SECTION 8

AMOUNT OF SUBSTANCE AND ITS UNIT, THE MOLE

Amount of substance: symbol *n*, a quantity fundamental to chemistry. Atoms and molecules are much too small or light to be counted or

a balance), and converting the mass of the sample to the amount of the sample in moles by rearranging the equation $m = nM$ to give $n = \frac{m}{M}$.

[e.g. What is the amount of copper of 20.0 g of the metal?

$$n(\text{Cu}) = \frac{m(\text{Cu})}{M(\text{Cu})} = \frac{20.0\ \text{g}}{63.5\ \text{g mol}^{-1}} = 0.3150\ \text{mol}].$$

For a liquid the volume might be measured and this converted to amount in moles by using both the density and the molar mass of the substance.

[e.g. What is the amount of tetrachloromethane in a 20.0 cm^3 sample? $\rho(\text{CCl}_4) = 1.584$ g cm^{-3}; $M(\text{CCl}_4) = 153.8$ g mol^{-1}. Convert from volume to mass using the density,

$$m(\text{CCl}_4) = \rho(\text{CCl}_4)V(\text{CCl}_4),$$

and then to amount using the molar mass,

$$n(\text{CCl}_4) = \frac{m(\text{CCl}_4)}{M(\text{CCl}_4)} = \frac{\rho(\text{CCl}_4)V(\text{CCl}_4)}{M(\text{CCl}_4)} \quad \{\text{by replacing } m(\text{CCl}_4) \text{ by } \rho(\text{CCl}_4)V(\text{CCl}_4)\}$$

$$= \frac{1.584\ \text{g cm}^{-3} \times 20.0\ \text{cm}^3}{153.8\ \text{g mol}^{-1}} = 0.206\ \text{mol }]$$

Stoichiometry: The quantitative relationship between the amounts of reactants consumed and products formed in a chemical reaction as expressed by its balanced chemical equation. The general chemical equation

$$a\text{A} + b\text{B} \rightarrow c\text{C} + d\text{D}$$

implies that a moles of substance A react with b moles of substance B to produce c moles of substance C and d moles of substance D.

[e.g. What amount of copper oxide could be formed from 20.0 g of copper in the reaction

$$4\text{Cu} + \text{O}_2 \rightarrow 2\text{Cu}_2\text{O}$$

From the stoichiometry of the equations, $\frac{n(\text{Cu}_2\text{O})}{n(\text{Cu})} = 2/4 = 0.5$

Therefore $n(\text{Cu}_2\text{O}) = 0.5n(\text{Cu}) = 0.5 \times 0.3150\ \text{mol} = 0.1575\ \text{mol}$

What is the mass of the Cu_2O formed?

$m(\text{Cu}_2\text{O}) = n(\text{Cu}_2\text{O})M(\text{Cu}_2\text{O}) = 0.1575\ \text{mol} \times (2 \times 63.5 + 16.0)\ \text{g mol}^{-1}$

$= 0.1575\ \text{mol} \times 143\ \text{g mol}^{-1} = 22.5\ \text{g }]$

The most useful expression for the stoichiometry of the above general chemical equation is

$$\frac{n(\text{A})}{a} = \frac{n(\text{B})}{b} = \frac{n(\text{C})}{c} = \frac{n(\text{D})}{d}$$

This equation and $n = \frac{m}{M}$ are two of the most important equations used in practical quantitative chemistry.

Avogadro Constant: Symbol N_A or L, the number (of entities) per mole. From many varied measurements its value has been determined as $6.022 \times 10^{23}\ \text{mol}^{-1}$.

Atomic mass constant: Symbol m_u, One twelfth of the mass of one atom of ^{12}C.
Also sometimes called **unified atomic mass unit**, symbol u, previously amu.

Thus m_u =