

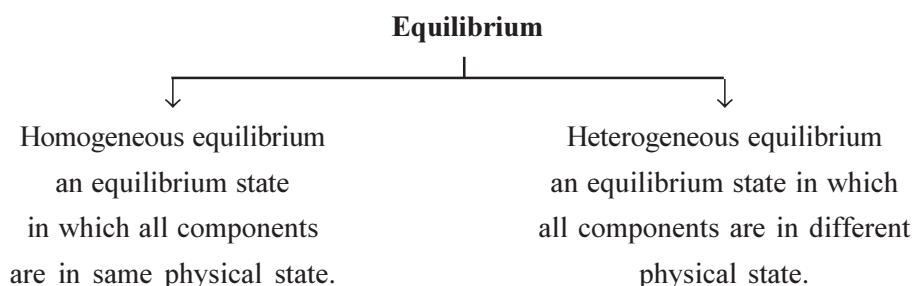
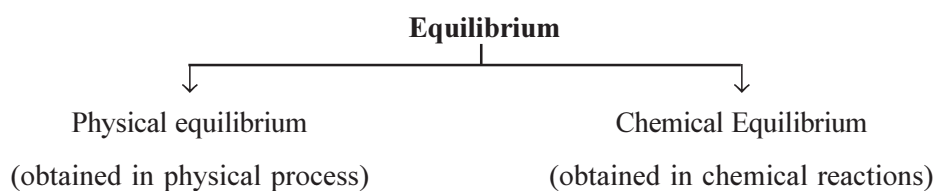
● Irreversible and reversible reactions

(1) **Irreversible reaction** : A reaction which moves only in one direction and all reactants are converted into products is called an irreversible reaction.

(2) **Reversible reaction** : The reaction occurs in both the directions and the reaction is never completed is called Reversible reaction.

In a reversible reaction if gases are involved, they are in closed container.

Equilibrium : at a constant temperature for any physical or chemical reaction rate of forward reaction is equal to rate of backward reaction and a stable state is created which is called equilibrium.



● Laws of chemical equilibrium and equilibrium constant

Homogeneous equilibrium : $aA + bB \rightleftharpoons cC + dD$,

According to law of active masses,

$$R_f \propto [A]^a[B]^b \text{ therefore } R_f = K_f \cdot [A]^a[B]^b$$

$$R_r \propto [C]^c[D]^d \text{ therefore } R_r = K_r \cdot [C]^c[D]^d$$

at equilibrium, $R_f = R_r$

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

If concentration of component at equilibrium is expressed in partial pressure then

$$K_p = \frac{(P_C)^c(P_D)^d}{(P_A)^a(P_B)^b}$$

If concentration of components at equilibrium is expressed in mole fraction then

$$K_x = \frac{(X_C)^c (X_D)^d}{(X_A)^a (X_B)^b}$$

$$K_p = K_C \cdot (R_T)^{\Delta n(g)}, K_p = K_x \cdot (P)^{\Delta n(g)}$$

● **Certain characteristics of equilibrium constant**

(i) At a definite temperature equilibrium constant of the reaction $aA + bB \rightleftharpoons cC + dD$, $K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$

$\therefore cC + dD \rightleftharpoons aA + bB$ reaction at the same temperature equilibrium constant $K'_c = \frac{1}{K_c}$

(ii) At a definite temperature equilibrium constant of the reaction $A + B \rightleftharpoons C + D$, $K_c = \frac{[C][D]}{[A][B]}$

$\therefore$ equilibrium constant of the reaction $nA + nB \rightleftharpoons nC + nD$ at the same temperature

$$K'_c = (K_c)^n$$

(iii) At a definite temperature equilibrium constant of the reaction $A + B \rightleftharpoons P + Q$ is K_3 .

This reaction is addition of the following two reactions.

(a) $A + B \rightleftharpoons C + D$, equilibrium constant = K_1

(b) $C + D \rightleftharpoons P + Q$, equilibrium constant = K_2

$$\therefore K_3 = K_1 \cdot K_2$$

In the same way $A + B \rightleftharpoons P + Q$, equilibrium constant = K_3

This reaction is difference of the following two reactions

(a) $A + B \rightleftharpoons C + D$, equilibrium constant = K_1

(b) $P + Q \rightleftharpoons C + D$, equilibrium constant = $K_2 \therefore K_3 = \frac{K_1}{K_2}$

Using equilibrium constant direction of reaction can be predicted. Calculate reaction Quotient

$$Q_c = \frac{[\text{Product}]}{[\text{Reactant}]}$$
 and compare with K_c ,

(i) If $K_c < Q_c$, Reaction will occur in forward direction

(ii) If $K_c > Q_c$ Reaction will occur in reverse direction

(iii) If $K_c = Q_c$ Reaction will remain in equilibrium

From the equation $\Delta G = \Delta G^\circ + RT \ln Q_c$ if $\Delta K = 0$, $Q_c = K_c$

$$\therefore \Delta G^\circ = -RT \ln K_c$$

$$\therefore \Delta G^\circ = -2.303RT \log K_c$$

For reaction occurring in an electrochemical cell, $E^\circ_{\text{cell}} = \frac{RT}{nF} \ln K_c$

$$\therefore E^\circ_{\text{cell}} = \frac{2.303RT}{nF} \log K_c$$

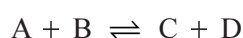
If for an equilibrium reaction, equilibrium constant is K_1 at temperature T_1 and equilibrium constant is K_2 at temperature T_2 , then the enthalpy change is

$$\log \frac{K_2}{K_1} = \frac{\Delta H}{2.303R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

(i) If $\Delta H = 0$, $K_1 = K_2$, (ii) If $\Delta H > 0$, $K_1 < K_2$, (iii) If $\Delta H < 0$, $K_1 > K_2$

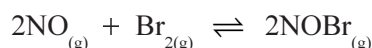
● Le-chatelier's Principle

For equilibrium reaction at a definite temperature and pressure



- (i) If concentration of A and/or B is increased or concentration of C and/or D is decreased, equilibrium will move in forward direction but equilibrium constant will not change.
- (ii) If concentration of A and/or B is decreased or concentration of C and/or D is increased, equilibrium will move in backward direction but equilibrium constant will not change.
- (iii) If reaction is endothermic and temperature is increased, equilibrium will move in forward direction, equilibrium constant will increase and equilibrium is established faster.
- (iv) If reaction is exothermic and temperature is increased, equilibrium will move in backward direction, equilibrium constant will decrease and equilibrium is established slower.
- (v) In the above reaction if components are in gaseous state
 - (a) $n_{p(g)} = n_{r(g)}$, then there is no effect of pressure on equilibrium
 - (b) $n_{p(g)} \neq n_{r(g)}$, then there is increase or decrease in pressure then equilibrium respectively will move in direction of more number of moles to less number of moles or less number of moles to more number of moles, equilibrium constant will not change.
- (vi) If catalyst is used equilibrium is achieved faster but equilibrium constant is not changed.

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1. On reacting Br_2 with Nitric oxide, Nitrosyl Bromide is obtained,



when 0.087 moles of NO and 0.0437 moles of Br_2 are mixed in a closed container at constant temperature and pressure at equilibrium 0.0518 moles of NOBr is obtained, then calculate concentration of NO and Br_2 at equilibrium.

- (A) 0.0352, 0.0178 (B) 0.0872, 0.0259 (C) 0.0518, 0.0259 (D) 0.0259, 0.0518

2. Which of the following is not a characteristic of equilibrium involving a physical process.

- (A) At a given temperature equilibrium is possible in closed container.
- (B) All measurable properties of the system are constant.
- (C) At equilibrium all physical processes stop.
- (D) Opposite to stable state equal rate is applicable to all processes.

3. For the following reaction at 25°C , value of equilibrium constant is 2×10^{-50} . At that temperature concentration of O_2 is $1.6 \times 10^{-2}\text{M}$ then calculate concentration of O_3 ?

