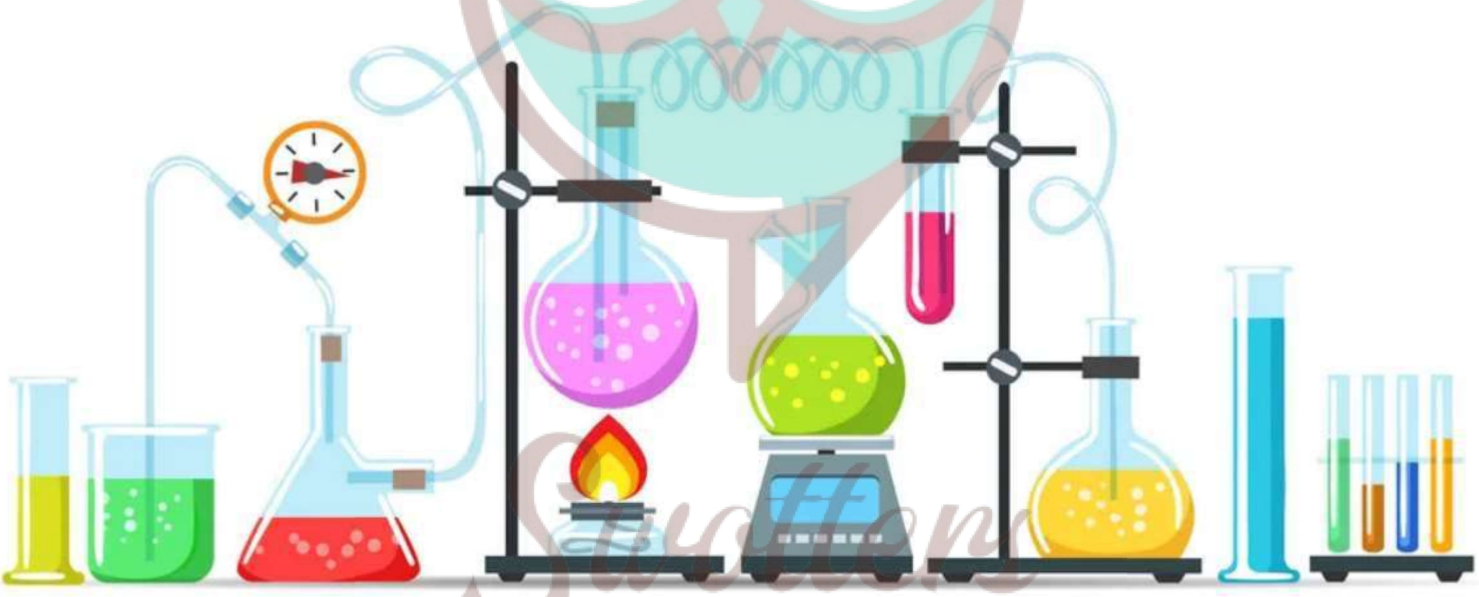
CHEMISTRY



Important Questions

Multiple Choice questions-

Question 1. Which of the following fluoro-compounds is most likely to behave as a Lewis base?

(a) BF_3

(b) PF_3

(c) CF_4

(d) SiF_4

Question 2. Calculate the pOH of a solution at 25°C that contains 1×10^{-10} M of hydronium ions, i.e. H_3O^+.

(a) 4.000

(b) 9.000

(c) 1.000

(d) 7.000

Question 3. When two reactants, A and B are mixed to give products C and D, the reaction quotient, Q, at the initial stages of the reaction

(a) is zero

(b) Decreases With Time

(c) Is Independent of Time

(d) Increases With Time

Question 4. 1 M NaCl and 1 M HCl are present in an aqueous solution. The solution is

(a) Not a buffer solution with pH < 7

(b) Not a buffer solution with pH > 7

(c) A buffer solution with pH < 7

(d) A buffer solution with pH > 7

Question 5. If, in the reaction N_2O_4 $2NO_2$, x is that part of N_2O_4 which dissociates, then the number of molecules at equilibrium will be

