

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	



General Certificate of Education  
Advanced Subsidiary Examination  
January 2011

# Chemistry

# CHEM1

## Unit 1 Foundation Chemistry

Thursday 13 January 2011 9.00 am to 10.15 am

**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. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

**Information**

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- The Periodic Table/Data Sheet is provided as an insert.
- 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 accurate scientific terminology.

**Advice**

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



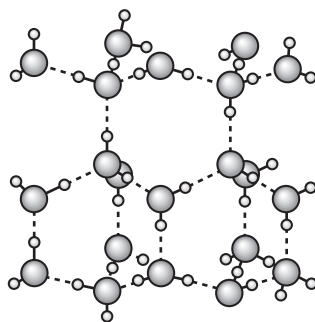
J A N 1 1 C H E M 1 0 1

## Section A

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

1 Water can be found as ice, water and steam.

1 (a) The following diagram shows the arrangement of some of the water molecules in a crystal of ice.



With reference to the structure shown above give **one** reason why ice is less dense than water.

.....

.....

.....

(1 mark)

1 (b) Water and methane have similar relative molecular masses and both contain the element hydrogen.  
The table below gives some information about water and methane.

	H <sub>2</sub> O	CH <sub>4</sub>
$M_r$	18.0	16.0
Melting point / K	273	91

1 (b) (i) State the strongest type of intermolecular force holding the water molecules together in the ice crystal.

.....

(1 mark)

1 (b) (ii) State the strongest type of intermolecular force in methane.

.....

(1 mark)



1 (b) (iii) Give **one** reason why the melting point of ice is higher than the melting point of methane.

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

(1 mark)

1 (c) A molecule of  $\text{H}_2\text{O}$  can react with an  $\text{H}^+$  ion to form an  $\text{H}_3\text{O}^+$  ion.

1 (c) (i) Draw and name the shape of the  $\text{H}_3\text{O}^+$  ion. Include any lone pairs of electrons.

Shape of the  $\text{H}_3\text{O}^+$  ion

Name of shape.....  
(2 marks)

1 (c) (ii) Suggest a value for the bond angle in the  $\text{H}_3\text{O}^+$  ion.

.....  
(1 mark)

1 (c) (iii) Identify **one** molecule with the same number of atoms, the same number of electrons and the same shape as the  $\text{H}_3\text{O}^+$  ion.

.....  
(1 mark)

1 (d) Water can also form the hydroxide ion.  
State the number of lone pairs of electrons in the hydroxide ion.

.....  
(1 mark)

9
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Turn over ►



**2** Indium is in Group 3 in the Periodic Table and exists as a mixture of the isotopes  $^{113}\text{In}$  and  $^{115}\text{In}$ .

**2 (a)** Use your understanding of the Periodic Table to complete the electron configuration of indium.

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$  .....  
(1 mark)

**2 (b)** A sample of indium must be ionised before it can be analysed in a mass spectrometer.

**2 (b) (i)** State what is used to ionise a sample of indium in a mass spectrometer.

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

**2 (b) (ii)** Write an equation, including state symbols, for the ionisation of indium that requires the minimum energy.

.....  
(1 mark)

**2 (b) (iii)** State why more than the minimum energy is **not** used to ionise the sample of indium.

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

**2 (b) (iv)** Give two reasons why the sample of indium must be ionised.

Reason 1 .....

Reason 2 .....  
(2 marks)



**2 (c)** A mass spectrum of a sample of indium showed two peaks at  $m/z = 113$  and  $m/z = 115$ . The relative atomic mass of this sample of indium is 114.5

**2 (c) (i)** Give the meaning of the term *relative atomic mass*.

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

(2 marks)

**2 (c) (ii)** Use these data to calculate the ratio of the relative abundances of the two isotopes.

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

(2 marks)

(Extra space) .....

**2 (d)** State and explain the difference, if any, between the chemical properties of the isotopes  $^{113}\text{In}$  and  $^{115}\text{In}$

Difference in chemical properties.....

Explanation.....

.....

(2 marks)

**2 (e)** Indium forms a compound **X** with hydrogen and oxygen. Compound **X** contains 69.2% indium and 1.8% hydrogen by mass. Calculate the empirical formula of compound **X**.

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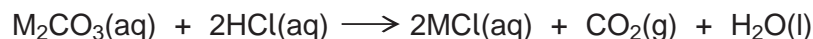
(3 marks)

15

Turn over ►



- 3 (a)** An unknown metal carbonate reacts with hydrochloric acid according to the following equation.



A 3.44 g sample of  $\text{M}_2\text{CO}_3$  was dissolved in distilled water to make  $250\text{ cm}^3$  of solution. A  $25.0\text{ cm}^3$  portion of this solution required  $33.2\text{ cm}^3$  of  $0.150\text{ mol dm}^{-3}$  hydrochloric acid for complete reaction.

