Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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

General Certificate of Education
Advanced Subsidiary Examination
January 2013

Chemistry CHEM1

Unit 1 Foundation Chemistry

Thursday 10 January 2013 9.00 am to 10.15 am

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 scientific terminology accurately.

Advice
- You are advised to spend about 50 minutes on **Section A** and about 25 minutes on **Section B**.

Do not write outside the box

Section A

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

1 (a) State the meaning of the term *mass number* of an isotope.

.....

.....

.....

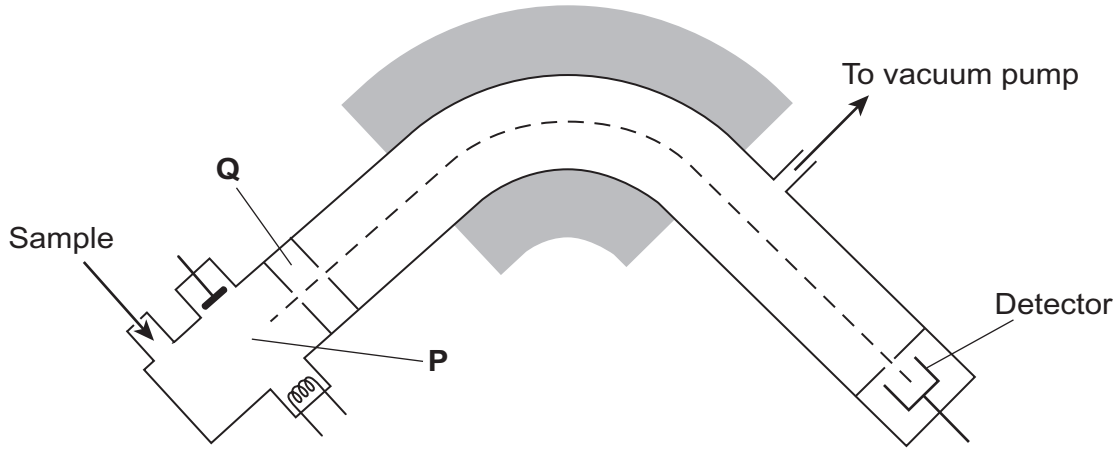
(1 mark)

1 (b) Give the symbol of the element that has an isotope with a mass number of 68 and has 38 neutrons in its nucleus.

.....

(1 mark)

1 (c) The following shows a simplified diagram of a mass spectrometer.



1 (c) (i) State what happens to the sample in the parts labelled **P** and **Q**.

P .....

Q .....

(2 marks)

Do not write outside the box

1 (c) (ii) In a mass spectrometer, the isotopes of an element are separated.
Two measurements for each isotope are recorded on the mass spectrum.

State the **two** measurements that are recorded for each isotope.

Measurement 1 .....

Measurement 2 .....

(2 marks)

1 (d) A sample of element **R** contains isotopes with mass numbers of 206, 207 and 208 in a 1:1:2 ratio of abundance.

1 (d) (i) Calculate the relative atomic mass of **R**. Give your answer to one decimal place.

.....

.....

.....

.....

.....

(3 marks)

1 (d) (ii) Identify **R**.

.....

(1 mark)

1 (d) (iii) All the isotopes of **R** react in the same way with concentrated nitric acid.

State why isotopes of an element have the same chemical properties.

.....

.....

(1 mark)

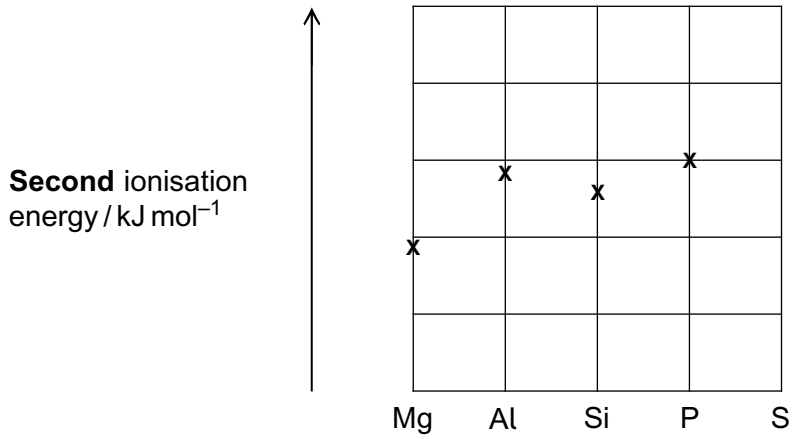
(Extra space) .....

