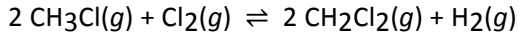
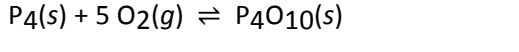
CHM 112 Chapter 13 Extra Credit : Chemical Equilibrium Name:_____

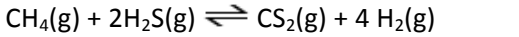
1. Write the equilibrium expression for following reactions. In each case indicate whether the equilibrium is Homogeneous or Heterogeneous



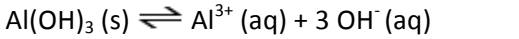
$2\ CH_3Cl(g) + Cl_2(g) \rightleftharpoons 2\ CH_2Cl_2(g) + H_2(g)$



$P_4(s) + 5\ O_2(g) \rightleftharpoons P_4O_{10}(s)$

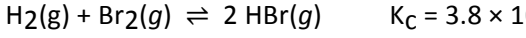


$CH_4(g) + 2H_2S(g) \rightleftharpoons CS_2(g) + 4\ H_2(g)$

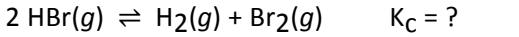


$Al(OH)_3\ (s) \rightleftharpoons Al^{3+}\ (aq) + 3\ OH^-\ (aq)$

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

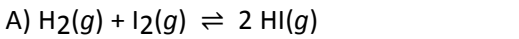


$H_2(g) + Br_2(g) \rightleftharpoons 2\ HBr(g)$ $K_C = 3.8 \times 10^4$

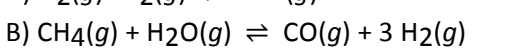


$2\ HBr(g) \rightleftharpoons H_2(g) + Br_2(g)$ $K_C = ?$

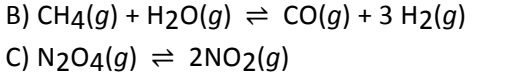
3. In which of the following reactions will $K_C = K_P$?

A) 

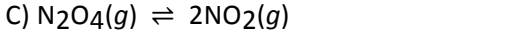
$H_2(g) + I_2(g) \rightleftharpoons 2\ HI(g)$

B) 

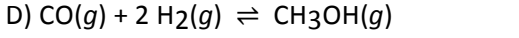
$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\ H_2(g)$

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?

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.

$$2\ HCl(g) + I_2(s) \rightleftharpoons 2\ HI(g) + Cl_2(g)$$

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.

$$2\ CO(g) + O_2(g) \rightleftharpoons 2\ CO_2(g)$$

7. Consider the following reaction and its equilibrium constant:

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

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?

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

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

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

(B) The water vapor is removed?

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

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

(E) The temperature is increased?

10 . Consider the following reaction:

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

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

(A) Adding N_2O

(B) Removing NO_2

(C) Removing N_2O

(D) Adding a catalyst

(E) Adding NO

(F) Increasing the temperature of the reaction mixture

(G) Adding He gas to the reaction mixture at constant volume

(H) Decreasing the volume of the reaction vessel

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)

(B) Removing H_2 (g)

(C) Increasing the temperature

(D) Adding a catalyst

(E) Decreasing the volume of the reaction container.

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.

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.

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?

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.

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.

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.

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