Chem 30A

Ch 13. Solutions

Chem 30A

Introduction

Solution

- Solution = Homogeneous mixture: A uniform mixture of two or more substances that has the same composition throughout
- Eg. (Air, seawater, gasoline)

Solutions: Solute and Solvent

- Solute: Substance present in the smaller amount; substance that is dissolved
- Solvent: Substance present in the larger amount; substance in which another substance is dissolved
- Eg. Salt water solution: Salt is the solute, water is the solvent.

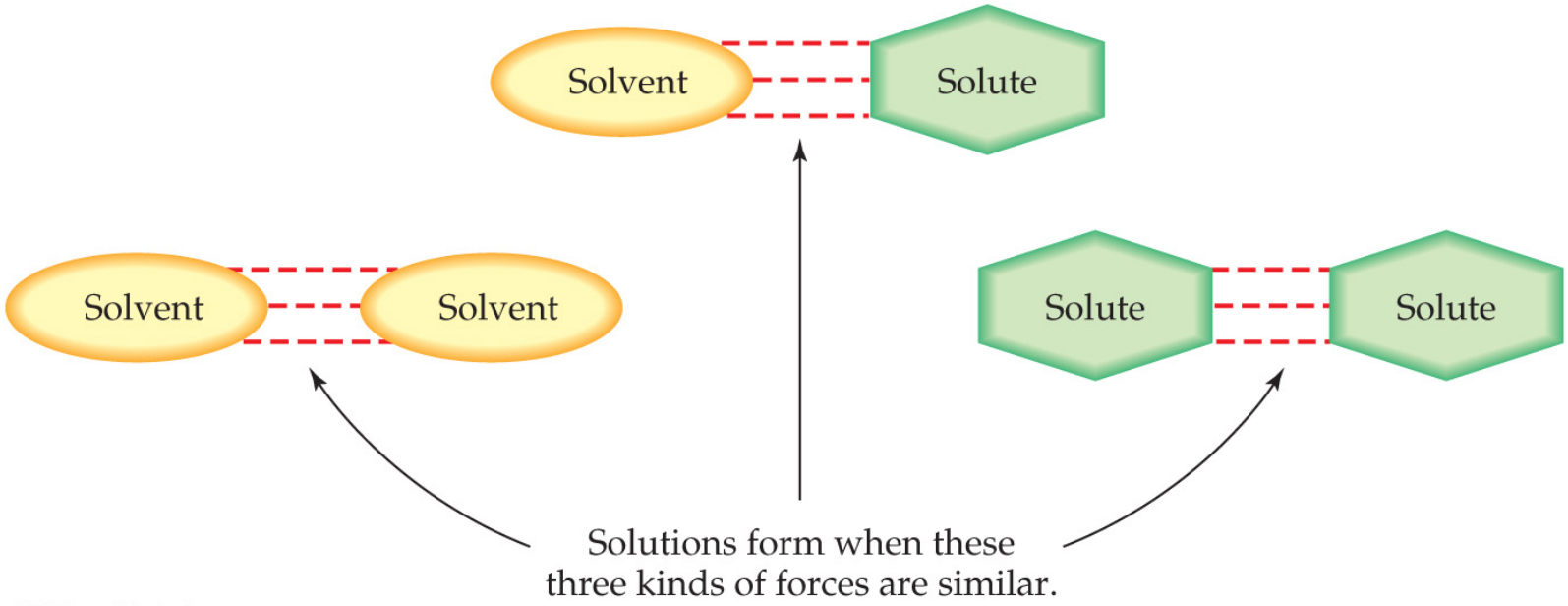
Various Types of Solutions

Table 15.1 Various Types of Solutions

Example	State of Solution	Original State of Solute	State of Solvent
air, natural gas	gas	gas	gas
vodka in water, antifreeze in water	liquid	liquid	liquid
brass	solid	solid	solid
carbonated water (soda)	liquid	gas	liquid
seawater, sugar solution	liquid	solid	liquid

Solubility Depends on Intermolecular Forces

- Solubility depends primarily on intermolecular forces: For a solute to be dissolved in a solvent, solute-solvent attraction must be comparable to or greater than the magnitudes of solute-solute or solvent-solvent attractive forces.

