

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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



General Certificate of Education
Advanced Subsidiary Examination
June 2012

Chemistry

CHEM1

Unit 1 Foundation Chemistry

Tuesday 15 May 2012 1.30 pm to 2.45 pm

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.
- You are expected to use a calculator where appropriate.
- 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 U N 1 2 C H E M 1 0 1

Section A

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

1 The element rubidium exists as the isotopes ^{85}Rb and ^{87}Rb

1 (a) State the number of protons and the number of neutrons in an atom of the isotope ^{85}Rb

Number of protons

Number of neutrons

(2 marks)

1 (b) (i) Explain how the gaseous atoms of rubidium are ionised in a mass spectrometer.

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

(2 marks)

1 (b) (ii) Write an equation, including state symbols, to show the process that occurs when the **first** ionisation energy of rubidium is measured.

.....

(1 mark)

1 (c) The table shows the first ionisation energies of rubidium and some other elements in the same group.

Element	sodium	potassium	rubidium
First ionisation energy / kJ mol^{-1}	494	418	402

State **one** reason why the first ionisation energy of rubidium is lower than the first ionisation energy of sodium.

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

(1 mark)



1 (d) (i) State the block of elements in the Periodic Table that contains rubidium.

.....
(1 mark)

1 (d) (ii) Deduce the full electron configuration of a rubidium atom.

.....
(1 mark)

1 (e) A sample of rubidium contains the isotopes ⁸⁵Rb and ⁸⁷Rb only.
The isotope ⁸⁵Rb has an abundance 2.5 times greater than that of ⁸⁷Rb

Calculate the relative atomic mass of rubidium in this sample.
Give your answer to one decimal place.

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

1 (f) By reference to the relevant part of the mass spectrometer, explain how the abundance of an isotope in a sample of rubidium is determined.

Name of relevant part

Explanation

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

1 (g) Predict whether an atom of ⁸⁸Sr will have an atomic radius that is larger than, smaller than or the same as the atomic radius of ⁸⁷Rb. Explain your answer.

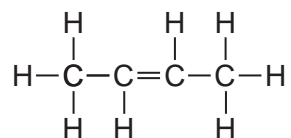
Atomic radius of ⁸⁸Sr compared to ⁸⁷Rb

Explanation

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



- 2 Compound **X** is shown below. It is a member of a homologous series of hydrocarbons.



- 2 (a) (i) Deduce the general formula of the homologous series that contains **X**.

..... (1 mark)

- 2 (a) (ii) Name a process used to obtain a sample of **X** from a mixture containing other members of the same homologous series.

..... (1 mark)

- 2 (b) There are several isomers of **X**.

- 2 (b) (i) Give the IUPAC name of the position isomer of **X**.

..... (1 mark)

- 2 (b) (ii) Draw the structure of a functional group isomer of **X**.

(1 mark)

- 2 (c) At high temperatures, one molecule of $\text{C}_{15}\text{H}_{32}$ can be converted into two molecules of **X** and one molecule of another compound.

- 2 (c) (i) Write an equation for this reaction.

..... (1 mark)



- 2 (c) (ii)** State the name of the process used to obtain a high yield of **X** from $C_{15}H_{32}$.
Give **one** reason why this process is used in industry.

Name

Reason

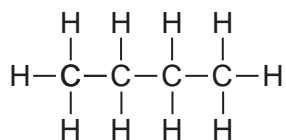
.....
(2 marks)

- 2 (c) (iii)** State why high temperatures are needed for this process.

.....

.....
(1 mark)

- 2 (d)** Compound **X** can be converted into compound **Y**.
Compound **Y** is shown below.



- 2 (d) (i)** Suggest the formula of a reagent that could be added to **X** in order to convert it into **Y**.

.....
(1 mark)

- 2 (d) (ii)** Give **one** use of **Y**.

.....
(1 mark)

- 2 (d) (iii)** Write an equation to show the reaction of **Y** in a limited supply of air to produce a solid and water only.

.....
(1 mark)

Question 2 continues on the next page

Turn over ►



2 (d) (iv) When a sample of **Y**, contaminated with CH_3SH , is burned completely in air, a toxic gas is formed.

Identify this toxic gas and suggest a compound that could be used to remove the toxic gas from the products of combustion.

Toxic gas

Compound used to remove toxic gas

.....
(2 marks)

2 (d) (v) Suggest the name of the process that occurs when the toxic gas in part **(d) (iv)** is removed.

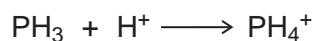
.....
(1 mark)

2 (e) Explain why the boiling points of **X** and **Y** are similar.

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



- 3** The following equation shows the reaction of a phosphine molecule (PH_3) with an H^+ ion.



- 3 (a)** Draw the shape of the PH_3 molecule. Include any lone pairs of electrons that influence the shape.

(1 mark)

- 3 (b)** State the type of bond that is formed between the PH_3 molecule and the H^+ ion. Explain how this bond is formed.

Name of bond

How bond is formed

.....

