Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
January 2009
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Friday 9 January 2009 1.30 pm to 2.30 pm

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 on blank pages will not be marked.
- Show all your working.
- 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 good English, to organise information clearly 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			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

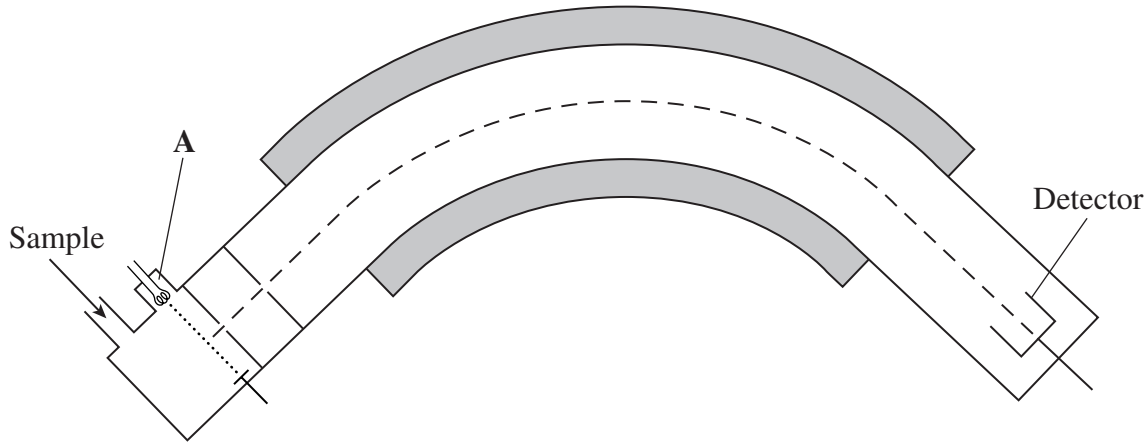
SECTION A

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

1 A sample of strontium contained the isotopes ^{84}Sr, ^{86}Sr, ^{87}Sr and ^{88}Sr

A mass spectrum of this sample of strontium was obtained.

A simplified diagram of a mass spectrometer is shown below. The line of dashes on the diagram represents the path followed by the $^{87}Sr^{+}$ ions that reach the detector.



1 (a) Identify the part of the mass spectrometer labelled **A** in the diagram.

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(1 mark)

1 (b) (i) On the diagram, draw a line to show a path which could be followed by the $^{88}Sr^{+}$ ions at the same time as the $^{87}Sr^{+}$ ions are being detected. *(1 mark)*

1 (b) (ii) Explain why the path of the $^{88}Sr^{+}$ ions you have drawn is different from that of the $^{87}Sr^{+}$ ions.

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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** Radius 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) State **one** adjustment made to the mass spectrometer to enable the $^{88}Sr^{+}$ ions to be detected. Explain your answer.

Adjustment .....

Explanation .....

.....

(2 marks)

1 (d) The table below shows the relative abundance of each isotope in this sample of strontium.

m/z	84	86	87	88
Relative abundance (%)	0.56	9.86	7.02	82.56

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

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(2 marks)

1 (e) State the block in the Periodic Table to which strontium belongs. Explain your answer.

Block .....

Explanation .....

.....

(2 marks)

10

2 Calcium carbide (CaC_2) is a solid which reacts with water to form the flammable gas ethyne (C_2H_2).

$$CaC_2(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(s) + C_2H_2(g)$$

In a 'Carbide lamp', once used by miners, water is dripped onto calcium carbide and the ethyne produced is burned to provide light.

2 (a) Write an equation for the complete combustion of ethyne to form carbon dioxide and water only.

.....

(1 mark)

2 (b) A student reacted a 1.33 g sample of impure calcium carbide with an excess of water and collected the ethyne produced in a gas syringe. The volume of ethyne collected was 3.88×10^{-4} m^3.

State the ideal gas equation and use it to calculate the number of moles of ethyne collected at 284 K and 101 kPa.
(The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$)

Ideal gas equation .....

Moles of ethyne collected .....

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(4 marks)

2 (c) Use your answer to part (b) to calculate the mass of calcium carbide (M_r = 64.1) which reacted with the water. Hence, calculate the percentage purity of the 1.33 g sample of impure calcium carbide used by the student.
(If you have been unable to obtain an answer for part (b), you should assume that the number of moles of ethyne collected was 0.0155 mol. This is not the correct value.)

