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.

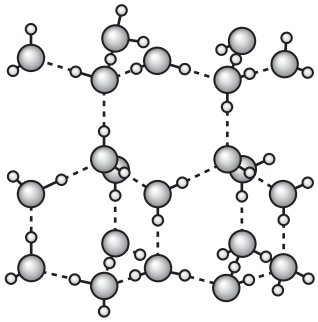
Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

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_2O	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.

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(1 mark)

9

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.

.....

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(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.

.....

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(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*.

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(2 marks)

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

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(2 marks)

(Extra space) .....

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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

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

$$M_2CO_3(aq) + 2HCl(aq) \longrightarrow 2MCl(aq) + CO_2(g) + H_2O(l)$$

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 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 mol dm^{-3} hydrochloric acid. Give your answer to 3 significant figures.

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(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.

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(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.

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.....

(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 CO_2 was produced. This gas occupied a volume of 0.0220 m^3 at a pressure of 100 kPa.
Calculate the temperature of this CO_2 and state the units.
(The gas constant R = 8.31 J K^{-1} 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.

$$MgCO_3 + H_2SO_4 \longrightarrow MgSO_4 + CO_2 + H_2O$$

3 (d) (i) Calculate the amount, in moles, of $MgCO_3$ in 6.27 g of magnesium carbonate.

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(2 marks)

3 (d) (ii) Calculate the mass of $MgSO_4$ 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 °C and a boiling point of 287 °C.
In polar regions vehicles that use diesel fuel may have ignition problems.
Suggest **one** possible cause of this problem with the diesel fuel.

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(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).

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(1 mark)

Do not write outside the box

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.

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(1 mark)

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

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(1 mark)

10

Turn over for the next question

Do not write outside the box

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.

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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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Do not write outside the box

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) .....

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12

Turn over ▶

Do not write outside the box

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

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

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(2 marks)

(Extra space) .....

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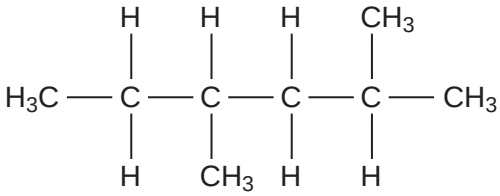
6 (b) Name a process used to separate octane from a mixture containing several different alkanes.

.....

.....

(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)

9

END OF QUESTIONS

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