Centre Number						Candidate Number				
Surname	MARK SCHEME									
Other Names										
Candidate Signature										

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

AQA

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**.

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

* Hydrogen atoms have one proton and one electron - just add them together.

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

[1 mark]

$1.6725 \times 10^{-24} + 0.0009 \times 10^{-24} = 1.6734 \times 10^{-24}$

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]

B

* Neutrons have no charge!

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]

If relative atomic mass is 10.8
Five 0.2's between 10 and 11 ∴ for an average of
10.8 must be four 11's and one 10!
$\frac{4}{5}$ = 80% ^{11}B and $\frac{1}{5}$ = 20% ^{10}B

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

Same electron configuration
* Because it's the electrons that take the active part in chemical reactions.

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	3-10k 4000	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]

$B^{+}(g) \rightarrow B^{2+}(g) + e^{-}$

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

Electron being removed from a positive ion therefore more energy needed to remove another due to increased attraction.

8

Do not outside box

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]

* Don't forget the 3sf!

Mr of iron(III) nitrate ↘ $\frac{2.16}{241.8} = 0.00893$

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

[1 mark]

$\left(\frac{0.00893}{4}\right) \times 3 = 6.70 \times 10^{-3}$

2 (a) (iii) Calculate the volume, in m^3, of **nitrogen dioxide** gas at 293 °C 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]

$PV = nRT$ $\left(\frac{0.00893}{4}\right) \times 12 = 0.02679$ moles

$273 + 293 = 566$ K

$V = \frac{nRT}{P}$ $V = \frac{0.02679 \times 8.31 \times 566}{100,000}$ → kPa × 1000! = Pa

$V = 1.26 \times 10^{-3}\ m^3$

2 (b) Suggest a name for this type of reaction that iron(III) nitrate undergoes. **[1 mark]**

Thermal decomposition

2 (c) Suggest why the iron(III) oxide obtained is pure.
Assume a complete reaction. **[1 mark]**

All other products are gases.

* Because they are gases they escape easily and will not contaminate the iron (III) oxide

8

Turn over for the next question

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]

d block.

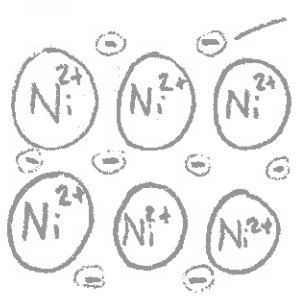
3 (a) (ii) Explain, in terms of its structure and bonding, why nickel has a high melting point.

[2 marks]

Metallic bonding positive metal ions surrounded by a 'sea' of delocalised electrons. Strong attraction between the paritive ions and delocalised electrons. So lots of energy needed to break them.

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]



* Regular arrangement shown with +ve charges - delocalise sea shown and labelled.

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

[1 mark]

Arranged in regular layers which are able to slide over each other.

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

* when removing electrons from transition metals - take 4s electrons first!

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

[1 mark]

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8$

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]

$$\ldots\ldots NiCl_2.6H_2O(s) + \ldots 6 \ldots SOCl_2(g) \longrightarrow \ldots\ldots NiCl_2(s) + \ldots 6 \ldots SO_2(g) + \ldots 12 \ldots HCl(g)$$

Substance NaOH

* Both SO_2 and HCl are acidic gases here and alkali is suitable.

9

Turn over for the next question

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

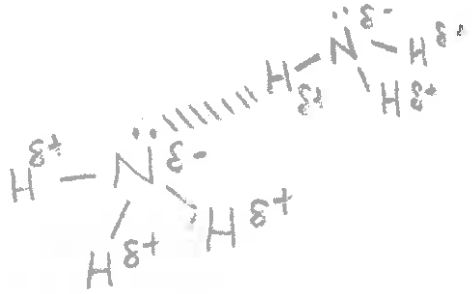
4 (a) (i) Name the strongest attractive force between two ammonia molecules.

