Chapter 11

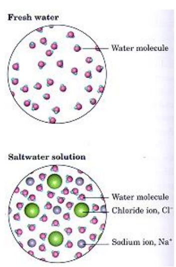
- Solution Properties
- Concentration Expressions
- Colligative Properties

Solutions

A solution is a homogeneous mixture of two or more substances in a single physical state.

Properties:

- particles in solution are very small (atoms, molecules or ions)
- particles are evenly distributed (every sample will have the same concentration as every other sample)
- particles will not separate out



Solutions

2 parts to a solution:

1) solute - substance that dissolves
2) solvent - substance doing dissolving.

4 types of solutions

1) alloys - solid solutions
2) gas solutions
3) liquid solutions
4) aqueous solutions - water is solvent

Solubility & Saturation

Solubility - The amount of a solute that will dissolve in a specific solvent.

Saturated - A solution is saturated if it contains as much solute as it possibly can.

Unsaturated - A solution that has less than the maximum amount of solute that can be dissolved.

Supersaturated - A solution that contains more than it should (highly unstable)

Miscibility

Pairs of liquids that mix in all proportions are said to be miscible.

Pairs of liquids that do not dissolve significantly in one another are immiscible.

Gasoline is miscible with ethanol but immiscible with water.

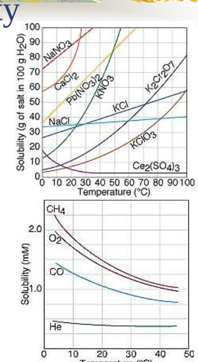
Effects on Solubility

Solubility can be affected by the temperature of the solvent

A point on the curve is saturated.

Below the curve indicates an unsaturated solution

Above is a supersaturated solution



Effects on Solubility

Substances with similar intermolecular forces tend to be soluble with one another, or the phrase "like dissolves like".

The larger the molecule of solute, the lower the solubility.

An increase in pressure will increase the solubility of a gas in solution

Greater temperature of the solvent usually increases the solubility of a solid or liquid in a solution and decreases the solubility of a gas.

Concentrations

Chemists often need to specify precisely how concentrated or dilute a solution is. The concentration is the amount of solute in a given amount of solution.

Mass concentrations:

1) Percent or pph (parts per hundred)

$$\text{pph} = \frac{\text{mass of component}}{\text{mass of solution}} \times 100$$

Concentrations

2) ppm - parts per million - number of solute molecules per 1 million molecules of solution molecules.

3) ppb - parts per billion - number of solute molecules per 1 billion molecules of solution molecules.

Concentrations

Mole concentrations:

1) Molarity - the number of moles of solute dissolved in each liter of solution.

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

2) Molality - the number of moles of solute dissolved in each kilogram of solvent.

$$\text{molality (m)} = \frac{\text{moles solute}}{\text{kg solvent}}$$

Concentrations

3) Mole Fraction - the number of moles of one component divided by the total number of moles in solution.

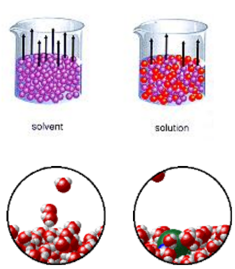
$$\text{Mole fraction (X)} = \frac{\text{moles component}}{\text{total moles of solution}}$$

Vapor Pressure Reduction

Vapor pressure is due to molecules at the surface of a liquid which break their intermolecular forces and become a gas.

By adding a nonvolatile substance to a liquid, the vapor pressure is reduced due to the solute taking up more room at the surface, so less solvent can vaporize.

Raoult's Law: $P_A = X_A P^o_A$



Boiling Point Elevation

When a solvent boils, the vapor pressure needs to be at the same pressure as the atmospheric pressure.

By adding solute, the solution's vapor pressure is reduced, therefore needing a higher temperature to boil off the liquid.

ΔT_b , the difference between the normal boiling point and the new boiling point depends on the molality of the solution:

$\Delta T_b = iK_b m$, where K_b depends on the solvent.

Freezing Point Depression

Same as BPE, except this colligative property requires a lower temperature to overcome the molecules of solute getting in the way of intermolecular forces.

Difference between the solvent freezing point and the solution freezing point is ΔT_f :

$\Delta T_f = iK_f m$, where K_f depends on the solvent

Using C.P. to find molar mass

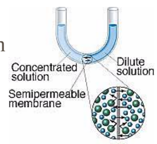
Example: A solution of an unknown nonvolatile nonelectrolyte was prepared by dissolving 0.250 g of the substance in 40.0 g of CCl_4. The boiling point of the solution was 0.357 ^{O}C higher than that of the pure solvent. Calculate the molar mass of the solute.

Osmosis

A semipermeable membrane is a material that lets some substances through but not others.

When a concentrated solution is separated from a dilute solution by a semipermeable membrane, solvent molecules move from the area of lower concentration to higher concentration. The net movement of solvent is always toward the higher concentration

The process of osmosis attempts to bring the two concentrations to equilibrium.



Osmotic Pressure

At some point though, the liquid levels of the two solutions becomes uneven enough that osmosis stops. This difference in height of the two columns causes osmotic pressure, and osmosis stops.

To prevent the net flow of solvent through osmosis, a pressure can be applied to the concentrated solution. This osmotic pressure is found to obey the ideal gas law, so that:

$$\pi = i\left(\frac{n}{V}\right)RT \text{ or } \pi = iMRT$$