WorkSheet 4 Equilibrium

1. For the following equilibrium

$$CH_3COOH(aq) \leftrightarrow CH_3COO^-(aq) + H^+(aq)$$

if K = 1.8 x 10^{-5} at what $[H^+]$ concentration will there be equal concentrations of CH_3COOH and CH_3COO^-?

2. For the following reaction

$$Fe_2O_3(s) \leftrightarrow 2Fe(s) + \frac{3}{2}O_2(g)$$

$\Delta_R H° = +825.5$ kJ mol^{-1}
$\Delta_R G° = +742.2$ kJ mol^{-1}

What is K for this reaction at 25°C?

Given that air is 21% O_2, what is Q for this reaction in air?

Assuming that $\Delta_R H°$ and $\Delta_R S°$ are independent of temperature, approximate at what temperature Fe_2O_3 would first start to form any Fe in air.

3. True/False Decide if each statement is true or false and write out an explanation.

For the following reaction an increase in the total pressure will lead to an increase in the equilibrium constant

$$A(g) + 2B(g) \longleftrightarrow C(g)$$

For endothermic reactions, increasing the temperature will increase the equilibrium constant.

Adding reactants to an equilibrium mixture will lower the equilibrium constant

For the following reaction, $K_p = K_c$

$$A(g) + B(g) \longleftrightarrow 2C(g)$$

4. The following reaction is exothermic and has a K_P = 1.9 x 10^{-4} at 400°C

$$N_2(g) + 3H_2(g) \longleftrightarrow 2NH_3(g)$$

which direction (if any) will the reaction have to shift toward to get back to equilibrium after the following changes (assume the change listed is the only change. i.e. increase in temperature at constant pressure) Explain your answer briefly.

Increase in the total pressure by compressing the volume

Increase the temperature

Add 1 mol N_2, 3 mol H_2,
and 2 mol NH_3

Increase the total pressure by adding 2 moles of He gas at constant volume

5. (note: this problem involves finding $\Delta_R H°$ and $\Delta_R S°$)
Calcium carbonate can decompose into calcium oxide and carbon dioxide by the following reaction.

$$CaCO_3(s) \longleftrightarrow CaO(s) + CO_2(g)$$

Given the data below
What is K for this reaction at 298 K?
What would K be at 500 K?
If 20 g of $CaCO_3$ were placed in an evacuated container. What would the partial pressure of CO_2 be in the container at equilibrium at 500 K if there is still some solid $CaCO_3$ remaining?

All data at 298K (you can assume H and S are independent of T)

Compound	$\Delta_f H°$ (kJ mol^{-1})	$\Delta_f G°$ (kJ mol^{-1})	$S°$(J K^{-1} mol^{-1})
$CaCO_3$ (s)	-1207	-1129	93
CaO (s)	-635	-604	40
CO_2 (g)	-393.5	-394.5	213.5

6. (10 points)
For the reaction

$$A(g) + 2B(g) \longleftrightarrow C(g)$$

At some temperature you find P_A = 0.5 atm P_B = 0.25 atm P_c = 1.5 atm

What is K_P at this temp?

Is $\Delta_R G°$ positive negative or zero at this temperature? Explain.

Do you think this reaction is exothermic or endothermic? Is there any way to tell?

If the total pressure was changed to 4 atm,

Would the number of moles of C increase, decrease, or stay the same?

Would K_p increase, decrease, or stay the same?

You must get down your stoichiometry. Answer the following

7.
For this reaction

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$$

You initially have concentration of SO_2 of 0.1 M, and O_2 of 0.5 M
At equilibrium you find you have a concentration of SO_3 of .09 M.

How much SO_2 and O_2 do you have at equilibrium?

8. For this reaction

$$A(s) \leftrightarrow B(g) + 2C(g)$$

If you start out with only solid A, what is the ratio of the partial pressures of B to C at equilibrium?

If the partial pressure of B is found to be 0.01 atm at 298K, what is $\Delta_R G°$?

9. Practice Practice Practice

Write down the equilibrium constants for the following reactions
Make RICE diagrams for each assuming you start with either 1M concentrations of gases or some amount of pure solid. Set up the algebra for how you would solve for the equilibrium concentrations (you can't do the algebra since you don't have the Ks)

$$2NH_3(g) + CO_2(g) \leftrightarrow N_2CH_4O(g) + H_2O(g)$$
$$2NBr_3(g) \leftrightarrow N_2(g) + 3Br_2(g)$$
$$2KClO_3(s) \leftrightarrow 2KCl(s) + 3O_2(g)$$
$$CuO(s) + H_2(g) \leftrightarrow Cu(l) + H_2O(g)$$