CHAPTER

6

Chemical Equilibrium

EXERCISE I (JEE MAIN)

Basic

1. The reaction which proceeds towards completion in the forward direction is
   - (a) $Fe_2O_3 + 6HCl \rightleftharpoons FeCl_3 + 3H_2O$
   - (b) $SnCl_4 + Hg_2Cl_2 \rightleftharpoons SnCl_2 + 2HgCl_2$
   - (c) $NH_3 + H_2O + NaCl \rightleftharpoons NH_4Cl + NaOH$
   - (d) $2CuI + I_2 + 4K^+ \rightleftharpoons 2Cu^{2+} + 4KI$

2. The concentration of a pure solid or liquid phase is not included in the expression of equilibrium constant because
   - (a) solid and liquid concentrations are independent of their quantities.
   - (b) solid and liquids react slowly.
   - (c) solid and liquids at equilibrium do not interact with gaseous phase.
   - (d) the molecules of solids and liquids cannot migrate to the gaseous phase.

3. For the reversible reaction: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ at 500°C, the value of K_p is 1.44×10^{-5} when partial pressure is measured in atmospheres. The corresponding value of K_c, with concentration in mole litre^{-1}, is
   - (a) $\dfrac{1.44\times10^{-5}}{(0.082\times500)^{-2}}$
   - (b) $\dfrac{1.44\times10^{-5}}{(8.314\times773)^{-2}}$
   - (c) $\dfrac{1.44\times10^{-5}}{(0.082\times773)^{2}}$
   - (d) $\dfrac{1.44\times10^{-5}}{(0.082\times773)^{-2}}$

4. 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

5. At constant temperature, the equilibrium constant (K_p) for the decomposition reaction: $N_2O_4 \rightleftharpoons 2NO_2$ is expressed by $K_p = \dfrac{4x^2P}{1-x^2}$, where P = total pressure at equilibrium, x = extent of decomposition. Which one of the following statements is true?
   - (a) K_p increases with increase of P.
   - (b) K_p increases with increase of x.
   - (c) K_p increases with decrease of x.
   - (d) K_p remains constant with change in P and x.

6. For the reaction: $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$, K_P is
   - (a) P_{CO_2}
   - (b) $\dfrac{P_{CO_2}}{P_{CaCO_3}}$
   - (c) $\dfrac{[CaO][CO_2]}{[CaCO_3]}$
   - (d) $\dfrac{P_{CaCO_3}}{P_{CaO}P_{CO_2}}$

7. $XeF_6 + H_2O \rightleftharpoons XeOF_4 + 2HF$; equilibrium constant = K_1.

$XeO_4 + XeF_6 \rightleftharpoons XeOF_4 + XeO_3F_2$; equilibrium constant = K_2.

Then equilibrium constant for the following reaction will be:

$XeO_4 + 2HF \rightleftharpoons XeO_3F_2 + H_2O$

(a) $\frac{K_1}{K_2}$ (b) $K_1 + K_2$
(c) $\frac{K_2}{K_1}$ (d) $K_2 - K_1$

8. K_P for formation of ethane from hydrogen and ethylene is 5.5×10^{18} atm^{-1} and K_P for formation of ethylene from hydrogen and acetylene is 5×10^{26} atm^{-1} at 323 K. What is K_P for the reaction between hydrogen and acetylene to form ethane at 323 K?

(a) 2.75×10^{45} atm^{-2}
(b) 1.1×10^{-8}
(c) 9.09×10^{7}
(d) 3.63×10^{-46} atm^{2}

9. For a reversible reaction: $A + B \rightleftharpoons C$, if the concentrations of the reactants are doubled at a definite temperature, then equilibrium constant will

(a) be doubled
(b) be halved
(c) be one fourth
(d) remain same

10. $\frac{K_C}{K_P}$ for reaction:

$CO(g) + \frac{1}{2}O_2(g) \rightleftharpoons CO_2(g)$ is

(a) $\frac{1}{\sqrt{RT}}$
(b) $\sqrt{RT}$
(c) $1/RT$
(d) 1

11. The equilibrium constant for the reaction: $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ is K_1 and the equilibrium constant for the reaction: $NO(g) \rightleftharpoons \frac{1}{2}N_2(g) + \frac{1}{2}O_2(g)$ is K_2, both at the same temperature. K_1 and K_2 are related as

(a) $K_1 = \left(\frac{1}{K_2}\right)^2$ (b) $K_1 = K_2^2$
(c) $K_2 = \left(\frac{1}{K_1}\right)^2$ (d) $K_2 = K_1^2$

12. Equilibrium constants for some reactions are given. In which of the following case does the reaction go farthest to completion?

(a) $K = 10^2$ (b) $K = 10^{-2}$
(c) $K = 10$ (d) $K = 1$

13. For a reversible reaction, the rate constants for the forward and backward reactions are 0.16 and 4×10^4, respectively. What is the value of equilibrium constant of the reaction?

(a) 0.25×10^6 (b) 2.5×10^5
(c) 4×10^{-6} (d) 4×10^{-4}

14. The following reaction has an equilibrium constant K_C equal to 3.07×10^{-4} at 24°C

$2NOB(g) \rightleftharpoons 2NO(g) + Br_2(s)$

The correct set of concentrations at which the rate of forward reaction is greater than that of backward reaction is

(a) [NOBr] = 0.06 M, [NO] = 0.015 M, [Br_2] = 0.01 M
(b) [NOBr] = 0.15 M, [NO] = 0.015 M, [Br_2] = 0.014 M
(c) [NOBr] = 0.18 M, [NO] = 0.012 M, [Br_2] = 0.02 M
(d) [NOBr] = 0.045 M, [NO] = 0.0105 M, [Br_2] = 0.01 M

15. NO_2 is involved in the formation of smog and acid rain. It is formed importantly as:

$NO(g) + O_3(g) \rightleftharpoons NO_2(g) + O_2(g)$; $K_C = 6.0 \times 10^{34}$

The air over a metropolitan city contained 1.0×10^{-5} M-NO, 1.0×10^{-6} M-O_3, 2.5×10^{-4} M-NO_2 and 8.2×10^{-3} M-O_2. These data suggest that

(a) more of NO and O_3 tend to be formed
(b) more of NO_2 and O_2 tend to be formed
(c) more of NO_2 and O_3 tend to be formed
(d) no tendency to change because the reaction is at equilibrium

16. For the reaction: $I_2(g) \rightleftharpoons 2I(g)$, $K_C = 1.0 \times 10^{-2}$ mol lit^{-1}. What volume of the vessel should be taken so that at equilibrium 1 mole of I_2 and 0.5 mole of 'I' are present at equilibrium?

(a) 25 l
(b) 0.04 l
(c) 0.25 l
(d) 5 l

17. The equilibrium constant for the reaction: $3C_2H_2 \rightleftharpoons C_6H_6$ is 4.0 at *T* K. If the equilibrium concentration of C_2H_2 is 0.5 M, then the concentration of C_6H_6 at equilibrium is

(a) 0.5 M
(b) 1.5 M
(c) 5×10^{-2} M
(d) 0.25 M

18. The equilibrium mixture for the reaction: $2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g)$ has 1 mole H_2S, 0.20 mole H_2 and 0.80 mole of S_2 in a 2 L vessel. K_C for the reaction is

(a) 0.16 M
(b) 0.008 M
(c) 0.016 M
(d) 0.032 M

19. A gaseous mixture contains 0.30 moles CO, 0.10 moles H_2, and 0.03 moles H_2O vapour and an unknown amount of CH_4 per litre. This mixture is at equilibrium at 1200 K.

$CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$; $K_C = 3.9$

What is the concentration of CH_4 in this mixture? The equilibrium constant K_C equals 3.92.

(a) 0.39 M
(b) 0.039 M
(c) 0.78 M
(d) 0.078 M

20. For the reaction: $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$, $\Delta H° = 18$ kcal and $\Delta S° = 30$ cal/K at 300 K. The equilibrium constant, $K_P°$ of the reaction at 300 K is

(a) e^{15}
(b) e^{-15}
(c) e^{-18}
(d) e^{-12}

21. For the gas phase reaction: $2NO(g) \rightleftharpoons N_2(g) + O_2(g)$; $\Delta H = -43.5$ kcal. Which one of the following is true for the reaction: $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$?

(a) *K* is independent of *T*
(b) *K* decreases as *T* decreases
(c) *K* increases as *T* decreases
(d) *K* varies with addition of NO

22. The equilibrium constant for the reaction: $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ is 4.0×10^{-4} at 2000 K. In the presence of a catalyst, the equilibrium is attained 10 times faster. Therefore, the equilibrium constant in presence of the catalyst at 2000 K is

(a) 4×10^{-3}
(b) 4×10^{-5}
(c) 4×10^{-4}
(d) Unpredictable

23. What is the approximate value of log K_P for the reaction:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ at 25°C.

The standard enthalpy of formation of $NH_3(g)$ is –40.0 kJ/mol and standard entropies of $N_2(g)$, $H_2(g)$ and $NH_3(g)$ are 191, 130 and 192 $JK^{-1}\ mol^{-1}$, respectively.

