Solutions

Terms

- **Solvent**—does the dissolving (acetone)
- **Solute**—the substance being dissolved (Styrofoam)
- **Soluble**—able to be dissolved

How do things dissolve?

- **"Like dissolves Like"**
- Ionic & polar compounds dissolve each other.
- Nonpolar dissolves nonpolar (grease, oil gasoline)

- Explain the difference between Ionic and Covalent compounds

- Label each as Ionic or covalent
- Glycerin
- Sucrose
- Calcium Carbonate
- Potassium Sulfate
- Ethanol

Types of Mixtures

- Solutions
- Suspensions
- Colloids

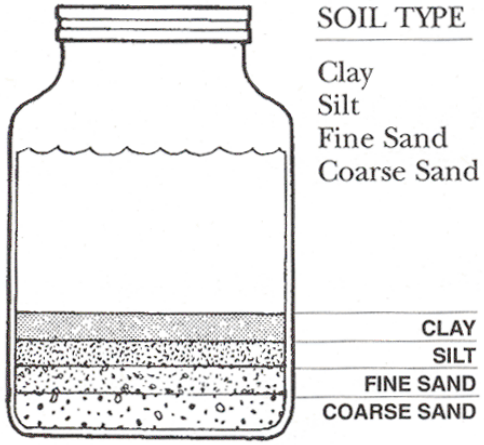
Solutions - a homogenous mixture of two or more substances in a single phase

- **Homogenous**—all samples are identical—uniform mixture of substances.
- Cannot be filtered or settle out (Particle size - less than 1 nm)
- Can be a solid (metal alloys), liquid (salt water), or gas (air).

Suspensions - a heterogeneous fluid containing solid particles that settle out

Properties of Suspensions:

- Heterogeneous mixtures—not all samples are identical—not uniform
- Particles are large enough to be filtered out. (larger than 1000 nm)
- Particles will settle out after mixture stands undisturbed for a period of time.
- Example: Muddy water with large soil particles



Colloids - a heterogeneous mixture of 2 phases of matter

Properties of a colloid:

- Particles will **NOT** settle out & can **NOT** be filtered out (1nm -1000 nm) medium size
- Cloudy looking
- Examples: glues, paints, smoke, muddy water

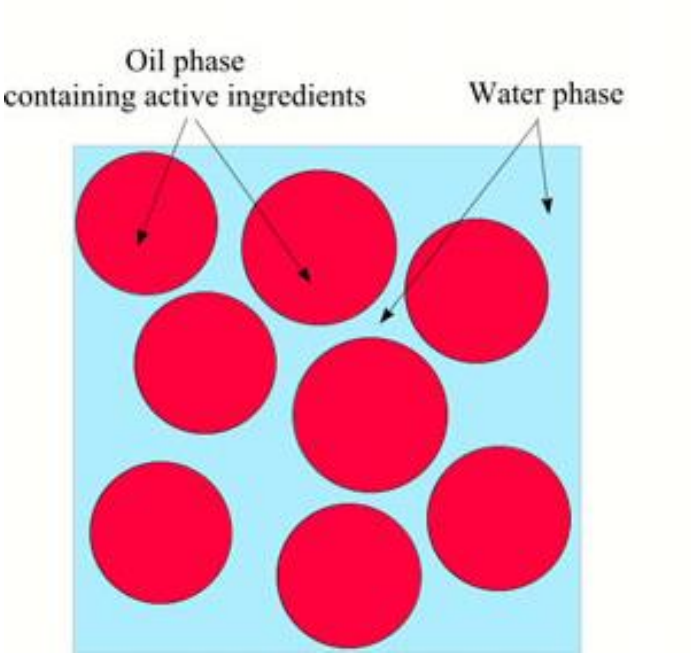
gold colloids→

Tyndall Effect

- Many colloids are hard to tell apart from solutions because they appear clear.
- But you can tell them apart because colloids have larger particles and they scatter light in all directions (called the Tyndall Effect)

Emulsions -is a heterogeneous mixture of two or more immiscible (unblendable) liquids

- This is a type of colloid
- Since they won't mix you get tiny droplets of one liquid in another.