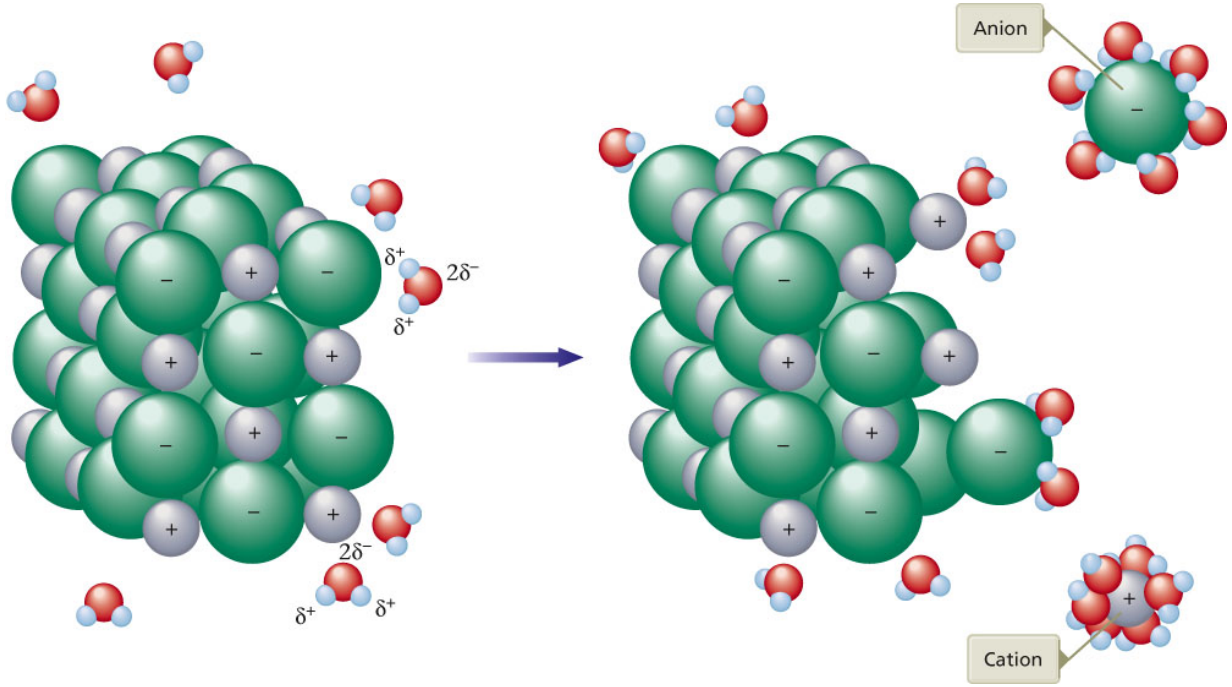


“Like Dissolves Like”

- Substances with similar intermolecular forces form solutions with one another.
- Polar solvents dissolve polar solutes and ionic solutes.
- Nonpolar solvents dissolve nonpolar solutes.

Soluble: Polar Solvent + Ionic Solute (Electrolyte Solution)

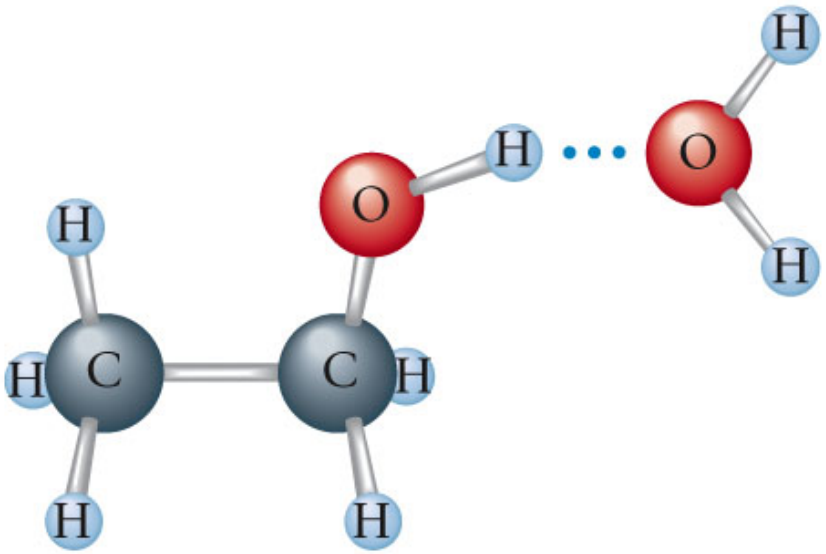
- Polar solvent molecules are attracted to the cations and anions of an ionic solid, and help break up the ionic solid into individual cations and anions.
- Ion-dipole force



Hydration: Solvation with water

Soluble: Polar Solvent + Polar Solute

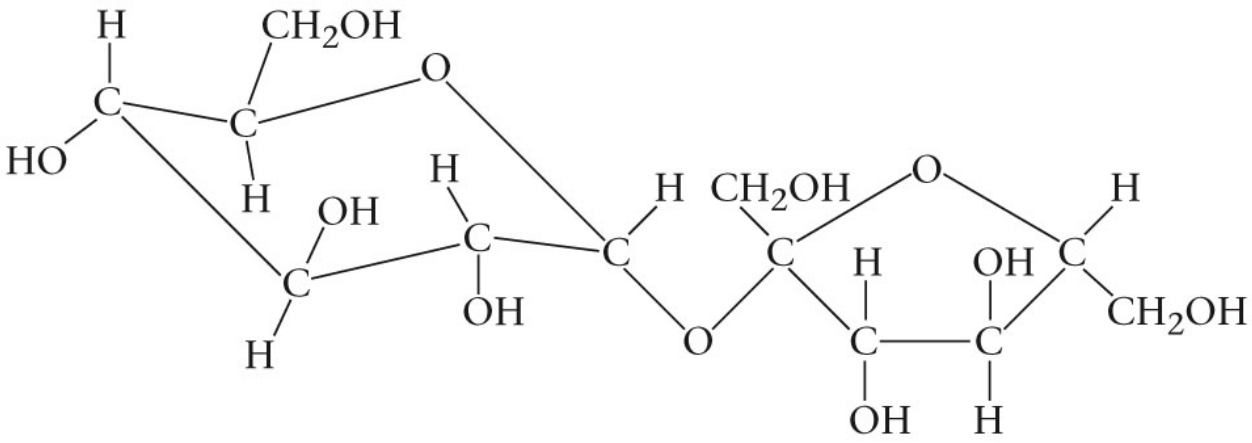
- Polar solute attracts polar solvent through dipole-dipole force and, if available, hydrogen bonding.



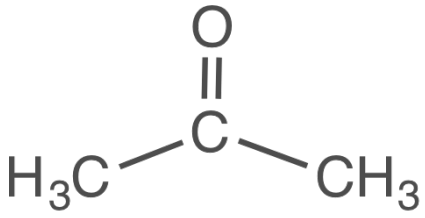
Eg. Water + Ethanol (C_2H_5OH)

Question

- Why is solid sugar soluble in water?

