

# Physical Pharmacy



Non-electrolytes 3

#### **Physical Properties of Substances**

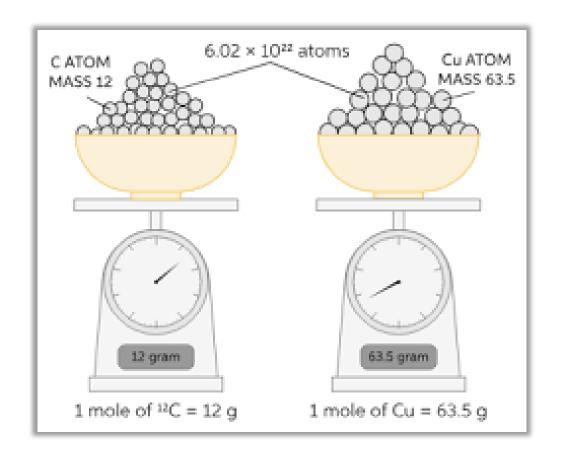
The physical properties of substances can be classified as colligative, additive, and constitutive

#### Additive properties:

- a. depend on the total contribution of the atoms in the molecule or on the sum of the properties of the constituents in a solution.
- b. An example of an additive property of a compound is:-
  - 1. The molecular weight, that is, the sum of the masses of the constituent atoms.
  - 2. The masses of the components of a solution are also additive, the total mass of the solution being the sum of the masses of the individual components.



### **Physical Properties of Substances**





#### **Physical Properties of Substances**

#### Constitutive properties:

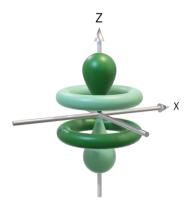
- a. depend on the arrangement and to a lesser extent on the number and kind of atoms within a molecule.
- b. Many physical properties may be partly additive and partly constitutive.
- c. The refraction of light, electric properties, surface and interfacial characteristics, and the solubility of drugs are at least in part constitutive and in part additive properties; these are considered in other sections of the book.



#### **Physical Properties of Substances**

#### Colligative properties:

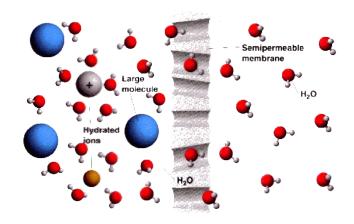
- a. depend mainly on the number of particles in a solution.
- b. The colligative properties of solutions are osmotic pressure, vapor pressure lowering, freezing point depression, and boiling point elevation.





### **Colligative properties: (Greek: "collected together")**

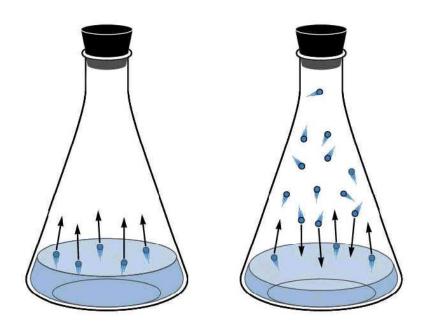
- Are those physical properties of a liquid that may be altered by the presence of solute and are depend on the number of solute particles in the solution and not on the nature of the solute,
- Therefore the values of the colligative properties are approximately the same for equal concentrations of different nonelectrolytes in solution regardless of the species or chemical nature of the constituents.





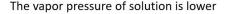
### **Colligative properties: (Greek: "collected together")**

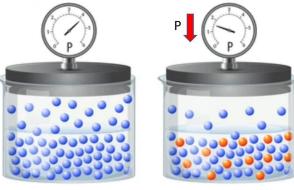
In considering the colligative properties of solid-in-liquid solutions, it is assumed that the solute is nonvolatile and that the pressure of the vapor above the solution is provided entirely by the solvent.





- When a nonvolatile solute is combined with a volatile solvent, the vapor above the solution is provided by the solvent.
- The solute reduces the escaping tendency of the solvent, Why?
- This is because the amount of surface area available for the escaping of solvent molecules is reduced because that area is occupied by solute particles, so the solvent molecules will have lower probability to escape the solution than that of pure solvent.



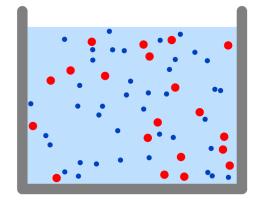


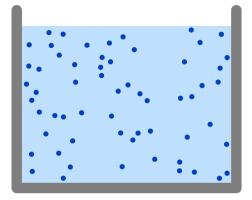
Pure Water

Solution of NaC



- That fact is reflected in the lower vapor pressure for a solution relative to the pure solvent.
- On the basis of **Raoult's law**, the vapor pressure of a solution containing a nonvolatile solute is lowered proportional to the relative number of the solute molecules.







