Review Questions

2. Give short answers.

i. Differentiate between forward and reverse reactions.

Ans. Difference between forward and reverse reactions:

Forward reaction	Reverse reaction
i. It is written from left to right. ii. Reactants produce products. ii. Rate is fastest in beginning and gradually slows down	i. It is written from right to left. ii. Products produce reactants. iii. Its rate is zero in the beginning and gradually speeds up.

ii. What is chemical equilibrium?

Ans. Chemical equilibrium:

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

iii. State the law of Mass Action.

Ans.Law of Mas Action:

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

iv. State conditions for equilibrium.

Ans.Conditions for equilibrium:

i. Concentration of none of the reactants or products is changed.

ii. Temperature of the system is kept constant.

iii. Pressure or volume of the system is kept constant.

v. What is the importance of equilibrium constant for a chemical reaction.

Ans. Importance of equilibrium constant:

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

(d) Predict the effect of change in conditions of the chemical reaction on the equilibrium state.

3. Following reaction can occur during lightning storms

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

For this reaction we write

(a). Equilibrium constant expression.

(b). Determine the units of equilibrium constant.

(c). Forward and reverse reaction.

Solution: (a)

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

$$K_c = \frac{[O_3]^2}{[O_2]^3}$$

(b) $K_c = \frac{[O_3]^2}{[O_2]^3} = \frac{[\text{mole.dm}^{-3}]^2}{[\text{mole.dm}^{-3}]^3} = [\text{mol.dm}^{-3}]^{-1} = \text{mol}^{-1}.\text{dm}^3$

(c) Forward reaction.

$$3O_{2\,(g)} \longrightarrow 2O_{3\,(g)}$$

Reverse reaction:

$$2O_{3\,(g)} \longrightarrow 3O_{2\,(g)}$$

4. Coal reacts with hot steam to form CO and H2. These substances react further in the presence of catalyst to give methane and water vapour.

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

(a). Write forward and reverse reaction.

(b). Derive K_c expression for the reaction.

(c). Determine units for K_c.

Solution:

(a). Forward reaction.

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

Reverse reaction.

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

(b).

$$K_c = \frac{[CH^4][H_2O]}{[CO][H_2]^3}$$

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

$$K_c = \frac{[CH^4][H_2O]}{[CO][H_2]^3} = \frac{[mole.dm^{-3}][mole.dm^{-3}]}{[mole.dm^{-3}][mole.dm^{-3}]^3} = \textbf{no units.}$$

Note: 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.

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

(a). $H_2O_{(g)} \rightleftharpoons H_2 + \frac{1}{2} O_{2(g)}$

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

(c). $COCL_{2(g)} \rightleftharpoons CO_{(g)} + Cl_{2(g)}$

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

Solution:

(a). $H_2O_{(g)} \rightleftharpoons H_2 + \frac{1}{2} O_{2(g)}$

$$K_c = \frac{[H_2][O_2]^{1/2}}{[H_2O]}$$

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

$$K_c = \frac{[CH_3OH]}{[CO][H_2]^2}$$

(c). $COCL_{2(g)} \rightleftharpoons CO_{(g)} + Cl_{2(g)}$

$$K_c = \frac{[CO][Cl_2]}{[COCl_2]}$$

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

$$K_c = \frac{[Cl_2]^2[H_2O]^2}{[HCl]^4[O_2]}$$

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

(a). $COCL_{2(g)} \rightleftharpoons CO_{(g)} + Cl_{2(g)}$

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

(c). $2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_20_{(g)}$

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

Solution:

(a). $COCL_{2(g)} \rightleftharpoons CO_{(g)} + Cl_{2(g)}$

$$K_c = \frac{[CO][Cl_2]}{[COCl_2]} = \frac{[mole.dm^{-3}][mole.dm^{-3}]}{[mole.dm^{-3}]} = [mol.dm^{-3}]$$

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

$$K_c = \frac{[HI]^2}{[H_2][I_2]} = \frac{[mole.dm^{-3}]^2}{[mole.dm^{-3}][mole.dm^{-3}]} = \text{no units}$$

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.

(c). $2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_20_{(g)}$

$$K_c = \frac{[H_2O]^2}{[H_2]^2[O_2]} = \frac{[mole.dm^{-3}]^2}{[mole.dm^{-3}]^2[mole.dm^{-3}]} = [mol.dm^{-3}]^{-1} = mol^{-1}dm^3$$

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

$$K_c = \frac{[NO_2]^2}{[N_2][O_2]^2} = \frac{[\text{mole.dm}^{-3}]^2}{[\text{mole.dm}^{-3}][\text{mole.dm}^{-3}]^2} = [\text{mol.dm}^{-3}]^{-1} = \text{mol}^{-1}\text{dm}^3$$

