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 2010

Chemistry CHEM1

Unit 1 Foundation Chemistry

Thursday 14 January 2010 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. **Answers written in margins or on blank pages will not be marked.**
- 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**.

SECTION A

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

1 Ionisation energies provide evidence for the arrangement of electrons in atoms.

1 (a) Complete the electron configuration of the Mg^+ ion.

$1s^2$ .....

(1 mark)

1 (b) (i) State the meaning of the term *first ionisation energy*.

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(2 marks)

1 (b) (ii) Write an equation, including state symbols, to show the reaction that occurs when the **second** ionisation energy of magnesium is measured.

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(1 mark)

1 (b) (iii) Explain why the second ionisation energy of magnesium is greater than the first ionisation energy of magnesium.

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(1 mark)

1 (b) (iv) Use your understanding of electron arrangement to complete the table by suggesting a value for the third ionisation energy of magnesium.

	First	Second	Third	Fourth	Fifth
Ionisation energies of magnesium / kJ mol^{-1}	736	1450		10 500	13 629

(1 mark)

1 (c) State and explain the general trend in the first ionisation energies of the Period 3 elements sodium to chlorine.

Trend .....

Explanation .....

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(3 marks)

(Extra space) .....

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1 (d) State how the element sulfur deviates from the general trend in first ionisation energies across Period 3. Explain your answer.

How sulfur deviates from the trend .....

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Explanation .....

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(3 marks)

(Extra space) .....

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1 (e) A general trend exists in the first ionisation energies of the Period 2 elements lithium to fluorine. Identify **one** element which deviates from this general trend.

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(1 mark)

13

2 Ammonium sulfate reacts with sodium hydroxide to form ammonia, sodium sulfate and water as shown in the equation below.

$$(NH_4)_2SO_4(s) + 2NaOH(aq) \longrightarrow 2NH_3(g) + Na_2SO_4(aq) + 2H_2O(l)$$

2 (a) A 3.14 g sample of ammonium sulfate reacted completely with 39.30 cm^3 of a sodium hydroxide solution.

2 (a) (i) Calculate the amount, in moles, of $(NH_4)_2SO_4$ in 3.14 g of ammonium sulfate.

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(2 marks)

2 (a) (ii) Hence calculate the amount, in moles, of sodium hydroxide which reacted.

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(1 mark)

2 (a) (iii) Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide solution used.

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(1 mark)

2 (b) Calculate the percentage atom economy for the production of ammonia in the reaction between ammonium sulfate and sodium hydroxide.

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(2 marks)

2 (c) Ammonia is manufactured by the Haber Process.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Calculate the percentage atom economy for the production of ammonia in this process.

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.....

(1 mark)

2 (d) A sample of ammonia gas occupied a volume of 1.53×10^{-2} m^3 at 37 °C and a pressure of 100 kPa.
(The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$)

Calculate the amount, in moles, of ammonia in this sample.

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(3 marks)

(Extra space) .....

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2 (e) Glauber's salt is a form of hydrated sodium sulfate that contains 44.1% by mass of sodium sulfate. Hydrated sodium sulfate can be represented by the formula $Na_2SO_4.xH_2O$ where x is an integer. Calculate the value of x.

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(3 marks)

(Extra space) .....

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13

3 The table below shows the boiling points of some hydrogen compounds formed by Group 6 elements.

	H_2O	H_2S	H_2Se	H_2Te
Boiling point / K	373	212	232	271

3 (a) State the strongest type of intermolecular force in water and in hydrogen sulfide (H_2S).

Water .....

Hydrogen sulfide .....

(2 marks)

3 (b) Draw a diagram to show how two molecules of water are attracted to each other by the type of intermolecular force you stated in part (a). Include partial charges and all lone pairs of electrons in your diagram.

(3 marks)

3 (c) Explain why the boiling point of water is much higher than the boiling point of hydrogen sulfide.

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(1 mark)

3 (d) Explain why the boiling points increase from H_2S to H_2Te

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(2 marks)

3 (e) When H^+ ions react with H_2O molecules, H_3O^+ ions are formed.

Name the type of bond formed when H^+ ions react with H_2O molecules.
Explain how this type of bond is formed in the H_3O^+ ion.

Type of bond .....

Explanation .....

.....

(2 marks)

3 (f) Sodium sulfide (Na_2S) has a melting point of 1223 K.
Predict the type of bonding in sodium sulfide and explain why its melting point is high.

Type of bonding .....

Explanation .....

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(3 marks)

(Extra space) .....

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13

Turn over for the next question

4 Alkanes are saturated hydrocarbons which can be obtained from crude oil.
Pentane is an example of an alkane. A molecule of pentane contains five carbon atoms.