(a) 1

(b) 3

(c) (1 + x)

(d) $(1 + xy)^2$

Question 6. The solubility product of a salt having general formula MX_2. In water is: 4×10^{-12}. The concentration of M^{2+}ions in the aqueous solution of the salt is

(a) 4.0×10^{-10} M

(b) 1.6×10^{-4} M

(c) 1.0×10^{-4} M

(d) 2.0×10^{-6} M

Question 7. Equimolar solutions of the following were prepared in water separately. Which one of the solutions will record the highest pH?

(a) $CaCl_2$

(b) $SrCl_2$

(c) $BaCl_2$

(d) $MgCl_2$

Question 8. Oxidation number of Iodine varies from

(a) -1 to +1

(b) -1 to +7

(c) +3 to +5

(d) -1 to +5

Question 9. Which of the following molecular species has unpaired electrons?

(a) N_2

(b) F_2

(c) O^{-}_2

(d) O_2^{-2}

Question 10. A certain buffer solution contains equal concentration of X– and HX. The ka for HX is 10-8. The pH of the buffer is

(a) 3

(b) 8

(c) 11

(d) 14

Question 11. Among the following the weakest Bronsted base is

(a) F–

(b) Cl–

(c) Br–

(d) I–

Question 12. Which of the following statements is correct about the equilibrium constant?

(a) Its value increases by increase in temperature

(b) Its value decreases by decrease in temperature

(c) Its value may increase or decrease with increase in temperature

(d) Its value is constant at all temperatures

Question 13. pH value of which one of the following is NOT equal to one.

(a) 0.1 M CH_3COOH

(b) 0.1 M HNO_3

(c) 0.05 M H_2SO_4

(d) $50cm^3$ 0.4 M HCl + $50cm^3$ 0.2 M NaOH

Question 14. [OH–] in a solution is 1 mol L–. The pH the solution is

(a) 1

(b) 0

(c) 14

(d) 10^{-14}

Question 15. What is the pH of a 0.10 M solution of barium hydroxide, Ba $(OH)_2$?

(a) 11.31

(b) 11.7

(c) 13.30

(d) None of these

Very Short:

1. Write the expression for the equilibrium constant K_p for the reaction $3Fe\ (s) + 4H_2O\ (g) \rightleftharpoons Fe_3O_4\ (s) + 4H_2\ (g)$

2. How are Kc and Kp related to each other in the reaction

$N_2\ (g) + O_2\ (g) \rightleftharpoons 2NO\ (g)$

3. What is the equilibrium constant expression for the reaction

$Al\ (s) + 3H^+\ (aq) \rightleftharpoons Al^{3}+\ (aq) + \frac{3}{2}H_2\ (g)$

4. What happens to the equilibrium

$PCl_5 (g) \rightleftharpoons PCl_3 (g) + Cl_2 (g)$ if nitrogen is added to it

(i) at constant volume

(ii) at constant pressure?

5. What does the equilibrium K < I indicate?

6. For an exothermic reaction, what happens to the equilibrium constant if the temperature is increased?

7. Under what conditions, a reversible process becomes irreversible?

8. What is the effect of increasing pressure on the equilibrium?

$N_2 (g) + 3H_2 (g) \rightleftharpoons 2NH_3 (g)$?

9. For which of the following cases does the reaction go farthest to completion: K = 1, K = 1010, K = 10-10.

10. Under what conditions ice water system is in equilibrium?

(a) at 273 K

(b) below 273 K

(c) above 273 K.

