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Centre Number						Candidate Number					
Candidate Signature											

For Examiner's Use
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General Certificate of Education  
June 2007  
Advanced Subsidiary Examination



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

**CHM1**

Wednesday 6 June 2007 9.00 am to 10.00 am

**For this paper you must have**

- 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.
- Answer the 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 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.
- 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			
Question	Mark	Question	Mark
1			
2			
3			
4			
5			
6			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

## SECTION A

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

- 1 (a) State and explain the trend in the atomic radius of the elements Na to Cl in Period 3.

*Trend* .....

*Explanation* .....

.....

.....

(3 marks)

- (b) The table below gives the values of the first three ionisation energies of magnesium.

	First ionisation energy	Second ionisation energy	Third ionisation energy
Ionisation energy /kJ mol <sup>-1</sup>	738	1451	7733

- (i) Write an equation to illustrate the process occurring when the **first** ionisation energy of magnesium is measured.

.....

- (ii) Explain why the third ionisation energy of magnesium is very much larger than the second ionisation energy of magnesium.

.....

.....

.....

- (iii) State and explain the trend in the first ionisation energy of the elements Mg to Ba in Group II.

*Trend* .....

*Explanation* .....

.....

.....

(6 marks)



Gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

**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/ $\text{cm}^{-1}$
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) There is a trend in the reactivity of the Group II metals with  $\text{H}_2\text{O}$ . State the conditions needed for Mg and Ca to react rapidly with  $\text{H}_2\text{O}$ . Write an equation for each of these reactions.

*Conditions for Mg* .....

*Equation* .....

*Conditions for Ca* .....

*Equation* .....

(4 marks)

13
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**Turn over for the next question**

**Turn over ►**

- 2 (a) Ammonium carbamate contains 15.38 % of carbon, 7.69 % of hydrogen, 35.90 % of nitrogen and 41.03 % of oxygen by mass.

Use these data to confirm that the empirical formula of ammonium carbamate is  $\text{CH}_6\text{N}_2\text{O}_2$

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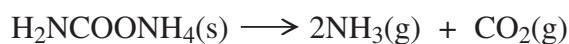
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(2 marks)

- (b) When heated, ammonium carbamate,  $\text{H}_2\text{NCOONH}_4$ , decomposes as shown below.



In a closed container, a 7.50 g sample of ammonium carbamate was heated. The solid decomposed completely into ammonia and carbon dioxide at 473 K and 98.7 kPa.

- (i) Calculate the number of moles of ammonium carbamate used and the total number of moles of gas produced.

*Moles of ammonium carbamate used* .....

.....

*Total moles of gas produced* .....

.....

- (ii) State the ideal gas equation and use it, together with your answer from part (b)(i), to calculate the total volume of gas produced at 473 K and 98.7 kPa. Include units in your final answer.

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

(If you have been unable to obtain an answer to part (b)(i), you should assume that the total number of moles of gas produced is 0.253 mol. This is not the correct answer.)

*Ideal gas equation* .....

*Calculation* .....

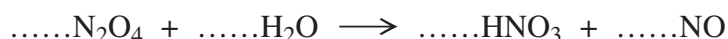
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(7 marks)

- 3 (a) Balance the equation below, in which nitric acid is formed by the reaction between dinitrogen tetroxide and water.



(1 mark)

- (b) A  $150\text{ cm}^3$  sample of  $1.65\text{ mol dm}^{-3}$  aqueous nitric acid was completely reacted with copper. The equation for the reaction which occurred is shown below.



- (i) Calculate the number of moles of nitric acid in  $150\text{ cm}^3$  of  $1.65\text{ mol dm}^{-3}$  aqueous nitric acid.

.....  
.....

- (ii) Calculate the number of moles, and hence the mass, of copper that would react completely with this amount of nitric acid.

(If you have been unable to obtain an answer to part (b)(i), you should assume that the total number of moles of nitric acid is 0.172. This is not the correct answer.)

*Moles of copper* .....

.....  
.....

*Mass of copper* .....

.....