(a) 0.04 (b) 7.05
(c) 8.6 (d) 3.73

24. If K_1 and K_2 are the equilibrium constants for a reversible reaction at T_1 K and T_2 K temperature, respectively ($T_1 < T_2$) and the reaction takes place with neither heat evolution nor absorption, then

(a) $K_1 > K_2$ at high temperature
(b) $K_1 < K_2$ at high temperature
(c) $K_1 = K_2$ only at high temperature
(d) $K_1 = K_2$ at any temperature

25. From the following data:

(i) $H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$; $K_{2000\ K} = 4.4$
(ii) $2H_2O(g) \rightleftharpoons 2H_2(g) + O_2(g)$; $K_{2000\ K} = 5.31 \times 10^{-10}$
(iii) $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$; $K_{1000\ K} = 2.24 \times 10^{22}$

Show whether the reaction (iii) is exothermic or endothermic or thermal?

(a) Exothermic
(b) Endothermic
(c) Thermal
(d) Cannot say

26. In the decomposition equilibrium of a certain metallic carbonate, the partial pressure of CO_2 becomes a hundred fold when the temperature increased from 400 K to 500 K. What is the mean value of $\Delta H°$ for the given range of temperature?

(a) 18.4 kcal/mol
(b) 13.84 kcal/mol
(c) 14.83 kcal/mol
(d) 10.83 kcal/mol

27. The equilibrium constants for the reaction: $A_2 \rightleftharpoons 2A$ at 500 K and 1000 K are 1×10^{-10} and 1×10^{-5}, respectively. The reaction is

(a) Exothermic
(b) Very slow
(c) Very fast
(d) Endothermic

28. The activation energies for the forward and reverse elementary reactions in the system: $A \rightleftharpoons B$, are 10.303 and 8.000 kcal, respectively, at 500 K. Assuming the pre-exponential factor to be the same for both the forward and reverse steps, the equilibrium constant of the reaction at 500 K is

(a) 1.00 (b) 10.0
(c) 100 (d) 0.1

29. $\Delta G°$ for the reaction: $X + Y \rightleftharpoons C$ is – 4.606 kcal at 1000 K. The equilibrium constant for the reverse mode of the reaction is

(a) 100 (b) 10
(c) 0.01 (d) 0.1

30. For a gaseous equilibrium: $2A(g) \rightleftharpoons 2B(g) + C(g)$, K_P has a value 1.8 at 700 K. The value of K_C for the equilibrium: $2B(g) + C(g) \rightleftharpoons 2A(g)$ at that temperature is about

(a) 0.031
(b) 32
(c) 57.4
(d) 103.3

Application of Equilibrium Constant

31. Amounts of 0.8 mol of PCl_5 and 0.2 mole of PCl_3 are mixed in a 1 l flask. At equilibrium, 0.4 mole of PCl_3 is present. The equilibrium constant for the reaction, $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ will be

(a) 0.05 mol l^{-1}
(b) 0.13 mol l^{-1}
(c) 0.013 mol l^{-1}
(d) 0.60 mol l^{-1}

32. One mole of pure PCl_5 is placed in an evacuated container and maintained at 250°C. The equilibrium is established at total pressure of 2 atm. What is the partial pressure of chlorine at equilibrium?

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$; $K_P = 1.6$ atm

(a) 0.4 atm (b) 0.67 atm
(c) 0.80 atm (d) 0.64 atm

33. For the reaction: $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, if initial moles of PCl_5 is 'x', a is the degree of dissociation and P is total pressure at equilibrium, then $P_{PCl_3} \cdot P^{-1}$ is equal to

(a) $\frac{x}{1+x}$ (b) $\frac{ax}{a+x}$
(c) $\frac{a}{1+a}$ (d) $\frac{a}{x+ax}$

34. In a 5.76 l vessel, 0.5 moles of H_2 gas and 0.5 moles of I_2 vapours are allowed to react to form HI(g) at 447°C, then total pressure of gases at equilibrium would be ($R = 0.08$ l-atm/K-mol)

(a) 20 atm (b) 10 atm
(c) 5 atm (d) 1 atm

35. In a closed tube, HI(g) is heated at 440°C up to establishment of equilibrium. If it dissociates into $H_2(g)$ and $I_2(g)$ up to 22%, the dissociation constant is

(a) 0.282 (b) 0.0796
(c) 0.0199 (d) 1.99

36. For the reaction: $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, the value of equilibrium constant is 9.0. The degree of dissociation of HI will be

(a) 0.5 (b) 0.33
(c) 0.4 (d) 0.67

37. At 444°C, HI is 30% dissociated. If initially 3 moles of HI are taken, the number of moles of HI at equilibrium is

(a) 0.9 (b) 2.1
(c) 0.45 (d) 1.8

38. One mole of N_2O_4 (g) at 300 K is kept in a closed container under one atm. It is heated to 600 K when 20% by mass of $N_2O_4(g)$ decomposes to $NO_2(g)$. The resultant pressure is

(a) 1.2 atm
(b) 2.4 atm
(c) 2.0 atm
(d) 1.0 atm

39. For the reaction: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, the relation between the degree of dissociation, α, of $N_2O_4(g)$ at pressure, P, with its equilibrium constant K_P is

(a) $\alpha = \frac{K_P/P}{4 + K_P/P}$

(b) $\alpha = \frac{K_P}{4 + K_P}$

(c) $\alpha = \left[\frac{K_P / P}{4 + K_P / P}\right]^{1/2}$

(d) $\alpha = \left[\frac{K_P}{4 + K_P}\right]^{1/2}$

40. At total pressure P_1 atm and P_2 atm, N_2O_4 is dissociated to an extent of 33.33% and 50.00%, respectively. The ratio of pressures P_1 and P_2 is

(a) 3:8 (b) 2:1
(c) 8:3 (d) 1:2

41. At 0°C and 1 atm pressure, 1 L of N_2O_4 decomposes to NO_2 according to the equation $N_2O_4(g) \rightleftharpoons 2NO_2\ (g)$. To what extent has the decomposition proceeded when the original volume is 25% less than that of existing volume?

(a) 0.67 (b) 0.33
(c) 0.25 (d) 0.75

42. Forty per cent of a mixture of 0.2 mol of N_2 and 0.6 mol of H_2 react to give NH_3 according to the equation:

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

at constant temperature and pressure. Then, the ratio of the final volume to the initial volumes of gases is

(a) 4:5 (b) 5:4
(c) 7:10 (d) 8:5

43. An amount of 4 moles of NH_3 gas is introduced with a previously evacuated 1 L container in which it is partially dissociated at high temperature as

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

At equilibrium, 2 mole of $NH_3(g)$ remained. The value of K_C for the reaction is

(a) $1.5M^2$ (b) $0.75M^2$
(c) $0.44M^{-2}$ (d) $2.25M^2$

44. In a closed container maintained at 1 atm pressure and 25°C, 2 moles of $SO_2(g)$ and 1 mole of $O_2(g)$ were allowed to react to form $SO_3(g)$ under the influence of a catalyst.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

At equilibrium, it was found that 50% of $SO_2(g)$ was converted to $SO_3(g)$. The partial pressure of $O_2(g)$ at equilibrium will be

(a) 0.17 atm (b) 0.5 atm
(c) 0.33 atm (d) 0.20 atm

45. One mole of ethanol is treated with one mole of ethanoic acid at 25°C. One-fourth of the acid changes into ester at equilibrium. The equilibrium constant for the reaction will be

(a) 1/9 (b) 4/9
(c) 9 (d) 9/4

46. One mole each of A and B and 3 moles each of C and D are placed in 1 L flask. If equilibrium constant is 2.25 for the reaction: $A + B \rightleftharpoons C + D$, equilibrium concentrations of A and C will be in the ratio

(a) 2:3 (b) 3:2
(c) 1:2 (d) 2:1

47. For the reaction: $XY_2(g) \rightleftharpoons XY(g) + Y(g)$, the reaction is started with initial pressure of XY_2, 600 mm Hg. The total pressure for gases at equilibrium is 800 mm Hg. Assuming volume and temperature of the system remains constant, the value of K_P is

(a) 100 atm
(b) 100 mm Hg
(c) 0.01 atm
(d) 400 mm Hg

48. For the reaction: $A + B \rightleftharpoons C + D$, the initial concentration of A and B is equal, but the equilibrium concentration of C is twice that of equilibrium concentration of A. The equilibrium constant is

(a) 4 (b) 9
(c) 1/4 (d) 1/9

49. $I_2 + I^- \rightleftharpoons I_3^-$. This reaction is set up in aqueous medium. We start with 1 mol of I_2 and 0.5 mol of I^- in 1L flask. After equilibrium is reached, excess of $AgNO_3$ gave 0.25 mol of yellow precipitate. Equilibrium constant is

(a) 1.33 (b) 2.66
(c) 0.375 (d) 0.75

50. The equilibrium constant for the mutarotation, α-D–glucose $\rightleftharpoons$ β–D–glucose is 1.8. What per cent of the α-form remains under equilibrium?

