OGUN DIGICLASS

CLASS: SECONDARY SCHOOL

SUBJECT: CHEMISTRY

TOPIC: Chemical Equilibrium

Chemical Equilibri
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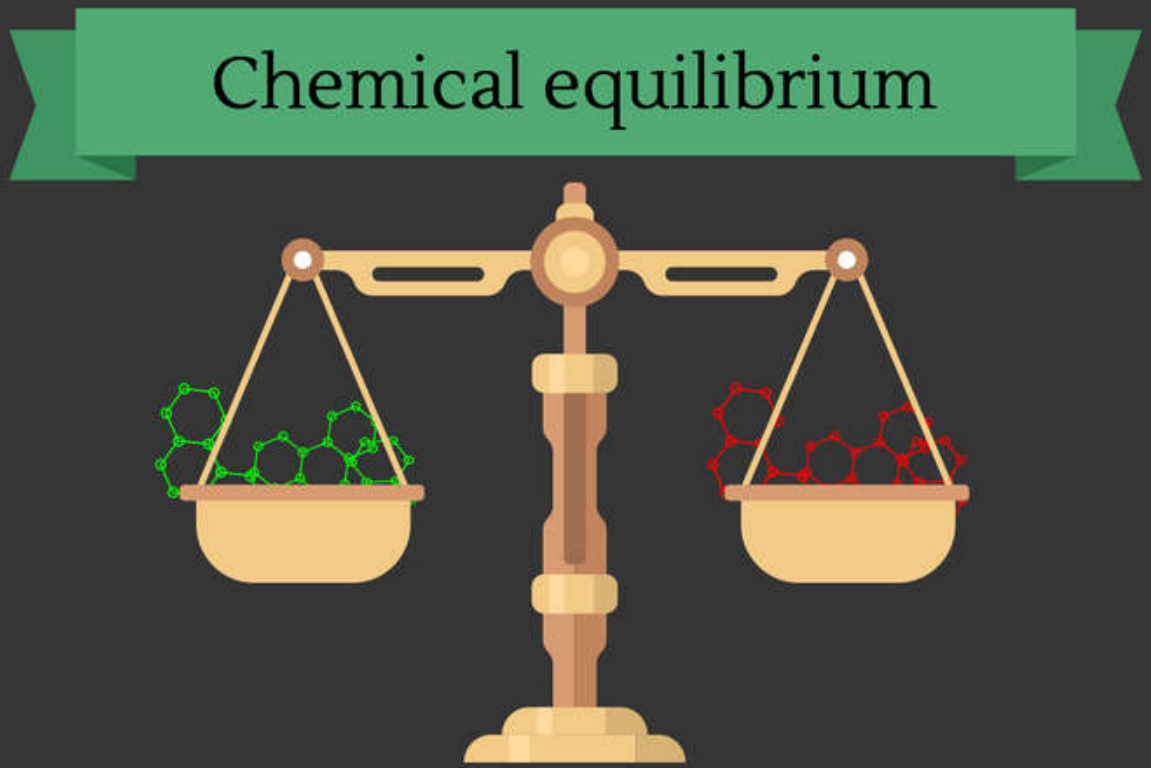


Learning Objectives

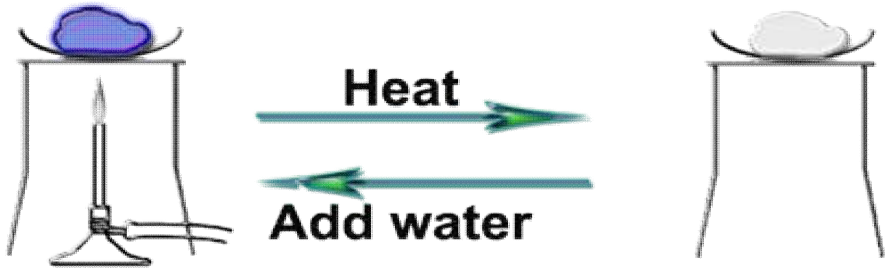
- At the end of the lesson, learner’s will be to:
- State the Conditions for obtaining equilibrium in a reversible reaction.
- State Equilibrium constant for given equations.
- Calculate the Equilibrium constant for give reactions.
- State Le Chateleir's Principle.
- State factors affecting chemical equilibrium.

Chemical Equilibrium

Chemical equilibrium occurs in chemical reactions that are reversible. In a reaction such as:

$$CH_4(g) + H_2O(g) \Leftrightarrow CO(g) + 3H_2(g)$$

The reaction can proceed in both directions



An Equilibrium System

$CH_4(g) + H_2O(g) \Leftrightarrow CO(g) + 3H_2(g)$

- After some of the products are created the products begin to react to form the reactants
- At equilibrium there is no net change in the concentrations of the reactants and products
- The concentrations do not change but they are not necessarily equal

Conditions for obtaining Chemical Equilibrium

The rate of forward reaction is equal to the rate of backward reaction.

There is no net change in the concentration of reactants and the concentration of the product.

The change in Free energy is zero.

The reaction occurs in a close system

Dynamic Equilibrium

An equilibrium is Dynamic

$CH_4(g) + H_2O(g) \Leftrightarrow CO(g) + 3H_2(g)$

The amount of products and the reactants are constant.

