Formulae and Hydrated Salts Map

Cambridge International AS & A Level Chemistry · Topic 2 Atoms, molecules and stoichiometry

1 Empirical formula 2.3.3

- **Simplest whole-number ratio** of atoms
- $C_6H_{12}O_6 \rightarrow CH_2O$
- $C_2H_6 \rightarrow CH_3$
- Ionic compounds: always empirical
- From experiment, not drawn



2 From masses 2.3.5

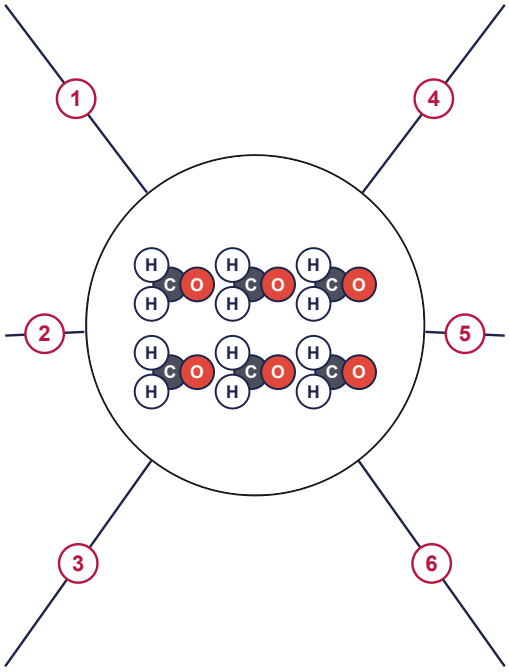
- Mass of each element
- Oxygen = mass gained
- Divide by A_r: **moles**
- **Divide by the smallest**
- Mg 0.243 g + O 0.160 g: MgO



3 Percentages and awkward ratios 2.3.5

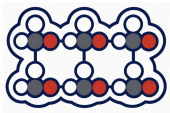
- Take **100 g**: % becomes g
- Missing element **by difference**
- .5: × 2; .33 or .67: × 3; .25: × 4
- Multiply **every** value; never round 1.5
- C 40.0, H 6.7, O 53.3 %: CH_2O





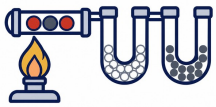
4 Molecular formula 2.3.3, 2.3.5

- **Actual** atoms in one molecule
- n = M_r ÷ empirical mass
- Multiply every subscript by n
- M_r from M^+ or M = m ÷ n
- $CH_2O \times 6 = C_6H_{12}O_6$



5 Combustion analysis 2.3.5

- All C → CO_2: n(C) = n(CO_2)
- All H → H_2O: n(H) = **2** × n(H_2O)
- O **by difference** in mass
- Then the ratio, then M_r
- 0.880 g CO_2 + 0.450 g H_2O: C_2H_5



6 Hydrated salts 2.3.4

- **Hydrated**: contains water of crystallisation
- **Anhydrous**: no water
- Heat to **constant mass**
- **x = n(H_2O) ÷ n(salt)**
- Water left in: x too low



From data to molecular formula

empirical formula mass × n = M_r; n is always a whole number

Compound	Data	Empirical	M_r	Molecular
glucose	C 40.0 %, H 6.7 %, O 53.3 %	CH_2O	180	$C_6H_{12}O_6$
ethanoic acid	C 40.0 %, H 6.7 %, O 53.3 %	CH_2O	60	$C_2H_4O_2$
butane	0.880 g CO_2, 0.450 g H_2O	C_2H_5	58	C_4H_{10}
benzene	C 92.3 %, H 7.7 %	CH	78	C_6H_6
cyclopentane	C 85.7 %, H 14.3 %	CH_2	70	C_5H_{10}
ethyl ethanoate	M^+ at m/e 88	C_2H_4O	88	$C_4H_8O_2$

Worked examples

From masses

- 2.80 g Fe, 1.20 g O
- 0.0502 : 0.0750 = 1 : 1.5
- **Fe_2O_3**

Water of crystallisation

- 2.50 g hydrate → 1.60 g $CuSO_4$
- H_2O 0.0500 : $CuSO_4$ 0.0100
- **$CuSO_4 \cdot 5H_2O$**

Molecular

- CH_2Cl = 49.5
- M^+ at m/e 99: × 2
- **$C_2H_4Cl_2$**

M_r values come from mass spectra (Topics 1 and 22) and from gas volumes (solutions and gases).

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