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**.

Section A

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

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

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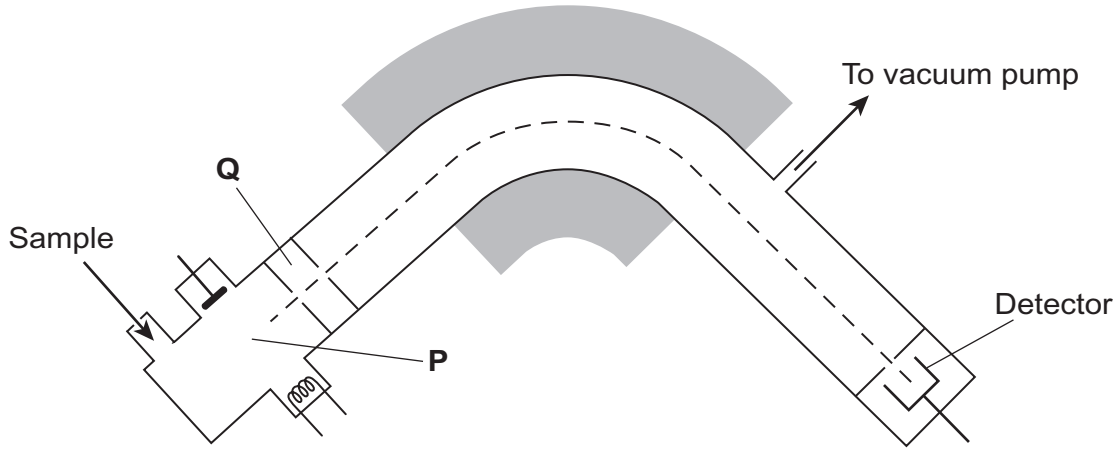
(1 mark)

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)

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.

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(3 marks)

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

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(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.

.....

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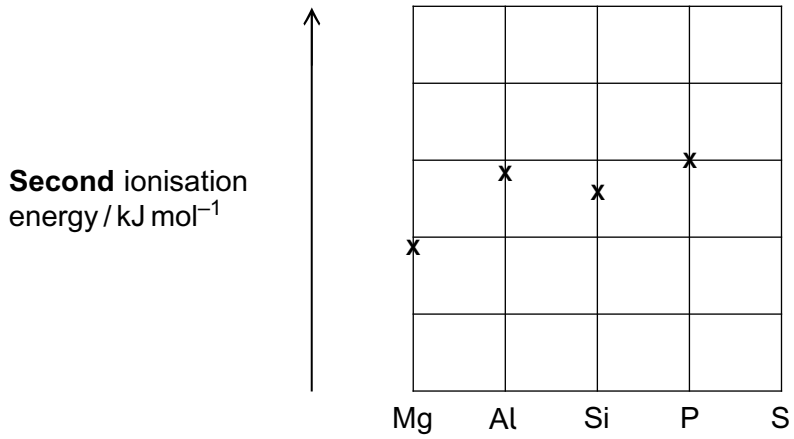
(1 mark)

(Extra space) .....

.....

11

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.

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(1 mark)

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

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*.

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(2 marks)

(Extra space) .....

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

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(2 marks)

(Extra space) .....

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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) .....

.....

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

.....

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(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 .....

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.....

.....

.....

Molecular formula .....

.....

(4 marks)

14

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.

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(1 mark)

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

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(1 mark)

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

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.....

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(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)

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.

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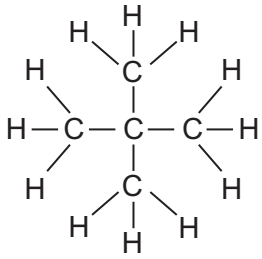
(2 marks)

Question 4 continues on the next page

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**.

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(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.

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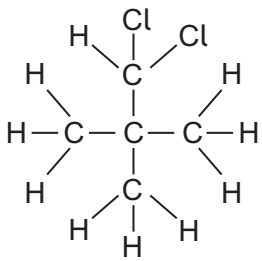
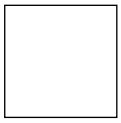
(2 marks)

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)

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

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})

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(4 marks)

(Extra space) .....

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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.

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(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.)

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(3 marks)

(Extra space) .....

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Question 5 continues on the next page

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.

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(2 marks)

(Extra space) .....

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

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(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

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.

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(4 marks)

(Extra space) .....

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

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(2 marks)

(Extra space) .....

.....

6

END OF QUESTIONS

There are no questions printed on this page

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