

# Chemistry 116

Dr. M. Richards-Babb  
“Dr. Babb”

## Tasks for first week of class:

- Read syllabus.
- Purchase lab goggles, lab apron, and Chem 116 Lab Manual from WVU Bookstore or Book Exchange. NOTE: White lab aprons sold at Book Exchange are not suitable for chemistry laboratory.
- Complete as lab homework Appendices A and B in the Chem 116 Lab Manual. This homework is due at the beginning of your first lab, **Wed. Sept. 2**.
- Check out Dr. Babb's Chem 116 website at <http://www.as.wvu.edu/~mbabb>. This site contains:
  - handouts, back tests, grades, answer keys, lecture notes, etc.
- Register for the online homework at <http://www.masteringenchem.com>
  - Course ID: WVUChem001F09 for Chem 116-001 (1 PM lecture)
  - Course ID: WVUChem003F09 for Chem 116-003 (8:30 AM lecture)
- Begin the first **Graded Online Homework** assignment (116-Review) which is due **Tuesday Sept 1 at 11:59 PM** (late Tuesday night).
- Begin working *Other Homework* as specified on the Homework Sheet.
- Attend one of the optional reviews (net ionic equations, electrolytes, etc.) on **Wed. Aug. 26**
  - For Chem 116-004 lab at 8:30-9:20 AM in 112 Clark Hall
  - For Chem 116-002 lab at 2:30-3:20 PM in 259 Hodges

# Chapter 11

## Solutions

### Mixtures

- Mixture**
- combination of two or more substances
  - no chemical reaction occurs upon mixing
  - can be heterogeneous or homogeneous

- Homogeneous mixture** – uniform mixture
- composition/properties are same throughout the sample
  - *Types: suspensions, colloids, and solutions*

#### Homogeneous Mixtures

- Suspension**
- - 
  - 
  - Ex. blood, paint

- Colloid**
- - 
  - 
  - Ex. milk, fog, mayonnaise, butter, cream, smoke, smog

- Solution**
- - 
  - 
  - Ex. seawater, tea, coffee

**Types of Solutions:**

Solute	Solvent	Appearance of Solution	Example
			O <sub>2</sub> in air
Liquid in	Gas	Gas	
			CO <sub>2</sub> in water (soda)
Liquid in	Liquid	Liquid	
			salt in water (seawater)
Liquid in	Solid	Solid	
			metal alloys e.g. brass (Zn/Cu) 14 kt Gold (Au/Ag)
Solid in	Gas	Gas	

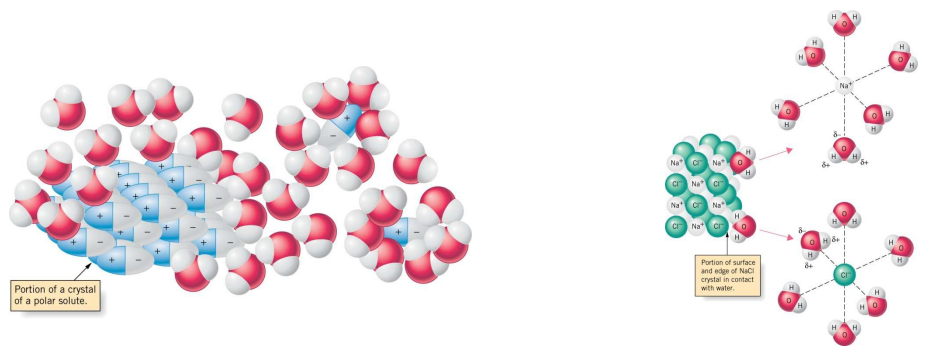
## Solubility

**Solvent:** water is the most common in general chemistry

**Solute:** What types of solutes will dissolve in water?

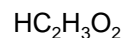
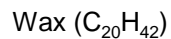
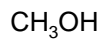
**Answer:**

*General Rule of Thumb:* \_\_\_\_\_



## Example

Which of the following would be more soluble in hexane ( $C_6H_{14}$ ) than in water?



## Solution Composition/Concentration

**Solute:** minor component  
**Solvent:** major component  
**Solution:** resulting mixture of solute and solvent

*There are many different solution concentration units, which all provide same basic information...*

We will discuss ..... A. Molarity  
B. Weight Percent (Wt %), ppm, ppb  
C. Mole Fraction  
D. Molality  
E. Normality

## Molarity

**Molarity** tells you how many *moles of solute* are present in every *liter of solution* (solute-to-solution).

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

**Ex. 0.15 M KCl implies what?**

*Is molarity temperature dependent?*

## Weight Percent (Wt %)

1. The **weight %**, or % (w/w), tells you how many grams of solute are present per 100 grams of the solution (solute-to-solution).

$$\text{Weight Percent (w/w)} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100\%$$

**Ex. 2.5% K<sub>2</sub>SO<sub>4</sub> implies what?**

2. Related concentration Units:
  - A. Parts per million, ppm (grams solute per 10<sup>6</sup> grams solution).

**Ex. 2.5 ppm Ca<sup>+2</sup> implies what?**

- B. Parts per billion, ppb (grams solute per 10<sup>9</sup> grams solution).

