CHE 1302

Basic Principles of Modern Chemistry II

Final Review

Guys! This is it! Study hard, and remember to sleep and eat. This week's resource will be a summary of the most important topics covered this semester. Study in shorter, more numerous blocks of time whenever possible!

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.

KEY WORDS: Final Review

TOPIC OF THE WEEK: Concentration Calculations

Knowing how to work concentration problems will most likely come up on your comprehensive final. Here are some key formulas you will need to know to work these problems:

- Molarity (M) = moles solute (mol) / volume of solution (L)
- Molality (m) = moles solute (mol) / mass of solvent (kg)
- % mass = (mass of solute (g) / mass of solution (g)) x 100
- Mole fraction (x) = moles of component / total moles present **has no unit**

- mass %, use 100g of solution
- volume %, use 100 mL of solution
- molarity (M), use 1.00L (or 1000 mL) of solution
- molality (m), use 1.00 kg (or 1000g) of solvent
- mole fraction (x), the denominator should include the sum of the moles of all components that make up the solution

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Highlight 1: Rate Laws & Method of Initial Rates

The rate law relates the instantaneous rate of a chemical reaction to reactant concentrations at a particular time.

For the reaction: $aA + bB \rightarrow cC$

Rate law is given as Rate = $k[A]^m[B]^n$, where k is rate constant; m and n are the orders of reaction. Overall order of reaction = m + n

NOTE: the m and n values are NOT derived from the coefficients in the balanced chemical equation! The orders of reaction must be determined by experiment. Examples of order of reaction: Zero-order, First-order, Second-order, etc.

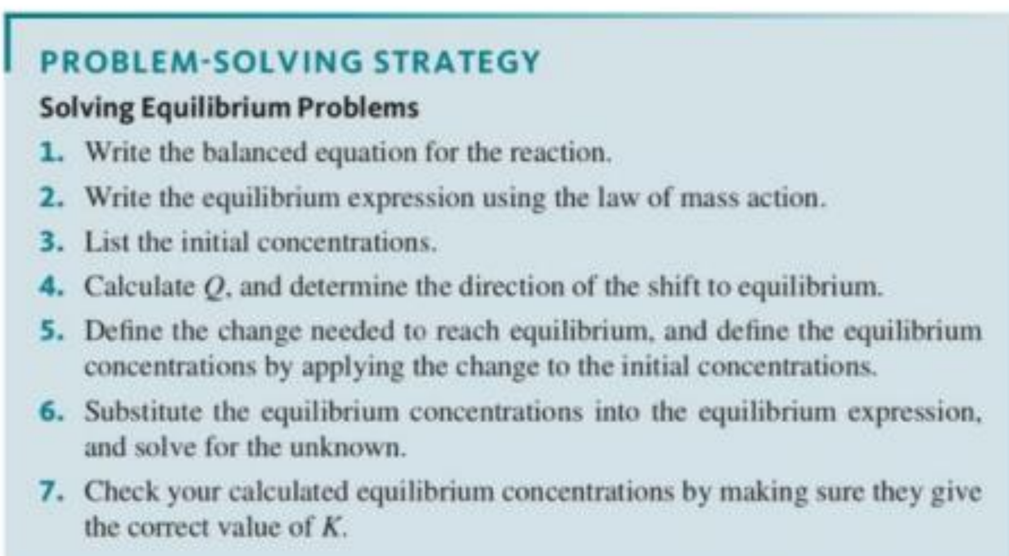
But how do we determine the form of the rate law when there are multiple reactants? We use the method of initial rates! The steps to using this method are:

1. Find two experiments where the **concentration of only ONE reactant changes**
2. Determine the **factor** by which the concentration changed using [X]1/[X]2
3. Determine the **ratio of the rates** for these two experiments using R1/R2
4. Use the formula **ratio = factor(order)** to determine the order of the reaction of these two experiments (m or n).
5. Repeat steps 1-4 for two more experiments where concentration of only one reactant changes.

