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Chem. 102 guidelines for the final exam: March 16, 2009 at 4:30pm-7pm

The final exam will be worth 240 points. It will be cumulative starting from chapter 8 and ending with chapter 15. Approximately 100 points will be from the chapters covered in the first and second midterm exams. The rest (about 140 points) will be from chapters 14 and 15. The exam will involve the use of **scantrons** but will also have essay and problem solving sections. You are expected to bring simple calculators (no alphanumeric, but able to do logarithms and exponentials). The format will be closer to the second midterm exam.

To assist in your review, you are advised to look at your review guides for tests 1 and 2 in addition to this guide (which will only discuss matters regarding the last 2 chapters).

Be advised to know about: Lewis structures, molecular domains, hybrid orbitals, intermolecular interactions, gas laws and ideal gas equation, phase diagrams and changes, properties of solids (crystals), liquids and gases, rate laws, catalysis, etc.

#### Chapter 14: Chemical Equilibrium:

1. Be prepared to do calculations which involve the equilibrium constants:  $K_c$ ,  $K_p$ ,  $K_f$ , &  $K_{sp}$ . Know how to write the equilibrium equation for each of these cases. Know how to write the equilibrium expressions for each of these equilibrium equations.
2. Know how to convert from  $K_p$  to  $K_c$ . Know the “meaning” of  $K$  (i.e. a large  $K$  means the product is favored, etc....) and be prepared to predict reaction direction using  $Q$ .
3. Given the value of the equilibrium constant, be able to calculate the equilibrium concentrations (or equilibrium partial pressures) given the initial concentrations of the reactants and products. (Use ICE)
4. Apply Le Chatelier’s principle for various scenarios: sudden change of concentration, pressure, volume, temperature, etc...

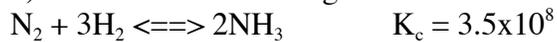
#### Chapter 15: Solutes and Solutions:

1. Understand the process of dissolution and the enthalpies involved. Effect of  $T$  on the solubility of solids and gases and why it is so.
2. Solubility of gases and Henry’s Law.
3. Know concentration units: molarity, molality,  $\%(w/w)$ ,  $\%(w/v)$ ,  $\%(v/v)$ , ppm, ppb, X. Know how to convert from one to the other (look at the examples in the book for your practice). It is not a bad idea to practice the use of conversion factors – which you learned in Chem 101. Can you convert from molarity to molality knowing the density of the solution and the molar weight of the solute? Under what conditions is  $M$  and  $m$  almost the same?
4. Know the various **colligative properties** and be able discuss and calculate values related to these colligative properties: Raoult’s Law, effects on  $T_b$  and  $T_f$ . Osmotic pressure and the various aspects of osmotic pressure: isotonic, hypotonic, etc solutions.
5. What are colloids (and their components), surfactants (describe them chemically) and micelles.
6. Read up on the water in our planet. How much is there available and why is it such a precious resource? Read up on municipal water purification. What are the methods to disinfect water and what are the advantages or disadvantages of each one?

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Sample problems: ( Do these first then consult the key attached in the following pages)

1) Consider the following reaction and its K:



Suppose you mix .20 M of  $\text{N}_2$  with .50 M of  $\text{H}_2$  and 1.00 M of  $\text{NH}_3$ , what will the final concentrations be when they reach equilibrium?

2) A  $10^\circ\text{C}$  aqueous solution of sodium carbonic,  $\text{Na}_2\text{CO}_3$ , ( 106 g/mol) contains 150. g  $\text{Na}_2\text{CO}_3$  in a 300. mL aqueous solution, and has a density of 1.25 g/mL. Calculate...

a) The weight % of carbonic acid in this solution:

b) The molarity of the solution

c) The molality of the solution

d) the osmotic pressure of the solution (in atm)

e) the freezing point of the solution ( $k_f = 1.86^\circ\text{C kg mol}^{-1}$ )

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KEY:

1) Solution: It is difficult to solve this using ICE approach without first letting it react toward a chemical state which is closer to the equilibrium condition. The trick is this: If we can make it go closer to equilibrium first, we can then use the ICE and hopefully, utilize the approximations for solving for x. (the alternative is very much harder to solve)

First, since  $K \gg 1$ , assume that it goes to 100% completion:

That means, we need to determine the limiting reagent: is it  $N_2$  or is it  $H_2$ ?

