Textbook of Chemistry

GRADE 10

National Book Foundation
as
Federal Textbook Board
Islamabad

Textbook of

Chemistry

Grade

10

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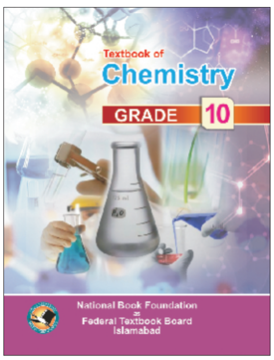
OUR MOTTO

• Standards • Outcomes • Access • Style

Textbook of
Chemistry Grade - 10



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PREFACE

Textbook of **Chemistry Grade 10** is developed according to the National Curriculum 2006 and National Style Guide. It is being published since 2013 and now it is presented under the new management and supervision of textbook development principles and guidelines with new designing and layout.

Chemistry Grade 10 aims to bring themes and topics closer to the interests of the children. The activities are also intended to encourage them towards taking the responsibility of their own learning. The success of the book will depend upon the ownership of the children towards declaring the book as their favourite.

In the previous sessions the students have gone through a mind map of the chemistry division. Half of this divide was introduced there. Now they will go beyond the organic, bio and usage of chemistry in the industries and their effect on environment.

This book is now presented in a new way so that Chemistry should become a vital subject. The text items given in the exercises are for learning reinforcement. The examination questions are to be prepared according to the SLO's and the Bloom's Taxonomy.

Quality of Standards, Pedagogical Outcomes, Taxonomy Access and Actualization of Style is our motto. With these elaborations, this series of new development is presented for use. After educational feedback and necessary changes, the book is being published again.

National Book Foundation

بِسۡمِ اللّٰهِ الرَّحۡمٰنِ الرَّحِيۡمِ

اللہ کے نام سے شروع جو بڑا مہربان، نہایت رحم والا ہے

CONTENTS

9

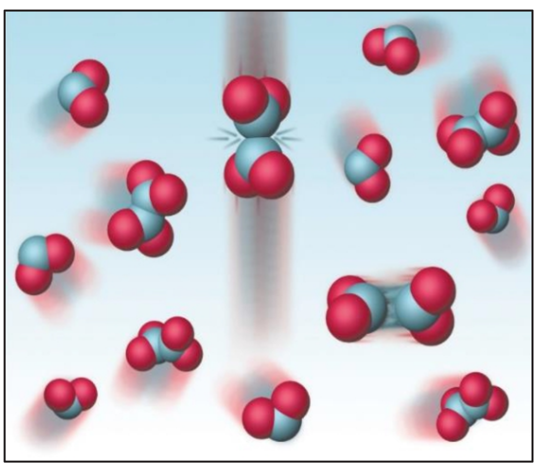
CHEMICAL EQULIBRIUM

After completing this lesson, you will be able to:

This is 11 days lesson (period including homework)

- Define chemical equilibrium in terms of a reversible reaction.
- Write both the forward and the reverse reactions and describe the macroscopic characteristics of each.
- Define Law of mass action
- Derive an expression for the equilibrium constant and its units
- State the necessary conditions for equilibrium and the ways that equilibrium can be recognized.
- Write the equilibrium constant expression of a reaction.
- Write the equilibrium constant expression for a given chemical reaction.
- Explain how components of atmosphere can be used successfully in producing important chemicals.

Reading



INTRODUCTION:

A complete reaction is one in which all the reactants have been converted to products. However, many important chemical reactions do not complete and a mixture of products and reactants are formed. In such a reaction product react together to re-form reactants. At the same time reactants form products. These reactions are called reversible reactions. An understanding of equilibrium is important in the chemical industry. Equilibrium reactions are involved in some of the stages in the commercia,l production of many important chemicals such as ammonia, sulphuric acid etc.