Properties of Emulsions

- Form between a polar liquid (water) dispersed in a nonpolar liquid (oil).
- Which is the solute which is the solvent?
- Ex: oil & water, mayonnaise, shaving cream.
- What is an emulsifying agent?
  - it is a bridge between the 2 liquids
  -soap will combine 2 liquids that otherwise would not mix. (Ex: oil/dirt & water)

Table 3 Page 404

Properties of Solutions, Colloids, and Suspensions

Solutions	Colloids	Suspensions
Homogeneous	Heterogeneous	Heterogeneous
Particle size: 0.01–1 nm; can be atoms, ions, molecules	Particle size: 1–1000 nm, dispersed; can be aggregates or large molecules	Particle size: over 1000 nm, suspended; can be large particles or aggregates
Do not separate on standing	Do not separate on standing	Particles settle out
Cannot be separated by filtration	Cannot be separated by filtration	Can be separated by filtration
Do not scatter light	Scatter light (Tyndall effect)	May scatter light, but are not transparent

Electrolytes

- Electrolytes are compounds that conduct an electric current when in solution because they have free ions (+ and – charges)
- Can be strong, weak or nonelectrolytes

https://www.youtube.com/watch?v=1XWnovm6JLs

Strong Electrolytes

- Compounds which when dissolved in water produce solutions that conduct an electric current. (Ionic compounds)
  - Ex: Ionic salts, Inorganic bases, Inorganic Acids, tap water with ions

Weak Electrolytes

- With weak electrolytes only a fraction of solute exists as ions when dissolved in water. Most ions remain bound in compound.
  - Applies mostly to aqueous polar compounds (in water)
  - Examples: heavy metal halides ($HgCl_2$); Inorganic base (NH_3); organic acid (Acetic acid); organic base (aniline); pure water (distilled to eliminate ions—this is a very weak electrolyte)

Nonelectrolytes

- compounds which when dissolved in water produce solutions that **do not** conduct an electric current.
- These are nonpolar molecules—mostly organic compounds.
- Ex: glucose (sugar), gasoline, methane, grease, distilled water

