

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**.



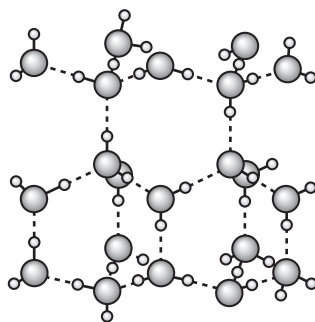
J A N 1 1 C H E M 1 0 1

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.

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.....

.....

(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 ₂ O	CH ₄
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.

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.....
.....

(1 mark)

1 (c) A molecule of H_2O can react with an H^+ ion to form an H_3O^+ ion.

1 (c) (i) Draw and name the shape of the H_3O^+ ion. Include any lone pairs of electrons.

Shape of the H_3O^+ ion

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

1 (c) (ii) Suggest a value for the bond angle in the H_3O^+ 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 H_3O^+ 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

Turn over ►



2 Indium is in Group 3 in the Periodic Table and exists as a mixture of the isotopes ^{113}In and ^{115}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}In and ^{115}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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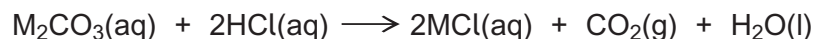
(3 marks)

15

Turn over ►



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



A 3.44 g sample of M_2CO_3 was dissolved in distilled water to make 250 cm^3 of solution. A 25.0 cm^3 portion of this solution required 33.2 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 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 M_2CO_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 M_2CO_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 M_2CO_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 CO₂ was produced. This gas occupied a volume of 0.0220 m³ at a pressure of 100 kPa. Calculate the temperature of this CO₂ 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.

.....

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(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 MgCO₃ in 6.27 g of magnesium carbonate.

.....

.....

(2 marks)

- 3 (d) (ii)** Calculate the mass of MgSO₄ produced in this reaction assuming a 95% yield.

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(3 marks)

15

Turn over ►



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 BAnswer **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.

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(3 marks)

(Extra space)

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.....

- 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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(3 marks)

(Extra space)

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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.

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

(Extra space)
.....

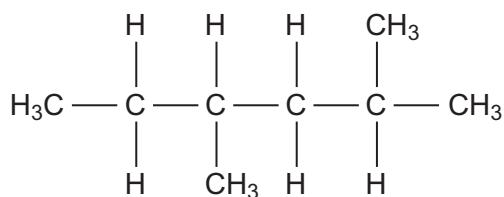
6 (b) Name a process used to separate octane from a mixture containing several different alkanes.

.....
.....

(1 mark)



- 6 (c) The structure shown below is one of several structural isomers of octane.



Give the meaning of the term structural isomerism.
Name this isomer and state its empirical formula.

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(4 marks)

(Extra space)

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- 6 (d) Suggest why the branched chain isomer shown above has a lower boiling point than octane.

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(2 marks)

END OF QUESTIONS



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