(A) $2 \times 10^{-15} \times (1.6 \times 10^{-2})^3$ (B) 2.86×10^{-28}
(C) $(1.6 \times 10^{-2})^4$ (D) Both (A) and (B)

4. $\text{HI}_{(\text{g})}$ filled in a closed container at 0.2 atm pressure and definite temperature undergoes dissociation. If partial pressure of HI at equilibrium is 0.04 atm then calculate value of K_p ?

(A) 3 (B) 4 (C) 6 (D) 8

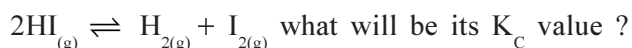
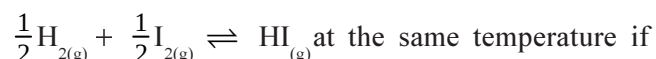
5. $\text{H}_{2(\text{g})}$ gas used in Haber's process is obtained from water gas of Methane. In this process there are two steps in 1st step CO and H_2 are produced in second step CO obtained in second step is reacted with excess of water gas. What will be P_{H_2} at equilibrium ? In the reaction container at 400°C initially $P_{\text{CO}} = P_{\text{H}_2\text{O}} = 4.0$ bar.

(K_p at $400^\circ\text{C} = 10.1$)



(A) 12.71 (B) 3.17 (C) 5.32 (D) 3.04

6. For the following reaction at 500 K its value of K_c is 5



(A) 0.04 (B) 0.4 (C) 25 (D) 2.5

7. For the following reaction at 899 K its $K_p = 0.04$ atm when C_2H_6 gas is filled in a container at 4 atm, calculate its partial pressure at equilibrium ?

(A) 0.30 (B) 3.6 (C) 4.0 (D) 2.8

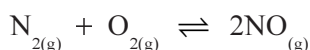
8. Dissociation of $\text{PCl}_{5(\text{g})}$ in a closed container is as follows



If pressure of the total mixture at equilibrium is P and degree of dissociation of PCl_5 is x, then calculate partial pressure of PCl_3 ?

(A) $\left(\frac{x}{x+1}\right)P$ (B) $\left(\frac{2x}{1-x}\right)P$ (C) $\left(\frac{x}{x-1}\right)P$ (D) $\left(\frac{x}{1-x}\right)P$

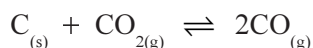
9. In a closed container at 800 K temperature and at equilibrium concentration of N_2 , O_2 and NO are $3 \times 10^{-3}\text{M}$, $4.2 \times 10^{-3}\text{M}$ and $2.8 \times 10^{-3}\text{M}$ respectively, then calculate K_c for the following reaction ?



(A) 0.622 (B) 6.22 (C) 0.0622 (D) 0.266

10. Pressure of the reaction $\text{NH}_4\text{COONH}_2 \rightleftharpoons 2\text{NH}_3 + \text{CO}_2$ at equilibrium is 3 bar then calculate its K_p value ?
- (A) 4 (B) 27 (C) $\frac{4}{27}$ (D) $\frac{1}{27}$
11. For the reaction $\text{A} + 3\text{B} \rightleftharpoons 4\text{C}$ Initially concentration of A is equal to concentration of B and at equilibrium concentration of A is equal to concentration of C, then calculate value of K_c ?
- (A) 0.08 (B) 0.8 (C) 8 (D) $\frac{1}{8}$
12. According to law of active masses, rate of reaction is proportional to which of the following ?
- (A) volume of container (B) equilibrium constant
(C) nature of Reaction (D) concentration of reactant
13. At 400 K temperature pressure of PCl_5 is 1 atmosphere. If it undergoes dissociation as follows having degree of dissociation 0.4. Calculate the density of mixture at equilibrium :
Reaction : $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$
- (A) 45.4 gm/litre (B) 4.54 gm/litre (C) 55.4 gm/litre (D) 3.45 gm/litre
14. Calculate concentration of I_2 and ICl at equilibrium obtained by dissociation of ICl having initial concentration 0.78M ? $2\text{ICl} \rightleftharpoons \text{I}_2 + \text{Cl}_2$, $K_c = 0.14$
- (A) 0.167 and 0.446 (B) 0.446 and 0.167 (C) 0.339 and 0.104 (D) 0.80 and 0.17
15. at 1000 K temperature there is a reaction as follows
 $\text{CO}_2 + \text{C} \rightleftharpoons 2\text{CO}$, $K_p = 3.0$ bar. If initially in presence of graphite $P_{\text{CO}_2} = 0.48$ bar and $P_{\text{CO}} = 0$, then calculate partial pressure of CO and CO_2 respectively at equilibrium ?
- (A) 0.66 and 0.15 bar (B) 0.15 and 0.66 bar (C) 6.6 and 1.5 bar (D) 0.066 and 0.015 bar
16. At a definite temperature and 10^5 pascal total pressure Iodine vapour contains 40% Iodine atoms than volume, then calculate K_p at equilibrium ? $\text{I}_2 \rightleftharpoons 2\text{I}$
- (A) 6.72×10^4 (B) 2.67×10^{-4} (C) 2.67×10^4 (D) 2.67×10^6
17. A sample of HI gas is filled in a flask at 0.2 atm pressure, at equilibrium partial press of HI is 0.04 atm, then calculate K_p for the equilibrium reaction ?
 $2\text{HI} \rightleftharpoons \text{H}_2 + \text{I}_2$
- (A) 4.0 (B) 0.4 (C) 6.0 (D) 8.0
18. At a definite temperature for the following equilibrium calculate value of K_c respectively ?
- (i) $2\text{NOCl} \rightleftharpoons 2\text{NO} + \text{Cl}_2$ $K_p = 1.8 \times 10^{-2}$, $T = 500$ K
(ii) $\text{CaCO}_3 \rightleftharpoons \text{CaO} + \text{CO}_2$ $K_p = 167$, $T = 1073$ K
- (A) 4.38×10^{-4} , 2.89 (B) 4.38×10^{-4} , 1.89 (C) 4.38×10^{-5} , 28.9 (D) 4.38×10^{-5} , 18.9
19. At 450 K temperature for the following reaction value of $K_p = 2 \times 10^{10}$ bar, then calculate value of K_c at same temperature ?
 $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$
- (A) 2.67×10^7 (B) 5.24×10^{10} (C) 5.41×10^8 (D) 7.38×10^{11}

20. At 1127 K temperature and 1 bar pressure solid carbon is in equilibrium with gaseous mixture of CO and CO₂ possessing 90.55 % by mass CO, then calculate value of K_c at the same temperature ?

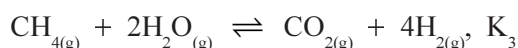
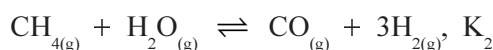
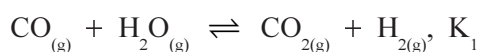


- (A) 0.283 (B) 0.513 (C) 0.153 (D) 0.365

21. For $\text{CO}_{(g)} + \text{Cl}_{2(g)} \rightleftharpoons \text{COCl}_{2(g)}$ which of the following is equal to $\frac{K_p}{K_c}$?

- (A) $\frac{1}{RT}$ (B) RT (C) $\sqrt{RT}$ (D) 1.0

22. For the following reactions which of the following relation between equilibrium constants is true ?



- (A) $K_1 \cdot \sqrt{K_2} = K_3$ (B) $K_2 \cdot K_3 = K_1$ (C) $K_3 = K_1 \cdot K_2$ (D) $K_3 \cdot K_2^3 = K_1^2$

23. For $2\text{NO}_{2(g)} \rightleftharpoons 2\text{NO}_{(g)} + \text{O}_{2(g)}$, $K_c = 1.8 \times 10^{-6}$. Temperature 184° C and R = 0.0831 KJ mole⁻¹, then on comparing K_p and K_c,

- (A) Depending upon the total pressure of the gas K_p can be less than, greater than or equal to K_c.
(B) K_p = K_c (C) K_p < K_c (D) K_p > K_c

24. At 700 K temperature for the reaction $2\text{SO}_{3(r)} \rightleftharpoons 2\text{SO}_{2(g)} + \text{O}_{2(g)}$ value of K_p is 1.8×10^{-3} K pascal, then at same temperature calculate value of K_c in mol dm³ ?

