acid.

.....

(ii) Deduce the number of moles, and hence calculate the mass, of Na_2CO_3 (M_r = 106.0) required to neutralise this sample of hydrochloric acid.

Moles of Na_2CO_3 .....

Mass of Na_2CO_3 .....

.....

(3 marks)

(b) Hydrated sodium carbonate has the formula $Na_2CO_3.10H_2O$

(i) Calculate the percentage, by mass, of Na_2CO_3 in hydrated sodium carbonate.

.....

.....

.....

(ii) Calculate the mass of hydrated sodium carbonate required to neutralise 0.267 mol of hydrochloric acid.

.....

.....

(4 marks)

(c) A sample of sodium carbonate reacted with hydrochloric acid to produce 7.75×10^{-2} mol of CO_2

State the ideal gas equation and use it to calculate the volume of CO_2 produced, at 298 K and 101 kPa, in this reaction.

Ideal gas equation .....

Volume of CO_2 produced .....

.....

.....

.....

.....

(4 marks)

11

Turn over for the next question

3 (a) A Period 3 element, **E**, forms an ion E^{2-} which has the electron arrangement shown below.

$$1s^2 2s^2 2p^6 3s^2 3p^6$$

Give the electron arrangement of an atom of element **E** and identify this element.

*Electron arrangement of an atom of **E*** .....

*Identity of **E*** .....

(2 marks)

(b) There is a trend in the electronegativity of the Period 3 elements Na to Cl

(i) Define the term *electronegativity*.

.....

.....

.....

(ii) State and explain the trend in the electronegativity of the Period 3 elements Na to Cl

Trend .....

Explanation .....

.....

.....

(5 marks)

(c) Some electronegativity values are given below.

	H	F	Cl	Br	I
Electronegativity value	2.1	4.0	3.0	2.8	2.5

(i) Explain why the covalent bond in HF is polar.

.....

.....

(ii) State and explain the trend in polarity of the covalent bonds in the hydrogen halides HF, HCl, HBr and HI

Trend .....

Explanation .....

.....

(3 marks)

(d) The boiling points of some hydrogen halides are shown in the table below.

Hydrogen halide	HF	HCl	HBr	HI
Boiling point / K	293	188	206	238

Explain, in terms of the intermolecular forces present, why

(i) the boiling point of HF is much higher than those of the other hydrogen halides.

.....

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.....

(ii) the boiling points increase from HCl to HI

.....

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.....

.....

(6 marks)

(e) Chloride ions are polarised by cations.

(i) State the meaning of the term *polarised* as applied to a Cl^- ion.

.....

.....

(ii) State a feature of a cation that would cause the Cl^- ion to be polarised strongly.

.....

.....

(2 marks)

18

4 A solution contains both sodium carbonate and sodium sulphate. Dilute hydrochloric acid, followed by dilute aqueous barium chloride, is added to this solution to confirm the presence of carbonate ions and sulphate ions.

(a) State what would be observed when an excess of dilute hydrochloric acid is added to this mixture. Identify the product responsible for this observation. Write an equation for the reaction which occurs.

Observation .....

.....

Product .....

Equation .....

.....

.....

(3 marks)

(b) State what would be observed when an excess of dilute aqueous barium chloride is added to the solution formed in part (a). Identify the product responsible for this observation. Write an equation for the reaction which occurs.

Observation .....

.....

Product .....

Equation .....

.....

(3 marks)

6

SECTION B

Answer **both** questions 5 and 6 in the space provided on pages 12–16.

5 (a) Explain why the shape of the NH_4^+ ion is regular tetrahedral. Explain why the bond angle in the NH_3 molecule is less than that in the NH_4^+ ion.

(4 marks)

(b) Draw the shape, including any lone pairs of electrons, of the NH_2^- ion. Name the shape produced by the arrangement of **atoms** in the NH_2^- ion.

(2 marks)

6 (a) Explain, in terms of its structure and bonding, why the melting point of silicon is very high.

(4 marks)

(b) Select any two of the Period 3 elements phosphorus, sulphur and chlorine. State and explain which of your selected elements has the higher melting point.

(5 marks)

END OF QUESTIONS

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