Effect of Temperature on the Rate of Reaction

Temperature is one of the most important factors affecting the rate of a chemical reaction. In general, an increase in temperature increases the rate of a reaction, while a decrease in temperature slows it down. This is because the kinetic energy of reactant molecules increases with temperature, causing them to move faster and collide more frequently. However, not every collision results in a chemical reaction. Only those collisions in which the reacting molecules possess sufficient energy and the proper orientation are called **effective collisions**. As the temperature increases, the number of molecules having energy greater than or equal to the activation energy also increases, thereby increasing the number of effective collisions and consequently the reaction rate.

Effect of Temperature

The influence of temperature on the reaction rate can be summarized as follows:

- As temperature increases, the kinetic energy of the reacting molecules increases.
- The frequency of molecular collisions increases.
- A larger fraction of molecules acquires energy greater than the activation energy.
- The number of effective collisions increases.
- The rate constant increases, resulting in a faster reaction.

Temperature Coefficient of a Reaction

The **temperature coefficient** of a reaction is defined as the ratio of the rate constant at a higher temperature to that at a lower temperature differing by $^{10^\circ C}$.

It is represented by the symbol $^{\mu}$.

$$\mu = \frac{k_{T+10}}{k_T}$$

where

- k_T is the rate constant at temperature T.
- k_{T+10} is the rate constant at temperature $T + 10^\circ\text{C}$.

For most chemical reactions, the value of the temperature coefficient lies between **2 and 3**. This means that the reaction rate approximately doubles or triples for every 10°C rise in temperature.

Reasons for Increase in Reaction Rate

The increase in the rate of reaction with temperature is mainly due to the following reasons:

1. Increase in the average kinetic energy of the reactant molecules.
2. Increase in the collision frequency between reacting particles.
3. Increase in the number of molecules possessing energy greater than the activation energy.
4. Increase in the number of effective collisions leading to product formation.

Graphical Representation

When the reaction rate is plotted against temperature, the rate increases rapidly with increasing temperature. Similarly, the fraction of molecules having energy greater than the activation energy increases with temperature, as represented by the Maxwell–Boltzmann distribution curve.

Applications

- Food preservation by refrigeration slows chemical and biological reactions.
- Chemical industries increase temperature to enhance production rates.
- Catalytic processes become more efficient at suitable temperatures.
- Many biological and enzymatic reactions are highly temperature dependent.

Important Points

- An increase in temperature increases the reaction rate.
- The rate constant increases with temperature.

- Only effective collisions produce products.
- The temperature coefficient of most reactions lies between 2 and 3.
- The quantitative relationship between temperature and the rate constant is explained by the Arrhenius equation, discussed in the next section.