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
June 2014

Chemistry CHEM1

Unit 1 Foundation Chemistry

Friday 23 May 2014 9.00 am to 10.15 am

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- 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 scientific terminology accurately.

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 (a) **Table 1** shows some data about fundamental particles in an atom.

Table 1

Particle	proton	neutron	electron
Mass / g	1.6725×10^{-24}	1.6748×10^{-24}	0.0009×10^{-24}

1 (a) (i) An atom of hydrogen can be represented as ^{1}H

Use data from **Table 1** to calculate the mass of this hydrogen atom.

[1 mark]

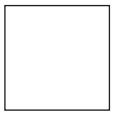
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1 (a) (ii) Which **one** of the following is a fundamental particle that would **not** be deflected by an electric field?

A electron
B neutron
C proton

Write the correct letter, **A**, **B** or **C**, in the box.

[1 mark]



Do not write outside the box

1 (b) A naturally occurring sample of the element boron has a relative atomic mass of 10.8 In this sample, boron exists as two isotopes, ^{10}B and ^{11}B

1 (b) (i) Calculate the percentage abundance of ^{10}B in this naturally occurring sample of boron.

[2 marks]

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1 (b) (ii) State, in terms of fundamental particles, why the isotopes ^{10}B and ^{11}B have similar chemical reactions.

[1 mark]

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1 (c) Complete **Table 2** by suggesting a value for the third ionisation energy of boron.

[1 mark]

Table 2

	First	**Second**	**Third**	**Fourth**	**Fifth**
Ionisation energy / kJ mol^{-1}	799	2420		25 000	32 800

1 (d) Write an equation to show the process that occurs when the **second** ionisation energy of boron is measured. Include state symbols in your equation.

[1 mark]

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1 (e) Explain why the second ionisation energy of boron is higher than the first ionisation energy of boron.

[1 mark]

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Turn over ▶

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2 When heated, iron(III) nitrate (M_r = 241.8) is converted into iron(III) oxide, nitrogen dioxide and oxygen.

$$4Fe(NO_3)_3(s) \longrightarrow 2Fe_2O_3(s) + 12NO_2(g) + 3O_2(g)$$

A 2.16 g sample of iron(III) nitrate was completely converted into the products shown.

2 (a) (i) Calculate the amount, in moles, of iron(III) nitrate in the 2.16 g sample.
Give your answer to 3 significant figures.

[1 mark]

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2 (a) (ii) Calculate the amount, in moles, of oxygen gas produced in this reaction.

[1 mark]

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2 (a) (iii) Calculate the volume, in m^3, of **nitrogen dioxide** gas at 293 ºC and 100 kPa produced from 2.16 g of iron(III) nitrate.
The gas constant is R = 8.31 $J\,K^{-1}\,mol^{-1}$.

(If you have been unable to obtain an answer to Question **2 (a) (i)**, you may assume the number of moles of iron(III) nitrate is 0.00642. This is **not** the correct answer.)

[4 marks]

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2 (b) Suggest a name for this type of reaction that iron(III) nitrate undergoes.

[1 mark]

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2 (c) Suggest why the iron(III) oxide obtained is pure.
Assume a complete reaction.

[1 mark]

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8

Turn over for the next question

Do not write outside the box

3 (a) Nickel is a metal with a high melting point.

3 (a) (i) State the block in the Periodic Table that contains nickel.

[1 mark]

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3 (a) (ii) Explain, in terms of its structure and bonding, why nickel has a high melting point.

[2 marks]

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3 (a) (iii) Draw a labelled diagram to show the arrangement of particles in a crystal of nickel. In your answer, include at least six particles of each type.

[2 marks]

3 (a) (iv) Explain why nickel is ductile (can be stretched into wires).

[1 mark]

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Do not write outside the box

3 (b) Nickel forms the compound nickel(II) chloride ($NiCl_2$).

3 (b) (i) Give the full electron configuration of the Ni^{2+} ion.

[1 mark]

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3 (b) (ii) Balance the following equation to show how anhydrous nickel(II) chloride can be obtained from the hydrated salt using $SOCl_2$
Identify **one** substance that could react with both gaseous products.

[2 marks]

.....$NiCl_2.6H_2O(s)$ + ... $SOCl_2(g)$ ⟶ .....$NiCl_2(s)$ + ...$SO_2(g)$ + ...$HCl(g)$

Substance .....

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Turn over for the next question

Do not write outside the box

4 (a) Ammonia gas readily condenses to form a liquid when cooled.

4 (a) (i) Name the strongest attractive force between two ammonia molecules.

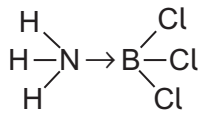
[1 mark]

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4 (a) (ii) Draw a diagram to show how two ammonia molecules interact with each other in the liquid phase.
Include all partial charges and all lone pairs of electrons in your diagram.

[3 marks]

4 (b) Ammonia reacts with boron trichloride to form a molecule with the following structure.



State how the bond between ammonia and boron trichloride is formed.

