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 NH_4^+, CO_3^{2-} and PO_4^{3-} are examples of molecular ions.

(d) There are many naturally occurring hydrated compounds that contain the anion PO_4^{3-}.

(i) Name the anion 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 NH_4MgPO_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, HO_2CCO_2H, 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, CaC_2O_4.

CaC_2O_4 breaks down when heated to form calcium oxide, carbon dioxide and carbon monoxide.

(i) Construct an equation to represent the reaction of CaC_2O_4 when heated. Include state symbols.

..... [2]

5 A Group 2 metal combines with bromine to form a crystalline solid, **M**Br_2.

Excess aqueous $AgNO_3$ is added to a solution of **M**Br_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 **M**Br_2 and $AgNO_3$.

.....**M**Br_2 + ...$AgNO_3$ → ..... [1]

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.

.....$CuSO_4$(.....) + ...KI(.....) → .....CuI(.....) + ...I_2(.....) + ...K_2SO_4(.....)

[2]

7 **(b)** In the reaction described in **(a)(i)**, a student uses 17.43 g of $CuSO_4$•**y**H_2O. By further titration of the reaction products the student concludes that the total amount of $CuSO_4$ 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 $CuSO_4$	..... g
amount of H_2O in 17.43 g of $CuSO_4$•**y**H_2O	..... mol H_2O
value of **y**	**y** = ...

[4]

8 Magnesium silicide, Mg_2Si, is a compound made by heating magnesium with sand.

(b) When solid Mg_2Si is added to water, silane gas, 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]