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General Certificate of Education
January 2002
Advanced Subsidiary Examination



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

Friday 11 January 2002 Afternoon Session

<p>In addition to this paper you will require:</p> <ul style="list-style-type: none"> a Periodic Table; a calculator.
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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.

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 $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
- 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**.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
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Total (Column 1)		→	
Total (Column 2)		→	
TOTAL			
Examiner's Initials			

SECTION A

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

- 1 (a) Define the term *atomic number* of an element.

.....
(1 mark)

- (b) Give the symbol, including mass number and atomic number, for an atom of an element which contains 12 neutrons and 11 electrons.

.....
(2 marks)

- (c) In terms of s and p sub-levels, give the electronic configuration of an aluminium atom.

.....
(1 mark)

- (d) How many neutrons are there in one ^{27}Al atom?

.....
(1 mark)

- (e) Define the term *relative atomic mass* of an element.

.....
.....
(2 marks)

- (f) Parts (i) to (iv) below refer to the operation of a mass spectrometer.

- (i) Name the device used to ionise atoms in a mass spectrometer.

.....

- (ii) Why is it necessary to ionise atoms before acceleration?

.....

.....

(iii) What deflects the ions?

.....

(iv) What is adjusted in order to direct ions of different mass to charge ratio onto the detector?

.....

(4 marks)

(g) A meteorite was found to contain three isotopes of element **X**. A mass spectrometer gave the following information about these isotopes.

m/z	24.0	25.0	26.0
Relative abundance	64.2	20.3	15.5

(i) Calculate the relative atomic mass of **X**.

.....

.....

.....

(ii) Using the Periodic Table, suggest the most likely identity of element **X**.

.....

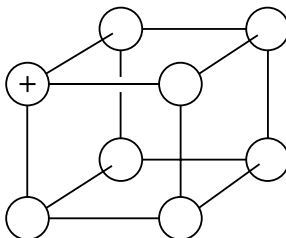
(iii) Suggest **one** reason why the relative atomic mass of **X**, given in the Periodic Table, differs from your answer to part (g)(i).

.....

.....

(5 marks)

- 2 (a) The diagram below represents a part of the structure of sodium chloride. The ionic charge is shown on the centre of only one of the ions.



- (i) On the diagram, mark the charges on the four negative ions.
- (ii) What change occurs to the motion of the ions in sodium chloride when it is heated from room temperature to a temperature below its melting point?

.....
(2 marks)

- (b) Sodium chloride can be formed by reacting sodium with chlorine.

- (i) Write an equation for this reaction.

.....

- (ii) A chloride ion has one more electron than a chlorine atom. In the formation of sodium chloride, from where does this electron come?

.....
(2 marks)

- (c) In some ionic compounds the chloride ions are polarised.

- (i) What is a polarised chloride ion?

.....

.....

- (ii) What feature of a cation causes a chloride ion to become polarised?

.....

.....
(2 marks)

(d) (i) What is a covalent bond?

.....

(ii) What property of the atoms joined by a covalent bond causes the bond to be polar?

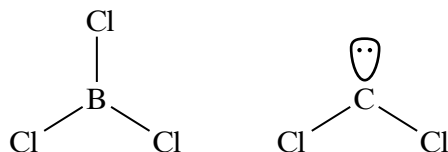
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(3 marks)

9

TURN OVER FOR THE NEXT QUESTION

- 3 (a) The shape of the molecule BCl_3 and that of the unstable molecule CCl_2 are shown below.



- (i) Why is each bond angle exactly 120° in BCl_3 ?

.....

- (ii) Predict the bond angle in CCl_2 and explain why this angle is different from that in BCl_3

Predicted bond angle

Explanation

.....
 (5 marks)

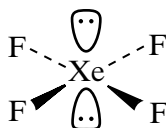
- (b) Give the name which describes the shape of molecules having bond angles of $109^\circ 28'$. Give an example of one such molecule.

Name of shape

Example

(2 marks)

- (c) The shape of the XeF_4 molecule is shown below.



- (i) State the bond angle in XeF_4

.....

- (ii) Suggest why the lone pairs of electrons are opposite each other in this molecule.

.....

.....

- (iii) Name the shape of this molecule, given that the shape describes the positions of the Xe and F atoms only.

.....
(4 marks)

- (d) Draw a sketch of the NF_3 molecule. Indicate in your sketch any lone pairs of electrons on nitrogen.

(2 marks)

13

TURN OVER FOR THE NEXT QUESTION

- 4 (a) State the meaning of the term *electronegativity*.

.....

 (2 marks)

- (b) State and explain the trend in electronegativity values across Period 3 from sodium to chlorine.

