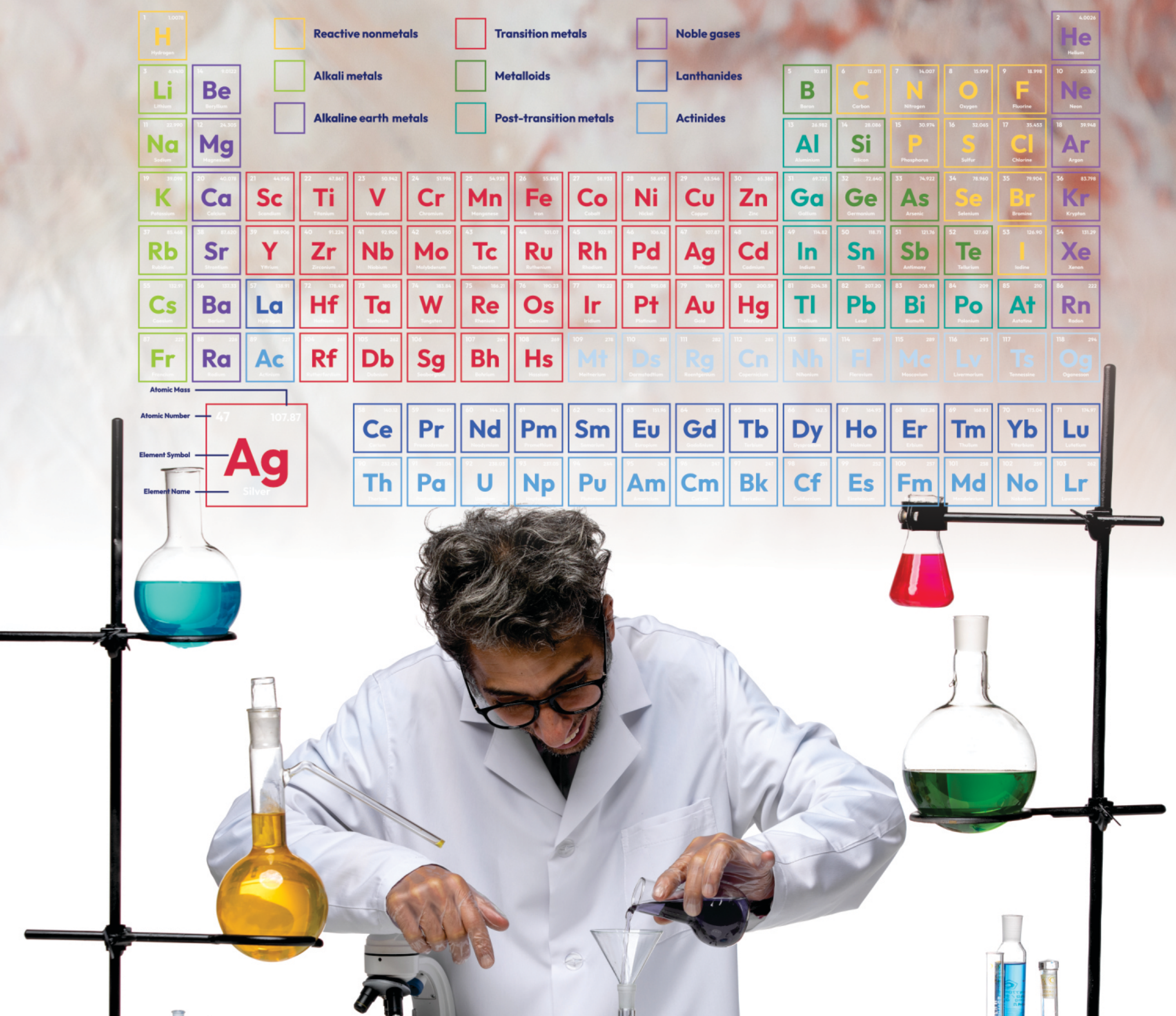
1st Choice of Position Holders

UNIQUE NOTES

CHEMISTRY 10

According to New Board Pattern



UNIQUE PUBLICATIONS
A Project of
UNIQUE GROUP OF INSTITUTIONS
106-A, New Muslim Town, Wahdat Road, Lahore. Tel: 92-42-35865461

CONTENTS

UNIT 09 Chemical Equilibrium

Long Answers Questions

Q.1. (Ex. Q. 1) **Describe a reversible reaction with the help of an example and graph.**

Ans. Reversible Reactions: (Board 2014,23) 10209001

Definition:

The reactions in which the products can recombine to form reactants, are called reversible reactions.

Characteristics:

1. These reactions never go to completion.
2. They are represented by a double arrow ($\rightleftharpoons$) between reactants and products.
3. These reactions proceed in both ways, i.e., they consist of two reactions; forward and reverse.

Example: Reaction between Hydrogen and Iodine:

Let us take the example of reaction between hydrogen and iodine. Because one of the reactants, iodine is purple, while the product hydrogen iodide is colourless and the proceedings of the reaction are easily observable. On heating hydrogen and iodine vapours in a closed flask, hydrogen iodide is formed. As a result purple colour of iodine fades as it reacts to form colourless hydrogen iodide, as shown in the figure.

$$H_{2(g)} + \underset{\text{Purple}}{I_{2(g)}} \xrightarrow{\Delta} \underset{\text{Colourless}}{2HI_{(g)}}$$

This reaction is called as **forward reaction**.

On the other hand, when only hydrogen iodide is heated in a closed flask, purple colour appears because of formation of iodine vapours. Such as

$$\underset{\text{Colourless}}{2HI_{(g)}} \xrightarrow{\Delta} H_{2(g)} + \underset{\text{Purple}}{I_{2(g)}}$$

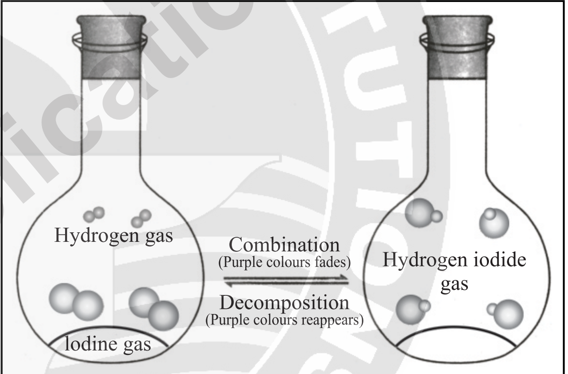


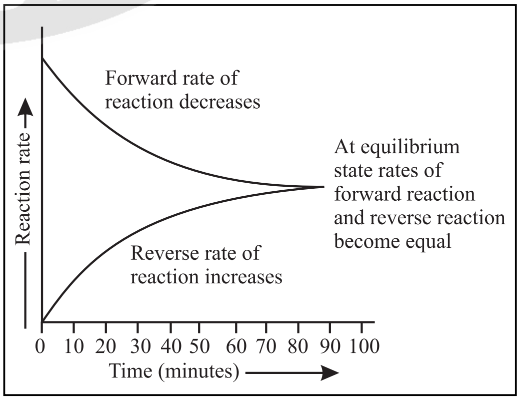
Fig. showing establishment of reversible reaction

In this case, hydrogen iodide acts as reactant and produces hydrogen and iodine vapours. This reaction is reverse of the above. Therefore, it is called as **reverse reaction**.