Here is a ~2min video: https://www.youtube.com/watch?v=6bsAf4Vn-mI

Highlight 2: ICE Tables & Equilibrium Calculations

It is important that you know how to set up each ICE table depending on what the question is asking for. Remember, ICE stands for Initial value + Change = Equilibrium value. The schematic for solving equilibrium problems as given is shown:



PROBLEM-SOLVING STRATEGY

Solving Equilibrium Problems

1. Write the balanced equation for the reaction.
2. Write the equilibrium expression using the law of mass action.
3. List the initial concentrations.
4. Calculate Q, and determine the direction of the shift to equilibrium.
5. Define the change needed to reach equilibrium, and define the equilibrium concentrations by applying the change to the initial concentrations.
6. Substitute the equilibrium concentrations into the equilibrium expression, and solve for the unknown.
7. Check your calculated equilibrium concentrations by making sure they give the correct value of K.

Picture from the textbook, Chemistry, An Atoms First Approach by Zumdahl and Zumdahl.

Highlight 3: Le Chatelier’s Principle

What will happen to the number of moles of SO_3 in equilibrium with SO_2 and O_2 in the reaction

$$2SO_3\,(g) \rightleftharpoons 2SO_2\,(g) + O_2\,(g)$$

in each of the following cases?

a. Oxygen gas is added.

b. The volume of the container is decreased.

c. In a rigid container the pressure is increased by adding argon gas.

d. The temperature is decreased (the reaction is endothermic).

e. The pressure is decreased

HOW TO SOLVE:

- According to Le Châtelier’s Principle, a system at equilibrium would try to **reverse** the change made to it in order to reestablish equilibrium conditions.
- Before trying to answer the questions, look at the chemical equation and try to figure out the direction (**left, right or no change**) the system would go if there is a change in concentration of a species, temperature (depends on the reaction being exothermic or endothermic), pressure or volume.
- Remember that the system just wants to do the opposite of the change.

Answers:

- increase
- increase
- no effect (partial pressures unchanged, so still at equilibrium)
- increase
- decrease

Highlight 4: Acid Strength

Highlight #4: Acid Strength Being able to tell the difference between the strengths of different acids is paramount in this class. In general, if you see an acid and don’t recognize it as one of the 6 strong acids (**HCl, H_2SO_4, HI, HNO_3, HBr, $HClO_4$**), then you can assume it is weak. However, if you must compare the acidity between different acids, here are a few rules you can follow:

- The higher the pK_a value, the lower the acidity
- The higher the K_a value, the higher the acidity
- Between oxyacids, the molecule with more oxygens will be more acidic (e.g. $HClO_4$ > $HClO_3$)

- Between oxyacids, the more electronegative the element, the higher the acidity (e.g. HOF > HOCl)
- Between binary acids, the more electronegative the element, the lower the acidity (e.g. HF < HCl)

Highlight 5: Solutions of Acids & Bases Containing a Common Ion

The ionization of a weak acid or base decreases in a solution containing a common ion from a strong electrolyte, thus affecting the pH. For example, the ionization of an NH_3 solution:

$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

Addition of NH_4Cl (producing NH_4^+) will shift the equilibrium to the left and suppress the ionization and increase $[NH_3]$, making the solution less basic. The shift in equilibrium position because of the addition of an ion already involved in the equilibrium reaction is called the common ion effect.

Highlight 6: Solubility Equilibria & The Solubility Product

The equilibrium constant expression for a slightly soluble solid in equilibrium with its ions is called the solubility product constant (K_{sp}).

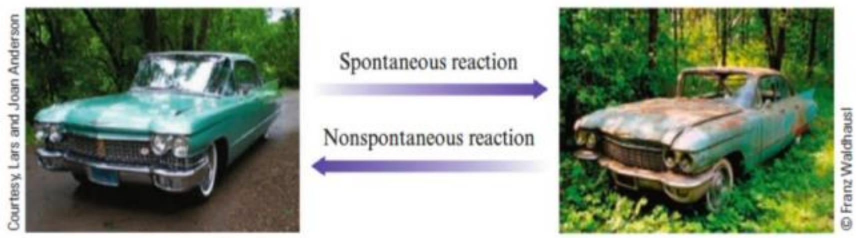
For the reaction: $CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2F^-(aq)$,

