Chapter 14

Solutions

- Solution - A general term for a solute dissolved in a solvent. A homogeneous mixture of 2 or more components in which particles intermingle at the molecular level.
- Solvent - The component of a solution that is the greater quantity.
- Solute - The component of a solution that is the lesser quantity.

Common Types of Solutions

• Gaseous	gas in gas
•	liquid in gas
• Liquid	gas in liquid
•	liquid in liquid
•	solid in liquid
• Solid	solid in solid

Gas Solubility

- Gases become less soluble as the temperature is raised.
- Gases are more soluble at high pressure

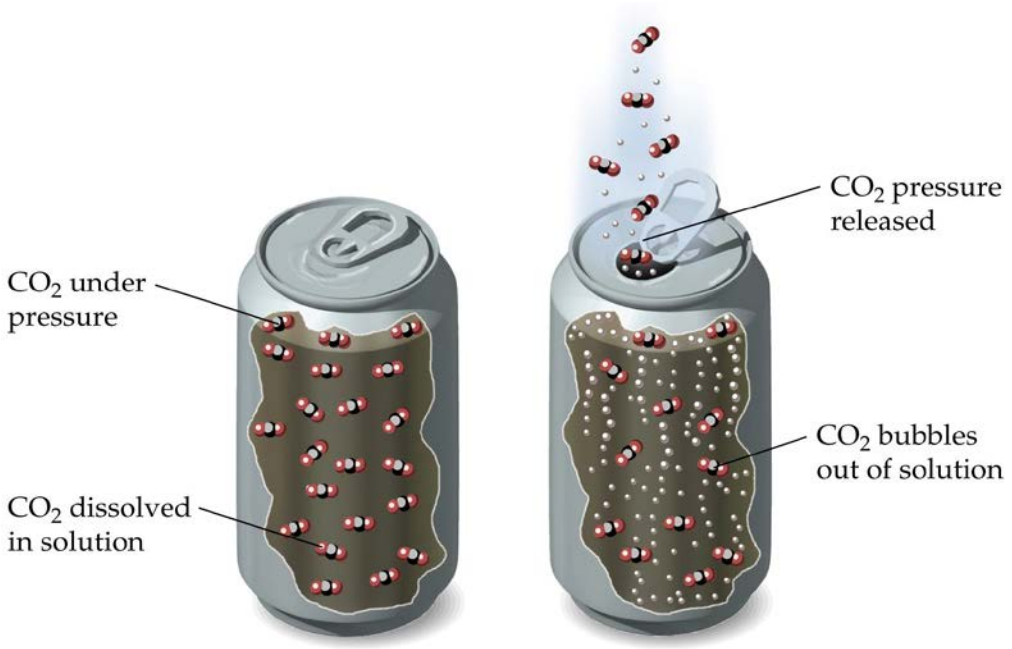


Table 14.2 Solubility of Carbon Dioxide in Water*

Temperature	Pressure	Solubility of CO_2
Temperature Effect		
0°C	1.00 atm	0.348 g/100 mL water
20°C	1.00 atm	0.176 g/100 mL water
40°C	1.00 atm	0.097 g/100 mL water
60°C	1.00 atm	0.058 g/100 mL water
Pressure Effect		
0°C	1.00 atm	0.348 g/100 mL water
0°C	2.00 atm	0.696 g/100 mL water
0°C	3.00 atm	1.044 g/100 mL water

Henry's Law

- The solubility of a gas is directly proportional to its partial pressure above the solution.

- Or Solubility = kP
  - where k = henry's law constant

Henry’s Law

- If the solubility of nitrogen is 1.90 mg/100mL blood at 1.00 atm, what is the solubility of nitrogen in a scuba diver’s blood at a depth of 155 feet where the pressure is 5.50 atm?

Liquids in Solution

- Miscible - refers to 2 or more liquids that are infinitely soluble in one another.

