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General Certificate of Education  
June 2005  
Advanced Subsidiary Examination



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

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

**SECTION A**

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

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

(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.

<i>m/z</i>	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)



**Table 1**  
Proton n.m.r chemical shift data

Type of proton	$\delta/\text{ppm}$
$\text{RCH}_3$	0.7–1.2
$\text{R}_2\text{CH}_2$	1.2–1.4
$\text{R}_3\text{CH}$	1.4–1.6
$\text{RCOCH}_3$	2.1–2.6
$\text{ROCH}_3$	3.1–3.9
$\text{RCOOCH}_3$	3.7–4.1
$\text{ROH}$	0.5–5.0

**Table 2**  
Infra-red absorption data

Bond	Wavenumber/ $\text{cm}^{-1}$
$\text{C—H}$	2850–3300
$\text{C—C}$	750–1100
$\text{C=C}$	1620–1680
$\text{C=O}$	1680–1750
$\text{C—O}$	1000–1300
$\text{O—H}$ (alcohols)	3230–3550
$\text{O—H}$ (acids)	2500–3000

- (c) (i) Give the electron arrangement of an  $\text{Fe}^{2+}$  ion.

.....

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

.....

.....

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

*Difference* .....

*Explanation* .....

.....

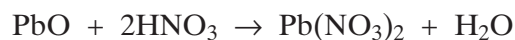
(4 marks)

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**TURN OVER FOR THE NEXT QUESTION**

Turn over 

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



An excess of lead(II) oxide was allowed to react with  $175 \text{ cm}^3$  of  $1.50 \text{ mol dm}^{-3}$  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.



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  $1.50 \times 10^{-4} \text{ m}^3$ .

- (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  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ )

*Ideal gas equation* .....

*Total number of moles of gas* .....

.....

.....

.....

- (ii) Deduce the number of moles, and the mass, of  $\text{NO}_2$  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  $2.23 \times 10^{-3}$  mol. This is not the correct answer.)

Number of moles of  $\text{NO}_2$  .....

.....

Mass of  $\text{NO}_2$  .....

.....

(7 marks)

11

**TURN OVER FOR THE NEXT QUESTION**

Turn over 

- 3 (a) When aluminium is added to an aqueous solution of copper(II) chloride,  $\text{CuCl}_2$ , copper metal and aluminium chloride,  $\text{AlCl}_3$ , are formed. Write an equation to represent this reaction.

.....  
(1 mark)

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

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

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.....  
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(4 marks)

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

.....  
(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)



4 Phosphorus and nitrogen are in Group V of the Periodic Table and both elements form hydrides. Phosphine,  $\text{PH}_3$ , reacts to form phosphonium ions,  $\text{PH}_4^+$ , in a similar way to that by which ammonia,  $\text{NH}_3$ , forms ammonium ions,  $\text{NH}_4^+$

- (a) Give the name of the type of bond formed when phosphine reacts with an  $\text{H}^+$  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.



*Shape of  $\text{PH}_3$*  .....

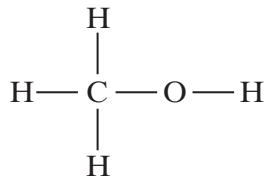
*Bond angle in  $\text{PH}_4^+$*  .....

(4 marks)

7

Turn over ►

- 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,  $\text{XCl}_2$ , forms a white precipitate when dilute aqueous sodium hydroxide is added. A separate sample of the solution of  $\text{XCl}_2$  does **not** form a precipitate when dilute aqueous sodium sulphate is added.

An aqueous solution of a different Group II metal chloride,  $\text{YCl}_2$ , does **not** form a precipitate when dilute aqueous sodium hydroxide is added. A separate sample of the solution of  $\text{YCl}_2$  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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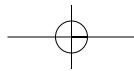
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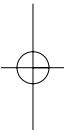
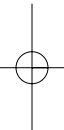
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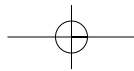
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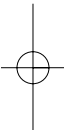
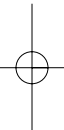
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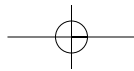


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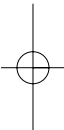
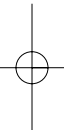


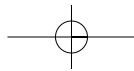
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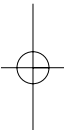
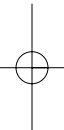
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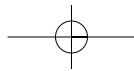


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A large rectangular area containing 25 horizontal dotted lines for writing.



Turn over 



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Handwriting practice area with 20 horizontal dotted lines.