In a closed container, the formation of ammonia from its elements does not proceed to any great extent. Yet as you will learn in this chapter, this vital substance is manufactured on multimillion ton scale annually by applying the principles of equilibrium. How? You will learn many important things about chemical equilibrium in this chapter.

9.1 REVERSIBLE REACTIONS AND DYNAMIC EQUILIBRIUM.

Recall what happens when some liquid is placed in a closed container? You have learnt about it in grade IX.

Some of the liquid undergoes a physical change by evaporating. As more liquid evaporates, some of the vapours condense due to collision with the surface of the liquid. Eventually the rate of evaporation equals the rate of condensation. At this stage equilibrium is established between forward and reverse changes.

$$\textbf{Liquid} \rightleftharpoons \textbf{Vapours}$$

Many chemical reactions do not reach completion. In such reactions the conversion of reactants into products and conversion of products into reactants can happen simultaneously. **A reaction in which the products can react together to re-form the original reactants is called reversible reaction OR a reaction which proceeds in the forward direction as well as in the reverse direction under the same conditions is called a reversible reaction. These reactions never go to completion.** All reversible changes (physical and chemical) occur simultaneously in both the directions. The double arrow ($\rightleftharpoons$) in the chemical equation shows that the reaction is reversible. For example:

$2SO_{2(g)}$	+	$O_{2(g)}$	$\xrightleftharpoons{V_2O_5}$	$2SO_{3(g)}$
Sulphur dioxide		Oxygen	**450°C, 200 atm**	Sulphur trioxide
$N_{2(g)}$	+	$3H_{2(g)}$	$\xrightleftharpoons{Fe}$	$2NO_{2(g)}$
Nitrogen		Hydrogen	**400°C, 200 atm**	Ammonia
$2N_{2(g)}$	+	$O_{2(g)}$	$\xrightleftharpoons{\text{Electric}}$	$2NO_{2(g)}$
Nitric oxide		Oxygen	**spark**	Nitrogen dioxide

Consider what happens when SO_2 and O_2 gases are mixed in a sealed container (Figure 9.1)

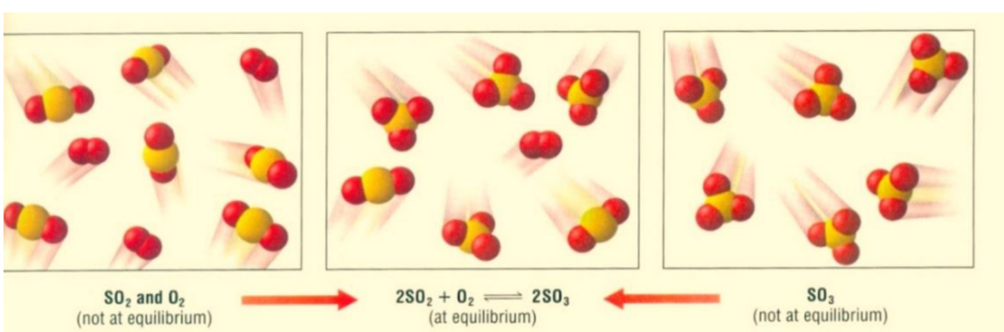


Figure 9.1 Reaction between SO_2 and O_2

Teacher's Point

Teacher may give more examples of reversible reactions.

Science Titbits

When fizzy drinks are made, CO_2 is dissolved in the liquid drink under pressure and sealed. When you remove lid of the bottle, bubbles of CO_2 suddenly appear. When you put the lid back on the bottle, the bubbles stop. This is due to the following equilibrium.

$$CO_{2(g)} \rightleftharpoons CO_{2(aq)}$$

The forward reaction happens during manufacturing and the reverse reaction happens on opening.

