AQA

Please write clearly in block capitals.

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

Surname Model Answer

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**.

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]

Average mass of 1 atom
1/12 mass of one atom of C^{12}

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 ☐

If it states deflection then it is magnetic field!

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

[2 marks]

The ions hit the metal plate of the detector and electrons flow from the plate to the positive ion where they are accepted. This causes a current to be generated.

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]

$$\frac{(92.23 \times 27.976) + (4.67 \times 28.976) + (3.10 \times 29.973)}{100}$$

$$= 28.085$$

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 peaks would be at the same m/z

Explanation It is the same sample.

Difference Additional peaks at smaller m/z values

Explanation More than one electron can be removed.

With a high energy electron gun you get +2 or +3 ions formed.

11

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

Explain how these forces arise.

[3 marks]

As electrons are always moving, at any one moment in time a temporary dipole could occur. This temporary dipole could then induce a dipole in a neighbouring molecule. These partial +ve and -ve charges attract each other. (M$^{\delta+}$–M$^{\delta-}$ M$^{\delta+}$–M$^{\delta-}$ M$^{\delta+}$–M$^{\delta-}$) etc.

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

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]

Methanol has hydrogen bonding whereas the strongest intermolecular forces methanethiol has is dipole-dipole. Hydrogen bonding is stronger than dipole-dipole ∴ has a higher boiling point.

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

[1 mark]

Distillation (separation by boiling point!)

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

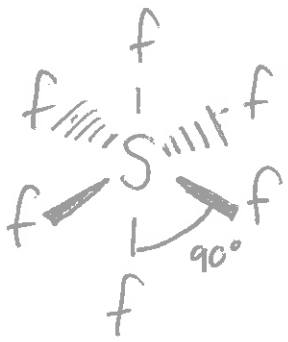
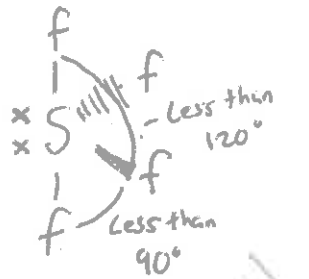
[2 marks]

Methaneselanol is a larger molecule as Se is a bigger atom with more electrons - this forms stronger Van der Waals forces between the molecules.

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	grp bonds (6 + 6) ÷ 2 = 6 electron pairs. No lone pairs. 	grp bonds (6 + 4) ÷ 2 = 5 electron pairs 1 lone pair  (this is sometimes called the sawhorse or seesaw)
Bond angle(s)	90°	85 - 89° 100 - 119°
Name of shape	octahedral	

Turn over ▶

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]

$3SCl_2 + 4NaF \longrightarrow SF_4 + S_2Cl_2 + 4NaCl$

If you look at what was not given to you I think it is fairly obvious that it is NaCl, after that you just need to balance.

17

Do not write outside the box

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]**

metal carbonate + acid gives salt + CO_2 + H_2O!!

$Cu_2(OH)_2CO_3 + 4HCl \rightarrow 2CuCl_2 + CO_2 + 3H_2O$

3 (a) (ii) Suggest **one** observation that could be made during the reaction. **[1 mark]**

effervescence from CO_2 gas released.

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]**

Lowest whole number ratio.

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

Cu = 5g − (0.0348 + 0.029 + 1.858) = 2.765

C	H	O	Cu
$\frac{0.348}{12} = 0.029$	$\frac{0.029}{1} = 0.029$	$\frac{1.858}{16} = 0.116125$	$\frac{2.765}{63.5} = 0.0435$
÷ 0.029	÷ 0.029	÷ 0.029	÷ 0.029
= 1	= 1	= 4	= 1.5
× 2 = 2	2	8	3

$\therefore Cu_3C_2H_2O_8$

DO NOT bother collect it

7

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]

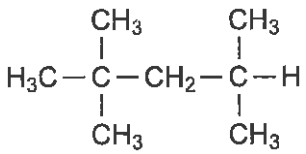
Alkanes

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

[1 mark]

$C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O$

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

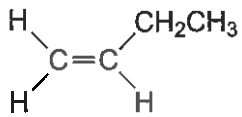


Give the IUPAC name of this isomer.

