Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2012

Chemistry CHEM1

Unit 1 Foundation Chemistry

Friday 13 January 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.
- 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**.

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Section A

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

1 Fluorine forms compounds with many other elements.

1 (a) Fluorine reacts with bromine to form liquid bromine trifluoride (BrF_3).
State the type of bond between Br and F in BrF_3 and state how this bond is formed.

Type of bond .....

How bond is formed .....

.....

(2 marks)

1 (b) Two molecules of BrF_3 react to form ions as shown by the following equation.

$$2BrF_3 \longrightarrow BrF_2^+ + BrF_4^-$$

1 (b) (i) Draw the shape of BrF_3 and predict its bond angle.
Include any lone pairs of electrons that influence the shape.

Shape of BrF_3

Bond angle .....

(2 marks)

1 (b) (ii) Draw the shape of BrF_4^- and predict its bond angle.
Include any lone pairs of electrons that influence the shape.

Shape of BrF_4^-

Bond angle .....

(2 marks)

Do not write outside the box

1 (c) BrF_4^- ions are also formed when potassium fluoride dissolves in liquid BrF_3 to form $KBrF_4$
Explain, in terms of bonding, why $KBrF_4$ has a high melting point.

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(3 marks)

(Extra space) .....

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1 (d) Fluorine reacts with hydrogen to form hydrogen fluoride (HF).

1 (d) (i) State the strongest type of intermolecular force between hydrogen fluoride molecules.

.....

(1 mark)

1 (d) (ii) Draw a diagram to show how two molecules of hydrogen fluoride are attracted to each other by the type of intermolecular force that you stated in part **(d) (i)**. Include all partial charges and all lone pairs of electrons in your diagram.

(3 marks)

1 (e) The boiling points of fluorine and hydrogen fluoride are –188 °C and 19.5 °C respectively.
Explain, in terms of bonding, why the boiling point of fluorine is very low.

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(2 marks)

(Extra space) .....

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15

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2 Trends in physical properties occur across all Periods in the Periodic Table.
This question is about trends in the Period 2 elements from lithium to nitrogen.

2 (a) Identify, from the Period 2 elements lithium to nitrogen, the element that has the largest atomic radius.

.....

(1 mark)

2 (b) (i) State the general trend in first ionisation energies for the Period 2 elements lithium to nitrogen.

.....

(1 mark)

2 (b) (ii) Identify the element that deviates from this general trend, from lithium to nitrogen, and explain your answer.

Element .....

Explanation .....

.....

.....

(3 marks)

(Extra space) .....

.....

2 (c) Identify the Period 2 element that has the following successive ionisation energies.

	First	Second	Third	Fourth	Fifth	Sixth
Ionisation energy / kJ mol^{-1}	1090	2350	4610	6220	37 800	47 000

.....

(1 mark)

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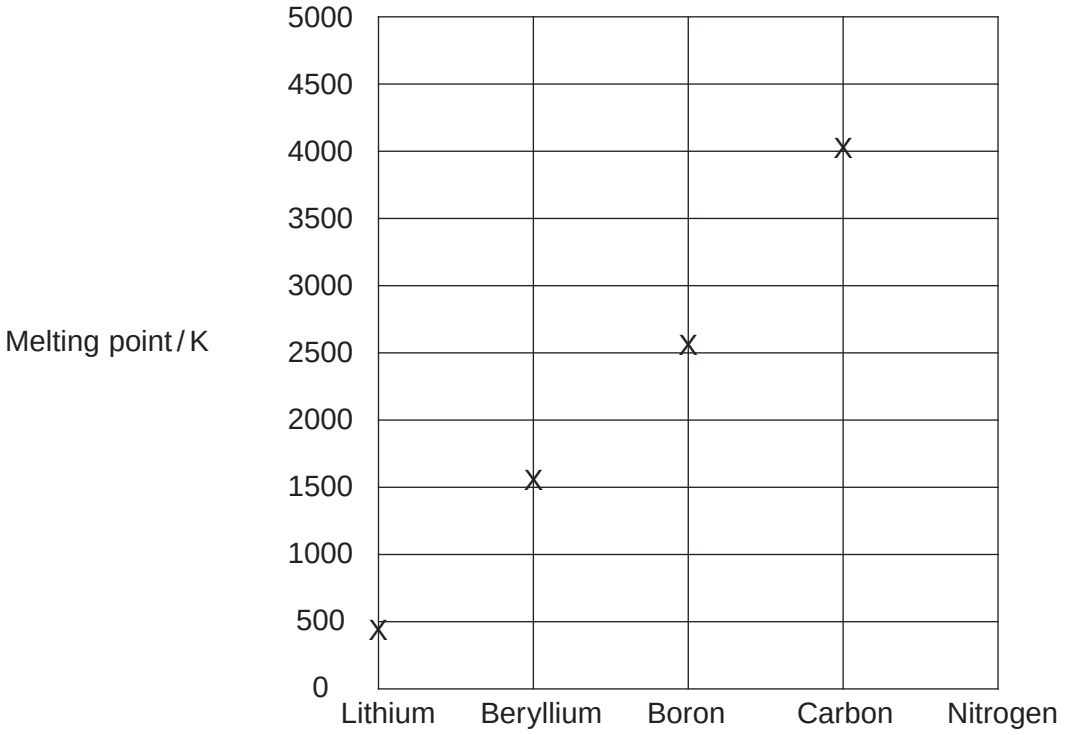
2 (d) Draw a cross on the diagram to show the melting point of nitrogen.



