SCH4U

Online Course

Stan Vincent

Lesson expectation for the day

Topic 1.

Reversible Reactions

Topic 2.

Law of Mass Action

Topic 3.

Homogenous Heterogenous Equilibrium

Topic 4.

Writing Equilibrium Expressions Kc and Kp

Topic 5.

Relation between Kc and Kp

Todays Lesson

We will cover these skills:

- Define Reversible reactions
- Equilibrium State
- Define Irreversible reactions
- Conditions for equilibrium
  - Closed System
  - Constant Temperature
- Difference between $\rightarrow$ and $\rightleftharpoons$

Reversible

$\leftrightharpoons$

Reactions

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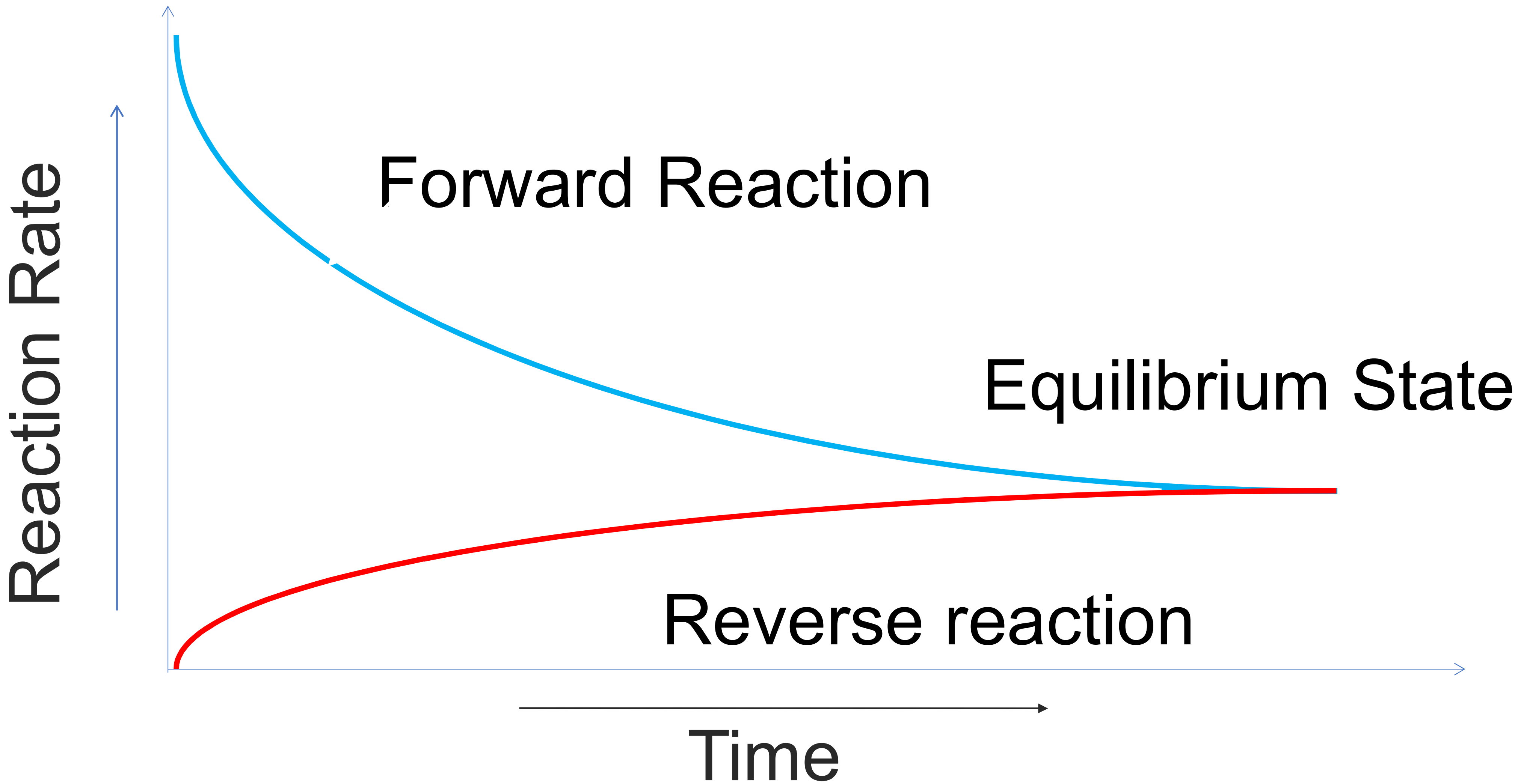
Reversible reaction

A reversible reaction is a chemical reaction where the reactants form products, that in turn, react together to give the reactants back.

