

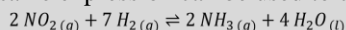
Exercise 18.1a

Equilibrium Expressions

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The equilibrium constant (K) is the ratio of the equilibrium concentration (or pressure) of product(s) to the equilibrium concentration (or pressure) of reactant(s). The same expression can be used to calculate the reaction quotient, (Q):

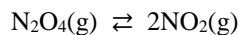


$$K_c = \frac{[\text{NH}_3]_{\text{eq}}^2}{[\text{NO}_2]_{\text{eq}}^2 [\text{H}_2]_{\text{eq}}^7} \quad (\text{at equilibrium}) \quad ; \quad Q = \frac{[\text{NH}_3]^2}{[\text{NO}_2]^2 [\text{H}_2]^7} \quad (\text{at any moment/point})$$

The coefficients from the balanced equation become exponents. Liquids and solids never appear in the expressions, because their concentrations (or pressures) do not change throughout the reaction.

DIRECTIONS: Answer the following in the space provided.

- Write the expressions for the equilibrium constants K_{eq} for each of the following reversible reactions.
 - $\text{H}_2\text{O}(\text{g}) + \text{CO}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{H}_2(\text{g})$
 - $\text{N}_2(\text{g}) + \text{H}_2(\text{g}) \rightleftharpoons \text{NH}_3(\text{g})$
 - $\text{NH}_3(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons \text{NO}(\text{g}) + \text{H}_2\text{O}(\text{l})$
- Determine the equilibrium constant (K_{eq}) for the following reaction if the equilibrium concentrations of $[\text{N}_2\text{O}_4] = 0.00150$ and $[\text{NO}_2] = 0.571$. Write the equilibrium expression, then substitute the values.



- For the reaction $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$, the equilibrium concentrations of the sulfur oxides are $[\text{SO}_2] = 2.00$ and $[\text{SO}_3] = 10.0$. What is the concentration of oxygen when the $K_{\text{eq}} = 800.0$ for the reaction?
- Nitrogen and hydrogen react together in a 4.00 liter container at 450°C . At equilibrium, $[\text{N}_2] = 0.130$, $[\text{H}_2] = 0.220$, and $[\text{NH}_3] = 0.650$. Calculate the equilibrium constant (K_{eq}) for this reaction.

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5. For the reaction, $\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$, the equilibrium concentrations are: $[\text{NO}_2] = 3.1 \times 10^{-2}$ and $[\text{N}_2\text{O}_4] = 4.5 \times 10^{-3}$. From this data, calculate K_{eq} for the reaction at this temperature.
6. Write the equilibrium expression for each equation then calculate the value of the equilibrium constant (K_{eq}). In each case, the concentrations listed are in the order of compounds in the equation.
- a. $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{PCl}_5(\text{g})$ (1.00 M, 0.900 M, 0.120 M at room temperature)
- b. $\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons \text{NO}_2(\text{g})$ (3.49×10^{-4} M, 0.800 M, 0.250 M at 500K)
7. At 448°C, $K_{\text{eq}} = 50.5$ for the reaction $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons \text{HI}(\text{g})$. Find Q and predict how the reaction proceeds if $[\text{H}_2] = 0.150\text{M}$, $[\text{I}_2] = 0.175\text{M}$, and $[\text{HI}] = 0.950\text{M}$.