12.12: Reaction Intermediate

Ozone $\left(O_3\right)$ depletion in the atmosphere is of significant concern. This gas serves as a protection against the ultraviolet rays of the sun. Ozone is naturally depleted in addition to the depletion caused by human-made chemicals. The depletion reaction is a two-step process:

$$O_3 + \text{ultraviolet light} \rightarrow O_2 + O\cdot \text{ (free radical) slow reaction}$$

$$O\cdot + O_3 \rightarrow 2O_2 \text{ fast reaction}$$

The free radical is not a part of the overall equation, but can be detected in the lab.

Intermediate

Reaction mechanisms describe how the material in a chemical reaction gets from the initial reactants to the final products. One reaction that illustrates a reaction mechanism is the reaction between nitrogen monoxide and oxygen to form nitrogen dioxide:

$$2NO\left(g\right) + O_2\left(g\right) \rightarrow 2NO_2\left(g\right)$$

It may seem as though this reaction would occur as the result of a collision between two NO molecules with one O_2 molecule. However, careful analysis of the reaction has detected the presence of N_2O_2 during the reaction. A proposed mechanism for the reaction consists of two elementary steps:

Step 1: $2NO\left(g\right) \rightarrow N_2O_2\left(g\right)$

Step 2: $N_2O_2\left(g\right) + O_2\left(g\right) \rightarrow 2NO_2\left(g\right)$

In the first step, two molecules of NO collide to form a molecule of N_2O_2. In the second step, that molecule of N_2O_2 collides with a molecule of O_2 to produce two molecules of NO_2. The overall chemical reaction is the sum of the two elementary steps:

$$\begin{aligned} 2NO\left(g\right) &\rightarrow \cancel{N_2O_2\left(g\right)} \\ \cancel{N_2O_2\left(g\right)} + O_2\left(g\right) &\rightarrow 2NO_2\left(g\right) \\ \hline 2NO\left(g\right) + O_2\left(g\right) &\rightarrow 2NO_2\left(g\right) \end{aligned}$$

The N_2O_2 molecule is not part of the overall reaction. It was produced in the first elementary step, then reacts in the second elementary step. An **intermediate** is a species which appears in the mechanism of a reaction, but not in the overall balanced equation. An intermediate is always formed in an early step in the mechanism and consumed in a later step.

Figure 12.12.1: Nitrogen dioxide (left) and dinitrogen tetroxide (right). (CC BY-NC; CK-12)

Summary

- Reaction mechanisms describe how the material in a chemical reaction gets from the initial reactants to the final products.
- An intermediate is a species which appears in the mechanism of a reaction, but not in the overall balanced equation.