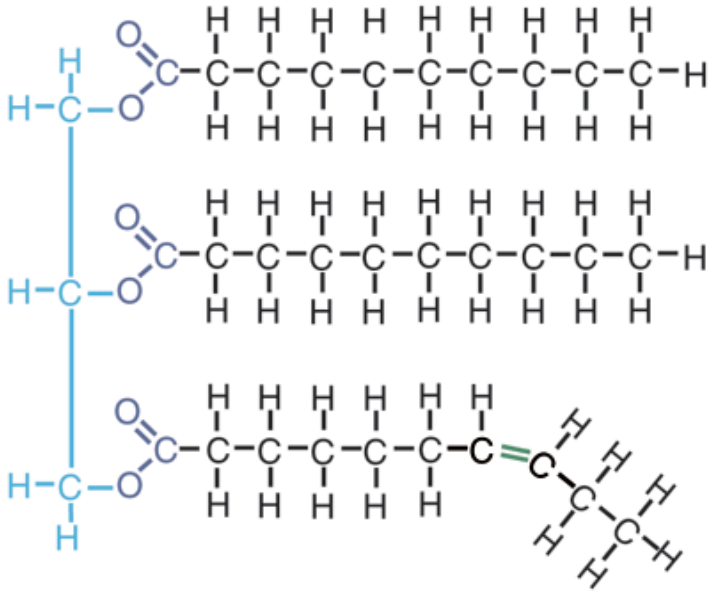


- Why is acetone soluble in water?

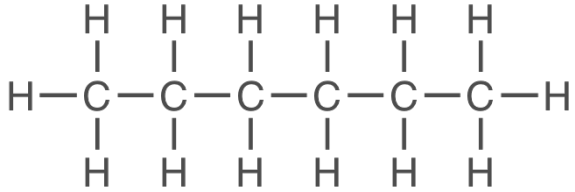


Soluble: Nonpolar Solvent + Nonpolar Solute

- Nonpolar solute attracts nonpolar solvent through London dispersion force.



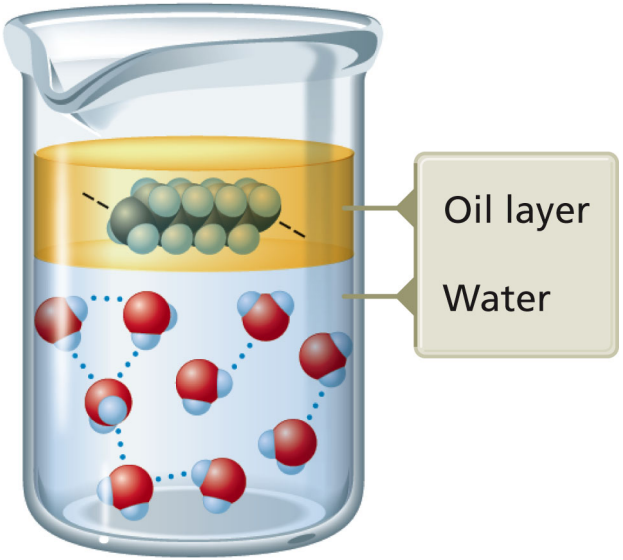
Eg. Fat



Hexane

Insoluble: Polar Solvent + Nonpolar Solute

- Nonpolar substances do not have strong attraction to polar substances.
- Eg. Oil and water mixture: There are stronger attractions between the water molecules and between the oil molecules than between water and oil molecules.



Ex Probs

Solubility

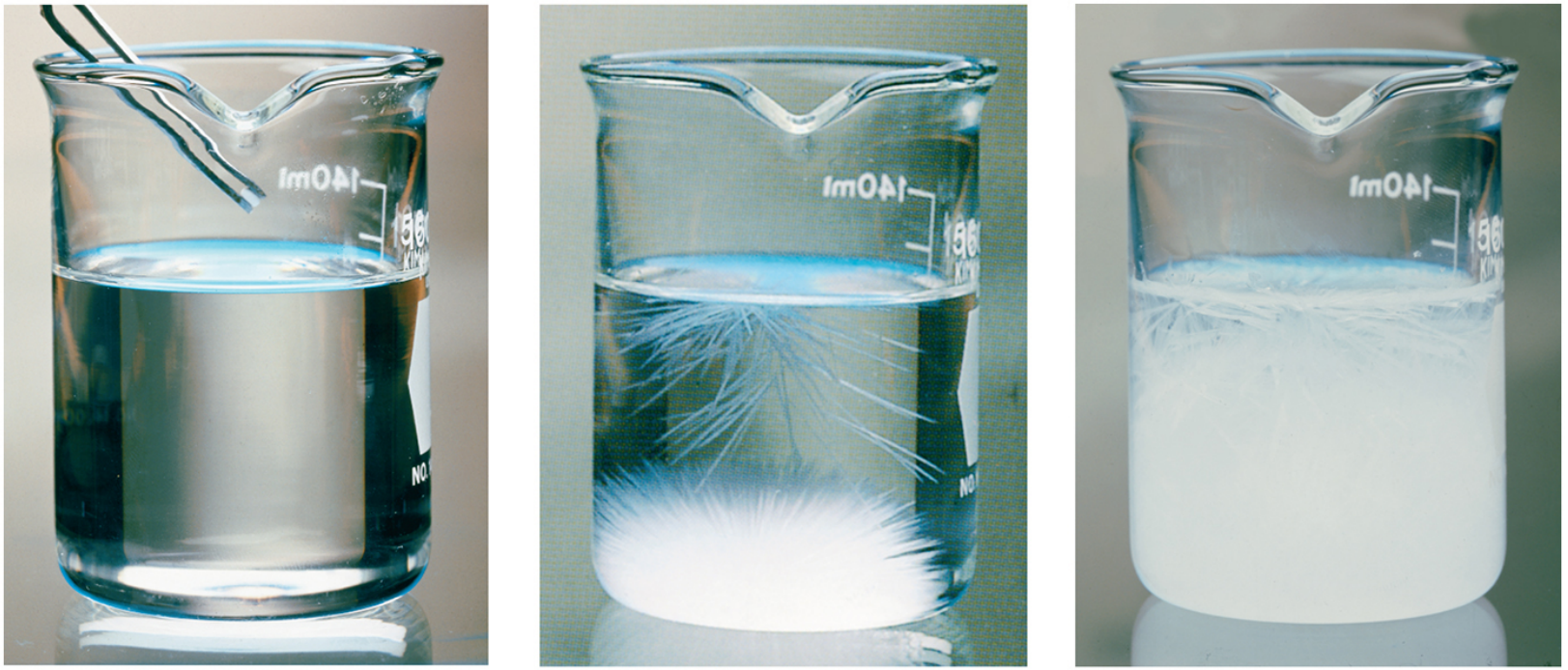
- Solubility (quantitative): Maximum amount of solute that can dissolve in a given amount of solvent at a specified temperature (eg. Solubility of NaCl is 357 mg/ml at 25°C.)