- (A) 9.03×10^{-7} (B) 3.09×10^{-7} (C) 3.09×10^{-4} (D) 3.09×10^{-9}

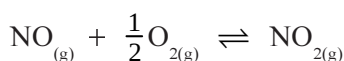
25. For phosphorylation of glucose, glycolysis reaction has value of ΔG° 13.8 KJmole⁻¹, then at 298 K temperature, calculate value of K_c ?

- (A) 2.83×10^{-3} (B) 3.86×10^3 (C) 3.82×10^{-3} (D) 3.82×10^3

26. at 1000 K temperature for the reaction $\text{C}_{(s)} + \text{H}_2\text{O}_{(g)} \rightleftharpoons \text{CO}_{(g)} + \text{H}_2\text{O}_{(g)}$ value of ΔG° is -8.1 KJmole⁻¹, calculate equilibrium constant ?

- (A) 6.24 (B) 3.84 (C) 2.64 (D) 4.64

27. At 298 K temperature, standard free energy of formation of NO₂, NO is 52.0 and 87.0 KJ/mole⁻¹ calculate equilibrium constant for the reaction ?



- (A) 1.362×10^6 (B) 1.362×10^{-6} (C) 2.287×10^{-6} (D) 4.862×10^{-5}

28. For $3X_{(g)} + Y_{(g)} \rightleftharpoons X_3Y_{(g)}$ What is the mass of X_3Y dependent on the following ?
 (A) only pressure (B) only temperature
 (C) temperature, pressure and catalyst (D) temperature and pressure
29. In which of the following reactions at constant volume addition of small amount of Argon does not affect equilibrium constant ?
 (A) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ (B) $PCl_{2(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$
 (C) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ (D) All the reaction
30. If reaction $A \rightleftharpoons B$ is completed half, then which of the following option is right ?
 (A) $\Delta G^\circ > 0$ (B) $\Delta G^\circ < 0$ (C) $\Delta G^\circ = 0$ (D) $\Delta G^\circ = -RT \log 2$
31. Equilibrium constant for the reaction $H_{2(g)} + S_{(s)} \rightleftharpoons H_2S_{(g)}$ at 925 K and 1000 K is 18.5 and 9.25 respectively, then calculate enthalpy of reaction ?
 (A) 2 KJmole⁻¹ (B) 71 KJmole⁻¹ (C) -71 KJmole⁻¹ (D) 57 KJmole⁻¹
32. At 500 K temperature in a 20 litre container 1.57 mole N_2 , 1.92 mole H_2 and 8.13 mole NH_3 is mixed, at that temperature value of equilibrium constant is 1.57×10^{-2} ?
 (A) Reaction is at equilibrium (B) Reaction occurs in direction of reactant
 (C) Reaction occurs in direction of product (D) Cannot be predicted
33. If concentration of OH^- is decreased $\frac{1}{4}$ th time in the following reaction at equilibrium
 $Fe(OH)_{3(aq)} \rightleftharpoons Fe^{3+}_{(aq)} + 3OH^-_{(aq)}$ then concentration of Fe^{3+} becomes time.
 (A) 8 (B) 16 (C) 64 (D) 4
34. Which of the following equilibrium reactions is not affected by change in volume of the container ?
 (A) $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$ (B) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$
 (C) $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$ (D) $SO_2Cl_{2(g)} \rightleftharpoons SO_{2(g)} + Cl_{2(g)}$
35. For $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$, $\Delta H^\circ = -198$ KJ, which of the following conditions will favour forward reaction ?
 (A) Decrease in temperature and pressure.
 (B) Increase in temperature and pressure.
 (C) Increase in temperature and decrease in pressure.
 (D) Decrease in temperature and increase in pressure.

Answers : 1. (A), 2. (C), 3. (B), 4. (B), 5. (D), 6. (A), 7. (B), 8. (A), 9. (A), 10. (A), 11. (C), 12. (D), 13. (B), 14. (A), 15. (A), 16. (C), 17. (A), 18. (B), 19. (D), 20. (C), 21. (A), 22. (C), 23. (D), 24. (B), 25. (C), 26. (C), 27. (A), 28. (D), 29. (D), 30. (C), 31. (C), 32. (B), 33. (C), 34. (C), 35. (D)

● Ionic Equilibrium

● Electrolyte and Non Electrolyte

A compound whose aqueous solution or molten state can conduct electricity is called an **electrolyte**.

A compound whose aqueous solution or molten state cannot conduct electricity is called **non-electrolyte**.

Amount of electrolyte compound dissolved is proportional to amount of compound undergoing dissociation (or ionisation) and it is known as degree of **dissociation (ionisation)** " α " of the electrolyte compound.

An electrolyte which undergoes complete ionization (dissociation) in its aqueous solution is called a strong electrolyte but electrolytes which undergoes partial ionization in its aqueous solution (dissociation) are called as weak electrolytes.

Strong acid, strong base and salts act as strong electrolytes while weak acid and weak base act as weak electrolytes.

● Principle of Acid-Base

(1) **Arrhenius Acid-Base** : Substances which ionize in aqueous solution and release H^+ ions are called acid and substances which ionize in aqueous solution and release OH^- ions are called base.

(2) **Bronstead-Lowry Acid-Base** : A substance which donate H^+ ion during a reaction is acid and which accept H^+ ion is base.

According to this principle acid which lose H^+ ion produce conjugate base and base which gain H^+ ion produce conjugate acid. A conjugate base and conjugate acid derived from strong acid and strong base respectively are weak base and weak acid.

(3) **Lewis Acid-Base** : Substance which donate electron pair during the reaction is called base and which accepts electron pair is called acid.

● Ionic product of water

At 298 K temperature $H_2O_{(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$ equilibrium constant of this reaction is called ionic product of water.

$$K_w = [H_3O^+] [OH^-] = 1 \times 10^{-14} M^2$$

$$\therefore [H_3O^+] = [OH^-] = 1 \times 10^{-7} M \text{ and } [H_2O] = 55.6 M$$

$$\therefore \alpha = \frac{10^{-7}}{55.6} = 1.8 \times 10^{-9}$$

● pH Scale

$$pH = -\log_{10} [H_3O^+] \text{ and } pOH = -\log_{10} [OH^-]$$

in an aqueous solution at 298 K temp.

$$K_w = [H_3O^+] [OH^-] = 1 \times 10^{-14}$$

$$\therefore pH + pOH = 14$$

For acid solution $pH < 7$, and base solution $pH > 7$ and for neutral solution $pH = 7$

● Weak acid and weak base ionization constant

For any weak monobasic (monoprotic) acid.

$$\text{ionization constant } K_a = \frac{\alpha^2 C}{1-\alpha} = \frac{[\text{H}_3\text{O}^+]^2}{C} \text{ and } [\text{H}_3\text{O}^+] = \sqrt{K_b \cdot C}$$

$$[\text{H}_3\text{O}^+] = \alpha \cdot C$$

where α = degree of ionization, C = concentration of acid (Molarity)

For any weak monoacidic base ionization constant,

$$K_b = \frac{\alpha^2 C}{1-\alpha} = \frac{[\text{OH}^-]^2}{C} \text{ and } [\text{OH}^-] = \sqrt{K_b \cdot C}$$

$$[\text{OH}^-] = \alpha \cdot C$$

$$\text{p}K_a = -\log K_a \text{ and } \text{p}K_b = -\log K_b$$

Relative strength of any weak acid or any weak base can be measured from their value of K_a ($\text{p}K_a$) and K_b ($\text{p}K_b$) and from $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ in their aqueous, solution pH and pOH can be measured.

If ionization constant of any weak acid is K_a and ionization constant of its conjugate base is K_b , then $K_a \cdot K_b = 10^{-14}$ or $\text{p}K_a + \text{p}K_b = 14$.

