FIGURE 5 Different temperatures can cause an equilibrium system to shift and seek a new equilibrium position.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) + \text{energy as heat}$$
(brown) (colorless)

the equilibrium shifts to the left, or in the direction of the endothermic reaction. This shift decreases the amount of colorless N_2O_4 gas and increases the amount of brown NO_2 gas, as shown in **Figure 5c.** Because less N_2O_4 gas is present, K is decreased. The change in temperature changes the value of K. For a system in which the forward reaction is an exothermic reaction, increasing the temperature decreases the value of K.

For an endothermic reaction, such as the decomposition of calcium carbonate, energy as heat shows up on the reactant side of the equation.

$$556\ \text{kJ} + CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

An increase in temperature caused by adding energy to the system causes the value of K to increase and the equilibrium to shift to the right.

The reactions of the system are also accelerated by a suitable catalyst. However, catalysts have no effect on relative equilibrium amounts. They only affect the rates at which equilibrium is reached. The reason is that catalysts increase the rates of forward and reverse reactions in a system by equal factors. Therefore, they do not affect K.

Reactions That Go to Completion

Some reactions involving compounds formed by the chemical interaction of ions in solutions appear to go to completion in the sense that the ions are almost completely removed from solution. The extent to which reacting ions are removed from solution depends on the solubility of the compound formed and, if the compound is soluble, on the degree of ionization. Thus, a product that escapes as a gas, precipitates as a solid, or is only slightly ionized effectively removes from solution the bulk of the reacting ions that compose it. Consider some specific examples of situations in which such ionic reactions go to completion.