- 3 (a) (i)** Calculate the amount, in moles, of HCl in  $33.2\text{ cm}^3$  of  $0.150\text{ mol dm}^{-3}$  hydrochloric acid. Give your answer to 3 significant figures.

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

- 3 (a) (ii)** Calculate the amount, in moles, of  $\text{M}_2\text{CO}_3$  that reacted with this amount of HCl. Give your answer to 3 significant figures.

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

- 3 (a) (iii)** Calculate the amount, in moles, of  $\text{M}_2\text{CO}_3$  in the 3.44 g sample. Give your answer to 3 significant figures.

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

- 3 (a) (iv)** Calculate the relative formula mass,  $M_r$ , of  $\text{M}_2\text{CO}_3$ . Give your answer to 1 decimal place.

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

- 3 (a) (v)** Hence determine the relative atomic mass,  $A_r$ , of the metal M and deduce its identity.

$A_r$  of M .....

Identity of M .....

(2 marks)



- 3 (b)** In another experiment, 0.658 mol of CO<sub>2</sub> was produced. This gas occupied a volume of 0.0220 m<sup>3</sup> at a pressure of 100 kPa. Calculate the temperature of this CO<sub>2</sub> and state the units. (The gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ )

.....

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(3 marks)

- 3 (c)** Suggest **one** possible danger when a metal carbonate is reacted with an acid in a sealed flask.

.....

.....

(1 mark)

- 3 (d)** In a different experiment, 6.27 g of magnesium carbonate were added to an excess of sulfuric acid. The following reaction occurred.



- 3 (d) (i)** Calculate the amount, in moles, of MgCO<sub>3</sub> in 6.27 g of magnesium carbonate.

.....

.....

(2 marks)

- 3 (d) (ii)** Calculate the mass of MgSO<sub>4</sub> produced in this reaction assuming a 95% yield.

.....

.....

.....

.....

(3 marks)



4 Cetane ( $C_{16}H_{34}$ ) is a major component of diesel fuel.

4 (a) Write an equation to show the complete combustion of cetane.

.....  
(1 mark)

4 (b) Cetane has a melting point of  $18^{\circ}C$  and a boiling point of  $287^{\circ}C$ .  
In polar regions vehicles that use diesel fuel may have ignition problems.  
Suggest **one** possible cause of this problem with the diesel fuel.

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

4 (c) The pollutant gases NO and  $NO_2$  are sometimes present in the exhaust gases of vehicles that use petrol fuel.

4 (c) (i) Write an equation to show how NO is formed and give a condition needed for its formation.

Equation .....

Condition .....

(2 marks)

4 (c) (ii) Write an equation to show how NO is removed from the exhaust gases in a catalytic converter. Identify a catalyst used in the converter.

Equation .....

Catalyst .....

(2 marks)

4 (c) (iii) Deduce an equation to show how  $NO_2$  reacts with water and oxygen to form nitric acid ( $HNO_3$ ).

.....  
(1 mark)





4 (d) Cetane ( $C_{16}H_{34}$ ) can be cracked to produce hexane, butene and ethene.

4 (d) (i) State **one** condition that is used in this cracking reaction.

.....  
(1 mark)

4 (d) (ii) Write an equation to show how one molecule of cetane can be cracked to form hexane, butene and ethene.

.....  
(1 mark)

4 (d) (iii) State **one** type of useful solid material that could be formed from alkenes.

.....  
(1 mark)

10
----

**Turn over for the next question**

**Turn over ►**



**Section B**

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

**5** The following table gives the melting points of some elements in Period 3.

Element	Na	Al	Si	P	S
Melting point / K	371	933	1680	317	392

**5 (a)** State the type of structure shown by a crystal of silicon.  
Explain why the melting point of silicon is very high.

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

(3 marks)

(Extra space) .....  
.....  
.....

**5 (b)** State the type of structure shown by crystals of sulfur and phosphorus.  
Explain why the melting point of sulfur is higher than the melting point of phosphorus.

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

(Extra space) .....  
.....  
.....



**5 (c)** Draw a diagram to show how the particles are arranged in aluminium and explain why aluminium is malleable.  
(You should show a minimum of six aluminium particles arranged in two dimensions.)

.....  
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(3 marks)

(Extra space) .....  
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**5 (d)** Explain why the melting point of aluminium is higher than the melting point of sodium.

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.....

(3 marks)

(Extra space) .....  
.....  
.....

12

Turn over ►



**6** Octane is the eighth member of the alkane homologous series.

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

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

(2 marks)

(Extra space) .....  
.....

**6 (b)** Name a process used to separate octane from a mixture containing several different alkanes.

.....  
.....

(1 mark)





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