36. Ionization constant of 0.05 M solution of phenol is 1×10^{-10} . If its concentration in a sodium phenolate solution is 0.01 M calculate its degree of ionization ?
 (A) 1×10^{-10} (B) 1×10^{-4} (C) 1×10^{-8} (D) 1×10^{-6}
37. On dissolving 0.16 gm N_2H_4 in 500 ml water an aqueous solution is prepared. If ionization constant of N_2H_4 is 4×10^{-6} calculate % ionization of N_2H_4 in its solution ?
 (A) 12 % (B) 8 % (C) 2 % (D) 5 %
38. If ionization constant of acetic acid is 1.74×10^{-5} , then for 0.05 M solution of CH_3COOH calculate degree of ionization and pH respectively ?
 (A) 1.86×10^{-2} , 4 (B) 1.24×10^{-3} , 4 (C) 1.24×10^{-3} , 3 (D) 1.86×10^{-2} , 3
39. Weak bases have strong conjugate base, then arrange the following in decreasing order of basicity of conjugate bases.
 (A) $\text{RO}^- > \text{OH}^- > \text{CH}_3\text{COO}^- > \text{Cl}^-$ (B) $\text{OH}^- > \text{RO}^- > \text{CH}_3\text{COO}^- > \text{Cl}^-$
 (C) $\text{Cl}^- > \text{RO}^- > \text{OH}^- > \text{CH}_3\text{COO}^-$ (D) $\text{CH}_3\text{COO}^- > \text{RO}^- > \text{OH}^- > \text{Cl}^-$
40. Three reactions involving H_2PO_4^- are shown :
 (i) $\text{H}_3\text{PO}_4 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{H}_2\text{PO}_4^-$, (ii) $\text{H}_2\text{PO}_4^- + \text{H}_2\text{O} \rightleftharpoons \text{HPO}_4^{2-} + \text{H}_3\text{O}^+$,
 (iii) $\text{H}_2\text{PO}_4^- + \text{OH}^- \rightleftharpoons \text{H}_3\text{PO}_4 + \text{O}^{2-}$

In which of the following reactions H_2PO_4^- is acting as an acid ?

- (A) Only I (B) Only III (C) I and II (D) Only II

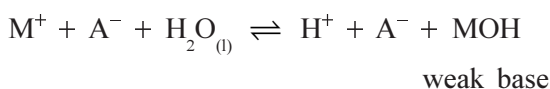
41. Four species are shown below
 (I) HCO_3^- (II) H_3O^+ (III) HSO_4^- (IV) HSO_3F
 Which of the following is correct for their acid strength ?
 (A) (IV) < (II) < (III) < (I) (B) (II) < (III) < (I) < (IV)
 (C) (I) < (III) < (II) < (IV) (D) (III) < (I) < (IV) < (II)
42. Which of the following can act as Bronstead acid and base both ?
 (A) H_2PO_2^- (B) HPO_3^- (C) HPO_4^{2-} (D) given all
43. Which of the following is conjugate base of OH^- ion ?
 (A) O^{2-} (B) O^- (C) H_2O (D) O_2
44. Calculate pH of solution produced by dissolving 0.023 gm Na metal in 100 cm^3 of water ?
 (A) 10 (B) 11 (C) 9 (D) 12
45. Calculate pH of 0.1M CH_3COOH solution having pK_a value 4.78 ?
 (A) 1.89 (B) 2.89 (C) 4.89 (D) 3.19
46. Which of the following is conjugate base of $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$?
 (A) $[\text{Al}(\text{H}_2\text{O})_5]^{2+}$ (B) $[\text{Al}(\text{H}_2\text{O})_5\text{OH}]^{2+}$ (C) $[\text{Al}(\text{H}_2\text{O})_5\text{OH}]^{3+}$ (D) not possible
47. Calculate value of pK_b for 0.004M Hydrazine solution having pH 9.7 ?
 (A) 6.20 (B) 7.20 (C) 8.20 (D) 9.20
48. 0.1M Bromoacetic acid solution has degree of ionisation 0.132 then calculate pK_a value of acid ?
 (A) 2.7 (B) 7.2 (C) 12.3 (D) 14
49. Calculate conjugate acid dissociation constant for CO_3^{2-} ionization constant of CO_3^{2-} is 2.1×10^{-4} .
 (A) 1.47×10^{-11} (B) 4.76×10^{-11} (C) 8.76×10^{-8} (D) 3.42×10^{-10}
50. $\text{H}_3\text{PO}_4 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{PO}_4^- + \text{H}_3\text{O}^+$ in which condition K_a , is affected most ?
 (A) adding H_2PO_4^- ion (B) adding H_3PO_4 (C) adding catalyst (D) On Heating
51. Which of the following is correct for diprotic acid H_2X ?
 (A) $K_{a2} > K_{a1}$ (B) $K_{a1} > K_{a2}$ (C) $K_{a1} = K_{a2}$ (D) $K_{a1} = \frac{1}{K_{a2}}$
52. If 200 ml of HCl solution having pH = 2 is mixed having pH = 12, then calculate pH of the mixture.
 (A) 2 (B) 12 (C) 11.3 (D) 7
53. If aqueous solution of 0.005 M cocaine ($\text{C}_{18}\text{H}_{21}\text{NO}_3$) has pH 9.95, then calculate its pK_b value ?
 (A) 8.92 (B) 3.76 (C) 4.29 (D) 5.81
54. An aqueous solution passes 10 % by mass ammonia and its density is 0.99 gm/cm^3 If K_a of NH_4^+ is 5×10^{-10} M then concentration of hydrogen ion is ?
 (A) 9.27×10^{-13} M (B) 9.27×10^{-11} M (C) 9.27×10^{-10} M (D) 9.27×10^{-6} M

55. Strong acid solution has pH = 5. If the given solution is diluted 100 times, then calculate pH of diluted solution ?
 (A) 5.8 (B) 6.7 (C) 9.3 (D) 13
56. How many moles of $[\text{Ca}(\text{OH})_2]$ is required to be dissolved in 250 ml of water to have pH of the solution 10.65 ? $\text{Ca}(\text{OH})_2$ undergoes complete ionisation.
 (A) 0.47×10^{-4} (B) 0.48×10^{-4} (C) 0.56×10^{-4} (D) 0.68×10^{-4}
57. 0.1 M aqueous solution of acid HQ has pH 3, then calculate its ionization constant ?
 (A) 3×10^{-1} (B) 1×10^{-3} (C) 1×10^{-5} (D) 1×10^{-7}
58. 0.2 M Hydrocyanic acid solution has K_a value of 4.9×10^{-10} calculate the percentage ionization in it ?
 (A) 4.95 % (B) 0.00549 % (C) 0.0495 % (D) 0.00495 %
59. Which of the following acid has lowest pK_a value ?
 (A) CH_3COOH (B) HCOOH (C) $(\text{CH}_3)_2\text{CHCOOH}$ (D) $\text{CH}_3\text{CH}_2\text{COOH}$

Answers : 36. (B), 37. (C), 38. (D), 39. (A), 40. (D), 41. (C), 42. (C), 43. (A), 44. (D), 45. (B), 46. (B), 47. (A), 48. (A), 49. (B), 50. (D), 51. (B), 52. (C), 53. (D), 54. (A), 55. (B), 56. (C), 57. (C), 58. (D), 59. (C)

● Hydrolysis of salt

Hydrolysis reaction of salt (MA) produced from strong acid with a weak base is as follows :



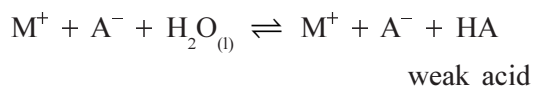
Hydrolysis constant of the salt,

$$K_h = \frac{K_w}{K_b} = \frac{[\text{H}_3\text{O}^+]^2}{C} \quad \text{where, } C = \text{concentration of salt}$$

K_b = ionization constant of base

∴ Acidic salt solution will have pH less than 7

Hydrolysis reaction of salt (MA) produced from weak acid with a strong base is as follows



Hydrolysis constant of salt,

$$K_h = \frac{K_w}{K_a} = \frac{[\text{OH}^-]^2}{C} \quad \text{where, } C = \text{concentration of salt}$$

K_a = ionization constant of acid

∴ Basic salt solution will have pH more than 7

Aqueous solution of salt produced from weak acid and weak base will have pH = 7.