Practice

- Text Page 426 #1-5

Saturation

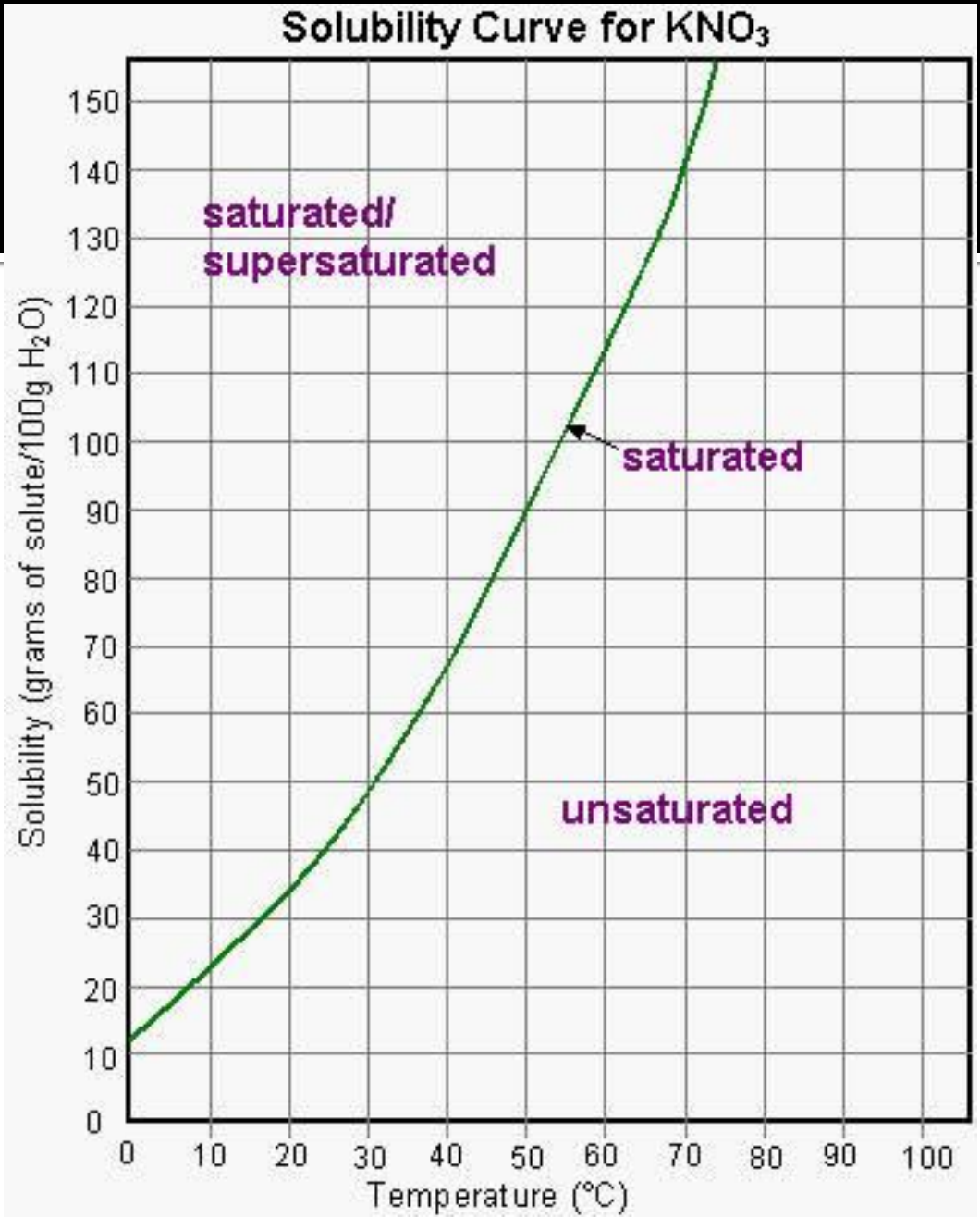
Unsaturated

↓ additional solute

Saturated

↓ additional solute

Supersaturated


Solubility Curve for KNO_3
saturated/
supersaturated
saturated
unsaturated
Solubility (grams of solute/100g H_2O)
Temperature (°C)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

Solubility

- The amount of substance that can dissolve at a given temperature to produce a saturated solution

- If you add spoonful after spoonful of sugar to tea, eventually no more sugar will dissolve.

- For every combination of solvent with a solid solute at a given temperature, there is a limit to the amount of solute than can be dissolved.

Rate of Dissolution

- How fast a solute goes into solution. A certain amount of solute per a certain amount of time.
  - Agitation—shake, mix, stir—this increases how fast it dissolves, but it does not affect how much solute will dissolve. "Shake it"
  - Temperature—increase temperature, increase energy input, increase force and frequency of collisions. This increases how fast it dissolves and how much solute a solution can hold. "Bake it"
  - Particle size—the smaller the particle, the greater the surface area exposed to solvent—cube vs powder—Only increases how fast, not how much. "Break it"

Unsaturated Solution

- An unsaturated solution contains less than the maximum amount of solute in a given amount of solvent at a constant temperature.
- It appears clear.

Saturated Solution

- A saturated solution contains the maximum amount of solute in a given quantity of solvent at a constant temperature.
  - Equilibrium—the rate of dissolution (dissolving) equals the rate of crystallization
  - At equilibrium the solution appears clear

Supersaturated Solution

- A solution which contains more solute than it can theoretically hold at a given temperature.
  - What happens? Add solute when solution is hot and leave to cool undisturbed. No un-dissolved solute—appears clear.
  - However, once crystals begin to form the process continues until equilibrium is reestablished at the lower temperature.
  - Crystallization of excess solute can be initiated by a single "seed" crystal.

