Concentration of Solution

- **Molarity:** is the number of moles of solute dissolved in one liter of solution. The units, therefore are **moles per liter**, specifically it's **moles of solute** per **liter of solution**.

$$\boldsymbol{Molarity = \frac{\neq\ of\ moles\ of\ solution}{Liters\ of\ solution}}$$

Example 1. What is the molarity of a 5.00 liter solution that was made with 10.0 moles of KBr?

Solution:

$$\boldsymbol{Molarity = \frac{\neq\ of\ moles\ of\ solution}{Liters\ of\ solution}}$$

$$Molarity = \frac{10.0\ moles\ of\ KBr}{5.0\ Liters\ of\ solution} = 2.00\ M$$

$$\boldsymbol{Molarity = \frac{Weight\ (g)}{Molecular\ Weight\ \left(\frac{g}{mol}\right)} \times \frac{1000}{Volume\ (ml)}}$$

Molecular Weight = Sum. Of atomic weight

Example 2: Prepare 0.1 M of NaCl in 250 ml of D.Water from Solid?

$$\boldsymbol{Wt = \frac{M\ \times M.wt\ \times V(ml)}{1000}}$$

= 0.1 x 55.5 x 250 / 1000

= 1.38 gm

- **Normality:** is the number of equivalents of solute dissolved in one liter of solution. The units, therefore are **equivalents per**

liter, specifically it's **equivalents of solute** per **liter of solution.**

$$Normality = \frac{No. of\ equivalents\ of\ solute}{Liter\ of\ solution}$$

$$N0. of\ equivalents = \frac{Weight(g)}{Equivalent\ Weight(\frac{g}{eq})}$$

$$Normality = \frac{Weight(g)}{Equivalent\ weiht\ (\frac{g}{eq})} \times \frac{1000}{Volume\ (ml)}$$

$$Eq.Wt = \frac{M.Wt}{n}$$

n = No. of (H) atoms for acids

For HCl n=1

n = No of OH groups for bases

For NaOH n=1

n = No of Cation atoms (M+) for salts

For Na_2CO_3 n= 2

n = No. of gained or lost electrons for oxidants and reductants

For $KMnO_4$ n= 7

- **Relationship between Molarity and Normality**

$$Molarity = \frac{Weight\ (g)}{Molecular\ Weight\ \left(\frac{g}{mol}\right)} \times \frac{1000}{Volume\ (ml)}$$

$$\boldsymbol{Normality = \frac{Weight(g)}{Equivalent\ weiht\ (\frac{g}{eq})} \times \frac{1000}{Volume\ (ml)}}$$

$$\boldsymbol{Eq.Wt = \frac{M.Wt}{N}}$$

Q / what is the normality of 0.1 mol / l of Na_2SO_4 ?

Concentration % (w/v%), (w/w%), (v/v%):

- Weight – Volume Percentage **(% w/v)**

$$\%\frac{W}{V} = \frac{Weight\ of\ solute\ (g)}{Volume\ of\ solution\ (ml)} \times 100$$

- Weight – Weight Percentage **(% w/w)**

$$\%\frac{w}{w} = \frac{Weight\ of\ solute\ (g)}{Weight\ of\ solution(g)} \times 100$$

- Volume – Volume Percentage **(% v / v)**

$$\boldsymbol{\%\frac{V}{V} = \frac{Volume\ of\ solute\ (ml)}{Volume\ of\ solution\ (ml)} \times 100}$$

Q/ What is the weight/volume percentage concentration of 250mL of aqueous sodium chloride solution containing 5g NaCl?

Calculate the weight/volume (%) = mass solute ÷ volume of solution x 100

mass solute (NaCl) = 5g
volume of solution = 250mL

w/v (%) = 5g ÷ 250mL x 100 = 2g/100mL (%)

Q / 2.0L of an aqueous solution of potassium chloride contains 45.0g of KCl. What is the weight/volume percentage concentration of this solution in g/100mL?

a. Convert the units (mass in grams, volume in mL):
   mass KCl = 45.0g
   volume of solution = 2.0L = 2.0 x 10^3mL = 2000mL
b. Calculate w/v (%) = mass solute (g) ÷ volume solution (mL) x 100
   w/v (%) = 45.0 ÷ 2000mL x 100 = 2.25g/100mL (%)

Q/ prepare 500 ml of 2 percent citric acid solution .