(1 mark)

2 (e) Explain, in terms of structure and bonding, why the melting point of carbon is high.

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(3 marks)

(Extra space) .....

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10

Do not write outside the box

3 Hexane (C_6H_{14}) is a member of the homologous series of alkanes.

3 (a) (i) Name the raw material from which hexane is obtained.

.....

(1 mark)

3 (a) (ii) Name the process used to obtain hexane from this raw material.

.....

(1 mark)

3 (b) C_6H_{14} has structural isomers.

3 (b) (i) Deduce the number of structural isomers with molecular formula C_6H_{14}

Write the number in this box.

(1 mark)

(*Space for working)*

3 (b) (ii) State **one** type of structural isomerism shown by the isomers of C_6H_{14}

.....

(1 mark)

3 (c) One molecule of an alkane **X** can be cracked to form one molecule of hexane and two molecules of propene.

3 (c) (i) Deduce the molecular formula of **X**.

.....

.....

(1 mark)

Do not write outside the box

3 (c) (ii) State the type of cracking that produces a high percentage of alkenes. State the conditions needed for this type of cracking.

Type of cracking .....

Conditions .....

.....

(2 marks)

3 (c) (iii) Explain the main economic reason why alkanes are cracked.

.....

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(1 mark)

3 (d) Hexane can react with chlorine under certain conditions as shown in the following equation.

$$C_6H_{14} + Cl_2 \longrightarrow C_6H_{13}Cl + HCl$$

3 (d) (i) Both the products are hazardous. The organic product would be labelled 'flammable'. Suggest the most suitable hazard warning for the other product.

.....

(1 mark)

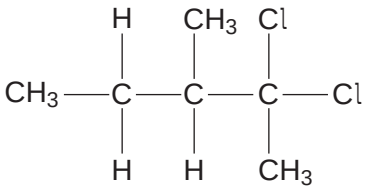
3 (d) (ii) Calculate the percentage atom economy for the formation of $C_6H_{13}Cl$ (M_r = 120.5) in this reaction.

.....

.....

(1 mark)

3 (e) A different chlorinated compound is shown below. Name this compound and state its empirical formula.



Name .....

Empirical formula .....

(2 marks)

12

Turn over ▶

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4 Alkanes are used as fuels. A student burned some octane (C_8H_{18}) in air and found that the combustion was incomplete.

4 (a) (i) Write an equation for the incomplete combustion of octane to produce carbon monoxide as the only carbon-containing product.

.....

(1 mark)

4 (a) (ii) Suggest **one** reason why the combustion was incomplete.

.....

.....

(1 mark)

4 (b) Catalytic converters are used to remove the toxic gases NO and CO that are produced when alkane fuels are burned in petrol engines.

4 (b) (i) Write an equation for a reaction between these two toxic gases that occurs in a catalytic converter when these gases are removed.

.....

(1 mark)

4 (b) (ii) Identify a metal used as a catalyst in a catalytic converter.
Suggest **one** reason, other than cost, why the catalyst is coated on a ceramic honeycomb.

Metal .....

Reason .....

.....

(2 marks)

Do not write outside the box

4 (c) If a sample of fuel for a power station is contaminated with an organic sulfur compound, a toxic gas is formed by complete combustion of this sulfur compound.