(a) 35.7 (b) 64.3
(c) 55.6 (d) 44.4

51. For the reaction:

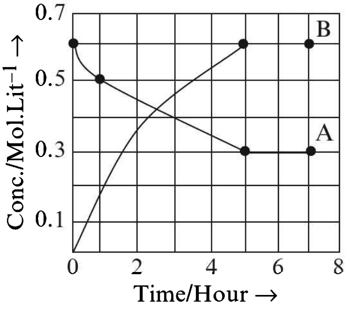
$2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$,

the ratio $\frac{K_P}{P}$, where P is the total pressure of gases at equilibrium and $P_{Br_2} = \frac{P}{9}$ at a certain temperature, is

(a) $\frac{1}{9}$ (b) $\frac{1}{81}$
(c) $\frac{1}{27}$ (d) $\frac{1}{3}$

52. The progress of the reaction A $\rightleftharpoons$ nB, with time is represented by the graph given below.

The value of n is



(a) 1 (b) 2
(c) 3 (d) 4

53. K_P for the reaction: $N_2O_4(g) \rightleftharpoons 2NO_2$ is 640 mm at 775 K. The percentage dissociation of N_2O_4 at equilibrium pressure of 160 mm is

(a) $\frac{100}{\sqrt{2}}$ (b) 50
(c) $\frac{50}{\sqrt{2}}$ (d) $10\sqrt{2}$

54. At 127°C and 1 atm pressure, $PCl_5(g)$ is partially dissociated into $PCl_3(g)$ and $Cl_2(g)$ as: $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$. The density of the equilibrium mixture is 3.5 g/L. Percentage dissociation of PCl_5 is ($R = 0.08$ L-atm/K-mol, P = 31, Cl = 35.5)

(a) 46.28 (b) 86.16
(c) 15.86 (d) 53.72

55. At T K, a compound $AB_2(g)$ dissociates according to the reaction: $2AB_2(g) \rightleftharpoons 2AB(g) + B_2(g)$, with a degree of dissociation 'x' which is small compared with unity. The expression for 'x' in terms of the equilibrium constant, K_P and the total pressure, P, is

(a) $\frac{K_P}{P}$
(b) $(K_P)^{1/3}$
(c) $\left(\frac{2K_P}{P}\right)^{1/3}$
(d) $\left(\frac{K_P}{P}\right)^{1/3}$

Heterogeneous Equilibrium

56. A quantity of 25 g sample of BaO_2 is heated to 954 K in a closed and rigid evacuated vessel of 8.21 L capacity. What percentage of peroxide is converted into oxide?

$2BaO_2\ (s) \rightleftharpoons 2BaO(s) + O_2\ (g)$; $K_P = 0.5$ atm

(a) 20% (b) 50%
(c) 75% (d) 80%

57. For the reaction: $NH_2COONH_4(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$, $K_P = 3.2 \times 10^{-5}$ atm^3. The total pressure of the gaseous products when sufficient amount of reactant is allowed to achieve equilibrium, is

(a) 0.02 atm
(b) 0.04 atm
(c) 0.06 atm
(d) 0.095 atm

58. At a certain temperature, K_P for the dissociation of solid $CaCO_3$ is 4.5×10^{-2} atm and for the reaction $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$, the K_P value is 2.0 atm. The pressure of carbon monoxide at this temperature, when solid carbon, CaO and $CaCO_3$ are mixed together and allowed to attain equilibrium, is

(a) 0.09 atm
(b) 0.30 atm
(c) 2.1 atm
(d) 0.47 atm

59. The value of K_P for the equilibrium: $NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$ at a certain temperature and total 2 atm pressure at equilibrium will be

(a) 0.25 atm^2
(b) 1.0 atm^2
(c) 4.0 atm^2
(d) 1.0 atm

60. Iron fillings and water were placed in a 5 L vessel and sealed. The tank was heated to 1000°C. Upon analysis, the tank was found to contain 1.2 g of $H_2(g)$ and 54.0 g of $H_2O(g)$. If the reaction is represented as: $3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$, the value of equilibrium constant is

(a) 0.2
(b) 0.04
(c) 0.008
(d) 0.0016

61. At 1000°C and a pressure of 16 atm, the equilibrium constant of the reaction:

$CO_2(g) + C(s) \rightleftharpoons 2CO(g)$

is such that for every nine moles of CO, there is one mole of CO_2. For what pressure of the mixture, is the ratio $CO:CO_2 = 4:1$? The temperature remains 1000°C.

(a) 40.5 atm
(b) 81 atm
(c) 33.75 atm
(b) 6.7 atm

62. At a certain temperature, K_P for the reaction: $2CO(g) \rightleftharpoons CO_2(g) + C(\text{graphite})$ is 0.1 atm^{-1}. What is the ratio of partial pressures of CO and CO_2 at equilibrium, taking the total pressure to be 1.1 atm?

(a) 9:1
(b) 10:1
(c) 1:10
(d) 1:9

63. For the equilibrium: $LiCl{\cdot}3NH_3(s) \rightleftharpoons LiCl{\cdot}NH_3(s) + 2NH_3(g)$; $K_P = 9$ atm^2 at 27°C. A 8.21 L vessel contains 0.1 mole of $LiCl.NH_3(s)$. How many moles of $NH_3(g)$ should be added to the flask at this temperature to derive the backward reaction for completion?

(a) 0.8
(b) 1.0
(c) 1.2
(d) 1.1

64. The reaction, $ZnO(s) + CO(g) \rightleftharpoons Zn(g) + CO_2(g)$, has an equilibrium constant of 1 atm at 1500 K. The equilibrium partial pressure of zinc vapour in a reaction vessel if an equimolar mixture of CO and CO_2 is brought into contact with solid ZnO at 1500 K and the equilibrium is achieved at 1 atm, is

(a) 0.68 atm
(b) 0.76 atm
(c) 0.24 atm
(d) 0.5 atm

65. If 0.3 moles of hydrogen gas and 2.0 moles of sulphur solid are heated to 87°C in a 2.0 L vessel, what will be the partial pressure of H_2S gas at equilibrium? (Given: $R = 0.08$ l-atm/K-mol)

$H_2(g) + S(s) \rightleftharpoons H_2S(g)$; $K_C = 0.08$

(a) 0.32 atm
(b) 0.43 atm
(c) 0.62 atm
(d) 0.48 atm

Le-Chatelier's Principle

66. Consider the following equilibrium in a closed container:

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$

At a fixed temperature, the volume of the reaction container is halved. For this change, which of the following statement holds true regarding the equilibrium constant (K_P) and degree of dissociation (α)?

(a) neither K_P nor α changes
(b) both K_P and α changes
(c) K_P changes, but α does not change
(d) K_P does not change, but α changes

67. Which of the following hypothetical reactions is favoured by increase of temperature as well as pressure?

(a) $A(s) + 2B(g) \rightleftharpoons C(g) + D(g)$; $\Delta H = +ve$
(b) $A(s) + 2B(g) \rightleftharpoons 2C(g) + D(g)$; $\Delta H = +ve$
(c) $2A(g) + B(g) \rightleftharpoons 2C(g) + D(s)$; $\Delta H = +ve$
(d) $2A(s) + 2B(g) \rightleftharpoons 2C(g) + 2D(g)$; $\Delta H = -ve$

68. In the system $AB(s) \rightleftharpoons A(g) + B(g)$, doubling the quantity of AB(s) would

(a) increase the amount of A to double its value
(b) increase the amount of B to double its value
(c) increase the amounts of both A and B to some extent
(d) cause no changes in the amounts of A and B

69. In a system: $A(s) \rightleftharpoons 2B(g) + 3C(g)$, if the concentration of C at equilibrium is increased by a factor of 2, it will cause the equilibrium concentration of B to decrease by

(a) two times the original value
(b) one half of its original value
(c) $2\sqrt{2}$ times its original value
(d) 8 times its original value

70. The reaction: $MgCO_3(s) \rightleftharpoons MgO(s) + CO_2(g)$ is in progress. If number of moles of MgO in the vessel is doubled at an instance

(a) the reaction quotient, Q is halved
(b) the reaction quotient, Q is doubled
(c) the moles of CO_2 present at equilibrium is halved
(d) the partial pressure of CO_2 in the vessel remains unchanged

71. When pressure is applied to the equilibrium system: Ice $\rightleftharpoons$ water, which of the following phenomenon will happen?

(a) more ice will be formed
(b) ice will sublime
(c) more water will be formed
(d) equilibrium will not disturb

72. The equilibrium: $SOCl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$ is attained at 25°C in a closed container and helium gas is introduced. Which of the following statements is correct?

(a) concentration of SO_2 is increased
(b) more Cl_2 is formed
(c) concentrations of all change
(d) concentrations will not change

73. When calcium acetate is dissolved in water, heat is evolved. If the temperature is raised, the solubility of calcium acetate

(a) increases
(b) decreases
(c) is not affected
(d) first increases and then decreases

74. The Haber's process for the manufacture of ammonia is usually carried out at about 500°C. If a temperature of about 250°C was used instead of 500°C,

(a) no ammonia would be formed at all
(b) the percentage of ammonia in the equilibrium mixture would be too low
(c) a catalyst would be of no use at all at this temperature
(d) the percentage of ammonia in the equilibrium mixture would be too high

75. Densities of diamond and graphite are 3.5 and 2.4 g/ml, respectively. The increase in pressure (at the constant temperature) at the equilibrium in C (diamond) $\rightleftharpoons$ C (graphite) will

(a) favour the forward reaction
(b) favour the backward reaction
(c) have no effect
(d) increases the equilibrium constant

76. In a flask, colourless N_2O_4 is in equilibrium with brown coloured NO_2. At equilibrium, when the flask is heated at 100°C the brown colour deepens and on cooling it becomes less coloured. The change in enthalpy, ΔH, for the system is

(a) negative
(b) positive
(c) zero
(d) undefined

77. For the chemical reaction: 3X(g) + Y(g) $\rightleftharpoons$ X_3Y(g), the amount of X_3Y at equilibrium is affected by

(a) temperature and pressure
(b) temperature only
(c) pressure only
(d) temperature, pressure and catalyst

78. What will the change on increasing the pressure at equilibrium: water $\rightleftharpoons$ water vapour?

(a) The boiling point of water will increase.
(b) The boiling point of water will decrease.
(c) The boiling point of water will not change.
(d) Boiling point is not related with pressure.