$$\%\frac{W}{V} = \frac{Weight\ of\ solute\ (g)}{Volume\ of\ solution\ (ml)} \times 100$$

$$\%2 = \frac{Weight\ of\ solute\ (g)}{500\ (ml)} \times 100$$

$$\frac{500\ ml\ \times 2\ g}{100\ ml} = 10\ g$$

Q/ apatient is given 1000 ml 0.9 % NaCl intravenously .How many grams of NaCl did the patient receive ?

$$\%\frac{W}{V} = \frac{Weight\ of\ solute\ (g)}{Volume\ of\ solution\ (ml)} \times 100$$

$$\%0.9 = \frac{Weight\ of\ solute\ (g)}{1000\ (ml) NaCl} \times 100$$

$$\frac{1000\ ml\ \times 0.9\ g}{100\ ml} = 9\ g\ NaCl$$

Q/ How can you prepare 0.9 % NaCl?

1) Weight out exactly 0.9 g NaCl.
2) Dissolve 0.9 g NaCl in a 100 ml water.

- **Mole Fraction**

The mole fraction, X, of a component in a solution is the ratio of the number of moles of that component to the total number of moles of all components in the solution.

To calculate mole fraction, we need to know:

- The number of moles of each component present in the solution.

The mole fraction of A, X_A, in a solution consisting of A, B, C,... is calculated using the equation:

$$\boldsymbol{X_A = \frac{moles\ of\ A}{moles\ of\ A + moles\ of\ B + moles\ of\ C + \cdots}}$$

To calculate the mole fraction of (B, X_B) use:

$$\boldsymbol{X_B = \frac{moles\ of\ B}{moles\ of\ A + moles\ of\ B + moles\ of\ C + \cdots}}$$

Molality

Molality, m, tells us the number of moles of solute dissolved in exactly one kilogram of solvent. (Represented by a lower case m.)

We need two pieces of information to calculate the molality of a solute in a solution:

- The moles of solute present in the solution.
- The mass of solvent (in kilograms) in the solution.

To calculate molality we use the equation:

$$\boldsymbol{Molality = \frac{moles\ of\ solute}{mass\ of\ solvent\ in\ kilograms}}$$

- **Parts per Millions (PPM)**

$$ppm = \frac{Weight\ of\ solute\ (g)}{Volume\ of\ Solution\ (ml)} \times 10^6$$

Relationship between PPM and Molarity and Normality

$$PPM = M \times M.Wt \times 1000$$

$$PPM = N \times Eq.Wt \times 1000$$

Converting weight/volume (w/v) concentrations to ppm
ppm = 1g/m^3 = 1mg/L = 1µg/mL

1. A solution has a concentration of 1.25g/L.
What is its concentration in ppm?

a. Convert the mass in grams to a mass in milligrams:
   1.25g = 1.25 x 1000mg = 1250mg
b. Re-write the concentration in mg/L = 1250mg/L = 1250ppm

2. A solution has a concentration of 0.5mg/ml.
what is its concentration in ppm?

a. Convert the volume to liters:
   volume = 1mL = 1mL ÷ 1000mL/L = 0.001L
b. Re-write the concentration in mg/L = 0.5mg/0.001L = 500mg/L = 500ppm

Converting weight/weight (w/w) concentrations to ppm
1ppm = 1mg/kg = 1µg/g

1. A solution has a concentration of 0.033g/kg.
What is its concentration in ppm?

a. Convert mass in grams to mass in milligrams:
   0.033g = 0.033g x 1000mg/g = 33mg
b. Re-write the concentration in mg/kg = 33mg/kg = 33ppm

2. A solution has a concentration of 2250μg/kg.
What is its concentration in ppm?

a. Convert mass in μg to mass in mg:
   2250μg = 2250μg ÷ 1000μg/mg = 2.25mg
b. Re-write the concentration in mg/kg = 2.25mg/kg = 2.25ppm

Parts Per Million (ppm) Concentration Calculations
1. 150mL of an aqueous sodium chloride solution contains 0.0045g NaCl.
Calculate the concentration of NaCl in parts per million (ppm).

a. ppm = mass solute (mg) ÷ volume solution (L)
b. mass NaCl = 0.0045g = 0.0045 x 1000mg = 4.5mg
   volume solution = 150mL = 150 ÷ 1000 = 0.150L
c. concentration of NaCl = 4.5mg ÷ 0.150L = 30mg/L = 30ppm

