Chapter 17 Equilibrium

17.1 Reaction Rates and Equilibrium

Key Terms

collision model
homogeneous reactions
chemical equilibrium
activation energy (E_a)
heterogeneous reactions
enzymes
equilibrium

Summary

The *collision model* assumes that for molecules to react, they must collide. High concentrations of reactants and high temperatures cause more collisions and therefore speed up reactions.

A certain minimum energy, called the *activation energy* (E_a), must be reached for a collision to form products. If a collision has energy less than E_a, the molecules will bounce apart unchanged. A catalyst is a substance that speeds up a reaction without having to change the temperature or the concentrations of reactants and without itself taking part in the reaction.

Reactions involving reactants in only one phase—all gases or all solids, for example—are called *homogeneous reactions. Heterogeneous reactions* involve reactants in different phases.

Chemists define *equilibrium* as the exact balance of two opposite processes. When a chemical reaction happens in a closed vessel, the system may achieve *chemical equilibrium.* In this state, the chemical reaction continues in both directions so that the products and reactants are forming in the forward reaction and decomposing in the reverse reaction at exactly the same rate.

As molecules collide, reactants are converted continually into products, and vice versa. The speed of the reaction depends in part on the concentrations of the reactants. As the reaction progresses and products are formed, the concentrations of the reactants decrease. With the presence of products, however, the reaction can begin to occur in the reverse direction as these products begin to act as reactants for the reverse reaction. The concentrations of the original reactants then begin to rise. Eventually, the system reaches equilibrium.

17.2 Characteristics of Equilibrium

Key Terms

equilibrium expression
homogeneous equilibria
equilibrium constant (K)
heterogeneous equilibria
equilibrium position

Summary

The law of chemical equilibrium is represented by an equation called the *equilibrium expression.* The equilibrium expression is a special ratio of the concentrations of the products to the reactants. For each reaction at a given temperature, the ratio defined by the equilibrium expression always will be equal to the same number, which is called the *equilibrium constant* (K) for that reaction.

Homogeneous equilibria occur when all reactants and products are in the same state. *Heterogeneous equilibria* occur when reactants and products are in different states.

17.3 Application of Equilibria

Key Terms

Le Châtelier's principle solubility product constant (K_{sp})

Le Châtelier's principle can predict the effects of changes in concentration, volume, and temperature on a system at equilibrium. This principle states that when a change is made to a system that upsets the equilibrium, the equilibrium shifts in a direction that tends to reduce the effect of that change.

Le Châtelier's Principle

Cause: Changes in Conditions	Effect: Changes in Equilibrium Positions
Concentration	
Increase in concentration of a reactant or product	Equilibrium shifts away from the added substance. When a reactant is added, equilibrium shifts to the right (toward the product). When a product is added, equilibrium shifts to the left (toward the reactant).
Volume	
Decrease in volume of a gaseous reaction system	*Equilibrium position shifts in the direction that lowers the system's pressure, or reduces the number of gas molecules.
Increase in volume of a gaseous reaction system	*Equilibrium position shifts in the direction that increases the system's pressure, or increases the number of gas molecules.
Temperature	
Increase	*In an exothermic reaction, equilibrium position shifts in the direction that consumes energy,or to the left. *In an endothermic reaction, equilibrium position shifts in the direction that produces energy, or to the right.
Decrease	*In an exothermic reaction, equilibrium position shifts in the direction that produces energy, or to the right. *In an endothermic reaction, equilibrium position shifts in the direction that consumes energy, or to the left.

The size of the equilibrium constant (K) tells how a reaction is likely to occur. A value of K much larger than 1 means that at equilibrium, the reaction system will be made up mostly of products. A small value for K means that the system at equilibrium is made up mostly of reactants.

The principle of equilibrium also can be applied when a large amount of a solid is added to water. At first, the solid dissolves, but as more ions concentrate in the water, they begin to collide and react to re-form a solid. Equilibrium is reached, and the solution becomes saturated. The *solubility product constant* (K_{sp}) is an equilibrium constant defined by the law of chemical equilibrium.

Additional Active Reading Questions

1. Describe the collision model of chemical reactions.
2. What happens if a collision has energy less than E_a?
3. What kind of reaction involves reactants in only one phase? in different phases?
4. Describe a reaction that is in a state of chemical equilibrium.
5. State Le Châtelier's principle.
6. What happens in the process of dissolving when equilibrium is reached?