When both of these reactions are written together as a reversible reaction, they are represented as:

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

In a reversible reaction a dynamic equilibrium is established before the completion of reaction. It is represented graphically in the following fig.



At initial stage:

At initial stage, the rate of forward reaction is very fast and reverse reaction takes place at a negligible rate.

With the passage of time:

Gradually forward reaction slows down and reverse reaction speeds up. Eventually, both reactions attain the same rate, it is called a dynamic equilibrium state.

Q.2 Define chemical equilibrium state and explain its types with examples. **10209002**

Ans. Chemical Equilibrium State:

When the rate of the forward reaction takes place at the rate of reverse reaction, the composition of the reaction mixture remains constant, it is called a **chemical equilibrium state**.

Types of Equilibrium:

There are two types of equilibrium:

i. Static Equilibrium:

When reaction ceases to proceed, it is called static equilibrium. This happens mostly in physical phenomenon.

For example, a building remains standing rather than falling down because all the forces acting on it are balanced. This is an example of static equilibrium.

ii. Dynamic Equilibrium State:

When reaction does not stop, only the rates of forward and reverse reactions become equal to each other but take place in opposite directions. This is called **dynamic equilibrium state**. Dynamic means reaction is still continuing. At dynamic equilibrium state:

Rate of forward reaction = Rate of reverse reaction

Example:

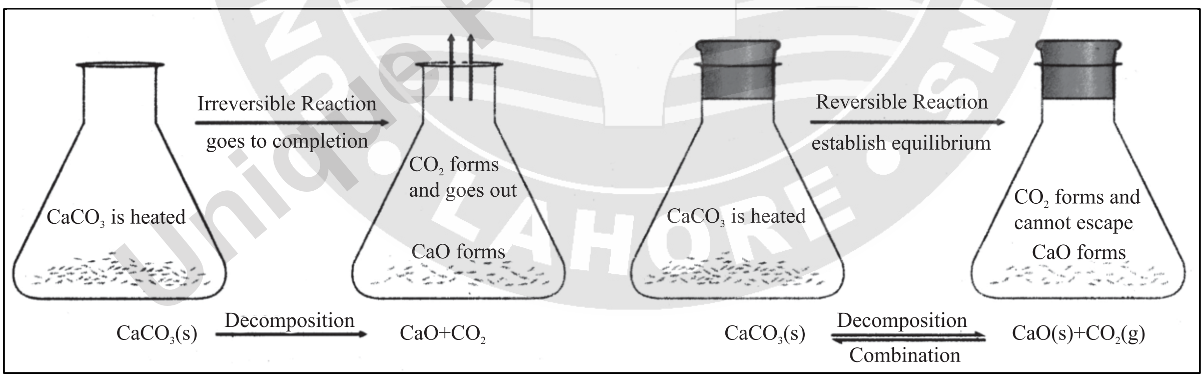
When calcium oxide and carbon dioxide react, they produce calcium carbonate.

$$CaO_{(s)} + CO_{2(g)} \longrightarrow CaCO_{3(S)} \text{ (combination)}$$

On the other hand, when $CaCO_3$ is heated in an open flask, it decomposes to form calcium oxide and carbon dioxide. CO_2 escapes out and reaction goes to completion.

$$CaCO_{3(s)} \xrightarrow{\text{Heat}} CaO_{(s)} + CO_{2(g)} \quad \text{(decomposition)}$$

In these two reactions, decomposition is reverse to combination or vice versa. When calcium carbonate is heated in a closed flask, so that CO_2 can't escape out as shown in figure. For sometime only, decomposition goes on (forward reaction) but after a while CO_2 starts combining with CaO to form $CaCO_3$ (reverse reaction).



In the beginning, forward reaction is fast and reverse reaction is slow. But eventually, the reverse reaction speeds up and both reactions go on at the same rate. At this stage, decomposition and combination take place at the same rate but in opposite directions, as a result amounts of $CaCO_3$, CaO and CO_2 do not change. It is written as:

$$CaCO_{3(s)} \overset{\Delta}{\rightleftharpoons} CaO_{(s)} + CO_{2(g)}$$

This is the chemical equilibrium state of this reaction.

Q.3 Write macroscopic characteristics of forward and reverse reactions. OR
Differentiate between forward and reverse reaction. (Board 2013,14,16,17) 10209003

Ans. Macroscopic characteristics of forward and reverse reactions: (Board 2021)

Forward Reaction	Reverse Reaction
i) It is a reaction in which reactants react to form products. (Board 2019)	It is reaction in which products react to produce reactants.
ii) It takes place from left to right.	It takes place from right to left.
iii) At initial stage the rate of forward reaction is very fast.	In the beginning the rate of reverse reaction is negligible.
iv) It slows down gradually.	It speeds up gradually.

Q.4 (Ex. Q. 2) **Write down macroscopic characteristics of dynamic equilibrium.** 10209004

Ans. Definition: (Board 2013, 14,15,23)

When reaction does not stop, only the rates of forward and reverse reactions become equal to each other but take place in opposite directions. This is called **dynamic equilibrium**.

Macroscopic characteristics of dynamic equilibrium:

A few important characteristic features of dynamic equilibrium are given below:

i. An equilibrium is achievable only in a closed system (in which substances can neither leave nor enter).
ii. At equilibrium state a reaction does not stop. Forward and reverse reactions keep on taking place at the same rate but in opposite direction.
iii. At equilibrium state, the amount (concentration) of reactants and products do not change. Even physical properties like colour, density, etc. remain the same.
iv. An equilibrium state is attainable from either way, i.e., starting from reactants or from products.
v. An equilibrium state can be disturbed and again achieved under the given conditions of concentration, pressure and temperature.

Q.5 (Ex. Q. 3) **State the Law of Mass Action and derive the expression for equilibrium constant for a general reaction.** (Board 2015,16,17,19)10209005

Ans. Introduction:

Law of Mass action was given by C. M Guldberg and P.Waage in 1869. They studied a lot of reversible reactions and put forward this law.

Statement:

"The rate at which a substance reacts is directly proportional to its active mass and the rate of a reaction is directly proportional to the product of the active masses of the reacting substances".

Active Mass:

Generally an active mass is considered as the molar concentration in units of mol dm^{-3}, expressed as square brackets [ ].

Consider for example, a reversible reaction of the type:

$$A + B \underset{k_r}{\overset{k_f}{\rightleftharpoons}} C + D$$

Suppose [A], [B], [C] and [D] are the molar concentrations (mol. dm^{-3}) of A, B, C and D respectively.

According to the Law of Mass Action:

The rate of the forward reaction $\propto$ [A] [B]

$$= k_f [A][B]$$

Similarly,

The rate of the reverse reaction $\propto$ [C] [D]

$$= k_r [C][D]$$

Where k_f and k_r are the proportionality constants called specific rate constants of the forward and the reverse reactions respectively.

At equilibrium state:

The rate of forward reaction = The rate of reverse reaction

$$k_f\,[A]\,[B] = k_r\,[C]\,[D]$$

$$\frac{k_f}{k_r} = \frac{[C][D]}{[A][B]}$$

$$\text{Where}\quad K_c = \frac{k_f}{k_r}$$

K_c is called equilibrium constant. It is represented as:

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

Law of Mass Action describes the relationship between active masses of the reactants and the rate of a reaction.