$K_{sp} = [^{Ca2+}][F-]^2$

Solubility, on the other hand, is the maximum amount of solute dissolved in a solvent at equilibrium (commonly expressed in mol/L or g/L). The solubility product (K_{sp}) is a constant value at a given temperature, while solubility is an equilibrium position which is subject to variation (e.g. in the presence of a common ion). Here is a link to a ~8 min. video explaining K_{sp} and showing how to find solubility and K_{sp}: https://www.youtube.com/watch?v=WjiXbemBXkE

Highlight 7: Spontaneous Processes and Entropy (S)

A spontaneous process is one that occurs without any external influence. An increase in entropy (degree of disorderliness) is the driving force for a spontaneous process. If a process is spontaneous, then the reverse process is non-spontaneous. Positional entropy increases from solid to liquid to gas. That is, $S_{solid} < S_{liquid} << S_{gas}$



Additionally, $S_{products} < S_{reactants}$ means that $\Delta S < 0$, and $S_{products} > S_{reactants}$ means that $\Delta S > 0$

Check Your Learning

1. Calculate the % by mass of HNO_3 in a solution that contains:
    a. 5.00 mol HNO_3 in 750g of solution
    b. 5.00 mol HNO_3 in 750g of H_2O
2. For the reaction A + 2B → C + 2D What are the values of m and n in the rate law, Rate = $k[A]^m[B]^n$ given the data in the table below?

Experiment	①	②	③
[A] (M)	0.400	0.400	0.800
[B] (M)	1.50	4.50	4.50
initial rate (M/min)	0.0580	0.0579	0.232

3. What is the value of K_c for the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ given the following information?
    a. At 525 K, a 20.82 g sample of PCl_5 is placed in a 5.00 L container. At equilibrium there are 19.32 g of PCl_3
4. Determine which acid is stronger.
    a. HClO (pK_a = 7.46) or $HC_2H_3O_2$ (pK_a = 4.74)
    b. HOF or HOI
    c. HBr or HF
5. A 1-liter solution of 0.500 M HCOOH ($K_a = 1.8 \times 10^{-4}$) has a pH of 2.03. What will be the pH after 0.200 mol of HCOOK has been added?
6. 1 L of saturated $Ag_2CO_{3(aq)}$ contains 0.035 g of solute. What is the value of K_{sp}? What mass of Ag_2CO_3 is contained in 3.65 L of saturated solution?
7. Is $\Delta S > 0$ or < 0 for these reactions?
    a. $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$
    b. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

Things you May Struggle With

1. Keep careful track of units. Make sure that you use the same units throughout an equation, and choose the right R! Units can also be a help for remembering equations or figuring out how to solve a problem.
2. When problem-solving, work backwards. Start by identifying the value required by the problem. Then, figure out an equation that could get you to this value. Look for the other pieces of the equation in the problem. Keep it in mind that you may need to use other equations to get to these values.
3. Thermodyanmics and kinetics are two major branches of chemistry often confused. Remember, thermodynamics has to do with the energy required to run a reaction; it includes spontaneity. Kinetics has to do with how fast a reaction takes places; it includes reaction rates from last semester.
    a. There are two different Ks, as K is (too) often used to denote a constant!
    b. One K is reaction rate K
    c. One K is equilibrium K
        i. This includes K_a (equilibrium constant of an acid's reaction), K_b (equilibrium constant of a base's reaction), K_w (equilibrium constant of water ionization), K_{sp} (equilibrium constant of a slightly soluble solid), and K_f (equilibrium constant of formation of a complex ion)

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 the Check Your Learning section are below.

1. 42%; 29.6%
2. m = 2, n = 0
3. $K_c = 0.0450$
4.
    a. $HC_2H_3O_2$
    b. HOF
    c. HBr
5. pH = 3.35
6. $K_{sp} = 8.8 \times 10^{-12}$; 0.13g Ag_2CO_3
7. $\Delta S < 0$; $\Delta S < 0$