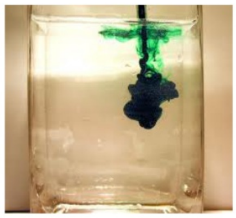
Unit 3 - Part 2 - Solutions

1. Solution - a homogeneous mixture
   - evenly mixed at the particle level
   - Ex: salt water

2. Alloy - a solid solutions of metals
   - Ex: bronze = Cu and Sn; brass = Cu and Zn

3. Solvent - the substance that dissolves the solute

Ex: Water   Salt



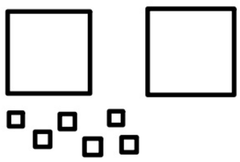
4. Soluble - "will dissolve in"
   Ex: Salt will dissolve in water

5. Miscible - refers to two gases or two liquids that form a solution
   - This is more specific than soluble
   - Ex: food coloring in water

6. Factors affecting solution formation

   a. temperature
      - As temperature increases, the rate increases
      - As temperature decreases, the rate decreases

   b. particle size
      - As particle size increases, the rate decreases
      - As particle size decreases, the rate increases

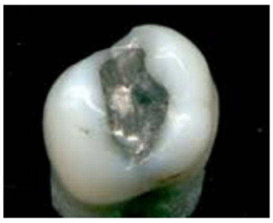


   c. mixing
      - As mixing increases, the rate increases
      - As mixing decreases, the rate decreases

   d. The nature of solvent and/or solute

7. Classes of Solutions

a. aqueous solution - solvent is water (H_2O)
  - water = "the universal solvent"



b. amalgam - solvent is mercury (Hg)
  - Ex: dental amalgam (Hg + Sn + Ag)

c. tincture - solvent is alcohol
  - Ex: tincture of iodine (for cuts)

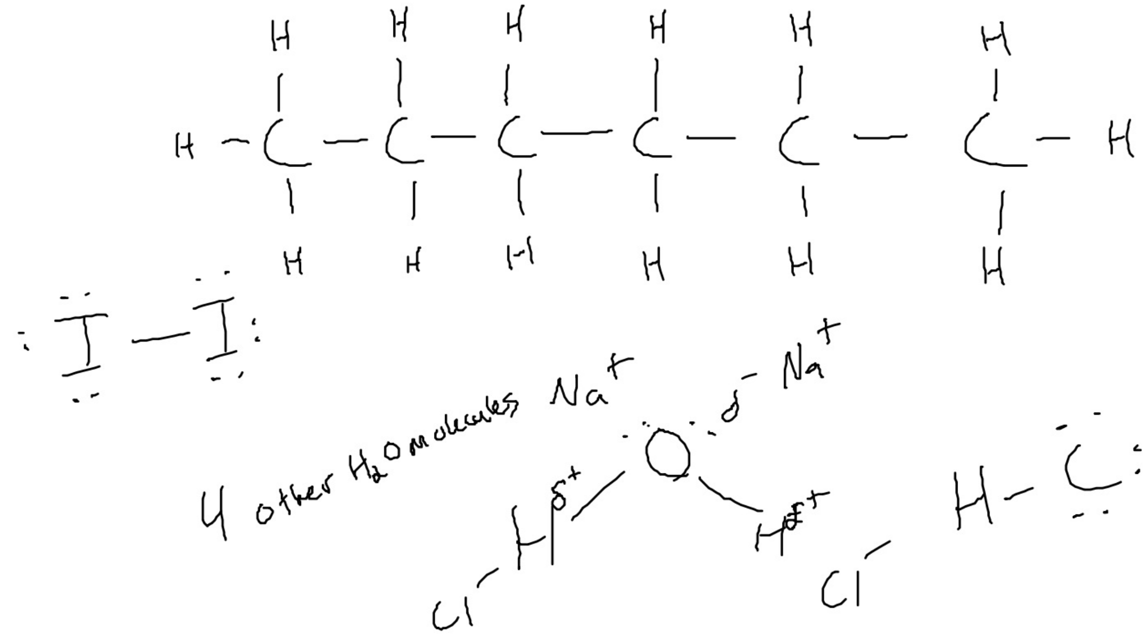
d. organic solution - solvent contains carbon
  - Ex: gasoline, benzene, toluene, hexane