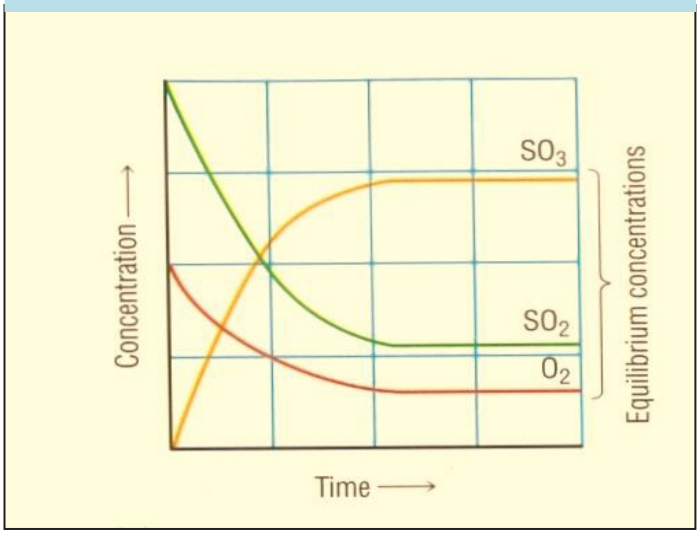


Figure 9.2 Concentration-time graph

Molecules of SO_2 and O_2 react to give SO_3. Molecules of SO_3 decompose to give SO_2 and O_2. What types of molecules are present at equilibrium?

In the first reaction (from left to right) SO_2 and O_2 produce SO_3. In the second reaction (from right to left) SO_3 decompose into SO_2 and O_2.

Which reaction is called forward reaction?

Which reaction is called the reverse reaction?

Initially there is no SO_3. So the rate of reverse reaction is zero. The rate of forward reaction is the highest, due to the high concentration of reactants. As the reaction proceeds, the concentration of reactants gradually decreases and the rate of forward reaction also decreases proportionately. (Figure 9.1)

$$2SO_{2(g)} + O_{2(g)} \longrightarrow SO_{3(g)}$$

As the concentration of SO_3 increases, a small amount of SO_3 slowly decomposes to SO_2 and O_2. This means reverse reaction has begun. In this reaction SO_3 acts as reactant and produces SO_2 and O_2. So the reverse reaction is

$$2SO_{3(g)} \longrightarrow 2SO_{2(g)} + O_{2(g)}$$

As the concentration of SO_3 becomes higher, the reverse reaction speeds up. Eventually the two rates become equal. At this stage SO_3 decomposes to SO_2 and O_2 as fast as SO_2 and O_2 produce SO_3. At this stage reaction is said to have reached equilibrium state. (Figure 9.2)

A state of a chemical reaction in which forward and reverse reactions take place at the same rate is called chemical equilibrium.

Chemical equilibrium is a dynamic equilibrium. This is because reactions do not stop when they come to equilibrium state. The individual molecules keep on reacting continuously. But there is no change in the actual amounts of reactants and products. This means concentration of reactants and products become constant at equilibrium stage.

Example 9.1: Writing the forward and the reverse reactions

Write the forward and the reverse reactions for the following reversible reactions.

$$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2\,(g)}$$

Problem Solving Strategy:

1. The reaction from left to right is the forward reaction.
2. The reaction from right to left is the reverse reaction.

Solution:

Forward reaction

$$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2\,(g)}$$

Reverse reaction

$$2NO_{2(g)} \longrightarrow 2NO_{(g)} + O_{2(g)}$$

Self Assessment Exercise – 9.1

Write both forward and reverse reactions and describe macroscopic characteristics of each?

(i) $\boldsymbol{N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}}$

(ii) $\boldsymbol{H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}}$

Reading

9.2. LAW OF MASS ACTION AND DERIVATION OF THE EXPRESSION FOR THE EQUILIBRIUM CONSTANT

Chemists generally express the composition of equilibrium mixture in terms of numerical values. These values relate the amounts of products to reactants at equilibrium. These values can be determined by using a relationship known as "**The law of mass action".**

Two chemists C.M Guldberg and P. Waage in 1864 proposed the law of mass action to describe the equilibrium state.

