Intermolecular Forces – 2nd Semester Review Questions and Problems

1. Complete the following table:

Molecule	Lewis Structure	Molecule Shape	Polar/Nonpolar
CS_2			
H_3O^+			
$CdBr_2$			
CHI_3			

2. What makes the dipole in the O-H bond stronger than the dipole found in the N-H bond?

3. Ionic solids do not conduct electricity, but molten ionic compound do. Explain.....

4. Why is CH_4 a gas room temperature while $C_{20}H_{42}$ is a solid? Give details........

5. Methyl amine, CH_3NH_2 , and water are very soluble. Why? Sketch a diagram to support your explanation.

6. Which of the following liquids would have the *highest* vapor pressure? Justify your answer.
$$H_2O , CS_2, CCl_4 , CH_3Cl$$

7. The bonds in beryllium hydride (BeH_2) molecules are polar, yet the molecule is classified as nonpolar. Explain.....

8. Why do metals feel cool to the touch?

9. In general, what class of solids (covalent, ionic, metallic, or molecular) have low melting points? Explain................

Thermochemistry- Review Questions and Problems

1. Translate the following word descriptions into balance **thermochemical** equations:
    (a) When a mole of steam, $H_2O_{(g)}$, condenses, 40 kJ are released.
    (b) The heat of formation of sodium carbonate is -1056 kJ.

3. When solid NH_4NO_3 dissolves in water it breaks apart into aqueous ions and the water temperature decreases.
(a) Write a balanced thermochemical equation for NH_4NO_3 dissolving in water. Include the 18 kJ as part of your equation.
(b) The ΔH_{soln} =+18 kJ/mol for this process. How many grams of NH_4NO_3 must be added to 240g of water to cause a 2.5°C decrease ?

4. Consider the reaction: $C + O_2 \rightarrow CO_2 + 394$ kJ
    (a) Sketch an energy diagram for this reaction. Label each axis and indicate where the ΔH is found. Your diagram should be as complete as possible,
    (b) What type of thermochemical reaction is this reaction?
    (c) Where does the 394kJ that is released originate ?
    (d) If 8.8 g of carbon dioxide are made, how much heat (kJ) will the reaction released?
    (e) If 236.4 kJ are released, how grams of **each** reactant are consumed?

5. An ace chemistry student conducts an experiment to determine the ΔH for the reaction of 4.60 g of sodium with HCl. Her data is summarized in the table below:
mass of water in calorimeter = 123.50 g   initial temperature of water = 20.4 °C
heat capacity of calorimeter = 25 J/°C   final temperature of water = 28.8 °C

    (a) Calculate the total heat (in kJ) released by this reaction.
    (b) Calculate the ΔH for this reaction. Report your answer in kJ/mol Na reacted.
    (c) If a larger amount of Na had been used, how would have ΔT changed?
        Would ΔH (your answer to 5 **b**) have changed? Explain...

6. (a) Given: $2 CH_3OH + 3 O_2 \rightarrow 2 CO_2 + 4 H_2O$ $\Delta H = -1452$ kJ
               $C + O_2 \rightarrow CO_2$ $\Delta H = -394$ kJ
               $H_{2(g)} + \frac{1}{2} O_2 \rightarrow H_2O$ $\Delta H = -286$ kJ

         Calculate the ΔH_{rxn} for $C + 2H_2 + \frac{1}{2} O_2 \rightarrow CH_3OH$

7. Consider the reaction $CO_{(g)} + 2 H_{2(g)} \Leftrightarrow CH_3OH_{(l)}$ $\Delta H = -128.1$ kJ

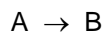| Substance	ΔH_f^o (kJ/mol)	S^o (J/Kmol)
$CO_{(g)}$	-110.5	+197.9
$H_{2(g)}$	0	+131.0
$CH_3OH_{(l)}$	-238.6	+126.8

    (a) Calculate the ΔG^o for the above reaction at 25°C.
    (b) Is the above reaction spontaneous or nonspontaneous at this temperature?

8. Predict the sign of ΔS^o for the following reactions:

    (a) $CaO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$
    (b) $CS_{2(l)} \rightarrow CS_{2(g)}$
    (c) $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$

Kinetics - Review Questions and Problems

1. For a certain reaction, E_a is 50 kJ and ΔH is +10 kJ. In the presence of a catalyst the activation energy is lowered to 30 kJ. Draw a an energy diagram for this reaction:
$$A \rightarrow B$$

2. The reaction $2X + Z \rightarrow X_2Z$ has the following rate data:

	Conc. X (M)	Conc. Z (M)	Initial Rate of Reaction (M/s)
exp. 1.	0.10	0.10	0.00046
exp. 2	0.20	0.10	0.00092
exp. 3.	0.30	0.10	0.00130
exp. 4	0.20	0.20	0.00180

   (a) Determine the order of the reaction with respect to each reactant.
   (b) Calculate the rate constant (k) for this reaction. Include the proper units for k.
   (c) If you start with [X] = 0.20M and [Z] = 0.30M, what would be the initial rate of reaction?

