CHEMISTRY – Chapter 13

Solutions

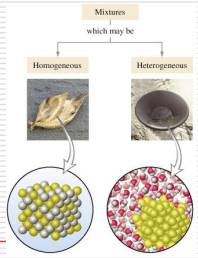
Chapter 13 – Section 1

Objectives:

1. Distinguish between heterogeneous and homogeneous mixtures.
2. List three different solute-solvent combinations.
3. Compare the properties of suspensions, colloids, and solutions.
4. Distinguish between electrolytes and nonelectrolytes.

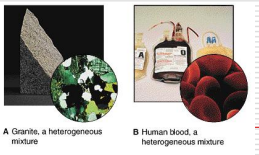
Mixtures

- 2 or more substances that each retain their own properties
  - Homogeneous
  - Heterogeneous



Heterogeneous Mixture

- Substances are not uniformly spread out
  - Different samples have different compositions



A Granite, a heterogeneous mixture

B Human blood, a heterogeneous mixture

Homogeneous Mixture

- Components are uniformly mixed
  - All samples have the same composition
  - The smaller the particles the more uniform the mixture will be
  - Called solutions

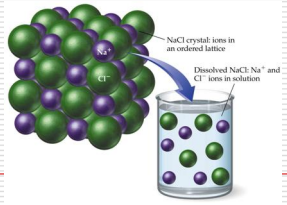
C Copper(II) sulfate ($CuSO_4$) in water, a homogeneous mixture (solution)

Solutions

- Homogeneous mixtures of two or more substances in the same phase
  - Thoroughly mixed
  - Same properties throughout
  - Particles cannot be seen
  - Particle size ranges from 0.01 to 1 nm
  - Do not scatter light
  - Cannot be separated by filtering
  - In one phase

Soluble

- Usually one substance is dissolved in the other



Solute and Solvent

- Solute – the substance that is dissolved in a solution
  - Usually of lesser quantity
- Solvent – the dissolving medium

Types of Solutions

- Can exist as gases, liquids, and solids
  - Solute-solvent combinations
  - Gas-gas – oxygen in nitrogen
  - Gas-liquid – carbon dioxide in water
  - Liquid-gas – water in air
  - Liquid-liquid – alcohol in water
  - Solid-liquid – sugar in water

Suspensions

- Particles in a solvent are so large that they settle out unless the mixture is constantly stirred
  - If not mixed particles settle to the bottom
  - Particles over 1000 nm
  - Can be separated by filtering
  - Heterogeneous
  - May scatter light
  - Not transparent

Colloids

- Particles are intermediate is size btwn those in solutions and suspensions
  - Particles are btwn 1 nm and 1000 nm
  - Particles are suspended but cannot be filtered
  - Particles are the dispersed phase
  - Water is the dispersing medium
  - Scatter light
  - Heterogeneous

Classes of Colloids

Class	Phases	Example
Sol	Solid dispersed in liquid	Paint, mud
Gel	Solid network throughout liquid	gelatin
Liquid emulsion	Liquid dispersed in liquid	Milk, mayo
Foam	Gas dispersed in liquid	Shaving cream, whipped cream
Solid aerosol	Solid dispersed in gas	Smoke, auto exhaust
Liquid aerosol	Liquid dispersed in gas	Fog, mist, aerosol spray
Solid emsulsion	Liquid dispersed in solid	Cheese, butter

Tyndall Effect

- Light is scattered by colloidal particles dispersed in a transparent medium
  - Used to distinguish btwn a solution and a colloid

Quick Lab

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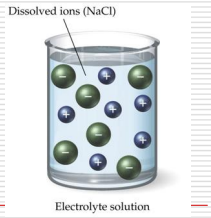
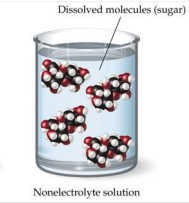
Electrolytes

- Substance that dissolves in water to give a solution that conducts electric current
  - Ionic compounds
    - Yield + and – ions
    - ex. NaCl and HCl



Non-electrolytes

- Substance that dissolves in water to give a solution that does not conduct an electric current
  - ex. sugar



Review and Assignment

1. Distinguish between heterogeneous and homogeneous mixtures.
2. List three different solute-solvent combinations.
3. Compare the properties of suspensions, colloids, and solutions.
4. Distinguish between electrolytes and nonelectrolytes.

Assignment: HW 13-1 and 13-2

Chapter 13 – Section 2

Objectives:

1. List and explain three factors that affect the rate at which a solid solute dissolves in a liquid solvent.
2. Explain solution equilibrium, and distinguish among saturated, unsaturated, and supersaturated solutions.
3. Explain the meaning of "like dissolves like" in terms of polar and nonpolar substances.
4. List the three interactions that contribute to the heat of solution, and explain what causes dissolution to be exothermic or endothermic.
5. Compare the effects of temperature and pressure on solubility.

Factors Affecting the Rate of Dissolution

- 1. surface area
  - If increased, increases rate
- 2. mixing
  - More movement of particles more contact
  - If increased, increases rate

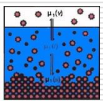
- 3. temperature
  - Increases movement, more collisions
  - If increased, increases rate

Demo.