[1 mark]

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Do not write outside the box

4 (c) **Table 3** shows the electronegativity values of some elements.

Table 3

	H	Li	B	C	O	F
Electronegativity	2.1	1.0	2.0	2.5	3.5	4.0

4 (c) (i) Give the meaning of the term **electronegativity**.

[2 marks]

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4 (c) (ii) Suggest the formula of an ionic compound that is formed by the chemical combination of two different elements from **Table 3**.

[1 mark]

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4 (c) (iii) Suggest the formula of the compound that has the least polar bond and is formed by chemical combination of two of the elements from **Table 3**.

[1 mark]

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9

Turn over for the next question

Do not write outside the box

5 Some oil-fired heaters use paraffin as a fuel.
One of the compounds in paraffin is the straight-chain alkane, dodecane ($C_{12}H_{26}$).

5 (a) Give the name of the substance from which paraffin is obtained.
State the name of the process used to obtain paraffin from this substance.

[2 marks]

Substance .....

Process .....

5 (b) The combustion of dodecane produces several products.

Write an equation for the **incomplete** combustion of dodecane to produce gaseous products only.

[1 mark]

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5 (c) Oxides of nitrogen are also produced during the combustion of paraffin in air.

5 (c) (i) Explain how these oxides of nitrogen are formed.

[2 marks]

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5 (c) (ii) Write an equation to show how nitrogen monoxide in the air is converted into nitrogen dioxide.

[1 mark]

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5 (c) (iii) Nitric acid (HNO_3) contributes to acidity in rainwater.

Deduce an equation to show how nitrogen dioxide reacts with oxygen and water to form nitric acid.

[1 mark]

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Do not write outside the box

5 (d) Dodecane ($C_{12}H_{26}$) can be cracked to form other compounds.

5 (d) (i) Give the general formula for the homologous series that contains dodecane.

[1 mark]

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5 (d) (ii) Write an equation for the cracking of one molecule of dodecane into equal amounts of two different molecules each containing the same number of carbon atoms.
State the empirical formula of the straight-chain alkane that is formed.
Name the catalyst used in this reaction.

[3 marks]

Equation .....

Empirical formula of alkane .....

Catalyst .....

5 (d) (iii) Explain why the melting point of dodecane is higher than the melting point of the straight-chain alkane produced by cracking dodecane.

[2 marks]

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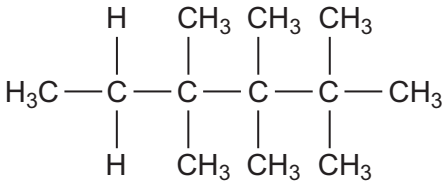
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Question 5 continues on the next page

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5 (e) Give the IUPAC name for the following compound and state the type of structural isomerism shown by this compound and dodecane.

[2 marks]



IUPAC name .....

Type of structural isomerism .....

5 (f) Dodecane can be converted into halododecanes.

Deduce the formula of a substance that could be reacted with dodecane to produce 1-chlorododecane and hydrogen chloride only.

[1 mark]

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16

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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Section B

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

6 (a) Calcium phosphate reacts with aqueous nitric acid to produce phosphoric acid and calcium nitrate as shown in the equation.

$$Ca_3(PO_4)_2 + 6HNO_3 \longrightarrow 2H_3PO_4 + 3Ca(NO_3)_2$$

6 (a) (i) A 7.26 g sample of calcium phosphate reacted completely when added to an excess of aqueous nitric acid to form 38.0 cm^3 of solution.

Calculate the concentration, in mol dm^{-3}, of phosphoric acid in this solution.
Give your answer to 3 significant figures.

[5 marks]

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6 (a) (ii) Calculate the percentage atom economy for the formation of calcium nitrate in this reaction.
Give your answer to 1 decimal place.

[2 marks]

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6 (b) Write an equation to show the reaction between calcium hydroxide and phosphoric acid to produce calcium phosphate and water.

[1 mark]

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6 (c) Calcium dihydrogenphosphate can be represented by the formula $Ca(H_2PO_4)_x$ where x is an integer.
A 9.76 g sample of calcium dihydrogenphosphate contains 0.17 g of hydrogen, 2.59 g of phosphorus and 5.33 g of oxygen.

Calculate the empirical formula and hence the value of x.
Show your working.

[4 marks]

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Turn over for the next question

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7 Thallium is in Group 3 of the Periodic Table.
Thallium reacts with halogens to form many compounds and ions.

7 (a) Draw the shape of the $TlBr_3^{2-}$ ion and the shape of the $TlCl_4^{3-}$ ion.
Include any lone pairs of electrons that influence the shapes.

Name the shape made by the atoms in $TlBr_3^{2-}$ and suggest a value for the bond angle.
[4 marks]

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7 (b) Thallium(I) bromide (TlBr) is a crystalline solid with a melting point of 480 ºC.

Suggest the type of bonding present in thallium(I) bromide and state why the melting point is high.
[3 marks]

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7 (c) Write an equation to show the formation of thallium(I) bromide from its elements.
[1 mark]

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END OF QUESTIONS

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