8. Non-Soluble Definitions

a. insoluble - "will not dissolve in"
  - Sand will not dissolve in water

b. immiscible - refers to two gases or two liquids that will NOT form a solution
  - Ex: water and oil

c. suspension - appears uniform while being stirred, but settles over time
  - Ex: orange juice



It's in Their Nature

Solute–Solvent Interactions

Post-Lab Questions *(Use a separate sheet of paper to answer the following questions.)*

1. In which solvents is iodine soluble? In which solvents is iodine insoluble?
2. Define the term miscibility, then circle the correct choice in each statement to summarize the miscibility of the solvent pairs tested in Part B:

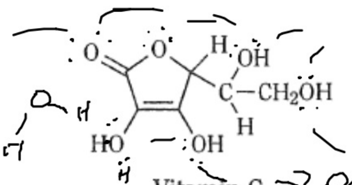
   Water and ethyl alcohol are *(miscible/immiscible)*.
   Water and hexane are *(miscible/immiscible)*.
   Water and toluene are *(miscible/immiscible)*.
   Hexane and ethyl alcohol are *(miscible/immiscible)*.
   Hexane and toluene are *(miscible/immiscible)*.
   Toluene and ethyl alcohol are *(miscible/immiscible)*.

3. Rank the four solvents tested in Parts A and B in order from most polar to least polar (nonpolar). Which two solvents are most alike in their polarity? Explain your reasoning.
4. Write a general statement describing the solubility of nonpolar solutes in different solvents and suggest a reason for this pattern.
5. Potassium nitrate (Part C) is an ionic compound. Write a general statement describing the solubility of ionic compounds in different solvents.
6. Dextrose, cholesterol, and benzoic acid are molecular (organic) compounds. Based on their solubility patterns in Part C, arrange these three solutes in order from most polar to least polar. Explain your reasoning.
7. Based on its solubility, would you expect cholesterol to be soluble in the bloodstream? Where does cholesterol tend to accumulate in the body? Why?

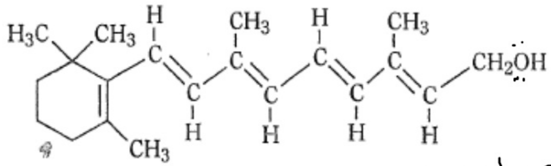
It's in Their Nature

Solute–Solvent Interactions

8. Vitamins are classified as either water-soluble or fat-soluble. The structures of Vitamin C (water-soluble) and Vitamin A (fat-soluble) are shown below. Identify the features of these molecules that give them their characteristic solubility.



Vitamin C → polar



Vitamin A → non-polar

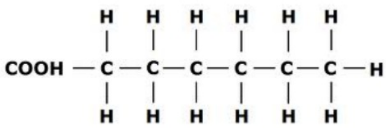
9. The simple rule *"Like dissolves like"* is often used to describe the solubility of a substance in different solvents. Write a short paragraph discussing your evidence for this rule. Include in your discussion where you think this rule works best and where it seems to be less reliable. Give specific examples to back up your statements.

10. *(Optional)* A drop of motor oil spilled on wet pavement will quickly spread out into a thin film. A drop of water spilled on a greasy plate, however, will bead up into a little sphere. Use these observations, and the nature of solute–solvent interactions, to explain why oil and water do not mix.

9. Molecular Polarity

A. non-polar molecules - electrons are shared equally and tend to be symmetric

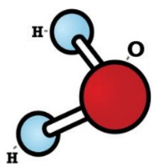
Ex: Fats and Oils

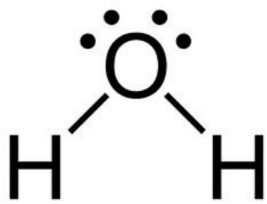


Saturated Fat

B. polar molecules - electrons are not shared equally

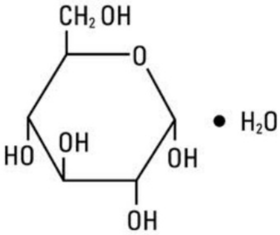
Ex: water



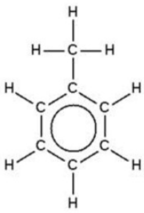


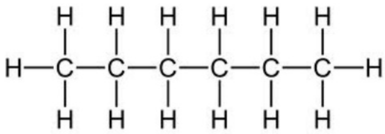
C. "Like dissolves Like"