4 (a) (i) State the meaning of the term *saturated* and of the term *hydrocarbon* as applied to alkanes.

Saturated .....

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Hydrocarbon .....

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(2 marks)

4 (a) (ii) Give the general formula for the alkanes.

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(1 mark)

4 (b) Pentane burns completely in oxygen.

4 (b) (i) Write an equation for this reaction.

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(1 mark)

4 (b) (ii) State how the products of this reaction may affect the environment.

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(1 mark)

4 (c) Give the name of a solid pollutant which may form when pentane burns incompletely in air.

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(1 mark)

4 (d) One molecule of C_9H_{20} can be cracked to form one molecule of pentane and one other product.

4 (d) (i) Write an equation for this cracking reaction.

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(1 mark)

4 (d) (ii) Suggest a type of compound that can be manufactured from the other product of this cracking reaction.

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(1 mark)

4 (d) (iii) State why a high temperature is needed for cracking reactions to occur.

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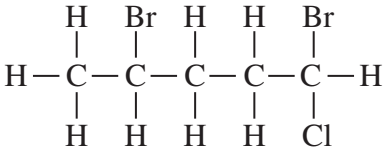
(1 mark)

Question 4 continues on the next page

4 (e) Pentane can react to form the following haloalkane **Q**.



4 (e) (i) Name **Q**.

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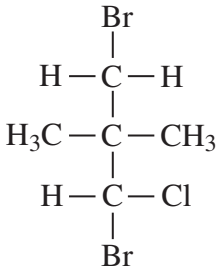
(1 mark)

4 (e) (ii) State the type of structural isomerism shown by **Q** and the haloalkane shown below.



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(1 mark)

11

SECTION B

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

5 A mass spectrometer can be used to investigate the isotopes in an element.

5 (a) Define the term *relative atomic mass* of an element.

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(2 marks)

(Extra space) .....

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5 (b) Element **X** has a relative atomic mass of 47.9

Identify the block in the Periodic Table to which element **X** belongs and give the electron configuration of an atom of element **X**.

Calculate the number of neutrons in the isotope of **X** which has a mass number 49

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(3 marks)

(Extra space) .....

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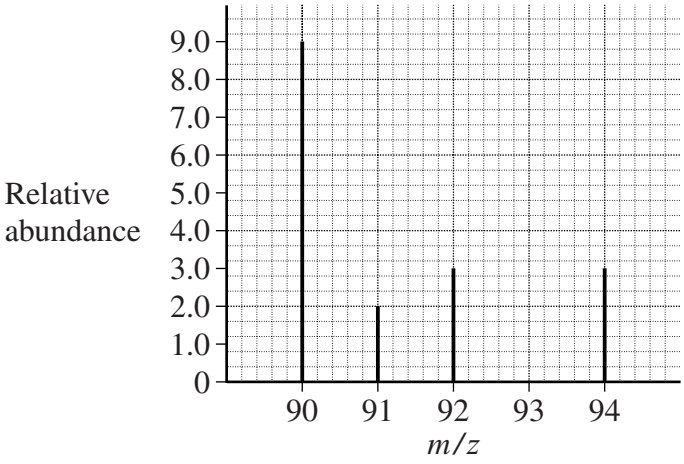
Question 5 continues on the next page

5 (c) The mass spectrum of element **Z** is shown below.

Use this spectrum to calculate the relative atomic mass of **Z**, giving your answer to one decimal place.

Identify element **Z**.



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(4 marks)

(Extra space) .....

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5 (d) State how vaporised atoms of **Z** are converted into $\mathbf{Z}^+$ ions in a mass spectrometer.

State and explain which of the $\mathbf{Z}^+$ ions formed from the isotopes of **Z** in part (c) will be deflected the most in a mass spectrometer.

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(4 marks)

(Extra space) .....

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5 (e) Explain briefly how the relative abundance of an ion is measured in a mass spectrometer.

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(2 marks)

(Extra space) .....

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15

6 A molecule of ClF_3 reacts with a molecule of AsF_5 as shown in the following equation.

$$ClF_3 + AsF_5 \longrightarrow ClF_2^+ + AsF_6^-$$

Use your understanding of electron pair repulsion to draw the shape of the AsF_5 molecule and the shape of the ClF_2^+ ion. Include any lone pairs of electrons.

Name the shape made by the atoms in the AsF_5 molecule and in the ClF_2^+ ion.

Predict the bond angle in the ClF_2^+ ion.

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(5 marks)

(Extra space) .....

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5

END OF QUESTIONS

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