Short Questions:

1. Justify the statement that water behaves like acid as well as a base on the basis of the protonic concept.
2. What is p^{OH}? What is its value for pure water at 298 K?
3. Calculate the p^H of a buffer solution containing 0.1 moles of acetic acid and 0.15 mole of sodium acetate. The ionization constant for acetic acid is 1.75×10^{-5}.
4. An aqueous solution of $CuSO_4$ is acidic while that of Na_2SO_4 is neutral. Explain.
5. The dissociation constants of HCN, CH_3COOH, and HF are 7.2×10^{-10}, 1.8×10^{-5}, and 6.7×10^{-4} respectively. Arrange them in increasing order of acid strength.
6. The dissociation of PCl_5 decreases in presence of Cl_2. Why?

Long Questions:

1. Explain chemical equilibrium with th^ help of an example of formation and decomposition of hydrogen iodide.
2. Name and explain the factors which influence the equilibrium state.
3. What is salt hydrolysis? Explain hydrolysis of salts of

   (i) strong acids and strong bases

(ii) strong acids and weak bases

(iii) strong bases and weak acids

(iv) strong acids and weak bases.

4. Calculate the pH of $\frac{N}{1000}$ Sodium hydroxide solution assuming complete ionisation ($K_w = 1.0 \times 10^{-14}$).
5. Calculate the p^H of a 0.01 N solution of acetic acid. K_a for acetic acid is 1.8×10^{-5} at 25°C

Assertion Reason Questions:

1. In the following questions, a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

Assertion (A) : Increasing order of acidity of hydrogen halides is HF < HCl < HBr < HI

Reason (R) : While comparing acids formed by the elements belonging to the same group of periodic table, H–A bond strength is a more important factor in determining acidity of an acid than the polar nature of the bond.

(i) Both A and R are true and R is the correct explanation of A.

(ii) Both A and R are true but R is not the correct explanation of A.

(iii) A is true but R is false.

(iv) Both A and R are false.

2. In the following questions, a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

Assertion (A) : A solution containing a mixture of acetic acid and sodium acetate maintains a constant value of pH on addition of small amounts of acid or alkali.

Reason (R) : A solution containing a mixture of acetic acid and sodium acetate acts as a buffer solution around pH 4.75.

(i) Both A and R are true and R is correct explanation of A.

(ii) Both A and R are true but R is not the correct explanation of A.

(iii) A is true but R is false.

(iv) Both A and R are false.

Case Study Based Question:

1. Le Chatelier's principle is also known as the equilibrium law, used to predict the effect of

change on a system at chemical equilibrium. This principle states that equilibrium adjusts the forward and backward reactions in such a way as to accept the change affecting the equilibrium condition. When factor-like concentration, pressure, temperature, inert gas that affect equilibrium are changed, the equilibrium will shift in that direction where the effects caused by these changes are nullified. This principle is also used to manipulate reversible reactions in order to obtain suitable outcomes.

(1) Which one of the following conditions will favour the maximum formation of the product in the reaction?

$$A_{2(g)} + B_{2(g)} \rightleftharpoons X_{2(g)}, \Delta_r H = -X \text{ kJ ?}$$

(a) Low temperature and high pressure

(b) Low temperature and low pressure

(c) High temperature and high pressure

(d) High temperature and low pressure

(2) For the reversible reaction,

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

The equilibrium shifts in forwarding direction

(a) By increasing the concentration of NH3(g)

(b) By decreasing the pressure

(c) By decreasing the concentrations of N2(g) and H2(g)

(d) By increasing pressure and decreasing temperature

(3) Favourable conditions for manufacture of ammonia by the reaction,

$$N_2 + 3H_2 \rightleftharpoons 2NH_3; \Delta H = -21.9 \text{ kcal are}$$

(a) Low temperature, low pressure and catalyst

(b) Low temperature, high pressure and catalyst

(c) High temperature, low pressure and catalyst

(d) High temperature, high pressure and catalyst

(4) For the above equilibrium, the reactant concentration is doubled, what would happen then to equilibrium constant?

$$X + Y \rightleftharpoons P + Q$$

(a) Remains constant

(b) Be doubled

(c) Be halved

(d) Cannot be predicted

(5) In which one of the following equilibria will the point of equilibrium shift to left when the pressure of the system is increased?