7. State the ways that equilibrium can recognized.

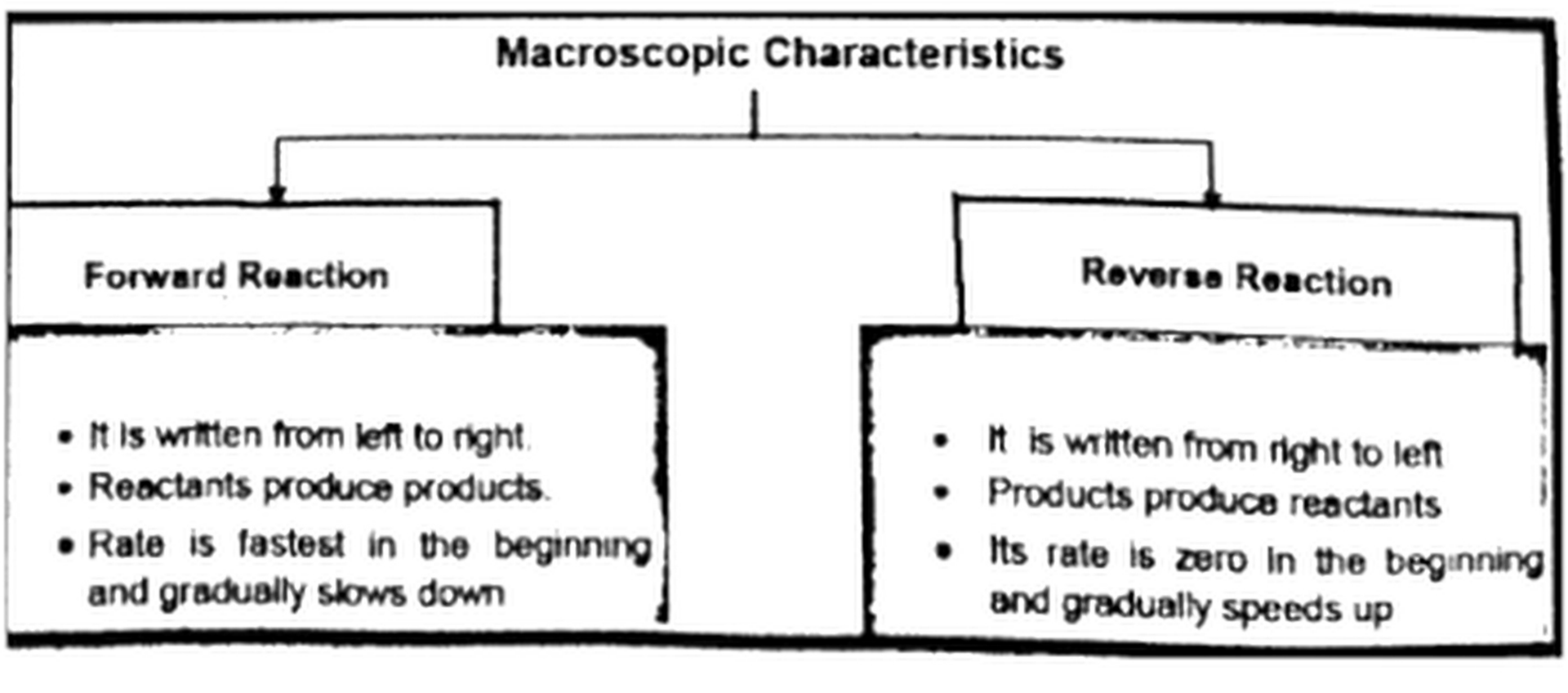
Ans. Ways to recognize equilibrium.

Equilibrium state of a chemical reaction can be determined by determining concentration of reactants and products at regular intervals. When constant concentration of reactants and products are observed, the reaction is at equilibrium. This can be done by both physical method as well as chemical methods such as titration, spectroscopy etc.

8. Describe the macroscopic characteristics of an equilibrium reaction.

Ans.

Macroscopic Characteristics of an equilibrium



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

(i). Chemical equation

(ii). K_c expression

(iii). Units for K_c

Solution:

(i). $2BrCl_{(g)} \rightleftharpoons Br_{2(g)} + Cl_{2(g)}$

(ii). $K_c = \frac{[Br_2][Cl_2]}{[BrCl]^2}$

(iii). $K_c = \frac{[Br_2][Cl_2]}{[BrCl]^2} = \frac{[mole.dm^{-3}][mole.dm^{-3}]}{[mole.dm^{-3}]^2}$ = no units.

10. Kc expression for a reaction is given below.

$$K_c = \frac{[NO_2]^2}{[N_2O]}$$

Write chemical equation for this reaction and derive the units for Kc.

Solution:

Chemical equation:

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

Units of K_c:

$K_c = \frac{[NO_2]^2}{[N_2O]} = \frac{[mole.dm^{-3}]^2}{[mole.dm^{-3}]} = mol^{-1}dm^3$

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

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

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

Solution:

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

In this reaction carbon reacts with oxygen to form carbon dioxide. This reaction is irreversible reaction because it takes place in one direction only. In irreversible reaction the tendency of reverse reaction is negligible.

Therefore, both reactant and products are not likely to be found when the reaction appears to be complete.

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

This reaction indicates decomposition of HF into H_2 and F_2. In this reaction forward as well as reverse reaction occurs to measurable extent.

Forward reaction:

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

Reverse reaction:

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

Therefore, reaction number (ii) appears to be complete.

A chemical reaction is in equilibrium when there is no tendency for the quantities of reactants and products to change.

The direction in which we write chemical reaction (and thus which components are considered reactants and which are products) is arbitrary. Thus the two equations.

$H_{2\,(g)} + I_{2\,(g)} \longrightarrow 2HI_{(g)}$ "synthesis of hydrogen iodide"

$2HI_{(g)} \longrightarrow H_{2\,(g)} + I_{2\,(g)}$ "dissociation of hydrogen iodide"

Represents the same chemical reaction system in which the roles of the components are reversed, *and both yield the same mixture of components when the change is completed.*

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

Ans. Cobalt chloride test paper turns pink when it is exposed to water or moisture. The blue form is cobaltous chloride dehydrate. The pink firm is cobaltous chloride hexahydrate.

Explanation:

Anhydrous cobalt chloride paper is blue; as it is in the presence of water or any sort of moisture it starts tom turn pink. So, if we are using it keep out of air until you are ready to use it and don't touch with your hands because the moisture on your fingers would change the outcome of your cobalt chloride paper.