Topic 4 – Moles
Revision Notes

1. Relative molecular mass and relative formula mass

- In Topic 1 we met relative isotopic mass and relative atomic mass. Remember that *relative* means compared with ^{12}C
- The relative mass of a simple covalent substance, like H_2O or O_2, is called its relative molecular mass
- The relative mass of a giant ionic or giant covalent substance, like NaCl or SiO_2, is called its relative formula mass
- Relative masses do not have units
- Relative molecular masses and relative formula masses are calculated by adding up relative atomic masses

Example – relative formula mass of sodium carbonate, Na_2CO_3

Na	2 x 23.0	= 46.0
C	1 x 12.0	= 12.0
O	3 x 16.0	= 48.0
Total		= 106.0

2. Empirical & Molecular Formulae

- The empirical formula is the simplest whole number ratio of the atoms of each element in a compound
- Write down mass or % of each element
- Divide each one by the relative atomic mass of that element
- Find the ratio of the numbers (divide them all by the smallest one)

Example – Find the empirical formula of a compound which is found to contain 1.40g of nitrogen and 0.30g of hydrogen

		N	H
Composition		1.40	0.30
Divide by r.a.m.		14.0 = 0.1	1.0 = 0.3
Divide by smallest		1	3
Empirical formula	NH_3		

- The molecular formula is the actual number of atoms of each element in a compound
- Molecular formula is a multiple of empirical formula

Example – Find the molecular formula of the compound whose empirical formula is CH_2O and whose relative molecular mass is 60.0

Mass of empirical formula = (1 x 12.0) + (2 x 1.0) + (1 x 16.0) = 30.0
60/30 = 2 so molecular formula = 2 x empirical formula = $C_2H_4O_2$

3. The mole

- In Chemistry amounts of substance are measured in moles
- A mole contains 6.02×10^{23} particles (atoms, molecules, ions or electrons)
- There are 4 ways of calculating a number of moles
- For a number of particles, moles = number of particles/6.02×10^{23}
- Given a mass (in grams), moles = mass/molar mass
- Given a gas volume, moles = volume in $dm^3/24$ or moles = volume in $cm^3/24000$
- For a solution, moles = concentration x volume/1000 (volume in cm^3)

4. Molar mass

- Molar mass is the mass of one mole of a substance
- Its units are g mol^{-1}
- For an atom, the molar mass is the relative atomic mass expressed in g mol^{-1} e.g. 23.0 g mol^{-1} for Na
- For a simple molecule, the molar mass is the relative molecular mass expressed in g mol^{-1} e.g. (2 x 16.0) = 32.0 g mol^{-1} for O_2
- For a giant ionic or giant covalent substance, the molar mass is the relative formula mass expressed in g mol^{-1} e.g. (23.0 x 35.5) = 58.5 g mol^{-1} for NaCl

5. Reacting Mass Calculations

Step 1 - Find the number of moles of the thing you are told about
Step 2 – Use the equation to find out the moles of the thing you are asked about.
Step 3 – Find the mass of the thing you are asked about.

Work out the mass of HCl formed from 6 g of hydrogen

$$\mathbf{H_2 + Cl_2 \rightarrow 2HCl}$$

Step 1: Moles H_2 = 6 ÷2.0 = 3 (mass ÷ molar mass)
Step 2: Moles HCl = 3 x 2 (from equation) = 6
Step 3: Mass HCl = 6 x molar mass = 6 x 36.5 = 219g (moles x molar mass)

6. Gas Volume Calculations

First 2 steps same as reacting mass calculations but in step 3 use 24 dm^3 per mole of gas.

Work out the volume of CO_2 formed from 3.99 kg of iron (III) oxide

$$\mathbf{Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2}$$

Step 1: Moles Fe_2O_3 = 3990 ÷ 159.6 = 25 (mass ÷ molar mass)
Step 2: Moles CO_2 = 25 x 3 (from equation) = 75
Step 3: Volume CO_2 = 75 x 24 = 1800 dm^3 (moles x 24)

7. Titration Calculations

Step 1 - Find the number of moles of the thing you know the concentration and volume of.
Step 2 – Use the equation to find out the moles of the thing you are asked about.
Step 3 – Find the unknown concentration or molar mass

25 cm^3 of NaOH needed 21.5 cm^3 of 0.1 mol dm^{-3} H_2SO_4 for neutralisation. Calculate the concentration of the NaOH solution.

H_2SO_4 + 2NaOH → 2NaCl + $2H_2O$

Step 1: Moles H_2SO_4 = 0.1 x 21.5 ÷ 1000 = 2.15 x 10^{-3} (conc x vol ÷ 1000)
Step 2: Moles NaOH = 2.15 x 10^{-3} x 2 (from equation) = 4.30 x 10^{-3}
Step 3: Conc NaOH = 4.30 x 10^{-3} ÷ (25 ÷ 1000) = 0.172 mol dm^{-3} (moles ÷ volume in dm^3)

8) Water of crystallisation

- Hydrated salts, like copper (II) sulphate crystals, contain water of crystallisation as part of their structure (they are not damp!)
- The water of crystallisation is shown in the formula by . which effectively means + e.g. $CuSO_4.5H_2O$
- The water of crystallisation can be driven off by strong heating to leave an anhydrous salt e.g.

$CuSO_4.5H_2O$ →	**$CuSO_4$ + $5H_2O$**
Blue (hydrated)	white (anhydrous)