

Unit 3 Chemistry - Amount of Substance

The amount of substance in chemistry is measured in **mole**. A mole is a number = 6.023×10^{23} [Avogadro's number]. One mole of pure zinc metal, for example, contains 6.023×10^{23} atoms of it; one mole of oxygen gas contains 6.023×10^{23} O₂ molecules.

Calculating Amount of Substance

1. Pure Solids, liquids or gases

For a pure substance, the number of mole, **$n = m/M_r$** ...where m is the mass in gram and M_r is the relative molar mass of the substance

Example: What amount of ammonia [NH₃] is 46.9 g of it?

$$n = m/M_r = 46.9/[14.0 + 3(1.01)] = 46.9/17.03 \approx 2.754 \text{ mole}$$

2. Solutions

For solutions of known concentration [molarity], the number of mole of a particular substance, **$n = CV$** ...where C is the mole per litre concentration of the substance and V is the volume of the solution in litres

Example: What amount of sodium hydroxide is in 25.8 ml of 0.1052 M NaOH solution?

$$n = CV = 0.1052(0.0258) \approx 0.002714 \text{ mole}$$

3. Gases

One mole of any ideal gas, under the same conditions, occupies the same volume.

At **SLC** [101.3 kPa pressure and 298 K]... 1 mole of a gas occupies 24.5 litres

At **STP** [101.3 kPa pressure and 273 K] ... 1 mole of a gas occupies 22.4 litres

So, at SLC, **$n_{\text{SLC}} = V/24.5$** and at STP, **$n_{\text{STP}} = V/22.4$**

Example: What amount of CO₂ gas is 2.35 L of it at STP?

$$n_{\text{STP}} = V/22.4 = 2.35/22.4 \approx 0.105 \text{ mole}$$

For any conditions, the number of mole of gas, **$n = PV/RT$** ... where P is the pressure in kilopascals, V is the volume in litres, R = 8.31[gas constant] and T is the temperature in Kelvin.

Example: What amount of argon gas occupies 580 ml at 96.0 kPa and 15°C?

$$\begin{aligned} n &= PV/RT \quad P = 96.0 \text{ kPa}, V = 0.580 \text{ L and } T = [273 + 15] = 288 \text{ K} \\ &= 96.0(0.580)/8.31(288) \\ &\approx 0.0233 \text{ mole} \end{aligned}$$

Moles of individual atoms in molecules or formulae

If the amount of a pure substance is known, the amount of individual atoms within it can be found. For example, in 2.46 mole of aluminium carbonate salt [Al₂(CO₃)₃] ...

... there are $2(2.46) = 4.92$ mole of Al³⁺ ions [each Al₂(CO₃)₃ has 2 Al³⁺ ions]

... there are $3(2.46) = 7.38$ mole of C atoms [each Al₂(CO₃)₃ has 3 carbon atoms]

... there are $9(2.46) = 22.14$ mole of O atoms [each Al₂(CO₃)₃ has 9 oxygen atoms]

Calculating Amount of Substance

1. How many mole of zinc oxide [ZnO] is 146.8 g of the substance?
2. What mass does 0.406 mole of copper sulfate [CuSO₄] have?
3. What amount of sodium sulfate [Na₂SO₄] is in 450 ml of a 0.750 M Na₂SO_{4(aq)} solution?
4. What mass of potassium chloride is dissolved to make 250.0 ml of a 0.0486 M KCl_(aq) solution?
5. What amount of rotten egg gas [H₂S] occupies 1.65 L at SLC?
6. What is the volume of 0.250 mole of oxygen gas [O₂] at STP?
7. What amount of water vapour occupies 894 ml at 108 kPa and 120°C?
8. What amount of carbon atoms are in 0.468 mole of CO_{2(g)}?
9. How many actual carbon atoms are in 0.468 mole of CO_{2(g)}?
10. What amount of Fe³⁺ ions are in 0.20 mole of Fe₂O_{3(s)}?
11. How many actual oxygen atoms are in 128 g of Al₂(SO₄)_{3(s)}?
12. How many actual hydrogen atoms are in 5.20 L of methane [CH₄] gas at a pressure of 124 kPa and a temperature of 300 K?