It states that the rate at which a substance reacts is directly proportional to its active mass. The rate at which the reaction proceeds, is directly proportional to the product of the active masses of the reactants.

The term "**active mass**" represents the concentration of reactants and products in $mol.dm^{-3}$ for a dilute solution, and is expressed in terms of square brackets [ ].

Consider a hypothetical reaction in which 'a' moles of reactant A and 'b' moles of reactant B react to give 'c' moles of product C and 'd' moles of product D at equilibrium.

$$aA_{(g)} + bB_{(g)} \rightleftharpoons cC_{(g)} + dD_{(g)}$$

According to the law of mass action;

Rate of forward reaction $\propto [A]^a[B]^b$

Rate of forward reaction = $k_f[A]^a[B]^b$

Rate of reverse reaction $\propto [C]^c[D]^d$

Rate of reverse reaction= $k_r[C]^c[D]^d$

Where K_f and K_r are the rate constants for forward and the reverse reactions respectively

At equilibrium state:

Rate of forward reaction = Rate of reverse reaction

Thus

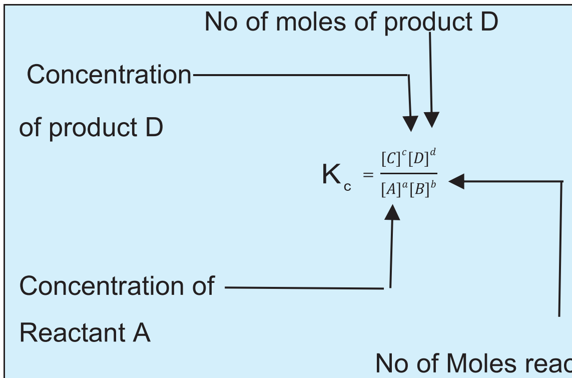
$$k_f [A]^a [B]^b = k_r [C]^c [D]^d$$

On rearranging $\frac{k_f}{k_r} = \frac{[C]^c [D]^d}{[A]^a [B]^b}$

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

Where $K_c = \frac{k_f}{k_r}$ and is known as equilibrium constant, and the above equation is called as equilibrium constant expression. The square brackets indicate the concentration of the chemical species at equilibrium in $moles/dm^{-3}$. Thus the equilibrium constant expression for any reaction can be written from its balanced equation. Concentration of products is taken in the numerator and concentration of reactants in the denominator. In K_c, the subscript 'c' denotes molar concentration at equilibrium.

Equilibrium constant is defined as the ratio of the product of concentration of products to the product of concentration of reactants each raised to the power equal to the coefficient in the balanced chemical equation. K_c is independent of the initial concentration of reactants but depends upon temperature.



Concentration of which species are taken in numerator in the K_c expression? Where are the co-efficients of balanced chemical equation shown in K_c expression?

Example 9.2: Writing Equilibrium Constant Expression.

Coal can be converted to a gaseous fuel as methane. Coal reacts with hot steam to form CO and H_2. These gases can react further to give methane.

$$C_{(s)} + H_2O_{(g)} \xrightarrow{1000^oC} CO_{(g)} + H_{2(g)}$$

$$CO_{(g)} + 3H_{2(g)} \longrightarrow CH_{4(g)} + H_2O_{(g)}$$

$$CO_{(g)} + 3H_{2(g)} \rightleftharpoons CH_{4\,(g)} + H_2O_{(g)}$$

Write equilibrium constant expression for this reaction.

Problem Solving Strategy

1. Write products in the numerator and reactants in the denominator in square brackets.
2. Raise each concentration to the power that corresponds to the co-efficient of each species in the balanced chemical equation.

Solution:

$$\boldsymbol{K_c = \frac{[CH_4][H_2O]}{[CO][H_2]^3}}$$

Self Assessment Exercise 9.2

1. Following reaction can occur during lightning storms.

$$3O_{2(g)d} \rightleftharpoons 2O_{3(g)}$$

Derive equilibrium constant expression for this reaction.