Derivation of the Expression for equilibrium constant for general reaction:

Consider a general reaction:

$$aA + bB \rightleftharpoons cC + dD$$

This reaction consists of two reactions i.e., forward and reverse reactions.

According to the law of mass action the rate of a chemical reaction is directly proportional to the product of the molar concentrations of its reactants raised to power equal to their number of moles in the balanced chemical equation of the reaction.

Forward Reaction:

In the forward reaction A and B are the reactants whereas 'a' and 'b' are their number of moles.

The rate of forward reaction according to law of Mass Action is:

$$R_f \propto [A]^a\,[B]^b$$
$$R_f = k_f\,[A]^a\,[B]^b$$

Where "k_f" is the rate constant for the forward reaction.

Reverse Reaction:

Rate of reverse reaction is written as:

$$R_r \propto [C]^c\,[D]^d$$
$$R_r = k_r\,[C]^c\,[D]^d$$

Where R_r is directly proportional to the product of $[C]^c$ $[D]^d$, where 'c' and 'd' are the number of moles as given in the balanced chemical equation and k_r is the rate constant for the reverse reaction. We know that at equilibrium state the rates of both the reactions are equal to each other.

The rate of forward reaction = The rate of reverse reaction

$$R_f = R_r$$

By putting the values of R_f and R_r

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

By taking the constants on one side and the variables on other side of the equation, the above equation turns into;

$$\frac{k_f}{k_r} = \frac{[C]^c [D]^d}{[A]^a [B]^b} \quad \text{or} \quad K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

Where, $\left(K_c = \frac{k_f}{k_r}\right)$ is called equilibrium constant. This expression is for chemical equilibrium constant. All the reversible reactions can be expressed in this form.

Q.6 Define equilibrium constant with its units. Or 10209006
Determine the concentration units for following reactions. (Board 2018,22)

Ans. Definition:

Equilibrium constant is a ratio of the product of concentration of products raised to the power of coefficient to the product of concentration of reactants raised to the power of coefficient as expressed in the balanced chemical equation.

Formula:

$$K_c = \frac{\text{Product of concentration of products raised to the power of coefficients}}{\text{Product of concentration of reactants raised to the power of coefficients}}$$

It is conventional to write the products as numerator and the reactants as denominator. By knowing, the balanced chemical equation for a reversible reaction, we can write the equilibrium expression. Thus we can calculate the numerical value of K_c by putting actual equilibrium concentrations of the reactants and products into equilibrium expression.

Factors affecting the value of K_c:

The value of K_c depends only on temperature, it does not depend on the initial concentrations of the reactants and products.

Units of K_c:

i) K_c has no units in reactions with equal number of moles on both sides of the equation. This is because concentration units cancel out in the expression for K_c, e.g. For the reaction:

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$ (Board 2022)

$$K_c = \frac{[HI]^2}{[H_2][I_2]} \qquad \text{Units} = \frac{(\text{mol dm}^{-3})^2}{(\text{mol dm}^{-3})\,(\text{mol dm}^{-3})} = \text{no units}$$

ii) For reactions in which the number of moles of reactants and products are not equal in the balanced chemical equation, K_c of course, have units, e.g. For the reaction:

(Board 2022)

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

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(\text{mol dm}^{-3})^2}{(\text{mol dm}^{-3})\,(\text{mol dm}^{-3})^3} = \frac{1}{(\text{mol dm}^{-3})^2} = \text{mol}^{-2}\,\text{dm}^6$$

Q.7 (Ex. Q.4) **What is the importance of equilibrium constant in predicting the direction of reaction?** (Board 2014,15,17,20) 10209007 (a)

Ans. Importance of Equilibrium Constant in predicting direction of a reaction: (Board 2018,19,24)

Direction of a reaction at a particular moment can be predicted by inserting the concentration of the reactants and products at that particular moment in the equilibrium expression. Consider the gaseous reaction of hydrogen with iodine.

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)} \qquad K_c = 57.0 \text{ at } 700\,\text{K}$$

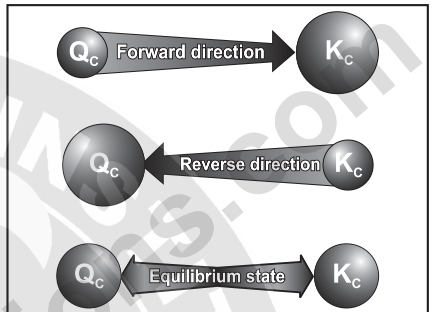
We withdraw the samples from the reaction mixture and determine the concentrations of $H_{2(g)}$, $I_{2(g)}$ and $HI_{(g)}$. Suppose concentrations of the components of the mixture are:

$$[H_2]_t = 0.10\,\text{mol dm}^{-3},\ [I_2]_t = 0.20\,\text{mol dm}^{-3} \text{ and } [HI]_t = 0.40\,\text{mol dm}^{-3}$$

The subscript 't' with the concentration symbols means that the concentrations are measured at some time t, not necessarily at equilibrium. When we put these concentrations into the equilibrium constant expression, we obtain a value called the **reaction quotient 'Q_c'**. The reaction quotient for this reaction is calculated as:

$$Q_c = \frac{[HI]_t^2}{[H_2]_t[I_2]_t} = \frac{(0.40)^2}{(0.10)(0.20)} = 8.0$$

As the numerical value of 'Q_c' (8.0) is less than K_c(57.0), the reaction is not at equilibrium. It requires more concentration of product. Therefore, reaction will move in the forward direction.
The reaction quotient 'Q_c' is useful because it predicts the direction of the reaction by comparing the value of 'Q_c' with K_c.
Thus, we can make the following generalizations about the direction of the reaction.



- If $Q_c < K_c$; the reaction goes from left to right, i.e. in forward direction to attain equilibrium.
- If $Q_c > K_c$; the reaction goes from right to left, i.e. in reverse direction to attain equilibrium.
- If $Q_c = K_c$; forward and reverse reactions take place at equal rates i.e. equilibrium has been attained.

Q.8 (Ex.Q.4)**What is the importance of Equilibrium Constant in predicting the Extent of a reaction?** 10209007(b) (Board 2018,22,24)

Ans. "Extent of reaction measures how far a reaction proceeds before establishing equilibrium state".

Numerical value of the equilibrium constant predicts the extent of a reaction. It indicates to which extent reactants are converted into products.

There are three possibilities of predicting extent of reactions.

(a) Large numerical value of K_c:

"If value of K_c is very large, this indicates that the reaction has almost gone to completion".

It also indicates that at equilibrium position the reaction mixture consists of almost all products and reactants are negligible. The reaction has almost gone to completion. For example, oxidation of carbon monoxide goes to completion at 1000 K.

$$2CO_{(g)} + O_{2(g)} \rightleftharpoons 2CO_{2(g)} \qquad K_c = 2.2\times10^{22}$$

(b) Small numerical value of K_c:

"If the value of K_c is very small, it reflects that such type of reactions never go to completion".

It may indicate that the equilibrium has established with a very small conversion of reactants into products. At equilibrium position, almost all reactants are present but amount of products is negligible.

