Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
June 2005
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY CHM1
Unit 1 Atomic Structure, Bonding and Periodicity

Wednesday 8 June 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 $R = 8.31\,J\,K^{-1}\,mol^{-1}$
- 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			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
6			
7			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

SECTION A

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

1 A sample of iron from a meteorite was found to contain the isotopes ^{54}Fe, ^{56}Fe and ^{57}Fe.

(a) The relative abundances of these isotopes can be determined using a mass spectrometer. In the mass spectrometer, the sample is first vaporised and then ionised.

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

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(ii) Explain how, in a mass spectrometer, ions are detected and how their abundance is measured.

How ions are detected .....

.....

How abundance is measured .....

.....

(5 marks)

(b) (i) Define the term *relative atomic mass* of an element.

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(ii) The relative abundances of the isotopes in this sample of iron were found to be as follows.

m/z	54	56	57
Relative abundance (%)	5.8	91.6	2.6

Use the data above to calculate the relative atomic mass of iron in this sample. Give your answer to one decimal place.

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(4 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) (i) Give the electron arrangement of an Fe^{2+} ion.

.....

(ii) State why iron is placed in the d block of the Periodic Table.

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.....

(iii) State the difference, if any, in the chemical properties of isotopes of the same element. Explain your answer.

Difference .....

Explanation .....

.....

(4 marks)

13

TURN OVER FOR THE NEXT QUESTION

2 (a) Lead(II) nitrate may be produced by the reaction between nitric acid and lead(II) oxide as shown by the equation below.

$$PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$$

An excess of lead(II) oxide was allowed to react with 175 cm^3 of 1.50 mol dm^{-3} nitric acid. Calculate the maximum mass of lead(II) nitrate which could be obtained from this reaction.

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(4 marks)

(b) An equation representing the thermal decomposition of lead(II) nitrate is shown below.

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

A sample of lead(II) nitrate was heated until the decomposition was complete. At a temperature of 500 K and a pressure of 100 kPa, the total volume of the gaseous mixture produced was found to be 1.50×10^{-4} m^3.

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

Ideal gas equation .....

Total number of moles of gas .....

.....

.....

.....

(ii) Deduce the number of moles, and the mass, of NO_2 present in this gaseous mixture. (If you have been unable to calculate the total number of moles of gas in part (b)(i), you should assume this to be 2.23×10^{-3} mol. This is not the correct answer.)

Number of moles of NO_2 .....

.....

Mass of NO_2 .....

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(7 marks)

11

TURN OVER FOR THE NEXT QUESTION

3 (a) When aluminium is added to an aqueous solution of copper(II) chloride, $CuCl_2$, copper metal and aluminium chloride, $AlCl_3$, are formed. Write an equation to represent this reaction.

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(1 mark)

(b) (i) State the general trend in the first ionisation energy of the Period 3 elements from Na to Ar.

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(ii) State how, and explain why, the first ionisation energy of aluminium does not follow this general trend.

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(4 marks)

(c) Give the equation, including state symbols, for the process which represents the second ionisation energy of aluminium.

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(1 mark)

(d) State and explain the trend in the melting points of the Period 3 metals Na, Mg and Al.

Trend .....

Explanation .....

.....

.....

(3 marks)

9

4 Phosphorus and nitrogen are in Group V of the Periodic Table and both elements form hydrides. Phosphine, PH_3, reacts to form phosphonium ions, PH_4^+, in a similar way to that by which ammonia, NH_3, forms ammonium ions, NH_4^+

(a) Give the name of the type of bond formed when phosphine reacts with an H^+ ion. Explain how this bond is formed.

Type of bond .....

Explanation .....

.....

.....

(3 marks)

(b) Draw the shapes, including any lone pairs of electrons, of a phosphine molecule and of a phosphonium ion.
Give the name of the shape of the phosphine molecule and state the bond angle found in the phosphonium ion.

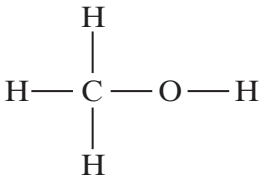
PH_3 PH_4^+

Shape of PH_3 ..... *Bond angle in PH_4^+* .....

(4 marks)

7

5 (a) Methanol has the structure



Explain why the O–H bond in a methanol molecule is polar.

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(2 marks)

(b) The boiling point of methanol is +65 °C; the boiling point of oxygen is –183 °C. Methanol and oxygen each have an M_r value of 32. Explain, in terms of the intermolecular forces present in each case, why the boiling point of methanol is much higher than that of oxygen.

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(3 marks)

5

SECTION B

Answer the questions below in the space provided on pages 11 to 16 of this booklet.

6 Diamond and graphite are both forms of carbon.
Diamond is able to scratch almost all other substances, whereas graphite may be used as a lubricant.
Diamond and graphite both have high melting points.

Explain each of these properties of diamond and graphite in terms of structure and bonding.
Give **one** other difference in the properties of diamond and graphite.

(9 marks)

7 This question concerns the chemistry of the Group II metals Mg to Ba.
An aqueous solution of a Group II metal chloride, **X**Cl_2, forms a white precipitate when dilute aqueous sodium hydroxide is added. A separate sample of the solution of **X**Cl_2 does **not** form a precipitate when dilute aqueous sodium sulphate is added.

An aqueous solution of a different Group II metal chloride, **Y**Cl_2, does **not** form a precipitate when dilute aqueous sodium hydroxide is added. A separate sample of the solution of **Y**Cl_2 forms a white precipitate when dilute aqueous sodium sulphate is added.

Suggest identities for the Group II metals **X** and **Y**. Write equations, including state symbols, for the reactions which occur.

(6 marks)

END OF QUESTIONS

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