Nature of solution of salt produced from weak acid and strong base depends on value of K_a and K_b .

If, $K_a = K_b$, Neutral salt

$K_a > K_b$, Acidic salt

$K_a < K_b$, Basic salt

● **Buffer solution, type of Buffer solution and pH Buffer solution**

Buffer solution : A solution which resist changes in pH due to small addition of acid or base is called buffer solution.

● **Type of Buffer solutions**

(1) **Acidic Buffer solution** : A solution prepared by mixing equal proportion of weak acid + salt of weak acid and strong base pH < 7 of solution.

(2) **Basic Buffer solution** : A solution prepared by mixing equal proportion of weak base + salt of weak base and strong acid pH > 7 of solution.

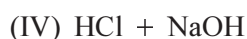
(3) **Neutral Buffer solution** : equal mixture of weak acid and weak base solution has pH = 7.

Acidic buffer solution, $\text{pH} = \text{pK}_a + \log \frac{[\text{salt}]}{[\text{Acid}]}$

Basic buffer solution $\text{pH} = 14 - \left(\text{pK}_b + \log \frac{[\text{salt}]}{[\text{Base}]} \right)$

-
60. 0.02M aqueous solution of pyridinium hydrochloride has pH = 3.44 then calculate ionization constant of pyridine ?
(A) 1.84×10^{-7} (B) 2.63×10^{-9} (C) 1.5×10^{-9} (D) 3.62×10^{-7}
61. pK_a value of a weak acid HA 4.8, weak base BOH has pK_b value of 4.78. Calculate pH of the aqueous solution of the salt BA ?
(A) 9.58 (B) 4.79 (C) 7.01 (D) 9.22
62. Calculate pH of a buffer solution made by equal molar concentrat of weak base and its chloride salt ?
(weak base $K_b = 2 \times 10^{-5}$)
(A) 5 (B) 9 (C) 4.7 (D) 9.5
63. pH of a mixture of 0.1M NH_4OH and 0.1M NH_4Cl is 9.25. Then calculate value of pK_b for NH_4OH ?
(A) 9.25 (B) 3.75 (C) 4.75 (D) 8.25
64. Calculate pK_b value of Ammonium Hydroxide. If pH of ammonium acetate solution is 7.005 and pK_a of CH_3COOH is 4.76 ?
(A) 5.35 (B) 3.45 (C) 2.25 (D) 4.75
65. How many moles of CH_3COONa should be added in a 1 litre 0.1 M CH_3COOH solution to have pH = 4 ? $K_a = 1.8 \times 10^{-5}$
(A) 1.80×10^{-2} (B) 4.70×10^{-2} (C) 2.86×10^{-4} (D) 3.32×10^{-4}
-

66. Which of the following is a buffer solution ?



(A) (II) and (III) (B) (I), (II) and (IV) (C) (II) and (IV) (D) (I) and (III)

67. 1 litre dilute solution is prepared by mixing 0.1 mole CH_3NH_2 ($K_b = 5 \times 10^{-4}$) and 0.08 mole HCl , calculate concentration of H^+ ion in the solution ?

(A) $8 \times 10^{-2}\text{M}$ (B) $8 \times 10^{-11}\text{M}$ (C) $1.6 \times 10^{-11}\text{M}$ (D) $8 \times 10^{-5}\text{M}$

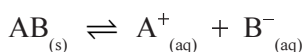
Answers : 60. (C), 61. (C), 62. (D), 63. (C), 64. (D), 65. (A), 66. (D), 67. (B)

● Sparingly soluble salt and solubility product

Sparingly soluble salt : A salt whose 0.01 M concentrated solution is a saturated solution or a salt whose solubility is less than 0.01 M is called a sparingly soluble salt.

The equilibrium constant established in a sparingly soluble salt solution is called solubility product (K_{sp}).

For AB type salt



$$\therefore K_{sp} = [\text{A}^+][\text{B}^-]$$

$$\therefore K_{sp} = (s)(s)$$

$$\therefore K_{sp} = s^2$$

$$\therefore s = \sqrt{K_{sp}}$$

$$\text{For } \text{A}_2\text{B or AB}_2 \text{ type salt, } K_{sp} = 4s^3, \therefore s = \sqrt[3]{\frac{K_{sp}}{4}}$$

$$\text{For } \text{A}_3\text{B or AB}_3 \text{ type salt, } K_{sp} = 27s^4 \therefore s = \sqrt[4]{\frac{K_{sp}}{27}}$$

$$\text{For } \text{A}_2\text{B}_3 \text{ or A}_3\text{B}_2 \text{ type salt, } K_{sp} = 108s^5 \therefore s = \sqrt[5]{\frac{K_{sp}}{108}}$$

● Common Ion effect

When aqueous solution of a weak electrolyte or saturated solution of a sparingly soluble salt has any other common ion possessing electrolyte added to them, it shifts the equilibrium in backward direction, which is known as common ion effect.

Due to common ion effect solubility of sparingly soluble salt decreases and pH of weak acid solution increases and pH of weak base solution decreases.

68. Solubility of product of $\text{Al}(\text{OH})_3$ is 2.7×10^{-11} , then its solubility and pH are respectively.
 (A) 7.8×10^{-2} , 11.5 (B) 7.8×10^{-3} , 9.5 (C) 7.8×10^{-2} , 9.5 (D) 7.8×10^{-3} , 11.5
69. How much water is needed to prepare a saturated solution of 0.1 gm lead (II) chloride ?
 (K_{sp} of $\text{PbCl}_2 = 3.2 \times 10^{-8}$, molecular mass of $\text{PbCl}_2 = 278$)
 (A) 100 ml (B) 80 ml (C) 120 ml (D) 150 ml
70. Solubility of a completely soluble salt A_xB_y at 25°C is $1.4 \times 10^{-4}\text{M}$. If solubility product is 1.1×10^{-11} , then which of the following is possible ?
 (A) $x = 1, y = 2$ (B) $x = 2, y = 1$ (C) $x = 3, y = 1$ (D) $x = 1, y = 3$
71. Solubility product of $\text{Mg}(\text{OH})_2$ at 25°C is 1.0×10^{-12} from the 0.001M Mg^{2+} ion solution at what pH, Mg^{2+} ion will start precipitating as $\text{Mg}(\text{OH})_2$?
 (A) 9 (B) 10 (C) 11 (D) 8
72. Solubility product of salt having common formula MX_2 is 4×10^{-12} , then calculate concentration of M^{2+} ion in its aqueous solution ?
 (A) $4 \times 10^{-10}\text{M}$ (B) $1.6 \times 10^{-4}\text{M}$ (C) $1 \times 10^{-4}\text{M}$ (D) $2 \times 10^{-6}\text{M}$
73. If solid $\text{Ba}(\text{NO}_3)_2$ is dissolved completely in a $1.0 \times 10^{-4}\text{M}$ Na_2CO_3 solution, then calculate concentration Ba^{2+} ion that will be precipitated ? (K_{sp} of $\text{BaCO}_3 = 5.1 \times 10^{-9}$)
 (A) $4.1 \times 10^{-5}\text{M}$ (B) $5.1 \times 10^{-5}\text{M}$ (C) $8.1 \times 10^{-8}\text{M}$ (D) $8.1 \times 10^{-7}\text{M}$
74. Solubility product of salts MX , MX_2 and M_3X at T temperature is 4.0×10^{-8} , 3.2×10^{-14} and 2.7×10^{-8} respectively. Then which of the following is order of solubility at temperature T.
 (A) $\text{MX} > \text{MX}_2 > \text{M}_3\text{X}$ (B) $\text{M}_3\text{X} > \text{MX}_2 > \text{MX}$ (C) $\text{MX}_2 > \text{M}_3\text{X} > \text{MX}$ (D) $\text{MX} > \text{M}_3\text{X} > \text{MX}_2$
75. At 298K solubility of $\text{Sr}(\text{OH})_2$ is 19.32 gm/litre , then calculate its pH ?
 (A) 12.60 (B) 11.50 (C) 13.50 (D) 10.60
76. Calculate solubility of Barium sulphate in 0.05M Barium chloride solution ? K_{sp} of $\text{BaSO}_4 = 1.1 \times 10^{-10}$
 (A) $2.2 \times 10^{-7}\text{M}$ (B) $2.2 \times 10^{-9}\text{M}$ (C) $4.2 \times 10^{-9}\text{M}$ (D) $8.9 \times 10^{-9}\text{M}$
77. Solubility product of A_2X_3 is 1.1×10^{-23} . If any type of the ions of this salt do not react with water, then calculate solubility of A_2X_3 in pure water ?
 (A) $1 \times 10^{-5}\text{M}$ (B) $2.5 \times 10^{-4}\text{M}$ (C) $1 \times 10^{-6}\text{M}$ (D) $2.5 \times 10^{-6}\text{M}$

