

SECTION 2

OBJECTIVES

- Discuss the factors that disturb equilibrium.
- Discuss conditions under which reactions go to completion.
- Describe the common-ion effect.



Module 7: Equilibrium

Shifting Equilibrium

In systems that have attained chemical equilibrium, the relative amounts of reactants and products stay the same. But changes in pressure, concentration, or temperature can alter the equilibrium position and thereby change the relative amounts of reactants and products. By shifting an equilibrium in the desired direction, chemists can often improve the yield of the product they are seeking.

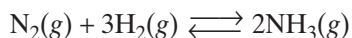
Predicting the Direction of Shift

In 1888, the French chemist Henri Louis Le Châtelier developed a principle that provides a means of predicting the influence of stress factors on equilibrium systems. Le Châtelier's principle states that *if a system at equilibrium is subjected to a stress, the equilibrium is shifted in the direction that tends to relieve the stress*. This principle is true for all dynamic equilibria, chemical as well as physical. Changes in pressure, concentration, and temperature illustrate Le Châtelier's principle.

Changes in Pressure

A change in pressure affects only equilibrium systems in which gases are involved. For changes in pressure to affect the system, the total number of moles of gas on the left side of the equation must be different from the total number of moles of gas on the right side of the equation.

Let us consider the Haber process for the synthesis of ammonia. Note that there is a total of four molecules of gas on the reactant side of the equation and two molecules of gas on the product side of the equation.



First, consider an increase in pressure as the applied stress. Can the system shift in a way that reduces the stress? Yes. An increase in pressure causes increases in the concentrations of all species. The system can reduce the number of molecules, and hence the total pressure, by shifting the equilibrium to the right. For each four molecules of reactants, nitrogen and hydrogen, there are two molecules of product, ammonia. By producing more NH_3 , and using up N_2 and H_2 , the system can reduce the total number of molecules. This leads to a decrease in pressure. Although the new equilibrium pressure is still higher than before, it is not as high as the pressure caused by the initial stress.

An increase in pressure on confined gases causes an increase in the concentrations of these gases. Even though changes in pressure may