Medical Chemistry

Stage: 1st

Concentration, preparation of solution

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Solutions:

We define a solution as a homogenous mixture of the molecules or ions of two or more different substances.

The component present in excess is called Solvent.

The other component is called Solute.

Solutions that contain liquids as solvents are the types of solutions most familiar to use. They have the following properties:

1- Consist of a soluble material (the solute) dissolved in a liquid (the solvent).

2- Are clear.

3- Are homogenous.

4- Don't settle.

5- May be separated by physical means.

6- Pass through filter papers.

Percent concentration:

Concentration can be expressed in terms of percent (parts per hundred).

Percent composition can be expressed in three different methods:

1- Weight percent (w/w):

$$\text{wt./wt.} = \frac{wt.solute}{wt.solution} x100\%$$

2- Volume percent (v/v):

$$\text{V/V} = \frac{V\ solute}{V\ solution} x100\%$$

3- Weight/Volume percent (w/v):

$$\text{V/V} = \frac{wt.solute}{V\ solution} x100\%$$

4- Parts Per Million and Parts Per Billion:

For very dilute solutions, parts per million (ppm) is a convenient way to express concentration.

$$\text{ppm} = \frac{wt.solute(g)}{wt.solution(g)} x10^6$$

For even more dilute solution parts per billion(ppb) is used:

$$\text{ppb} = \frac{wt.solute(g)}{wt.solution(g)} x10^9$$

When we have an aqueous solution at room temperature, we can also conclude that a concentration of 1 ppm1 ppm corresponds to the following:

$$\text{ppm} = \frac{wt.solute\ (g)}{V\ solution(ml)} x10^6$$

$$\text{ppb} = \frac{wt.solute(g)}{V\ solution(ml)} x10^9$$

- 1ppm = 1mg/L = 10^{-3} g/L.
- 1ppb = 1mg/ml = 10^{-3} g/ml = 1µg /L.

1µg = one microgram which equals 10^{-6} g = 10^{-3} mg.

Q: What is the percent by weight of sugar in a solution made by (10g) sugar in (90g) of water?

$$W/W\ \% = \frac{\text{Wt. of solute (g)}}{\text{Total Wt. of soln.}} \times 100$$

$$\frac{10}{10+90} \times 100 = 10\%$$

Q: What is the percent by volume of ethyl alcohol in a solution made by diluting 10 ml of ethyl alcohol to 100 ml of water?

$$V/V = \% = \frac{\text{Volume of solute (ml)}}{\text{Total volume of solution(ml)}} \times 100$$

$$\frac{10(\text{ml})}{100(\text{ml})} \times 100 = 10\%$$

Q: What is the percent by (w/v) of NaCl in a solution made by 1.5g of NaCl to 100ml with water?

$$W/V\% = \frac{\text{Wt. of solute (g)}}{\text{Vol. of solution (ml)}} \times 100$$

$$\frac{1.5\text{g}}{100\text{ ml}} \times 100 = 1.5\ \%$$

Chemical Concentrations:

The **concentration** of a solution is a measure of the amount of solute that is dissolved in a given quantity of solvent.

–A **dilute solution** is one that contains a small amount of solute.

–A **concentrated** solution contains a large amount of solute.

The Mole: The mole is the SI unit for the amount of chemical species. The mole is associated with a chemical formula and Avogadro’s number (6.022 x 1023) of particles. The molar mass (M) of a substance is the mass in grams of one mole of the substance. Molar masses are calculated by summing the atomic masses of all the elements appearing in a chemical formula.

1- Molarity (M): is the number of moles of solute dissolved in one liter of solution. To calculate the molarity of a solution, divide the moles of solute by the volume of the solution. Remember that volume is always in liter.

$$M = \frac{No.of\ moles\ of\ solute}{V\ solution\ (L)}$$

$$\text{No. of mole(n)} = \frac{Wt.of\ solute\ (g)}{M.wt.(\frac{g}{mol})}$$

$$M = \frac{Wt.}{M.wt.} x \frac{1000}{\text{V (ml)}}$$

Ex: If 5 liters of water is added to two moles of glucose to make a solution, What is the Molarity of solution?

Ex: What is the molarity of 600 mL of potassium iodide solution that contains 5.50 moles of the solute?

Ex: A saline solution contains 0.90 g of NaCl per 100 mL of solution. What is its molarity?

Ex: What volume of a 4.0 M solution would contain 15.5 moles of sodium thiosulfate?

Ex: What mass of sodium iodide (NaI) is contained in 250 mL of a 0.500M solution?