3. The data below is for the reaction: $2NO + Cl_2 \rightarrow 2\ NOCl$

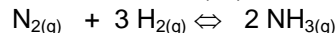| Conc. Cl_2 (M)	Conc. NO (M)	Initial Rate of Reaction (M/s)
0.05	0.05	1×10^{-3}
0.15	0.05	3×10^{-3}
0.05	0.15	9×10^{-3}

   (a) What is the order with respect to NO? with respect to Cl_2?
   (b) Write the rate expression for this reaction.
   (c) Calculate k, the rate constant. Include the proper units with your k value.
   (d) Determine the rate of reaction when the[Cl_2] and [NO] are 0.2M and 0.4M, respectively.

4. What is the only factor that will change the value of the rate constant?

5. The greatest increase in rate for the reaction between X and Z where $R = k[X][Z]^2$ will be caused by:
   (a) doubling[Z]   (b) doubling [X]   (c) tripling [X]   (d) lowering the temperature

6. Given: $R = k[A]^2[B]$. What effect will doubling the [A] while cutting the [B] in fourth have on the rate of reaction? (Will the rate be halved, double, triple,…… ?)

7. Iodine-131 is a radioactive isotope of iodine which has a half-life of eight days. Starting with a 176 g sample of ^{131}I, how many grams remain after 40 days?

8. The reaction $X + Y \rightarrow Z$ has an activation energy of 40 kJ and a $\Delta H = -130$ kJ.
   Draw an energy diagram for this reaction and indicate on it the ΔH and the E_a values.
   Sketch the above diagram the effects of adding a catalyst to the reaction.

9. The reaction $2 SO_2 + O_2 \rightarrow 2 SO_3$ has a three step reaction mechanism.
   step (1) $O_2 \rightarrow O + O$ (slow)
   step (2) $SO_2 + O \rightarrow SO_3$
   (a) What is the third step of this reaction mechanism ?
   (b) Identify the intermediate species in this reaction mechanism.
   (c) What role does step I of the above reaction mechanism play ?

10. Suggest three ways to slow down a reaction.

Equilibrium - Review Questions and Problems

1. Write the equilibrium expressions for the following reactions:
   (a) $FeCl_{2(aq)} + H_2S_{(g)} \Leftrightarrow FeS_{(s)} + 2 HCl_{(aq)}$ (b) $H^+_{(aq)} + OH^-_{(aq)} \Leftrightarrow H_2O_{(l)}$
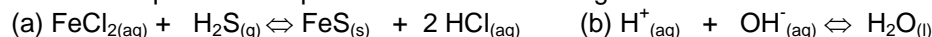
2. At the start of a reaction, there are 0.50 mol of NH_3, 0.005 mol of N_2, and 0.02 mol of H_2 in a two liter container stored at 200°C. If the equilibrium constant (K_c) for the reaction
 $$N_{2(g)} + 3 H_{2(g)} \Leftrightarrow 2 NH_{3(g)}$$
   is 1.54 at this temperature, decide whether the system is at equilibrium. If it is not, predict which way (forward or reverse) reaction will proceed.

3. Arrange the following reactions in order of their **increasing** tendency to proceed toward completion.
   (a) $A \Leftrightarrow B$ $K = 200$
   (b) $C \Leftrightarrow D$ $K = 2 \times 10^{-4}$
   (c) $E \Leftrightarrow F$ $K = 0.4$

4. Consider the following equilibrium: $2 HI_{(g)} \Leftrightarrow H_{2(g)} + I_{2(g)}$. Six moles of HI are placed in an empty eight liter steel vessel and is allowed to come to equilibrium. Upon analysis it is found that vessel contains 1.60 moles of I_2. Calculate the equilibrium constant (K_c) for this reaction.

5. A sample of pure SO_3 gas heated to 400°C decomposes and reaches equilibrium:

   $$2 SO_{3(g)} \Leftrightarrow 2 SO_{2(g)} + O_{2(g)}$$
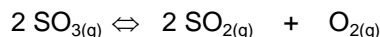
   The equilibrium constant, K_p, is 2000. Analysis shows that the partial pressure of O_2 is 0.5 atm. Calculate the equilibrium partial pressures (concentrations) of SO_2 and SO_3.

