

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



General Certificate of Education
Advanced Subsidiary Examination
June 2009

Chemistry

CHEM1

Unit 1 Foundation Chemistry

Wednesday 3 June 2009 9.00 am to 10.15 am

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a calculator.

Time allowed

- 1 hour 15 minutes

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. **Answers written in margins or on blank pages will not be marked.**
- All working must be shown.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The Periodic Table/Data Sheet is provided as an insert.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- Your answers to the questions in **Section B** should be written in continuous prose, where appropriate.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.

Advice

- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.



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APW/Jun09/CHEM1

CHEM1

SECTION A

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

- 1 (a) Complete the electronic configuration for the sodium ion,
- Na^+

 $1s^2$
(1 mark)

- 1 (b) (i) Write an equation, including state symbols, to represent the process for which the energy change is the second ionisation energy of sodium.

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(2 marks)

- 1 (b) (ii) Explain why the second ionisation energy of sodium is greater than the second ionisation energy of magnesium.

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(3 marks)

- 1 (b) (iii) An element
- X**
- in Period 3 of the Periodic Table has the following successive ionisation energies.

	First	Second	Third	Fourth
Ionisation energies / kJ mol^{-1}	577	1820	2740	11600

Deduce the identity of element **X**.

.....

(1 mark)


- 1 (c) State and explain the trend in atomic radius of the Period 3 elements from sodium to chlorine.

Trend

Explanation

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(3 marks)

- 1 (d) Explain why sodium has a lower melting point than magnesium.

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(3 marks)

- 1 (e) Sodium reacts with ammonia to form the compound NaNH_2 which contains the NH_2^- ion. Draw the shape of the NH_2^- ion, including any lone pairs of electrons. Name the shape made by the three atoms in the NH_2^- ion.

Shape of NH_2^-

Name of shape

(2 marks)

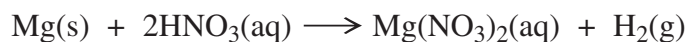
- 1 (f) In terms of its electronic configuration, give **one** reason why neon does not form compounds with sodium.

.....

(1 mark)



- 2 Under suitable conditions magnesium will react with dilute nitric acid according to the following equation.



A 0.0732 g sample of magnesium was added to 36.4 cm³ of 0.265 mol dm⁻³ nitric acid. The acid was in excess.

- 2 (a) (i) Calculate the amount, in moles, of magnesium in the 0.0732 g sample.

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(1 mark)

- 2 (a) (ii) Hence calculate the amount, in moles, of nitric acid needed to react completely with this sample of magnesium.

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(1 mark)

- 2 (a) (iii) Calculate the amount, in moles, of nitric acid originally added to this sample of magnesium.

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(1 mark)

- 2 (a) (iv) Hence calculate the amount, in moles, of nitric acid that remains unreacted.

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.....
(1 mark)



- 2 (b) In a second experiment, 0.512 mol of hydrogen gas was produced when another sample of magnesium reacted with dilute nitric acid. Calculate the volume that this gas would occupy at 298 K and 96 kPa. Include units in your final answer. (The gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)

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(3 marks)

- 2 (c) Concentrated nitric acid reacts with magnesium to form an oxide of nitrogen which contains 30.4% by mass of nitrogen.

Calculate the empirical formula of this oxide of nitrogen. Show your working.

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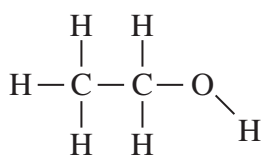
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(3 marks)

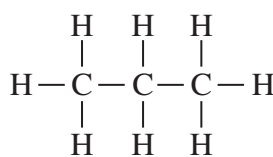
Turn over for the next question



- 3 (a) Two organic compounds with similar relative molecular masses are shown below.



Ethanol



Propane

- 3 (a) (i) State the type of bond present between the C and H atoms in both of these molecules. Explain how this type of bond is formed.

Type of bond

Explanation

..... (2 marks)

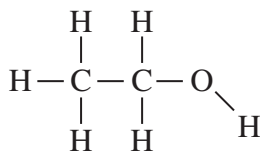
- 3 (a) (ii) State the strongest type of intermolecular force present in each compound.

Liquid ethanol

Liquid propane

(2 marks)

- 3 (b) Ethanol dissolves in water. Draw a diagram to show how one molecule of ethanol interacts with one molecule of water in the solution. Include partial charges and all lone pairs. The ethanol molecule has been drawn for you.



(3 marks)



3 (c) Ethanol was the fuel used in the first mass-produced car, the Model T Ford.

3 (c) (i) Write an equation which shows how ethanol burns completely in air to form carbon dioxide and water as the only products.

.....
(1 mark)

3 (c) (ii) Suggest **one** environmental problem caused by incomplete combustion of ethanol in a car engine.

.....
(1 mark)

3 (c) (iii) Suggest **one** economic problem for the car user caused by incomplete combustion of ethanol in the car engine.

.....
(1 mark)

3 (d) Propane is also used as a fuel, although sometimes it can be contaminated with sulfur-containing impurities. When this propane burns, these impurities form sulfur dioxide.