Solubility problems Table 4 page 410

Formula:

solubility = g solute /100 g solvent

1) How many grams of potassium chloride can be dissolved in 350g of water at 40°C. (look up ratio in table)

$$\frac{40.1 \text{ g KCl}}{100 \text{ g } H_2O} = \frac{? \text{ g KCl}}{350 \text{ g } H_2O}$$

$$? \text{ g KCl} = \frac{40.1 \text{ g KCl} \times 350 \text{ g } H_2O}{100 \text{ g } H_2O}$$

Now you try

Table 4 page 410

2) How many grams of $AgNO_3$ can be dissolved in 1000g of water at 60°C?

3) How many grams of KI can be dissolved in 650g of water at 0°C?

Solute-Solvent Interactions

- Solvation—occurs when the solute dissolves into charged ions
  - "Like dissolves like"

1. Polar solvents dissolve polar and ionic solutes (charges attract). Water is polar.
2. Why?
   - Hydrogen bonds and dipole interactions pull apart charged particles of solute.
   - Exceptions: Water will not dissolve Barium Sulfate or calcium carbonate. (their ionic bonds are stronger than water's hydrogen bonds)

Like Dissolves Like (cont.)

2. Nonpolar solvents dissolve nonpolar solutes.
   a. London dispersion forces (remember the styrofoam cup with acetate?)
   b. Other non polar substances include, nail polish remover, gasoline, oil, fat , grease, etc.

Solubility Lab Curve

Hydration

- The slightly charged parts of water molecules attract the ions in the ionic compounds and surround them, separating them from the crystal surface and drawing them into the solution.
- This solution process with water as the solvent is referred to as hydration. The ions are said to be *hydrated*.
- The crystal contains water but it appears dry.
- Example: Blue copper sulfate crystals—1 molecule of copper sulfate contains 5 molecules of water—$CuSO_4 \cdot 5H_2O$

- Anydrous—dry, no water in crystal, dehydrated, powdery.

- Efflorescence—the process of losing water, becoming dry. The hydrated crystals lose water.

- Hygroscopic—compounds absorb water from air. May dissolve at room temperature as they absorb water.

Liquid Solutes and Solvents

- What happens when two liquids try to mix?
- Miscible—two liquids that can dissolve each other. Example: water and alcohol
- Immiscible—two liquids that cannot dissolve each other. Example: water and oil

End notes

Factors that affect Solubility

- Temperature
  1. Solids as solutes—increase temperature, increase energy, increase collisions, USUALLY increases solubility.

  Example: Hot Tea and Sugar

  2. Gases as solutes—increase temperature, increase energy, increase ability for a gas to escape, so decreases solubility.

  Example: Open Soda—increase temperature, increases CO_2 escaping—soda goes flat

Factors that affect Solubility

- Pressure
  - By increasing the pressure you can increase the solubility of a gas. Pressure has little affect on solids and liquids.
  - Henry's Law states that the solubility of a gas is directly proportional to the partial pressure of that gas on the surface of the liquid.
  - Why does a sealed can of soda retain the gas?
  - Why do scuba divers get the bends?

Effervescence—The rapid escape of a gas from a liquid in which it is dissolved. Visual Concept

Henry's Law Formula

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

If the solubility of the gas in water is 0.77g/L at 350kPa, what is the solubility of that gas, in g/L at 100 kPa?

.22g/L

Molar Enthalpy of Dissolution

- The formation of a solution is accompanied by an energy change.
  - If you dissolve some potassium iodide, KI, in water, you will find that the outside of the container feels cold to the touch.
  - But if you dissolve some sodium hydroxide, NaOH, in the same way, the outside of the container feels hot.
  - The formation of a solid-liquid solution can either absorb energy (KI in water) or release energy as heat (NaOH in water)

$\Delta H_{solution}$

- Process of Solvation—Energy is required to separate the solute into the solvent.
- When the solvent solvates the solute particles, energy is released.
- ΔH is negative when the final energy released is greater than the energy absorbed. (Exothermic)
- ΔH is positive when the energy absorbed is greater than the energy released. (Endothermic)
- Visual Concept

Homework—Due Thursday 3/12

- Text Page 406 #1-6
- Text page 416 #1, 3, 5, 6
- Text page 426 #2, 4, 5, 9, 10, 11, 12