2. Write equilibrium constant expression for the following reactions.

a. $4HCl_{(g)} + O_2(g) \rightleftharpoons 2H_2O_{(g)} + 2Cl_{2(g)}$

b. $CH_3COOH_{(\ell)} + C_2H_5OH_{(\ell)} \rightleftharpoons CH_3COOC_2H_{5(\ell)} + H_2O_{(\ell)}$

c. $2HF_{(g)} \rightleftharpoons H_{2(g)} + F_{2(g)}$

d. $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$

Reading

9.2.1. Conditions for Equilibrium

Equilibrium is reached when pure reactants, pure products or a mixture of reactants and products is first placed in a closed container. In any such case, the forward and reverse action in the container will occur at the same rate. This leads to a situation where the concentration of reactants and products remain the same indefinitely, for an indefinite time so long the following conditions are observed:

1. Concentration of the reactant or product remains unchanged.
2. Temperature of the system remains constant.
3. Pressure or volume of the system remains constant.

9.2.2 Ways to Recognize Equilibrium

When constant concentration of products and reactants is observed, the reaction is at equilibrium. This can be done by both physical as well as chemical methods such as titration, spectroscopy etc. You will learn these methods in detail in Grade XI.

9.3 EQUILIBRIUM CONSTANT AND ITS UNITS

Equilibrium constant may or may not have units. In the equilibrium expression each figure within a square bracket represents the concentration in mol dm^{-3}. The units of K_c therefore depend on the form of equilibrium expression.

Example: 9.3. Determining units of equilibrium constants

Determine the units of equilibrium constants for the following reactions.

(i) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

(ii) $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$

(iii) $2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$

Problem Solving Strategy

1. Write the equilibrium constant expression.
2. Write units of concentration of each species i.e. mol dm^{-3} within the square bracket.
3. Simplify the expression.

Solution:-

(i) $K_c = \frac{[HI]^2}{[H_2][I_2]}$

$$K_c = \frac{[moldm^{-3}]^2}{[moldm^{-3}][moldm^{-3}]}$$

K_c = no units

K_c has no units when the total number of moles of reactants is equal to the total number of moles of products in a balanced chemical equation.

Do you know?
A catalyst is a substance which increases the rate of a chemical reaction. Catalysts reduce the time taken to reach equilibrium, but they have no effect on the position of equilibrium once this is reached.

(ii) $K_c = \frac{[NO_2]^2}{[N_2O_4]}$

$$K_c = \frac{[mol\ dm^{-3}]^2}{[mol\ dm^{-3}]}$$

$$K_c = mol\ dm^{-3}$$

(iii) $K_c = \frac{[NO_2]^2}{[NO]^2[O_2]}$

$$K_c = \frac{[mol\ dm^{-3}]^2}{[mol\ dm^{-3}]^2[mol\ dm^{-3}]}$$

$$K_c = dm^3 mol^{-1}$$

Science Titbits
The addition of water to the concentrated sulphuric acid produces a vigorous reaction, which often causes acid droplets to spew in all directions. For this reason this must be avoided. Add water to dilute acid.

Examples (ii) and (iii) show that K_c has units. A close observation reveals that reversible reaction in which, the total number of moles of reactants is different from the total number of moles of products in a balanced chemical equation, K_c has units.

Self Assessment Exercise 9.3

Determine the units of equilibrium constants for the following reactions.

1. $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$
2. $H_{2(g)} + CO_{2(g)} \rightleftharpoons H_2O_{(g)} + CO_{(g)}$
3. $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$
4. $CO_{(g)} + 2H_{2(g)} \rightleftharpoons CH_3OH_{(g)}$

Reading

9.4 IMPORTANCE OF EQUILIBRIUM CONSTANT

Equilibrium constant for a reaction can be used to predict many important features of a chemical reaction. It can be used to

(a) determine the equilibrium concentration of equilibrium mixture knowing the initial concentration of reactants.
(b) predict the direction of a chemical reaction.
(c) Predict the extent of a chemical reaction.
(d) predict the effect of change in conditions of the chemical reaction on the equilibrium state.

