Summary

7.1 Describing Reactions

In a chemical reaction, the substances that undergo change are called reactants. The new substances formed as a result of that change are called products.

During a chemical reaction, the reactants change into products. To describe the burning of coal, you can write the reactants and products as chemical formulas.

$$C + O_2 \longrightarrow CO_2$$

Now you have a chemical equation. A chemical equation represents a chemical reaction in which the reactants and products are written as formulas.

During a chemical reaction, the mass of the products is always equal to the mass of the reactants. The law of conservation of mass states that mass is neither created nor destroyed in a chemical reaction.

In order to show that mass is conserved during a reaction, a chemical equation must be balanced. In a balanced chemical equation, the number of atoms on the left side of the equation equals the number of atoms on the right. You can balance a chemical equation by changing the coefficients, which are the numbers that appear before the formulas.

Because chemical reactions often involve large numbers of small particles, chemists use a counting unit called the mole to measure amounts of a substance. A mole (mol) is an amount of a substance that contains approximately 6.02×10^{23} particles of that substance. This number is known as Avogadro's number.

The mass of one mole of a substance is called a molar mass. For an element, the molar mass is the same as its atomic mass expressed in grams. Once you know the molar mass of a substance, you can convert moles of that substance into mass or a mass of that substance into moles.

In chemical reactions, the mass of a reactant or product can be calculated by using a balanced chemical equation and molar masses of the reactants and products. The chemical equation tells you how to relate amounts of reactants to amounts of products.

7.2 Types of Reactions

Some general types of chemical reactions are

- synthesis reactions,
- decomposition reactions,
- single-replacement reactions,
- double-replacement reactions, and
- combustion reactions.

A synthesis reaction is a reaction in which two or more substances react to form a single substance. The reactants may be either elements or compounds. The general equation for a synthesis reaction is

$$A + B \longrightarrow AB$$

The opposite of synthesis is decomposition. A decomposition reaction is a reaction in which a compound breaks down into two or more simpler substances. The reactant in a decomposition reaction must be a compound. The products may be elements or compounds. The general equation for a decomposition reaction is

$$AB \longrightarrow A + B$$

A single-replacement reaction is a reaction in which one element takes the place of another element in a compound. Single-replacement reactions have the general form

$$A + BC \longrightarrow B + AC$$

A double-replacement reaction is one in which two different compounds exchange positive ions and form two new compounds. The general form of a double-replacement reaction is

$$AB + CD \longrightarrow AD + CB$$

A combustion reaction is one in which a substance reacts rapidly with oxygen, often producing heat and light.

A reaction in which electrons are transferred from one reactant to another is called an oxidation-reduction reaction, or redox reaction. Any process in which an element loses electrons during a chemical reaction is called oxidation. A reactant is oxidized if it loses electrons. The process in which an element gains electrons during a chemical reaction is called reduction. A reactant is said to be reduced if it gains electrons.

7.3 Energy Changes in Reactions

Chemical energy is the energy stored in the chemical bonds of a substance. Chemical reactions involve the breaking of chemical bonds in the reactants and the formation of chemical bonds in the products.

During a chemical reaction, energy is either released or absorbed. A chemical reaction that releases energy to its surroundings is called an exothermic reaction. In exothermic reactions, the energy released as the products form is greater than the energy required to break the bonds in the reactants.

A chemical reaction that absorbs energy from its surroundings is called an endothermic reaction. In endothermic reactions, more energy is required to break the bonds in the reactants than is released when the products form.

In both exothermic reactions and endothermic reactions, the total amount of energy before and after the reaction is the same. This principle is known as the law of conservation of energy.

7.4 Reaction Rates

Any change that happens over a period of time can be expressed as a rate. A reaction rate is the rate at which reactants change into products over time. Reaction rates tell you how fast a reaction is going.

Chemical reactions involve collisions between particles of reactants. If collisions occur more frequently, the reaction rate increases. Factors that affect reaction rates include

- temperature,
- surface area,
- concentration,
- stirring, and
- catalysts.

Increasing the temperature of a substance causes its particles to move faster, on average. Particles that move faster are more likely to collide and also more likely to react. If the number of collisions that produce reactions increases, then the reaction rate increases.

An increase in surface area increases the exposure of reactants to one another. Increasing the surface area of a reactant tends to increase the reaction rate.

You can also increase the exposure of reactants to each other by stirring them. Stirring the reactants usually increases the reaction rate.

Another way you can change the reaction rate is to change the concentration of the reactants. Concentration refers to the number of particles in a given volume. The more reacting particles that are present in a given volume, the more opportunities there are for collisions of those particles. The reaction rate is faster.

Sometimes you can change a reaction rate by using catalysts. A catalyst is a substance that affects the reaction rate without being used up in the reaction.

7.5 Equilibrium

Equilibrium is a state in which the forward and reverse paths of a change take place at the same rate. When opposing physical changes take place at the same rate, a physical equilibrium is reached. When a physical change does not go to completion, a physical equilibrium is established between the forward and reverse changes.

When opposing chemical changes take place at the same rate, a chemical equilibrium is reached. Most chemical reactions are reversible to some extent. A reversible reaction is a reaction in which the reactants can change into products and the products can change into reactants at the same time. When a chemical reaction does not go to completion, a chemical equilibrium is established between the forward and reverse reactions.

Chemical equilibria can change depending on the conditions of the reaction. When a change is introduced to a system in equilibrium, the equilibrium shifts in the direction that relieves the change. This rule is known as Le Châtelier's principle.