4 (c) (i) State **one** environmental problem that can be caused by the release of this gas.

.....

.....

(1 mark)

4 (c) (ii) Identify **one** substance that could be used to remove this gas.
Suggest **one** reason, other than cost, why this substance is used.

Substance .....

Reason why used .....

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(2 marks)

8

Turn over for the next question

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5 The element nitrogen forms compounds with metals and non-metals.

5 (a) Nitrogen forms a nitride ion with the electron configuration $1s^2\ 2s^2\ 2p^6$
Write the formula of the nitride ion.

.....

(1 mark)

5 (b) An element forms an ion **Q** with a single negative charge that has the same electron configuration as the nitride ion.
Identify the ion **Q**.

.....

(1 mark)

5 (c) Use the Periodic Table and your knowledge of electron arrangement to write the formula of lithium nitride.

.....

(1 mark)

5 (d) Calcium nitride contains 81.1% by mass of the metal.
Calculate the empirical formula of calcium nitride.
Show your working.

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(3 marks)

5 (e) Write an equation for the reaction between silicon and nitrogen to form silicon nitride, Si_3N_4

.....

(1 mark)

7

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Section B

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

6 The metal lead reacts with warm dilute nitric acid to produce lead(II) nitrate, nitrogen monoxide and water according to the following equation.

$$3Pb(s) + 8HNO_3(aq) \longrightarrow 3Pb(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$$

6 (a) In an experiment, an 8.14 g sample of lead reacted completely with a 2.00 mol dm^{-3} solution of nitric acid.

Calculate the volume, in dm^3, of nitric acid required for complete reaction.
Give your answer to 3 significant figures.

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(3 marks)

(Extra space) .....

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6 (b) In a second experiment, the nitrogen monoxide gas produced in the reaction occupied 638 cm^3 at 101 kPa and 298 K.
Calculate the amount, in moles, of NO gas produced.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

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(3 marks)

(Extra space) .....

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6 (c) When lead(II) nitrate is heated it decomposes to form lead(II) oxide, nitrogen dioxide and oxygen.

6 (c) (i) Balance the following equation that shows this thermal decomposition.

.....$Pb(NO_3)_2(s)$ ⟶ ..... $PbO(s)$ + ...$NO_2(g)$ + ...$O_2(g)$

(1 mark)

6 (c) (ii) Suggest **one** reason why the yield of nitrogen dioxide formed during this reaction is often less than expected.

.....

.....

(1 mark)

6 (c) (iii) Suggest **one** reason why it is difficult to obtain a pure sample of nitrogen dioxide from this reaction.

.....

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(1 mark)

9

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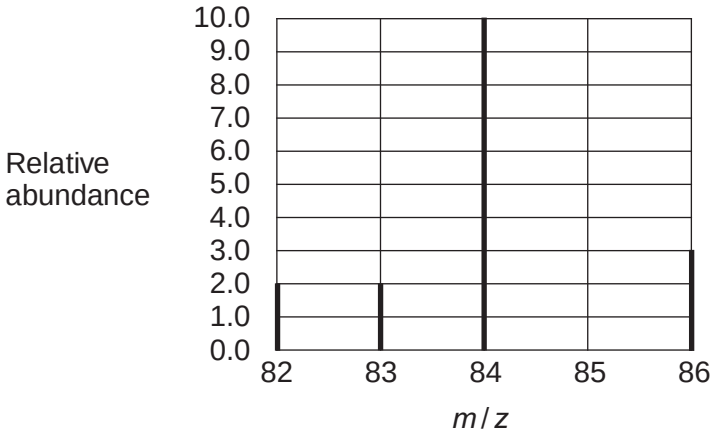
7 The mass spectrum of a sample of krypton taken from a meteorite is shown below.



7 (a) Use this spectrum to calculate the relative atomic mass of this sample of krypton. Give your answer to one decimal place.

Explain why the value you have calculated is slightly different from the relative atomic mass given in the Periodic Table.

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(4 marks)

(Extra space) .....

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7 (b) State how krypton is ionised in the mass spectrometer.

Write an equation, including state symbols, to show the reaction that occurs when the **first** ionisation energy of Kr is measured.

Sometimes the mass spectrum of Kr has a very small peak with an *m*/*z* value of 42 Explain the occurrence of this peak.

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(5 marks)

(Extra space) .....

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9

END OF QUESTIONS

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