Chemical Equilibrium

Chemistry Olympiad Club
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Forward and Reverse Reactions

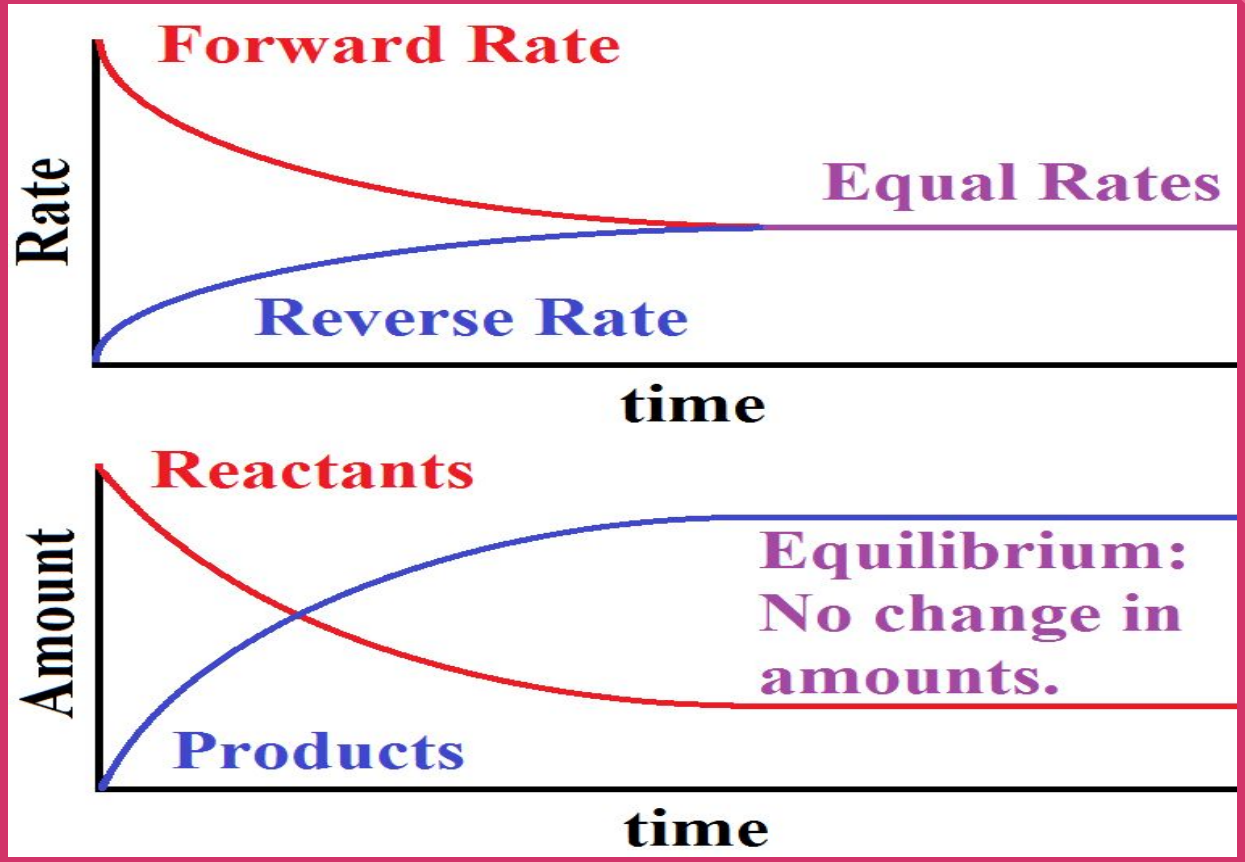
- For any reaction that occurs, producing products from reactants, there is a reverse reaction that consumes products to produce reactants
- The relative rates of these two reactions are determined by the concentrations of reactants and products

For a reaction A + B <-> C + D where k_1 is the rate constant of the forward reaction and k_{-1} is the rate constant of the backward reaction:

$Rate_{forward} = k_1[A][B]$ and $Rate_{backward} = k_{-1}[C][D]$

Forward and Reverse Reactions

- Initially, there are no products, so the reverse reaction does not occur
- But as the forward reaction proceeds, the product concentrations increase
- Simultaneously, reactants are consumed so their concentrations decrease
- Therefore, according to the rate laws, as the reaction proceeds, the rate of the forward reaction decreases and the rate of the backward reaction increases
- Once the reaction reaches a certain point, the rate forward and rate backward are equal to each other, and this situation is called equilibrium


Forward Rate
Rate
Equal Rates
Reverse Rate
time
Reactants
Amount
Equilibrium:
No change in
amounts.
Products
time

Equilibrium

- An important distinction to note is that although the concentrations of reactants and products no longer change at equilibrium, the reaction does not stop producing reactants
- Instead, the reactants are being consumed by the reverse reaction as fast as they are being produced, so no net change is observable
- This type of equilibrium is known as dynamic equilibrium since the reactions continue to proceed

Equilibrium Constants

- Equilibrium is useful because it tells us how much product a reaction will create before the forward and reverse rates equal each other
- To quantify this point, we use equilibrium constants which are called K
- K is the ratio of the concentrations of the products raised to their stoichiometric coefficients divided by the concentrations of the reactants raised to their stoichiometric coefficients, at equilibrium
- The relationship between the equilibrium expression and the chemical equation is called the law of mass action

For the reaction

aA + bB <-> cC + dD

$$K_{eq} = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

What Does the Equilibrium Constant Tell Us

- The value of K is the ratio of products to reactants, so a value of K greater than 1 tells us that the reaction proceeds farther in the forward direction
- A value of K less than one tells us that the reaction proceeds farther in the reverse direction, and a value of K that equals 1 tells us that the forward reaction only proceeds about halfway