# CHE 1302

# Basic Principles of Modern Chemistry II

# Week 3

Hello and welcome to the weekly resources for Chemistry 1302! This resource covers topics typically taught by professors during the 3rd week of classes.

On our website, https://baylor.edu/tutoring, you'll find the following links:

"Online Study Guide Resources" – If you don't see the topics you're learning right now, click here to find the weekly resources for the rest of the semester!

"How to Participate in Group Tutoring" - See if there is a Chemistry 1302 group tutoring session being hosted this semester – these are weekly question/answer sessions taught by our master tutors!

You can also view tutoring times for your course or schedule a private 30-minute appointment! Check out the website to learn more. You can also give us a call at (254)710-4135, or drop in. Our hours are Monday-Thursday 9 am – 8 pm on class days.

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**KEY WORDS: Concentration Calculations, Colligative Properties, Reaction Rates**

## TOPIC OF THE WEEK:

## Concentration Calculations

Knowing how to work concentration problems is essential throughout this course. Below are some key formulas you will need to know to work these problems. Be conscious of what you use as the denominator when applying a formula!

$$Molarity\ (M) = \frac{moles\ solute\ (mol)}{volume\ of\ solution\ (L)}$$

$$Molality\ (m) = \frac{moles\ solute\ (mol)}{mass\ of\ solvent\ (kg)}$$

$$\%\ mass = \frac{mass\ of\ solute}{mass\ of\ solution} * 100$$

NOTE: Since both the numerator and denominator are asking for mass, any units can be used! But make sure you use the same units for both the numerator and the denominator. For example, using grams (5 g/10 g *100) will yield the same answer as using kilograms (.005 kg/.010 kg * 100).

$$Mole\ fraction\ (X) = \frac{moles\ of\ component}{total\ moles\ present}$$

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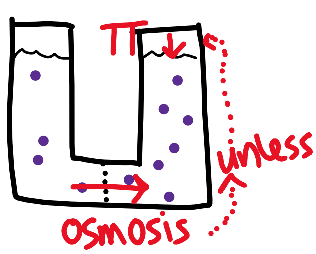
# Highlight 1: Colligative Properties

Colligative properties are properties of solutions that depend only on the quantity (concentration) of solute particles, not on their identity.

There are 4 main colligative properties in chapter 10 that we cover:

1. Vapor Pressure Lowering & Raoult's Law
    a. **Adding** nonvolatile **solute** to a solvent always **lowers** its **vapor pressure**.
    b. Raoult's Law: $P_{total} = P_A + P_B + \cdots = X_A P_A^0 + X_B P_B^0 + \cdots$
    c. Read: Total pressure = the sum of the partial pressures from each solvent. The partial pressure from each solvent can be calculated by multiplying the mole fraction (moles solute/total moles present) by the partial pressure that would've been caused by pure solvent
2. Freezing Point Depression
    a. **Adding solute lowers freezing point**.
    b. $T_f = T_{f(solvent)} - T_{f\ (solution)} = K_f m$
    c. $T_f$: amount that a solvent's freezing point is lowered by the addition of some solute
    d. $m$: new solute concentration is expressed as molality
    e. $K_f$: a constant that depends on the solvent
3. Boiling Point Elevation
    **a. Adding solute increases boiling point.**
    b. $T_b = T_{f(solution)} - T_{f(solvent)} = K_b m$
    c. $T_b$: amount that a solvent's boiling point is raised by the addition of some solute
    d. $m$: new solute concentration is expressed as molality
    e. $K_f$: a constant that depends on the solvent
4. Osmotic Pressure
    a. *Review:* **Osmosis** is the net movement of solvent towards a solution of higher concentration
    b. Osmotic pressure is the **amount of pressure that it would take to stop osmosis**:
        i. Imagine a U-shaped tube with a semipermeable membrane in the middle (shown below). Water can travel through the membrane, but solute cannot. Osmosis will take place (in this case, water will move left to right)… unless a certain amount of pressure is applied on the right side of the tube. How much pressure is needed to stop the water from moving across? That's what's called *osmotic pressure*.



c. $\pi = MRT$

i. π = osmotic pressure (atm)

ii. M = molarity (mol/L)

iii. R= ideal gas constant: $0.08206\frac{L*atm}{mol*K}$

iv. T= temperature (K)

v. NOTE: The units cancel out on the right to yield the atm found on the left! This is a good way to remember this formula. Also, think "Pie Mart" :)

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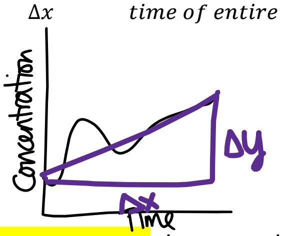
# Highlight 2: Reaction Rates

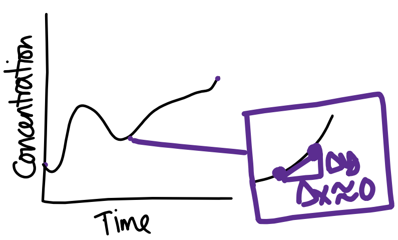
A reaction rate describes how fast or slow a reaction is occurring, and it is always expressed in **units of concentration per unit of time**.