For example:

$$2NH_{3(g)} \rightleftharpoons N_{2(g)} + 3H_{2(g)} \qquad K_c = 3.0\times10^{-9}$$

(c) Numerical value of K_c is neither small nor large:

Such reactions have comparable amounts of reactants and products at equilibrium position. For example:

$$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)} \qquad K_c = 0.211$$

It indicates that the rates of decomposition of N_2O_4 and combination of NO_2 to form N_2O_4 are almost comparable to each other.

Book Examples

Example 9.1:

When hydrogen reacts with iodine at 25°C to form hydrogen iodide by a reversible reaction as follows: 10209008

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

The equilibrium concentrations are:
[H_2] = 0.05 mol dm^{-3} ;
[I_2] = 0.06 mol dm^{-3} and
[HI] = 0.49 mol dm^{-3}
Calculate the equilibrium constant for this reaction.

Solution:

Given equilibrium concentrations are;
[H_2] = 0.05 mol dm^{-3} ;
[I_2] = 0.06 mol dm^{-3} and
[HI] = 0.49 mol dm^{-3}

Write the equilibrium constant expression as:

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

Now put the equilibrium concentration values in the equilibrium expression:

$$K_c = \frac{[0.49]^2}{[0.05][0.06]} = \frac{0.2401}{0.0030} = 80$$

Example 9.2:

For the formation of ammonia by Haber's process hydrogen and nitrogen react reversibly at 500°C as follows: 10209009

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

The equilibrium concentrations of these gases are: nitrogen 0.602 mol dm^{-3}; hydrogen 0.420 mol dm^{-3} and ammonia 0.113 mol dm^{-3}. What is value of K_c?

Solution:

The equilibrium concentrations are:
[N_2] = 0.602 mol dm^{-3},
[H_2] = 0.420 mol dm^{-3} and
[NH_3] = 0.113 mol dm^{-3}

The equilibrium constant expression for this reaction is:

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

Now put the equilibrium concentration values into the equilibrium expression:

$$K_c = \frac{[0.113]^2}{[0.602][0.420]^3} = 0.286\,mol^{-2}\,dm^6$$

Example 9.3:

For a reaction between PCl_3 and Cl_2 to form PCl_5, the equilibrium constant is 0.13 mol^{-1} dm^3 at a particular temperature. When the equilibrium concentrations of PCl_3 and Cl_2 are 10.0 and 9.0 mol dm^{-3} respectively, what is the equilibrium concentration of PCl_5? 10209010

Solution:

[PCl_3] = 10 mol dm^{-3}
[Cl_2] = 9.0 mol dm^{-3}
K_c = 0.13 mol^{-1} dm^3 [PCl_5]= ?

Now write the balanced chemical equation and equilibrium constant expression:

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

$$K_c = \frac{[PCl_5]}{[PCl_3][Cl_2]}$$

Now put the known values in above equation and rearrange:

$$0.13 = \frac{[PCl_5]}{(10.0)(9.0)}$$

$$[PCl_5] = 0.13 \times 10.0 \times 9.0 = 11.7\ mol.\ dm^{-3}$$

Exercise Numericals

1. For the decomposition of dinitrogen oxide (N_2O) into nitrogen and oxygen reversible reaction takes place as follows:

10209011

$$2N_2O_{(g)} \rightleftharpoons 2N_{2(g)} + O_{2(g)}$$

The concentration of N_2O , N_2 and O_2 are 1.1 $mol.dm^{-3}$, 3.90 $mol\ dm^{-3}$ and 1.95 $mol\ dm^{-3}$, respectively, at equilibrium. Find out K_c for this reaction.

Ans. Data:

The concentration of

$[N_2O] = 1.1\ mol\,dm^{-3}$
$[N_2] = 3.90\ mol\,dm^{-3}$
$[O_2] = 1.95\ mol\,dm^{-3}$
$K_c = ?$

Solution: The equilibrium constant expression for this reaction is:

$$K_c = \frac{[N_2]^2[O_2]}{[N_2O]^2}$$

$$K_c = \frac{[3.90]^2[1.95]}{[1.1]^2}$$

$$K_c = \frac{[15.21]\ [1.95]}{[1.21]}$$

$K_c = 24.51\ mol\,dm^{-3}$ Ans.

2. Hydrogen iodide decomposes to form hydrogen and iodine. If the equilibrium concentration of HI is 0.078 $mol\ dm^{-3}$, H_2 and I_2 is same 0.011 $mol\ dm^{-3}$. Calculate the equilibrium constant value for this reversible reaction. **10209012**

Ans. Data: Reversible reaction takes place as follows.

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

The equilibrium concentration of:

$[HI] = 0.078\ mol\,dm^{-3}$
$[H_2] = 0.011\ mol\,dm^{-3}$
$[I_2] = 0.011\ mol\,dm^{-3}$
$K_c = ?$

Solution: The equilibrium constant expression for this reaction is

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

$$K_c = \frac{[0.011]\ [0.011]}{[0.078]^2}$$

$K_c = 0.019$ Ans.

3. For the fixation of nitrogen following reaction takes place : **10209013**

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

When the reaction takes place at 1500 K, the K_c for this is 1.1×10^{-5}. If equilibrium concentration of nitrogen and oxygen are 1.7×10^{-3} $mol\ dm^{-3}$ and 6.4×10^{-3} $mol\ dm^{-3}$, respectively, how much NO is formed?

Ans. Data:

Temperature = 1500 K
$K_c = 1.1\times10^{-5}$
$[N_2] = 1.7\times10^{-3}\ mol\,dm^{-3}$
$[O_2] = 6.4\times10^{-3}\ mol\,dm^{-3}$
$[NO] = ?$

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

Solution: The equilibrium constant expression for this reaction is:

$$K_c = \frac{[NO]^2}{[N_2][O_2]}$$

$$1.1\times10^{-5} = \frac{[NO]^2}{[1.7\times10^{-3}][6.4\times10^{-3}]}$$

$$[NO]^2 = 1.1\times10^{-5}\times1.7\times10^{-3}\times6.4\times10^{-3}$$

$$[NO]^2 = 11.96\times10^{-11}$$

$$[NO]^2 = 1.196\times10^{-10}$$

Taking square root on both sides

$$\sqrt{[NO]^2} = \sqrt{1.196\times10^{-10}}$$

$$[NO] = 1.09\times10^{-5}\,mol\,dm^{-3}$$

4. When nitrogen reacts with hydrogen to form ammonia, the equilibrium mixture contains 0.31 $mol\ dm^{-3}$ and 0.50 $mol\ dm^{-3}$ of nitrogen and hydrogen respectively. If the 'K_c' is 0.50 $mol^{-2}dm^{6}$, what is the equilibrium concentration of ammonia?

10209014

Ans. Data: Reversible reaction takes place as follows:

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

$[N_2] = 0.31 \text{ mol dm}^{-3}$

$[H_2] = 0.50 \text{ mol dm}^{-3}$

$K_c = 0.50 \text{ mol}^{-2} \text{ dm}^6$

$[NH_3] = ?$

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

The equilibrium constant expression for this reaction is:

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

By putting the values, we get:

$$0.50 = \frac{[NH_3]^2}{[0.31][0.50]^3}$$

$$[NH_3]^2 = 0.50 \times [0.31][0.50]^3$$

$$[NH_3]^2 = 0.01875$$

By taking square root on both sides :

$$\sqrt{[NH_3]^2} = \sqrt{0.01875}$$

$$[NH_3] = 0.14 \text{ mol dm}^{-3}$$

Short Answers Questions

Exercise Short Answer Questions

Q.1 What are irreversible reactions? Give a few characteristics of them.

