

The mole and molar mass

Atomic mass scale - based on  $C^{12}$  ← mass number (nucleon number)  
 $(6p + 6n)$   
 $= 12 \text{ nucleons}$

- used to using kg as a unit for mass  
 ↳ not very practical
- unified atomic mass unit ( $\mu$ )

$$1\mu = \frac{1}{12} \text{ mass of } C^{12} = 1.661 \times 10^{-27} \text{ kg}$$

If carbon-12 has 12 nucleons then each nucleon has a mass of approximately  $1\mu$  (the mass of a proton and a neutron are approximately the same) the mass of an electron is very small compared to the mass of a nucleon.

$$\text{mass of carbon-12} = 12\mu \quad (\text{definition})$$

$$\text{mass of oxygen-16} \approx 16\mu \quad (\text{approximately})$$

$$\text{mass of oxygen molecule } (O_2) \approx 32\mu$$

$$\text{mass of water } (H_2O) \approx 18\mu$$

Molar Mass  $\rightarrow g \text{ mol}^{-1}$       molar mass      atomic mass

$$\text{molar mass } C-12 = 12g \text{ mol}^{-1} \quad (12\mu)$$

$$\text{molar mass } O-16 = 16g \text{ mol}^{-1} \quad (16\mu)$$

$$\text{molar mass } U-238 = 238g \text{ mol}^{-1} \quad (238\mu)$$

The Mole  $\rightarrow$  SI unit for the amount of a substance.

$$1 \text{ mol } C-12 = 12g$$

$$1 \text{ mol } O-16 = 16g$$

$$1 \text{ mol } U-238 = 238g$$

Avogadro's Constant

1 atom of carbon<sup>-12</sup> has a mass of 12 u  
 1 mol = 12g

$$= \frac{12 \text{ u}}{\text{atom}} \left( \frac{1.661 \times 10^{-24} \text{ g}}{1 \text{ u}} \right)$$

$$1.661 \times 10^{-27} \text{ kg} \\ = 1.661 \times 10^{-24} \text{ g}$$

$$= \frac{12 (1.661 \times 10^{-24} \text{ g})}{\text{atom}} \left( \frac{1 \text{ mol}}{12 \text{ g}} \right)$$

$$= 1.661 \times 10^{-24} \frac{\text{mol}}{\text{atom}}$$

$$\Rightarrow 1 \text{ atom} = 1.661 \times 10^{-24} \text{ mol}$$

$$\frac{1}{1.661 \times 10^{-24} \text{ mol/atom}} = 6.02 \times 10^{23} \frac{\text{atoms}}{\text{mol}}$$

1 mol of C-12 has  $6.02 \times 10^{23}$  atoms.

1 mol of anything has  $6.02 \times 10^{23}$  entities.

$$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$$

$$2.3 \text{ mol C} \left( \frac{12 \text{ g}}{1 \text{ mol C}} \right)$$

## Examples

① What is the mass in kilograms of  $1.20 \times 10^{25}$  molecules of oxygen? (atomic mass of  $16 \mu$ )

② The density of aluminium is  $2.7 \text{ g cm}^{-3}$  and its molar mass is  $27 \text{ g mol}^{-1}$ .

- Find the mass of an atom of aluminium in kg.
- Find the number of aluminium atoms per cubic metre.
- Estimate the diameter of an aluminium atom.

③ The world's population is about 6 billion. How many moles of humans are there on Earth?