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

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

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

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

Answer Key:

MCQ

1. (b) PF_3
2. (a) 4000
3. (d) Increases With Time
4. (a) Not a buffer solution with pH < 7
5. (a) 1
6. (c) 1.0×10^{-4} M
7. (c) $BaCl_2$
8. (b) -1 to +7
9. (c) O^{-}_2
10. (b) 8
11. (d) I^-
12. (c) Its value may increase or decrease with increase in temperature
13. (a) 0.1 M CH_3COOH

14.(c) 14

15.(c) 13.30

Very Short Answer:

1.

$$K_p = \frac{p^4_{H_2}}{p^4_{H_2O}} = \frac{p_{H_2}}{p_{H_2O}}$$

2. $K_p = K_c$.

3. $Kc = [Al^{3+} (aq)][H2 (g)^{3/2}/[H+ (aq)]^3$.

4. The state of equilibrium remains unaffected.

(ii)Dissociation increases, i.e., the equilibrium shifts forward.

5. The reaction does not proceed much in the forward direction.

6. $K = K/K_b$.

K_b increases much more than when the temperature is increased in an exothermic reaction. Hence K decreases.

7. If one of the products (gaseous) is allowed to escape out (i.e., in the open vessel).

8. Equilibrium will shift in the forward direction forming more ammonia

9. The reaction having K = 1010 will go farthest to completion because the ratio

(product)/(reactants) is maximum in this case.

10. (a) At 273 K.

Short Answer:

Ans: 1. Water ionizes as $H_2O + H_2O \rightleftharpoons H_3O+ + OH–$

With strong acids, water behaves as a base by accepting a proton from an acid.

$HCl + H_2O \rightleftharpoons H_3O+ (aq) + Cl– (aq)$

While with bases, water behaves as an acid by liberating a proton

$NH_3 + H_2O \rightleftharpoons NH_4{+}$ (aq) + OH (aq).

Ans: 2. $p^{OH} = -\log [OH-]$

$pH + p^{OH} = 14$ for pure water at 298 K

pH = 7

or

p^{OH} of water at 298 = 7.

Ans: 3.

$$p^{H} = p^{K_a} + \log \frac{[\text{Salt}]}{[\text{Acid}]}$$

$$= -\log 1.75 \times 10^{-5} + \log \frac{0.15}{0.10} [p^{K_a} = -\log K_a]$$

$$= -\log 1.75 \times 10^{-5} + \log 1.5 = 4.9.$$

Ans: 4. $CuSO_4 + 2H_2O \rightleftharpoons Cu(OH)_2 + H_2SO_4$ (weak base strong acid)

$CuSO_4$ is the salt of weak base $Cu(OH)_2$ and a strong acid H_2SO_4.

Thus, the solution will have free H^+ ions and will, therefore, be acidic.

Na_2SO_4, being the salt of a strong acid H_2SO_4 and a strong base.

NaOH does not undergo hydrolysis. The solution is, therefore, neutral.

Ans: 5. More the value of Ka, the stronger the acid

Their Ka1S are $6.7 \times 10^{-4} > 1.8 \times 10^{-5} > 7.2 \times 10^{-10}$

$\therefore$ HCN < CH_3COOH < HF.

Ans: 6. For $PCl_5 \rightleftharpoons PCl_3 + Cl_2$.