(Board 2016,18,19,24) 10209015

Ans. The reactions in which products do not recombine to form reactants are called irreversible reactions.

Characteristics:

i. These reactions proceed in one direction only.

ii. These are represented by a single arrow ($\rightarrow$) between reactants and products.

iii. Reactants are completely converted into products at the end of reaction.

Q.2 Define chemical equilibrium state.

(Board 2013, 17, 18, 19, 21,24) 10209016

Ans. When the rate of the forward reaction takes place at the rate of reverse reaction, the composition of the reaction mixture remains constant; it is called a chemical equilibrium state.

Q.3 Give the characteristics of reversible reactions. /Define reversible reaction & its characteristics. **(Board 2017, 20, 21,24) 10209017**

Ans. The reactions in which products react to produce reactants are called reversible reactions.

i. These reactions never go to completion.

ii. They are represented by a double arrow ($\rightleftharpoons$) between reactants and products.

iii. These reactions proceed in both ways; forward and reverse until they attain dynamic equilibrium state.

Q.4 How is dynamic equilibrium established? / What is meant by dynamic equilibrium state? **(Board 2013,19,22,23) 10209018**

Ans. "Dynamic equilibrium is established when reaction does not stop, only the rates of forward and reverse reactions become equal to each other but take place in opposite direction". In a reversible reaction, dynamic equilibrium is established before the completion of reaction.

Q.5 Why at equilibrium state reaction does not stop? **10209019**

Ans. At equilibrium state the reaction does not stop because the rate of forward reaction is exactly equal to that of the reverse reaction but in opposite direction.

Q.6 Why is equilibrium state attainable from either way? **10209020**

Ans. An equilibrium state is attainable from either way because it may start from reactants to give products or products can react to give reactants. Reactants $\rightleftharpoons$ Products

Q.7 What is the relationship between active mass and rate of reaction?

(Board 2016) 10209021

Ans. According to Guldberg and Waage's law of Mass Action, the rate of reaction is directly proportional to the product of the active masses of the reacting substances. i.e.

Rate of reaction $\propto$ Active masses of reacting substances.

Q.8 Derive equilibrium constant expression for the synthesis of ammonia from nitrogen and hydrogen. **(Board 2014, 20)** **10209022**

Ans. For the reaction of nitrogen with hydrogen to form ammonia, the balanced chemical equation is: $N_2 + 3H_2 \rightleftharpoons 2NH_3$

For the reaction

The rate of forward reaction

$(R_f) = k_f[N_2][H_2]^3$

The rate of reverse reaction

$(R_r) = k_r[NH_3]^2$

At equilibrium $R_f = R_r$

$$k_f[N_2][H_2]^3 = k_r[NH_3]^2$$

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

The expression for the equilibrium constant for this reaction is:

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

Q.9 Write the equilibrium constant expression for the following reactions:

(Board 2014) 10209023

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

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

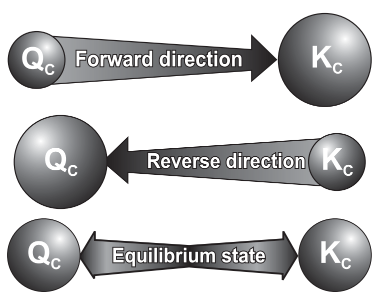
Ans. The equilibrium constant expression for these reactions is:

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

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

Q.10 How can direction of a reaction be predicted? /Which two generalizations can be made about direction of a chemical reaction **(Board 2013,17,23)** **10209024**

Ans. Direction of a reaction at a particular moment can be predicted by comparing the value of Q_c with K_c.



- If **$Q_c < K_c$;** the reaction goes from left to right, i.e. in forward direction to attain equilibrium.
- If **$Q_c > K_c$;** the reaction goes from right to left, i.e. in reverse direction to attain equilibrium.
- If **$Q_c = K_c$;** forward and reverse reactions take place at equal rates i.e. equilibrium has been attained.

Q.11 How can you know that a reaction has achieved an equilibrium state? **10209025** **(Board 2016)**

Ans. If **$Q_c = K_c$,** it indicates that forward and reverse reactions are taking place at equal rates .i.e. equilibrium has been attained.

Q.12 What are the characteristics of a reaction that establishes equilibrium state at once? **10209026**

Ans. The reactions which attain the equilibrium are called reversible reactions.

(i) In these reactions dynamic state of equilibrium is established with very small conversion of reactants to products.

(ii) These reactions never go to completion.

(iii) They proceed in both directions.

(iv) For these reactions, value of 'K_c' is small.

Q.13 If reaction quotient Q_c of a reaction is more than K_c. What will be the direction of the reaction? **(Board 2014,22)** **10209027**

Ans. If **Q_c** of a reaction is more than 'K_c' the reaction goes from right to left, i.e. in reverse direction.

Q.14 An industry was established based upon a reversible reaction. It failed to achieve products on commercial level. Can you point out the basic reasons of its failure being a chemist? 10209028

Ans. Industry established on the basis of a reversible reaction fails because reaction is reversible in which dynamic equilibrium is established between reactants and products. Products recombine to form the reactants so desired commercial product and required amount is not obtained.

Additional Short Answer Questions

Q.15 Which natural process is responsible for existence of life on earth? 10209029

Ans. We inhale oxygen and exhale carbon dioxide while plants consume carbon dioxide and release oxygen. So an equilibrium is established between these gases that is responsible for existence of life on earth.

Example:

Photosynthesis and Respiration

Q.16 Differentiate between reactants and products.

Ans. (Board 2024) 10209030

Reactants	Products
In a chemical reaction, the substances that combine or decompose to form products are called reactants.	In a chemical reaction, the new substances which are formed by the combination or decomposition of reactants are called products.

$$\underset{\text{Reactants}}{2H_2 + O_2} \xrightarrow{Pt} \underset{\text{Products}}{2H_2O}$$

Q.17 Differentiate between irreversible reactions and reversible reactions. (Board 2015,18,19)

Ans. 10209031

Irreversible reactions	Reversible reactions
i. The reactions in which products do not recombine to form reactants. **ii.** They are supposed to complete. **iii.** These are represented by a single arrow ($\rightarrow$) between reactants and products.	**i.** The reactions in which products react to produce reactants are called reversible reactions. **ii.** These reactions never go to completion. **iii.** They are represented by a double arrow ($\rightleftharpoons$) between reactants and products.

Q.18 What are the uses of atmospheric gases in the manufacture of chemicals? (Board 2013,18) 10209032

Ans. Nitrogen is used to prepare ammonia, which is further used to manufacture nitrogenous fertilizers.

Oxygen is used to prepare sulphur dioxide which is further used to manufacture king of chemicals; sulphuric acid.

Q.19 Write the importance of equilibrium constant. (Board 2014) 10209033

Ans.

(i) It is used to predict the direction of reaction i.e., forward or reverse.

(ii) It is used to predict the extent of reaction, means how much reactants are converted into products.

Q.20 Which physical factor effects the value of K_c? 10209034

Ans. Temperature highly effects the numeric value of 'K_c'. Change in temperature will effect both equilibrium position and equilibrium constant.