Answers : 69. (B), 70. (A), 71. (B), 72. (C), 73. (B), 74. (D), 75. (C), 76. (B), 77. (A)

● Miscellaneous type of Questions

78. If pH of 1 litre HCl solution is 1, then How much water should be added to make $\text{pH} = 2$ of the solution ?
 (A) 0.1 liter (B) 0.9 liter (C) 2.0 liter (D) 9.0 liter
79. CO_2 gas filled in closed container at 1000 K temperature has 0.5 atm pressure. If graphite is added then CO_2 is converted into CO . Its total pressure at equilibrium is 0.8 atm , calculate value of K_p ?
 (A) 1.8 atm (B) 13 atm (C) 0.3 atm (D) 0.18 atm

80. K_{sp} of $\text{Cr}(\text{OH})_3 = 1.6 \times 10^{-30}$. Then molar solubility of $\text{Cr}(\text{OH})_3$ is
- (A) $\sqrt[2]{1.6 \times 10^{-30}}$ (B) $\sqrt[4]{1.6 \times 10^{-30}}$ (C) $\sqrt[4]{1.6 \times 10^{-\frac{30}{27}}}$ (D) $1.6 \times 10^{-\frac{30}{27}}$
81. Ionization constant of aqueous solution of carbonic acid is $K_1 = 4.2 \times 10^{-7}$ and $K_2 = 4.8 \times 10^{-11}$ then which of the following statement is correct for 0.034 M saturated solution of carbonic acid ?
- (A) Concentration of CO_3^{2-} ion is 0.034 M.
 (B) Concentration of CO_3^{2-} ion is more than concentration of HCO_3^- .
 (C) Concentration of H^+ and HCO_3^- is approximately same.
 (D) Concentration of H^+ is double than concentration of CO_3^{2-} .
82. Calculate pH of 0.005M calcium acetate solution ? pK_a of CH_3COOH is 4.74.
- (A) 7.04 (B) 9.37 (C) 8.37 (D) 10.26
83. Which of the following compound has more tendency to accept a proton ?
- (A) H_2O (B) H_2S (C) NH_3 (D) PH_3
84. Which of the following is a formula for equilibrium constant for the reaction $\text{P}_{4(s)} + 5\text{O}_{2(g)} \rightleftharpoons \text{P}_4\text{O}_{10(s)}$?
- (A) $K_c = \frac{[\text{P}_4\text{O}_{10}]}{[\text{P}_4][\text{O}_2]^5}$ (B) $K_c = \frac{[\text{P}_4\text{O}_{10}]}{5[\text{P}_4][\text{O}_2]^5}$ (C) $K_c = [\text{O}_2]^5$ (D) $K_c = \frac{1}{[\text{O}_2]^5}$
85. Calculate concentration of H^+ ion at neutralization pt when 2.5 ml $\frac{2}{5}$ M weak monoacidic base ($K_b = 1 \times 10^{-12}$) is neutralised by $\frac{2}{15}$ M HCl ?
- (A) $3.7 \times 10^{-13}\text{M}$ (B) $3.2 \times 10^{-7}\text{M}$ (C) $3.2 \times 10^{-2}\text{M}$ (D) $2.7 \times 10^{-2}\text{M}$
86. Reaction : $\text{Ag}^+ + \text{NH}_3 \rightleftharpoons [\text{Ag}(\text{NH}_3)]^+$; $K_1 = 3.5 \times 10^{-3}$
 $[\text{Ag}(\text{NH}_3)_2]^+ + \text{NH}_3 \rightleftharpoons [\text{Ag}(\text{NH}_3)_2]^+$; $K_2 = 1.7 \times 10^{-3}$. $[\text{Ag}(\text{NH}_3)_2]^+$ Calculate equilibrium constant for preparation of $[\text{Ag}(\text{NH}_3)_2]^+$?
- (A) 6.08×10^{-6} (B) 6.08×10^6 (C) 6.08×10^{-9} (D) 6.08×10^9
87. Weak acid HX having $K_a = 10^{-5}$ reacts with 0.1 M concentrated caustic soda and produce salt NaX. Calculate degree of ionisation of Na X ?
- (A) 0.01 % (B) 0.0001 % (C) 0.1 % (D) 0.5 %
88. If solubility product of sparingly soluble salt A_pB_q is (L_s) and solubility (S), then
- (A) $L_s = S^{p+q} \cdot p^p \cdot q^q$ (B) $L_s = S^{p+q} \cdot p^q \cdot q^p$ (C) $L_s = S^{pq} \cdot p^p \cdot q^q$ (D) $L_s = S^{pq} \cdot (pq)^{p+q}$
89. Which of the following is the increasing order of pH for 0.1 M salt solutions ?
- (A) $\text{NaCl} < \text{NH}_4\text{Cl} < \text{NaCN} < \text{HCl}$ (B) $\text{HCl} < \text{NH}_4\text{Cl} < \text{NaCl} < \text{NaCN}$
 (C) $\text{NaCN} < \text{NH}_4\text{Cl} < \text{NaCl} < \text{HCl}$ (D) $\text{HCl} < \text{NaCl} < \text{NaCN} < \text{NH}_4\text{Cl}$
90. Calculate pH of the mixture produced by mixing 40 ml 0.1 M Ammonia solution with 20 ml 0.1 M HCl solution ? ($\text{pK}_b(\text{NH}_3) = 4.74$)
- (A) 4.74 (B) 2.26 (C) 9.26 (D) 5.00

