Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

AS CHEMISTRY

Unit 1 Foundation Chemistry

Friday 27 May 2016 Morning Time allowed: 1 hour 15 minutes

Materials

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a calculator.

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**.

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Section A

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

1 Mass spectrometry is a technique that can be used to separate isotopes of an element in order to determine relative atomic mass.

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

[2 marks]

1 (b) In a spectrometer, isotopes are converted into ions that are separated by deflection and are then detected.

1 (b) (i) Ions are deflected using

[1 mark]

Tick (✓) one box.

- an electric field ☐
- an electron gun ☐
- a magnetic field ☐
- a potential difference ☐

1 (b) (ii) Describe how the ions are detected.

[2 marks]

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1 (c) **Table 1** gives the relative abundance of each isotope in the mass spectrum of a sample of silicon, recorded using a high-resolution mass spectrometer.

Table 1

m/*z*	Relative abundance / %
27.976	92.23
28.976	4.67
29.973	3.10

Use the data to calculate a value for the relative atomic mass of this sample of silicon. Give your answer to 3 decimal places.

[2 marks]

1 (d) A second mass spectrum was recorded for the same sample of silicon.
The energy of the electrons from the electron gun was higher for this second spectrum.

State and explain **one** similarity and **one** difference between the two spectra.

[4 marks]

Similarity

Explanation

Difference

Explanation

11

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2 (a) Van der Waals' forces exist between all molecules.

Explain how these forces arise.

[3 marks]

2 (b) **Table 2** shows the boiling points of methanol (CH_3OH) and methanethiol (CH_3SH).

Table 2

Compound	Boiling point / ºC
Methanol	65
Methanethiol	6

2 (b) (i) Explain, in terms of their intermolecular forces, why the boiling points of these compounds are different.

[3 marks]

2 (b) (ii) Suggest how a mixture of methanol and methanethiol could be separated.

[1 mark]

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2 (c) Suggest why methaneselenol (CH_3SeH) has a higher boiling point than methanethiol (CH_3SH).

[2 marks]

2 (d) Sulfur forms many molecular compounds with the halogens.

2 (d) (i) Draw the shape of an SF_6 and of an SF_4 molecule.
Include any lone pairs that influence the shape.
State the bond angle(s) in SF_6 and in SF_4
Name the shape of SF_6

[6 marks]

	SF_6	**SF_4**
Shape		
Bond angle(s)		
Name of shape		

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2 (d) (ii) SCl_2 reacts with NaF to form SF_4 and S_2Cl_2 and one other product.

Write an equation for the reaction.

[2 marks]

17

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3 Compounds containing Cu^{2+}, OH^- and CO_3^{2-} ions are sometimes described as basic copper carbonates.

3 (a) Solid $Cu_2(OH)_2CO_3$ is added to an excess of dilute hydrochloric acid.
A solution of copper(II) chloride is formed, together with two other products.

3 (a) (i) Write an equation for the reaction.

[2 marks]

3 (a) (ii) Suggest **one** observation that could be made during the reaction.

[1 mark]

3 (b) A 5.000 g sample of a different basic copper carbonate contains 0.348 g of carbon, 0.029 g of hydrogen and 1.858 g of oxygen.

3 (b) (i) State what is meant by the term empirical formula.

[1 mark]

3 (b) (ii) Calculate the empirical formula of this basic copper carbonate.
Show your working.

[3 marks]

7

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4 (a) Octane (C_8H_{18}) is an important compound in petrol.

4 (a) (i) Identify the homologous series to which octane belongs.

[1 mark]

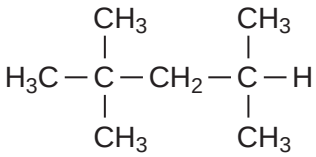
_____

4 (a) (ii) Write an equation to show the complete combustion of C_8H_{18}

[1 mark]

_____

4 (a) (iii) An isomer of octane used to improve the performance of car engines is shown.

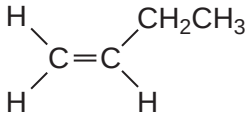


Give the IUPAC name of this isomer.

[1 mark]

_____

4 (b) Compound **X** is produced when an alkane is cracked.



X

4 (b) (i) Give the IUPAC name for compound **X**.

[1 mark]

_____

4 (b) (ii) One molecule of an alkane is cracked to produce one molecule of compound **X**, one molecule of octane and one molecule of ethene.

Deduce the molecular formula of this alkane.

[1 mark]

_____

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4 (b) (iii) Name the type of cracking that produces a high yield of compound **X**.
Give **two** conditions required for this process.

[2 marks]

Type of cracking _____

Conditions _____

_____

Question 4 continues on the next page

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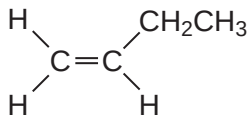
4 (b) (iv) Compound **X** has several isomers. The structure of **X** is repeated here.



X

Draw the displayed formula of a chain isomer, a position isomer and a functional group isomer of compound **X**.

[3 marks]

Type of isomer	Displayed formula of isomer of compound X
Chain	
Position	
Functional group	

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Section B

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

5 This question is about the periodicity of the Period 3 elements.

5 (a) State and explain the general trend in first ionisation energy across Period 3.

[4 marks]

5 (b) Give one example of an element which deviates from the general trend in first ionisation energy across Period 3.

Explain why this deviation occurs.

[3 marks]

Turn over ▶

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5 (c) **Table 3** shows successive ionisation energies of an element **Y** in Period 3.

Table 3

Ionisation number	1	2	3	4	5	6	7	8
Ionisation energy / kJ mol^{-1}	1000	2260	3390	4540	6990	8490	27 100	31 700

Identify element **Y**.

Explain your answer using data from **Table 3**.

[2 marks]

5 (d) Identify the Period 3 element that has the highest melting point.

Explain your answer by reference to structure and bonding.

[4 marks]

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Turn over for the next question

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6 Phosphoric(V) acid (H_3PO_4) is an important chemical. It can be made by two methods. The first method is a two-step process.

6 (a) In the first step of the first method, phosphorus is burned in air at 500 ºC to produce gaseous phosphorus(V) oxide.

$$P_4(s) + 5O_2(g) \longrightarrow P_4O_{10}(g)$$

220 g of phosphorus were reacted with an excess of air.

Calculate the volume, in m^3, of gaseous phosphorus(V) oxide produced at a pressure of 101 kPa and a temperature of 500 ºC.
The gas constant $R = 8.31$ J K^{-1} mol^{-1}
Give your answer to 3 significant figures.

[4 marks]

6 (b) In the second step of the first method, phosphorus(V) oxide reacts with water to form phosphoric(V) acid.

$$P_4O_{10}(s) + 6H_2O(l) \longrightarrow 4H_3PO_4(aq)$$

Calculate the mass of phosphorus(V) oxide required to produce 3.00 m^3 of 5.00 mol dm^{-3} phosphoric(V) acid solution.

[3 marks]

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6 (c) In the second method to produce phosphoric(V) acid, 3.50 kg of $Ca_3(PO_4)_2$ are added to an excess of aqueous sulfuric acid.

$$Ca_3(PO_4)_2(s) + 3H_2SO_4(aq) \longrightarrow 2H_3PO_4(aq) + 3CaSO_4(s)$$

1.09 kg of phosphoric(V) acid are produced.

Calculate the percentage yield of phosphoric(V) acid.

[4 marks]

6 (d) Explain whether the first method or the second method of production of phosphoric acid has the higher atom economy.
You are not required to do a calculation.

[1 mark]

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END OF QUESTIONS

There are no questions printed on this page

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