Le Chatelier's Principle

Henri Louis Le Châtelier* (1850–1936) is a French industrial chemist:
If a system at equilibrium is disturbed, the system adjusts in a way to reduce the change.

Chemical equilibria respond to three kinds of stress: Changes in the concentrations of reactants or products, changes in temperature, and changes in pressure.

a) Change the Reactant or Product Concentration:

If a chemical system is already at equilibrium and the concentration of any substance in the mixture is increased (either reactant or product), the system reacts to consume some of that substance.

Conversely, if the concentration of a substance is decreased, the system reacts to produce some of that substance.

Changes in concentration does not change the value of K_{eq}.

b) Effects of Volume and Pressure Changes:

Pressure has almost no effect on equilibrium reactions that are in solution. Gases in equilibrium may be affected by changes in pressure. Changes in partial pressure does not change the value of K_{eq}.

At constant temperature, a pressure increase favors the reaction that produces fewer gas molecules.

In a reaction with the same number of moles of gas in the products and reactants, changing the pressure has no effect on the equilibrium.

In addition, no change will occur if we increase the total gas pressure by the addition of a gas that is not involved in the reaction.

c) Effect of Temperature Changes:

The equilibrium constant is temperature dependent. Changing the temperature changes the equilibrium constant (K_{eq}).

Heat can be treated as a chemical reagent. The equilibrium shifts in the direction that consumes the excess heat.

In an endothermic (heat-absorbing, $\Delta H < 0$),) reaction, we consider heat a reactant. Increasing the temperature of an equilibrium mixture usually leads to a shift in favor of the product. The K_{eq} increases.

In an exothermic (heat-releasing, $\Delta H > 0$) reaction, we consider heat a product. Increasing the temperature of an equilibrium mixture usually leads to a shift in favor of the reactant. The K_{eq} decreases.

Endothermic: $\text{Reactants} + \textit{heat} \rightleftharpoons \text{products}$

Exothermic: $\text{Reactants} \rightleftharpoons \text{products} + \textit{heat}$

The Common-Ion Effect

It is the phenomenon in which the addition of an ion common to two solutes brings about precipitation and reduce solubility.

Example:

Magnesium hydroxide is slightly soluble.

$$Mg(OH)_2(s) \rightleftarrows Mg^{2+}(aq) + 2OH^-(aq)$$
$$[Mg^{2+}][OH^-]^2 = K_{sp} = 1.8 \times 10^{-11}$$

Magnesium is the third most abundant ion in the ocean. Adding hydroxide ion will increase the concentration of hydroxide ion so that $[Mg^{2+}][OH^-]^2$ would be greater than 1.8×10^{-11}. As a result, magnesium hydroxide ($Mg(OH)_2$)and will precipitates and can be collected. Magnesium is rigid with low weight. It is used when light weight and strength are needed such as cameras, cars, and airplanes.

Table 4 Ions in the Ocean

Ions	Concentration in the ocean (mol/L)
Cl^-	0.554
Na^+	0.470
Mg^{2+}	0.047
SO_4^{2-}	0.015
K^+	0.010
Ca^{2+}	0.009

Summary: Le Chatelier's Principle. "When a system at equilibrium is disturbed, the system adjusts in a way to reduce the change."

$$jA + kB \rightleftharpoons lC + mD$$

reactants products

Concentration Effect:

If you add more reactant to a system in chemical equilibrium, the forward reaction is increasing and the equilibrium is said to shift right.

If you add more product to a system in chemical equilibrium, the reverse reaction is increasing.

Temperature Effect:

For all exothermic forward reactions ($\Delta H < 0$), increasing the temperature of an equilibrium mixture, usually lead to a shift in favor of the reactants.

For all endothermic forward reactions ($\Delta H > 0$), increasing the temperature of an equilibrium mixture, usually lead to a shift in favor of the products.

Pressure Effect:

In an equilibrium, a pressure increase favors the reaction that produces fewer gas molecules.