- Immiscible - refers to 2 liquids that are not soluble in one another and if mixed separate into 2 layers.

Liquids in Solution

- General rule – Like dissolves Like

- Polar solvents are miscible with polar solutes
- Non-polar solvents are miscible with non-polar solutes

Table 14.4 Summary of the *Like Dissolves Like* Rule for Two Liquids

Liquid Solute	Polar Solvent	Nonpolar Solvent
polar	miscible	immiscible
nonpolar	immiscible	miscible

Solids in Solution

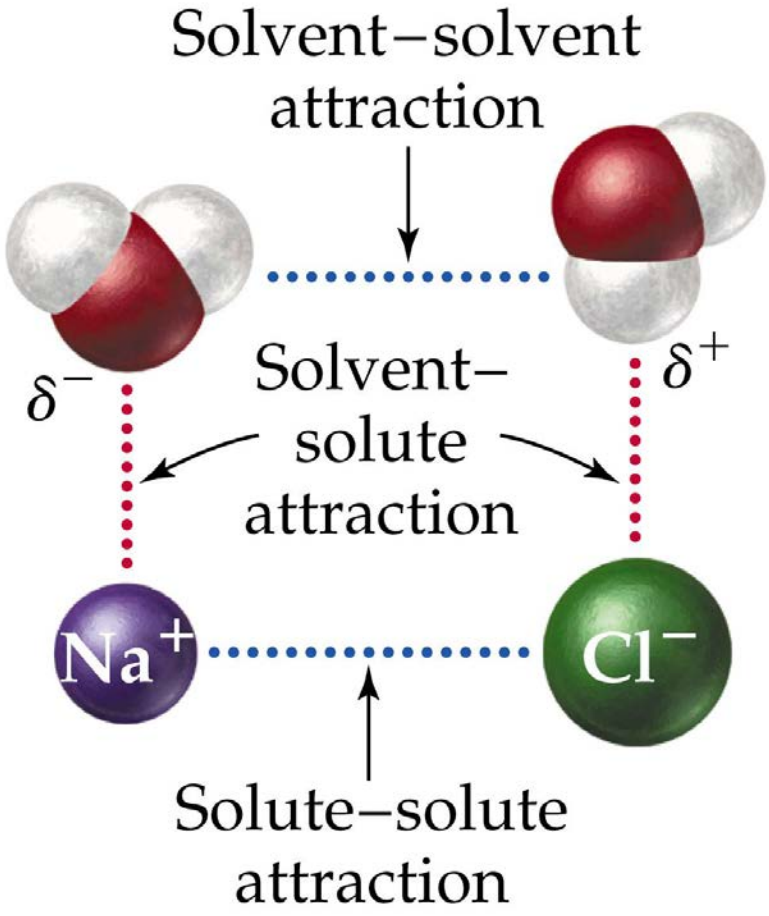
- Follows general rule – Like dissolves Like