91. What is the temperature of neutral water having pH = 6.5 ?
 (A) 25° C. (B) more than 25° C.
 (C) less than 25° C. (D) more or less than 25° C.
92. pH of HCOOH and CH₃COOH solution is same. If $\frac{K_1}{K_2}$ is ratio of ionization constant of both the acid and its value is 4.0, then calculate their molar concentration ratio ?
 (A) 2 (B) 0.5 (C) 4 (D) 0.25
93. If two equal volume of AgNO₃ and NaCl solution are mixed then AgCl ($K_{sp} = 1.81 \times 10^{-10}$) is preprecipitated, then concentration of Ag⁺ and Cl⁻ is respectively.
 (A) 10⁻³M, 10⁻¹⁰M (B) 10⁻⁵M, 10⁻⁵M (C) 10⁻⁶M, 10⁻⁵M (D) 10⁻⁴M, 10⁻⁴M
94. If solubility of M molecular mass calcium phosphate at 25° C is w gm per 100 ml then calculate its solubility product at the same temperature ?
 (A) $10^9 \left(\frac{W}{M}\right)^5$ (B) $10^7 \left(\frac{W}{M}\right)^5$ (C) $10^5 \left(\frac{W}{M}\right)^5$ (D) $10^3 \left(\frac{W}{M}\right)^3$
95. 0.1M aqueous solution of weak base MOH undergoes 1 % ionisation. If 0.2 M MCl is added to 1 litre MOH aqueous solution then calculate ionisation constant of MOH ?
 (A) 0.02 (B) 0.005 (C) 5×10^{-5} (D) 2×10^{-3}
96. Reaction $2AB_{2(g)} \rightleftharpoons 2AB_{(g)} + B_{2(g)}$ has degree of dissociation X whose value is very small compared to 1 then which of the following indicates relation between dissociation constant (X), equilibrium constant (K_p) and total pressure P ?
 (A) $\left(\frac{2K_p}{P}\right)^{\frac{1}{2}}$ (B) $\left(\frac{K_p}{P}\right)$ (C) $\left(\frac{2K_p}{P}\right)$ (D) $\left(\frac{2K_p}{P}\right)^{\frac{1}{3}}$
97. Reaction $A_{(g)} + 3B_{(g)} \rightleftharpoons 4C_{(g)}$ has initial concentration of A and B equal. At equilibrium concentration of A and C are same. Then K_c =
 (A) 0.08 (B) 0.8 (C) 80 (D) 8
98. Reaction $NH_4COONH_{2(s)} \rightleftharpoons 2NH_{3(g)} + CO_{2(g)}$ at equilibrium has pressure 6 atm then calculate its K_p ?
 (A) 32 (B) $\frac{4}{27}$ (C) 27 (D) $\frac{4}{32}$
99. $2PQ \rightleftharpoons P_2 + Q_2$; $K_1 = 2.5 \times 10^{+5}$
 $PQ + \frac{1}{2}R_2 \rightleftharpoons PQR$; $K_2 = 5 \times 10^{-3}$
 What will be the value of equilibrium constant K₃ if the following reaction occurs from the above reaction ?
 $\frac{1}{2}P_2 + \frac{1}{2}Q_2 + \frac{1}{2}R_2 \rightleftharpoons PQR$
 (A) 2.5×10^{-3} (B) 2.5×10^3 (C) 1×10^{-5} (D) 5×10^3

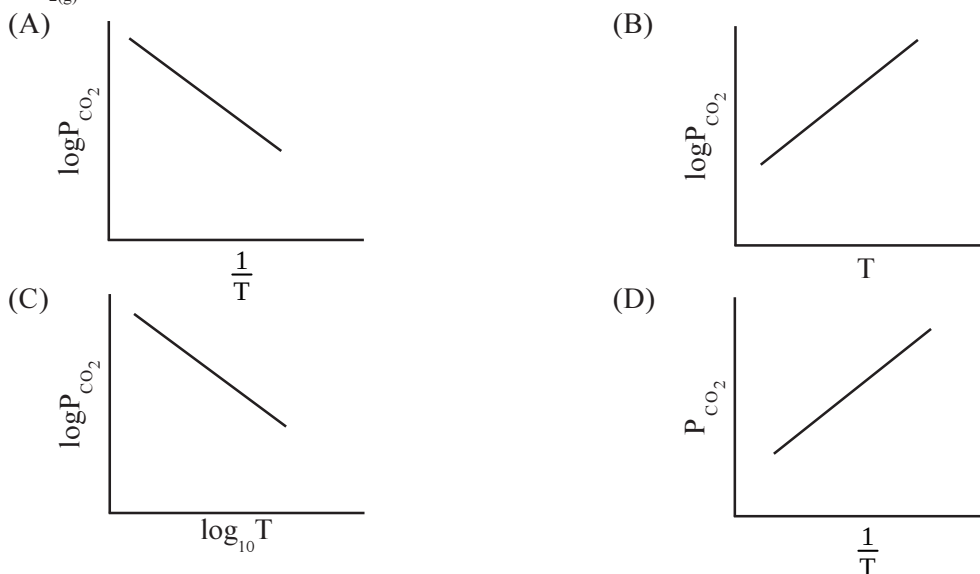
100. $X \rightleftharpoons 2Y$ and $Z \rightleftharpoons P + Q$ reactions have equilibrium constant k_{p1} and k_{p2} respectively ratio of this equilibrium constant is 1:9. If degree of dissociation of X and Z is same, then ratio of total pressure at equilibrium is

- (A) 1:1 (B) 1:3 (C) 1:9 (D) 1:36

101. Which of the following statement is true for $2XY \rightleftharpoons X_2 + Y_2$, $\Delta H^\circ = 50 \text{ KJ}$?

- (A) Value of K increases on adding XY.
 (B) Value of K increases with increase in temperature
 (C) Value of K decreases with decrease in temperature.
 (D) value of K is independent of temperature.

102. Which of the following graph can be used to calculate value of $\Delta_f H^\circ$ for $\text{CaCO}_{3(s)} \rightleftharpoons \text{CaO}_{(s)} + \text{CO}_{2(g)}$ at equilibrium ?



103. For reaction $\text{NH}_4\text{HS}_{(s)} \rightleftharpoons \text{NH}_{3(g)} + \text{H}_2\text{S}_{(g)}$ at equilibrium and 300 K temperature has pressure 100 atm. Then calculate value of equilibrium constant ?

- (A) 2500 atm² (B) 50 atm² (C) 100 atm² (D) 200 atm²

104. $\text{AB}_{(g)} \rightleftharpoons \text{A}_{(g)} + \text{B}_{(g)}$ reaction of 33 % dissociation of AB at total pressure, P mention relation between total pressure and equilibrium constant ?

- (A) $P = K_p$ (B) $P = 3K_p$ (C) $P = 4K_p$ (D) $P = 8K_p$

105. For reaction $\text{PCl}_{5(g)} \rightleftharpoons \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$

at 500K temperature and $K_p = 0.497$. These three gases are filled in a container of initial pressure of these gases is 1 atm. Which of the following statement is correct ?

- (A) PCl_5 is produced more.
 (B) PCl_3 is produced more.
 (C) equilibrium is established after 50 % reaction is completed.
 (D) Cl_2 is produced more.

106. $\text{SO}_2\text{Cl}_{2(g)} \rightleftharpoons \text{SO}_{2(g)} + \text{Cl}_{2(g)}$ reaction at equilibrium has vapour density 50. Calculate percentage of dissociation of $\text{SO}_2\text{Cl}_{2(g)}$?

