

ANSWERS

I. Multiple Choice Questions (Type-I)

1. (iv) 2. (iv) 3. (iii) 4. (ii) 5. (ii) 6. (i)
7. (iii) 8. (iv) 9. (i) 10. (iii) 11. (iii) 12. (iv)
13. (i) 14. (iii)

15. (i) $\Delta G^\ominus = 0$

Justification : $\Delta G^\ominus = -RT \ln K$

At the stage of half completion of reaction $[A] = [B]$, Therefore, $K = 1$.

Thus, $\Delta G^\ominus = 0$

16. (i), *Justification*: According to Le-Chatelier's principle, at constant temperature, the equilibrium composition will change but K will remain same.
17. (ii)
18. (i)
19. (iv)

II. Multiple Choice Questions (Type-II)

20. (i), (iii) and (iv)

Justification : (i) K increases with increase in temperature.

(iii) $Q > K$, Therefore, reaction proceeds in the backward direction.

(iv) $\Delta n > 0$, Therefore, $\Delta S > 0$.

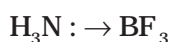
21. (i) and (iv)

III. Short Answer Type

22. HCl Cl⁻
acid conjugate base
H₂O H₃O⁺
base conjugate acid

23. • Sugar does not ionise in water but NaCl ionises completely in water and produces Na⁺ and Cl⁻ ions.
• Conductance increases with increase in concentration of salt due to release of more ions.

24. BF_3 acts as a Lewis acid as it is electron deficient compound and coordinate bond is formed as given below :



25. • Order of extent of ionisation at equilibrium is as follows :
Dimethylamine > Ammonia > Pyridine > Urea
• Since dimethylamine will ionise to the maximum extent it is the strongest base out of the four given bases.

26. $\text{RO}^- > \text{OH}^- > \text{CH}_3\text{COO}^- > \text{Cl}^-$

27. $\text{NH}_4\text{Cl} < \text{C}_6\text{H}_5\text{COONH}_4 < \text{KNO}_3 < \text{CH}_3\text{COONa}$

28. At a given time the reaction quotient Q for the reaction will be given by the expression.

$$Q = \frac{[\text{H}_2][\text{I}_2]}{[\text{HI}]^2}$$

$$= \frac{1 \times 10^{-5} \times 1 \times 10^{-5}}{(2 \times 10^{-5})^2} = \frac{1}{4}$$

$$= 0.25 = 2.5 \times 10^{-1}$$

As the value of reaction quotient is greater than the value of K_c i.e. 1×10^{-4} the reaction will proceed in the reverse direction.

29. Concentration of $10^{-8} \text{ mol dm}^{-3}$ indicates that the solution is very dilute. Hence, the contribution of H_3O^+ concentration from water is significant and should also be included for the calculation of pH.

30. (i) pH = 5

$$[\text{H}^+] = 10^{-5} \text{ mol L}^{-1}$$

On 100 times dilution

$$[\text{H}^+] = 10^{-7} \text{ mol L}^{-1}$$

On calculating the pH using the equation $\text{pH} = -\log [\text{H}^+]$, value of pH comes out to be 7. It is not possible. This indicates that solution is very dilute. Hence,

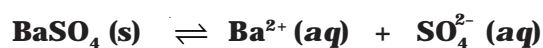
$$\text{Total hydrogen ion concentration} = [\text{H}^+]$$

$$= \left[\begin{array}{l} \text{Contribution of} \\ \text{H}_3\text{O}^+ \text{ ion} \\ \text{concentration} \\ \text{of acid} \end{array} \right] + \left[\begin{array}{l} \text{Contribution of} \\ \text{H}_3\text{O}^+ \text{ ion} \\ \text{concentration} \\ \text{of water} \end{array} \right]$$

$$= 10^{-7} + 10^{-7}$$

$$\text{pH} = 2 \times 10^{-7} = 7 - \log 2 = 7 - 0.3010 = 6.6990$$

31.



At t = 0	1	0	0
At equilibrium in water	1-S	S	S
At equilibrium in the presence of sulphuric acid	1-S	S	(S+0.01)

$$K_{\text{sp}} \text{ for BaSO}_4 \text{ in water} = [\text{Ba}^{2+}] [\text{SO}_4^{2-}] = (\text{S})(\text{S}) = \text{S}^2$$

$$\text{But } \text{S} = 8 \times 10^{-4} \text{ mol dm}^{-3}$$

$$\therefore K_{\text{sp}} = (8 \times 10^{-4})^2 = 64 \times 10^{-8} \quad \dots (1)$$

The expression for K_{sp} in the presence of sulphuric acid will be as follows :

$$K_{\text{sp}} = (\text{S})(\text{S} + 0.01) \quad \dots (2)$$

Since value of K_{sp} will not change in the presence of sulphuric acid, therefore from (1) and (2)

$$(\text{S})(\text{S} + 0.01) = 64 \times 10^{-8}$$

$$\Rightarrow \text{S}^2 + 0.01 \text{S} = 64 \times 10^{-8}$$

$$\Rightarrow \text{S}^2 + 0.01 \text{S} - 64 \times 10^{-8} = 0$$

$$\Rightarrow \text{S} = \frac{-0.01 \pm \sqrt{(0.01)^2 + (4 \times 64 \times 10^{-8})}}{2}$$

