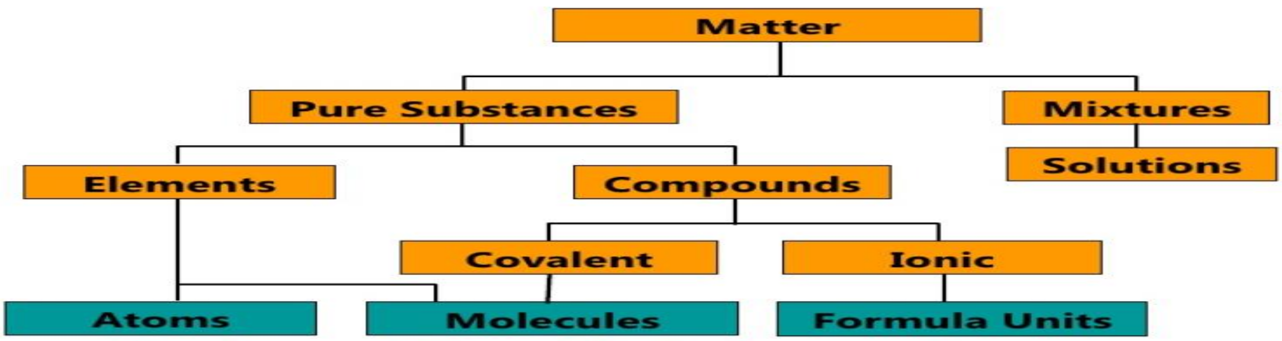
المحاضرة رقم 2

The Structure of Matter



Fundamental "particles" of pure substances

Some important units of measurement

SI is the acronym for the French "**Systeme International Unites.**"

➢ **The International System of Units (SI) is based on 7 fundamental base units.**

- **Mass**: g = 10^3 mg = 10^6 µg
- **Volume**: L = 10^3 mL = 10^6 µL
- **Temperature**: K = 273.15 + ℃

Volumes of liquids are measured in units of liters (L), milliliters (mL), microliters (µL), and sometimes nanoliters (nL).

The

SI Base Units

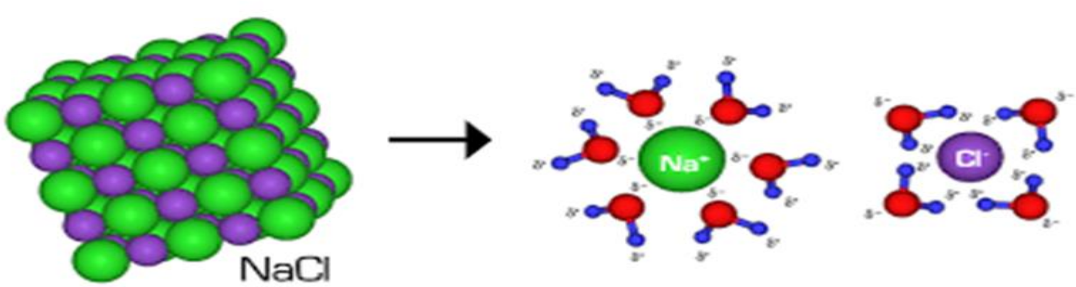
Physical Quantity	Name of Unit	Abbreviation
Mass	kilogram	kg
Length	meter	m
Time	second	s
Temperature	kelvin	K
Amount of substance	mole	mol
Electric current	ampere	A
Luminous intensity	candela	cd

formula weight

of a substance is the sum of the atomic weights of each atom in its chemical formula.

in chemistry, a quantity computed by multiplying the atomic weight (in atomic mass units) of each element in a formula by the number of atoms of that element present in the formula,

From the formula and the atomic mass of the atoms you can find the formula weight or molecular mass for the compound.



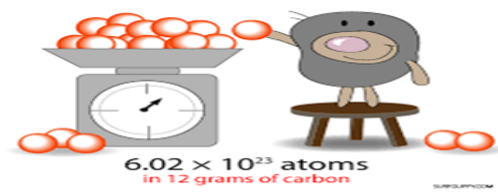
For example, **water (H_2O)** has a formula weight of:

Formula weight (F.wt) = $\sum$ (no. of atom x Atomic weight)

Formula weight (F.wt) = [H(2 x 1) + O (1x 16)]

F.wt(H2O) = 18 g/mol

The Mole



The mole is the amount of a chemical substance.