1. polar + polar = solution



2. nonpolar + nonpolar = solution



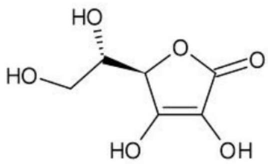


3. polar + nonpolar = suspension (won't mix evenly)

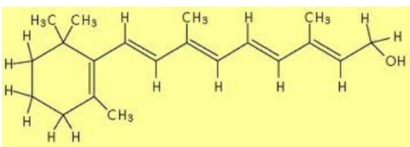
D. Applications of Solubility Principles

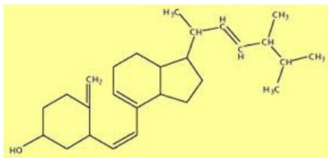
1. Chemicals used by body obey solubility principles

   - <u>water-soluble vitamins</u>: Vitamin C



   - <u>fat-soluble vitamins</u>: Vitamins A and D



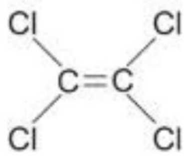


2. <u>Dry Cleaning</u> employs non-polar liquids

   -polar liquids damage wool and silk

   - also, dry cleaning removes ink, rust, and grease

   - they use tetrachloroethylene



E. <u>Emulsifying Agent (emulsifier)</u>:

1. molecules with both a polar **<u>AND</u>** a nonpolar end

2. allows polar and nonpolar substances to mix

3. Examples: soap 

-made from animal and vegetable fats

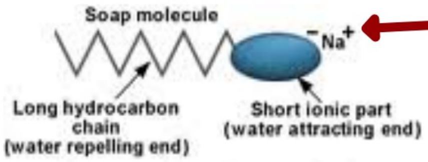
detergent 

-made from petroleum
-works better in hard water

 eggs

4. Model of a soap molecule

Notice the Na is part of the ionic portion



Representation of a soap molecule.

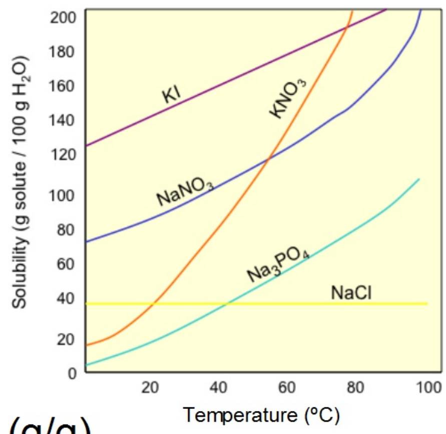
a. Hard water contains minerals with ions (Ca^{2+}, Mg^{2+}, and Fe^{3+} that replace Na^{1+} at polar end of soap molecule.

b. Soap is then changed from an emulsifier into an insoluble precipitate (soap scum)

10. **Solubility Curves**

a. <u>Solubility</u> - how much solute dissolves in a given amount of solvent at a given temperature

Solubility vs. Temperature



b. It is a general rule is that the solubility of solids increases with increasing temp.

c. Solubility is expressed as:

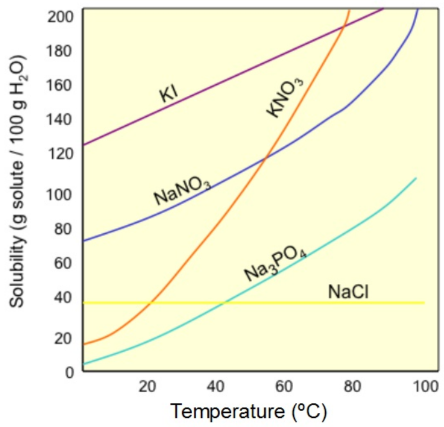
the mass of solute per volume - (g/L)
OR
the mass of solute per mas of solute - (g/g)
OR
the mols of solute per volume - (mol/L)

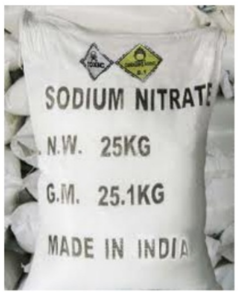
11. **Saturation Terms**

a. <u>Saturated</u> - A solution that containes the maximum possible amount of solute

b. <u>Unsaturated</u> - If a solution contains less than the maximum amount of solute

c. <u>Supersaturated</u> - when a solution is prepared at a higher temperature and then allowed to cool, there is more solute then its saturation point