[1 mark]

2,2,4-trimethylpentane

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



X

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

[1 mark]

But-1-ene

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]

$C_{14}H_{30}$

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

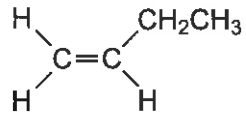
[2 marks]

Type of cracking Thermal

Conditions High temperature and high pressure.

Question 4 continues on the next page

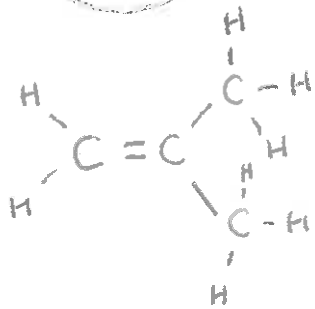
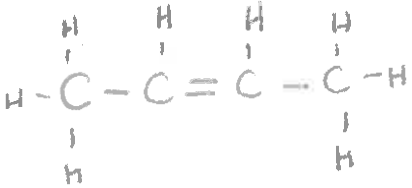
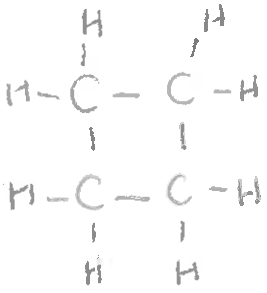
4 (b) (iv) Compound **X** has several isomers. The structure of **X** is repeated here.



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	 DO NOT MISS the displayed part!!
Position	
Functional group	 If asked for a functional group isomer of an alkene then it will be a ring structure!

10

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]

- Increases across period 3.
- It increases as nuclear charge increases across a period but it has similar shielding. This means that generally there is a stronger attraction from nucleus to outer electrons.

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]

Aluminium is lower than Magnesium as there is now a sub orbital change (from 3s to 3p). The 3p is higher in energy so is slightly easier to remove.

Could also talk about repulsion of electrons in sub-shell!

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**.

Linear until no. 7!! This shows an orbital change! ∴ grp 6 element.

[2 marks]

Y = Sulfur. This is because the ionisation energy value jumped between 6 + 7 - showing an orbital level change.

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

Explain your answer by reference to structure and bonding.

[4 marks]

Silicon. It has a giant covalent structure with many strong covalent bonds which required large amounts of energy to break.

13

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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 °C 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 °C.
The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$
Give your answer to 3 significant figures.

[4 marks]

Mr of P4 → 220 / 124 = 1·78 moles temp = 500°C or 773K

pressure = 101000Pa.

$PV = nRT$ $V = \frac{nRT}{P}$

$V = \frac{1.78 \times 8.31 \times 773}{101000} = 0.113\ m^3$

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]

$C = \frac{m}{V}$ $5.00 \times (3 \times 1000) = 15000$ moles of H_3PO_4 (m^3 to dm^3)

$\frac{15000}{4} = 3750$ moles of P_4O_{10} Mr of P_4O_{10}

moles = mass / mr $3750 \times 284 = 1065000\ g$ or 1065 kg.

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]

3.50 × 1000 = 3500g

3500 / 310.3 = 11.28 moles of $Ca_3(PO_4)_2$ (mr of $Ca_3(PO_4)_2$)

ratio of 1:2 from equation.

11.28 × 2 = 22.56 moles of H_3PO_4

22.56 × 98 = 2210.88 g or 2.21 kg (theoretical yield)

(actual yield) 1.09 kg / 2.21 kg (theoretical yield) × 100 = 49.3 % yield.

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]

Method 1 because there was only one product and hence 100 % atom economy. ✓

12

END OF QUESTIONS

There are no questions printed on this page

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