$aA + bB \leftrightharpoons cC + dD$

State of Equilibrium

- Reversible reactions will reach an equilibrium point where the concentrations of the reactants and products will no longer change
- Only closed systems can attain Equilibrium



Reaction Rate
Forward Reaction
Equilibrium State
Reverse reaction
Time

Irreversible reaction

An irreversible reaction always goes to completion and the products cannot combine to give the reactants back in one step.

$aA + bB \rightarrow cC + dD$

LAW OF MASS ACTION

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Law of Mass Action

The rate of a reaction is directly proportional to the product of the concentrations of the reactants raised to the appropriate coefficients.

$aA + bB \leftrightharpoons cC + dD$

$Rate = k[A]^a[B]^b$ For forward reaction

$Rate = k[C]^c[D]^d$ For backward reaction

Equilibrium Constant Kc

A numerical value representing the equilibrium state which is a ratio of the product of concentration of products to reactants

aA + bB ⇋ cC + dD

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

Equilibrium Constant Kc

$$N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$$

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

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HOMOGENOUS HETEROGENOUS EQUILIBRIA

Homogenous Equilibria

If the reactants and products are in the same phase (state) in a chemical reaction, then the reaction is referred to as a homogenous equilibria

$N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$

Kc for Homogenous Equilibria Gas phase

$N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$

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

Kc for Homogenous Equilibria Gas phase

$N_2O_{4(\text{brown gas})} \leftrightharpoons 2NO_{2(\text{colorless gas})}$

$$Kc = \frac{[NO_2]^2}{[N_2O_4]}$$

Kc for Homogenous Equilibria Aqueous solutions

$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \leftrightharpoons [FeSCN]^{2+}_{(aq)}$

Reactants and products in aqueous phase (homogenous)

$$Kc = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^{-}]}$$

Heterogenous Equilibria

If the reactants and products are in different phases (state) in a chemical reaction, then the reaction is referred to as a heterogenous equilibria

$$MgCO_{3(s)} \leftrightharpoons MgO_{(s)} + CO_{2(g)}$$

Kc for Heterogenous Equilibria Solid / Gas

$MgCO_{3(s)} \leftrightharpoons MgO_{(s)} + CO_{2(g)}$

Solids and liquids not included in the equilibrium expression

$$Kc = \frac{[CO_2]}{[1]}$$

Kc for Heterogenous Equilibria Solid and Aqueous ions

$3Ca^{2+}_{(aq)} + 2PO_4^{3-}_{(aq)} \leftrightharpoons Ca_3(PO_4)_{2(s)}$

Solids are not included in the equilibrium expression

$$Kc = \frac{[1]}{[Ca^{3+}]^3[PO_4^{3-}]^2}$$

CONVERTING K_C TO K_P

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Kc Expression For Molar Concentrations

If for a chemical reaction molar concentrations are given, we can write the Kc expression

$N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$

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

Kp Expression For Partial Pressures

If on the other hand the partial pressures are given in a reaction involving gases, we can write the Kp expression

$N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$

$$Kp = \frac{[P_{NH3}]^2}{[P_{N2}][P_{H2}]^3}$$

Relation between Kc and Kp

$$Kc = \frac{K_p}{(RT)^{\triangle n}}$$

$$Kp = Kc\ RT^{\triangle n}$$

$\triangle n$

For

$N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$

$\triangle n = (n_{\text{gas products}}) - (n_{\text{gas reactants}})$

$\triangle n = (n_{\text{gas products}}\ 2) - (n_{\text{gas reactants}}\ 1+3)$

$\triangle n = 2 - 4 = -2$

Reactants and products should be gases. Do not include moles of reactants and products that are solids in the reaction

Determine Kp for the following reaction at 500°C if Kc is 6.0×10^{-2} $R = 0.0821$ L atm K^{-1} mol^{-1}

$N_{2(g)} + 3H_{2(g)} \leftrightharpoons 2NH_{3(g)}$

$\Delta n = (n_{gas\ products}\ 2) - (n_{gas\ reactants}\ 1+3)$

$\Delta n = 2 - 4 = -2$

$Kp = Kc\ RT^{\Delta n}$

$Kp = (6.0x10^{-2})[(0.0821)(773K)]^{-2}$

$Kp = (6.0x10^{-2})\ (63.5)^{-2}$

$Kp = 1.5x10^{-5}$