79. In equilibrium:

$$\underset{\text{colourless}}{SCN^-(aq)} + \underset{\text{yellow}}{Fe^{+3}(aq)} \rightleftharpoons \underset{\text{deep red}}{[Fe(SCN)^{2+}](aq)}$$

If thiocyanate ions are added in equilibrium mixture

(a) The solution becomes colourless.
(b) The yellow colour of solution deepens.
(c) The red colour of the solution deepens.
(d) Concentration of $[Fe(SCN)]^{2+}$ ion will decrease.

80. An aqueous solution of volume 500 ml, when the reaction: $2Ag^+(aq) + Cu(s) \rightleftharpoons Cu^{2+}(aq) + 2Ag(s)$, reached equilibrium, the concentration of Cu^{2+} ions was x M. To this solution, 500 ml of water is added. At the new equilibrium, the concentration of Cu^{2+} ions would be

(a) $2x$ M
(b) x M
(c) between x and $0.5x$ M
(d) less than $0.5x$ M

81. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$. In the above reaction, the partial pressure of PCl_3, Cl_2 and PCl_5 are 0.3, 0.2 and 0.6 atm, respectively. If partial pressure of PCl_3 and Cl_2 was increased twice at the new equilibrium, what will be the new partial pressure of PCl_5 (in atm)?

(a) 0.3 (b) 1.2
(c) 2.4 (d) 0.15

82. In the equilibrium mixture: $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, the mole ratio of gases are $\sqrt{2} : \sqrt{2} : 10$, respectively. What would be the effect on the mole ratio on adding 5 mole of He gas at constant pressure?

(a) No change
(b) The new molar ratio becomes 1:1:5
(c) The new molar ratio becomes 2:2:5
(d) The new molar ratio becomes $2:2:5\sqrt{2}$

83. One mole of He (g, colourless) is added to the equilibrium mixture containing N_2O_4 (g, colourless) and NO_2 (g, red-brown) present in a cylinder piston arrangement maintained at constant pressure and temperature. It will result

(a) no change in colour of the equilibrium mixture.
(b) lightening the colour of the equilibrium mixture.
(c) darkening the colour of the equilibrium mixture.
(d) no effect on the equilibrium composition.

84. Consider the formation of SO_3 according to the reaction: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$; $\Delta H = -198$ kJ. Which of the following may change the value of equilibrium constant of the above reaction?

(a) Adding He gas to reaction vessel
(b) Adding more of O_2 to the reaction vessel
(c) Increasing the temperature
(d) Doubling the volume of reaction vessel

85. For the given chemical equation: $2X(g) + Y(g) \rightleftharpoons 2Z(g) + 8$ kcal, which combination of pressure and temperature gives the highest yield of 'Z' at equilibrium?

(a) 1000 atm and 500°C
(b) 500 atm and 500°C
(c) 500 atm and 100°C
(d) 1000 atm and 100°C

Answer Keys – Exercise I

Basic

1. (a) 2. (a) 3. (d) 4. (d) 5. (d) 6. (a) 7. (c) 8. (a) 9. (d) 10. (b)
11. (a) 12. (a) 13. (c) 14. (c) 15. (b) 16. (a) 17. (a) 18. (c) 19. (b) 20. (b)
21. (b) 22. (c) 23. (d) 24. (d) 25. (a) 26. (a) 27. (d) 28. (d) 29. (d) 30. (b)

Application of Equilibrium Constant

31. (b) 32. (c) 33. (c) 34. (b) 35. (c) 36. (c) 37. (b) 38. (b) 39. (c) 40. (c)
41. (b) 42. (a) 43. (d) 44. (d) 45. (a) 46. (a) 47. (b) 48. (a) 49. (a) 50. (a)
51. (b) 52. (b) 53. (a) 54. (b) 55. (c)

Heterogeneous Equilibrium

56. (d) 57. (c) 58. (b) 59. (b) 60. (d) 61. (a) 62. (c) 63. (c) 64. (c) 65. (a)

Le-Chatelier's Principle

66. (d) 67. (c) 68. (d) 69. (c) 70. (d) 71. (c) 72. (d) 73. (b) 74. (a) 75. (b)
76. (b) 77. (a) 78. (a) 79. (c) 80. (d) 81. (c) 82. (a) 83. (b) 84. (c) 85. (d)

CHAPTER 7

Ionic Equilibrium

EXERCISE I (JEE MAIN)

Basics

1. When rain is accompanied by a thunder storm, the collected rain water will have a pH value
   (a) depending on the amount of dust in air.
   (b) slightly lower than that of rain water without thunderstorm.
   (c) slightly higher than that when the thunder storm is not there.
   (d) uninfluenced by occurrence of thunderstorm.

2. pH of water is 7.0 at 25°C. If water is heated to 70°C, the
   (a) pH will decrease and the sample becomes acidic.
   (b) pH will increase but the sample will remain neutral.
   (c) pH will remain constant as 7.
   (d) pH will decrease but the sample will remain neutral.

3. The degree of dissociation of water at 25°C is 1.8×10^{-7}% and density is $1.0\ g\ cm^{-3}$. The ionic constant for water is
   (a) 1.0×10^{-14} (b) 2.0×10^{-16}
   (c) 1.0×10^{-16} (d) 1.0×10^{-8}

4. The degree of dissociation of pure water at 25°C is found to be 1.8×10^{-9}. The dissociation constant, K_d of water, at 25°C is
   (a) 10^{-14}
   (b) 1.8×10^{-16}
   (c) 5.56×10^{-13}
   (d) 1.8×10^{-14}

5. What is the pH of a neutral solution at 37°C, where K_w equals 2.5×10^{-14}? ($\log 2 = 0.3$)
   (a) 7.0 (b) 13.6
   (c) 6.8 (d) 6.6

6. At 40°C, the density of heavy water is 1.02 g/ml and its ionic product is 5.1×10^{-15}. Which of the following if the only incorrect information regarding heavy water at 40°C?
   (a) The molar concentration of heavy water is 51 M.
   (b) The dissociation constant of heavy water is 10^{-16}.
   (c) Its degree of dissociation is 10^{-8}.
   (d) The molal concentration of heavy water is 50 m.

7. The ionic product of water is 1.0×10^{-14} at 25°C. Assuming the density of water independent from change in temperature, the ionic product of water at 50°C will be

(a) 2.0×10^{-14} (b) 5.0×10^{-15}
(c) 5.9×10^{-14} (d) 1.0×10^{-14}

8. The hydronium ion concentration in an aqueous solution of H_2SO_4 is 2.0×10^{-4} M at 25°C. The hydroxide ion concentration in the solution is

(a) 0 (b) 2.0×10^{-4} M
(c) 5×10^{3} M (d) 5×10^{-11} M

9. The pH of an aqueous solution of sodium chloride at 60°C is

(a) 7.0
(b) > 7.0
(c) < 7.0
(d) 0

10. The number of hydronium ions in 1 ml of an aqueous solution of pH 12.0 at 25°C is

(a) 0.01
(b) 10^{-12}
(c) 6.02×10^{8}
(d) 6.02×10^{11}

Strong Acids and Bases

11. The pH of 4.0×10^{-4} M – HNO_3 solution is (log 2 = 0.3)

(a) 4.6 (b) 3.4
(c) 3.6 (d) 4.0

12. The pH of 0.005 M – NaOH solution is (log 2 = 0.3)

(a) 2.3 (b) 2.7
(c) 11.3 (d) 11.7

13. How many grams of HCl should be dissolved in sufficient water to get 500 ml of an aqueous solution of pH, 2.0?

(a) 0.01 (b) 0.005
(c) 0.1825 (d) 0.365

14. What is the pH of 10^{-7} M – HCl solution at 25°C?

(a) 7.0 (b) 6.70
(c) 6.62 (d) 6.79

15. What mass of NaOH should be dissolved in sufficient water to get 20 m^3 of an aqueous solution of pH, 7.3, at 25°C?

(a) 0.16 g (b) 1.6×10^{-4} g
(c) 0.04 g (d) 0.12 g

16. What is the pH of solution made by mixing equal volumes of 0.1 N – H_2SO_4, 0.1 N – HNO_3, 0.1 N – HCl?

(a) 1 (b) 2
(c) 3 (d) 4

17. Following five solutions of KOH were prepared as: first, 0.1 mole in 1 L; second, 0.2 mole in 2 L; third, 0.3 mole in 3 L; fourth, 0.4 mole in 4 L; fifth, 0.5 mole in 5 L. The pH of resultant solution, when all these solutions are mixed, is

(a) 2 (b) 1
(c) 13 (d) 7

18. At 90°C, the hydronium ion concentration in pure water is 10^{-6} M. If 100 ml of 0.5 M – NaOH solution is mixed with 250 ml of 0.2 M – HNO_3 solution at 90°C, pH of the resulting solution will be

(a) 7.0 (b) 6.0
(c) 8.0 (d) 0.85

19. Three solutions of strong electrolytes, 25 ml of 0.1 M – HX, 25 ml of 0.1 M – H_2Y and 50 ml of 0.1 N – $Z(OH)_2$ are mixed. pOH of the resulting solution is

(a) 1.6 (b) 7.0
(c) 12.4 (d) 11.6

20. What will be the percentage error in measuring hydrogen ion concentration in a 10^{-6} M – HCl solution on neglecting the contribution of water at 25°C?