(5 marks)

6
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**Turn over for the next question**

**Turn over ►**

4 Molecules of  $\text{NH}_3$ ,  $\text{H}_2\text{O}$  and  $\text{HF}$  contain covalent bonds. The bonds in these molecules are polar.

(a) State what is meant by a *covalent bond* and by a *polar bond*.

*Covalent bond* .....

.....

*Polar bond* .....

.....

(2 marks)

(b) (i) Explain why the H–F bond is polar.

.....

.....

.....

(ii) State which one of the molecules  $\text{NH}_3$ ,  $\text{H}_2\text{O}$  or  $\text{HF}$  contains the least polar bond.

.....

(iii) Explain why the bond in your chosen molecule from part (b)(ii) is less polar than the bonds found in the other two molecules.

.....

.....

(4 marks)

(c) The boiling points of  $\text{NH}_3$ ,  $\text{H}_2\text{O}$  and  $\text{HF}$  are all high for molecules of their size. This is due to the type of intermolecular force present in each case.

(i) Identify the type of intermolecular force responsible.

.....

(ii) Draw a diagram to show how two molecules of ammonia are attracted to each other by this type of intermolecular force. Include partial charges and all lone pairs of electrons in your diagram.

(4 marks)



(d) When an  $\text{H}^+$  ion reacts with an  $\text{NH}_3$  molecule, an  $\text{NH}_4^+$  ion is formed.

- (i) Give the name of the type of bond formed when an  $\text{H}^+$  ion reacts with an  $\text{NH}_3$  molecule. Describe how this bond is formed in the  $\text{NH}_4^+$  ion.

*Type of bond* .....

*Description* .....

.....

.....

- (ii) Draw the shape, including any lone pairs of electrons, of an  $\text{NH}_3$  molecule and of an  $\text{NH}_4^+$  ion.



- (iii) Name the shape produced by the arrangement of the **atoms** in the  $\text{NH}_3$  molecule.

.....

- (iv) Give the bond angle in the  $\text{NH}_4^+$  ion.

.....

(7 marks)

**SECTION B**

Answer questions 5 and 6 in the space provided on pages 11 and 12.

- 5 (a) The two isotopes normally found in a sample of nitrogen are  $^{14}\text{N}$  and  $^{15}\text{N}$ . Compare these two isotopes in terms of their fundamental particles. State and explain the difference, if any, in the chemical properties of these two isotopes. (4 marks)

- (b) State the block in the Periodic Table to which nitrogen belongs and explain your answer.

Give the electron arrangement of the  $\text{N}^{3-}$  ion.

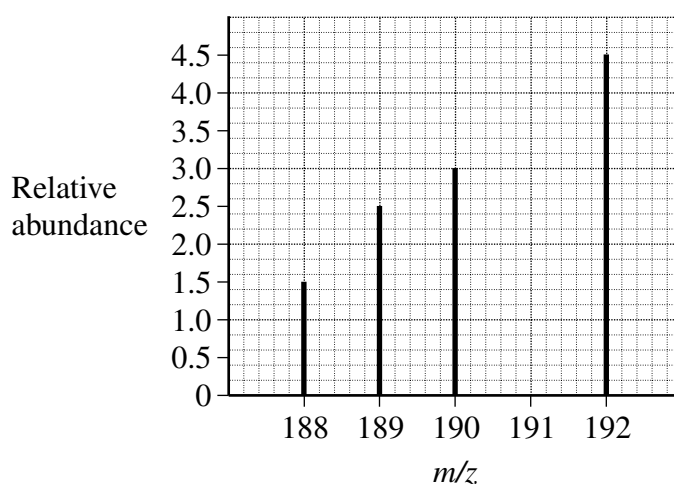
(3 marks)

- 6 (a) Acceleration and detection are two processes involved in obtaining the mass spectrum of a vaporised sample of a metal.

Name the other two main processes involved. In each case, identify the part of the mass spectrometer responsible for that process.

(4 marks)

- (b) The diagram below shows the mass spectrum of a gaseous sample of a metal **Z**.



Use the spectrum to calculate the relative atomic mass of **Z**. Give your answer to one decimal place.

Deduce the identity of **Z**.

(4 marks)

**END OF QUESTIONS**