- Saturated solution: is at solubility limit at equilibrium (contains maximum amount of solute that can dissolve)

- Unsaturated solution: is under solubility limit.

- Supersaturated solution: is over solubility limit for a given temp. (Occurs when solution is saturated at a higher temp then allowed to cool slowly; unstable.)

A Supersaturated Solution



(a) (b) (c)

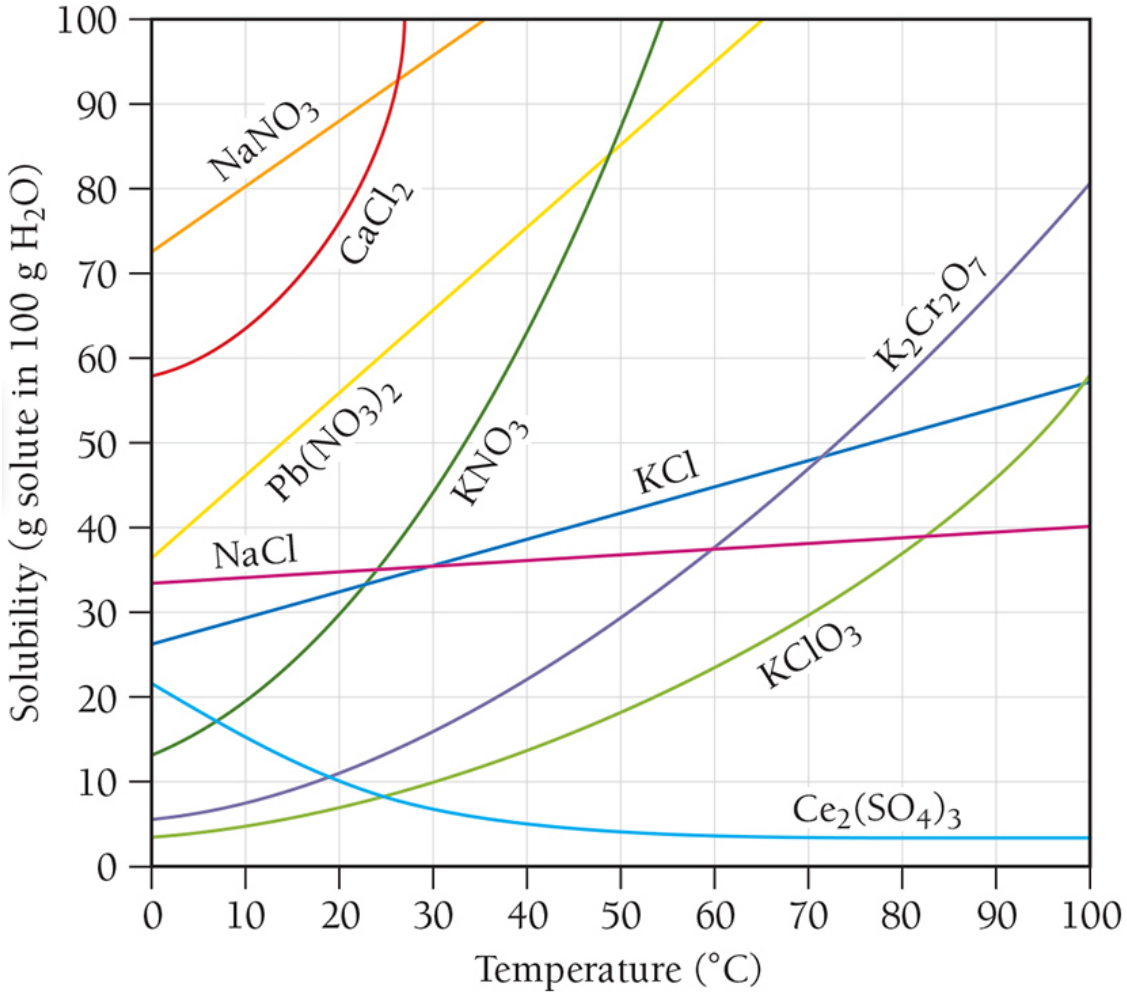
Supersaturated sodium acetate solution is disturbed.

