AP Worksheet 7a (Equilibrium, K, Q)

Part 1 – Kc, Kp, Q

1. Balance the equation and write the equilibrium constant expression, K_c, for each of the following reactions. All reactants and products are gases.

   a. $NH_3 + O_2 \rightleftharpoons NO + H_2O$

   b. $COCl_2 \rightleftharpoons CO + Cl_2$

   c. $H_2O + CO \rightleftharpoons H_2 + CO_2$

   d. $N_2O_4 \rightleftharpoons NO_2$

2. If K_c for $2A + B \rightleftharpoons 2C$ is 8.0, set up the expression used to calculate the concentration of C at equilibrium. Calculate the equilibrium concentration of C if the equilibrium conditions were 0.50 mol each of A and B in a 10.0 L container. *(0.032 M)*

3. At 2000 °C, nitrogen and oxygen react according to the following equation.

   $$N_2 + O_2 \rightleftharpoons 2NO$$

   The equilibrium constant for this reaction at 2000 °C is 1.2×10^{-4}. At equilbrium, the concentrations of N_2 and O_2 are found to be 0.166 M and 0.145 M, respectively. What is the concentration of NO? *(1.7×10^{-3} M)*

4. Ammonia combines with oxygen to produce water vapor and nitrogen.
   a. Write a balanced equation for the equilibrium reaction.
   b. Write the expression for the equilibrium constant.
   c. At a certain temperature, the concentration of each substance is 1.0 M. Calculate K_c for that temperature. *(1.0)*
   d. Calculate K_c if $[NH_3]$ is 3.0 M, $[O_2]$ is 2.0 M, $[H_2O]$ is 4.0 M, and $[N_2]$ is 2.0 M. *(25)*

Part 2 – Interpreting K and Q

5. For the reaction $2CO(g) \rightleftharpoons C(s) + CO_2(g)$, $K_c = 7.7 \times 10^{-15}$. At a particular time, the following concentrations are measured: [CO] = 0.034 M, $[CO_2] = 3.6 \times 10^{-17}$ M. Is this reaction at equilibrium? If not which direction will the reaction proceed?

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6. For the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, $K_c = 0.2$. At a particular time, the following concentrations are measured: $[N_2O_4] = 2.0$ M, $[NO_2] = 0.2$ M. Is this reaction at equilibrium? If not which direction will the reaction proceed?

7. At 340 °C, $K_c = 0.064$ for the reaction $Fe_2O_3(s) + 3H_2(g) \rightleftharpoons 2Fe(s) + 3H_2O(g)$ Given that $[H_2] = 0.45$ M and $[H_2O] = 0.37$ M, find Q and predict how the reaction will proceed.

Extra problems (optional)

8. Determine the equilibrium constant of the following reaction using the data given.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

At equilibrium at 295°C, a 2.00 L flask was found to contain 0.35 mole of SO_2, 0.70 mole of O_2, and 1.40 moles SO_3. *(46)*

9. The equilibrium constant for the reaction below, at a given temperature, is 45.6. If the equilibrium concentrations of $F_2$and BrF_3 are 0.124 M and 0.199 M respectively, calculate the equilibrium concentration of Br_2. *(0.455 M)*

$$Br_2(g) + 3F_2(g) \rightleftharpoons 2BrF_3(g)$$

10. An equilibrium is established in the reaction below and the concentrations of each component are determined. Calculate the value of K_c at this temperature *(2.52×10^5)*

$$2N_2O(g) + 3O_2(g) \rightleftharpoons 2N_2O_4(g)$$

Equilibrium concentrations, $N_2O = 0.0155$ M, $O_2 = 0.0169$ M, $N_2O_4 = 0.0171$ M

11. For the reaction $2\,ICl(g) \rightleftharpoons I_2(g) + Cl_2(g)$, $K_c = 0.11$. At a particular time, the following concentrations are measured: $[ICl]=2.5$ M, $[I_2] =2.0$ M, $[Cl_2]= 1.2$ M. Is this reaction at equilibrium? If not which direction will the reaction proceed?