جامعة المستقبل
AL MUSTAQBAL UNIVERSITY
كلية التقنيات الصحية والطبية

Aesthetic and Laser Techniques Department

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General Chemistry (2024-2025) lecture (2)

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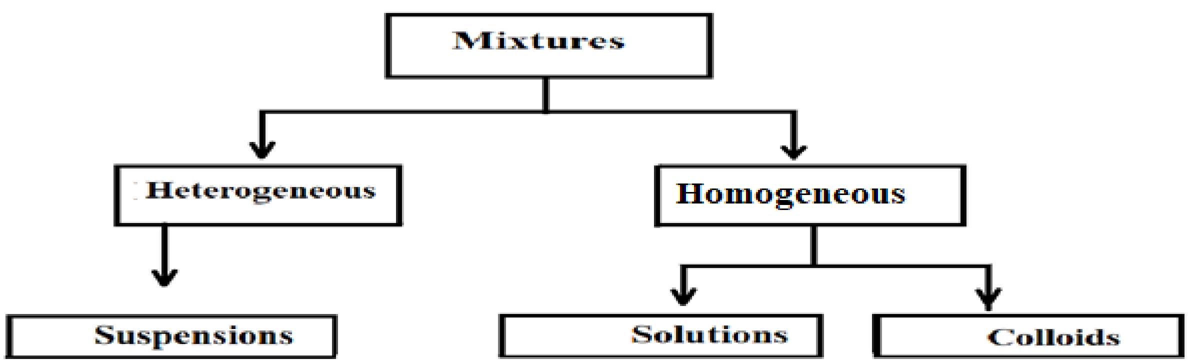
Solution and Methods of Expressing Concentration

Solutions

- **Solutions are homogeneous mixtures of two or more pure substances.**
- **In a solution, the solute is dispersed uniformly throughout the solvent.**

Types of Mixtures



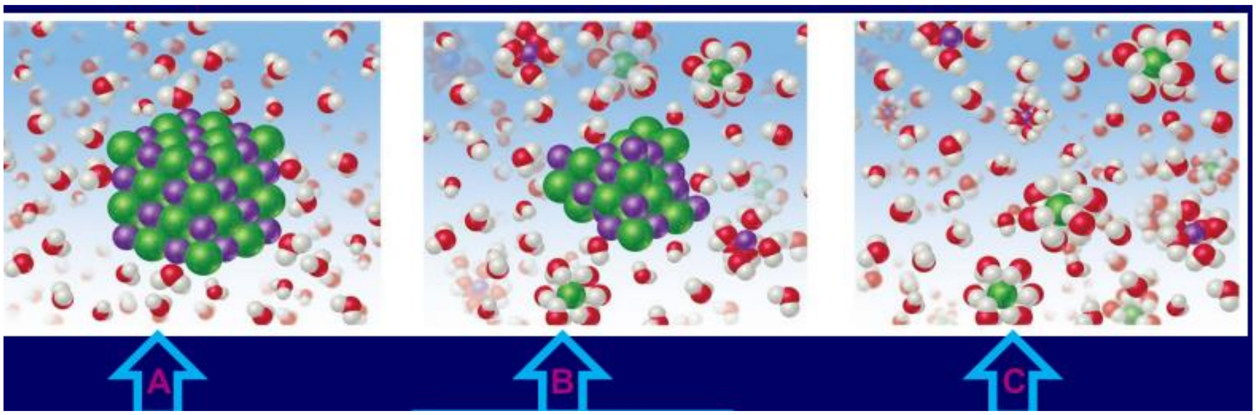
Solutions:-

• Solutions are homogeneous mixtures of two or more pure substances.

• In a solution, the solute is dispersed uniformly throughout the solvent.

State of solution	State of solvent	State of solute	Example
Liquid	Liquid	Gas	Air in water
Liquid	Liquid	Liquid	Alcohol in water
Liquid	Liquid	Salt	Salt in water
Solid	Solid	Gas	Hydrogen in palladium
Solid	Solid	Liquid	Mercury in silver
Solid	Solid	Solid	Silver in gold

Formation of Solution:-



A- Solvent molecules attracted to surface ions
B- Each ion is surrounded by solvent molecules
C- The ions are solvated (surrounded by solvent)

Degree of saturation

a-Saturated Solution

1.Solvent holds as much solute as it possible at that temperature.

2. Undissolved solid remains in flask.

3. Dissolved solute is in dynamic equilibrium with solid solute particles

b-Unsaturated Solution

1. Less than the maximum amount of solute for that temperature is dissolved in the solvent.

2. No solid remains in flask.

Factors Affecting Solubility

The stronger the intermolecular attractions (H-bonds; ion-dipole forces) between solute and solvent, the more likely the solute will dissolve.

- **a- Glucose which has hydrogen bonding is very soluble in water>**
- **b- Cyclohexane which only has dispersion forces is not water soluble.**
- **c- Vitamin A is soluble in nonpolar compounds (like fats).**

Methods of expressing Concentration

The term concentration is used to refer to the amount of solute that is dissolved in a solvent. There are several different ways to quantitatively describe the concentration of a solution.

