CHM 112 Chapter 13 Chemical Equilibrium Extra Credit Name:_____Key_____

1. Write the equilibrium expression (Kc) for following reactions. In each case indicate whether the equilibrium is Homogeneous or Heterogeneous

$2\ CH_3Cl(g) + Cl_2(g) \rightleftharpoons 2\ CH_2Cl_2(g) + H_2(g)$

$P_4(s) + 5\ O_2(g) \rightleftharpoons P_4O_{10}(s)$ $K_c = 1/[O_2]^5$

$CH_4(g) + 2H_2S(g) \rightleftharpoons CS_2(g) + 4\ H_2(g)$ $K_c = [CS_2][H_2]^4/[CH_4][H_2S]^2$

$Al(OH)_3\ (s) \rightleftharpoons Al^{3+}\ (aq) + 3\ OH^-\ (aq)$ $K_c = [Al^{3+}][OH^-]^3$

2. The equilibrium constant is given for one of the reactions below. Determine the value of the missing equilibrium constant.

$H_2(g) + Br_2(g) \rightleftharpoons 2\ HBr(g)$ $K_c = 3.8 \times 10^4$

$2\ HBr(g) \rightleftharpoons H_2(g) + Br_2(g)$ $K_c = ?$ 2.6×10^{-5}

3. In which of the following reactions will $K_c = K_p$?

A) $H_2(g) + I_2(g) \rightleftharpoons 2\ HI(g)$

B) $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\ H_2(g)$

C) $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

D) $CO(g) + 2\ H_2(g) \rightleftharpoons CH_3OH(g)$

E) $N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$

4. For the reaction: $N_2O\ (g) + NO_2\ (g) \rightleftharpoons 3\ NO(g)$, $K_c = 4.2 \times 10^{-4}$ at 500. K.
What is K_p for the reaction at this temperature? $K_p = 0.017$

5. Determine the value of K_c for the following reaction if the equilibrium concentrations are as follows: $[HCl]_{eq} = 0.13$ M, $[HI]_{eq} = 5.6 \times 10^{-16}$ M, $[Cl_2]_{eq} = 0.0019$ M.

$2\ HCl(g) + I_2(s) \rightleftharpoons 2\ HI(g) + Cl_2(g)$ $K_c = 3.5 \times 10^{-32}$

6. Determine the value of K_p for the following reaction if the equilibrium concentrations are as follows: $P(CO)_{eq} = 6.8 \times 10^{-11}$ atm, $P(O_2)_{eq} = 1.3 \times 10^{-3}$ atm, $P(CO_2)_{eq} = 0.041$ atm.

$2\ CO(g) + O_2(g) \rightleftharpoons 2\ CO_2(g)$ $K_p = 2.8 \times 10^{20}$

7. Consider the following reaction and its equilibrium constant:

$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$ $K_c = 0.33$

Is the reaction at equilibrium if it contains: 0.39 M SO_2, 0.14 M NO_2, 0.11 M SO_3 and 0.14 M NO.

If it is not at equilibrium, in which direction will the equilibrium shift?

$Q<K$ right!

8. Consider the following reaction, equilibrium concentrations, and equilibrium constant at a particular temperature. Determine the equilibrium concentration of $H_2O(g)$.

$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$ $K_c = 9.0 \times 10^3$

$[C_2H_4]_{eq} = 0.015$ M $[C_2H_5OH]_{eq} = 1.69$ M

$[H_2O] = 0.013$ M

9. Consider the exothermic equilibrium reaction

$$UO_2(s) + 4HF(g) \rightleftharpoons UF_4(g) + 2H_2O(g)$$

In which direction will the equilibrium shift when the following changes are made? Explain your reasoning.

(A) Additional $UO_2(s)$ is added? No effect

(B) The water vapor is removed? Right

(C) The reaction takes place in a glass container and the HF reacts with the glass? Left

(D) The volume of the reaction vessel is reduced? Right

(E) The temperature is increased? left

10 . Consider the following reaction:

$$N_2O\,(g) + NO_2\,(g) \rightleftharpoons 3\,NO(g) \qquad \Delta H^\circ = +155.7\ kJ$$

In which direction will the equilibrium be shifted by the following changes? Explain your reasoning.

(A) Adding N_2O Right

(B) Removing NO_2 Left

(C) Removing N_2O Left

(D) Adding a catalyst No effect

(E) Adding NO Left

(F) Increasing the temperature of the reaction mixture Right

(G) Adding He gas to the reaction mixture at constant volume no effect

(H) Decreasing the volume of the reaction vessel Left

11. Consider the following reaction at equilibrium: $CO\ (g) + 2\ H_2\ (g) \rightleftharpoons CH_3OH\ (g)$ $\Delta H° = -18$ kJ

How will the amount of CH_3OH at equilibrium be affected by the following changes? Explain your reasoning.

(A) Adding CO (g) go up

(B) Removing H_2 (g) go down

(C) Increasing the temperature go down

(D) Adding a catalyst no effect

(E) Decreasing the volume of the reaction container. Go up

12. Consider the following reaction:

$$CH_4(g) + 2\ H_2S(g) \rightleftharpoons CS_2(g) + 4\ H_2(g)$$

A reaction mixture initially contains 0.50 M CH_4 and 0.75 M H_2S. If the equilibrium concentration of H_2 is 0.44 M, find the equilibrium constant (K_c) for the reaction.

Kc = .038

13. Consider the following reaction:

$$CO_2(g) + C(graphite) \rightleftharpoons 2\ CO(g)$$

A reaction mixture initially contains 0.56 atm CO_2 and 0.32 atm CO. Determine the equilibrium pressure of CO if K_p for the reaction at this temperature is 2.25.

P(CO) = .85 atm

14. For the reaction: $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$, $K_c = 1.6 \times 10^{-5}$.
What are the equilibrium concentrations of each species if 1.0 mole of NOCl is initially placed in an empty 2.0 L flask?

[NO] = .020 M, $[Cl_2]$ = .010 M, $[NOCl_2]$ = .50 M

15. A reaction vessel is charged with hydrogen iodide, which partially decomposes to molecular hydrogen and iodine:

$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$: When the system comes to equilibrium at 425 °C, $P_{HI} = 0.708$ atm and $P_{H_2} = P_{I_2} = 0.0960$ atm. Calculate K_p for this reaction.

Kp = Kc = .018

Calculate K_c for the same reaction.

16. Consider the reaction

$CH_2O(g) \rightleftharpoons CO(g) + H_2(g)$

In an experiment, 0.050 mol of CH_2O (g) was placed in empty 500. mL vessel. At equilibrium, the concentration of CH_2O (g) was found to be 0.066 M. Calculate K_c for the reaction.

Kc = .018

17. At 298 K, $K_c = 1.45$ for the following reaction

$2\ BrCl(g) \rightleftharpoons Br_2(g) + Cl_2(g)$

A reaction mixture was prepared with the following initial concentrations.
$[BrCl] = 0.0400$ M, $[Br_2] = 0.0300$ M and $[Cl_2] = 0.0300$ M
Calculate their equilibrium concentrations.

$[Br_2] = [Cl_2] = 0.035$ M, $[BrCl] = 0.029$ M

18. In air, at 25 ºC and 1.00 atm, the concentrations of N_2 and O_2 are 0.033 M and 0.00180, respectively. The reaction $N_2(g) + O_2(g) \rightleftharpoons 2\ NO(g)$ has $K_c = 4.8 \times 10^{-11}$ at 25 °C
Taking the given concentrations as the initial concentrations, calculate the equilibrium concentration of NO at 25 °C

[NO] = 5.3×10^{-8} M