- In the case of a single volatile liquid (solvent) and a non-volatile solute:-
  - a. The vapor pressure of a solution of a non-volatile solute is equal to:-
    - 1) The vapor pressure of the pure solvent at that temperature multiplied by its mole fraction

$$P = P^{o}_{solvent} \cdot X_{solvent}$$



#### **Lowering of the Vapor Pressure**

But since the vapor pressure of solution is affected by the solute molecules, therefore; it is more convenient to express the vapor pressure of the solution in terms of the concentration of the solute, rather than the mole fraction of solvent and this may be accomplished in the following way:-

$$P = P^{\circ}_{1}X_{1}$$

Since 
$$X_1+X_2=1 \longrightarrow X_1=1-X_2$$

$$P = P^{\circ}_{1} (1-X_{2})$$

$$P = P_1^{\circ} - P_1^{\circ} X_2$$

$$P_1^{\circ}X_2 = \Delta P$$

Therefore vapor pressure lowering:

$$\Delta P = P^{\circ}_{1} - P$$
(solvent) - (solution)

**Relative vapor pressure lowering:** 

$$\frac{\Delta \mathbf{P}}{\mathbf{P}^{\circ}\mathbf{1}} = \mathbf{X}_2$$



- Since both vapor pressure lowering and relative vapor pressure lowering depend on the mole fraction of solute ( no. of particles of solute in certain volume of solution )
- So they are considered as colligative properties
- Since we deal with molality, therefore we have to re –write the above equation in term of molality

$$\frac{\Delta \mathbf{P}}{\mathbf{P}^{\circ}\mathbf{1}} = \mathbf{X}_2 = \frac{n2}{n1+n2}$$



### **Lowering of the Vapor Pressure**

In very dilute solution (the no. of moles of solute is very small)

$$\frac{n2}{n1+n2} = \frac{n2}{n1}$$

$$\frac{\Delta \mathbf{P}}{\mathbf{P}^{\circ} \mathbf{1}} = X_2 = \frac{n2}{n1} = \frac{Wt \ 2/Mwt2}{Wt \ 1/Mwt1}$$

As you know the  $m = \frac{Wt}{Mwt}$   $x = \frac{1000}{wt \ of \ solvent}$  it can be written as

$$m = \frac{Wt2}{Mwt 2} \quad x \quad \frac{1000}{wt \ 1}$$



#### **Lowering of the Vapor Pressure**

By several derivation steps and re-arrangement we will end with following equations

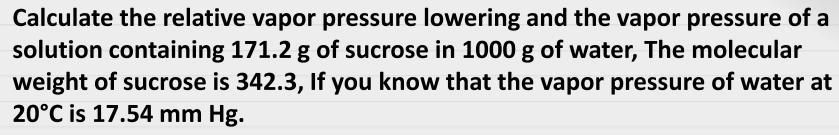
$$\frac{\Delta P}{P^{\circ}1} = m \quad \frac{Mwt \ 1}{1000}$$
 This is a general equation for any solvent

Since we deal with water which has a Mwt of 18 therefore the equation will be

$$\frac{\Delta P}{P^{\circ}1} = 0.018m$$
 This is a specific equation for water



### **Lowering of the Vapor Pressure : Example**



 $\frac{\Delta P}{P^{\circ}} = 0.018 \times 0.5 = 0.009$ 

**Answer: First** 

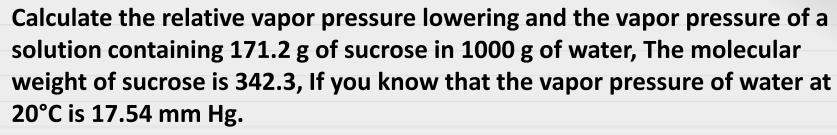
$$\frac{\Delta P}{P_1^{\circ}} = 0.018$$

$$m = \frac{Wt}{Mwt} x \frac{1000}{Wt \ of \ solvent}$$

$$m = \frac{171.2}{342.3} x \frac{1000}{1000} = 0.5$$



#### **Lowering of the Vapor Pressure : Example**



 $\Delta P = Psolvent - Psolution$ 

0.16 = 17.54 - P solution

P solution = 17.38mmHg

**Answer: second** 

$$\frac{\Delta P}{P_1^{\circ}} = 0.018$$

$$\Delta P = P_1^{\circ} 0.018m$$

$$= 17.54x 0.018x0.5$$

$$= 0.158 \approx 0.16 \, mmHg$$