You will learn about these features in detail in grade XI. Industrial chemists take help from the effects of changes in conditions such as concentrations, temperature, pressure etc. They choose conditions needed for the desired products.

Nitrogen and Oxygen are main gases of the air. They are effectively converted in the large scale production of many important chemicals such as ammonia, sulphuric acid etc.

Ammonia is produced by the reaction of nitrogen with hydrogen at 400ºC, 200 atm pressure and in the presence of a catalyst.

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

This process is known as Haber process . This is a reversible process and produces only 33% NH_3 at equilibrium. The high pressure is used to favour the formation of ammonia. Then, cooling the equilibrium mixture gives 98% ammonia.

Sulphuric acid is produced on a large scale by the contact process. In this process sulphur is converted into sulphur dioxide.

$$S_{(s)} + O_{2\,(g)} \longrightarrow SO_{2\,(g)}$$

Sulphur dioxide is purified and further oxidized at 450°C and 200 atm pressures in the presence of Pt or V_2O_5 as catalyst.

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$$

This reaction is a reversible reaction. Here again by the application of principles of chemical equilibrium, maximum amount of SO_2 is converted into SO_3. Sulphur trioxide is then converted into 100% pure sulphuric acid.

Society, Technology and Science

Although reversible reactions do not complete, yet such reactions are not economical for the large scale production of chemicals. However, progress of the science has enabled us to deal with such reactions and obtain maximum amount of products from reversible reactions. An important principle called **Le Chatellier's principle** is very useful about chemical equilibrium systems, it says that **if you impose a change in concentration, temperature or pressure on a chemical system at equilibrium, the system responds in a way that opposes the change.** With the application of this principle, components of air i.e N_2 and O_2 can be used successfully in producing important chemicals, ammonia and sulphuric acid in 98% yield. Both these processes involve reversible reactions, so inadequate amount of products are formed under normal conditions.

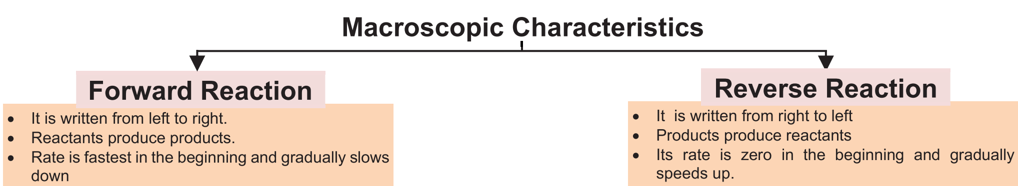
$$2SO_{2(g)} + O_{2(g)} \underset{450^oC,200atm}{\overset{V_2O_5}{\rightleftharpoons}} 2SO_{3(g)}$$