1-Concentration by Percent

In general, percentage can be defined as:

% = (Part / whole) x 100

In chemistry, we are usually interested in percent by mass:

%Mass= (Mass of part/ Total mass)100

Concentration by Percent. Percent means the same thing as "parts per hundred" , So when percent is used as a concentration unit, the number of parts of solute present in every 100 parts of solution is being specified.
There are three commonly used percent measurements for concentration:

1. weight/weight %(w/w)

2. volume/volume %(v/v)

3. weight/volume %(w/v)

% (Weight/Weight) = (grams of Solute/grams of Solution) x 100%

% (Vol/Vol) =(mL of Solute / mL of Solution)x100%

% (Weight/Vol) = (grams of Solute /mL of Solution) x 100%

when percent is used as a concentration unit, the number of parts of solute present in every 100 parts of solution is being specified when percent is used as a concentration unit,

2-Molarity: -

Molarity is a useful way to describe solution concentrations for reactions that are carried out in solution.

$$\text{Molarity (M)} = \frac{\text{moles of solute}}{\text{liters of solution}}$$

3-Molality: -

The concentration of a solution can also be described by its molality (m), the number of moles of solute per kilogram of solvent:

$$\text{Molality (m)} = \frac{\text{moles of solute}}{\text{per kilogram of solvent}}$$

4-Mole fractions: -

Mole fraction: It is the number of moles of solute divided by the total moles of solute and solvent, or the number of moles of solvent divided by the total number of moles of solute and solvent.

$$x_i = \frac{n_i}{n_{\text{tot}}}$$

x_i=mole fraction , n_i= amount of a constituent in moles . n_{tot} = total amount of all constituents in a mixture in moles

(Table -1) Different Units for Expressing the Concentrations of Solutions*

Unit	Definition	Application
molarity (M)	moles of solute/liter of solution (mol/L)	Used for quantitative reactions in solution and titrations; mass and molecular mass of solute and volume of solution are known.
mole fraction (χ)	moles of solute/total moles present (mol/mol)	Used for partial pressures of gases and vapor pressures of some solutions; mass and molecular mass of each component are known.
molality (m)	moles of solute/kg of solvent (mol/kg)	Used in determining how colligative properties vary with solute concentration; masses and molecular mass of solute are known.
mass percentage (%)	[mass of solute (g)/mass of solution (g)] × 100	Useful when masses are known but molecular masses are unknown.
parts per thousand (ppt)	[mass of solute /mass of solution] × 10^3 (g solute/kg solution)	Used in the health sciences, ratio solutions are typically expressed as a proportion, such as 1:1000.
parts per million (ppm)	[mass of solute /mass of solution] × 10^6 (mg solute/kg solution)	Used for trace quantities; masses are known but molecular masses may be unknown.
parts per billion (ppb)	[mass of solute/mass of solution] × 10^9 (µg solute/kg solution)	Used for trace quantities; masses are known but molecular masses may be unknown.
*The molarity of a solution is temperature dependent, but the other units shown in this table are independent of temperature.		

Different units are used to express the concentrations of a solution depending on the application. The concentration of a solution is the quantity of solute in a given quantity of solution. It can be expressed in several ways: molarity (moles of solute per liter of solution); mole fraction, the ratio of the number of moles of solute to the total number of moles of substances present; mass percentage, the ratio of the mass of the solute to the mass of the solution times 100; parts per thousand (ppt), grams of solute per kilogram of solution; parts per million (ppm), milligrams of solute per kilogram of solution; parts per billion (ppb), micrograms of solute per kilogram of solution; and molality (m), the number of moles of solute per kilogram of solvent.

Q1-While Vitamin C is soluble in water. Why?

Q2-The solubility of gases in water increases with increasing mass because larger molecules have stronger dispersion forces why.

Q3-Generally, the solubility of solid solutes in liquid solvents increases with increasing temperature why?

Q4-The solubility of liquids and solids does not change appreciably with pressure. But, the solubility of a gas in a liquid is directly

proportional to its pressure

Example :- Commercial vinegar is essentially a solution of acetic acid in water. A bottle of vinegar has 3.78 g of acetic acid per 100.0 g of solution. Assume that the density of the solution is 1.00 g/mL.

Solution:

A: The molarity is the number of moles of acetic acid per liter of solution. We can calculate the number of moles of acetic acid as its mass divided by its molar mass.

$$\text{Molarity (M)} = \frac{\text{No. of moles of solute}}{\text{liters of solution}}$$

$$\text{moles } CH_3CO_2H = \frac{3.78 \not{g}\ CH_3CO_2H}{60.05 \not{g}/\text{mol}} = 0.0629 \text{ mol}$$

Then calculate the molarity directly.

Molarity of CH_3CO_2H=moles CH_3CO_2H / liter of solution

Molarity of CH_3CO_2H = 0.0629molCH_3CO_2H / (100mL) (1L/1000mL)

=0.629M CH_3CO_2H

B: To calculate the mole fraction of acetic acid in the solution

The mole fraction of acetic acid is the ratio of the number of moles of acetic acid to the total number of moles of substances present:

To calculate the mole fraction χ of acetic acid in the solution, we need to know the number of moles of both acetic acid and water. The number of moles of acetic acid is 0.0629 mol, as calculated in part (a). We know that 100.0 g of vinegar contains 3.78 g of acetic acid; hence the solution also contains (100.0 g − 3.78 g) = 96.2 g of water. We have

$$\text{moles of } H_2O = \frac{96.2\ \text{g}\ H_2O}{18.02\ \text{g/mol}} = 5.34\ \text{mol}\ H_2O$$

The mole fraction χ of acetic acid is the ratio of the number of moles of acetic acid to the total number of moles of substances present:

$$\chi_{CH_3COOH} = \frac{\text{moles of } CH_3COOH}{\text{moles of } CH_3COOH + \text{moles of } H_2O}$$

$$\chi_{CH_3COOH} = \frac{0.0629\ \text{mol}}{0.0629\ \text{mol} + 5.34\ \text{mol}} = 1.16 \times 10^{-2}$$