- (A) 32 (B) 35 (C) 60 (D) 66

107. Aqueous solution of 0.1 M NaZ has pH = 8.90 then HZ has $K_a = \dots\dots\dots$.
 (A) 6.3×10^{-11} (B) 6.3×10^{-10} (C) 1.6×10^{-5} (D) 1.6×10^{-6}
108. For which of the following titration phenol is not a useful indicator ?
 (A) HCl and NH_4OH (B) $\text{Ca}(\text{OH})_2$ and HCl
 (C) NaOH and H_2SO_4 (D) KOH and CH_3COOH
109. When a weak base is neutralised by strong acid the pH of the solution is 8 then calculate K_b of the base ?
 (A) 1×10^{-4} (B) 1×10^{-6} (C) 1×10^{-8} (D) 1×10^{-10}
110. PbSO_4 of $k_{sp} = 1.8 \times 10^{-8}$ and K_a of HSO_4^- is $k_a = 1.0 \times 10^{-2}$.
 calculate equilibrium constant for $\text{PbSO}_{4(s)} + \text{H}^+_{(aq)} \rightleftharpoons \text{HSO}_{4(aq)}^- + \text{Pb}^{2+}_{(aq)}$
 (A) 1.8×10^{-6} (B) 1.8×10^{-10} (C) 2.8×10^{-10} (D) 1×10^{-2}
111. $[\text{OH}^-] = 10^{-6}$ M in an aqueous solution of NH_4Cl and NH_4OH . If equal volume of above mentioned solution and which of the following 0.1 M aqueous solution of metal ion should be mixed to precipitate metal Hydroxide ?
 $\text{Mg}(\text{OH})_2$ ($K_{sp} = 3 \times 10^{-11}$) $\text{Cd}(\text{OH})_2$ ($K_{sp} = 8 \times 10^{-6}$)
 $\text{Fe}(\text{OH})_2$ ($K_{sp} = 8 \times 10^{-16}$) AgOH ($K_{sp} = 5 \times 10^{-3}$)
 (A) Mg^{2+} (B) Fe^{2+} (C) Cd^{2+} (D) Ag^+
112. Buffer solution having equal concentration of B^- and HB has K_b for B^- to 10^{-10} , then calculate pH of the solution ?
 (A) 10 (B) 7 (C) 6 (D) 4
113. Calculate concentration of $\text{H}^+_{(aq)}$ ion if equal volume of three acid solution having pH 3, 4 and 5 are mixed ?
 (A) 3.7×10^{-3} M (B) 1.11×10^{-3} M (C) 1.11×10^{-4} M (D) 3.7×10^{-4} M
114. Which compounds will be precipitated if H_2S is passed through mixture of acid solution having Mn^{2+} , Ni^{2+} , Cu^{2+} and Hg^{2+} ion ?
 (A) CuS and HgS (B) MnS and CuS (C) MnS and NiS (D) NiS and HgS
115. Calculate the concentration of H^+ ion if 0.1 mole CH_3NH_2 ($K_b = 5 \times 10^{-4}$) and 0.05 mole HCl are mixed and one litre aqueous solution is formed ?
 (A) 8×10^{-2} M (B) 8×10^{-11} M (C) 1.6×10^{-11} M (D) 8×10^{-5} M
116. Solubility of $\text{C}_6\text{H}_5\text{COOAg}$ in water and solution having pH 2, 3 and 4 are S_1 , S_2 , S_3 and S_4 respectively then which of the following is decreasing order of solubility of $\text{C}_6\text{H}_5\text{COOAg}$?
 (A) $S_1 > S_2 > S_3 > S_4$ (B) $S_4 > S_3 > S_2 > S_1$ (C) $S_2 > S_3 > S_4 > S_1$ (D) $S_3 > S_2 > S_4 > S_1$
117. Calculate the volume required to dissolve 1 mg PbSO_4 at 25°C temperature ?
 (K_{sp} of $\text{PbSO}_4 = 1.44 \times 10^{-8}$, $M_w = 303$ gm/mole)
 (A) 80 ml (B) 43 ml (C) 27.5 ml (D) 10 ml

118. Calculate solubility of CH_3COOAg in a buffer solution having $\text{pH} = 4$ ($K_w = 10^{-14}$, $K_a = 10^{-5}$)

- (A) 10^{-6}M (B) $0.5 \times 10^{-6}\text{M}$ (C) $5 \times 10^{-6}\text{M}$ (D) $2 \times 10^{-6}\text{M}$

119. Which of the following substance has its aqueous solution with pH greater than 7 ?

- (I) BaF_2 (II) RbI (III) $\text{C}_6\text{H}_5\text{COONa}$ (IV) $(\text{CH}_3\text{COO})_2\text{Ba}$
 (A) I (B) I, III (C) I, II, III (D) I, III, IV

● Questions having more than one correct options :

120. From the mixture of which of the following substance buffer solution can be prepared ?

- (A) Sodium acetate and Acetic acid (B) Sodium acetate and Hydrochloric acid
 (C) Ammonia and Ammonium chloride (D) Ammonia and sodium hydroxide

121. Which of the following aqueous solution will have $\text{pH} = 13$?

- (A) 2 gm NaOH in 500 ml solution (B) 0.05M $\text{Ca}(\text{OH})_2$ in 100 ml solution
 (C) 0.1N $\text{Ca}(\text{OH})_2$ in 100 ml solution (D) 4 gm NaOH containing 500 ml solution

122. Which of the following is true for various dissociation constant of H_3PO_4 ?

- (A) $K_{a1} = K_{a2} \times K_{a3}$ (B) $K_{a1} < K_{a2} < K_{a3}$
 (C) $K_{a1} = K_{a2} = K_{a3}$ (D) $K_{a1} > K_{a2} > K_{a3}$

123. Which of the following is true if 0.1 litre 0.0015 M MgCl_2 is mixed with 0.1 litre of 0.025 M NaF (K_{sp} of $\text{MgF}_2 = 3.7 \times 10^{-8}$)

- (A) MgF_2 remains in solution. (B) MgF_2 will be precipitated
 (C) MgCl_2 is precipitated. (D) Cl^- remains in the solution

124. Which of the following aqueous solution on dilution will not change pH ?

- (A) NH_4CN (B) NH_4Cl (C) CH_3COONa (D) $\text{CH}_3\text{COONH}_4$

125. Which of the following statement is correct :

- (A) On adding more salt pH of acid buffer solution decreases.
 (B) On adding more salt pH of acid buffer solution increases.
 (C) On adding more salt pH of basic buffer solution increases.
 (D) On adding more salt pH of basic buffer solution decreases.

● Given below each question has two statements. Where one is assertion (A) and second is reason (R). Studying the statement carefully according to given instruction select correct option :

- (A) Assertion (A) and reason (R) both are correct and reason (R) is not correct explanation of assertion (A).
 (B) Assertion (A) and reason (R) both are correct but reason (R) is not correct explanation of assertion (A).
 (C) Assertion (A) is not correct while reason (R) is incorrect.
 (D) Assertion (A) is incorrect while reason (R) is correct.

126. **Assertion (A)** : On passing HCl gas in saturated solution of NaCl , precipitation of NaCl occurs.

Reason (R) : HCl is a strong acid.

127. **Assertion (A)** : If H_2S is passed through alkaline solution Sb (III) is not precipitated as sulphide.
Reason (R) : Proportion of S^{2-} ion in alkaline medium is not enough.
128. **Assertion (A)** : CHCl_3 is stronger acid than CHCl_3 .
Reason (R) : Conjugate base of CHCl_3 is more stable than conjugate base of CHF_3 .
129. **Assertion (A)** : Equal concentration containing HCl solution has pH less than pH of CH_3COOH solution.
Reason (R) : Equimolar concentration solution of HCl does not have enough proton to undergo Neutralisation.
130. **Assertion (A)** : Calcium phosphate is more soluble in HNO_3 than water.
Reason (R) : Phosphate which is a weak base, reacts with H^+ ion and produce soluble nitrate of calcium.

● **Integer type Questions**

131. How many acids from the following acids are diprotic ?
 H_3PO_4 , H_2SO_4 , H_3PO_3 , H_2CO_3 , $\text{H}_2\text{S}_2\text{O}_3$, H_3BO_3 , H_3PO_2 , H_2CrO_4 , H_2SO_3
132. At 25°C temperature, $\text{C}_6\text{H}_5\text{COOH}$ has $K_a = 1 \times 10^{-4}$ then what will be the pH of its 0.01M sodium salt solution ?
133. In 1 litre saturated solution of AgCl ($K_{sp}(\text{AgCl}) = 1.6 \times 10^{-10}$), if 0.1 M CuCl ($K_{sp} = 1 \times 10^{-6}$) is added, then concentration of Ag^+ in the solution is 1.6×10^{-x} , then what will be the value of X ?

Answers : 78. (D), 79. (A), 80. (C), 81. (C), 82. (A), 83. (C), 84. (D), 85. (D), 86. (A), 87. (A), 88. (A), 89. (B), 90. (C), 91. (B), 92. (D), 93. (B), 94. (B), 95. (C), 96. (D), 97. (D), 98. (A), 99. (C), 100. (D), 101. (C), 102. (A), 103. (A), 104. (D), 105. (A), 106. (B), 107. (C), 108. (A), 109. (B), 110. (A), 111. (B), 112. (D), 113. (D), 114. (A), 115. (B), 116. (C), 117. (C), 118. (D), 119. (C), 120. (A), 121. (A), (B), (C), 122. (A), (D), 123. (B), (D), 124. (A), (D), 125. (B), (C), 126. (B), 127. (A), 128. (A), 129. (C), 130. (A), 131. (6), 132. (8), 133. (7)