*Are weight percentages temperature dependent?*

## Mole Fraction

$$\text{Mole Fraction} = X = \frac{n_{\text{component}}}{n_{\text{total}}} = \frac{n_i}{n_T}$$

$$\text{Solute: } X_{\text{solute}} = \frac{n_{\text{solute}}}{n_{\text{solute}} + n_{\text{solvent}}}$$

$$\text{Solvent: } X_{\text{solvent}} = \frac{n_{\text{solvent}}}{n_{\text{solute}} + n_{\text{solvent}}}$$

$$X_{\text{solute}} + X_{\text{solvent}} = 1$$

*Are mole fractions temperature dependent?*

## Molality

**Molality** tells you how many *moles of solute* are present in every *kilogram of solvent* (solute-to-solvent).

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

$$\text{Ex. } 0.43 \text{ m MgSO}_4 = \frac{0.43 \text{ mol MgSO}_4}{1 \text{ kg water}}$$

*Is molality temperature dependent?*

## Normality

**Normality** tells you how many *equivalents of acid/base* are present in every *liter of solution* (solute-to-solution).

**Equivalent of Acid:** amount of acid that furnished one mole of H<sup>+</sup> ions. (1 eq = 1 mol H<sup>+</sup>)

**Equivalent of Base:** amount of base that furnishes one mole of OH<sup>-</sup> ions. (1 eq base = 1 mole OH<sup>-</sup>)

$$\text{Normality} = \frac{\text{equivalents solute}}{\text{vol. of soln. in liters}} = \frac{\text{eq. solute}}{\text{L soln}} = N$$

$$\text{Ex. } 0.45 \text{ N Ca(OH)}_2 = \frac{0.45 \text{ eq. Ca(OH)}_2}{1 \text{ L solution}}$$

What is the molarity of this solution?

“ Normality **IS** temperature dependent ”

## Sample Questions

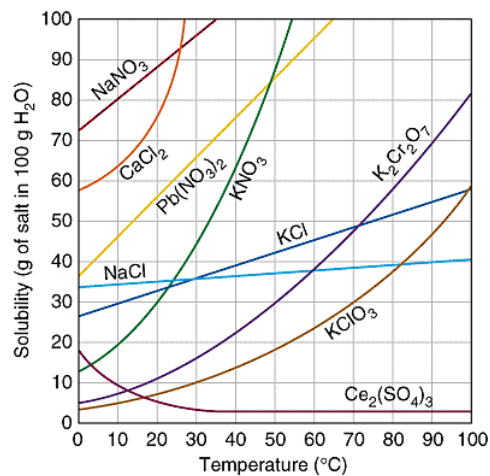
1. What is the mole fraction, molality, and molarity of a solution made by dissolving 20.0 g calcium chloride in 500. g of water?
2. A solution is 5.0 m NaCl. What is the mole fraction of NaCl and water in this solution?
3. A glycerol (C<sub>3</sub>H<sub>8</sub>O<sub>3</sub>)-water solution is 40.0% glycerol and has a density of 1.101 g/mL. Calculate the molality, molarity, and mole fraction of glycerol in this solution.

- A 0.944 M solution of glucose,  $C_6H_{12}O_6$  in water has a density of 1.0624 g/ml at 20 °C. What is the molality of this solution?
- A sample of hard water has 1.5 g  $Ca^{+2}$  in every 500. mL of water. Calculate the molarity, molality, and ppm  $Ca^{+2}$  in this sample.

## Solubility of Solids in Liquid

**Effect of Pressure:** Pressure has **NO** effect on the solubility of solid solutes in liquid solvents. Why?

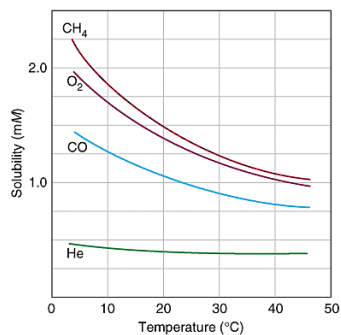
**Effect of Temperature:** Variable, mostly dependent on the sign for the  $\Delta H$  for the dissolution process.  
Consider:  $CuSO_4(s)$  w/  $\Delta H_{diss}=+$  and  $SrSO_4(s)$  w/  $\Delta H_{diss}=-$



## Solubility of Gases in Liquids

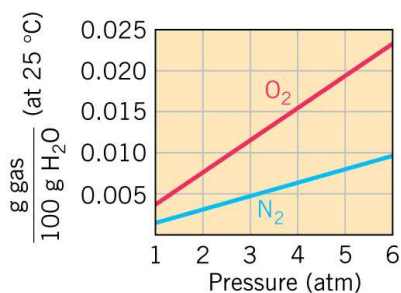
### Effect of Temperature:

Solubility decreases with increase in temperature.  
Why?



### Effect of Pressure:

Solubility increases with increase in pressure.  
Why?



## Pressure and the Solubility of Gases HENRY'S LAW

$$S_{\text{gas}} = k_{\text{H}} P_{\text{gas}}$$

Diagram showing arrows pointing from the variables in the equation to their respective labels:  $S_{\text{gas}}$  points to 'S<sub>gas</sub>',  $k_{\text{H}}$  points to 'k<sub>H</sub>', and  $P_{\text{gas}}$  points to 'P<sub>gas</sub>'.

### Sample Questions

1. The Henry's-law constant of methyl bromide (CH<sub>3</sub>Br), a gas used as a soil fumigating agent, is  $k = 0.159$  mol/L-atm at 25 °C. What is the solubility (in mol/L) of methyl bromide in water at 25 °C and a partial pressure of 125 mm Hg? (0.0261 M)
2. 54 g of gaseous acetylene will dissolve in 1.0 L of liquid acetone at a partial pressure of 1520 torr. What is the Henry's Law constant for acetylene? What is the solubility of acetylene at 12 atm?