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**.

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.

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(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.

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(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.

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(1 mark)

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

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(1 mark)

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

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(1 mark)

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

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

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(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 .....

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(2 marks)

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

Atomic radius of ^{88}Sr compared to ^{87}Rb .....

Explanation .....

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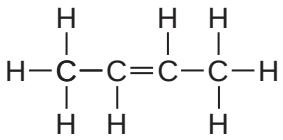
(3 marks)

16

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.

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(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 $C_{15}H_{32}$ 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.

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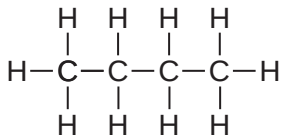
(1 mark)

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**.

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(1 mark)

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

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(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.

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(1 mark)

Question 2 continues on the next page

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 .....

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(2 marks)

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

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(1 mark)

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

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(2 marks)

16

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

$$PH_3 + H^+ \longrightarrow PH_4^+$$

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.

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(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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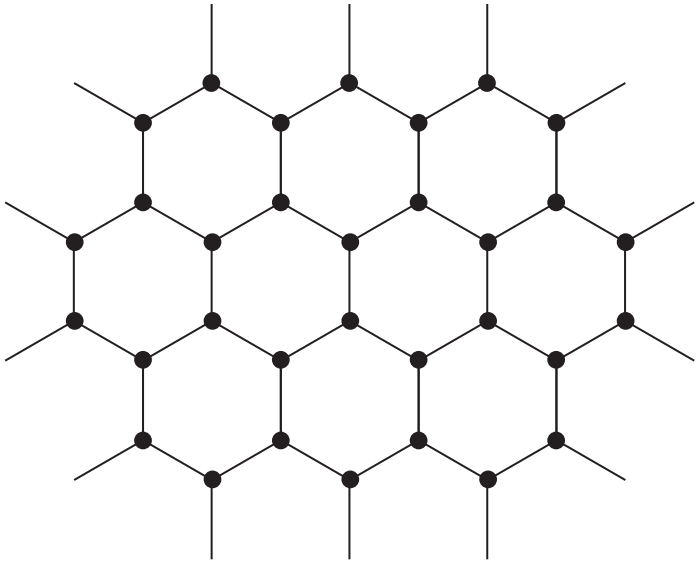
(1 mark)

5

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.

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(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.

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(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.

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(1 mark)

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

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(1 mark)

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

Type of crystal structure .....

Explanation .....

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(3 marks)

13

Section B

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

5 (a) Boron trichloride (BCl_3) can be prepared as shown by the following equation.

$$B_2O_3(s) + 3C(s) + 3Cl_2(g) \longrightarrow 2BCl_3(g) + 3CO(g)$$

A sample of boron oxide (B_2O_3) was reacted completely with carbon and chlorine. The two gases produced occupied a total volume of 5000 cm^3 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 $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

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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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(3 marks)

(Extra space) .....

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

$$BCl_3(g) + 3H_2O(l) \longrightarrow H_3BO_3(aq) + 3HCl(aq)$$

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 cm^3 of solution.
Give your answer to 3 significant figures.

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(4 marks)

(Extra space) .....

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5 (c) (ii) Boric acid (H_3BO_3) 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

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

$$BCl_3(g) + 1\tfrac{1}{2}H_2(g) \longrightarrow B(s) + 3HCl(g)$$

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.

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(3 marks)

(Extra space) .....

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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.

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(4 marks)

(Extra space) .....

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20

END OF QUESTIONS