- Rate of dissolution

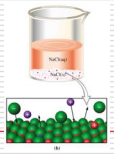
Solubility

- The amount of that substance required to form a saturated solutions with a specific amount of solvent at a specified temperature
- There is a limit to the amount of solute that can be dissolved
  - Depends on
    - 1. nature of the solute
    - 2. nature of the solvent
    - 3. temperature



Solution equilibrium

- Physical state in which the opposing processes of dissolution and crystallization occur at equal rates
  - Solutes dissolve until this is reached



Stages of Solubility

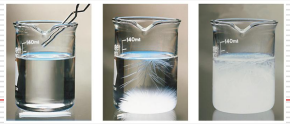
- Saturated – solution that contains the maximum amount of dissolved solute
  - If more is added it does not dissolve and falls to the bottom

Stages of Solubility

- Unsaturated – solution that contains less solute than a saturated solution under the existing conditions

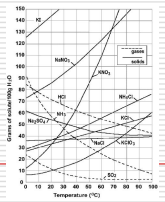
Stages of Solubility

- Supersaturated – solution that contains more dissolved solute than a saturated solution under the same conditions
  - Happens after a solution is heated and then cooled
  - If left undisturbed



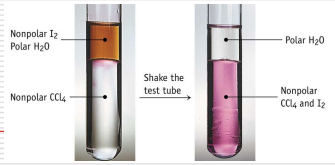
Solubility Values

- Temperature must be specified b/c solubility varies w/temperature
- Different for every substance



Solute-Solvent Interactions

- Not all solvents will dissolve all solutes
- "like dissolves like"
  - Helps predict if one substance will dissolve another
  - d/o polarity
  - Polar dissolves polar
  - Nonpolar dissolves nonpolar



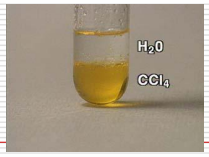
Water as a solvent

- Water is polar
- Charged end of water attracts ions
- Water surrounds the ions
- Water dissolves polar substances

- Hydration – process when water surrounds ions
  - ex. $CuSO_4 \cdot 5H_2O$ (hydrate)

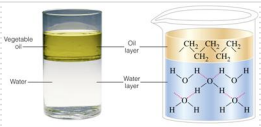
Nonpolar Solvents

- Do not dissolve ionic compounds
- ex. CCl_4 and toluene



Immiscible liquids

- Liquid solutes and solvents that are not soluble in each other
  - Oil and water



Miscible liquids

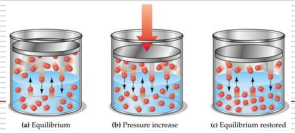
- Liquids that dissolve freely in one another in any proportion
  - ex. water and ethanol

Pressure and Solubility

- Changes in pressure have very little effect on solubilities of liquids or solids
- Increase in pressure increases the solubility of gases

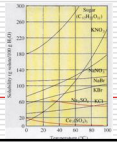
Henry's Law

- Solubility of a gas in a liquid is directly proportional to the partial pressure of that gas on the surface of the liquid
  - ex. pop
  - When pressure is released gas escapes as bubbles
    - Effervescence



Temperature and Solubility

- Gases – increase in temperature leads to a decrease in solubility
- Liquids and solids – usually increase temperature leads to an increase in solubility
- Shown on a solubility curve
  - How much solute will dissolve in a given amount of solvent over a range of temperatures



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5. Compare the effects of temperature and pressure on solubility.

Assignment: HW 13-3,13-4, and WS

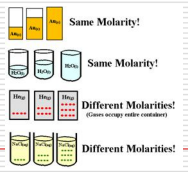
Chapter 13 – Section 3

Objectives:

1. Given the mass of solute and volume of solvent, calculate the concentration of a solution.
2. Given the concentration of a solution, determine the amount of solute in a given amount of solution.
3. Given the concentration of a solution, determine the amount of solution that contains a given amount of solute.

Concentration

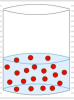
- The measure of the amount of solute in a given amount of solvent or solution
  - Two ways to express this
    - 1. Molarity
    - 2. Molality



Dilute and Concentrated

- Dilute – small amount of solute

- Concentrated – large amount of solute



Molarity

- Number of moles of solute in one liter of solution

Molarity (M) = $\frac{\text{amount of solute (mol)}}{\text{volume of solution (L)}}$

Example

- You have 3.50 L of solution that contains 90.0 g of sodium chloride. What is the molarity of that solution?

$\frac{90.0 \text{ g NaCl}}{58.44 \text{ g}} \times \frac{1 \text{ mol}}{} = 1.54 \text{ mol NaCl}$

$\frac{1.54 \text{ mol}}{3.5 \text{ L}} = 0.440 \text{ M NaCl}$

Molality

- The concentration of a solution expressed in moles of solute per kilogram of solvent

Molality (m) = $\frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$

Example

A solution was prepared by dissolving 17.1 g of sucrose ($C_{12}H_{22}O_{11}$) in 125 g of water. Find the molal concentration of this solution.

$\frac{17.1 \text{ g } C_{12}H_{22}O_{11}}{342 \text{ g}} \times \frac{1 \text{ mol}}{} = 0.0500 \text{ mol}$

$\frac{125 \text{ g}}{1000 \text{ g}} \times \frac{1 \text{ kg}}{} = 0.125 \text{ kg water}$

$\frac{0.0500 \text{ mol}}{0.125 \text{ kg}} = 0.400 \ m$

Review and Assignment

Given the mass of solute and volume of solvent, calculate the concentration of a solution.

2. Given the concentration of a solution, determine the amount of solute in a given amount of solution.

3. Given the concentration of a solution, determine the amount of solution that contains a given amount of solute.

Assignment: HW 13-5, 13-6, and WS