(2 marks)

- 3 (c)** Predict the bond angle in the PH_4^+ ion.

.....

(1 mark)

- 3 (d)** Although phosphine molecules contain hydrogen atoms, there is no hydrogen bonding between phosphine molecules. Suggest an explanation for this.

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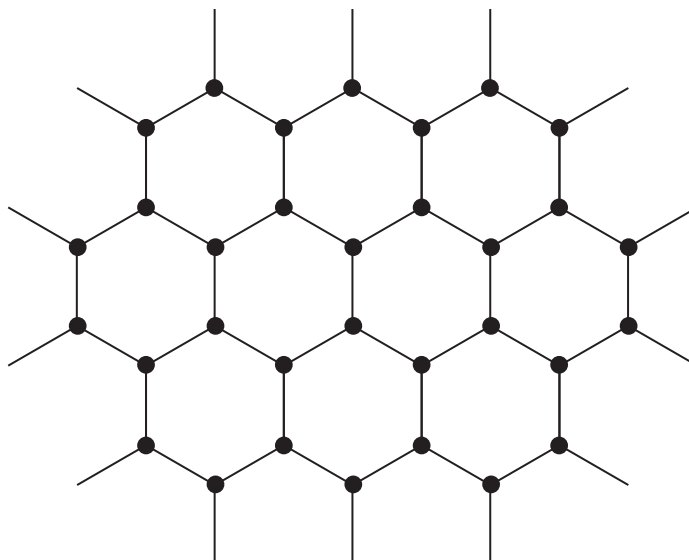
(1 mark)

5

Turn over ►



- 4 (a)** Graphene is a new material made from carbon atoms. It is the thinnest and strongest material known. Graphene has a very high melting point and is an excellent conductor of electricity.
Part of the structure of graphene is illustrated in the diagram.



- 4 (a) (i)** Deduce the type of crystal structure shown by graphene.

.....
(1 mark)

- 4 (a) (ii)** Suggest why graphene is an excellent conductor of electricity.

.....
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(2 marks)

- 4 (a) (iii)** Explain, in terms of its structure and bonding, why graphene has a high melting point.

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(2 marks)



4 (b) Titanium is also a strong material that has a high melting point. It has a structure similar to that of magnesium.

4 (b) (i) State the type of crystal structure shown by titanium.

..... (1 mark)

4 (b) (ii) Explain, in terms of its structure and bonding, why titanium has a high melting point.

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

4 (c) Titanium can be hammered into objects with different shapes that have similar strengths.

4 (c) (i) Suggest why titanium can be hammered into different shapes.

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

4 (c) (ii) Suggest why these objects with different shapes have similar strengths.

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

4 (d) Magnesium oxide (MgO) has a melting point of 3125K. Predict the type of crystal structure in magnesium oxide and suggest why its melting point is high.

Type of crystal structure

Explanation

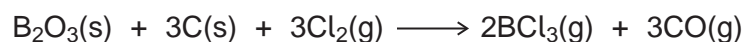
.....
.....
..... (3 marks)



Section B

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

5 (a) Boron trichloride (BCl₃) can be prepared as shown by the following equation.



A sample of boron oxide (B₂O₃) was reacted completely with carbon and chlorine. The two gases produced occupied a total volume of 5000 cm³ at a pressure of 100 kPa and a temperature of 298 K.

Calculate the mass of boron oxide that reacted.
Give your answer to 3 significant figures.

(The gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)

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(5 marks)

(Extra space)

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5 (b) Boron trichloride can also be prepared from its elements.

Write an equation for this reaction.

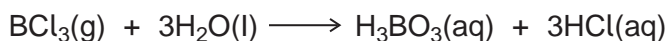
Explain why boron trichloride has a trigonal planar shape with equal bond angles.

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.....
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(3 marks)

(Extra space)
.....

5 (c) (i) Boron trichloride is easily hydrolysed to form two different acids as shown in the following equation.



Calculate the concentration, in mol dm⁻³, of hydrochloric acid produced when 43.2 g of boron trichloride are added to water to form 500 cm³ of solution.

Give your answer to 3 significant figures.

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(4 marks)

(Extra space)
.....

5 (c) (ii) Boric acid (H₃BO₃) can react with sodium hydroxide to form sodium borate and water. Write an equation for this reaction.

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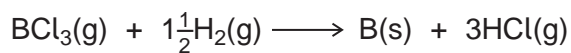
(1 mark)

Question 5 continues on the next page

Turn over ►



5 (d) Boron trichloride can be reduced by using hydrogen to form pure boron.



Calculate the percentage atom economy for the formation of boron in this reaction.

Apart from changing the reaction conditions, suggest **one** way a company producing pure boron could increase its profits from this reaction.

.....

(3 marks)

(Extra space)

5 (e) A different compound of boron and chlorine has a relative molecular mass of 163.6 and contains 13.2% of boron by mass.

Calculate the molecular formula of this compound.
 Show your working.

.....

(4 marks)

(Extra space)

20

END OF QUESTIONS

