Chemical Equilibrium

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#Chemistry

> *In our everyday lives, there are many examples of balances or equilibrium. A see-saw is in equilibrium when the forces on either side are balanced, and the see-saw remains horizontal. Water in a rainforest is in equilibrium when the amount of rainfall balances the amount of evaporation and use. In this instance, the equilibrium described is a 'dynamic equilibrium' as the rain continues to fall and evaporation continues to take place. Both processes occur continuously but at the same rate, so that there is no net overall change.*

Le Chatelier

Henri Louis Le Chatelier (1850-1936), the French physical chemist and metallurgist, seen here while a student at the Ecole Polytechnique. His early research was on cement; he worked also on the structure of alloys, on flames and on thermometry. In the 1880's he developed the idea known as Le Chatelier's principle: this states that if the conditions (temperature, pressure or volume) of a chemical system initially at equilibrium are changed, then the equilibrium will shift in the direction which will tend to annul the change, if possible. Although far from perfect and much critized, this principle is still used today.

Le Chatelier's Principle

> *If a factor affecting the position of an equilibrium is altered, the position of the equilibrium shifts to oppose the effect of change.*

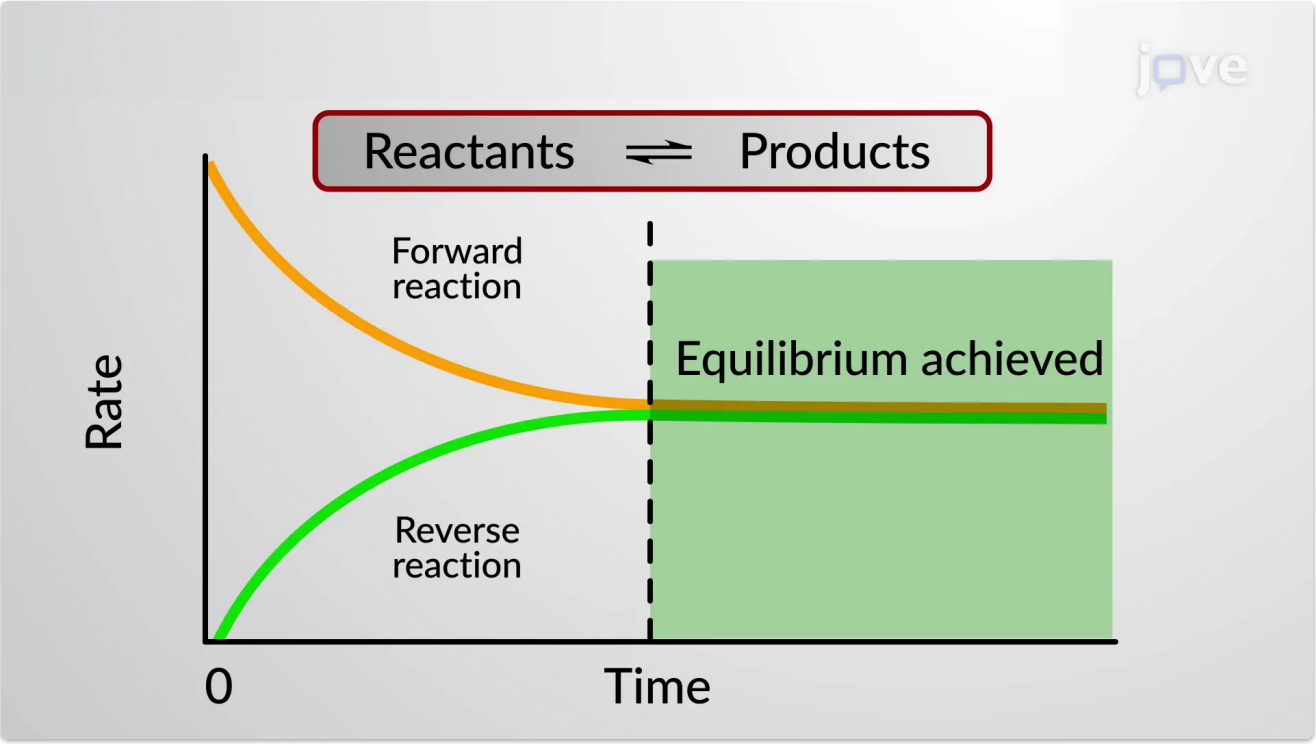
Catalysts **do not** change the position of equilibrium.

The products and reactants' energy is relatively close after reaction occurs, making it a **reversible** reaction.

Chemical Equilibrium is dependent on pressure, concentration, and temperature.

At a equilibrium, the proportion **may not be** 50:50.

Concentration and Equilibrium



Solids, liquids, and aqueous solutions do not exert pressure.

If the concentration of one of the substances involved in a dynamic equilibrium changes, the equilibrium will shift to oppose that change.

$A + B \rightleftharpoons C + D$

If the concentration of A is increased, the equilibrium will shift to the right to reduce the amount of A. Increasing the concentration of any substance casuses the equilibrium to shift to use up more of that substance.

If the concentration of A is reduced, the equilibrium will shift to the left to increase the amount of A. Decreasing the concentration of any substance causes the equilibrium to shift to make more of that substance.

Temperature and Equilibrium

Example

$A + B \rightleftharpoons C + D$

Catalysts and Equilibrium

A catalyst is a substance that speeds up the rate of reaction by providing an alternative reaction pathway of lower energy.

When added to a reversible reaction, a catalyst increases the rate of both the forward and reverse reactions equally. This has two results:

- There is no change to the position of the equilibrium
- Equilibrium is reached faster.

The use of catalysts is particularly important in industry.

$$[Co(H_2O)_6]^{2+}_{(aq)} \rightleftharpoons [CoCl_4]^{2-} + H_2O_{(l)}$$

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Some Equilibrium Problems

1. The hydrogen used in the Haver process is made in the reaction shown below, which is an equilibrium.

$$CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g)$$

    1. If the temperature is increased, the yield of hydrogen would be increased. This is due to the endothermic rate being favoured and that increasing the temperature, the opposite side of the reaction would have to decrease in temperature. If the temperature is an endothermic, the heat is a reactant:

$$Heat + A \rightleftharpoons B$$

For an exothermic reaction, the situation is just the opposite. Heat is released in the reaction, so heat is a product, and the value of ΔH is negative:

$$A \rightleftharpoons B + Heat$$

1.
2. A change in pressure or volume will result in an attempt to restore equilibrium by creating more or less moles of gas. For example, if the pressure in a system increases, or the volume decreases, the equilibrium will shift to favor the side of the reaction that involves fewer moles of gas. Similarly, if the volume of a system increases, or the pressure decreases, the production of additional moles of gas will be favored. ***This means that the yield of the hydrogen will decrease.***
3. According to Le Chatelier's principle, adding additional reactant to a system will shift the equilibrium to the right, towards the side of the products. By the same logic, reducing the concentration of any product will also shift equilibrium to the right. ***This means that the yield of the hydrogen will increase.***