2. What mass in milligrams of potassium nitrate is present in 0.25kg of a 500ppm $KNO_{3(aq)}$?

a. ppm = mass solute (mg) ÷ mass solution (kg)
b. Re-arrange this equation to find the mass of solute:
   mass solute (mg) = ppm x mass solution (kg)
c. Substitute in the values:
   mass KNO_3 = 500ppm x 0.25kg = 125mg

3. A student is provided with 500mL of 600ppm solution of sucrose.
What volume of this solution in milliliters contains 0.15g of sucrose?

a. ppm = mass solute (mg) ÷ volume solution (L)
b. Re-arrange this equation to find volume of solution:
   volume solution (L) = mass solute (mg) ÷ ppm
c. Substitute in the values:
   volume solution (L) = (0.15g x 1000mg/g) ÷ 600 = 0.25L
d. Convert liters to milliliters: volume solution = 0.25L x 1000mL/L = 250mL

- **DILUTIONS**

Whenever you need to go from a more concentrated solution ["stock"] to a less concentrated one, you add solvent [usually water] to "dilute" the solution. No matter what the units of concentration are, you can always use this one formula

$$C_1 V_1 = C_2 V_2$$

[Concentration of the stock] x [Volume of the stock] = [Concentration of the final solution] x Volume of the final solution]

$$N_1 V_1 = N_2 V_2$$

$$M_1 V_1 = M_2 V_2$$

Q / What is the volume of 0.2 mol / L of NaOH that it required to dilute it to 0.05 mol /L in 100 ml?

$N_1 V_1 = N_2 V_2$

$0.2 \times V_1 = 0.05 \times 100 \Longrightarrow V_1 = 25$ ml complete to 100 ml

- **Normality of Concentrated Reagents**

$$\boldsymbol{Normality = \frac{Specific\ Gravity\ \left(\frac{g}{l}\right) \times Percentage\ (\%) \times 1000}{Equivalent\ Weight\ (\frac{g}{eq})}}$$

$$\boldsymbol{Molarity = \frac{Specific\ Gravity\ \left(\frac{g}{l}\right) \times Percentage (\%) \times 1000}{Molecular\ Weight\ (\frac{g}{mol})}}$$

Q / Describe the preparation of 900 mL of 3.00 M $HN0_3$ from the commercial reagent that is 70.5% HN0 3 (w/w) and has a specific gravity of 1.42.

$$Molarity = \frac{Specific\ Gravity\ \left(\frac{g}{l}\right) \times Percentage (\%) \times 1000}{Molecular\ Weight\ (\frac{g}{mol})}$$

$$M_{HNO3} = \frac{1.42 \times (\frac{70.5}{100}) \times 1000}{63} = 15.9$$

$M_1 V_1 = M_2 V_2$

15.9 x V1 = 3 x 900 ⟹ V_1 = 159 ml diluted to 900 ml

Formality

Formula weight and **molecular weight** have slightly different definitions, though for many substances, the two measurements are the same.
Formula weight is the sum of the atomic weights of the atoms in a molecule's **empirical formula.**
Molecular formula is a notation that indicates the type and number of atoms in a molecule. The molecular formula of glucose is $C_6H_{12}O_6$, which indicates that a molecule of glucose contains 6 atoms of carbon, 12 atoms of hydrogen, and 6 atoms of oxygen.
Empirical formulas show which elements are present in a compound, with their mole ratios indicated as subscripts. For example the empirical formula of glucose is CH_2O, which means that for every mole of carbon in the compound, there are 2 moles of hydrogen and one mole of oxygen.
Example:
A compound have molecular weight 56g/mol contains 85.6% carbon and 14.4% hydrogen. What is the empirical and molecular formula of this compound?

H.W:

1) a patient is given 1000 ml 0.9 percent NaCl intravenously. How many grams of NaCl did the patient receive?

2) How many grams of glucose are present in 0.5L of 2.0 *M* of glucose solution?

3) what are the molality of KOH solution, if dissolve 23 g of KOH in 500 ml water

4) Prepare 250 ml of 0.1 *N* sodium carbonate solution. (Na:23; C: 12; O: 16)
Results: wt: 1.325 gm.

5) Dissolve 5.3 gm of sodium carbonate in water, then complete the volume of the solution to ¼ liter. Compute molarity of solution. (Na: 23; C: 12; O: 16). Results: 0.2 mol/liter.