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Centre Number						Candidate Number					
Candidate Signature											

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General Certificate of Education
January 2003
Advanced Subsidiary Examination



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

Friday 10 January 2003 Morning Session

In addition to this paper you will require:
a calculator.

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			

Time allowed: 1 hour 30 minutes

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 90.
- 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 $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
- Your answers to 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 1 hour on **Section A** and about 30 minutes on **Section B**.

SECTION AAnswer **all** questions in the spaces provided.

- 1 (a) Complete the following table.

Particle	Relative charge	Relative mass
Proton		
Neutron		
Electron		

(3 marks)

- (b) An atom of element
- Z**
- has two more protons and two more neutrons than an atom of
- ${}^{34}_{16}\text{S}$
- . Give the symbol, including mass number and atomic number, for this atom of
- Z**
- .

.....
(2 marks)

- (c) Complete the electronic configurations for the sulphur atom, S, and the sulphide ion,
- S^{2-}
- .

S $1s^2$ S^{2-} $1s^2$

(2 marks)

- (d) State the block in the Periodic Table in which sulphur is placed and explain your answer.

Block

Explanation

(2 marks)

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

(e) Sodium sulphide, Na_2S , is a high melting point solid which conducts electricity when molten. Carbon disulphide, CS_2 , is a liquid which does not conduct electricity.

(i) Deduce the type of bonding present in Na_2S and that present in CS_2

Bonding in Na_2S

Bonding in CS_2

(ii) By reference to all the atoms involved explain, in terms of electrons, how Na_2S is formed from its atoms.

.....

.....

(iii) Draw a diagram, including all the outer electrons, to represent the bonding present in CS_2

(iv) When heated with steam, CS_2 reacts to form hydrogen sulphide, H_2S , and carbon dioxide.
Write an equation for this reaction.

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(7 marks)

16

TURN OVER FOR THE NEXT QUESTION

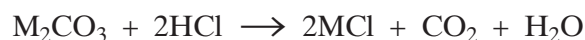
Turn over 

- 2 (a) Calculate the concentration, in mol dm^{-3} , of the solution formed when 19.6 g of hydrogen chloride, HCl, are dissolved in water and the volume made up to 250 cm^3 .

.....

(3 marks)

- (b) The carbonate of metal **M** has the formula M_2CO_3 . The equation for the reaction of this carbonate with hydrochloric acid is given below.



A sample of M_2CO_3 , of mass 0.394 g, required the addition of 21.7 cm^3 of a $0.263 \text{ mol dm}^{-3}$ solution of hydrochloric acid for complete reaction.

- (i) Calculate the number of moles of hydrochloric acid used.

.....

- (ii) Calculate the number of moles of M_2CO_3 in 0.394 g.

.....

- (iii) Calculate the relative molecular mass of M_2CO_3

.....

- (iv) Deduce the relative atomic mass of **M** and hence suggest its identity.

Relative atomic mass of **M**

.....

Identity of **M**

(6 marks)

9

3 When a sample of liquid, **X**, of mass 0.406 g was vaporised, the vapour was found to occupy a volume of $2.34 \times 10^{-4} \text{ m}^3$ at a pressure of 110 kPa and a temperature of 473 K.

(a) Give the name of the equation $pV = nRT$.

.....
(1 mark)

(b) Use the equation $pV = nRT$ to calculate the number of moles of **X** in the sample and hence deduce the relative molecular mass of **X**.
(The gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)

Moles of **X**

.....
.....

Relative molecular mass of **X**

.....
(4 marks)

(c) Compound **X**, which contains carbon, hydrogen and oxygen only, has 38.7% carbon and 9.68% hydrogen by mass. Calculate the empirical formula of **X**.

.....
.....
.....
.....
(3 marks)

(d) Using your answers to parts (b) and (c) above, deduce the molecular formula of **X**.

.....
.....
(1 mark)

9

Turn over ►

4 (a) The boiling point of H_2O is 373 K and that of H_2S is 212 K.

(i) Name the strongest type of intermolecular attraction present in water.

.....

(ii) Name the strongest type of intermolecular attraction present in hydrogen sulphide.

.....

(iii) Explain why the boiling point of water is so much higher than that of hydrogen sulphide.

.....

.....

(4 marks)

(b) Define the term *electronegativity*.

.....

.....

(2 marks)

(c) State and explain the trend in electronegativity down Group II from Be to Ba.

Trend

Explanation

.....

.....

(3 marks)

(d) (i) Give the type of bonding present in BeCl_2

.....

(ii) Give the type of bonding present in BaCl_2

.....

(iii) Explain why the type of bonding is different in these two compounds.

.....

.....

(3 marks)

- (e) (i) Explain what is meant by the term *amphoteric*. Write **two** equations involving $\text{Be}(\text{OH})_2$ to illustrate your answer.

Explanation

.....

Equation 1

Equation 2

- (ii) In what way is this behaviour of $\text{Be}(\text{OH})_2$ atypical of the behaviour of Group II metal hydroxides?

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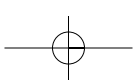
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(4 marks)

16

TURN OVER FOR THE NEXT QUESTION

Turn over 



5 There is a general trend in the values of the first ionisation energies of the elements Na to Ar. The first ionisation energies of the elements Al and S deviate from this trend.

(a) Write an equation, including state symbols, to represent the process for which the energy change is the first ionisation energy of Na.

.....
(2 marks)

(b) State and explain the general trend in the values of the first ionisation energies of the elements Na to Ar.

Trend

Explanation

.....
.....
(3 marks)

(c) State how, and explain why, the values of the first ionisation energies of the elements Al and S deviate from the general trend.

How the values deviate from the trend

Explanation for Al

.....
.....

Explanation for S

.....
.....
(5 marks)

SECTION B

Answer **both** questions below in the space provided on pages 12 to 16 of this booklet.

- 6 (a) Ionisation is the first of the four main stages involved in obtaining the mass spectrum of a sample of gaseous titanium atoms. Explain how ionisation is achieved. Name the remaining three stages and, in each case, state how each stage is achieved. Explain why it would be difficult to distinguish between $^{48}\text{Ti}^{2+}$ and $^{24}\text{Mg}^+$ ions using a mass spectrometer. (10 marks)
- (b) State any differences and similarities in the atomic structure of the isotopes of an element. State the difference, if any, in the chemistry of these isotopes. Explain your answer. (4 marks)
- (c) The table below gives the percentage abundance of each isotope in the mass spectrum of a sample of titanium.

m/z	46	47	48	49	50
% abundance	8.02	7.31	73.81	5.54	5.32

Define the term *relative atomic mass* of an element. Use the above data to calculate the value of the relative atomic mass of titanium in this sample. Give your answer to two decimal places. (4 marks)

- 7 (a) Predict the shapes of the SF_6 molecule and the AlCl_4^- ion. Draw diagrams of these species to show their three-dimensional shapes. Name the shapes and suggest values for the bond angles. Explain your reasoning. (8 marks)
- (b) Perfume is a mixture of fragrant compounds dissolved in a volatile solvent.

When applied to the skin the solvent evaporates, causing the skin to cool for a short time. After a while, the fragrance may be detected some distance away. Explain these observations. (4 marks)

END OF QUESTIONS

Turn over 