Miscibility

Applies to liquid-liquid mixtures

- Miscible: Two liquids dissolve each other in all proportions.
  - Eg., Ethanol and water
- Immiscible: Two liquids are insoluble in each other.
  - Eg., hexane and water
- Partially miscible: Two liquids dissolve each other in limited amounts.
  - Eg., butanol and water

Effect of Temperature on Solubility in Water



The solubility of solids in water generally increases with increasing temperature.

Solution Concentration Terms

Solution Concentration Terms

1. Mass percent (also parts per million ppm and parts per billion ppb)
2. Molarity

Mass Percent

Mass percent

$$= \frac{\text{mass of solute [g]}}{\text{mass of solution [g]}} \times 100$$

*Note: solution = solute + solvent

Ex Probs

ppm and ppb

For VERY dilute solutions

$$\text{Parts per million (ppm)} = \frac{\text{mass of solute [g]}}{\text{mass of solution [g]}} \times 10^6$$

$$\text{Parts per billion (ppb)} = \frac{\text{mass of solute [g]}}{\text{mass of solution [g]}} \times 10^9$$

Ex Probs

Molarity

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

eg. 3 M HCl $= \frac{3 \text{ moles of HCl}}{1 \text{ L of solution}}$

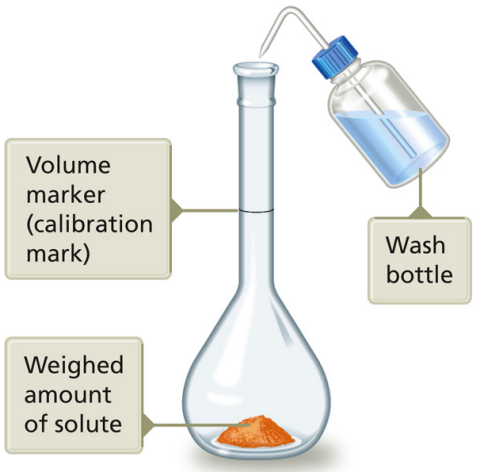
Read: “3 molar HCl”

- Moles of solute = M x L
- $L = \frac{\text{moles of solute}}{M}$

Ex probs

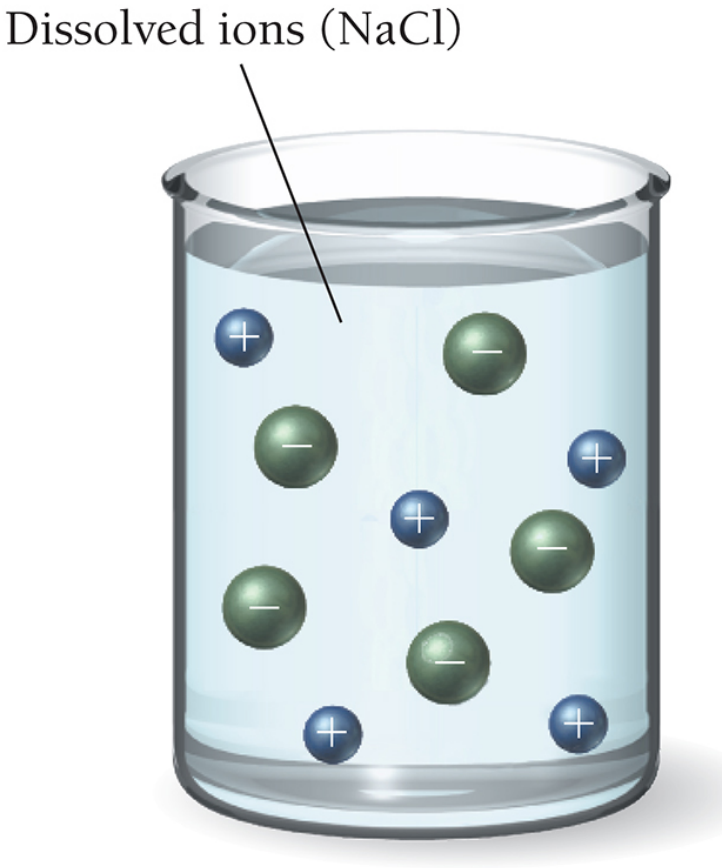
Standard Solution

- Standard solution: A solution whose concentration is accurately known.
- Steps to preparing a standard solution
  1. Weigh out a sample of solute and transfer to a volumetric flask.
  2. Add solvent and mix to dissolve the solute.
  3. Finish adding solvent to volume mark on flask and mix.