Q.21 Write the names of two chemicals in which nitrogen is used. 10209035

Ans. (i) Urea (H_2NCONH_2)

(ii) Nitric Acid (HNO_3)

Q.22 Write the names of two major gases of atmosphere. **(Board 2013)** 10209036

Ans. Nitrogen and Oxygen are two major gases of our atmosphere. The total proportion of N_2 and O_2 is 99%.

Nitrogen = 78% Oxygen = 21%

Q.23 Write macroscopic characteristics of a reverse reaction. **(Board 2015,21)** 10209037

Ans.

i. It is a reaction in which products react to produce reactants.

ii. It takes place from right to left.

iii. In the beginning the rate of reverse reaction is negligible.

iv. It speeds up gradually.

Q.24 How does large numerical value of K_c help us to predict the extent of a chemical reaction? **(Board 2013,15,20)** 10209038

Ans. "If value of K_c is very large, this indicates that the reaction has almost gone to completion".

It also indicates that at equilibrium position the reaction mixture consists of almost all products and reactants are negligible. The reaction has almost gone to completion. For example, oxidation of carbon monoxide goes to completion at 1000 K.

$$2CO_{(g)} + O_{2(g)} \rightleftharpoons 2CO_{2(g)}$$

$$K_c = 2.2\times10^{22}$$

Q.25 How does small numerical value of K_c help us to predict the extent of a chemical reaction? 10209039

Ans. "If the value of K_c is very small, it reflects that such type of reactions never go to completion".

It may indicate that the equilibrium has established with a very small conversion of reactants into products. At equilibrium position, almost all reactants are present but amount of products is negligible.

For example:

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

$$K_c = 3.0\times10^{-9}$$

Q.26 Write equation of forward reaction between hydrogen and iodine. 10209040

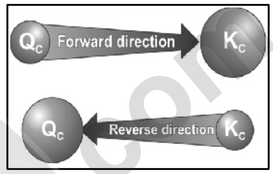
(Board 2014)

Ans. Equation of forward reaction between hydrogen and iodine is given below:

$$H_{2(g)} + \underset{\text{Purple}}{I_{2(g)}} \xrightarrow{\Delta} \underset{\text{Colourless}}{2HI_{(g)}}$$

Q.27 Which two generalizations can be made about direction of a chemical reaction? **(Board 2014)** 10209041

Ans. We can make the following generalizations about the direction of the reaction:



- If $Q_c < K_c$; the reaction goes from left to right, i.e. in forward direction to attain equilibrium.
- If $Q_c > K_c$; the reaction goes from right to left, i.e. in reverse direction to attain equilibrium.

Q.28 What is active mass? Also write its units. **(Board 2015,18)** 10209042

Ans. Active Mass:

The term active mass represents the concentration of reactants and products in a reversible reaction. It is represented by [ ].

Units:

Its units are mol dm^{-3}.

Q.29 Define reversible reactions. Write their two characteristics. 10209043

(Board 2013, 2015,18)

Ans. "The reactions in which products react to produce reactants are called reversible reactions."

- These reactions never go to completion.
- They are represented by a double arrow ($\rightleftharpoons$) between reactants and products.

Example:

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

Q.30 Define irreversible reactions.

(Board 2017) 10209044

Ans. "The reactions in which products do not recombine to form reactants are called irreversible reactions."

- They are supposed to complete.

- These are represented by a single arrow ($\rightarrow$) between reactants and products.

Example:

$$2H_{2(g)} + O_{2(g)} \xrightarrow[\text{Heat}]{\text{Pt}} 2H_2O_{(l)}$$

Q.31 Balance and complete the chemical equation: **(Board 2013,19)** **10209045**

$$H_{2(g)} + I_{2(g)} \longrightarrow$$

Ans. $H_{2(g)} + I_{2(g)} \xrightarrow{\text{Heat}} 2HI_{(g)}$

Q.32 What is meant by dynamic equilibrium state? **(Board 2013,23)** **10209046**

Ans. When reaction does not stop, only the rates of forward and reverse reactions become equal to each other but take place in opposite directions. This is called **dynamic equilibrium state**. Dynamic means reaction is still continuing. At dynamic equilibrium state:

Rate of forward reaction = Rate of reverse reaction

Q.33 $N_2 + O_2 \rightleftharpoons 2NO$ Write its K_c expression. **(Board 2013)** **10209047**

Ans. $N_2 + O_2 \rightleftharpoons 2NO$

The rate of forward reaction

$$R_f = k_f[N_2][O_2]$$

The rate of reverse reaction

$$R_r = k_r[NO]^2$$

The equilibrium constant expression for this reaction is:

$$K_c = \frac{[NO]^2}{[N_2][O_2]}$$

Q.34 $2NH_{3(g)} \rightleftharpoons N_{2(g)} + 3H_{2(g)}$

$$K_c = 3.0 \times 10^{-9}$$

What is the meaning of low K_c value for this process? **(Board 2013)** **10209048**

Ans. Small value of K_c indicates that the equilibrium has established with a very small conversion of reactants into products. At equilibrium position, almost all reactants are present but amount of products is negligible.

Q.35 Why is equilibrium achievable only in a closed system? **10209049**

Ans. A closed system is the one in which substances can neither leave nor enter so there is no effect on the concentrations of the reactants and products due to external disturbance. Moreover, reaction conditions such as pressure and temperature are also not disturbed in such systems so equilibrium state can be achieved easily.

Test yourself 9.1

Q.36 Why do reversible reactions never complete? **(Board 2013)** **10209050**

Ans. Reversible reactions never complete because products recombine to form reactants again, that is why forward and reverse reactions keep on taking place continuously.

Q.37 What is a static equilibrium state? Explain with an example. **10209051** **(Board 2015,21)**

Ans. When reaction ceases to proceed, it is called static equilibrium state.

Example: A building remains standing rather than falling down because all the forces acting on it are balanced.

Q.38 Why do the amounts of reactants and products not change in a reversible reaction? **(Board 2013)** **10209052**

Ans. The amounts of reactants and products do not change in a reversible reaction because a state of dynamic equilibrium establishes in it. In dynamic equilibrium state, rate of forward and reverse reaction becomes equal but amount of reactants and products remains the same.

Test yourself 9.2

Q.39 State the Law of Mass Action. **(Board 2014,17,18,24)** **10209053**

Ans. "The rate at which a substance reacts is directly proportional to its active mass and the rate of a reaction is directly proportional to the product of the active masses of the reacting substances".

Q.40 How is the active mass represented? **10209054**

Ans. An active mass is considered as the molar mass concentration with unit of $moldm^{-3}$, expressed as square brackets [ ].

Q.41 What is equilibrium constant? **(Board 2015,17,19,20) 10209055**

Ans. Equilibrium constant is a ratio of the product of concentration of products raised to the power of coefficient to the product of concentration of reactants raised to the power of coefficient as expressed in the balanced chemical equation.

$$K_c = \frac{\text{Product of concentration of products raised to the power of coefficients}}{\text{Product of concentration of reactants raised to the power of coefficients}}$$

Q.42 Point out the coefficients of each in the following hypothetical reactions: **10209056**

a. $2A+3B \rightleftharpoons 4C+2D$ **b.** $4X \rightleftharpoons 2Y+3Z$ **c.** $2M+4N \rightleftharpoons 5O$

Ans.