(a) 5% (b) 9.8%
(c) 1.98% (d) 0.98%

Weak Acids and Bases

21. When 0.05 moles of the following acids are dissolved in 1000 ml of H_2O, the $[H^+]$ will be greatest in

(a) HNO_2; $pK_a = 3.0$
(b) HCOOH; $pK_a = 3.75$
(c) HCN; $pK_a = 9.4$
(d) CH_3COOH; $pK_a = 4.75$

22. The concentration of acetate ions in 1 M acetic acid ($K_a = 2 \times 10^{-5}$) solution containing 0.1 M – HCl is

(a) 2×10^{-1} M
(b) 2×10^{-3} M
(c) 2×10^{-4} M
(d) 4.4×10^{-3} M

23. The dissociation constants of formic and acetic acids are 1.77×10^{-4} and 1.75×10^{-5}, respectively

(a) Formic acid is 3.18 times stronger than acetic acid, at equal concentration.
(b) Acetic acid is 3.18 times stronger than formic acid, at equal concentrations.
(c) Formic acid is 10.11 times stronger than acetic acid, at equal concentrations.
(d) Formic acid is 10.11 times stronger than acetic acid, at different concentrations.

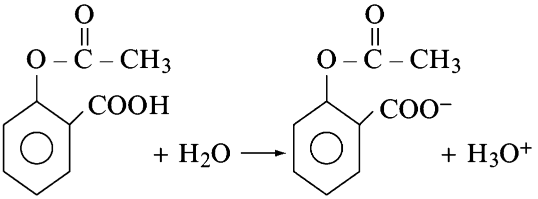
24. The dissociation constant of acetic acid is 0.000018 and that for cyanoacetic acid is 0.0036 at 298 K. What would be the ratio of volumes of the two acid solutions, each containing equal moles of the acids, so that the solutions becomes isohydric?

(a) 1:1
(b) $1:\sqrt{200}$
(c) 1:200
(d) 200:1

25. The p*K*a of acetylsalicylic acid (aspirin) is 3.5. The pH of gastric juice in human stomach is about 2 to 3 and the pH in the small intestine is about 8. Aspirin will be

(a) unionized in the small intestine as well as in the stomach
(b) completely ionized in the small intestine as well as in the stomach
(c) ionized in the stomach and almost unionized in the small intestine
(d) ionized in the small intestine and almost unionized in the stomach

26. The active ingredient in aspirin is acetyl salicylic acid



with $K_a = 4.0 \times 10^{-9}$. The pH of the solution obtained by dissolving two aspirin tablets (containing 0.36 g of acetyl salicylic acid in each tablet) in 250 ml of water is (log 2 = 0.3)

(a) 5.1
(b) 8.9
(c) 10.2
(d) 5.25

27. For weak electrolyte, AB, the degree of ionization would be (V = volume of solution having 1 mole of electrolyte and K is the ionization constant of the electrolyte)

(a) $\frac{K}{V^2}$
(b) $K.V$
(c) $\frac{K}{V}$
(d) $\sqrt{K \cdot V}$

28. What would be the pH of an ammonia solution if the pH of acetic acid solution of same strength is 3.2? The dissociation constants of ammonia and acetic acid are same.

(a) 3.2
(b) 3.8
(c) 10.2
(d) 10.8

29. Isohydric solutions are the solutions having the same concentration of hydronium ion. If 0.2 M – HA solution is isohydric with 4×10^{-4} M – HCl solution, then K_b of A^- is

(a) 8×10^{-7}
(b) 1.25×10^{-8}
(c) 1.25×10^{-6}
(d) 8×10^{7}

30. If pK_b for fluoride ion at 25°C is 10.3, the ionization constant of hydrofluoric acid in water at this temperature is (log 2 = 0.3)

(a) 2×10^{-4}
(b) 2×10^{-3}
(c) 2×10^{-5}
(d) 5×10^{-11}

31. *n*-coproic acid, $C_5H_{11}COOH$, found in coconut and palm oil is used in making artificial flavours, has solubility in water equal to 11.6 g/L. The saturated solution has pH = 3.0. The K_a of acid is

(a) 10^{-6}
(b) 10^{-5}
(c) 2×10^{-5}
(d) 2×10^{-6}

32. The dissociation constant of formic acid is 0.00024. The hydrogen ion concentration in 0.002 M – HCOOH solution is nearly

(a) 6.93×10^{-4} M
(b) 4.8×10^{-7} M
(c) 5.8×10^{-4} M
(d) 1.4×10^{-4} M

33. Calculate pH of 0.02 M – HA solution. K_a for HA = 2×10^{-12}. (log 2 = 0.3, log 3 = 0.48)

(a) 6.65
(b) 6.70
(c) 6.85
(d) 6.52

34. How much water must added to 300 ml of 0.2 M solution of CH_3COOH for the degree of dissociation of the acid to double? K_a for the acetic acid = 1.8×10^{-5}.

(a) 1200 ml
(b) 300 ml
(c) 600 ml
(d) 900 ml

35. A solution has initially 0.1 M – HCOOH and 0.2 M – HCN. K_a of HCOOH = 2.56×10^{-4}, K_a of HCN = 9.6×10^{-10}. The only incorrect statement for the solution is (log 2 = 0.3)

(a) $[H^+] = 1.6 \times 10^{-3}$ M
(b) $[HCOO^-] = 1.6 \times 10^{-3}$ M
(c) $[CN^-] = 1.2 \times 10^{-7}$ M
(d) pOH = 2.8

Polyprotic Acids and Bases

36. What is the pH of 4×10^{-3} M–$Y(OH)_2$ solution assuming the first dissociation to be 100% and second dissociation to be 50%, where Y represents a metal cation? (log 2 = 0.3, log 3 = 0.48)

(a) 11.78
(b) 11.22
(c) 2.22
(d) 2.78

37. The species present in solution when CO_2 is dissolved in water

(a) CO_2, H_2CO_3, HCO_3^-, CO_3^{2-}
(b) H_2CO_3, CO_3^{2-}
(c) CO_3^{2-}, HCO_3^-
(d) CO_2, H_2CO_3

38. An aqueous solution is prepared by dissolving 0.1 mole H_2CO_3 in sufficient water to get 100 ml solution at 25°C. For H_2CO_3, $K_{a1} = 4.0 \times 10^{-6}$ and $K_{a2} = 5.0 \times 10^{-11}$. The only incorrect equilibrium concentration is

(a) $[H^+] = 6.32 \times 10^{-4}$ M

(b) $[HCO_3^-] = 2 \times 10^{-3}$ M

(c) $[CO_3^{2-}] = 5 \times 10^{-11}$ M

(d) $[OH^-] = 5 \times 10^{-12}$ M

39. Ascorbic acid (vitamin C) is a diprotic acid, $H_2C_6H_6O_6$. What is the pH of a 0.10 M solution? The acid ionization constants are $K_{a1} = 9.0 \times 10^{-5}$ and $K_{a2} = 1.6 \times 10^{-12}$. (log 2 = 0.3, log 3 = 0.48)

(a) 3.52 (b) 2.52

(c) 1.52 (d) 2.48

40. The pH of 0.1 M – N_2H_4 solution is (For N_2H_4, $K_{b1} = 3.6 \times 10^{-6}$, $K_{b2} = 6.4 \times 10^{-12}$, log 2 = 0.3, log 3 = 0.48)

(a) 3.22 (b) 2.72

(c) 10.78 (d) 11.22

Buffer Solutions

41. The dissociation constant of a weak acid HX is, 10^{-5}. The buffer HX + NaX can be best used to maintain the pH in the range

(a) 9–11 (b) 2–4

(c) 11–13 (d) 4–6

42. A physician wishes to prepare a buffer solution at pH = 3.58 that efficiently resists a change in pH yet contains only small concentrations of the buffering agents. Which one of the following weak acid together with its sodium salt would be best to use?

(a) *m*-chloro benzoic acid ($pK_a = 3.98$)

(b) *p*-chlorocinnamic acid ($pK_a = 4.41$)

(c) 2,5-dihydroxy benzoic acid ($pK_a = 2.97$)

(d) acetoacetic acid ($pK_a = 3.58$)

43. pH of 0.01 M – $(NH_4)_2SO_4$ and 0.02 M – NH_4OH buffer (pK_a of $NH_4^+ = 9.26$) is

(a) 9.26 + log 2 (b) 9.26 – log 2

(c) 4.74 + log 2 (d) 9.26

44. The addition of sodium acetate to acetic acid solution will cause

(a) increase in its pH value

(b) decrease in its pH value

(c) no change in pH value

(d) change in pH which cannot be predicted

45. A 0.1 M acetic acid solution is titrated against 0.1 M – NaOH solution. What would be the difference in pH between 1/4 and 3/4 stages of neutralization of the acid?

(a) 2 log(0.75)

(b) 2 log(0.25)

(c) log 3

(d) 2 log 3

46. An amount of 0.1 mole of CH_3NH_2 ($K_b = 5 \times 10^{-4}$) is mixed with 0.08 mole of HCl and diluted to one litre. What will be the H^+ concentration in the solution?