The molar mass M of a substance is the mass in grams of 1 mole of that substance

$$no. of\ mole = \frac{mass\ of\ substance}{formule\ weight}$$

$$no. of\ mole = \frac{no. of\ particales}{Avogadro\ number}$$

Q/ Calculate the number of mole in 12 g of CH2O ?

$$no. of\ mole = \frac{12\ g}{30\ g/mol}$$

$$no. of\ mole = 0.4\ mol$$

Q/ Calculate the number of molecules in 1.058 mole of H_2O ?

$$1.058 = \frac{no. of\ particales}{6.02\ x\ 1010^{23}}$$

$$no. of\ particales = 1.058\ x\ 6.02\ x\ 10^{23}$$

$$no. of\ particales = 6.37\ x\ 10^{23}$$

The Millimole

1 mmol = 10^{-3} mol

10^3 mmol = 1 mol

Q/ find the number of moles and millimoles of 2 g benzoic acid (Hbz) (F.wt = 122.1 g/mol)

$$no. of\ mole = \frac{mass\ of\ substance}{formule\ weight}$$

$$no. of\ mole\ (Hbz) = \frac{2g}{122.1\ g/mol}$$

$$no. of\ mole\ (Hbz) = 0.01638\ mole$$

$$no. of\ millimole = no\ of\ mole\ x\ 1000$$

$$no. of\ millimole = 0.01638\ mole\ x\ 1000$$

$$no. of\ millimole = 16.38\ mmole$$

Q/ What is the mass in grams of Na_1 (22.99 g/mol) in 25.0 g of Na_2SO_4 (142.0 g/mol)?

Na_2SO_4 (2 mol) → Na (1 mol)

① n_{Na^+} (amount) = mol Na_2SO_4 × $\frac{2 \text{ mol } Na^+}{\text{mol } Na_2SO_4}$

② $n_{Na_2SO_4} = \frac{\text{mass } (Na_2SO_4)\ g}{f.wt\ (Na_2SO_4)\ g/mol}$

$n_{Na_2SO_4} = \frac{25\ g}{142\ g/mol}$ ⇒ $n_{Na_2SO_4} = n_{Na^+}$

③ $n_{Na^+} = n_{Na_2SO_4} \times \frac{2 \text{ mol } Na^+}{1 \text{ mol } Na_2SO_4}$

$n_{Na^+} = \frac{25\ g}{142\ g/mol} \times \frac{2 \text{ mol } Na^+}{1 \text{ mol } Na_2SO_4}$

$n_{Na^+} = 0.352$ mol

$n_{Na^+} = \frac{\text{mass } Na^+}{f.wt\ Na^+}$ ⇒ $0.352\ mol = \frac{\text{mass } Na^+}{22.99\ g/mol}$

$\text{mass}_{Na^+} = 8.10$ g

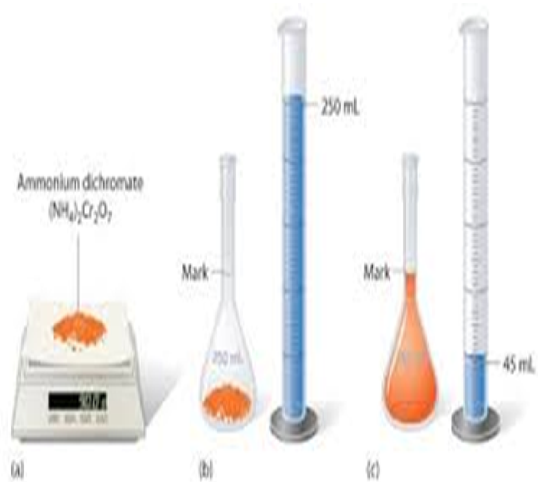
Calculations Used in Analytical Chemistry

Concentration of a solution can be expressed either quantitatively or qualitatively (dilute or concentrated).

Methods of Expressing Concentrations of Solutions

Many ways of expressing concentration: –

- weight (% w/w)
- volume (% v/v)
- parts per million (ppm)
- parts per billion (ppb) for very low concentrations
- Molarity (M)



Parts Per Million, Parts per Billion

ppm → parts, per, million

$$c\ ppm = \frac{mass\ of\ solute\ (g)}{mass\ of\ solution\ (g)} \times 10^{6}$$

$$c\ ppm = \frac{mass\ of\ solute\ (mg)}{volume\ of\ solution\ (L)} \times 10^{6}$$

ppb → parts, per, pillion

$$c\ ppb = \frac{mass\ of\ solute\ (g)}{mass\ of\ solution\ (g)} \times 10^{9}$$

$$c\ ppb = \frac{mass\ of\ solute\ (mg)}{volume\ of\ solution\ (L)} \times 10^{9}$$

Q/ 4 mg of NaCl is dissolved in 8 kg of solution . What is the molar concentration of NaCl in a ppm and ppb?