Ex probs

Ion Concentration



5 M NaCl

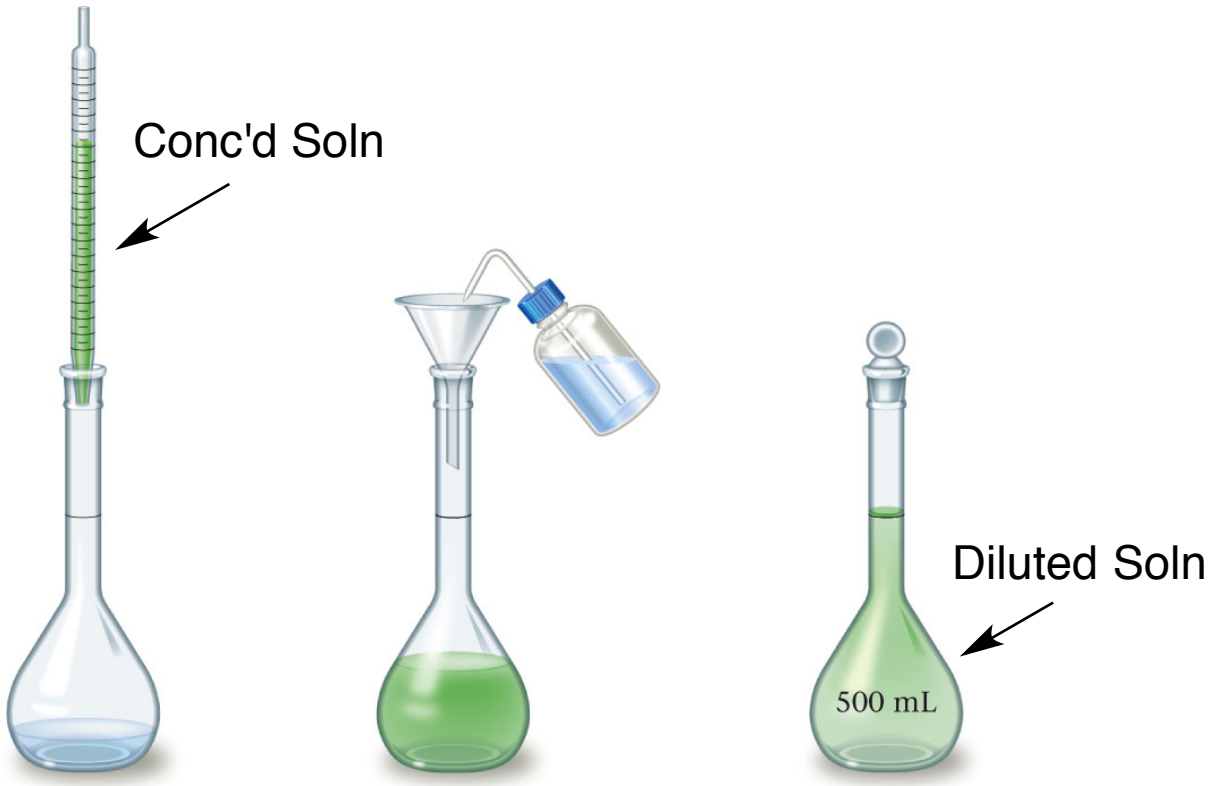
- What is the molar concentration of Na^+? 5M
- What is the molar concentration of Cl^-? 5M

Dilution

- Dilution: the process of adding water to a concentrated (stock) solution to get a solution of desired molarity

Dilution

Eg. Prepare 500.0 mL of 0.40 M HCl from 10.0 M HCl.



How much stock solution and how much water?