[1 mark]

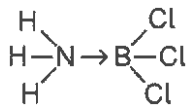
Hydrogen Bonding

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]

Lone pair donated from the nitrogen atom to the Boron atom.

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]

The power of an atom to withdraw a pair of electrons in a covalent bond.

* Don't forget the covalent bond - this is a mark!

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]

LiF

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]

BH_3

9

Turn over for the next question

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 Crude oil

Process fractional distillation

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]

$C_{12}H_{26} + 12{\cdot}5O_2 \longrightarrow 12CO + 13H_2O$

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]

Nitrogen and oxygen react at high temperatures.

* N_2 and O_2 don't normally react but at the high temps during combustion they will.

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

[1 mark]

$2NO + O_2 \longrightarrow 2NO_2$

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]

$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$

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]

C_nH_{2n+2}

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 $C_{12}H_{26} \longrightarrow C_6H_{14} + C_6H_{12}$

Empirical formula of alkane C_3H_7

Catalyst Zeolite

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.

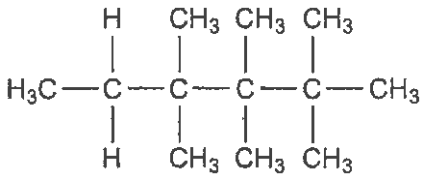
[2 marks]

The melting point of dodecane is higher because it is a larger molecule - therefore more electrons which gives rise to increased numbers of vander waals forces.

Question 5 continues on the next page

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 2,2,3,3,4,4-hexamethylhexane

Type of structural isomerism Chain

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]

Cl_2

* Remember to read the question - it says formula not name!

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Do not outside box

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]

Mr of Calcium phosphate = 310.3

$\frac{7.26}{310.3}$ = 0.0234 moles 0.0234 × 2 = 0.0468

* This is the moles of phosphoric acid. The ×2 was from the ratio

* Convert to dm^3!

$\frac{38.0}{1000}$ = $0.038 dm^3$

$\frac{0.0468}{0.038}$ = 1.23 mol dm^{-3}

* Remember the two formula's! moles = mass / mr and conc = mol / vol

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]

$\frac{492.3}{588.3}$ × 100 = 71.5%

Do not write outside the box

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

[1 mark]

$3Ca(OH)_2 + 2H_3PO_4 \rightarrow Ca(PO_4)_2 + 6H_2O$

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]

$9.76 - (0.17 + 2.59 + 5.33) = 1.67$g of Calcium

$\frac{1.67}{40.1}$	$\frac{0.17}{1}$	$\frac{2.59}{31}$	$\frac{5.33}{16}$
$= 0042$	0.17	0.084	0.333
0.042	0.042	0.042	0.042
$= 1$	4	2	8

$CaH_4P_2O_8$ or $Ca(H_2PO_4)_2$ $x = 2$

12

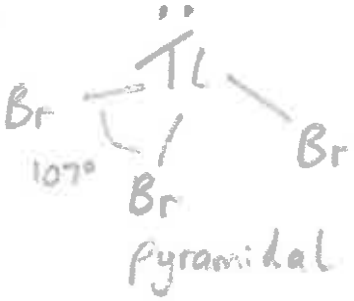
Turn over for the next question

Do not write outside the box

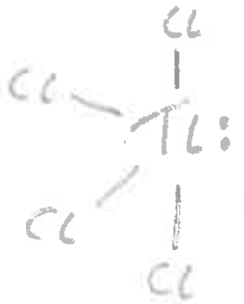
7 Thallium is in Group 3 of the Periodic Table.
Thallium reacts with halogens to form many compounds and ions.

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]



pyramidal



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

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

Ionic bonding. Strong attraction between Tl^+ ions and Br^- ions.

* Remember your definitions! Easy marks.

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

$Tl + \frac{1}{2} Br_2 \rightarrow TlBr$

8

END OF QUESTIONS