6. Consider the following equilibrium system: $2 A_{(g)} \Leftrightarrow B_{(g)} + M_{(s)}$ $\Delta H = + 128$ kJ
   Predict which direction the equilibrium will shift, (towards products , towards reactants, or no change) when the following changes are imposed on the equilibrium system.
   (a) Some A is removed. (b) The temperature is increased. (c) The pressure is decreased.
   (d) Some M is added.   (e) Some B is removed.   (f) A catalyst is removed.

7. Consider the following equilibrium system: $A_{(aq)} \Leftrightarrow Z_{(aq)}$. Substance A is yellow in appearance and substance Z is blue in appearance. When the equilibrium system is heated the solution changes from blue to yellow. What type of thermochemical reaction is the forward reaction, exothermic or endothermic ?   Explain ....

8. Suggest three specific ways to decrease the concentration of C in the following equilibrium reaction:

   $$F(g) \Leftrightarrow A_{(g)} + 2 C_{(g)} \quad \Delta H = -350 \text{ kJ}$$
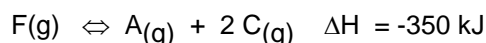
Thermodynamics- Review Questions and Problems

1. Predict the sign (+ or −) of ΔS for each of the following reactions:
   (a) $H_{2(g)}$ + $F_{2(g)}$ → 2 $HF_{(g)}$
   (b) 2 $H_2S_{(g)}$ + 3 $O_{2(g)}$ → 2 $SO_{2(g)}$ + 2 $H_2O_{(l)}$
   (c) $Cu(NO_3)_{2(aq)}$ + $NaOH_{(aq)}$ → 2 $NaNO_{3(aq)}$ + $Cu(OH)_{2(s)}$

2. There are two primary driving forces behind a chemical reaction, ΔH and ΔS. What does *each* prefer to "see" in a reaction?

4. What can be done to a spontaneous reaction to make it stop? What can be done to a nonspontaneous reaction to make it happen?

5. When is the spontaneity of a reaction in doubt? How do you decide if the reaction is spontaneous or not?

6. Given the reaction: $X_{(s)}$ + 12 kJ → $X_{(l)}$. The melting point of substance X is 6.5°C.
   What is the ΔS for the melting of substance X? Report your answer in units of J/Kmol.

7. Dry ice , $CO_{2(s)}$ sublimes (changes form a solid to a gas) at room temperature.
   (a) Write a reaction for the above process
   (b) What is the sign of ΔH for this process
   (c) What is the sign of ΔS for this process?
   (d) What is the sign of ΔG for this process?
   (e) Which driving force, ΔH or ΔS, has final "say" in the outcome of the reaction ?
        Explain………

Acid-Base Equilibrium- Review Questions and Problems

1. (a) Predict if the following salt solutions are either *acidic, basic, or neutral*: NH_4NO_3 ; K_2CO_3 ; NaI

   (b) Write the hydrolysis reaction for *one* of above salts that would support your prediction.

2. Calculate the pH of a 0.02 M NaOH solution.

3. Calculate the pH of a 1.0 M NH_3 solution. Start by writing an ionization reaction that represents NH_3 reacting with water. The $K_b = 1.8 \times 10^{-5}$.

4. Milly Mole, ace chemistry student, has to perform a titration of a strong acid with a weak base. From the information given below, what indicator should Milly use for her titration ? *Explain....*

Indicator	Approximate pH range for color change
Bromophenol blue	3.0 - 4.6
Cresol red	7.2 - 8.8
Thymol blue	1.2 - 2.8

5. (a) Calculate the pH of a buffer solution containing 0.3 M $NaHCO_3$ and 0.40 M H_2CO_3.
       $K_a = 4.4 \times 10^{-7}$.
   (b) Write a reaction that shows how this buffer neutralizes HCl.
   (c) Write a reaction that shows how this buffer neutralizes NaOH.
   (d) Is this buffer more effective in neutralizing acid or base? Explain..
   (e) An ace chemistry adds 0.1 mol of NaOH to one liter of this buffer solution. Calculate the pH of the resulting solution.

6. Give the conjugate base for: $H_2PO_4^-$; H_2S

7. Give the conjugate acid for: CO_3^{2-} ; $H_2PO_4^-$

8. (a) Milk of Magnesia is a saturated solution of magnesium hydroxide, $Mg(OH)_2$. The K_{sp} is 1.2 x 10-^{11} , calculate the pH of Milk of Magnesia.Start by writing an equilibrium equation that represents the saturated solution.

    (b) What would you added to this saturated solution to get more of the solid to dissolve ?
        Explain.

9. The pK_as of two acids HA and HB are 8.8 and 4.5 respectively. Which of these two acids is the *stronger* acid ? Justify your answer.

10. Given the K_a of a weak acid (HA) is 2.7 x 10^{-6}, find the K_b value for the A- ion.