Dilution

$$M_c \times V_c = M_d \times V_d$$

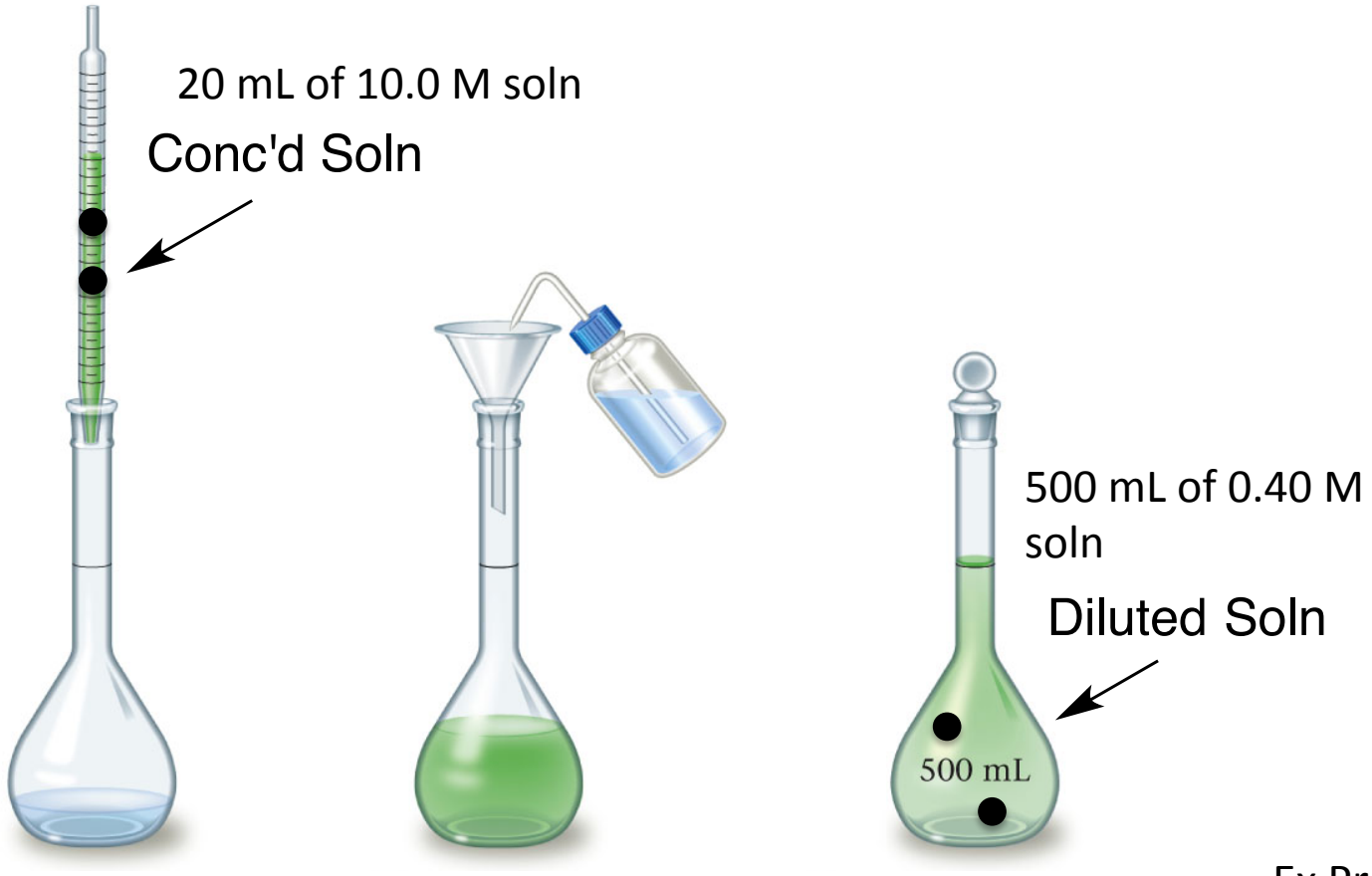
$$(\text{moles}_c = \text{moles}_d)$$

- Amount of water that needs to be added:

$$V_c + V_{water} = V_d \rightarrow V_{water} = V_d - V_c$$

Dilution

Moles of solute in conc'd solution = moles of solute in diluted solution



Ex Probs

Osmosis

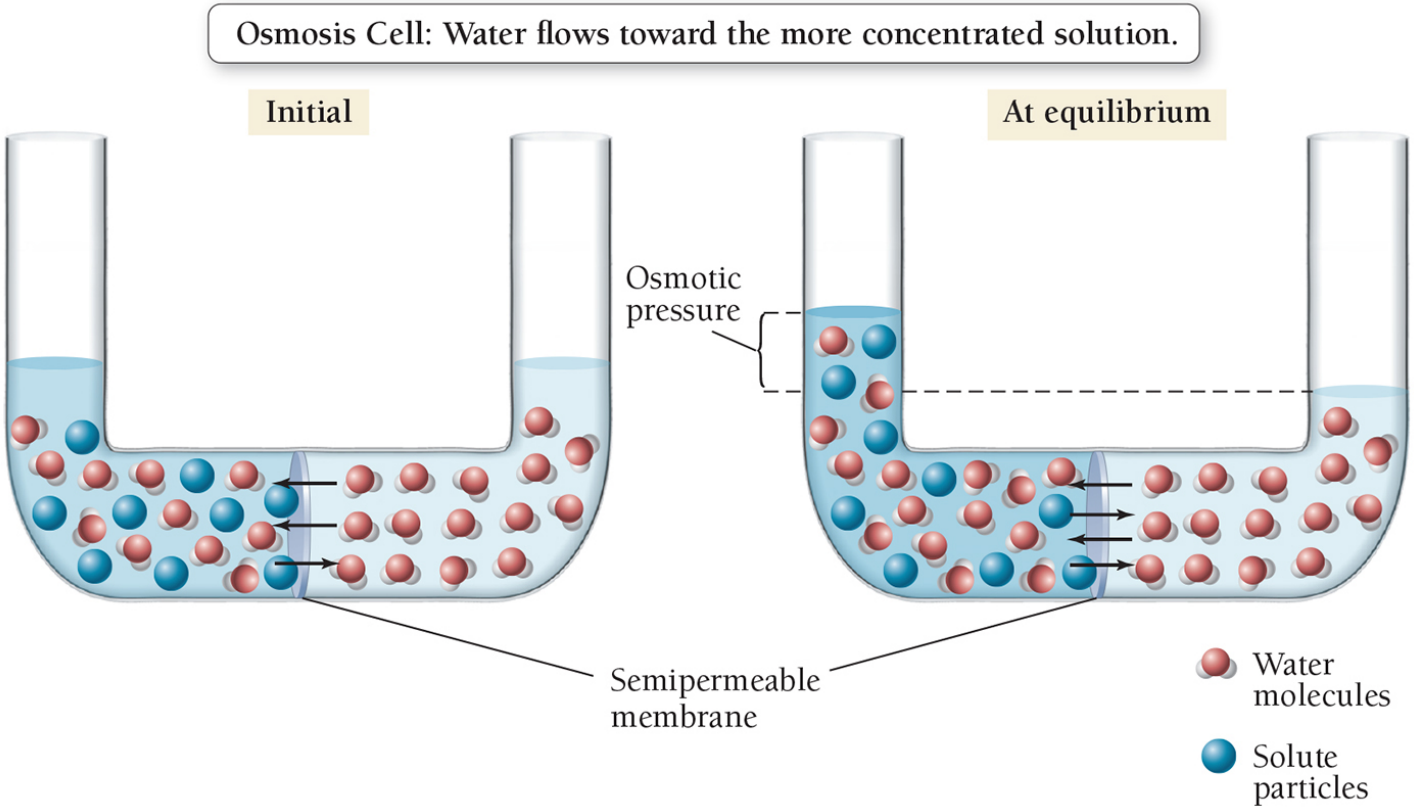
Osmosis

- Osmosis: the passage of solvent through a semipermeable membrane separating two solutions of different concentrations

- Semipermeable membrane: a membrane that allows some substances to pass through but not others