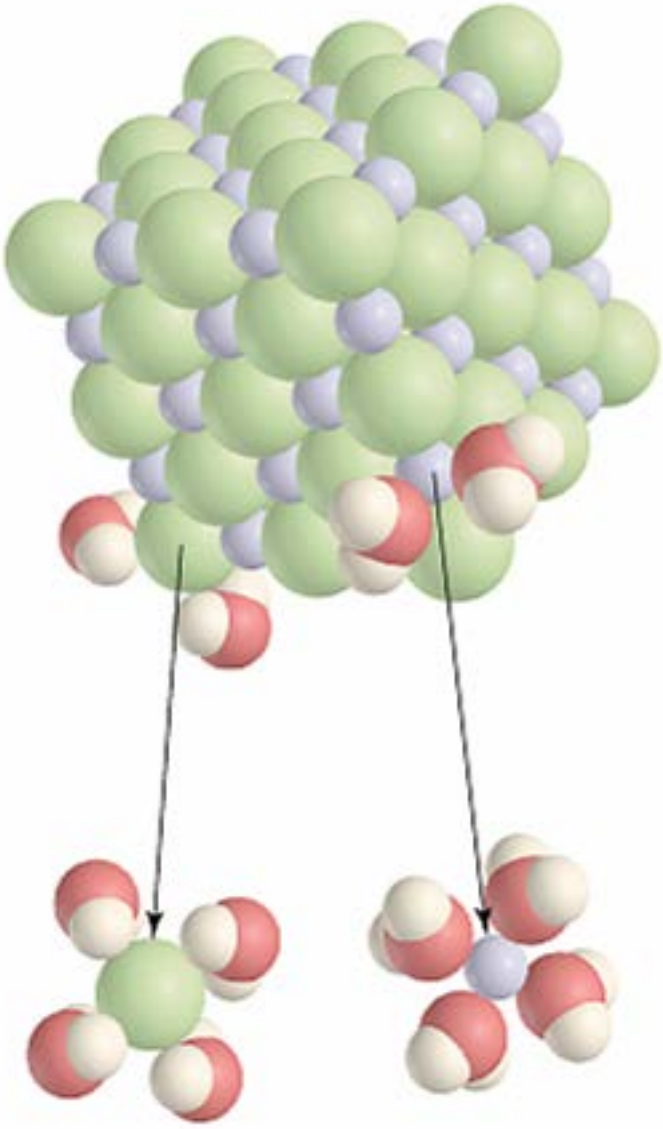
Table 14.5 Summary of the *Like Dissolves Like* Rule for a Solid in a Liquid

Solid Solute	Polar Solvent	Nonpolar Solvent
polar	soluble	insoluble
nonpolar	insoluble	soluble
ionic	soluble	insoluble

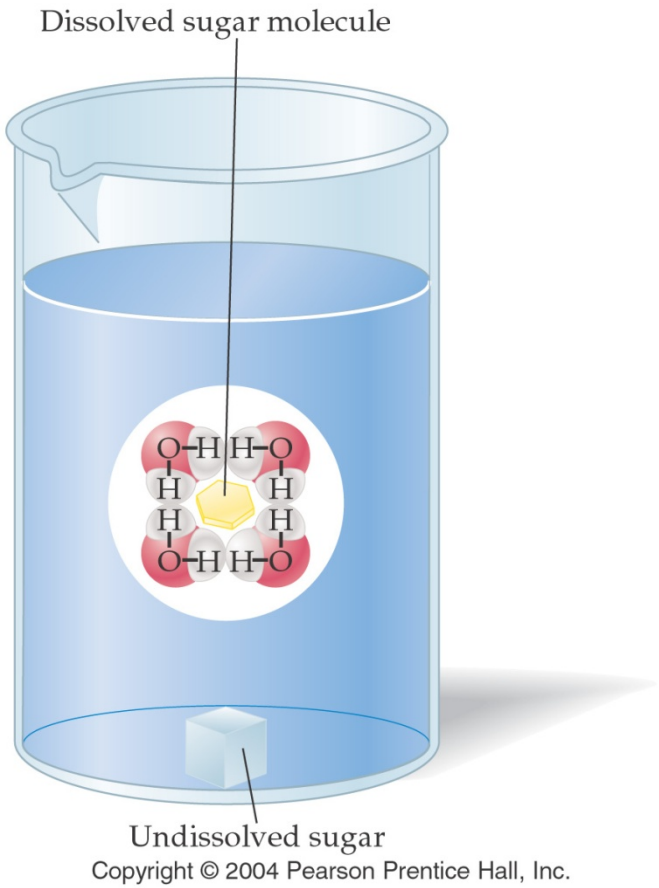
What causes substances to dissolve?

- Interactions between solute and solvent are stronger than solute/solute and solvent/solvent interactions.

