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 2011

Chemistry CHEM1

Unit 1 Foundation Chemistry

Monday 23 May 2011 1.30 pm to 2.45 pm

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.
- 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**.

Do not write outside the box

Section A

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

1 Mass spectrometry can be used to identify isotopes of elements.

1 (a) (i) In terms of fundamental particles, state the difference between isotopes of an element.

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(1 mark)

1 (a) (ii) State why isotopes of an element have the same chemical properties.

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(1 mark)

1 (b) Give the meaning of the term *relative atomic mass.*

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(2 marks)

(Extra space).....

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Do not write outside the box

1 (c) The mass spectrum of element **X** has four peaks. The table below gives the relative abundance of each isotope in a sample of element **X**.

m/*z*	64	66	67	68
Relative abundance	12	8	1	6

1 (c) (i) Calculate the relative atomic mass of element **X**.
Give your answer to one decimal place.

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(3 marks)

1 (c) (ii) Use the Periodic Table to identify the species responsible for the peak at *m*/*z* = 64

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(2 marks)

1 (d) Suggest **one** reason why particles with the same mass and velocity can be deflected by different amounts in the same magnetic field.

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(1 mark)

1 (e) Explain how the detector in a mass spectrometer enables the abundance of an isotope to be measured.

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(2 marks)

(Extra space) .....

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12

Do not write outside the box

2 Norgessaltpeter was the first nitrogen fertiliser to be manufactured in Norway. It has the formula $Ca(NO_3)_2$

2 (a) Norgessaltpeter can be made by the reaction of calcium carbonate with dilute nitric acid as shown by the following equation.

$$CaCO_3(s) + 2HNO_3(aq) \longrightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

In an experiment, an excess of powdered calcium carbonate was added to 36.2 cm^3 of 0.586 mol dm^{-3} nitric acid.

2 (a) (i) Calculate the amount, in moles, of HNO_3 in 36.2 cm^3 of 0.586 mol dm^{-3} nitric acid. Give your answer to 3 significant figures.

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(1 mark)

2 (a) (ii) Calculate the amount, in moles, of $CaCO_3$ that reacted with the nitric acid. Give your answer to 3 significant figures.

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(1 mark)

2 (a) (iii) Calculate the minimum mass of powdered $CaCO_3$ that should be added to react with all of the nitric acid.
Give your answer to 3 significant figures.

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(2 marks)

2 (a) (iv) State the type of reaction that occurs when calcium carbonate reacts with nitric acid.

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(1 mark)

Do not write outside the box

2 (b) Norgessaltpeter decomposes on heating as shown by the following equation.

$$2Ca(NO_3)_2(s) \longrightarrow 2CaO(s) + 4NO_2(g) + O_2(g)$$

A sample of Norgessaltpeter was decomposed completely.

The gases produced occupied a volume of $3.50 \times 10^{-3}\,m^3$ at a pressure of 100 kPa and a temperature of 31 °C.
(The gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

2 (b) (i) Calculate the total amount, in moles, of gases produced.

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(3 marks)

2 (b) (ii) Hence calculate the amount, in moles, of oxygen produced.

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(1 mark)

2 (c) Hydrated calcium nitrate can be represented by the formula $Ca(NO_3)_2.xH_2O$ where x is an integer.

A 6.04 g sample of $Ca(NO_3)_2.xH_2O$ contains 1.84 g of water of crystallisation.

Use this information to calculate a value for x.
Show your working.

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(3 marks)

12

Turn over ▶

Do not write outside the box

3 Fluorine and iodine are elements in Group 7 of the Periodic Table.

3 (a) Explain why iodine has a higher melting point than fluorine.

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(2 marks)

(Extra space).....

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3 (b) (i) Draw the shape of the NHF_2 molecule and the shape of the BF_3 molecule.
Include any lone pairs of electrons that influence the shape.
In each case name the shape.

Shape of NHF_2 Shape of BF_3

Name of shape of NHF_2 .....

Name of shape of BF_3 .....

(4 marks)

3 (b) (ii) Suggest a value for the F—N—F bond angle in NHF_2

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(1 mark)

3 (c) State the strongest type of intermolecular force in a sample of NHF_2

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(1 mark)

Do not write outside the box

3 (d) A molecule of NHF_2 reacts with a molecule of BF_3 as shown in the following equation.

$$NHF_2 + BF_3 \longrightarrow F_2HNBF_3$$

State the type of bond formed between the N atom and the B atom in F_2HNBF_3
Explain how this bond is formed.

Name of type of bond .....

How bond is formed .....

.....

.....

(2 marks)

10

Turn over for the next question

Do not write outside the box

4 There are several types of crystal structure and bonding shown by elements and compounds.

4 (a) (i) Name the type of bonding in the element sodium.

.....