Sulphur dioxide Oxygen Sulphur trioxide

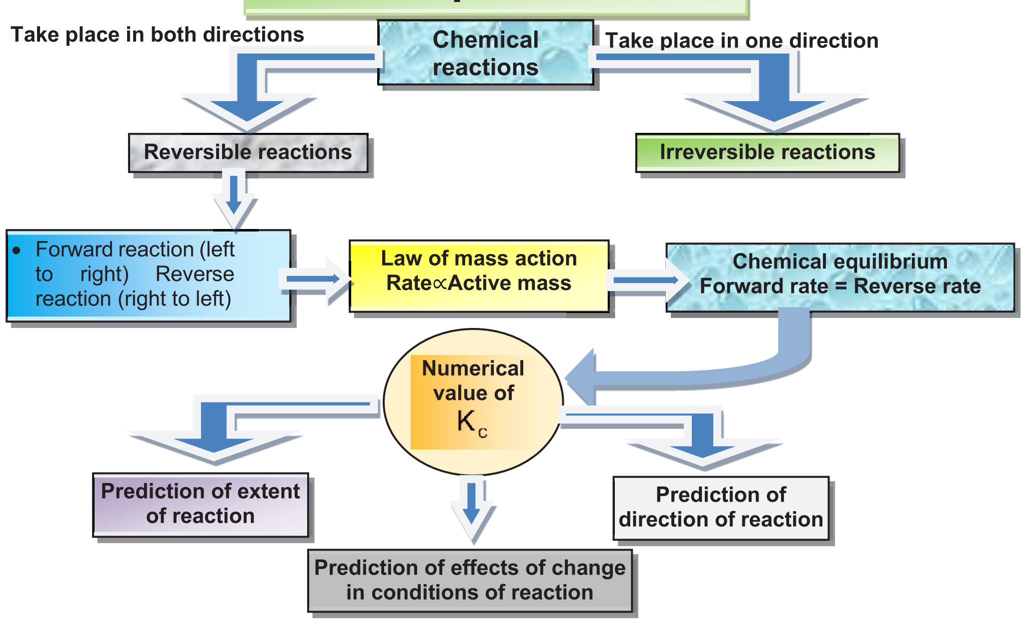
$$N_{2(g)} + 3H_{2(g)} \underset{400^o C,200atm}{\overset{Fe}{\rightleftharpoons}} 2NH_{3(g)}$$

Nitrogen Hydrogen Ammonia

As such these reactions are uneconomical. However, Le Chatelliers's principle has made it possible to get maximum amount of products. First, equilibrium is established in the presence of catalyst in minimum time and then by increasing pressure and decreasing temperature, equilibrium is shifted towards right. Such conditions tend to increase the yield of NH_3 and SO_3 to about 98%.



Concepts in brief



Key Points

- A reaction in which the products can react together to re-form the original reactants is called reversible reaction.
- A state of a chemical reaction in which forward and reverse reactions take place at the same rate is called chemical equilibrium.
- The law of mass action states that the rate at which a substance reacts is directly proportional to its active mass and the rate at which the reaction proceeds is directly proportional to the product of the active masses of the reactants.
- The term **"active mass"** represents the concentration of reactants and products in $moldm^{-3}$ for a dilute solution.
- Equilibrium constant is defined as the ratio of the product of concentration of products to the product of concentration of reactants each raised to the power equal to the coefficient in the balance chemical equation.

References for additional information

- Chemistry, Roger Norris, Lawrie Ryen and David Acaster.
- Principals of chemical equilibrium, Kenneth Denbigh.

Review Questions

1. Encircle the correct answer.

(i) Which is true about the equilibrium state?

(a) The forward reaction stops.
(b) The reverse reaction stops.
(c) Both forward and reverse reactions stop.
(d) Both forward and reverse reactions continue at the same rate.

(ii) When a mixture of H_2 and I_2 is sealed in a flask and temperature is kept at 25ºC, following equilibrium is established.

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

Which substance or substances will be present in the equilibrium mixture?

(a) H_2 and I_2
(b) HI only
(c) H_2 only
(d) H_2, I_2 and HI

(iii) What are the units for

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$$

(a) mol.dm^{-3}

(b) mol^{2}. dm^{-6}

(c) dm^{3}.mol^{-1}

(d) No units

(iv) Which of the following reaction will not have any units for K_c?

(a) $H_{2(g)} + CO_{2(g)} \rightleftharpoons H_2O_{(g)} + CO_{(g)}$

(b) $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$

(c) $2A_{(g)} + B_{(g)} \rightleftharpoons 3AC_{(g)}$

(d) All of these

(v) Concentration of reactants and products at equilibrium remains unchanged if

(a) concentration of any reactant or product is not changed.