.....

11

Do not write outside the box

2 (a) Use your knowledge of electron configuration and ionisation energies to answer this question.
The following diagram shows the **second** ionisation energies of some Period 3 elements.



2 (a) (i) Draw an '**X**' on the diagram to show the **second** ionisation energy of sulfur.

(1 mark)

2 (a) (ii) Write the full electron configuration of the Al^{2+} ion.

.....

(1 mark)

2 (a) (iii) Write an equation to show the process that occurs when the **second** ionisation energy of aluminium is measured.

.....

(1 mark)

2 (a) (iv) Give **one** reason why the **second** ionisation energy of silicon is lower than the **second** ionisation energy of aluminium.

.....

.....

.....

(1 mark)

Do not write outside the box

2 (b) Predict the element in Period 3 that has the highest **second** ionisation energy. Give a reason for your answer.

Element .....

Reason .....

.....

.....

(2 marks)

2 (c) The following table gives the successive ionisation energies of an element in Period 3.

	First	Second	Third	Fourth	Fifth	Sixth
Ionisation energy / kJ mol^{-1}	786	1580	3230	4360	16 100	19 800

Identify this element.

.....

(1 mark)

2 (d) Explain why the ionisation energy of every element is endothermic.

.....

.....

.....

(1 mark)

(Extra space) .....

.....

8

Do not write outside the box

3 The following table shows the electronegativity values of the elements from lithium to fluorine.

	Li	Be	B	C	N	O	F
Electronegativity	1.0	1.5	2.0	2.5	3.0	3.5	4.0

3 (a) (i) State the meaning of the term *electronegativity*.

.....

.....

.....

(2 marks)

(Extra space) .....

.....

3 (a) (ii) Suggest why the electronegativity of the elements increases from lithium to fluorine.

.....

.....

.....

(2 marks)

(Extra space) .....

.....

3 (b) State the type of bonding in lithium fluoride.
Explain why a lot of energy is needed to melt a sample of solid lithium fluoride.

Bonding .....

Explanation .....

.....

.....

(3 marks)

(Extra space) .....

.....

Do not write outside the box

3 (c) Deduce why the bonding in nitrogen oxide is covalent rather than ionic.

.....

.....

(1 mark)

(Extra space) .....

.....

3 (d) Oxygen forms several different compounds with fluorine.

3 (d) (i) Suggest the type of crystal shown by OF_2

.....

(1 mark)

3 (d) (ii) Write an equation to show how OF_2 reacts with steam to form oxygen and hydrogen fluoride.

.....

(1 mark)

3 (d) (iii) One of these compounds of oxygen and fluorine has a relative molecular mass of 70.0 and contains 54.3% by mass of fluorine.

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

Empirical formula .....

.....

.....

.....

.....

.....

Molecular formula .....

.....

(4 marks)

14

Do not write outside the box

4 The following table shows the boiling points of some straight-chain alkanes.

	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}
Boiling point / °C	–162	–88	–42	–1	36

4 (a) State a process used to separate an alkane from a mixture of these alkanes.

.....

(1 mark)

4 (b) Both C_3H_8 and C_4H_{10} can be liquefied and used as fuels for camping stoves.

Suggest, with a reason, which of these two fuels is liquefied more easily.

.....

.....

.....

(1 mark)

4 (c) Write an equation for the complete combustion of C_4H_{10}

.....

(1 mark)

4 (d) Explain why the complete combustion of C_4H_{10} may contribute to environmental problems.

.....

.....

.....

(1 mark)

4 (e) Balance the following equation that shows how butane is used to make the compound called maleic anhydride.

$$\text{.....}CH_3CH_2CH_2CH_3 + \text{.....}\ O_2 \longrightarrow \text{.....}C_2H_2(CO)_2O + \text{.....}\ H_2O$$

(1 mark)

Do not write outside the box

4 (f) Ethanethiol (C_2H_5SH), a compound with an unpleasant smell, is added to gas to enable leaks from gas pipes to be more easily detected.

4 (f) (i) Write an equation for the combustion of ethanethiol to form carbon dioxide, water and sulfur dioxide.

.....

(1 mark)

4 (f) (ii) Identify a compound that is used to react with the sulfur dioxide in the products of combustion before they enter the atmosphere.

Give **one** reason why this compound reacts with sulfur dioxide.

Substance .....

Reason .....

.....