3 (d) (i) State how the sulfur dioxide can be removed from the waste gases produced when this propane is burned on a large scale in industry. Suggest a reason why the method you have stated may not be 100% efficient.

How removed

Reason for less than 100% efficiency

.....
(2 marks)

3 (d) (ii) Although propane has a boiling point of -42°C , it is usually supplied as a liquid for use in camping stoves. Suggest why it is supplied as a liquid.

.....
(1 mark)



4 Hexane is a member of the homologous series of alkanes.

4 (a) State **two** characteristics of a *homologous series*.

Characteristic 1

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Characteristic 2

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(2 marks)

4 (b) (i) Hexane can be converted into 2,2-dichlorohexane.

Draw the displayed formula of 2,2-dichlorohexane and deduce its empirical formula.

Displayed formula

Empirical formula

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(2 marks)

4 (b) (ii) Explain why 2,2-dichloro-3-methylpentane is a structural isomer of 2,2-dichlorohexane.

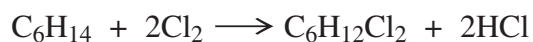
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(2 marks)



- 4 (c) A reaction of hexane with chlorine is shown by the equation below.



Calculate the percentage atom economy for the formation of $\text{C}_6\text{H}_{12}\text{Cl}_2$ in this reaction.

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(2 marks)

- 4 (d) The boiling points of some straight-chain alkanes are shown below.

Alkane	C_4H_{10}	C_5H_{12}	C_6H_{14}
Boiling point / °C	-0.5	36.3	68.7

- 4 (d) (i) Explain the trend in these boiling points.

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(2 marks)

- 4 (d) (ii) Name a process which can be used to separate C_5H_{12} from C_6H_{14}

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(1 mark)



SECTION B

Answer Question 5 in the spaces provided.

- 5** (a) (i) Define the term *relative atomic mass* (A_r) of an element.

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(2 marks)

- 5** (a) (ii) A sample of the metal silver has the relative atomic mass of 107.9 and exists as two isotopes. In this sample, 54.0% of the silver atoms are one isotope with a relative mass of 107.1

Calculate the relative mass of the other silver isotope.

State why the isotopes of silver have identical chemical properties.

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(4 marks)



- 5** (b) The isotopes of silver, when vaporised, can be separated in a mass spectrometer.

Name the **three** processes that occur in a mass spectrometer before the vaporised isotopes can be detected.

State how each process is achieved.

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(6 marks)

Question 5 continues on the next page

Turn over ►



- 5** (c) State the type of bonding involved in silver.

Draw a diagram to show how the particles are arranged in a silver lattice and show the charges on the particles.

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(3 marks)



- 5** (d) Silver reacts with fluorine to form silver fluoride (AgF).

Silver fluoride has a high melting point and has a structure similar to that of sodium chloride.

State the type of bonding involved in silver fluoride.

Draw a diagram to show how the particles are arranged in a silver fluoride lattice and show the charges on the particles.

Explain why the melting point of silver fluoride is high.

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(5 marks)

20

END OF QUESTIONS



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GCE Chemistry Data Sheet

Table 1

Infrared absorption data

Bond	Wavenumber /cm ⁻¹
N—H (amines)	3300–3500
O—H (alcohols)	3230–3550
C—H	2850–3300
O—H (acids)	2500–3000
C≡N	2220–2260
C=O	1680–1750
C=C	1620–1680
C—O	1000–1300
C—C	750–1100


Table 2

¹H n.m.r. chemical shift data

Type of proton	δ/ppm
ROH	0.5–5.0
RCH ₃	0.7–1.2
RNH ₂	1.0–4.5
R ₂ CH ₂	1.2–1.4
R ₃ CH	1.4–1.6
$\text{R}-\text{C}(\text{H})=\text{O}$	2.1–2.6
$\text{R}-\text{O}-\text{C}(\text{H})-\text{H}$	3.1–3.9
RCH ₂ Cl or Br	3.1–4.2
$\text{R}-\text{C}(\text{H})=\text{O}$	3.7–4.1
$\text{R}-\text{C}(\text{H})=\text{C}(\text{H})-\text{H}$	4.5–6.0
$\text{R}-\text{C}(\text{H})=\text{C}(\text{H})-\text{O}-\text{H}$	9.0–10.0
$\text{R}-\text{C}(\text{H})=\text{C}(\text{H})-\text{O}-\text{H}$	10.0–12.0

Table 3

¹³C n.m.r. chemical shift data

Type of carbon	δ/ppm
$-\text{C}-$	5–40
$\text{R}-\text{C}-\text{Cl}$ or Br	10–70
$\text{R}-\text{C}(=\text{O})-$	20–50
$\text{R}-\text{C}-\text{N}-$	25–60
$-\text{C}-\text{O}-$ alcohols, ethers or esters	50–90
$\text{C}=\text{C}$	90–150
$\text{R}-\text{C}\equiv\text{N}$	110–125
	110–160
$\text{R}-\text{C}(=\text{O})-$ esters or acids	160–185
$\text{R}-\text{C}(=\text{O})-$ aldehydes or ketones	190–220

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