Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
June 2008
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Wednesday 4 June 2008 9.00 am to 10.00 am

For this paper you must have
- a calculator.

Time allowed: 1 hour

Instructions

- Use black ink or black 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. Answers written in margins or blank pages will not be marked.
- 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, in terms of protons and neutrons, the meaning of the term *isotopes*.

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(1 mark)

1 (b) The table below gives the relative abundance of each isotope in a mass spectrum of a sample of lead, Pb

m/z	204	206	207	208
Relative abundance (%)	1.5	23.6	21.4	53.5

Use these data to calculate the relative atomic mass of this sample of lead. Give your answer to **one** decimal place.

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(2 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 $R = 8.31$ J K^{-1} 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

1 (c) Lead is used in lead-acid car batteries.

1 (c) (i) Balance the equation, given below, for the overall reaction which occurs when a lead-acid battery produces a current.

$$PbO_2 + Pb + \ldots\ldots H_2SO_4 \longrightarrow \ldots\ldots PbSO_4 + \ldots\ldots H_2O$$

1 (c) (ii) State what chemical difference there will be, if any, if the lead used in the above reaction is ^{204}Pb rather than ^{206}Pb. Explain your answer.

Chemical difference .....

Explanation .....

.....

(3 marks)

1 (d) An atom has four times the number of protons, and three times the number of neutrons, as there are in the ^{7}Li atom.

Deduce the symbol, including the mass number, of this atom.

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(2 marks)

1 (e) Before deflection or detection can occur in a mass spectrometer, a sample of gaseous atoms must first be ionised.

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

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1 (e) (ii) Identify another process in a mass spectrometer, apart from deflection and detection, which depends on the sample being ionised.

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(3 marks)

11

2 (a) Oxygen may be prepared by the decomposition of hydrogen peroxide, H_2O_2, as shown in the equation below.

$$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$$

A 150 cm^3 sample of 2.72 mol dm^{-3} aqueous hydrogen peroxide was decomposed completely.

Calculate the number of moles of hydrogen peroxide in the 150 cm^3 sample and hence deduce the number of moles of oxygen gas produced.

Moles of H_2O_2 in sample .....

.....

Moles of O_2 produced .....

.....

(3 marks)

2 (b) Phosphine, PH_3, and oxygen can react to form phosphoric acid, H_3PO_4, as shown in the equation below.

$$PH_3 + 2O_2 \longrightarrow H_3PO_4$$

An excess of oxygen was mixed with 1.43 g of phosphine in a sealed container and allowed to react.

2 (b) (i) Calculate the number of moles of PH_3 in 1.43 g of phosphine.

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2 (b) (ii) Calculate the number of moles of oxygen which reacted with this amount of phosphine.

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2 (b) (iii) Calculate the mass of phosphoric acid formed in this reaction.

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(4 marks)

2 (c) After the reaction in part (b) was complete, 0.166 mol of oxygen was left unreacted. The final temperature was 300 K. The volume of the sealed container was 1725 cm^3.

State the ideal gas equation and use it to calculate the pressure of the oxygen in the container after the reaction was complete.
(The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$)

Ideal gas equation .....

Pressure .....

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(4 marks)

11

Turn over for the next question

3 (a) State the meaning of the term *first ionisation energy* of an atom.

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(2 marks)

3 (b) Explain why there is a general increase in the first ionisation energies of the Period 3 elements Na to Ar

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(2 marks)

3 (c) State how the first ionisation energy of sulphur deviates from the general trend in part (b). Explain your answer.

Deviation of sulphur from the general trend .....

Explanation .....

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(3 marks)

3 (d) (i) Draw the shape of a BF_3 molecule and the shape of a H_2S molecule. In each case show any lone pairs of electrons.

BF_3 *H_2S*

3 (d) (ii) Explain why a BF_3 molecule has the shape you have drawn.

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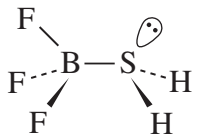
(4 marks)

3 (e) Hydrogen sulphide, H_2S, reacts with boron trifluoride, BF_3, to form compound **A**.



A

Predict the value of the H-S-H bond angle in compound **A**.

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(1 mark)

12

Turn over ▶

4 (a) State which has the larger atomic radius, a sodium atom or a chlorine atom. Explain your answer.

Atom with larger atomic radius .....

Explanation .....

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(4 marks)

4 (b) (i) Give the electron arrangement of the sodium atom.

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4 (b) (ii) State which has the larger radius, a sodium atom or a sodium ion (Na^+). Explain your answer.

Larger radius .....

Explanation .....

.....

4 (b) (iii) Suggest why a chloride ion (Cl^-) has a larger radius than a chlorine atom.

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(5 marks)

4 (c) Consider the sulphates and the hydroxides of the Group II elements Mg to Ba

4 (c) (i) Give the formula of the **least** soluble sulphate .....

4 (c) (ii) Give the formula of the **most** soluble hydroxide .....

(2 marks)

11

SECTION B

Answer **both** questions in the space provided on pages 11-16.

5 Diamond and graphite are both giant covalent (macromolecular) forms of carbon.

State how the structures of diamond and graphite are different. Briefly explain why diamond is very hard, and why graphite is able to act as a lubricant and as an electrical conductor.

(7 marks)

6 On heating, a mixture of sodium and iodine react to form sodium iodide as shown by the equation below.

$$2Na + I_2 \longrightarrow 2NaI$$

The melting points of iodine and sodium iodide are 114 °C and 662 °C respectively.

For each of the substances sodium, iodine and sodium iodide, state the type of bonding present and explain the nature of the attractive forces holding each solid together.

Briefly explain why the melting point of iodine is much lower than that of sodium iodide.

Explain, in terms of electrons, how the reaction between sodium and iodine occurs.

(8 marks)

END OF QUESTIONS

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