(a) 1.25×10^{-4} M

(b) 8×10^{-11} M

(c) 1.6×10^{-11} M

(d) 2×10^{-3} M

47. A volume of 10 ml of a strong acid solution of pH = 2.0 are mixed with 990 ml of a buffer solution of pH = 4.0. The pH of the resulting solution will be

(a) 4.2

(b) 6.0

(c) 4.002

(d) 4.0

48. An amount of 0.15 mole of pyridinium chloride has been added into 500 ml of 0.2 M pyridine solution. Calculate pH and hydroxyl ion concentration in the resulting solution assuming no change in volume. K_b for pyridine = 1.5×10^{-9}. (log 2 = 0.3, log 0.3 = 0.48)

(a) 9.0 (b) 5.0
(c) 8.64 (d) 5.36

49. A volume of 20 ml of 0.8 M – HCN solution is mixed with 80 ml of 0.4 M – NaCN solution. Calculate the pH of the resulting solution. K_a of HCN = 2.5×10^{-10}. (log 2 = 0.3)

(a) 9.9 (b) 9.3
(c) 4.1 (d) 4.7

50. The base imidazole has a K_b of 1.0×10^{-7} at 25°C. In what volumes should 0.02 M – HCl and 0.02 M imidazole be mixed to make 120 ml of a buffer at pH = 7?

(a) 60 ml, 60 ml
(b) 40 ml, 80 ml
(c) 30 ml, 90 ml
(d) 20 ml, 100 ml

Hydrolysis of Salts

51. Separate solutions of NaW, NaX, NaY and NaZ, each of concentrations 0.1 M, has pH 7.0, 9.0, 10.0 and 11.0, respectively, at 25°C. The strongest acid among these is

(a) NaW (b) NaX
(c) NaY (d) NaZ

52. If pH of 0.001 M potassium propionate solution be 8.0, then the dissociation constant of propionic acid will be

(a) 10^{-3} (b) 10^{-2} (c) $10^{-2.5}$ (d) 10^{-5}

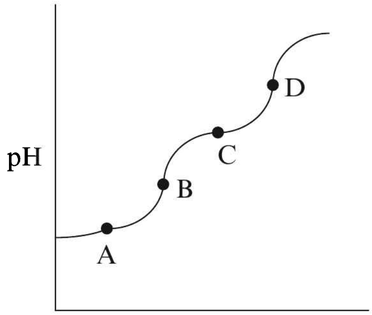
53. The correct order of increasing [OH$^-$] in the following aqueous solution is

(a) 0.01 M – $NaHCO_3$ < 0.01 M – NaCN < 0.01 M – KCl
(b) 0.01 M – KCl < 0.01 M – NaCN < 0.01 M – $NaHCO_3$
(c) 0.01 M – KCl < 0.01 M – $NaHCO_3$ < 0.01 M – NaCN
(d) 0.01 M – NaCN < 0.01 M – KCl < 0.01 M – $NaHCO_3$

54. The pH of solutions of both ammonium acetate and sodium chloride is 7 due to

(a) hydrolysis in both case
(b) the former hydrolyses and not the latter
(c) no hydrolysis in both
(d) hydrolysis of the latter but not the former

55. For the titration of a dibasic weak acid H_2A $\left(p^{K_{a(2)}} - p^{K_{a(1)}} \geq 2\right)$ with a strong base, pH versus volume of the base graph is as shown in the figure. $p^{K_{a(1)}}$ and $p^{K_{a(2)}}$ are equal to the pH values corresponding to the points:



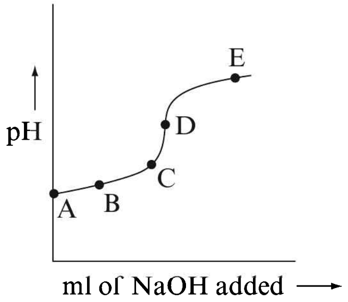
Volume of NaOH added

(a) B and D, respectively
(b) A and B, respectively
(c) C and D, respectively
(d) A and C, respectively

56. A salt of strong acid and a weak base is dissolved in water. Its hydrolysis in solution is

(a) not affected by heating
(b) increased by adding the strong acid
(c) suppressed by adding strong acid
(d) suppressed by dilution

57. The curve in the figure shows the variation of pH during the course of titration of a weak acid, HA with a strong base (NaOH). At which point in the titration curve is the concentration of the acid equal to that of its conjugate base?



(a) Point D (b) Point E
(c) Point C (d) Point B

58. The pH of 0.1 M solution of the following compounds increases in the order

(a) $NaCl < NH_4Cl < NaCN < HCl$
(b) $HCl < NH_4Cl < NaCl < NaCN$
(c) $NaCN < NH_4Cl < NaCl < HCl$
(d) $HCl < NaCl < NaCN < NH_4Cl$

59. The pH value of 0.1 M solutions of CH_3COONa (I), CH_3COOH (II), CH_3COONH_4 (III), NaOH (IV) and HCl (V) is in the order

(a) I < II < III < IV < V
(b) V < IV < III < II < I
(c) V < II < III < I < IV
(d) V < II < I < III < IV

60. A weak acid HX has the dissociation constant 1×10^{-5} M. It forms a salt NaX on reaction with alkali. The percentage hydrolysis of 0.1 M solution of NaX is

(a) 0.0001%
(b) 0.01%
(c) 0.1%
(d) 0.15%

61. The pH of an aqueous solution of 1.0 M ammonium formate assuming complete dissociation is (pK_a of formic acid = 3.8 and pK_b of ammonia = 4.8)

(a) 7.0
(b) 7.5
(c) 6.5
(d) 4.3

62. What is the pH of a 0.50 M aqueous NaCN solution? pK_b of CN^- is 4.70. (log 2 = 0.3)

(a) 3.0
(b) 11.0
(c) 4.7
(d) 9.3

63. The pH at the equivalence point when a solution of 0.01 M – CH_3COOH is titrated with a solution of 0.01 M – NaOH, is (pK_a of CH_3COOH = 4.7, log 5 = 0.7)

(a) 10.5
(b) 3.5
(c) 10.35
(d) 3.65

64. The acid ionization constant of Zn^{2+} is 2.0×10^{-10}. What is the pH of 0.001 M solution of $ZnCl_2$? (log 2 = 0.3)

(a) 9.7
(b) 4.85
(c) 6.35
(d) 3.35

65. The addition of ammonium chloride to acetic acid solution will cause

(a) increase in its pH value
(b) decrease in its pH value
(c) no change in pH value
(d) change in pH which cannot be predicted

Indicators

66. The indicator constant for an acidic indicator, HIn, is 5×10^{-6} M. This indicator appears only in the colour of acidic form when $\frac{[\text{In}^-]}{[\text{HIn}]} \le \frac{1}{20}$ and it appears only in the colour of basic form when $\frac{[\text{HIn}]}{[\text{In}^-]} \le 40$. The pH range of indicator is ($\log 2 = 0.3$)

(a) 4.3 – 6.3 (b) 4.0 – 6.6
(c) 4.0 – 6.9 (d) 3.7 – 6.6

67. For the indicator thymol blue, the value of pH is 2.0 when half of the indicator is present in the unionized form. The percentage of the indicator in the unionized form in a solution of 4.0×10^{-3} M hydrogen ion concentration is

(a) 40% (b) 28.6%
(c) 71.4% (d) 60%

68. A certain sample of rainwater gives a yellow colour with methyl red [pH range 4.2 (red) – 6.2 (yellow)] and a yellow colour with phenol red [pH range 6.4 (yellow) – 8.0 (red)]. What is the approximate pH of the water? Is the rainwater acidic, neutral, or basic?

(a) 6.3, acidic
(b) 6.1, acidic
(c) 6.5, acidic
(d) 6.3, basic

69. An acid type indicator, HIn differs in colour from its conjugate base (In^-). The human eye is sensitive to colour differences only when the ratio $[\text{In}^-]/[\text{HIn}]$ is greater than 10 or smaller than 0.1. What should be the minimum change in the pH of the solution to observe a complete colour change ($K_a = 1.0 \times 10^{-5}$)?

(a) 0.0 (b) 1.0
(c) 2.0 (d) 5.0

70. The range of most suitable indicator which should be used for titration of NaX (0.1 M, 10 ml) with 0.1 M HCl should be (K_b of $\text{X}^- = 10^{-6}$)

(a) 2–3 (b) 3–5
(c) 6–8 (d) 8–10

Solubility

71. If ionization of X_aY_b takes place then, number of Y^{-a} ions will be equal to

(a) *b*/*a* times of X^{+b}
(b) *a*/*b* times of X^{+b}
(c) *b*/*a* times of X^{a+}
(d) equal to X^{+b}

72. The solubility of sparingly soluble salt A_3B_2 (molar mass = 'M' g/mol) in water is 'x' g/L. The ratio of molar concentration of B^{3-} to the solubility product of the salt is

(a) $\frac{108\,x^5}{M^5}$ (b) $\frac{x^4}{108\,M^4}$
(c) $\frac{x^4}{54\,M^4}$ (d) $\frac{x^3}{27\,M^3}$

73. The solubility product of $Zn(OH)_2$ is 10^{-14} at 25°C. What would be the concentration Zn^{+2} ion in 0.1 M – NH_4OH solution which is 50% ionized?

(a) 2×10^{-13}
(b) 4×10^{-12}
(c) 4×10^{-8}
(d) 2×10^{-11}

74. In which of the following, solubility of AgCl will be maximum?

(a) 0.1 M – $AgNO_3$
(b) Water
(c) 0.1 M – NH_3(aq)
(d) 0.1 M – NaCl

75. What is the equilibrium constant of the reaction: $Fe(OH)_3(s) + 3H_3O^+ \rightleftharpoons Fe^{3+} + 6H_2O$? K_{sp} of $Fe(OH)_3 = 4 \times 10^{-38}$

(a) 2.5×10^{-5}
(b) 4.0×10^{4}
(c) 4.0×10^{-4}
(d) 4×10^{-80}

76. The solubility product of AgCl is 1.0×10^{-10}. The equilibrium constant of the reaction

$AgCl(s) + Br^- \rightleftharpoons AgBr(s) + Cl^-$

is 200 and that of the reaction

$2AgBr(s) + S^{2-} \rightleftharpoons Ag_2S(s) + 2Br^-$

is 1.6×10^{24}. What is the K_{sp} of Ag_2S?