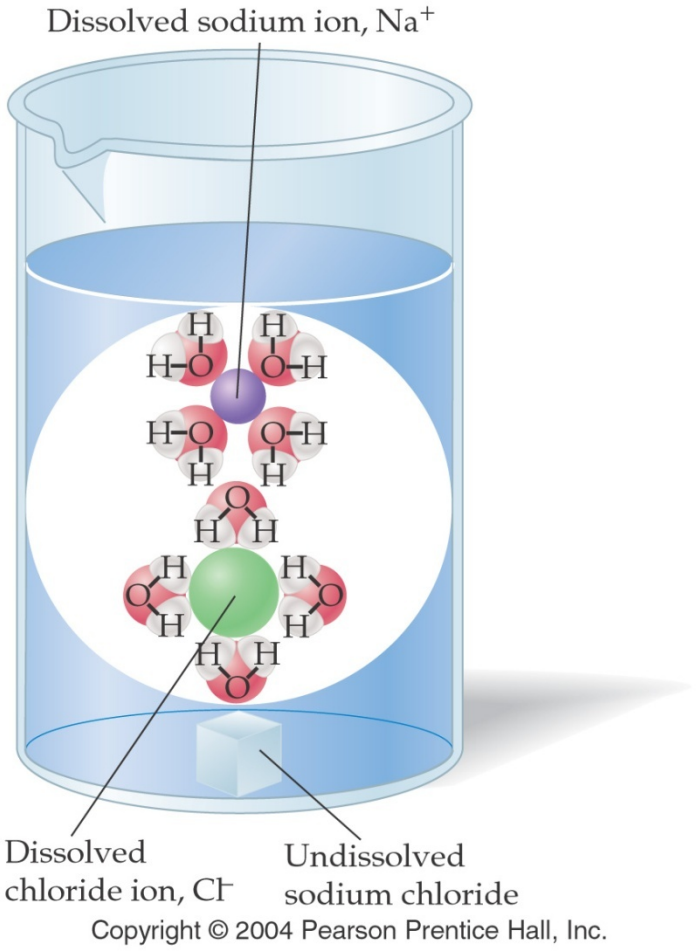




Covalent compounds remain as complete molecules when they dissolve.



- Ionic compounds dissociate into ions when they dissolve.



Rate of Dissolving

Determined by

- temperature
- stirring
- particle size

Solubility and Temperature

- generally solubility of solids and liquids increases with added heat.

- Heat of solution - the amount of energy releases or absorbed when a solute dissolves.

