States of Matter
Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	States of Matter
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 2

Time Allowed: **59 minutes**

Score: **/49**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 Compound **A** is an organic compound which contains carbon, hydrogen and oxygen.

When 0.240 g of the vapour of **A** is slowly passed over a large quantity of heated copper(II) oxide, CuO, the organic compound **A** is completely oxidised to carbon dioxide and water. Copper is the only other product of the reaction.

The products are collected and it is found that 0.352 g of CO_2 and 0.144 g of H_2O are formed.

(a) In this section, give your answers to <u>three</u> decimal places.

    (i) Calculate the mass of carbon present in 0.352 g of CO_2.

        Use this value to calculate the amount, in moles, of carbon atoms present in 0.240 g of **A**.

    (ii) Calculate the mass of hydrogen present in 0.144 g of H_2O.

        Use this value to calculate the amount, in moles, of hydrogen atoms present in 0.240 g of **A**.

    (iii) Use your answers to calculate the mass of oxygen present in 0.240 g of **A**.

        Use this value to calculate the amount, in moles, of oxygen atoms present in 0.240 g of **A**.

[6]

(b) Use your answers to **(a)** to calculate the empirical formula of **A**.

[1]

(c) When a 0.148 g sample of **A** was vapourised at 60°C, the vapour occupied a volume of 67.7 cm^3 at a pressure of 101 kPa.

   (i) Use the general gas equation $pV = nRT$ to calculate M_r of **A**.

M_r =....................

   (ii) Hence calculate the molecular formula of **A**.

[3]

(d) Compound **A** is a liquid which does **not** react with 2,4-dinitrophenylhydrazine reagent or with aqueous bromine.

Suggest **two** structural formulae for **A**.

[2]

(e) Compound **A** contains only carbon, hydrogen and oxygen.

Explain how the information on the opposite page about the reaction of **A** with CuO confirms this statement.

....

.... [1]

[Total: 13]

2 Copper, proton number 29, and argon, proton number 18, are elements which have different physical and chemical properties.

In the solid state, each element has the same face-centred cubic crystal structure which is shown below.
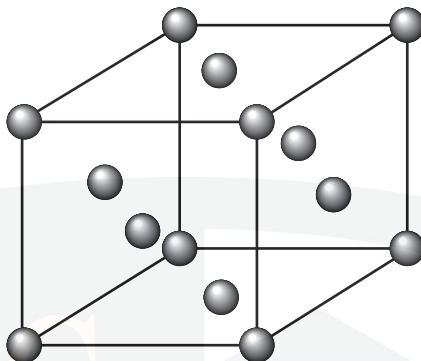
The particles present in such a crystal may be atoms, molecules, anions or cations. In the diagram above, the particles present are represented by ⚪.

(a) Which types of particle are present in the copper and argon crystals?
In each case, give their formula.

element	particle	ormula
copper		
argon		

[2]

At room temperature, copper is a solid while argon is a gas.

(b) Explain these observations in terms of the forces present in **each** solid structure.

....

....

....

....

....

.... [4]

Although copper is a relatively unreactive element, when it is heated to a high temperature in an excess of chlorine, copper(II) chloride is formed.

When a mixture of argon and chlorine is heated to a high temperature, no reaction occurs.

(c) (i) How does chlorine behave in its reaction with copper?

....

(ii) Suggest a reason for the lack of a reaction between argon and chlorine.

....

....

[2]

The melting points of the noble gases neon to xenon are given below.

	Ne	Ar	Kr	Xe
melting point/K	25	84	116	161

(d) Explain why there is an increase in melting point from neon to xenon.

....

....

.... [2]

[Total: 10]

3 An organic compound, **E**, has the following composition by mass:
C, 48.7%; H, 8.1%; O, 43.2%.

(a) Calculate the empirical formula of **E**.

[2]

(b) When vaporised in a suitable apparatus, 0.130 g of **E** occupied a volume of 58.0 cm^3 at 127 °C and 1.00×10^5 N m^{-2}.

(i) Use the expression $pV = \dfrac{mRT}{M_r}$ to calculate M_r of **E**,

where m is the mass of **E**.

(ii) Hence calculate the molecular formula of **E**.

[4]

(c) Compound **F**, is an ester with the molecular formula $C_4H_8O_2$.

F is one of four isomers, **S**, **T**, **U**, and **V**, that are all esters.

In the boxes below, the structural formula of **S** is given.

Draw the structural formulae of the other **three** isomers of **F** that are esters.

HCO$_2$CH(CH$_3$)$_2$			
S	**T**	**U**	**V**

[3]

(d) When the ester **F** is hydrolysed, an alcohol **G** is produced.

    (i) What reagent can be used to hydrolyse an ester to an alcohol?

    ....

    (ii) What other type of organic compound is produced at the same time?

    ....

                                                                    [2]

(e) On mild oxidation, the alcohol **G** gives a compound **H** which forms a silver mirror with Tollens' reagent.

    (i) What functional group does the reaction with Tollens' reagent show to be present in compound **H**? Give the name of this group.

    ....

    (ii) What type of alcohol is **G**?

    ....

    (iii) What could be the structural formula of the alcohol **G**?

                                                                    [3]

(f) **(i)** Which of the four isomers, **S**, **T**, **U**, or **V**, could **not** be **F**?

    ....

    (ii) Explain your answer.

    ....

    ....

                                                                   [2]

                                                                                  [Total: 16]

4 Mohr's salt is a pale green crystalline solid which is soluble in water. Mohr's salt is a 'double salt' which contains

two cations, one of which is Fe^{2+},

one anion which is SO_4^{2-},

and water of crystallisation.

(a) The identity of the second cation was determined by the following test.
Solid Mohr's salt was heated with solid sodium hydroxide and a colourless gas was evolved. The gas readily dissolved in water giving an alkaline solution.

(i) What is the gas?

....

(ii) What is the formula of the second cation identified by this test?

....

(iii) In this test, a grey/green solid residue was also formed.

Suggest a name **or** formula for this solid.

....

[3]

(b) The identity of the anion present in Mohr's salt was confirmed by adding dilute hydrochloric acid followed by aqueous barium chloride to an aqueous solution of Mohr's salt. A white precipitate was formed.

Suggest the identity of the white precipitate.

....[1]

(c) When a double salt such as Mohr's salt is made, the two individual salts are mixed together in a 1:1 molar ratio, dissolved in water and the solution crystallised.

(i) Give the formula of **each** of the two salts that would be mixed to make the double salt, Mohr's salt.

salt 1 ....

salt 2 ....

(ii) Calculate the relative formula mass of **each** of the salts present in Mohr's salt.

salt 1

relative formula mass of salt 1 ....

salt 2

relative formula mass of salt 2 ....

(iii) The crystals of the double salt contain water of crystallisation.

The relative formula mass of Mohr's salt is 392. Use your answers to **(ii)** to calculate the number of moles of water of crystallisation present in one mole of Mohr's salt.

[6]

[Total: 10]