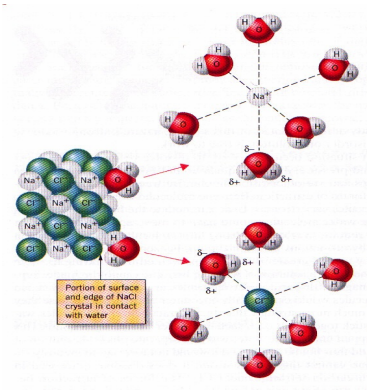
# Chapter 15 – Properties of Solutions

1) Sec 15.1 – Solution Formation




a) Stirring or shaking the solution – The solute dissolves more rapidly because the agitation brings fresh solvent into contact with solute. This does not change the actual amount of solute that dissolves.

b) Heating the solution usually causes more solute to dissolve and it also causes it to dissolve faster.

c) The particle size affects the rate at which a solute dissolves. The greater the surface area exposed (smaller particles) to the solvent, the faster the solute will dissolve. This does not change the amount of solute that dissolves.

2) Sec 15.2 – Solubility

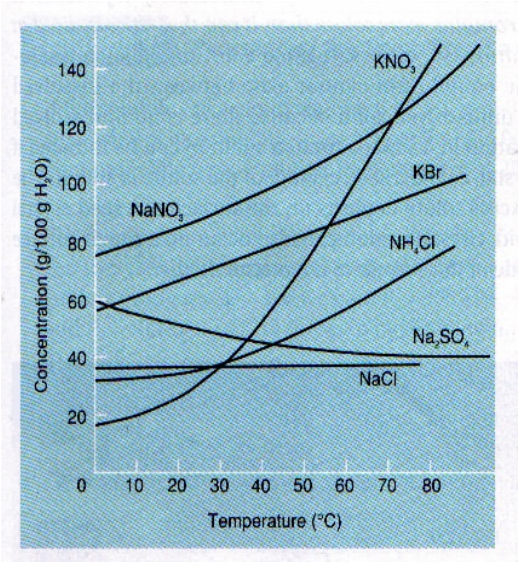
a) Solution – A homogeneous mixture in which all the ions or molecules are fully intermingled.

b) Solvent – The medium into which material (solute) is mixed or dissolved.

c) Solute – Any substance that is dissolved in a solvent.

d) Saturated Solution – The solvent contains all the solute it can hold permanently at a given temperature.

e) The solubility of a substance is the amount of substance that dissolves in a given quantity of a solvent at a given temperature.




Example – How much NaCl can be dissolved in 750 g of water at 25 °C. (Assume: 35 g / 100g)

$$\frac{750\text{ g}}{1} \times \frac{35}{100} = \mathbf{285\text{ g}}$$

f) Unsaturated Solution – A solution that contains less solute than a saturated solution.

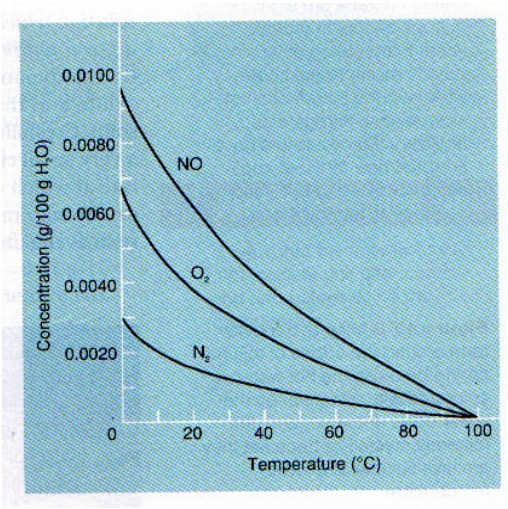
g) Supersaturated Solution – A solution which contains more solute than it can permanently hold at a given temperature. Eventually the excess solute will settle out.

3) Sec 17.3 – Factors Affecting Solubility

a) The solubility of most solids in water increases as the temperature is increased.

Example – How much $KNO_3$ will dissolve in 100 g of water at 20 °C and how much will dissolve at 60 °C?

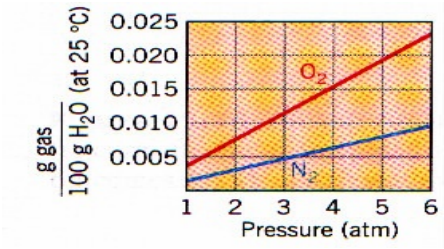
b) The solubility of gases is greater in cold water than in hot water. (This generalization should not be extended to nonaqueous solvents, where the situation is not so simple.)




Example – How much oxygen will dissolve in 100 g of water at 20 °C and how much will dissolve at 60 °C?

c) The solubility of gases in a liquid can be increased by putting the gas under pressure. Henry's Law states that, at a given temperature, the solubility of a gas in a liquid (S) is directly proportional to the pressure of the gas above the liquid (P).

$$\frac{S_1}{P_1} = \frac{S_2}{P_2}$$




Example – A gas has a solubility at 0 °C of 3.6 g/L at a pressure of 100 kPa. What pressure is needed to produce an aqueous solution containing 9.5 g/L at 0 °C?

4) Sec 17.4 – Molarity

a) The Concentration of a solution is the measure of the amount of solute that is dissolved in a given amount of the solvent.

b) A dilute solution contains only a small amount of solute.

c) A concentrated solution contains a large amount of solute.

d) The most important unit of concentration is molarity. It is the number of moles of solute dissolved in 1 liter of solution. It is expressed with the symbol M or M.

$$M = \frac{\text{moles of solute}}{\text{volume of solution (L)}}$$

A 6 M HCl solution means: $\frac{6 \text{ moles of HCl}}{1 \text{ L of solution}} = \frac{6 \text{ moles of HCl}}{1000 \text{ mL of solution}}$

Examples

1) Calculate the molarity of a solution made by dissolving 80 g of NaOH in enough water to give 400 mL of final solution.

2) How many grams of silver nitrate, $AgNO_3$, are needed to make 2 liters of a 0.20 M silver nitrate solution?

3) Calculate the molarity of a concentrated HCl solution if it has a density of 1.18 g/mL and contains 37 g of HCl per 100 g of solution.

5) Sec 17.5 – Making Dilutions

Dilution – The process in which more solvent is added to a solution in order to lower its concentration. The number of moles of solute does not change when a solution is diluted.

$$M_1V_1 = M_2V_2$$

Example – How many milliliters of 1.0 M NaCl solution are needed to make 250 mL of an 0.20 M NaCl solution?

6) Solution Stoichiometry

Just like other reactions, we need to have the balanced chemical equation to know how the reaction goes. In the case of acid-base reactions, we need to include the mole-to-mole ratio in the solution calculation

$$M_b * V_b = n * M_a * V_a$$

where n is the mole-to-mole ratio
$M_b$ and $M_a$ are the molarities of the base and acid
$V_b$ and $V_a$ are the volumes of the base and acid

Examples

1. How many grams of NaOH are needed to neutralize 100 mL of 6.0 M $H_2SO_4$?

2 What volume of carbon dioxide at 20 °C and 740 mm of Hg will be produced by the reaction of 55 g of $Na_2CO_3$ with 400 mL of 2.0 M HCl?