Ex: What is the molarity of a solution that was prepared by dissolving 14.2 g of $NaNO_3$ (molar mass = 85.0 g/mol) in enough water to make 350 mL of solution?

2- Normality (N):

Represents the number of equivalents contained in one liter solution or the number of milli equivalents of solute contained in one milliliter of solution.

$$N = \frac{No. of\ equivalents\ of\ solute}{V\ solution\ (L)}$$

$$\text{No. of } equivalents \text{(eq)} = \frac{Wt. of\ solute\ (g)}{eq. wt. (g)}$$

$$M = \frac{Wt.}{eq. wt.} x \frac{1000}{\text{V (ml)}}$$

$$\text{Eq. wt} = \frac{M. wt}{\eta}$$

$$N = Mx\eta$$

A) Equivalent mass of acids (Eq.wt):

Is the mass that either contribute or reacts with one mole of hydrogen ion in the reaction.

$\text{Eq. wt} = \frac{M.wt}{\eta}$ (η = No. of H)

B) Equivalent mass of Bases(Eq.wt):

Is the mass that either contribute or reacts with one mole of OH in the reaction.

$\text{Eq. wt} = \frac{M.wt}{\eta}$ (η = No. of OH)

C) Equivalent mass for salts(Eq.wt):

$\text{Eq. wt} = \frac{M.wt}{\eta}$

η = Σ [no. of cations x cation charge]

- $AgNO_3$ ($AgNO_3 \rightarrow Ag^+ + NO^-_{3}$)

η= Ag^+ (1) x 1= 1

- Na_2CO_3 ($Na_2CO_3 \rightarrow 2\ Na^+ + CO_3^-$)

η= Na^+ (2) x 1= 2

- $BaSO_4$ ($BaSO_4 \rightarrow Ba^{+2} + SO_4^{-2}$

η= Ba^{+2} (1) x 2= 2

- $KAl(SO_4)_2$:

η= K^+(1) X (1) +Al^{+3}(1) x (3) = 4

Example

Find the Normality of the solution containing 5.3 g/L of Na_2CO_3 (106 g/mol).

Solution:

To find η for Na_2CO_3 (**η**) = **Σ [no. of cations x its valency(cation charge)]**

No. of cations =2Na+ while the cation charge for Na^+ = 1 ,

Then (**η**) = 2 x 1 = 2

Eq. of Na_2CO_3 = $\frac{Mwt}{2} = \frac{106}{2}$ =**53.0 gm**

Normality (N) = $\frac{wt}{Eq.\ x\ VL}$

Normality (N) = $\frac{5.3gm}{53.0\ x\ 1L}$ = 0.1N

Second method:

Normality (N) = $(\frac{wt\ x1000}{Mwt\ x\ V(mL)})$ **η**

Normality (N) = $(\frac{5.3\ x1000}{106\ x\ 1000(mL)})$ **2 = 0.1 N**

3-Molality (Molal concentration) (m): The solution concentration produce from dissolved solute (mole) in solvent (kg), molality does not change with temperature and used for physicochemical measurements.

$$m = \frac{No.of\ moles\ of\ solute}{wt.solvent\ (kg)}$$

$$m = \frac{Wt.}{M.wt.} x \frac{1000}{wt.(g)}$$

Ex: Calculate the molal concentration for solution preparing from mixing 4 g NaOH with 500 g water?

$$m = \frac{4}{40} x \frac{1000}{500}$$

m= 0.2

4- Formality (F): The number of moles of solute contained in each liter of solution. Formal concentration (also called Formality). Chemists sometime use the term formality for solutions of ionic salts that do not exist as molecules in the solid or in solution. The concentration is given as formal (F).Formality is numerically the same as molarity.

$$F = \frac{Wt.}{F.wt.} x \frac{1000}{V\ (ml)}$$

F = Formality for solid compound , F.Wt = formula weight

more accurate description for substances that do not exist as molecules but exist as ionic compounds , used for strong electrolytes-acids, bases, salts.

5- Density(d): The density of a substance is its mass per unit volume. Density is expressed in units of kg/L or g/mL.

6-Specific Gravity(SP.G): Specific gravity is the ratio of its mass to the mass of an equal volume of water at $4^{o}C$. Specific gravity is dimensionless.

Ex: A solution contains 55ppb of Ca, calculate its molar and normal concentrations?

The solution:

Wt. of NaCl in litre of solution =N×Eq.wt. → =0.01×58.5 →

=0.585g/lit → =585mg/lit → =585ppm as NaCl.

