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Centre number

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# 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**.



J U N 1 6 C H E M 1 0 1

WMP/Jun16/E4

**CHEM1**

**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]**

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**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**

<i>m/z</i>	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]**

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- 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 \_\_\_\_\_

\_\_\_\_\_



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

Explain how these forces arise.

**[3 marks]**

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**2 (b)** Table 2 shows the boiling points of methanol ( $\text{CH}_3\text{OH}$ ) and methanethiol ( $\text{CH}_3\text{SH}$ ).

**Table 2**

Compound	Boiling point / °C
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]**

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**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 ( $\text{CH}_3\text{SeH}$ ) has a higher boiling point than methanethiol ( $\text{CH}_3\text{SH}$ ).

[2 marks]

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

- 2 (d) (i)** Draw the shape of an  $\text{SF}_6$  and of an  $\text{SF}_4$  molecule.  
Include any lone pairs that influence the shape.  
State the bond angle(s) in  $\text{SF}_6$  and in  $\text{SF}_4$   
Name the shape of  $\text{SF}_6$

[6 marks]

	$\text{SF}_6$	$\text{SF}_4$
Shape		
Bond angle(s)		
Name of shape		

Turn over ►



**2 (d) (ii)**  $\text{SCl}_2$  reacts with  $\text{NaF}$  to form  $\text{SF}_4$  and  $\text{S}_2\text{Cl}_2$  and one other product.

Write an equation for the reaction.

**[2 marks]**

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**3** Compounds containing  $\text{Cu}^{2+}$ ,  $\text{OH}^-$  and  $\text{CO}_3^{2-}$  ions are sometimes described as basic copper carbonates.

**3 (a)** Solid  $\text{Cu}_2(\text{OH})_2\text{CO}_3$  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]

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

[1 mark]

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**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]

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

[3 marks]

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4 (a) Octane (C<sub>8</sub>H<sub>18</sub>) is an important compound in petrol.

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

[1 mark]

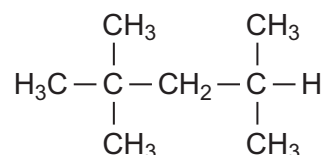
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4 (a) (ii) Write an equation to show the complete combustion of C<sub>8</sub>H<sub>18</sub>

[1 mark]

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

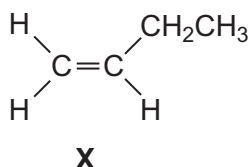


Give the IUPAC name of this isomer.

[1 mark]

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



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

[1 mark]

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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 \_\_\_\_\_

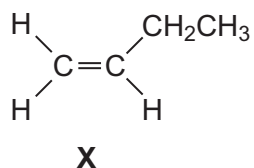
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**Question 4 continues on the next page**

**Turn over ►**



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



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	



**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]**

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**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]**

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**Turn over ►**



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 <sup>-1</sup>	1000	2260	3390	4540	6990	8490	27 100	31 700

Identify element Y.

Explain your answer using data from Table 3.

[2 marks]

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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**

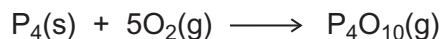
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**6** Phosphoric(V) acid ( $\text{H}_3\text{PO}_4$ ) is an important chemical. It can be made by two methods. The first method is a two-step process.

**6 (a)** In the first step of the first method, phosphorus is burned in air at  $500\text{ }^\circ\text{C}$  to produce gaseous phosphorus(V) oxide.



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

Calculate the volume, in  $\text{m}^3$ , of gaseous phosphorus(V) oxide produced at a pressure of 101 kPa and a temperature of  $500\text{ }^\circ\text{C}$ .

The gas constant  $R = 8.31\text{ J K}^{-1}\text{ mol}^{-1}$

Give your answer to 3 significant figures.

**[4 marks]**

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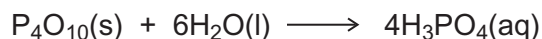
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**6 (b)** In the second step of the first method, phosphorus(V) oxide reacts with water to form phosphoric(V) acid.



Calculate the mass of phosphorus(V) oxide required to produce  $3.00\text{ m}^3$  of  $5.00\text{ mol dm}^{-3}$  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  $\text{Ca}_3(\text{PO}_4)_2$  are added to an excess of aqueous sulfuric acid.



1.09 kg of phosphoric(V) acid are produced.

Calculate the percentage yield of phosphoric(V) acid.

**[4 marks]**

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- 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**



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