General Reactions	Co-efficients in forward reaction	Co-efficients in reverse reaction
$2A+3B \rightleftharpoons 4C+2D$	2, 3	4,2
$4X \rightleftharpoons 2Y+3Z$	4	2,3
$2M+4N \rightleftharpoons 5O$	2,4	5

Q.43 Write the equilibrium constant expressions for the following reactions: **10209057**

(Board 2020,21)

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

b. $PCl_{3\,(g)} + C\ell_{2\,(g)} \rightleftharpoons PC\ell_{5(g)}$

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

Ans.

General Reactions	Equilibrium Constant Expression
$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$ **(Board 2021)**	$K_c = \frac{[N_2O_4]}{[NO_2]^2}$
$PCl_{3\,(g)} + C\ell_{2\,(g)} \rightleftharpoons PC\ell_{5(g)}$	$K_c = \frac{[PCl_5]}{[PCl_3]\,[Cl_2]}$
$2SO_{2(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3(g)}$	$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$

Test yourself 9.3

Q.44 What do you mean by the extent of a reaction? **(Board 2019,20)** **10209058**

Ans. It indicates to which extent reactants are converted into products. It measures how far a reaction proceeds before establishing equilibrium state.

Q.45 Why do the reversible reactions not go to completion? **10209059**

Ans. Because products recombine to form reactants and reaction occurs in both directions i.e. forward and backward. The composition of reaction mixture remains constant at this state because the rate of forward reaction is equal to the rate of reverse reaction.

Q.46 If a reaction has large value of 'K_c', will it go to completion and why? 10209060

Ans. The large value of 'K_c' indicates that at equilibrium position the reaction mixture consists of almost all products and reactants are negligible. The reaction has almost gone to completion. Example: **(Board 2020)**

$$2CO_{(g)} + O_{2(g)} \rightleftharpoons 2CO_{2(g)}$$

$$K_c = 2.2 \times 10^{22}$$

Q.47 Which types of reactions do not go to completion? 10209061

Ans. Reversible reactions do not go to completion because reactants react to form products and products can recombine to form reactants and dynamic equilibrium is established. They have very small value of K_c.

Q.48 Why does the reaction mixture not have 50% reactants and 50% products at equilibrium position? 10209062

Ans. Because equilibrium does not depend upon concentrations, rather it is a state at which rate of forward and reverse reactions must be equal. So, it is not necessary that reaction mixture contains 50% reactants and 50% products.

Multiple Choice Questions

Exercise MCQs

1. The characteristics of reversible reactions are the following except: 10209063

(a) products never recombine to form reactants
(b) they never complete
(c) they proceed in both ways
(d) they have a double arrow between reactants and products

2. In the lime kiln, the reaction $CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$ goes to completion because: **(Board 2013,14,15,19)** 10209064

(a) of high temperature
(b) CaO is more stable than $CaCO_3$
(c) CO_2 escapes continuously
(d) CaO is not dissociated

3. For the reaction, $2A_{(g)} + B_{(g)} \rightleftharpoons 3C_{(g)}$ the expression for the equilibrium constant is: 10209065 **(Board 2013, 2014)**

(a) $\frac{[2A][B]}{[3C]}$ (b) $\frac{[A]^2[B]}{[C]^3}$
(c) $\frac{[3C]}{[2A]\,[B]}$ (d) $\frac{[C]^3}{[A]^2[B]}$

4. When a system is at equilibrium state: 10209066

(a) the concentration of reactants and products becomes equal
(b) the opposing reactions (forward and reverse) stop
(c) the rate of the reverse reaction becomes very low
(d) the rates of the forward and reverse reactions become equal

5. Which one of the following statements is not correct about active mass? 10209067

(a) rate of reaction is directly proportional to active mass
(b) active mass is taken in molar concentration
(c) active mass is represented by square brackets
(d) active mass means total mass of substances

6. When the magnitude of K_c is very large it indicates: 10209068

(a) reaction mixture consists of almost all products
(b) reaction mixture has almost all reactants
(c) reaction has not gone to completion

(d) reaction mixture has negligible products

7. When the magnitude of K_c is very small it indicates: 10209069

(a) equilibrium will never establish
(b) all reactants will be converted into products
(c) reaction will go to completion
(d) the amount of products is negligible

8. Reactions which have comparable amounts of reactants and products at equilibrium state have: (Board 2017,20) 10209070

(a) very small K_c value
(b) very large K_c value
(c) moderate K_c value
(d) none of the above

9. At dynamic equilibrium: (Board 2023) 10209071

(a) the reaction stops to proceed
(b) the amounts of reactants and products are equal
(c) the speeds of the forward and reverse reactions are equal
(d) the reaction can no longer be reversed

10. In an irreversible reaction dynamic equilibrium: 10209072

(a) never establishes
(b) establishes before the completion of reaction
(c) establishes after the completion of reaction
(d) establishes rapidly

11. A reverse reaction is one that: 10209073 (Board 2013,19)

(a) proceeds from left to right
(b) in which reactants react to form products
(c) slows down gradually
(d) speeds up gradually

12. Nitrogen and hydrogen were reacted together to make ammonia: 10209074

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \quad K_c = 2.86\,mol^{-2}\,dm^6$$

What will be present in the equilibrium mixture? (Board 2013,15,21)

(a) NH_3 only
(b) N_2, H_2 and NH_3
(c) N_2 and H_2 only
(d) H_2 only

13. For a reaction between PCl_3 and Cl_2 to form PCl_5, the units of K_c are: (Board 2014,20,24) 10209075

(a) $mol\ dm^{-3}$ (b) $mol^{-1}\ dm^{-3}$
(c) $mol^{-1}\ dm^{3}$ (d) $mol\ dm^{3}$

Additional MCQs

14. The reactions in which the products do not recombine to form reactants are called: 10209076

(a) irreversible reactions
(b) reversible reactions
(c) decomposition reactions
(d) addition reactions

15. The reactions in which the products can recombine to form reactants are called: 10209077

(a) irreversible reactions
(b) reversible reactions
(c) decomposition reactions
(d) addition reactions

16. The colour of iodine is: (Board 2014,23) 10209078

(a) purple (b) black
(c) red (d) pink

17. The colour of hydrogen iodide is: (Board 2014,16,18,19,21) 10209079

(a) colourless (b) black
(c) red (d) pink

18. When the rate of the forward reaction takes place at the rate of reverse reaction the composition of the reaction mixture remains constant, it is called: 10209080

(a) chemical equilibrium
(b) static equilibrium
(c) both (a) & (b)
(d) none of the above

19. When a reaction ceases to proceed, it is called: 10209081

(a) chemical equilibrium state
(b) static equilibrium state

(c) dynamic equilibrium state
(d) all of the above

20. Guldberg and Waage put forward law of mass action in: 10209082
(a) 1860 (b) 1869
(c) 1870 (d) 1879

21. The % age of nitrogen and oxygen in our atmosphere is: (Board 2013) 10209083
(a) 80% (b) 90%
(c) 95% (d) 99%

22. Which gas is used to prepare ammonia? 10209084
(a) N_2 (b) O_2
(c) Cl_2 (d) S

23. Which gas is used to manufacture king of chemicals (sulphuric acid)? 10209085
(a) N_2 (b) O_2
(c) Cl_2 (d) CO_2

24. Equilibrium constant has no unit when number of moles of reactants and products are: 10209086
(a) same (b) different
(c) both (a) & (b) (d) none of these