$585\times\frac{23}{58.5}$ =230mg/lit =230ppm as Na^+

$585\times\frac{35.5}{58.5}$ =355mg/lit =355ppm as Cl^-

Mole fraction:

The number of moles of one component relative to the total number of moles of all components in the solution.

$$\text{Mole fraction of solute}(X1) = \frac{No.of\ moles\ of\ solute\ (n1)}{mole\ of\ solute\ (n1) + moles\ of\ solvent\ (n2)}$$

$$\text{Mole fraction of } solvent\ (X2) = \frac{No.of\ moles\ of\ solvent\ (n2)}{mole\ of\ solute\ (n1) + moles\ of\ solvent\ (n2)}$$

$$\mathbf{X_T = \sum X_i = 1}$$

$$\mathbf{X_1 + X_2 = 1}$$

Ex: calculate the mole fraction for each of solute and solvent in a solution if the solute is (2 mole) and the solvent is (3 mole)?

Ex: Calculate the mole fraction of water in a mixture consists of 9 g of water (18 g / mol) and 120 g of acetic acid (CH_3COOH)(60 g / mol) ?

Dilution law:

Preparation of diluted acid from concentrated acid by using **dilution low**

$$M1 \times V1 = M2 \times V2$$

Concentrated acid   diluted acid

Prepare 100 ml. of diluted HCl (0.1M) from 5M concentrated HCl.

$M1 \times V1 = M2 \times V2$

Concentrated acid   diluted acid

$$5 \times V1 = 0.1 \times 100 \rightarrow\rightarrow V1 = \frac{0.1 \times 100}{5}$$

$$V1 = \frac{10}{5} \rightarrow\rightarrow V1 = 2ml.$$

We measure (2ml) of concentrated HCl and adding D.W until complete the final volume which is 100 ml.

You prepare a Cu stock solution with a concentration of 209.5 ppm. You need to now prepare a standard solution with a concentration of 7.5 ppm in a 25 mL volumetric flask. How do you prepare the standard?

$C_1 = 209.5$ ppm $V_1 = ?$

$C_2 = 7.5$ ppm $V_2 = 25$ mL

$$V_1 = \frac{C_2 V_2}{C_1} = \frac{(7.5\ \text{ppm})(25\ \text{mL})}{(209.5\text{ppm})} = 0.895\ \text{mL}$$

Solubility:

Defined as the amount of solute that dissolved in given quantity of solvent to form a saturated solution.

We call the substances being dissolved the **solute,** whereas the **solvent** is the substances in which the solute being dissolved. The **aqueous** solutions, which are the solutions in which water is the solvent.

Saturated Solution

Defined as a solution in which no more solute will dissolve in the solvent at a temperature.

We may say that a solution is **dilute** if there are only a new solute particles dissolved in it, or **concentrated** if there are many solute particles dissolved.

Factors affecting the solubility of a solute

1-The nature of solvent and solute (like dissolve like) polar solvent dissolve polar solute.

2-Tempreture, for most solids increase the solubility will increase the solubility except $Ca(OH)_2$, $CaCr_2O_7$, $CaSo_4$, the solubility decrease with increase the temperature and gas in liquid the solubility decrease with increase the temperature.

3-The pressure, gas in liquid, the solubility will increase with the increase the pressure.

General Rule

"Like dissolves like"

*Polar solvent (water) is a good solvent for ionic compounds (NaCl).

*Gasoline (non polar compounds is a good solvents for other non polar organic compounds (oil).

Types of Solutions according to Physical State:

1- Solid solute in solid solvent (Ag in Ni or Cu in Au).

2- Solid solute in liquid solvent (NaCl in water or sugar in water).

3- Liquid solute in liquid solvent (ethanol in water).

4- Gas solute in liquid solvent (carbon dioxid CO_2 in water).

5- Gas solute in gas solvent (oxygen in acetylene).

Types of Solutions according to tonicity:

1-Isotonic Solutions:

The normal concentration of NaCl in blood is 0.9% and this usually called normal saline solution.

No effect on the red blood cell (RBC). The cell membrane behaves as semipermeable membrane, and since the concentration of NaCL inside and outside the RBC is the same then no flow of water will occur.

2- Hypertonic solutions:

That solutions with contain more than 0.9% of NaCL. If RBC put in this solution, then it will shrink since water will flow from the inside to outside the cell.

3- Hypotonic solutions:

That solutions with contain more than 0.9% of NaCL. If RBC put in this solution, then it will swell or brust, since water will flow from the outside to inside the cell.

Electrolytes and non electrolytes

An electrolyte is a substance that, when dissolved in water, results in a solution that can conduct electricity. For example: salt (NaCL).

A non electrolyte does not conduct electricity when dissolved in water. For example: sugar molecular ($C_6H_{12}O_6$).