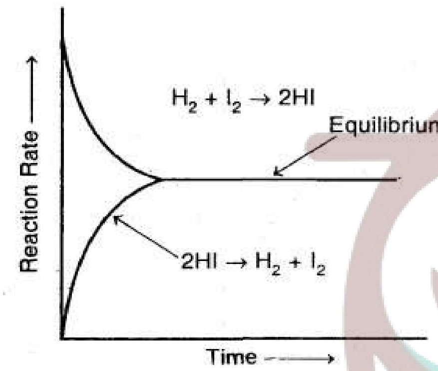
According to Le Chatelier's principle, an increase in the concentration of Cl_2 (one of the products) at equilibrium will favor the backward reaction, and thus the dissociation of PCl_5 into PCl_3 and Cl_2 decreases

Long Answer:

Ans: 1. Consider the reaction between hydrogen and iodide at a constant temperature of 720 K in a closed vessel. The reaction involved is:

$H_2(g) + I_2(g) \rightarrow 2HI(g)$

Accordingly, the effective collision amongst the reactant molecules will result in the production of HI. Since the product molecules are not permitted to leave the vessel (i.e., the reaction is carried out in a closed vessel), they will also collide amongst themselves leading to the formation of reactant molecules. Under these conditions, the reaction takes place in both directions. Hence, it is called a reversible reaction.



Graphical representation of the change of reaction rates with time for the formation and decomposition of hydrogen iodide

Forward reaction: $H_2\ (g) + I_2\ (g) \rightarrow 2HI\ (g)$

Backward reaction: $2HI\ (g) \rightarrow H_2\ (g) + I_2\ (g)$

Reversible reaction: $H_2\ (g) + I_2\ (g) \rightleftharpoons 2HI\ (g)$.

To begin with, with the concentration of the reactants being higher in comparison to the product molecules, the rate of the forward reaction will be high as compared to the backward reaction. As the reaction proceeds further, the molar concentration of the reactants will gradually decrease while that of the product will gradually increase.

Apparently, the rate of forwarding reaction goes on decreasing while that of the backward reaction. This state is the reversible chemical reaction is called a chemical equilibrium state.

Ans: 2. The various factors which influence the equilibrium state are:

1. Concentration: Concentration change influences the equilibrium state. If the concentration of the reactants is increased, the equilibrium will shift in such a direction in which more to the products are formed and vice-versa.
On the other hand, if the concentration of the products is increased, the equilibrium will

shift in such a direction in which more of the reactants are formed.

2. Temperature: Like concentration, the temperature change also affects the equilibrium state. An increase in temperature of the system will shift the equilibrium in such a direction in which heat is absorbed (i.e. rate of endothermic reaction will increase).

On the other hand, a decrease in temperature of the system will shift the equilibrium in such a direction in which heat is evolved (i.e., rate of exothermic reaction will increase).

3. Pressure: Like concentration and temperature, the pressure also influences the equilibrium state only when the reaction proceeds with a change in volume. An increase in pressure of the system will shift the equilibrium in such a direction in which the volume of the system decreases.

On the other hand, a decrease in pressure of the system will shift the equilibrium in such a direction in which the volume of the system increases.

To explain the effect of temperature, pressure, and concentration on the equilibrium state, consider the combination of N_2 and H_2 to form NH_3
$N_2 (g) + 3H_2 (g) \rightleftharpoons 2NH_3 (g)$; $\Delta H = -93.6$ kJ

The reaction is reversible, exothermic, and accompanied by a decrease in volume.
Effect of temperature: According to Le-Chatelier's principle, an increase in temperature shifts the equilibrium in the direction in which heat is absorbed, and a decrease in temperature shifts the equilibrium in the direction in which heat is evolved. Since the formation of ammonia is accompanied by the evolution of heat, it is favored by a decrease in temperature.

Effect of pressure: According to Le-Chatelier's principle, an increase of pressure on a system in equilibrium, favors the direction which is accompanied by a decrease in volume and vice-versa. While going from, left to right in the above reaction, there is a decrease in the number of moles or say volume, the formation of ammonia is favored by an increase in pressure.