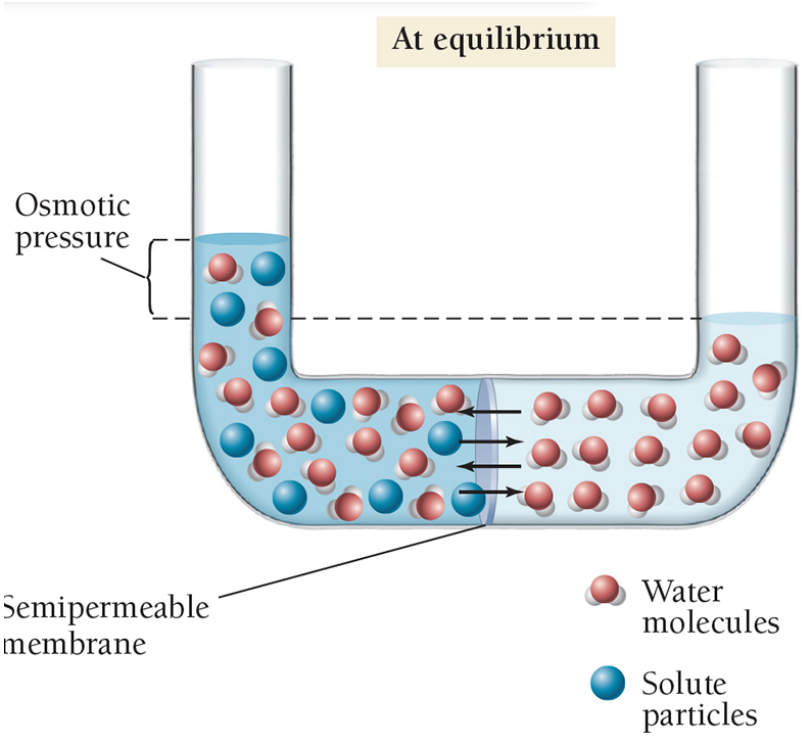
Osmosis

The net movement of solvent is always toward the solution with the higher concentration (Solvent can pass through; solute cannot).



Osmotic Pressure

Osmotic pressure: the excess pressure that a dissolved substance exerts on the semipermeable membrane



Relative Solute Concentrations

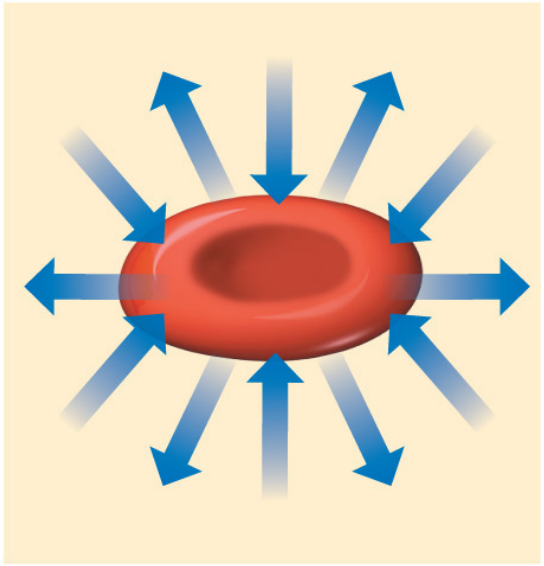
- Isotonic: Having the same solute concentration as another solution
- Hypertonic: Having a greater solute concentration than another solution
- Hypotonic: Having a lower solute concentration than another solution

Osmosis Through Red Blood Cell Membrane

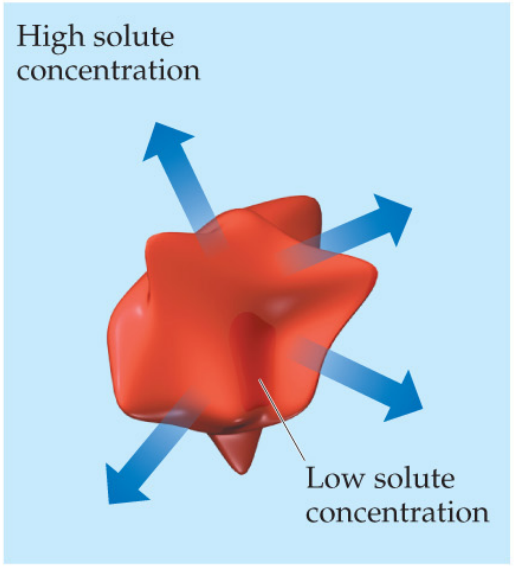
Cell membranes are semipermeable.

Cytoplasm has a constant solute concentration (~ 0.30 osmol).

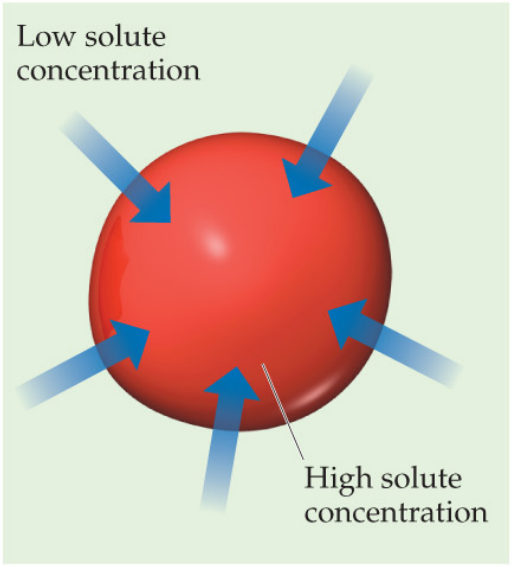
➡ H_2O movement



Cell in Isotonic Solution



Cell in Hypertonic Solution



Cell in Hypotonic Solution