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(4 marks)

2 (d) Use your knowledge of bonding to draw a diagram showing the bonding in a molecule of C_2H_2

(1 mark)

2 (e) (i) State what is meant by the term e*mpirical formula* of a compound.

.....

.....

(1 mark)

2 (e) (ii) Deduce the empirical formula of ethyne.

.....

(1 mark)

Question 2 continues on the next page

2 (f) Ethyne can be used to make compound **B** (M_r = 215.8) which contains 22.24 % carbon, 3.71 % hydrogen and 74.05 % bromine, by mass. Calculate the empirical formula of **B** and hence deduce its molecular formula.

*Empirical formula of **B*** .....

.....

.....

.....

*Molecular formula of **B*** .....

.....

(3 marks)

15

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

3 Water can exist as a solid, a liquid or a gas. In some ways, liquids are similar to solids, and in other ways they are similar to gases.

3 (a) (i) State **one** way in which the movement of particles in a liquid is different from that in a solid.

.....

.....

(1 mark)

3 (a) (ii) State **one** way in which the positioning of particles in a liquid is different from that in a gas.

.....

.....

(1 mark)

3 (b) Explain the heat energy change associated with boiling.

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(2 marks)

3 (c) The boiling points of the Group VI hydrides H_2O and H_2S are 373 K and 212 K, respectively. Water molecules form hydrogen bonds with each other but hydrogen bonding does not occur between H_2S molecules.

3 (c) (i) Define the term *electronegativity*.

.....

.....

(2 marks)

3 (c) (ii) Explain, in terms of electronegativity, why hydrogen bonds form between H_2O molecules but not between H_2S molecules.

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(2 marks)

3 (c) (iii) Explain, in terms of the intermolecular forces present, why the boiling point of H_2S is so much lower than that of H_2O

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(1 mark)

3 (c) (iv) Identify an element, other than oxygen, that when bonded to hydrogen can be involved in hydrogen bonding.

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(1 mark)

3 (d) Draw a diagram to show how **two** molecules of water are attracted to each other by hydrogen bonding. Include partial charges and all lone pairs of electrons in your diagram.

(3 marks)

13

Turn over for the next question

4 The reactive methylene molecule (CH_2) has one lone (non-bonding) pair of electrons. An H^+ ion reacts readily with a methylene molecule to produce a CH_3^+ ion.

4 (a) The methylene molecule can be represented as $:CH_2$
The equation for the reaction between H^+ and $:CH_2$ is shown below.

$$H^+ + :CH_2 \longrightarrow CH_3^+$$

Name the type of bond formed between a $:CH_2$ molecule and an H^+ ion.
Describe how this bond in the CH_3^+ ion is formed.

Type of bond .....

Description .....

.....

(2 marks)

4 (b) Draw the shape, including any lone pairs of electrons, of a CH_2 molecule and the shape of a CH_3^+ ion.

CH_2 CH_3^+

(2 marks)

4 (c) Name the shape of the CH_2 molecule and the shape of the CH_3^+ ion.

Shape of CH_2 .....

Shape of CH_3^+ .....

(2 marks)

4 (d) State the bond angle in the CH_3^+ ion.

.....

(1 mark)

7

SECTION B

Answer Question 5 in the space provided on pages 13–16.

5 There are trends in the properties of the elements, both across Periods and down Groups in the Periodic Table.

5 (a) The melting points of some of the halogens are shown in the table below.

Halogen	fluorine	chlorine	bromine	iodine
Melting point / K	53	172	266	387

5 (a) (i) Describe the structure of, and the bonding in, solid iodine. *(3 marks)*

5 (a) (ii) Explain the trend in the melting points of the halogens shown in the table above. *(2 marks)*

5 (b) There are trends in the melting point and in the electrical conductivity of the metals in Period 3. Using Na and Al as your examples, state these trends and explain each trend in terms of the bonding. *(6 marks)*

5 (c) There is a trend in the reactivity of the Group II elements Mg to Ba with H_2O
State the conditions necessary for Mg and for Ba to react rapidly with H_2O
Write equations for the reactions which occur. *(4 marks)*

END OF QUESTIONS

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