(a) 3.2×10^{16}
(b) 1.56×10^{-49}
(c) 3.95×10^{-25}
(d) 3.13×10^{-17}

77. What is the solubility product of $Al(OH)_3$ in water. Given:

$Al(OH)_4^-(aq) \rightleftharpoons Al^{3+}(aq) + 4OH^-(aq)$; $K = 1.3 \times 10^{-34}$

$Al(OH)_3(s) + OH^-(aq) \rightleftharpoons Al\,(OH)_4^-(aq)$; $K = 38.5$

(a) 3.1×10^{-35}
(b) 5×10^{-33}
(c) 6.1×10^{-33}
(d) 5×10^{-34}

78. A recent investigation of the complexation of SCN^- with Fe^{3+} led to values of 125, 20 and 1.0 for K_1, K_2 and K_3, respectively. What is the dissociation constant of $Fe(SCN)_3$ into its simplest ions on the basis of these data?

(a) 2.5×10^{3}
(b) 4.0×10^{-4}
(c) 1.0
(d) 8.0×10^{-3}

79. Solubility of BaF_2 in a solution of $Ba(NO_3)_2$ will be represented by the concentration term

(a) $[Ba^{2+}]$
(b) $[F^-]$
(c) $0.5\,[F^-]$
(d) $2\,[NO_3^-]$

80. How many times solubility of CaF_2 is decreased in 4×10^{-3} M – KF(aq) solution as compared to pure water at 25°C. Given: $K_{sp}\,(CaF_2) = 3.2 \times 10^{-11}$

(a) 50
(b) 100
(c) 500
(d) 1000

81. The solubility of A_2X_3 is y mol dm^{-3}. It solubility product is

(a) $6y^4$
(b) $64y^4$
(c) $36y^4$
(d) $108y^5$

82. For a sparingly soluble salt A_pB_q, the relationship of its solubility product (L_S) with its solubility (S) is

(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) $L_S = S^{pq} \cdot (pq)^{p+q}$

83. $Ag^+ + NH_3 \rightleftharpoons [Ag(NH_3)^+]$; $K_1 = 1.6 \times 10^3$

$[Ag(NH_3)^+] + NH_3 \rightleftharpoons [Ag(NH_3)_2^+]$; $K_2 = 6.8 \times 10^3$.

The formation constant of $[Ag(NH_3)_2^+]$ is

(a) 1.08×10^{7}
(b) 6.08×10^{6}
(c) 1.08×10^{3}
(d) 1.08×10^{5}

84. Solubility product constant (K_{sp}) of salts of types MX, MX_2 and M_3X at temperature, T are 4.0×10^{-8}, 3.2×10^{-14} and 2.7×10^{-15}, respectively. Solubilities (in M) of the salts at temperature, T, are in the order

(a) $MX > MX_2 > M_3X$
(b) $M_3X > MX_2 > MX$
(c) $MX_2 > M_3X > MX$
(d) $MX > M_3X > MX_2$

85. The solubility of AgCl in water is 0.001435 g per litre at 15°C. The solubility product of AgCl is (Ag = 108, Cl = 35.3)

(a) 10^{-5}
(b) 10^{-10}
(c) 2×10^{-10}
(d) 10^{-9}

86. The solubility of $Li_3Na_3(AlF_6)_2$ is 0.0744 g per 100 ml at 298 K. Calculate the solubility product of the salt. (Atomic masses: Li = 7, Na = 23, Al = 27, F = 19)

(a) 2.56×10^{-22}
(b) 2×10^{-3}
(c) 7.46×10^{-19}
(d) 3.46×10^{-12}

87. The solubility product of CaF_2 is 1.08×10^{-10}. What mass of CaF_2 will dissolve in 500 ml water in order to make a saturated solution? (Ca = 40, F = 19)

(a) 3×10^{-4} g
(b) 1.17×10^{-2} g
(c) 1.17 mg
(d) 3×10^{-3} g

88. The solubility product of $Mg(OH)_2$ is 9.0×10^{-12}. The pH of an aqueous saturated solution of $Mg(OH)_2$ is (log 1.8 = 0.26, log 3 = 0.48)

(a) 3.58
(b) 10.42
(c) 3.88
(d) 6.76

89. The molar solubility of $Zn(OH)_2$ in 1 M ammonia solution at room temperature is (K_{sp} of $Zn(OH)_2 = 1.6 \times 10^{-17}$; K_{stab} of $Zn(NH_3)_4^{2+} = 1.6 \times 10^{10}$)

(a) 4×10^{-3} M
(b) 1.58×10^{-6} M
(c) 4×10^{-9} M
(d) 2.56×10^{-7} M

90. Assuming no change in volume, calculate the minimum mass of NaCl necessary to dissolve 0.01 mole of AgCl in 100 L solution. K_{sp} of AgCl = 2.0×10^{-10} and K_f of $AgCl_2^- = 2.5 \times 10^5$.

(a) 117 g
(b) 11.7 kg
(c) 58.5 kg
(d) 585 g

91. The solubility product of AgC_2O_4 at 25°C is 2.3×10^{-11} M^3. A solution of $K_2C_2O_4$ containing 0.15 moles in 500 ml water is shaken at 25°C with excess of Ag_2CO_3 till the following equilibrium is reached:

$$Ag_2CO_3 + K_2C_2O_4 \rightleftharpoons Ag_2C_2O_4 + K_2CO_3$$

At equilibrium, the solution contains 0.035 mole of K_2CO_3. Assuming the degree of dissociation of $K_2C_2O_4$ and K_2CO_3 to be equal, calculate the solubility product of Ag_2CO_3.

(a) 2.3×10^{-11} M^3
(b) 7.0×10^{-10} M^3
(c) 3.0×10^{-13} M^3
(d) 7.0×10^{-12} M^3

92. For the reaction $[Ag(CN)_2]^- \rightleftharpoons Ag^+ + 2CN^-$, the equilibrium constant, at 25°C, is 4.0×10^{-19}. Calculate the silver ion concentration in a solution which was originally 0.10 molar in KCN and 0.03 molar in $AgNO_3$.

(a) 0
(b) 0.03 M
(c) 3×10^{-19} M
(d) 1.71×10^{-19} M

93. A sample of AgCl was treated with 5.00 ml of 2.0 M Na_2CO_3 solution to give Ag_2CO_3. The remaining solution contained 0.00355 g of Cl^- ions per litre. The solubility product of AgCl is (K_{sp} of Ag_2CO_3 is 8.0×10^{-12}).

(a) 2×10^{-10} (b) 1×10^{-10}
(c) 4×10^{-10} (d) 8×10^{-10}

94. Given: $Ag(NH_3)_2^+ \rightleftharpoons Ag^+ + 2NH_3$, $K_c = 7.2 \times 10^{-8}$ and K_{sp} of AgCl = 1.8×10^{-10} at 298 K. If ammonia is added to a water solution containing excess of AgCl(s) only, calculate the concentration of the complex in 1.0 M aqueous ammonia.

(a) 1.0 M
(b) 0.091 M
(c) 0.0455 M
(d) 0.023 M

95. The solubility of $Pb(OH)_2$ in water is 6.0×10^{-6} M. The solubility of $Pb(OH)_2$ in a buffer solution of pH = 8 is

(a) 8.64 M
(b) 2.16×10^{-16} M
(c) 8.64×10^{-16} M
(d) 8.64×10^{-4} M

96. The silver ion concentration in a 0.2 M solution of $Ag(NH_3)_2NO_3$ is ($K_{diss} = 6.8 \times 10^{-8}$, $1.5^3 = 3.4$)

(a) 0.2 M
(b) 1.5×10^{-3} M
(c) 1.16×10^{-4} M
(d) 6.8×10^{-8} M

97. The formation constant of $Cu(NH_3)_4^{2+}$ is 1.25×10^{12}. What will be the equilibrium concentration of Cu^{2+} if 0.0125 moles of Cu is oxidized and put into 1.0 L of 0.25 M–NH_3 solution?

(a) 2.5×10^{-11} M
(b) 2.5×10^{-13} M
(c) 4×10^{-12} M
(d) 0

98. The simultaneous solubilities of AgSCN and AgBr are, respectively (K_{sp} of AgSCN $= 1 \times 10^{-12}$, K_{sp} of AgBr $= 2.1 \times 10^{-13}$),

(a) 9.09×10^{-7} M, 1.909×10^{-7} M
(b) 1.909×10^{-7} M, 9.09×10^{-7} M
(c) 9.09×10^{-6} M, 1.909×10^{-7} M
(d) 1.1×10^{-6} M, 2.1×10^{-7} M

99. The solubility of AgCN in a buffer solution of pH = 3.0 is (K_{sp} of AgCN $= 1.2 \times 10^{-16}$; K_a of HCN $= 4.8 \times 10^{-10}$)

(a) 1.58×10^{-5} M
(b) 2.0×10^{-5} M
(c) 1.58×10^{-4} M
(d) 2.5×10^{-9} M

100. The solubility of $PbCl_2$ when it is 80% ionized is

(a) 25% less than the solubility of $PbCl_2$ when it is 100% ionized.
(b) 50% less than the solubility of $PbCl_2$ when it is 100% ionized.
(c) More than the solubility of $PbCl_2$ when it is 100% ionized.
(d) is equal to the solubility of $PbCl_2$ when it is 100% ionized.