Examples:

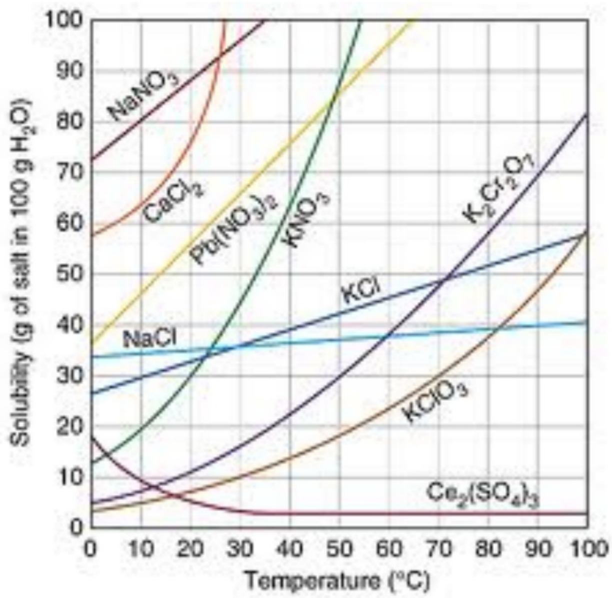
All of these are in 100g of H_2O

80g of $NaNO_3$ @ 30ºC

45g of KCl @ 60ºC

50g of KNO_3 @ 10ºC

70g of NaCl @ 30ºC

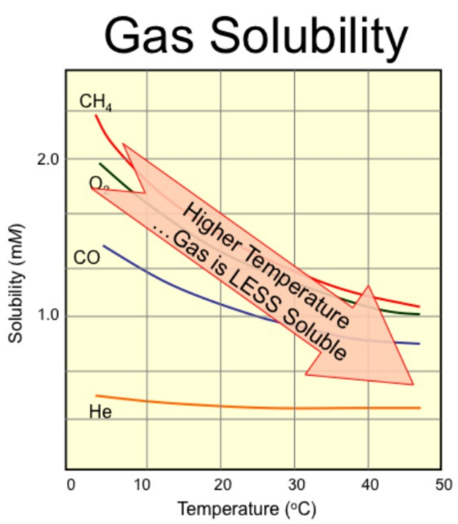


12. Solubility of Gases

a. Gases have the opposite relationship between temp and solubility

b. As temperature increases, the solubility decreases

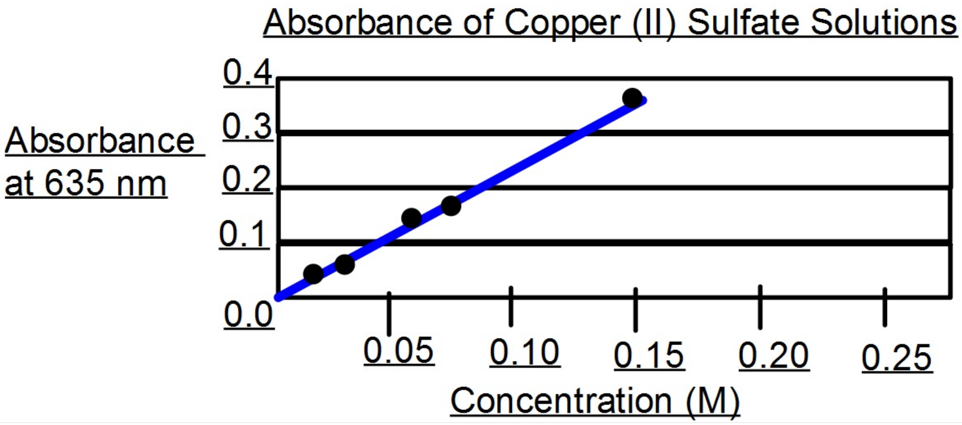
c. Example: Which goes flat first: a cold pop or a warm pop.



Data Table

Test Tube	1*	2	3	4	5
Volume of Stock Solution (V_1)	10 mL	3.8 mL	2.4 mL	5.0 mL	1.5 mL
Concentration of Stock Solution (M_1)	0.15 M	0.15 M	0.15 M	0.15 M	0.15 M
Final Volume of Diluted Solution (V_2)		10 mL	10 mL	10 mL	10 mL
Concentration of Diluted Solution (M_2)		? M	? M	? M	? M
Color Comparison (Rank solutions from lightest blue = 1, deepest blue = 5)					
Absorbance at 635 nm	0.335	0.117	0.079	0.157	0.043

*Test tube #1 contains the initial stock solution.