- $CaCl_2(s) \longrightarrow Ca^{+2}(aq) + Cl^{-1}(aq) + energy$
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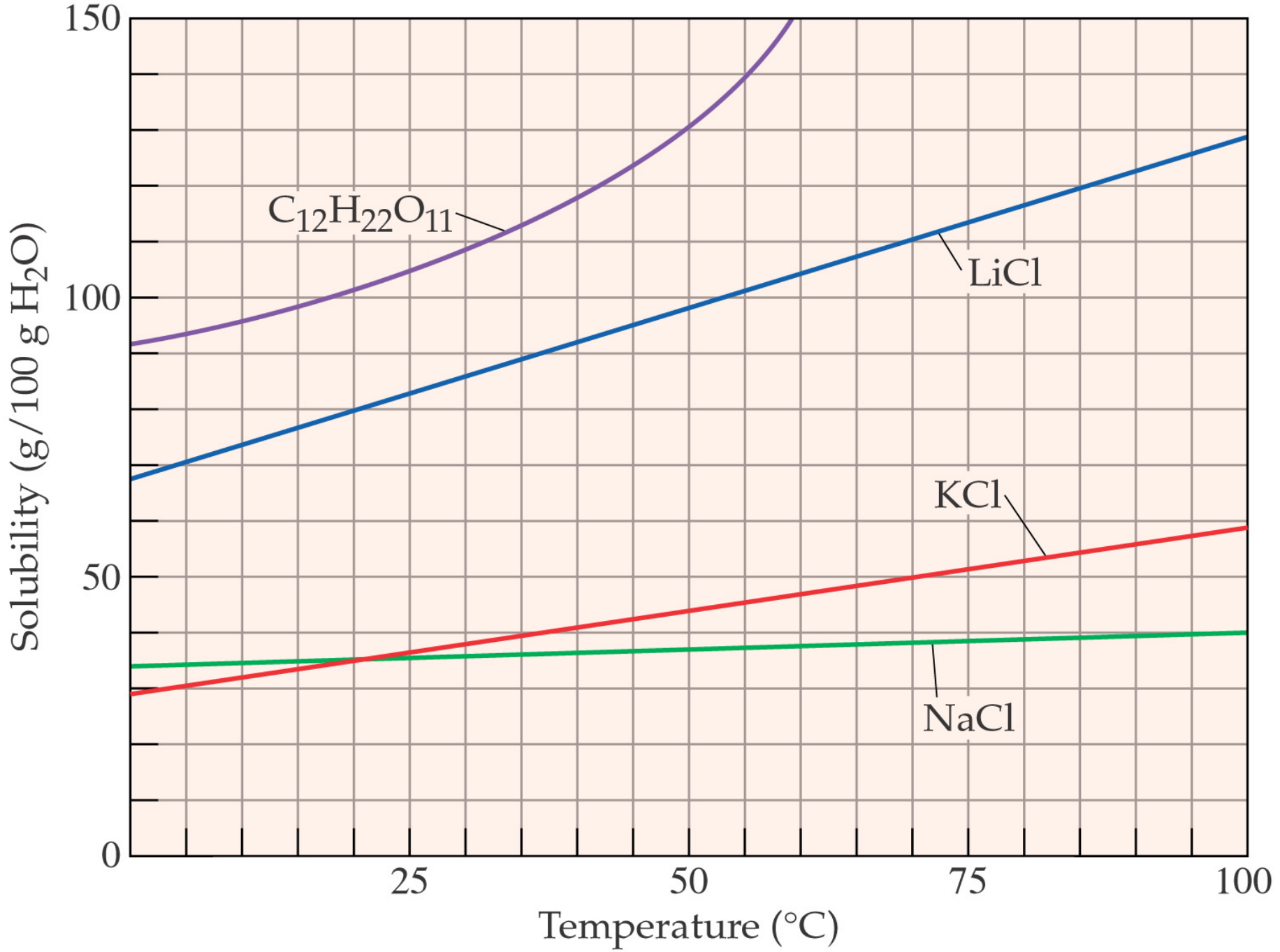
- $NH_4NO_3(s) + energy \rightarrow NH_4^{+1}(aq) + NO_3^{-1}(aq)$



Solubility and Saturation

- **Saturated solution** - a solution that contains the maximum amount of dissolved solute that will dissolve at a given temperature.
- **Unsaturated solution** - a solution that contains less solute than can be dissolved at a given temperature.
- **Supersaturated solution** - a solution that contains more dissolved solute than will ordinarily dissolve at a given temperature.

Solution Concentration Units

Mass Percent (% m/m)	$\left(\frac{mass\ solute}{mass\ solution}\right) \times 100$
Mass/Volume Percent (% m/v)	$\left(\frac{mass\ solute\ (g)}{volume\ solution\ (mL)}\right) \times 100$
Volume Percent (% v/v)	$\left(\frac{volume\ solute}{volume\ solution}\right) \times 100$
ppm and ppb	Same as % but per million or billion instead of per hundred
Molarity (M)	$\frac{moles\ solute}{L\ solution}$
Molality (m)	$\frac{moles\ solute}{kg\ solvent}$

Mass percent (% m/m)

- A solution consists of 31.7 g of $AgNO_3$ in 52.0 g of water. What is the mass % of $AgNO_3$?

- A paint requires 42.8 g of iron(III) oxide to give it the correct yellow tint. How many grams of a 30.0% by mass solution of Fe_2O_3 should be used in the paint?