OK. Try  $N_2$ : #M of  $H_2$  needed =  $.20M N_2 (3M H_2/1M N_2) = .60 M H_2$ . But that's more than the  $H_2$  present. So, the limiting reagent must be  $H_2$  not  $N_2$  (otherwise there would have been excess  $H_2$ ). Ok.

So # M  $N_2$  reacted =  $.50 M H_2 (1 M N_2/3M H_2) = 0.167 M N_2$

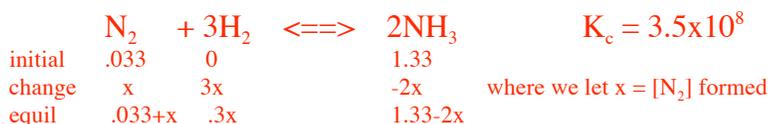
And # M  $NH_3$  formed =  $.50 M H_2 (2 M NH_3/3 M H_2) = .333 M NH_3$  formed.

So at 100% completion, we'll have the following concentrations remaining:

$[N_2] = .20M - .167M = .033M N_2$  ;  $[H_2] = .50M - .50M = 0 M$

and  $[NH_3] = 1.00M + .333M = 1.33 M NH_3$

Now we can use this as the initial condition. We let the change be toward the reactant side since  $Q$  would be infinity (i.e.  $1.33/((.033(0))) > K$ ).



So,  $K_c = 3.5 \times 10^8 = [NH_3]^2 / \{ [N_2][H_2]^3 \} = (1.33-2x)^2 / \{ (.033+x)(3x)^3 \}$

Assume that  $x \ll .033$ , we can write:

$K = 3.5 \times 10^8 \approx (1.33)^2 / \{ .033(3x)^3 \} \approx 1.985/x^3 \Rightarrow x^3 = 1.985/3.5 \times 10^8 = 5.67 \times 10^{-9}$

Or,  $x \approx 1.78 \times 10^{-3} M$

Let's check if our assumption is OK: is  $x \ll .033M$ ?  $100\%(1.78 \times 10^{-3}M)/(.033M) = 5.4\%$  (that's good enough since it's not much over 5%, a boundary which is not etched in stone anyway!).

OK. That allows us to predict the concentrations at equilibrium!

$[N_2] = .033 M + 1.78 \times 10^{-3}M = 3.48 \times 10^{-2}M$  ;  $[H_2] = 3(1.78 \times 10^{-3}M) = 5.34 \times 10^{-3}M$

$[NH_3] = 1.33 - 2(1.78 \times 10^{-3}M) = 1.326 M$

2) Solution:

a) (w/w)% = g solute x 100% / g solution =  $100\% \times 150 \text{ g } Na_2CO_3 / (300 \text{ mL} \times 1.25 \text{ g/mL}) = 40\%$

b) M  $Na_2CO_3$  = moles solute / L solution  
 $= (150 \text{ g } Na_2CO_3) (1 \text{ mol} / 106 \text{ g}) / .300 \text{ L} = 4.72 M Na_2CO_3$

c) m  $Na_2CO_3$  = moles solute / kg solvent .

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It is convenient to consider 300 mLs of solution: We know that there are 150 g of  $\text{Na}_2\text{CO}_3$  in 300 mLs. We also know that 300 mLs has a mass of  $300 \text{ mLs} \times 1.25 \text{ g/mL} = 375 \text{ g}$ . Therefore, the grams of water in 300 mLs is  $375 - 150 = 225 \text{ g water} \times (1 \text{ kg}/1000 \text{ g}) = 0.225 \text{ kg}$  of water (i.e. solvent)

Thus:  $m = (150 \text{ g Na}_2\text{CO}_3)(1 \text{ mol}/106 \text{ g})/(0.225 \text{ kg}) = 6.29 \text{ m Na}_2\text{CO}_3$ .

d) Osmotic pressure:  $\pi = iMRT$  where  $i = \text{“Van’t Hoff factor”} = \# \text{ particles per formula unit} = 3$   
 $\pi = 3(4.72 \text{ M})(.0821 \text{ atm-L/molK})(273+10) \text{ K} = 329 \text{ atm}$  ! Wow that IS high! Shows just how sensitive osmotic pressure is to concentration.

e) The freezing point depression:  $\Delta T_f = k_f m = 1.86^\circ/\text{m} (6.29 \text{ m}) = 11.7^\circ$

Since the normal freezing point of pure water is  $0^\circ\text{C}$ , the new freezing point has been depressed to  $0^\circ\text{C} - 11.7^\circ\text{C} = -11.7^\circ\text{C}$