Effect of concentration: According to Le-Chatelier's principle, an increase of concentration of any of the substances in the system shifts the equilibrium in the direction in which the concentration of that substance is reduced. Thus, the addition of N_2 or H_2 favors the formation of ammonia.
Ans: 3. Salt hydrolysis: Hydrolysis is a process in which a salt reacts with water to form acid and base.
Salt + Water $\rightleftharpoons$ Acid + Base
B A + $H_2O \rightleftharpoons$ HA + BOH

That is the interaction of the cations of the salt with OH ions furnished by water and anions of the salt with H+ ions furnished by water to form an acidic or basic solution is called salt hydrolysis.

(i) Salts of strong acids and strong bases like NaCl, KCl, KNO_3 $NaNO_3$, Na_2SO_4, K_2SO_4 do not undergo hydrolysis because the acids and bases furnished by them in aqueous solutions are strong acids and strong bases which are completely dissociated.

$NaCl + H_2O \rightleftharpoons NaOH + HCl$

$NaOH (aq) \rightleftharpoons Na+ + OH–$

$HCl (Aq) \rightleftharpoons H+ + Cl–$

Since $[H^+] = [OH–]$ the resulting solution is neutral and its pH = 7.

(iii) Hydrolysis of salts of strong acids and weak bases:

The salts belonging to this type are NH_4NO_3, NH_4Cl, $(NH_4)_2SO_4$, $CuSO_4$, $AlCl_3$, $Ca(NO_3)_2$, etc.

Let us take the case of NH_4NO_3

$NH_4NO_3 + H_2O \rightleftharpoons NH_4OH + HNO_3$

$NH_4+ + NO_3– + H_2O \rightleftharpoons NH_4OH + HNO_3$

or

$NH_4+ + H_2O \rightleftharpoons NH_4OH + H+$

The resulting solution after hydrolysis is basic (pH > 7). Since only the anions of the salt have taken place in the hydrolysis, it is called anionic hydrolysis.

(iv) Hydrolysis of salts of weak acids and weak bases:

The salts belonging to this type are:

CH_3COONH_4, $(NH_4)_2CO_3$, $Ca_3(PO_4)_2$ etc.

Let us take the case of hydrolysis of CH_3COONH_4

$CH_3COONH_4 + H_3O \rightleftharpoons CH_3COOH + NH_4OH$

or

$CH_3CO\bar{O} + NH_4 + H_2O \rightleftharpoons CH_3COOH + NH_4OH$

Since both the cations and anions of the salt have participated in the hydrolysis, it is known as cationic as well as anionic hydrolysis. The nature of the solution or pH depends upon the relative strengths of the acid and base that are formed on hydrolysis.

Ans: 4. Since NaOH is completely ionized

$\therefore$ $[NaOH] = [OH–] = 10^{-3}$ N $= 10^{-3}$ M

Ans: 5. $CH_3COOH \underset{}{\overset{H_2O}{\rightleftharpoons}} CH_3CO\bar{O} + H_3^+O$

Applying the law of chemical equilibrium

Ka = $[CH_3CO\bar{O}][H_3O^+]/[CH_3COOH]$

$$\therefore \quad [H_3O^+] = \sqrt{K_a[CH_3COOH]}$$

as $[CH_3CO\bar{O}] = [H_3O^+]$

Putting the value of $K_a = 1.8 \times 10^{-5}$ and

$$[CH_3COOH] = 0.01\ N = 0.01\ M = 10^{-2}\ M$$

$$[H_3O^+] = \sqrt{1.8 \times 10^{-5} \times 10^{-2}}$$

$$= \sqrt{18} \times 10^{-4}\ \text{g ion L}^{-1}$$

$$\therefore \quad p^H = -\log[H_3O^+] = -\log(4.242 \times 10^{-4})$$

$$= -(0.6276 - 4) = 3.37$$

Assertion Reason Answer:

1. (i) Both A and R are true and R is the correct explanation of A.
2. (i) Both A and R are true and R is the correct explanation of A.

Case Study Answer:

1. **Answer:**

(1) (a) Low temperature and high pressure

(2) (d) By increasing pressure and decreasing temperature

(3) (b) Low temperature, high pressure and catalyst

(4) (a) Remains constant

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