1.10.5: Disturbing a Reaction at Equilibrium- Le Châtelier's Principle

Learning Objectives

- State Le Chatelier's Principle.
- Describe the effect of concentration on an equilibrium system.
- Describe the effect of temperature as a stress on an equilibrium system.

When a reaction has reached equilibrium with a given set of conditions, if the conditions are not changed, the reaction will remain at equilibrium forever. The forward and reverse reactions continue at the same equal and opposite rates and the macroscopic properties remain constant.

It is possible, however, to disturb that equilibrium by changing conditions. For example, you could increase the concentration of one of the products, or decrease the concentration of one of the reactants, or change the temperature. When a change of this type is made within a reaction at equilibrium, the reaction is no longer in equilibrium. When you alter something in a reaction at equilibrium, chemists say that you put **stress** on the equilibrium. When this occurs, the reaction will no longer be in equilibrium and the reaction itself will begin changing the concentrations of reactants and products until the reaction comes to a new position of equilibrium. How a reaction will change when a stress is applied can be explained and predicted. That is the topic of this section.

Le Chatelier's Principle

Think back to our escalator example, with you walking up a downward moving escalator. With the rate of the moving stairs and your walking evenly matched, you appear to be at a standstill. But what happens if the escalator begins moving just a little faster? If you want to maintain the same position you had, at some specific point between the bottom and the top of the stairs, you'll also need to make some adjustments. Chemical systems at equilibrium tend to make these adjustments as well.

In the late 1800's, a chemist by the name of Henry-Louis Le Chatelier was studying stresses that were applied to chemical equilibria. He formulated a principle from this research and, of course, the principle is called Le Chatelier's Principle. **Le Chatelier's Principle** states that when a stress is applied to a system at equilibrium, the equilibrium will shift in a direction to partially counteract the stress and once again reach equilibrium. Le Chatelier's principle is not an explanation of what happens on the molecular level to cause the equilibrium shift, it is simply a quick way to determine which way the reaction will run in response to a stress applied to the system at equilibrium.

Le Chatelier's Principle

If a system at **equilibrium** is subjected to an external stress, the equilibrium will shift to **minimize** the effects of that stress.

Equilibrium is all about rates—the rate of the forward reaction is equal to the rate of the reverse reaction. External stresses are factors that will cause the rate of either the forward or reverse reaction to change, throwing the system out of balance. Le Chatelier's Principle allows us to predict how this will affect our system.

In our unit on Kinetics we examined factors that influenced reaction rates. Recall these factors:

1. concentration
2. pressure and volume
3. temperature
4. catalysts

We will see how changing these factors affects a system at equilibrium.

Effect of Concentration Changes on a System at Equilibrium

For instance, if a stress is applied by increasing the concentration of a reactant, the reaction will adjust in such a way that the reactants and products can get back to equilibrium. In the case of too much reactant, the reaction will use up some of the reactant to make more product. It is said in this scenario that the reaction "shifts to the products" or "shifts to the right". If the concentration of a product is increased, there is an opposite effect. The reaction will use up some of the product to make more reactant. The reaction "shifts to the reactants" or "shifts to the left".

What if some reactant or product is removed? If a stress is applied by lowering a reactant concentration, the reaction will try to replace some of the missing reactant. It uses up some of the product to make more reactant, and the reaction "shifts to the reactants". If a stress is applied by reducing the concentration of a product, the equilibrium position will shift toward the products.