(Note)

The concentrations are not necessarily equal but constant. Both reactions are still occurring, but at the same rate)

The Equilibrium Constant

$aA + bB \Leftrightarrow cC + dD$

- **The upper case letters are the molar concentrations of the reactants and products. The lower case letters are the coefficients that balance the equation.**
- Law of Mass Action, states that at constant temperature, the rate of reaction is proportional to the active masses of each of the reactants

The Equilibrium Constant

$$aA + bB \Leftrightarrow cC + dD$$

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

Equilibrium Constant Calculations

Example

$$N_2(g) + 3H_2(g) \Leftrightarrow 2NH_3(g)$$

At equilibrium, a one-liter container has 1.60 moles NH_3, .800 moles N_2, and 1.20 moles of H_2. What is the equilibrium constant?

Equilibrium Constant Calculations

At equilibrium, a one-liter container has 1.60 moles NH_3, .800 moles N_2, and 1.20 moles of H_2. What is the equilibrium constant?

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$K_c = \frac{[1.60]^2}{[.800][1.20]^3} = 1.85$$

Reaction quotient

- The equilibrium constant is a constant ratio only when the system is in equilibrium.
- If the system it not at equilibrium the ratio is known as a Reaction Quotient
- If the reaction quotient is equal to the equilibrium constant then the system is at equilibrium

Using Equilibrium Constants f or other calculations

If a solution is not at equilibrium the ratio of the r ight side over the left is called a reaction quotie nt.

$$aA + bB \Leftrightarrow cC + dD$$

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$ If not at equilibrium

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$ If at equilibrium

Equilibrium Constants and calculations

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

If Q > Keq , the product side is too high and the equilibrium will shift to the left to restore equilibrium

If Q < Keq , the product side is too low and the equilibrium will shift to the right to restore equilibrium

Equilibrium Calculations

Hydrogen and iodine are in equilibrium with Hydrogen iodide to this reaction:

$$H_2 + I_2 \Leftrightarrow 2HI$$

Suppose that 1.5 mole of H_2 and 1.2 m ole of I_2 are placed in a 1.0 dm^3 contain er. At equilibrium it was found that there were 0.4 mole of HI.

Calculate the equilibrium constant

Equilibrium Calculation

Sulphur 1v oxide reacts with oxygen to produce sulphur v1 oxide according to this reaction:

$2\ SO_2 + \ O_2 \Leftrightarrow 2SO_3$

Suppose that 1.4 mole of SO_2 and 0.8 mole of SO_3 are placed in a 1.0 dm^3 container.

At equilibrium it was found that there were 0.6 dm^3 of SO_3. Calculate the equilibrium constant.

Equilibrium Calculations
Problem 2 Solution

Sulfur dioxide reacts with oxygen to produce sulfur trioxide according to this reaction:

$$2\,SO_2 + O_2 \Leftrightarrow 2SO_3$$

Suppose that 1.4 mole of SO_2 and 0.8 mole of SO_3 are placed in a 1.0 dm^3 container.

At equilibrium it was found that there were 0.6 dm^3 of SO_3. Calculate the equilibrium constant for the reaction.

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2\,[O_2]} = \frac{(0.6)^2}{(0.8)^2(0.5)} = 0.281$$

Le Chatelier's Principle

- **Le Chatelier's Principle states: When a system in chemical equilibrium is disturbed by a change of temperature, pressure, or a concentration, the system shifts in equilibrium composition in a way that tends to counteract this change of variable.**
- **A change imposed on an equilibrium system is called a stress**
- **The equilibrium always responds in such a way so as to counteract the stress**

Factors Affecting Chemical Equilibrium

- Change in concentration
- Change in temperature
- Change in pressure

Effect of a Change in Temperature

- An increase in the temperature causes the

equilibrium to shift in the direction of the endother mic reaction

- $N_2\,(g) + 3\,H_2\,(g) \Leftrightarrow 2NH_3\,(g)$ $\Delta H = -92\ kJ\ mol^{-1}$
- Since ΔH is negative the endothermic reaction is the reverse direction.

An increase in temperature causes the reaction to shift to the left, resulting in an increase in N_2 and H_2 and a decrease in NH_3

Effect of a Change in Pressure

Pressure affects only gases in an equilibrium

An increase in pressure causes the equilibrium to shift in the direction that has the fewer number of moles

$N_2\,(g) + 3\,H_2\,(g) \Leftrightarrow 2NH_3\,(g)$ $\Delta H = -92\ kJ\ mol^{-1}$

An increase in pressure results in a decrease in N_2 and H_2 and an increase in NH_3

Effect of a Change in one of the reactants or products

Substances on the same side of the arrow respo nd in opposite directions.

Substances on the opposite side of the arrow mo ve in the same direction

$N_2\,(g) + 3\,H_2\,(g) \Leftrightarrow 2NH_3\,(g)$

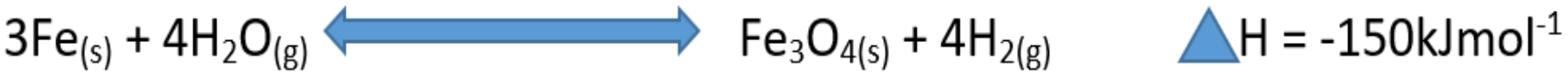
An increase in [N_2] results in a decrease in N_2 an d H_2 and an increase in NH_3

Effect of a Catalyst

- Catalysts affect both the forward and reverse directions equally
- A catalyst does not change the concentrations but reduces the time required for the system to come to equilibrium

Assignment

Consider the following equilibrium reaction:



a. Write equilibrium constant, K_p, for the reaction.

b. Explain the effect of the following factors on the yield of hydrogen gas:

(I) Increase in pressure

(II) Decrease in temperature

(III) Removal of hydrogen

(IV) Addition of H_2O