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**.

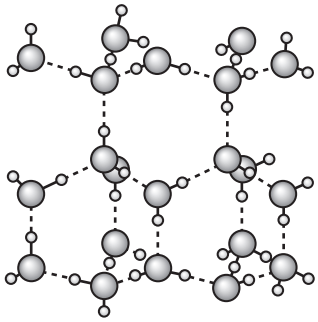
Do not write outside the box

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_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)

Do not write outside the box

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 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

Do not write outside the box

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)

Do not write outside the box

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**.

.....

.....

.....

.....

.....

(3 marks)

15

Do not write outside the box

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.

.....

.....

(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)

Do not write outside the box

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})

.....

.....

.....

.....

.....

.....

.....

(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.

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

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

.....

.....

(2 marks)

3 (d) (ii) Calculate the mass of $MgSO_4$ produced in this reaction assuming a 95% yield.

.....

.....

.....

.....

(3 marks)

15

Do not write outside the box

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.

.....

.....

(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)

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.

.....

(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

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.

.....

.....

.....

.....

.....

(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.

.....

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

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.)

.....

.....

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

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

.....

.....

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

12

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.

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

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

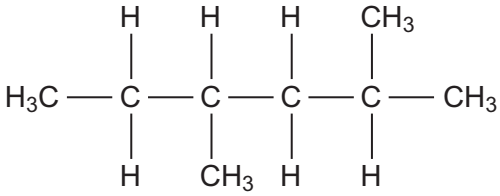
.....

.....

(1 mark)

Do not write outside the box

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.

.....

.....

.....

.....

.....

.....

(4 marks)

(Extra space) .....

.....

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

.....

.....

.....

.....

(2 marks)

9

END OF QUESTIONS

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

ACKNOWLEDGEMENT OF COPYRIGHT-HOLDERS AND PUBLISHERS

Question 1 Structure of Ice diagram from ZUMDAHL. Introductory Chemistry, 3E © 1996 Brooks/Cole a part of Cengage Learning, inc. Reproduced by permission. www.cengage.com/permissions

Copyright © 2011 AQA and its licensors. All rights reserved.