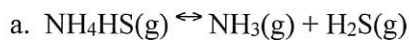
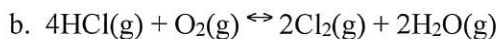


Equilibrium Constant Practice Problems

1. Write equilibrium expressions for the following reactions.



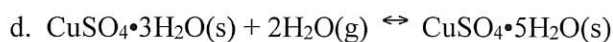
$$K_{eq} = \frac{[\text{NH}_3][\text{H}_2\text{S}]}{[\text{NH}_4\text{HS}]}$$



$$K_{eq} = \frac{[\text{Cl}_2]^2 [\text{H}_2\text{O}]^2}{[\text{HCl}]^4 [\text{O}_2]}$$



$$K_{eq} = \frac{[\text{Cl}_2][\text{PCl}_3]}{[\text{PCl}_5]}$$



$$K_{eq} = \frac{1}{[\text{H}_2\text{O}]^2}$$

2. At 793 K, the equilibrium constant for the reaction $\text{NCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \leftrightarrow \text{NCl}_5(\text{g})$ is 39.3.

a. Do products or reactants dominate in this equilibrium?

Products dominate ($K_{eq} > 1$)

b. If the equilibrium constant for this reaction were less than 1, would the reactants or products be dominant?

Reactants dominate ($K_{eq} < 1$)

3. At 773 K, the reaction $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$ produces the following concentrations:
 $[\text{NO}] = 3.49 \times 10^{-4} \text{M}$; $[\text{O}_2] = 0.80 \text{M}$; $[\text{NO}_2] = 0.25 \text{M}$.

a. What is the equilibrium constant expression for the reaction?

$$K_{eq} = \frac{[\text{NO}_2]^2}{[\text{NO}]^2 [\text{O}_2]}$$

b. What is the equilibrium constant for the reaction?

$$K_{eq} = \frac{[0.25]^2}{[3.49 \times 10^{-4}]^2 [0.80]} = 6.4 \times 10^5$$

4. If you wished to maximize the products of the following reactions, which concentrations would you lower or raise?

a. $\text{H}_2(\text{g}) + \text{Br}_2(\text{g}) \rightleftharpoons 2\text{HBr}(\text{g})$

$$K_{eq} = \frac{[\text{HBr}]^2}{[\text{H}_2][\text{Br}_2]}$$

- Add H_2 or Br_2

or

- Remove HBr

b. $\text{CO}_2(\text{g}) + \text{H}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g})$

$$K_{eq} = \frac{[\text{H}_2\text{O}][\text{CO}]}{[\text{CO}_2][\text{H}_2]}$$

- Add CO_2 or H_2

or

- Remove CO or H_2O

c. $\text{SO}_2(\text{g}) + \text{NO}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g}) + \text{NO}(\text{g})$

$$K_{eq} = \frac{[\text{SO}_3][\text{NO}]}{[\text{SO}_2][\text{NO}_2]}$$

- Add SO_2 or NO_2

or

- Remove SO_3 or NO

d. $\text{C}(\text{s}) + \text{CO}_2(\text{g}) \rightleftharpoons 2\text{CO}(\text{g})$

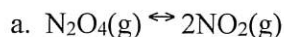
$$K_{eq} = \frac{[\text{CO}]^2}{[\text{C}][\text{CO}_2]}$$

- Add CO_2

or

- Remove CO

5. For each reaction, state whether increasing or decreasing the volume of the reaction vessel would yield more product at equilibrium. Give the reason for your choice.



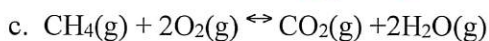
$$K_{eq} = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]}$$

\uparrow Volume = \uparrow NO_2
(Pressure \downarrow = More moles)



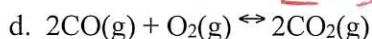
$$K_{eq} = \frac{[\text{SO}_2]^2 [\text{O}_2]}{[\text{SO}_3]^2}$$

\uparrow Volume = \uparrow SO_2 ; \uparrow O_2
(Pressure \downarrow = More moles)



$$K_{eq} = \frac{[\text{CO}_2] [\text{H}_2\text{O}]^2}{[\text{CH}_4] [\text{O}_2]^2}$$

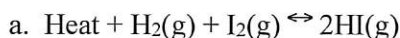
No effect = Same # moles on both sides



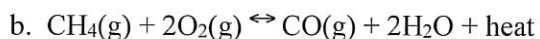
$$K_{eq} = \frac{[\text{CO}_2]^2}{[\text{CO}]^2 [\text{O}_2]}$$

\downarrow Volume = \uparrow CO_2
(Pressure \uparrow = Less moles)

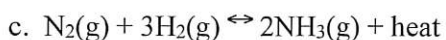
6. What effect would an increase in temperature have on these reactions at equilibrium? Why?



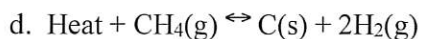
\uparrow Temp. = Favours forward rxn
(Right consumes heat = Less stress)



\uparrow Temp. = Favours reverse rxn
(Left consumes heat = Less stress)



\uparrow Temp. = Favours reverse rxn
(Left consumes heat = Less stress)



\uparrow Temp. = Favours forward rxn
(Right consumes heat = Less stress)

7. Phosphorous pentachloride decomposes to phosphorous trichloride according to this equation:
 $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$. At equilibrium, $[\text{PCl}_5] = 1.00\text{M}$ and $[\text{Cl}_2] = 3.16 \times 10^{-2}\text{M}$.

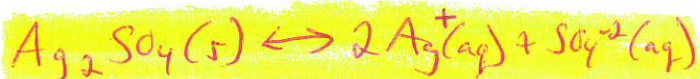
a. Write the expression for determining the concentration of PCl_3 .

$$K_{\text{eq}} = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} \rightarrow [\text{PCl}_3] = K_{\text{eq}} \left(\frac{[\text{PCl}_5]}{[\text{Cl}_2]} \right)$$

b. What is the equilibrium concentration of PCl_3 ? Use: $K_{\text{eq}} = 1.00 \times 10^{-3}$.

$$[\text{PCl}_3] = (1.00 \times 10^{-3}) \left(\frac{1.00}{3.16 \times 10^{-2}} \right) = 3.16 \times 10^{-2}\text{M}$$

8. The solubility product constant (K_{sp}) of Ag_2SO_4 is 1.2×10^{-5} .



a. How would you estimate the molar solubility of SO_4^{2-} without actually calculating it?

$$K_{\text{sp}} = [\text{Ag}^+]^2 [\text{SO}_4^{2-}] = 1.2 \times 10^{-5}$$

$$\text{Cube root} = 10^{-1} \text{ or } 10^{-2}$$

b. What is the calculated molar solubility of SO_4^{2-} ?



(#1) Substitute terms into K_{sp} (solve for s)

$$\begin{aligned} \text{(#2)} \quad K_{\text{sp}} &= (2s)^2 (s) = 4s^3 = 1.2 \times 10^{-5} \\ s^3 &= 3.0 \times 10^{-6} \\ s &= 1.4 \times 10^{-2} = [\text{SO}_4^{2-}] \end{aligned}$$