There are several different ways we can measure reaction rates:

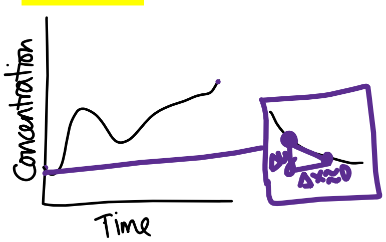
1. Average rate: how much concentration changes during the entire reaction
   a. Mathematically: calculate the slope over the whole graph
   b. $\frac{\Delta y}{\Delta x} = \frac{total\ change\ in\ concentration}{time\ of\ entire\ reaction}$




2. Instantaneous rate: how much the concentration is changing at a specific moment in time
   a. Mathematically: calculate the slope over a very (very!) small part of the graph
   b. $\frac{\Delta y}{\Delta x} = \frac{change\ in\ concentration}{infinitely\ small\ piece\ of\ time}$
   c. In calc, this would be called the derivative at that point




   d. Initial rate: instantaneous rate at start of reaction



3. Total reaction
    a. In general, for the reaction: aA + bB → cC + dD,
    b. $-\frac{1}{a} * \frac{\Delta[A]}{\Delta t} = -\frac{1}{b} * \frac{\Delta[B]}{\Delta t} = \frac{1}{c} * \frac{\Delta[C]}{\Delta t} = \frac{1}{d} * \frac{\Delta[D]}{\Delta t}$
    c. NOTE: negatives accompany terms from the left side of the equation, positives on the right. Why is this? The rate at which each mole of a reactant gets used up (the rate at which its concentration decreases) is the same rate at which a mole of each product is formed

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# Highlight 3: Activity – Formulas

Try to write the formula based on the definition:

| | |
|---|---|
| Molarity: how concentrated a solution is per unit volume | |
| Molality: how concentrated a solution is per unit mass | |
| Percent mass: what fraction of mass of a solution is composed by the solute | |
| Mole fraction: what fraction of the moles are comprised by a certain one substance | |
| Rate of a reaction aA +bB → cC+ dD, in terms of [A], [B], [C], and [D]: How much is each of these concentrations changing over time? Adjust them so that they are equal to each other despite having different coefficients. | |

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# Check Your Learning

1. Calculate the % by mass of HNO3 in a solution that contains:
    a. 5.00 mol HNO3 in 750g of solution
    b. 5.00 mol HNO3 in 750g of H2O
2. The vapor pressure of H2O at 20 degrees Celsius is 17.5 torr. What is the vapor pressure of H2O over a glucose solution for which $\chi_{glucose}$ = 0.200?
3. For the reaction 3A → B: after 1 minute of reaction [B] = 1.2M, and after 10 more minutes, [B] = 9.0 M. Calculate the average rate in the first minute and in the next 10 minutes.

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# Things You May Struggle With

1. Chem 2 is all about math! Pay special attention to what each term in a formula stands for – molality and molarity are especially similar-sounding.
2. When calculating molarity, molality, and the rest of these fractions, make sure you know what you are calculating a fraction of. For example, the m in colligative properties means molality of solute (not solvent).
3. "Aqueous solution" means the solvent that makes up the solution is water
4. It is easy to mix up average and instantaneous rates; make sure you are sure of which one is being asked in the problem!

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That's all this week! Please reach out if you have any questions and don't forget to visit the Tutoring Center website for further information at www.baylor.edu/tutoring. Answers to Check Your Learning are below.

1. For both calculations, we will need the mass of solute: Mass of HNO3 = 5.00 mol HNO3 x (63.0g HNO3/1mol HNO3) = 315g HNO3
    a. % mass = mass of solute/mass of solution x 100 = 315g/750g x100 = **42%**
    b. % mass = mass of solute/mass of solution x 100 = 315g/(750+315)g) x100 = **29.6%**
2. We use Raoult's Law! = (1-0.200) x (17.5 torr) = **14.0 torr**
    a. **Note: this question says that we have a glucose solution which is composed of glucose + water, so to get $\chi_{solvent}$, we do 1-0.200.
3. In the first minute: Rate = Δ[B]/Δt = (1.2-0)M / (1-0) min = **1.2M $min^{-1}$**
    a. In the next 10 minutes: Rate = Δ[B]/Δt = (9.0-1.2)M / (11-1) min = **0.78M $min^{-1}$**
    b. **Note how the rate is decreasing as reactant A is being consumed because the more reactant there is, the faster the reaction occurs!