Math Tutor DETERMINING EQUILIBRIUM CONSTANTS

For a given temperature, you can write a mathematical equation that describes the equilibrium of a reaction in terms of concentration. The equation defines an equilibrium constant, *K*, as a function of the concentrations of products and reactants at equilibrium.

Consider an equilibrium process in which reactants A and B form products C and D.

$$nA + mB \rightleftharpoons xC + yD$$

The terms *n*, *m*, *x*, and *y* are the coefficients of the balanced equation.

$$K = \frac{[C]^x[D]^y}{[A]^n[B]^m}$$

Problem-Solving TIPS

- Always use a balanced chemical equation to write an equilibrium-constant equation.
- To write an equation, place the product concentrations in the numerator and the reactant concentrations in the denominator. Raise each substance's concentration to the power equal to the substance's coefficient in the balanced chemical equation.
- The concentration of any solid or pure liquid that takes part in the reaction is left out because these concentrations never change.

SAMPLE

Write an equation for the equilibrium constant of the reaction in which nitrogen monoxide changes to dinitrogen monoxide and nitrogen dioxide.

To write an equation for an equilibrium constant, you must start with a balanced chemical equation for the equilibrium reaction. By writing the formulas of the compounds mentioned in the description, you get the unbalanced equilibrium equation $NO(g) \rightleftharpoons N_2O(g) + NO_2(g)$.

Balancing the equation requires a coefficient of 3 in front of NO, giving $3NO(g) \rightleftharpoons N_2O(g) + NO_2(g)$. Next, write an equilibrium equation. Remember, each concentration in the equilibrium equation is raised to a power equal to its coefficient in the balanced chemical equation. The product concentrations, $[N_2O]$ and $[NO_2]$, are placed in the numerator. The coefficient of each of the products is 1, so the exponent of each concentration is 1. There is only one reactant, so its concentration, [NO], is written in the denominator. Its coefficient is 3 in the balanced chemical equation, so the concentration of NO is raised to the third power. The exponents with a value of 1 do not have to be written. The resulting equation is

$$K = \frac{[N_2O]^1[NO_2]^1}{[NO]^3} = \frac{[N_2O][NO_2]}{[NO]^3}$$

PRACTICE PROBLEMS

1. Write equations for the equilibrium constant of each of the following hypothetical reactions:
   a. $A(aq) + 2B(aq) \rightleftharpoons AB_2(aq)$
   b. $2DE_2(g) \rightleftharpoons D_2(g) + 2E_2(g)$

2. Use the equilibrium concentrations below to calculate the equilibrium constant for the following decomposition reaction:
   $2BrF_5(g) \rightleftharpoons Br_2(g) + 5F_2(g)$
   $[BrF_5] = 0.000137$ mol/L, $[Br_2] = 0.00050$ mol/L, and $[F_2] = 0.0025$ mol/L