

Equilibrium Worksheet

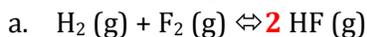
- Write the equilibrium expressions (K_{eq}) for each of these reactions. (Hint: make sure that all equations are balanced first).
 - $H_2(g) + F_2(g) \rightleftharpoons HF(g)$
 - $NO(g) + O_2(g) \rightleftharpoons N_2O_5(g)$
 - $BaCO_3(s) \rightleftharpoons BaO(s) + CO_2(g)$
 - $Na_2CO_3 \cdot 10H_2O(s) \rightleftharpoons Na_2CO_3 \cdot H_2O(s) + H_2O(g)$
- How can you increase the concentration of the product(s) in each of these reactions by varying the temperature and pressure (caused by a volume change)?
 - $4NH_3(g) + 2O_2(g) \rightleftharpoons 4NO(g) + 6H_2(g)$
 $\Delta H = -216 \text{ kcal/mol}$
 - $Br_2(g) + Cl_2(g) \rightleftharpoons 2BrCl(g)$
 $\Delta H = 3.5 \text{ kcal/mol}$
 - $BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$
 $\Delta H = 5800 \text{ kcal/mol}$
- Under a given set of condition an equilibrium mixture exists:
 $SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$
A one liter container was analyzed and found to contain 0.300 mol of SO_3 , 0.200 mol of NO , 0.0500 mol of NO_2 , and 0.400 mol of SO_2 . Calculate the equilibrium constant for this reaction.
- What is the molar concentration of $O_2(g)$ in an equilibrium mixture at 1000 K that has equimolar amount of SO_2 and SO_3 ?
 $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad K_{eq} = 2.8 \times 10^2$
- Equilibrium is established in the reversible reaction: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ at 25 °C. The amounts of reactant and product present in a 3.0 liter flask are found to be 1.56 g of NO_2 and 7.64 g of N_2O_4 . What is the value of K_{eq} for this reaction?
- Continuous removal of one of the products of a chemical reaction has the effect of causing the reaction to go to completion. Explain.

Equilibrium Worksheet

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Answer Key

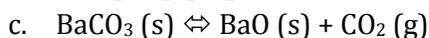
1. Write the equilibrium expressions (K_{eq}) for each of these reactions. (Hint: make sure that all equations are balanced first).



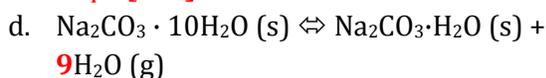
$$K_{eq} = \frac{[HF]^2}{[H_2][F_2]}$$



$$K_{eq} = \frac{[N_2O_5]^2}{[NO]^4[O_2]^5}$$

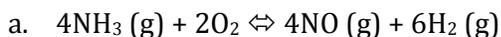


$$K_{eq} = [CO_2]$$



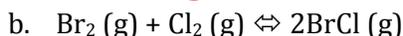
$$K_{eq} = [H_2O]^9$$

2. How can you increase the concentration of the product(s) in each of these reactions by varying the temperature and pressure (caused by a volume change)?



$$\Delta H = -216 \text{ kcal/mol}$$

To shift right, ↓T, ↓P



$$\Delta H = 3.5 \text{ kcal/mol}$$

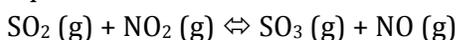
To shift right, ↑T, no change in P = #moles



$$\Delta H = 5800 \text{ kcal/mol}$$

To shift right, ↑T, no change in P; solid and aq species

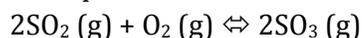
3. Under a given set of condition an equilibrium mixture exists:



A one liter container was analyzed and found to contain 0.300 mol of SO_3 , 0.200 mol of NO , 0.0500 mol of NO_2 , and 0.400 mol of SO_2 . Calculate the equilibrium constant for this reaction.

$$K_{eq} = \frac{[SO_3][NO]}{[SO_2][NO_2]} = \frac{(0.3)(0.2)}{(0.4)(0.05)} = 3$$

4. What is the molar concentration of $O_2(g)$ in an equilibrium mixture at 1000 K that has equimolar amount of SO_2 and SO_3 ?



$$K_{eq} = 2.8 \times 10^2$$

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = 2.8 \times 10^2$$

$$\frac{1}{[O_2]} = 2.8 \times 10^2 \text{ so } [O_2] = 3.57 \times 10^{-3} \text{ M}$$

5. An equilibrium is established in the reversible reaction: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ at 25 °C. The amounts of reactant and product present in a 3.0 liter flask are found to be 1.56 g of NO_2 and 7.64 g of N_2O_4 . What is the value of K_{eq} for this reaction?

$$K_{eq} = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(0.011)^2}{(0.027)}$$

$$1.56 \text{ g } NO_2 \div 46 \text{ g/mol} \div 3.0 \text{ L}$$

$$7.64 \text{ g } N_2O_4 \div 92 \text{ g/mol} \div 3 \text{ L}$$

6. Continuous removal of one of the products of a chemical reaction has the effect of causing the reaction to go to completion. Explain.

As you are continually removing one of the products the equilibrium continues to shift in the forward direction to produce more of what is being removed, eventually running out of reactants.