

# **2. Atoms, molecules and stoichiometry**

## **2.3 Formulas**

### **Paper 2**

Question Paper

**1** Compound **V** is a liquid.

**V** contains 77.2% carbon, 11.4% hydrogen and 11.4% oxygen by mass.

**V** has a relative molecular mass of 280.

(a) Calculate the molecular formula of **V**. Show your working.

molecular formula of **V** = ..... [3]

**2** **Z** is a molecule which contains the elements carbon, hydrogen and oxygen only.

**Z** contains only alkene and carboxyl functional groups.

(b) Table 6.2 shows the percentage by mass of each element present in **Z**.

**Table 6.2**

element	percentage by mass / %
carbon	41.38
hydrogen	3.45
oxygen	55.17

Using the data in Table 6.2, demonstrate that the empirical formula of **Z** is CHO.  
Show your working.

[1]

**3** Species such as  $\text{NH}_4^+$ ,  $\text{CO}_3^{2-}$  and  $\text{PO}_4^{3-}$  are examples of molecular ions.

(d) There are many naturally occurring hydrated compounds that contain the anion  $\text{PO}_4^{3-}$ .

(i) Name the anion  $\text{PO}_4^{3-}$ .

..... [1]

(ii) Struvite is a soft hydrated mineral with  $M_r = 245.3$ . The anhydrous form of the mineral has the formula  $\text{NH}_4\text{MgPO}_4$ .

Calculate the number of molecules of water of crystallisation in struvite.

Give your answer to the nearest integer. Show your working.

number of molecules of water of crystallisation = ..... [2]

**4** Ethanedioic acid,  $\text{HO}_2\text{CCO}_2\text{H}$ , has a relative molecular mass of 90.0.

(a) (ii) State the empirical formula of ethanedioic acid.

..... [1]

(b) Solid ethanedioic acid reacts with aqueous calcium ions to make a precipitate of calcium ethanedioate,  $\text{CaC}_2\text{O}_4$ .

$\text{CaC}_2\text{O}_4$  breaks down when heated to form calcium oxide, carbon dioxide and carbon monoxide.

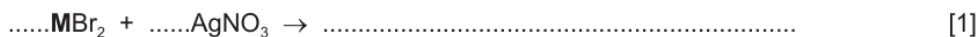
(i) Construct an equation to represent the reaction of  $\text{CaC}_2\text{O}_4$  when heated. Include state symbols.

..... [2]

- 5 A Group 2 metal combines with bromine to form a crystalline solid,  $\text{MBr}_2$ .

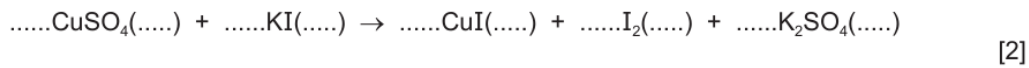
Excess aqueous  $\text{AgNO}_3$  is added to a solution of  $\text{MBr}_2$  and a precipitate forms. The mixture is filtered. The precipitate is dried and the mass of the precipitate is recorded.

- (b) Complete the equation to represent the reaction between  $\text{MBr}_2$  and  $\text{AgNO}_3$ .



- 6 (a) The equation shown in (a)(i) describes the reaction which occurs when aqueous potassium iodide is added to aqueous copper(II) sulfate. A white precipitate of copper(I) iodide forms in a brown solution of iodine and potassium sulfate.

- (i) Balance the equation and include state symbols.



- 7 (b) In the reaction described in (a)(i), a student uses 17.43 g of  $\text{CuSO}_4 \cdot y\text{H}_2\text{O}$ . By further titration of the reaction products the student concludes that the total amount of  $\text{CuSO}_4$  in the sample is 0.0982 mol.

Use the *Data Booklet* to complete the table to calculate the value of  $y$ , where  $y$  is an integer. Show your working.

mass of 0.0982 mol $\text{CuSO}_4$	..... g
amount of $\text{H}_2\text{O}$ in 17.43 g of $\text{CuSO}_4 \cdot y\text{H}_2\text{O}$	..... mol $\text{H}_2\text{O}$
value of $y$	$y = \dots\dots\dots$

[4]

**8** Magnesium silicide,  $\text{Mg}_2\text{Si}$ , is a compound made by heating magnesium with sand.

**(b)** When solid  $\text{Mg}_2\text{Si}$  is added to water, silane gas,  $\text{SiH}_4$ , and a solution of magnesium hydroxide are produced.

Construct the equation for this reaction. Include state symbols.

..... [2]

**9** Many naturally occurring esters are used as flavourings in food.

**(b)** Ester **W** is made up of 54.5% carbon, 9.1% hydrogen and 36.4% oxygen.

**(i)** Calculate the empirical formula of **W**.

[3]