25. For reaction having large K_c value, the reaction proceeds to: 10209087
(a) completion
(b) equilibrium state
(c) backward
(d) none of the above

26. The two major components of Atmosphere are: 10209088
(a) carbon and nitrogen
(b) nitrogen and oxygen
(c) oxygen and chlorine
(d) none of the above

27. Which type of reactions do not go to completion? 10209089
(a) irreversible reactions
(b) reversible reactions
(c) addition reactions
(d) decomposition reactions

28. Which type of reactions speed up gradually? 10209090
(a) irreversible reactions
(b) reverse reactions
(c) forward reactions
(d) decomposition reactions

29. Such reactions which continue in both directions are called:(Board 2016)10209091
(a) Irreversible
(b) Reversible
(c) Non-reactive
(d) Dynamic

30. In a chemical reaction, the substances that combine are called: 10209092
(a) reactants (b) products
(c) masses (d) materials

31. 'K_c' represents: 10209093
(a) ionic product of water
(b) equilibrium constant
(c) reaction quotient
(d) proportionality constant

32. Dynamic means, reaction is: 10209094
(a) in forward direction
(b) stopped
(c) in reverse direction
(d) still continuing

33. The forward reaction takes place from: 10209095
(a) right to left
(b) left to right
(c) Both a & b
(d) None of the above

34. The units of molar concentration:
(Board 2013,17,19,20)10209096
(a) mol. dm^{-2} (b) mol. dm^{-1}
(c) mol. dm (d) mol. dm^{-3}

35. "K_c" is always equal to: 10209097
(Board 2015)
(a) R_f/R_r (b) k_r/k_f
(c) k_f/k_r (d) R_r/R_f

36. Which chemical is called king of chemicals? 10209098
(a) KNO_3 (b) H_2SO_4
(c) HCl (d) HNO_3

37. For the following reaction, equilibrium mixture will contain:
(Board 2013) 10209099

$$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)} \qquad K_c = 0.211$$

(a) Only N_2O_4 (b) Only NO_2
(c) NO_2 and N_2O_4 in reasonable amount
(d) NO_2 in large amount.

38. If $Q_c < K_c$, the reaction goes in: (Board 2015,16,18,20,24) 10209100
(a) forward
(b) reverse
(c) at equilibrium state
(d) none of the above

39. Who proposed the Law of Mass Action? (Board 2013) 10209101
(a) Newton
(b) Boyles
(c) Guldberg and Waage
(d) Lavoisier

40. The unit of equilibrium constant for the following reaction is: (Board 2017) 10209102

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

(a) $mol dm^{-3}$ (b) $mol^{-2} dm^{6}$
(c) $mol dm^{-6}$ (d) $mol^{-1} dm^{3}$

41. The value of K_c depends on: 10209103
(a) Initial concentration of the reactants
(b) Initial concentration of the products
(c) Temperature of the system
(d) Initial concentration of both reactants and products.

42. For the following reaction : 10209104

$$aA + bB \rightleftharpoons cC + dD$$

According to Law of Mass Action the rate of forward reaction is directly proportional to:
(a) $[A]^a [B]^b$ (b) $k_f [A]^a [B]^b$
(c) $[C]^c [D]^d$ (d) $k_r [C]^c [d]^d$

43. Law of Mass Action describes the relationship between active masses of the reactants and: 10209105
(a) Concentration of products
(b) Rate of the reaction
(c) Conditions of the reaction
(d) All of the above

44. Molar concentration of a substance having units of mol dm^{-3} and expressed in square brackets is termed as: 10209106
(a) Molarity
(b) Molar concentration
(c) Active mass
(d) None of these

45. While writing the K_c expression of the reaction, products and reactants are written respectively as: 10209107
(a) Numerator and denominator
(b) Denominator and numerator
(c) Numerator (d) None of these

46. Oxidation of carbon monoxide goes to completion at: 10209108
(a) 500 K (b) 700 K
(c) 1000 K (d) 1200 K

47. Formation of water by the combination of H_2 and O_2 is catalyzed by: 10209109
(a) Ni (b) Pt
(c) Cd (d) Pd

48. $CaCO_3$ decomposes to produce: 10209110
(a) CaO (b) $CaO + CO_2$
(c) $CaO + CO$ (d) $CO_2 + CO$

49. Equilibrium constant expression for the following reaction is represented as: 10209111

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

(a) $\frac{[H_2][I_2]}{[2HI]}$ (b) $\frac{[2HI]}{[H_2][I_2]}$
(c) $\frac{[H]^2[I]^2}{[2HI]}$ (d) $\frac{[HI]^2}{[H_2][I_2]}$

50. When we put concentrations of substances into the equilibrium constant expression, we obtain a value at some time is called: 10209112
(a) Equilibrium constant
(b) Equilibrium quotient
(c) Reaction quotient
(d) Stability quotient

51. Which of the following reactions can be represented with the K_c expression:

$$K_c = \frac{[PC\ell_5]}{[PCl_3][Cl_2]}$$ 10209113

(a) $PC\ell_{3(g)} + C\ell_{2(g)} \rightleftharpoons PC\ell_{5(g)}$
(b) $PC\ell_{5(g)} \rightleftharpoons PC\ell_{3(g)} + C\ell_{2(g)}$
(c) $3PC\ell_{(g)} + 2C\ell_{(g)} \rightleftharpoons 5PC\ell_{(g)}$
(d) None of these

52. Equilibrium state is achievable in: 10209114

(a) Closed system (b) Open system
(c) Both (a) & (b) (d) None of these

53. A complete reaction is in which: (Board 2016)10209115

(a) All the reactants convert into products
(b) All the reactants do not convert into products
(c) Half reactants convert into products
(d) Only 10% reactants convert into Products

54. In the beginning the rate of reverse reaction is: (Board 2018) 10209116

(a) Moderate (b) Negligible
(c) Slow (d) Very fast

55. The new substance formed in a chemical reaction is: (Board 2021) 10209117

(a) Reactant (b) Product
(c) Forward (d) Reverse

56. Kc depends upon: (Board 2022) 10209118

(a) Temperature (b) Pressure
(c) Volume (d) Atmosphere

Answer Key

1.	a	**2.**	c	**3.**	d	**4.**	d	**5.**	d
6.	a	**7.**	d	**8.**	c	**9.**	c	**10.**	a
11.	d	**12.**	b	**13.**	c	**14.**	a	**15.**	b
16.	a	**17.**	a	**18.**	a	**19.**	b	**20.**	b
21.	d	**22.**	a	**23.**	b	**24.**	a	**25.**	a
26.	b	**27.**	b	**28.**	b	**29.**	b	**30.**	a
31.	b	**32.**	d	**33.**	b	**34.**	d	**35.**	c
36.	b	**37.**	c	**38.**	a	**39.**	c	**40.**	b
41.	c	**42.**	a	**43.**	b	**44.**	c	**45.**	a
46.	c	**47.**	b	**48.**	b	**49.**	d	**50.**	c
51.	a	**52.**	a	**53**	a	**54.**	b	**55.**	b
56.	a								