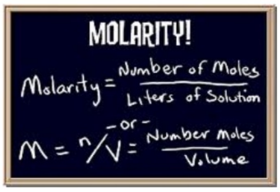


13. Concentration - a measure of solute-to-solvent ratio

a. concentrated - "lots of solute"

b. dilute - "not much solute", "watery"

c. Concentration Units

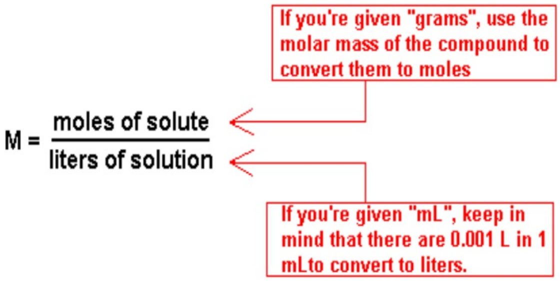


1. mass % = mass of solute/mass of solvent

2. parts per million (ppm) - commonly used for minerals or contaminents in water supplies

3. molarity (M) = moles of solute/liters of solution
   Ex: what I use, what is commonly used in class

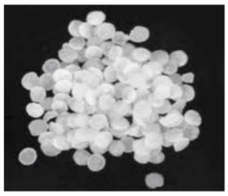
$$M = \frac{mol}{L}$$



Example: How many mols of solute are required to make 1.35 L of 2.50 M solution?

$$M = \frac{mol}{L} \qquad 2.50M = \frac{mol}{1.35\ L} \qquad = 3.38\ mol$$

What mass of sodium hydroxide is this?



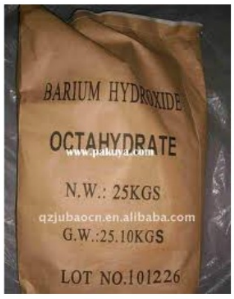
$$\left(\frac{3.38\ mol\ NaOH}{1}\right)\left(\frac{40.0g\ NaOH}{1\ mol\ NaOH}\right) = 135g\ NaOH$$

What mass of magnesium phosphate($Mg_3(PO_4)_2$) is this?

Example: Find the molarity of 58.6g of barium hydroxide {$Ba(OH)_2$} that are in 5.65 L of solution.

$$\left(\frac{58.6 \text{ g } Ba(OH)_2}{1}\right)\left(\frac{1 \text{ mol } Ba(OH)_2}{171.3 \text{ g } Ba(OH)_2}\right) = 0.34 \text{ mol } Ba(OH)_2$$

$$\frac{0.34 \text{ mol}}{5.65 \text{ L}} = 0.06 \text{ M } Ba(OH)_2 \text{ Solution}$$



You have 10.8g of potassium nitrate (KNO_3). How many mL of solution will make this a 0.14 M solution.

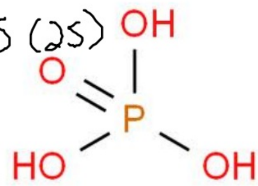
14. <u>Dilutions of Solutions</u> - acids and bases are purchased in concentrated form and must be diluted to desired concentrations.

a. Dilution Equation: $M_cV_c = M_DV_D$

M = molarity C = Concentrated
V = Volume D = Diluted

Example: Concentrated H_3PO_4 is 14.8 M. What volume of concentrated H_3PO_4 is required to make 25.0 L of 0.5 M H_3PO_4?

$M_cV_c = M_DV_D$ $14.8\ (V_c) = 0.5\ (25)$



$14.8\ M\ (V_c) = 0.5\ M\ (25.0\ L)$

$V_c = 0.845\ L = 845\ mL$

Example: You have 75 mL of concentrated HF (28.9M) and you need 15.0 L of 0.1 M HF. Do you have enought to do the experiment?

$M_c = 28.9$
$V_c = ?$
$M_D = 0.1$
$V_D = 15L$

$28.9\ (V_c) = 0.1\ (15)$

$\frac{28.9\ V_c}{28.9} = \frac{1.5}{28.9}$

$V_c = .051\ L = 51\ mL$