Mass/Volume Percent (% m/v)

- Determine the mass volume percent of a solution prepared by dissolving 24.1 g of cadmium chloride in water, giving a final volume of 250. mL of solution.

- A 2.65 % (m/v) solution of sodium alginate is prepared for use in an experimental kitchen. How many mL of this solution must be added to a sample of raspberry puree if 0.45 g of sodium alginate are needed to form it into caviar-like spheres?

Molarity M = moles/L

- What is the molarity of a sodium hydroxide solution that contains 57.0 g of NaOH dissolved to 300.0 mL total volume?

- Calculate the volume in mL of a 2.50 M solution of sodium acetate that will contain 0.650 mol of sodium acetate.

What volume(mL) of 3.0 M ferric chloride can be prepared from 84.0 g $FeCl_3$?

Calculate the mass(g) of HNO_3 needed to prepare 500. ml of a 0.28 M solution?

Dilutions

- Calculate the volume of 0.24 M KI needed to prepare 250 ml of 0.15 M KI.

- $M_1V_1 = M_2V_2$

Solution Stoichiometry

- We can do stoichiometry using solutions just as we always have.

- Calculate the mass in grams of $BaSO_4$ formed from 0.104 L of 2.00 M H_2SO_4 and excess $Ba(OH)_2$.

- Antacids containing $CaCO_3$ react with stomach acid according to the reaction
- $CaCO_3(s) + 2\ HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$
- How many grams of $CaCO_3(s)$ are needed to react with 53.0 ml of 6.0 M HCl?

Solution properties

- Solutions that contains ions conduct electricity.

- Electrolyte - a solute that when dissolved in water forms a solution that conducts electricity.
- Nonelectrolyte - a solute that when dissolved in water forms a solution that does not conduct electricity.

Colligative properties

- properties that depend on the number of particles dissolved in a solution
  - boiling point elevation
  - freezing point depression
  - osmotic pressure

- A certain alloy is made by dissolving 5.31 g of copper and 4.03 g of zinc in 145 g of iron. Calculate the percent of each component in the alloy.

- How much water must be added to 500.0 mL of 0.200 M HCl to produce a 0.150 M solution? (Assume that the volumes are additive.)

- Suppose 1.01 g of $FeCl_3$ is placed in a 10.0 mL volumetric flask, water is added, the mixture is shaken to dissolve the solid, and then water is added to the calibration mark of the flask. Calculate the molarity of each ion present in the solution.

- When aqueous solutions of lead(II) ion are treated with potassium chromate solution, a bright yellow precipitate of lead(II) chomate, $PbCrO_4$, forms. How many grams lead chromate forms when a 1.00 g sample of $Pb(NO_3)_2$ is added to 25.0 mL of 1.00 M K_2CrO_4 solution?

- Standard solutions of calcium ion used to test for water hardness are prepared by dissolving pure calcium carbonate, $CaCO_3$, in dilute hydrochloric acid. A 1.745 g sample of $CaCO_3$ is placed in a 250.0 mL volumetric flask and dissolved in HCl. Then the solution is diluted to the calibration mark of the volumetric flask. Calculate the resulting molarity of calcium ion.

- Calculate the molarity of a solution that is 30.0% glucose and has a density of 1.42 g/mL.

- Calculate the % acetic acid in a solution of vinegar that is 3.50 M in acetic acid and has a density of 1.06 g/mL.

In class problems

- How many grams of calcium nitrate are required to make 500.0 mL of a 0.2221M calcium nitrate solution? Answer 18.22 g
- What volume of a 6.217M solution of copper(II) acetate is required to produce 2.177 mol of cupric acetate? Answer 0.3502 L
- To what volume must 50.61 mL of 0.9466 M sodium phosphate be diluted to make a 0.3014 M solution of sodium phosphate? Answer 158.9 mL soln