

## Concentration

### Percent concentration by mass

$$\% \text{conc.} = \frac{\text{mass solute}}{\text{mass solution}} \times 100$$

### Parts per million by mass

$$\text{ppm} = \frac{\text{mass solute}}{\text{mass solution}} \times 10^6$$

### Percent concentration by volume

$$\% \text{conc.} = \frac{\text{volume solute}}{\text{volume solution}} \times 100$$

For the concentration equations, mass and volume can be in any units as long as the numerator and denominator match.

### Molarity (M)

$$M = \frac{\text{moles solute}}{\text{liters solution}}$$

### Molality (m)

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

## Density

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Density of water = 1 g/ml

## Colligative Properties

### Freezing Point Depression

$$\Delta T_F = i \cdot K_F \cdot m$$

$\Delta T_F$  - Freezing point depression;  $i$  - # ion particles per solute molecule;  
 $m$  - molality;  $K_B$  - Cryoscopic constant of the solvent

### Boiling Point Elevation

$$\Delta T_B = i \cdot K_B \cdot m$$

$\Delta T_B$  - Boiling point elevation;  $i$  - # ion particles per solute molecule;  
 $m$  - molality;  $K_B$  - Ebullioscopic constant of the solvent

**For water...**

$$K_F = 1.86 \text{ } ^\circ\text{C kg/mol}$$

$$K_B = 0.512 \text{ } ^\circ\text{C kg/mol}$$

### Osmotic Pressure

$$\Pi = iMRT$$

$\Pi$  - osmotic pressure, atm;  $i$  - # ion particles per solute molecule;  
 $M$  - molarity;  $T$  - temperature,  $^\circ\text{K}$ ;  $R$  - ideal gas constant, 0.08206