Precipitation

101. Solubility products of $Mg(OH)_2$, $Cd(OH)_2$, $Al(OH)_3$ and $Zn(OH)_2$ are 4×10^{-11}, 8×10^{-6}, 8.5×10^{-23} and 1.8×10^{-14}, respectively. The cation that will precipitate first as hydroxide, on adding limited quantity of NH_4OH in a solution containing equimolar amount of metal cations, is

(a) Al^{3+}
(b) Zn^{2+}
(c) Mg^{2+}
(d) Cd^{2+}

102. Silver ions are slowly added in a solution with $[Br^-] = [Cl^-] = [CO_3^{2-}] = [AsO_4^{3-}] = 0.1$ M. Which compound will precipitate first?

(a) AgBr ($K_{sp} = 5 \times 10^{-13}$)
(b) AgCl ($K_{sp} = 1.8 \times 10^{-10}$)
(c) Ag_2CO_3 ($K_{sp} = 8.1 \times 10^{-12}$)
(d) Ag_3PO_4 ($K_{sp} = 1 \times 10^{-22}$)

103. The K_{sp} of $Ag_2CrO_4 = 1.2 \times 10^{-11}$. What concentration Ag^+ ion in aqueous solution will just fail to give a precipitate of Ag_2CrO_4 with a solution in which $[CrO_4^{-2}] = 3 \times 10^{-4}$ M?

(a) 10^{-3} M
(b) 10^{-1} M
(c) 10^{-4} M
(d) 2×10^{-4} M

104. A 0.1 mole of $AgNO_3$ is dissolved in 1 L of 1 M – NH_3. If 0.01 mole of NaCl is added to this solution, will AgCl(s) precipitate? K_{sp} for AgCl $= 1.8 \times 10^{-10}$ and K_{stab} for $Ag(NH_3)_2^+ = 1.6 \times 10^7$.

(a) Yes
(b) No
(c) Addition of NaCl in any amount can never result precipitation.
(d) Addition of even smaller amount of NaCl may result precipitation.

105. In 500 ml of 2.5×10^{-5} M – $AgNO_3$ solution, 2000 ml of 5.0×10^{-2} M – NaCl solution is added. The mass of precipitate of AgCl formed is (K_{sp} of AgCl = 2×10^{-10}, Ag = 108)

(a) 1.794 g
(b) 1.794 mg
(c) 5×10^{-6} g
(d) 1.25×10^{-2} g

106. The solubility product of PbI_2 is 7.2×10^{-9}. The maximum mass of NaI which may be added in 500 ml of 0.005 M – $Pb(NO_3)_2$ solution without any precipitation of PbI_2 is (I = 127)

(a) 0.09 g (b) 1.2×10^{-3} g
(c) 6×10^{-4} g (d) 1.08×10^{-5} g

107. The minimum mass of NaBr which should be added in 200 ml of 0.0004 M – $AgNO_3$ solution just to start the precipitation of AgBr. K_{sp} of AgBr = 4×10^{-13}. (Br = 80)

(a) 1.0×10^{-9} g
(b) 2×10^{-10} g
(c) 2.06×10^{-8} g
(d) 1.03×10^{-7} g

108. A sample of hard water contains 0.005 mole of $CaCl_2$ per litre. What is the minimum concentration of $Al_2(SO_4)_3$ which must be exceeded for removing Ca^{2+} ions from this water sample? The solubility product of $CaSO_4$ is 2.4×10^{-5}.

(a) 4.8×10^{-3} M
(b) 1.2×10^{-3} M
(c) 0.0144 M
(d) 2.4×10^{-3} M

109. To 100 ml of a solution, which contains 8.32×10^{-3} g lead ions, 10^{-4} moles of H_2SO_4 is added. How much lead remains in the solution unprecipitated? K_{sp} of $PbSO_4$ = 1.6×10^{-7}. (Pb = 208)

(a) 4×10^{-4} g
(b) 2.67×10^{-4} g
(c) 2×10^{-4} g
(d) 4.16×10^{-3} g

110. An aqueous solution of a metal bromide MBr_2 (0.04 M) is saturated with H_2S. What is the minimum pH at which MS will precipitate? K_{sp} for MS = 6.0×10^{-21}; concentration of saturated H_2S = 0.1M, $K_1 = 10^{-7}$ and $K_2 = 1.5 \times 10^{-13}$ for H_2S.

(a) 1.0 (b) 1.3
(c) 13.0 (d) 0.7

111. An amount of 0.1 millimole of $CdSO_4$ is present in 10 ml acid solution of 0.08 M – HCl. Now H_2S is passed to precipitate all the Cd^{2+} ions. What would be the pH of solution after filtering off precipitate, boiling off H_2S and making the solution 100 ml by adding water?

(a) 3.0 (b) 2.0
(c) 4.0 (d) 2.22

112. A solution contains a mixture of Ag^+ (0.10 M) and Hg_2^{2+} (0.10 M), which are to be separated by selective precipitation. Calculate the maximum concentration of iodide ion at which one of them gets precipitated almost completely. What per cent of that metal ion is precipitated, before the start of precipitation of second metal ion? $K_{sp}(AgI) = 8.5 \times 10^{-17}$ and $K_{sp}(Hg_2I_2) = 2.5 \times 10^{-26}$.

(a) 5×10^{-13} M, 99.83%
(b) 8.5×10^{-16} M, 99.83%
(c) 2.5×10^{-25} M, 100%
(d) 5×10^{-13} M, 98.3%

113. The solubility of $CaCO_3$ is 7 mg/litre. Calculate the solubility product of $BaCO_3$ from this information and from the fact that when Na_2CO_3 is added slowly to a solution containing equimolar concentration of Ca^{2+} and Ba^{2+}, no precipitate of $CaCO_3$ is formed until 90% of Ba^{2+} has been precipitated as $BaCO_3$.

(a) 4.9×10^{-8}
(b) 4.9×10^{-9}
(c) 4.9×10^{-10}
(d) 7×10^{-4}

114. Small amount of freshly precipitated magnesium hydroxides are stirred vigorously in a buffer solution containing 0.25 M of NH_4Cl and 0.05 M of NH_4OH. $[Mg^{2+}]$ in the resulting solution is (K_b for $NH_4OH = 2.0 \times 10^{-5}$ and K_{sp} of $Mg(OH)_2 = 8.0 \times 10^{-12}$)

(a) 4×10^{-6} M
(b) 2×10^{-6} M
(c) 0.5 M
(d) 2.0 M

115. The solubility of metal sulphide in saturated solution of H_2S (concentration = 0.1 M) can be represented as:

$$MS(s) + 2H^+(aq) \rightleftharpoons M^{2+}(aq) + H_2S(aq);$$

$$K_{eq} = \frac{[M^{2+}][H_2S]}{[H^+]^2}$$

The values of K_{eq} for the metal sulphides, MnS, ZnS, CoS and PbS are 3×10^{10}, 3×10^{-2}, 3 and 3×10^{-7}, respectively. If the concentration of each metal ion in a saturated solution of H_2S is 0.01 M, which metal sulphide(s) will precipitate at $[H^+] = 1.0$ M?

(a) MnS, ZnS, CoS
(b) PbS
(c) PbS, ZnS, CoS
(d) PbS, ZnS

Answer Keys – Exercise I

Basics

1. (b) 2. (d) 3. (a) 4. (b) 5. (c) 6. (c) 7. (c) 8. (d) 9. (c) 10. (c)

Strong Acids and Bases

11. (b) 12. (d) 13. (c) 14. (d) 15. (d) 16. (a) 17. (c) 18. (b) 19. (c) 20. (d)

Weak Acids and Bases

21. (a) 22. (c) 23. (a) 24. (c) 25. (d) 26. (a) 27. (d) 28. (d) 29. (b) 30. (a)
31. (b) 32. (c) 33. (a) 34. (d) 35. (d)

Polyprotic Acids and Bases

36. (a) 37. (a) 38. (a) 39. (b) 40. (c)

Buffer Solutions

41. (d) 42. (d) 43. (d) 44. (a) 45. (d) 46. (b) 47. (d) 48. (b) 49. (a) 50. (b)

Hydrolysis of Salts

51. (a) 52. (d) 53. (c) 54. (b) 55. (d) 56. (c) 57. (d) 58. (b) 59. (c) 60. (b)
61. (c) 62. (b) 63. (a) 64. (c) 65. (b)

Indicators

66. (c) 67. (b) 68. (a) 69. (c) 70. (b)

Solubility

71. (a) 72. (c) 73. (b) 74. (c) 75. (b) 76. (b) 77. (b) 78. (b) 79. (c) 80. (b)
81. (d) 82. (a) 83. (d) 84. (d) 85. (b) 86. (c) 87. (b) 88. (b) 89. (a) 90. (b)
91. (d) 92. (c) 93. (a) 94. (c) 95. (d) 96. (b) 97. (b) 98. (a) 99. (a) 100. (c)

Precipitation

101. (a) 102. (a) 103. (d) 104. (b) 105. (b) 106. (a) 107. (c) 108. (b) 109. (d) 110. (a)
111. (b) 112. (a) 113. (c) 114. (c) 115. (b)