4 mg = NaCl
8 Kg = solution
g = 1000 mg
∴ $\frac{4\ mg}{1000\ mg/g} = 0.004\ g$

Kg = 1000 g
8 kg = 1000 × 8 = 8000 g
$ppm = \frac{g\ solute}{g\ solution} \times 10^6$
$ppm = \frac{0.0004\ g}{8000\ g} \times 10^6$

ppm = 0.5 ppm
$ppb = \frac{g\ solute}{g\ solution} \times 10^9$
$ppb = \frac{0.0004\ g}{8000\ g} \times 10^9$
ppb = 0.0005

Molarity Calculation for solid

is the number of moles of that species that is contained in 1 liter of the solution

$$Molarity = \frac{no.of\ moles\ solute\ (mole)}{volume\ of\ solution\ (L)} \quad (1)$$

$$no.of\ moles\ solute = \frac{mass\ of\ solute(g)}{formule\ weight\ (\frac{g}{mole})} \quad (2)$$

$$volume\ of\ solution\ (L) = x\ ml \times (\frac{1\ L}{1000\ ml}) \quad (3)$$

Finally, to obtain the ***Molarity***, we rewrite eq. (1)

$$Molarity = \frac{mass\ of\ solute\ (g)}{formule\ weight(\frac{g}{mol})} \times \frac{\frac{1\ L}{1000\ ml}}{x\ ml}$$

Q/ What is the Molar concentratiaon of a solution if 0.28 g NaOH is dissolved in 500 ml of water? (F.wt = 40 g/ mol)

Solution/

$$Molarity = \frac{mass\ of\ solute\ (g)}{formule\ weight(\frac{g}{mol})} \times \frac{\frac{1000\ ml}{1\ L}}{x\ ml}$$

$$Molarity\ (NaOH) = \frac{0.28(g)}{40\ (\frac{g}{mol})} \times \frac{\frac{1000\ ml}{1\ L}}{500\ ml}$$

$$Molarity\ (NaOH) = 0.014\ mol/L$$

Molarity Calculation for Liquid

$$Molarity\left(\frac{mole}{L}\right) = \frac{specific\ gravity\ \left(\frac{g}{ml}\right)\ x\ Percentage\ of\ purity\ \%\ \ x\ \ 1000\frac{ml}{L}}{Formule\ weight\ (\frac{g}{mole})}$$

Density expresses the mass of a substance per unit volume.
In SI units, density is expressed in units of **kg/L** or alternatively **g/mL**.

Specific gravity is the ratio of the mass of a substance to the mass of an equal volume of water.

Please note that all of the above information you can find on packing lable of solution.

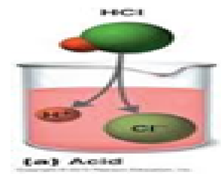
Q/ Calculate the molar concentration of HCl (36.5 g/mol) in a solution that has a specific gravity of 1.18 g/ml and is 37 % HCl (w/w)?.

$$Molarity\left(\frac{mole}{L}\right) = \frac{specific\ gravity\ \left(\frac{g}{ml}\right)\ x\ Percentage\ of\ purity\ \%\ x\ 1000\frac{ml}{L}}{Formule\ weight\ \left(\frac{g}{mole}\right)}$$

1. Molecular Weight : 36.5 g/mole
2. Specific Gravity : 1.18 g/ml
3. Percentage of Purity : 37 %

$$Molarity\left(\frac{mole}{L}\right) = \frac{1.18\left(\frac{g}{ml}\right)\ x\ \frac{37}{100}\ x\ 1000\frac{ml}{L}}{36.5\left(\frac{g}{mole}\right)}$$

$$Molarity\left(\frac{mole}{L}\right)\ HCl\ Conc. = 11.9\ mole/L$$



Q/ the preparation of 100 mlof 6.0 M HCl from a concentrated solution that has a specific gravity of 1.18 and is 37% (w/w) HCl (36.5 g/mol)?.

$$Molarity\left(\frac{mole}{L}\right) = \frac{1.18\left(\frac{g}{ml}\right)\ x\ \frac{37}{100}\ x\ 1000\ \frac{ml}{L}}{36.5\left(\frac{g}{mole}\right)} \longrightarrow Molarity\left(\frac{mole}{L}\right)\ HCl\ Conc. = 11.9\ mole/L$$

M conc. = 11.9 Mol/L
V conc. = ?
M dil. = 6 mol/L
V dil = 100 ml

$$M\ dil. \times V\ dil = M\ conc. \times V\ conc.$$

$$6\ \frac{mol}{L} \times 100\ ml = 11.9\ mol/L \times V\ conc.$$

$$6\ \frac{mol}{L} \times 100\ ml = 11.9\ mol/L \times V\ conc.$$

$$V\ HCl\ conc. = 50.4\ ml$$