(b) temperature of the reaction is not changed.

(c) pressure or volume of the system is not changed.

(d) all of the above are observed

(vi) Which of the following does not happen, when a system is at equilibrium state?

(a) forward and reverse reactions stop.

(b) forward and reverse rates become equal.

(c) concentration of reactants and products stop changing.

(d) reaction continues to occur in both the directions.

(vii) For which reaction, K_c has units of mol.dm^{-3}.

(a) $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$

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

(c) $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$

(d) $2ICl_{(g)} \rightleftharpoons I_{2(g)} + Cl_{2\,(g)}$

(viii) In an irreversible reaction equilibrium is

(a) established quickly

(b) established slowly

(c) never established

(d) established when reaction stops.

(ix) Active mass means

(a) total mass of reactants

(b) total mass of products

(c) total mass of reactants and products

(d) mass of substance in moles per dm^3 in a dilute solution

(x) For a reversible reaction

$$K_c = \frac{[C]^2}{[A][B]}$$

Which substance is product of the reaction?

(a) A

(b) B

(c) Both A and B

(d) C

2. Give short answer.

(i) Differentiate between forward and reverse reactions.

(ii) What is chemical equilibrium?

(iii) Write the law of Mass Action.

(iv) Write down the conditions for equilibrium.

(v) What is the importance of equilibrium constant for a chemical reaction?

3. Following reaction can occur during lightning storms

$$3O_{2(g)} \rightleftharpoons 2O_{3(g)}$$

For this reaction write

(i) Equilibrium constant expression.

(ii) Determine the units of equilibrium constant.

(iii) Forward and reverse reactions.

4. Coal reacts with hot steam to form CO and H_2. These substances react further in the presence of a catalyst to give methane and water vapour.

$$CO_{(g)} + 3H_{2(g)} \rightleftharpoons CH_{4(g)} + H_2O_{(g)}$$

(i) Write forward and reverse reactions for it.

(ii) Derive K_C expression for the reaction.

(iii) Determine units for K_C

5. Write equilibrium constant expression for each of the following reactions.

(i) $H_2O_{(g)} \rightleftharpoons H_{2(g)} + \frac{1}{2}O_{2(g)}$

(ii) $CO_{(g)} + 2H_{2(g)} \rightleftharpoons CH_3OH_{(g)}$

(iii) $COCl_{2(g)} \rightleftharpoons CO_{(g)} + Cl_{2(g)}$

(iv) $4HCl_{(g)} + O_{2(g)} \rightleftharpoons 2Cl_{2(g)} + 2H_2O_{(g)}$

6. Determine the units of equilibrium constants for the following reactions.

(i) $COCl_{2(g)} \rightleftharpoons 2CO_{(g)} + Cl_{2(g)}$

(ii) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

(iii) $2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)}$

(iv) $N_{2(g)} + 2O_{2(g)} \rightleftharpoons 2NO_{2(g)}$

7. State the ways that equilibrium can be recognized.

8. Describe the macroscopic characteristics of an equilibrium reaction.

Think-Tank

1. Bromine chloride (BrCl) decomposes to form chlorine and bromine. For this reaction write.

(i) Chemical equation

(ii) K_c expression

(iii) Units of K_c

2. K_C expression for a reaction is given below

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

Choose reactant and product to derive the units of K_C for this reaction.

3. For which of the following reactions are both reactants and products likely to be found when the reaction appears to be complete. Justify.

(i) $C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$

(ii) $2HF_{(g)} \rightleftharpoons H_{2(g)} + F_{2(g)}$

Cobalt chloride forms pink crystals $(CoCl_3.6H_2O)$. When they are heated water is evolved and they turn blue $(CoCl_3)$. Can you use Cobalt chloride as a test for water, argue.

$$CoCl_3.6H_2O \rightleftharpoons CoCl_3 + 6H_2O$$