Trend

Explanation

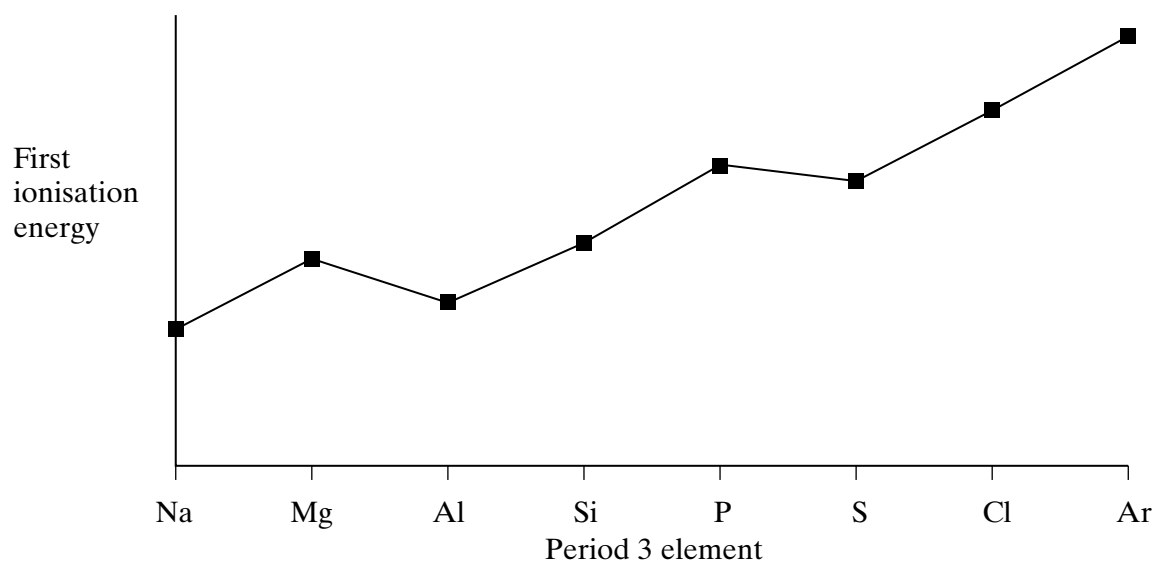
.....
 (3 marks)

- (c) What is meant by the term *first ionisation energy*?

.....

 (2 marks)

- (d) The diagram below shows the variation in first ionisation energy across Period 3.



- (i) What is the maximum number of electrons that can be accommodated in an s sub-level?

.....

(ii) What evidence from the diagram supports your answer to part (d)(i)?

.....
.....

(iii) What evidence from the diagram supports the fact that the 3p sub-level is higher in energy than the 3s?

.....
.....

(iv) What evidence from the diagram supports the fact that no more than three unpaired electrons can be accommodated in the 3p sub-level?

.....
.....
.....

(5 marks)

12

TURN OVER FOR THE NEXT QUESTION

5 (a) (i) Describe the bonding in a metal.

.....
.....
.....

(ii) Explain why magnesium has a higher melting point than sodium.

.....
.....
.....

(4 marks)

(b) Why do diamond and graphite both have high melting points?

.....
.....
.....
.....

(3 marks)

(c) Why is graphite a good conductor of electricity?

.....

(1 mark)

(d) Why is graphite soft?

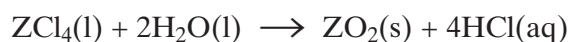
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(2 marks)

SECTION B

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

- 6 (a) A small sample of barium metal was added to water in a flask. When the reaction had ceased, the contents of the flask were treated with a small amount of dilute aqueous sodium sulphate.
Describe all that you would observe and write equations, with state symbols, for the reactions that occur. (8 marks)
- (b) Dilute sodium hydroxide solution was added dropwise until in excess to separate dilute aqueous solutions of beryllium chloride, magnesium chloride and barium chloride.
Describe what you would observe in each case and account for your observations. (8 marks)
- (c) (i) A naturally occurring compound of calcium contains by mass 23.29% of calcium, 18.64% of sulphur and 2.32% of hydrogen, the remainder being oxygen.
Determine the empirical formula of this compound.
- (ii) For any compound, what is the relationship between empirical and molecular formula? What additional information is required to determine a molecular formula from an empirical formula? (5 marks)
- 7 The chloride of an element **Z** reacts with water according to the following equation.



A 1.304 g sample of ZCl_4 was added to water. The solid ZO_2 was removed by filtration and the resulting solution was made up to 250 cm^3 in a volumetric flask. A 25.0 cm^3 portion of this solution was titrated against a $0.112 \text{ mol dm}^{-3}$ solution of sodium hydroxide, of which 21.7 cm^3 were required to reach the end point.

Use this information to calculate the number of moles of HCl produced and hence the number of moles of ZCl_4 present in the sample. Calculate the relative molecular mass, M_r , of ZCl_4 . From your answer deduce the relative atomic mass, A_r , of element **Z** and hence its identity. (9 marks)

END OF QUESTIONS

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