Aqueous solution that conducts electricity is called an electrolytic solution. One that does not is called a non electrolytic solution.

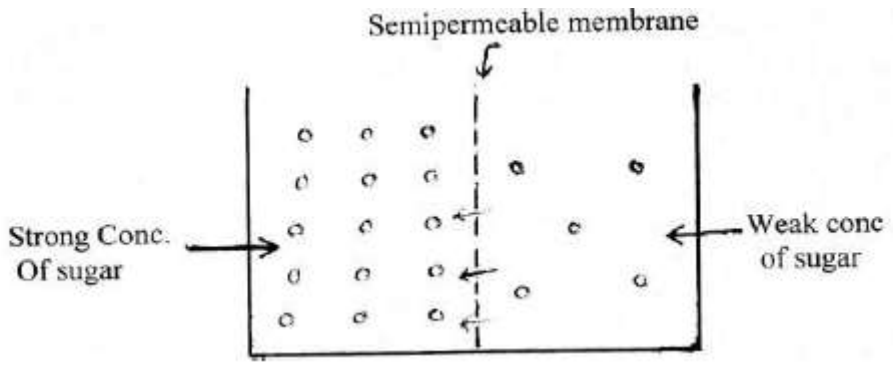
Classification of electrolyte

Strong electrolyte	weak electrolyte	non electrolyte
HCl	CH_3COOH	$(NH_2)_2CO$ Urea
HNO_3	HF	CH_3OH
$HClO_4$	HNO_2	Glucose
H_2SO_4	NH_3	Sucrose
NaOH	H_2O	Nitrogen
$Ba(OH)_2$		Oxygen
NaCl		Carbon dioxide
$CaCl_2$		

The mode of electrolytic and non-electrolytic solutions has been used to explain all the physical properties of solutions (osmosis and dialysis).

Osmosis and osmotic pressure

Cells have limiting boundary membranes that are called plasma membranes. These allow the exchange of materials back and forth between the interior of the cell and its exterior materials. Osmosis and dialysis are two ways that such an exchange of materials occurs. Osmosis is the movement of water though an osmotic membrane from an aqueous solution that is less concentrated to one that is more concentrated. If we have two sugar solutions one has a strong concentration and the other has a weak concentration and the two solutions separated by semipermeable membrane, as shown:



The two solutions try to be the same in concentration.

Preventing osmosis from occurring applying pressure is needed to stop water movement from to place to another (osmotic pressure). The greater the number of particles, whether ions or molecules, in a solution, the greater it's osmotic pressure.

Suspensions

When some powdered clay is placed in water and strongly shaken, a suspension of clay in water will be produced.

This suspension will not be clear opaque upon standing, the clay will slowly settle.

When the suspension is poured into a funnel containing a piece of filter paper, only water passes through the filter paper, the clay doesn't of same medications, such as milk of magnesia, are administered as a suspension. Many bottles of medications state on the label shake before using. A mist is a suspension of liquid in a gas, water droplets suspension in air are one example of a mist.

Colloids and colloidal Dispersions

The particles in a solution are the size of atoms and molecules (0.05-0.25 nm).

Sometimes intermolecular attractions between molecules cause several hundred or thousand of them to cluster together. The size of these clusters range from 1-100 nm. Matter containing particles of this size is called a "Colloid".

A uniform dispersion of a colloid in water is called a "Colloidal dispersion".

A colloidal dispersion usually appears cloudy. The colloid in a colloidal dispersion is called the dispersed substance. Proteins form colloidal dispersion in water being colloidal so they can pass through a filter paper but no in membrane. Proteins present in blood stream cannot pass through the cell membranes and should remain in blood stream.

Since the present of protein in the urine indicates damage to the membranes in the kidneys.

Solution	Suspension	Colloid
Pass through a filter paper and membrane	Don't pass through filter paper and membrane	Pass through a filter paper but not through membrane

Dialysis and Living Systems

Cell membranes that allow small molecules and ions to pass while holding back large molecules and colloidal particles are called "Dialyzing membranes". The selective passage of small molecules and ions in either direction by a dialyzing membrane is called "Dialysis". "Dialysis" differs from "Osmosis" in that osmotic membranes allow only solvent molecules to pass.

The kidneys are an example of organ in the body that uses dialysis to maintain the solute and electrolytes balance of the blood.

The main purpose of the kidneys is to clean the blood by removing the waste products of metabolism and control the concentrations of electrolytes, by allow blood cells and plasma proteins to pass. A180L of blood are purified daily in adult (68Kg). 1 percent is eliminated as urine.