(2 marks)

4 (f) (iii) Ethanethiol and ethanol molecules have similar shapes.

Explain why ethanol has the higher boiling point.

.....

.....

.....

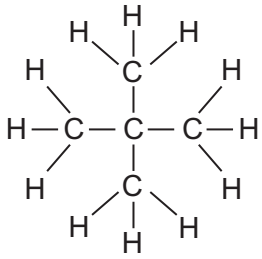
.....

(2 marks)

Question 4 continues on the next page

Do not write outside the box

4 (g) The following compound **X** is an isomer of one of the alkanes in the table on page 8.



4 (g) (i) Give the IUPAC name of **X**.

.....

(1 mark)

4 (g) (ii) **X** has a boiling point of 9.5 ºC.

Explain why the boiling point of **X** is lower than that of its straight-chain isomer.

.....

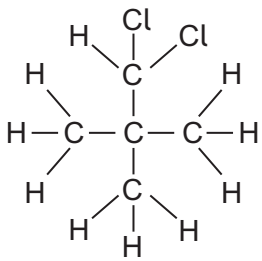
.....

.....

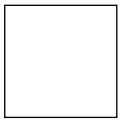
.....

(2 marks)

4 (g) (iii) The following compound **Y** is produced when **X** reacts with chlorine.



Deduce how many **other** position isomers of **Y** can be formed.
Write the number of **other** position isomers in this box.



(1 mark)

Do not write outside the box

4 (h) Cracking of one molecule of an alkane **Z** produces one molecule of ethane, one molecule of propene and two molecules of ethene.

4 (h) (i) Deduce the molecular formula of **Z**.

.....

(1 mark)

4 (h) (ii) State the type of cracking that produces a high proportion of ethene and propene. Give the **two** conditions for this cracking process.

Type of cracking .....

Conditions .....

.....

(2 marks)

17

Turn over for the next question

Do not write outside the box

Section B

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

5 Ammonia is used to make nitric acid (HNO_3) by the Ostwald Process.
Three reactions occur in this process.

Reaction **1** $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$

Reaction **2** $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

Reaction **3** $3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$

5 (a) In one production run, the gases formed in Reaction **1** occupied a total volume of 4.31 m^3 at 25 °C and 100 kPa.

Calculate the amount, in moles, of NO produced.
Give your answer to 3 significant figures.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

.....

.....

.....

.....

.....

.....

(4 marks)

(Extra space) .....

.....

.....

Do not write outside the box

5 (b) In another production run, 3.00 kg of ammonia gas were used in Reaction **1** and all of the NO gas produced was used to make NO_2 gas in Reaction **2**.

5 (b) (i) Calculate the amount, in moles, of ammonia in 3.00 kg.

.....

.....

.....

.....

(2 marks)

5 (b) (ii) Calculate the mass of NO_2 formed from 3.00 kg of ammonia in Reaction **2** assuming an 80.0% yield.
Give your answer in kilograms.
(If you have been unable to calculate an answer for part **(b) (i)**, you may assume a value of 163 mol. This is **not** the correct answer.)

.....

.....

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

Question 5 continues on the next page

Do not write outside the box

5 (c) Consider Reaction **3** in this process.

$$3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$$

Calculate the concentration of nitric acid produced when 0.543 mol of NO_2 is reacted with water and the solution is made up to 250 cm^3.

.....

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

5 (d) Suggest why a leak of NO_2 gas from the Ostwald Process will cause atmospheric pollution.

.....

.....

(1 mark)

5 (e) Give **one** reason why excess air is used in the Ostwald Process.

.....

.....

(1 mark)

5 (f) Ammonia reacts with nitric acid as shown in this equation.

$$NH_3 + HNO_3 \longrightarrow NH_4NO_3$$

Deduce the type of reaction occurring.

.....

(1 mark)

14

Do not write outside the box

6 Chlorine can form molecules and ions that contain only chlorine, or that contain chlorine combined with another element.

6 (a) Use your understanding of the electron pair repulsion theory to draw the shape of the $AsCl_3$ molecule and the shape of the Cl_3^+ ion.
Include any lone pairs of electrons that influence the shape.

Name the shape made by the atoms in the $AsCl_3$ molecule and in the Cl_3^+ ion.

.....

.....

(4 marks)

(Extra space) .....

.....

6 (b) Explain why the $AsCl_4^+$ ion has a bond angle of 109.5º

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

6

END OF QUESTIONS

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Copyright © 2013 AQA and its licensors. All rights reserved.