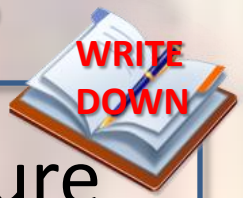
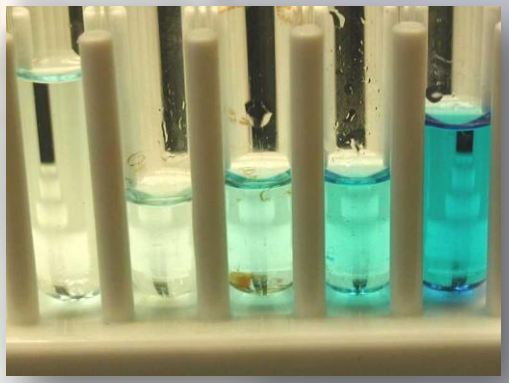
The Nature of Solutions

Solubility

The Definition of Solutions



- Definition: Solution = homogeneous mixture
- Nature of mixtures
  - Consists of two or more kinds of matter
  - Each substance in a mixture retains its own properties
    - sugar and water - sweet and wet
    - brine (salt water) - salty liquid
  - The composition is variable (not constant)
  - Can be separated by physical means

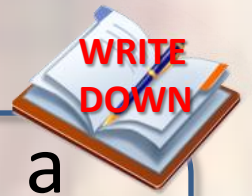


Solutions vs. Mechanical Mixtures

Solution	Mechanical Mixture
Homogeneous	Heterogeneous

- Solutions are composed of two or more substances *BUT* the particles are distributed evenly throughout each other *SO* the composition is uniform.
  - The solution appears to be one substance even though it is two or more.

Parts of a Solution



- A solution consists of a ***solute*** dissolved in a ***solvent***.
- Solute - substance that *IS* dissolved by another
- Solvent
  - substance that dissolves another
  - continuous phase
    - ✓<u>Example</u>:
      Salt dissolved in water appears to be a liquid.
      The water is the continuous phase.
      The water is the solvent.


The ability to dissolve in water
SOLUBILITY

Factors Affecting Solubility

- Degree of solubility (how much dissolves)
- Temperature
- Pressure

Degree of Solubility

- Nature of solute and solvent
  - In order for a solvent to dissolve a solute, it must exert forces of attraction on the solute.
  - Polar solvents such as water dissolve polar and ionic solutes because they exert mutual attractions that cause their particles to intermingle.
  - Nonpolar solvents such as benzene do NOT dissolve polar and ionic substances because they exert no forces of attraction that would cause the particles to separate so they can intermingle.
    - Oil and water do NOT mix.
  - Nonpolar substances such as fat dissolve in nonpolar solvents such as benzene because the forces of attraction are too weak to prevent the particles from freely intermingling.
- **Like** dissolves **like**.

Solubility Guidelines

- The *Reference Tables* provide solubility guidelines.

Solubility Guidelines

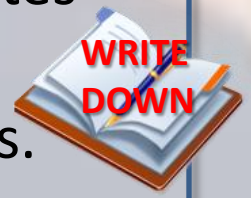
Ions That Form *Soluble* Compounds	Exceptions
Group 1 ions (Li^+, Na^+, etc.)	
ammonium (NH_4^+)	
nitrate (NO_3^-)	
acetate ($C_2H_3O_2^-$ or CH_3COO^-)	
hydrogen carbonate (HCO_3^-)	
chlorate (ClO_3^-)	
perchlorate (ClO_4^-)	
halides (Cl^-, Br^-, I^-)	when combined with Ag^+, Pb^{2+}, and Hg_2^{2+}
sulfates (SO_4^{2-})	when combined with Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, and Pb^{2+}

Ions That Form *Insoluble* Compounds	Exceptions
carbonate (CO_3^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
chromate (CrO_4^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
phosphate (PO_4^{3-})	when combined with Group 1 ions or ammonium (NH_4^+)
sulfide (S^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
hydroxide (OH^-)	when combined with Group 1 ions, Ca^{2+}, Ba^{2+}, or Sr^{2+}

Which of the following is soluble in water?

- $(NH_4)_3PO_4$ ✓
- Ag_2S ✗
- Na_2CO_3 ✓

Temperature

Considerations	Effect of Temperature
• What happens to the particles of a solid when they dissolve in water? They separate. • What happens to the particles of a gas when they dissolve in water? • They come together.	• Solubility of solid solutes generally increases as temperature increases.  • Solubility of gaseous solutes generally decreases as temperature increases.

Pressure

Considerations

- When solids dissolve in water the particles separate. What effect does pressure have on the distance between the particles of a solid?

  None.

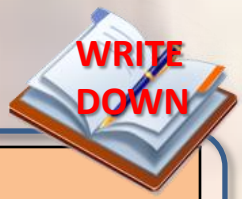
- When gases dissolve in water the particles come together. What effect does pressure have on the distance between the particles of a gas?
- Pressure pushes them together.

Effect of Pressure

- Solubility of solid solutes is not affected by pressure.

- Solubility of gaseous solutes increases as pressure increases.
  - Henry's Law – the mass of a dissolved gas in a liquid is directly proportional to the pressure of the gas.

Rate of Solution



Factor	Affect on Solid Solute	Affect on Gaseous Solute
Particle Size	Reducing particle size by crushing increases the rate by increasing surface area.	Not applicable
Stirring	Increases the rate by exposing fresh solvent to solute and increasing kinetic energy.	Decreases the rate by increasing kinetic energy, thereby reducing solubility.
Amount of dissolved solute	As the amount of dissolved solute increases, the rate decreases.	As the amount of dissolved solute increases, the rate decreases.
Temperature	As the temperature increases, the rate increases.	As the temperature increases, the rate decreases.