Chapter 16

Properties of solutions

Making solutions

- Whether the solute and the solvent are polar, nonpolar, or ionic determines
  - How much will dissolve.
  - Whether a substance will dissolve.
- A substance dissolves faster if-
  - It is stirred or shaken.
  - The particles are made smaller.
  - The temperature is increased.
- Why?

Stirring

- In order to dissolve the solvent molecules must touch the solute.
- Solvent molecules hold on to and surround the solute
- Stirring moves fresh solvent next to the solute.
- Dissolves faster

Particle size

- The solvent touches the surface of the solute.
- Smaller pieces increase the amount of surface of the solute.
- Solvent and solute touch each other more often
- Smaller particles dissolve faster

Temperature

- Higher temperature makes the molecules of the solvent move around faster and contact the solute harder and more often.
- More pieces are broken off
- Speeds up dissolving.
- Usually increases the amount of solid that will dissolve.

How Much?

- Dissolved particles are surrounded by solvent particles
- Eventually solvent particles are all occupied
- Begin turning back to solid
- Equilibrium reached where dissolved particles are turning to solid as fast as solid is being dissolved
- No more will dissolve

How Much?

- Solubility- The maximum amount of substance that will dissolve at that temperature (usually g/L).
- Saturated solution- Contains the maximum amount of solid that can be dissolved.
- Unsaturated solution- Can dissolve more solute.
- Supersaturated- A solution that is temporarily holding more than it can, a seed crystal will make it come out

Liquids

- Miscible means that two liquids can dissolve in each other.
- Immiscible means they can't

Why does Italian dressing separate?

A) Oil and vinegar are immiscible

B) Oil is nonpolar and vinegar polar

C) Vinegar particles are attracted to themselves more than they are attracted to the oil particles.

D) All of the above

What affects solubility?

- For solids in liquids as the temperature goes up the solubility goes up. (usually)
- For gases in a liquid as the temperature goes up the solubility goes down.
  - Thermal pollution

What affects solubility?

- For gases in a liquid- as the partial pressure goes up the solubility goes up.
  - Oxygen for patients
- As gas pressure goes down, solubility goes down
  - The bends

Measuring Solutions

Concentration

- A measure of the amount of solute dissolved in a certain amount of solvent.
- Concentrated solution has a large amount of solute.
- Dilute solution has a small amount of solute
- Separate from Saturated / unsaturated

Concentration

- units
- Sometimes g/L or g/mL or g/100 mL.
- But chemical reactions don't happen in grams

Molarity

- The number of moles of solute in 1 Liter of the solution.
- M = moles/Liter
- What is the molarity of a solution with 2.0 moles of NaCl in 4.0 Liters of solution.

Molarity

- What is the molarity of a solution with 3.0 moles dissolved in 250 mL of solution.

Making solutions

- Pour in a small amount of solvent
- Then add the solute and dissolve it
- Then fill to final volume.
- M x L = moles
- How many moles of NaCl are needed to make 6.0 L of a 0.75 M NaCl solution?

Making solutions

- How many grams of $CaCl_2$ are needed to make 625 mL of a 2.0 M solution?

Making solutions

- 10.3 g of NaCl are dissolved in a small amount of water then diluted to 250 mL. What is the concentration?

Making solutions

- How many grams of sugar are needed to make 125 mL of a 0.50 M $C_6H_{12}O_6$ solution?

Dilution

Adding solvent to a solution

Dilution

- The number of moles of solute doesn't change if you add more solvent.
- The moles before = the moles after
- $M_1 \times V_1 = M_2 \times V_2$
- M is concentration and V is volume.
- Stock solutions are pre-made to known M

Practice

- 2.0 L of a 0.88 M solution are diluted to 3.8 L. What is the new molarity?

Practice

- You have 150 mL of 6.0 M HCl. What volume of 1.3 M HCl can you make?

Practice

- You need 450 mL of 0.15 M NaOH. All you have available is a 2.0 M stock solution of NaOH. How do you make the required solution?

Percent solutions

- Percent means per 100 so
- Percent by volume
  $$= \frac{\text{Volume of solute}}{\text{Volume of solution}} \times 100\%$$
- indicated %(v/v)
- What is the percent solution if 25 mL of CH_3OH is diluted to 150 mL with water?

Percent solutions

- Percent by mass
  $$= \frac{\text{Mass of solute(g)}}{\text{mass of solution(g)}} \times 100\%$$
- Indicated %(m/m)
- More common

Percent solutions

- 4.8 g of NaCl are dissolved in 82 g of solvent. What is the percent of the solution?

Percent solutions

- How many grams of salt are there in 52 g of a 6.3 % solution?

Colligative Properties

Depend on the number of dissolved particles

Not on what kind of particle

How many pieces?

- Electrolytes form ions when dissolved - more pieces.
- More pieces bigger effect.
- $NaCl \rightarrow Na^+ + Cl^-$ 2 pieces
- AlF_3
- $NaNO_3$
- $Ca_3(PO_4)_2$

Vapor Pressure

- Pressure caused by escaped vapor molecules in a sealed container
- The attractions between molecules keep molecules from escaping.
- In a solution, some of the solvent is busy keeping the solute dissolved.
- Fewer escape
- Lowers the vapor pressure.

Boiling Point Elevation

- The vapor pressure determines the boiling point.
- Lower vapor pressure - higher boiling point.
- Salt water boils above 100ºC
- The solvent determines how much.

Freezing Point Depression

- Solids form when molecules make an orderly pattern.
- The solute molecules break up the orderly pattern.
- Makes the freezing point lower.
- Salt water freezes below 0ºC
- How much depends on the solvent.

Molality

- a new unit for concentration
- $m = \frac{\text{Moles of solute}}{\text{kilogram of solvent}}$

Molality

- What is the molality of a solution with 9.3 mole of NaCl in 450 g of water?

Why molality?

- The size of the change in boiling point is determined by the molality.
- $\Delta T_b = K_b \times m \times n$
- ΔT_b is the change in the boiling point
- K_b is a constant determined by the solvent(pg 495).
- *m* is the molality of the solution.
- n is the number of pieces it falls into when it dissolves.
- n is 1 for molecular compounds

What about Freezing?

- The size of the change in freezing point is determined by the molality.
- $\Delta T_f = -K_f \times m \times n$
- ΔT_f is the change in the freezing point
- K_f is a constant determined by the solvent (pg 494).
- *m* is the molality of the solution.
- n is the number of pieces it falls into when it dissolves.

Problems

- What is the boiling point of a solution made by dissolving 1.20 moles of NaCl in 750 g of water?
- What is the freezing point?

Problems

- What is the boiling point of a solution made by dissolving 1.20 moles of $CaCl_2$ in 750 g of water?
- What is the freezing point?