(1 mark)

4 (a) (ii) Use your knowledge of structure and bonding to draw a diagram that shows how the particles are arranged in a crystal of sodium.
You should identify the particles and show a minimum of six particles in a two-dimensional diagram.

(2 marks)

4 (b) Sodium reacts with chlorine to form sodium chloride.

4 (b) (i) Name the type of bonding in sodium chloride.

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(1 mark)

4 (b) (ii) Explain why the melting point of sodium chloride is high.

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(2 marks)

(Extra space) .....

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Do not write outside the box

4 (c) The table below shows the melting points of some sodium halides.

	NaCl	NaBr	NaI
Melting point / K	1074	1020	920

Suggest why the melting point of sodium iodide is lower than the melting point of sodium bromide.

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(1 mark)

7

Turn over for the next question

Do not write outside the box

5 This question is about the first ionisation energies of some elements in the Periodic Table.

5 (a) Write an equation, including state symbols, to show the reaction that occurs when the first ionisation energy of lithium is measured.

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(1 mark)

5 (b) State and explain the general trend in first ionisation energies for the Period 3 elements aluminium to argon.

Trend .....

Explanation .....

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(3 marks)

(Extra space).....

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5 (c) There is a similar general trend in first ionisation energies for the Period 4 elements gallium to krypton.
State how selenium deviates from this general trend and explain your answer.

How selenium deviates from this trend .....

Explanation .....

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(3 marks)

(Extra space).....

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5 (d) Suggest why the first ionisation energy of krypton is lower than the first ionisation energy of argon.

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(1 mark)

Do not write outside the box

5 (e) The table below gives the successive ionisation energies of an element.

	First	Second	Third	Fourth	Fifth
Ionisation energy / kJ mol^{-1}	590	1150	4940	6480	8120

Deduce the group in the Periodic Table that contains this element.

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(1 mark)

5 (f) Identify the element that has a 5+ ion with an electron configuration of $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$

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(1 mark)

10

Turn over for the next question

Do not write outside the box

Section B

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

6 (a) There is a risk of gas explosions in coal mines. This risk is mainly due to the presence of methane. If the percentage of coal-mine methane (CMM) in the air in the mine is greater than 15%, the explosion risk is much lower. CMM slowly escapes from the mine into the atmosphere.

Write an equation to show the complete combustion of methane.

Suggest **one** reason why there is a much lower risk of an explosion if the percentage of CMM is greater than 15%.

State why it is beneficial to the environment to collect the CMM rather than allowing it to escape into the atmosphere.

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(3 marks)

(Extra space) .....

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Do not write outside the box

6 (b) Methane can be obtained from crude oil. Some of this crude oil contains an impurity called methanethiol (CH_3SH). This impurity causes environmental problems when burned.

Write an equation to show the complete combustion of methanethiol.

State why calcium oxide can be used to remove the sulfur-containing product of this combustion reaction.

State **one** pollution problem that is caused by the release of this sulfur-containing product into the atmosphere.

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(3 marks)

(Extra space).....

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6

Turn over for the next question

Do not write outside the box

7 Pentane is a member of the alkane homologous series.

7 (a) Give the general formula for the homologous series of alkanes.

.....

(1 mark)

7 (b) One of the structural isomers of pentane is 2,2-dimethylpropane.

Draw the displayed formula of 2,2-dimethylpropane.

State the type of structural isomerism shown.

.....

(2 marks)

Do not write outside the box

7 (c) A molecule of hydrocarbon **Y** can be thermally cracked to form one molecule of pentane and two molecules of ethene only.

Deduce the molecular formula of **Y**.

State why high temperatures are necessary for cracking reactions to occur.

Give **one** reason why thermal cracking reactions are carried out in industry.

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(3 marks)

(Extra space) .....

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7 (d) Write an equation for the incomplete combustion of pentane to form a solid pollutant.

Suggest why this solid pollutant is an environmental problem.

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(2 marks)

(Extra space) .....

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Question 7 continues on the next page

Do not write outside the box

7 (e) Pentane can react with chlorine as shown in the following equation.

$$C_5H_{12} + Cl_2 \longrightarrow C_5H_{11}Cl + HCl$$

Calculate the percentage atom economy for the formation of $C_5H_{11}Cl$

Deduce how many straight-chain isomers of $C_5H_{11}Cl$ could be formed.

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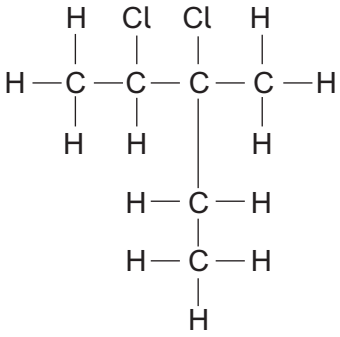
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(3 marks)

(Extra space).....

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7 (f) Consider the following compound.



Name this compound.

Deduce the empirical formula of this compound.

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(2 marks)

13

END OF QUESTIONS

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