

*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.

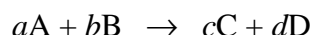
[ e.g. What is the amount of tetrachloromethane in a 20.0 cm<sup>3</sup> sample?  $\rho(\text{CCl}_4) = 1.584 \text{ g cm}^{-3}$ ;  $M(\text{CCl}_4) = 153.8 \text{ g mol}^{-1}$ . Convert from volume to mass using the density,

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

and then to amount using the molar mass,

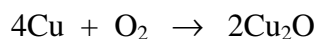
$$\begin{aligned} n(\text{CCl}_4) &= \frac{m(\text{CCl}_4)}{M(\text{CCl}_4)} = \frac{\rho(\text{CCl}_4)V(\text{CCl}_4)}{M(\text{CCl}_4)} \quad \{\text{by replacing } m(\text{CCl}_4) \text{ by } \rho(\text{CCl}_4)V(\text{CCl}_4)\} \\ &= \frac{1.584 \text{ g cm}^{-3} \times 20.0 \text{ cm}^3}{153.8 \text{ g mol}^{-1}} = 0.206 \text{ mol} \end{aligned}$$

**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



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



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<sub>2</sub>O formed?

$$\begin{aligned} m(\text{Cu}_2\text{O}) &= n(\text{Cu}_2\text{O})M(\text{Cu}_2\text{O}) = 0.1575 \text{ mol} \times (2 \times 63.5 + 16.0) \text{ g mol}^{-1} \\ &= 0.1575 \text{ mol} \times 143 \text{ g mol}^{-1} = 22.5 \text{ g} \end{aligned}$$

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 <sup>12</sup>C. Also sometimes called **unified atomic mass unit**, symbol u, previously amu.

Thus  $m_u =$