$$= \frac{-0.01 \pm \sqrt{10^{-4} + (256 \times 10^{-8})}}{2}$$

$$= \frac{-0.01 \pm \sqrt{10^{-4} (1 + 256 \times 10^{-2})}}{2}$$

$$= \frac{-0.01 \pm 10^{-2} \sqrt{1 + 0.256}}{2}$$

$$= \frac{-0.01 \pm 10^{-2} \sqrt{1.256}}{2}$$

$$= \frac{-10^{-2} + (1.12 \times 10^{-2})}{2}$$

$$= \frac{(-1 + 1.12) \times 10^{-2}}{2} = \frac{0.12}{2} \times 10^{-2}$$

$$= 6 \times 10^{-4} \text{ mol dm}^{-3}$$

32. pH of HOCl = 2.85

But, $-\text{pH} = \log [\text{H}^+]$

$\therefore -2.85 = \log [\text{H}^+]$

$\Rightarrow \bar{3}.15 = \log [\text{H}^+]$

$\Rightarrow [\text{H}^+] = 1.413 \times 10^{-3}$

For weak mono basic acid $[\text{H}^+] = \sqrt{K_a \times C}$

$$\begin{aligned}\Rightarrow K_a &= \frac{[\text{H}^+]^2}{C} = \frac{(1.413 \times 10^{-3})^2}{0.08} \\ &= 24.957 \times 10^{-6} = 2.4957 \times 10^{-5}\end{aligned}$$

33. pH of Solution A = 6

Therefore, concentration of $[\text{H}^+]$ ion in solution A = $10^{-6} \text{ mol L}^{-1}$

pH of Solution B = 4

Therefore, Concentration of $[\text{H}^+]$ ion concentration of solution B = $10^{-4} \text{ mol L}^{-1}$

On mixing one litre of each solution, total volume = 1L + 1L = 2L

Amount of H^+ ions in 1L of Solution A = Concentration \times volume V
 $= 10^{-6} \text{ mol} \times 1\text{L}$

Amount of H^+ ions in 1L of solution B = $10^{-4} \text{ mol} \times 1\text{L}$

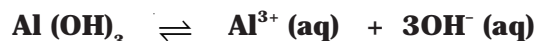
\therefore Total amount of H^+ ions in the solution formed by mixing solutions A and B is $(10^{-6} \text{ mol} + 10^{-4} \text{ mol})$

This amount is present in 2L solution.

$$\begin{aligned}\therefore \text{Total } [\text{H}^+] &= \frac{10^{-4}(1 + 0.01)}{2} = \frac{1.01 \times 10^{-4}}{2} \text{ mol L}^{-1} = \frac{1.01 \times 10^{-4}}{2} \text{ mol L}^{-1} \\ &= 0.5 \times 10^{-4} \text{ mol L}^{-1} \\ &= 5 \times 10^{-5} \text{ mol L}^{-1}\end{aligned}$$

$$\begin{aligned}\text{pH} &= -\log [\text{H}^+] = -\log (5 \times 10^{-5}) \\ &= -[\log 5 + (-5 \log 10)] \\ &= -\log 5 + 5 \\ &= 5 - \log 5 \\ &= 5 - 0.6990 \\ &= 4.3010 = 4.3\end{aligned}$$

34. Let S be the solubility of $\text{Al}(\text{OH})_3$.



Concentration of species at t = 0	1	0	0
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Concentration of various species at equilibrium	1-S	S	3S
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$$K_{sp} = [\text{Al}^{3+}][\text{OH}^-]^3 = (S)(3S)^3 = 27S^4$$

$$S^4 = \frac{K_{sp}}{27} = \frac{27 \times 10^{-11}}{27 \times 10} = 1 \times 10^{-12}$$

$$S = 1 \times 10^{-3} \text{ mol L}^{-1}$$

- (i) **Solubility of $\text{Al}(\text{OH})_3$**

Molar mass of $\text{Al}(\text{OH})_3$ is 78 g. Therefore,

$$\begin{aligned} \text{Solubility of } \text{Al}(\text{OH})_3 \text{ in } \text{g L}^{-1} &= 1 \times 10^{-3} \times 78 \text{ g L}^{-1} = 78 \times 10^{-3} \text{ g L}^{-1} \\ &= 7.8 \times 10^{-2} \text{ g L}^{-1} \end{aligned}$$

- (ii) **pH of the solution**

$$S = 1 \times 10^{-3} \text{ mol L}^{-1}$$

$$[\text{OH}^-] = 3S = 3 \times 1 \times 10^{-3} = 3 \times 10^{-3}$$

$$\text{pOH} = 3 - \log 3$$

$$\text{pH} = 14 - \text{pOH} = 11 + \log 3 = 11.4771$$

35. K_{sp} of $\text{PbCl}_2 = 3.2 \times 10^{-8}$

Let S be the solubility of PbCl_2 .



Concentration of species at t = 0	1	0	0
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Concentration of various species at equilibrium	1-S	S	2S
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$$K_{sp} = [\text{Pb}^{2+}][\text{Cl}^-]^2 = (S)(2S)^2 = 4S^3$$

$$K_{sp} = 4S^3$$

$$S^3 = \frac{K_{sp}}{4} = \frac{3.2 \times 10^{-8}}{4} \text{ mol L}^{-1} = 8 \times 10^{-9} \text{ mol L}^{-1}$$

$$S = \sqrt[3]{8 \times 10^{-9}} = 2 \times 10^{-3} \text{ mol L}^{-1} \therefore S = 2 \times 10^{-3} \text{ mol L}^{-1}$$

Molar mass of $\text{PbCl}_2 = 278$

$$\begin{aligned}\therefore \text{Solubility of } \text{PbCl}_2 \text{ in } \text{g L}^{-1} &= 2 \times 10^{-3} \times 278 \text{ g L}^{-1} \\ &= 556 \times 10^{-3} \text{ g L}^{-1} \\ &= 0.556 \text{ g L}^{-1}\end{aligned}$$

To get saturated solution, 0.556 g of PbCl_2 is dissolved in 1 L water.

$$0.1 \text{ g } \text{PbCl}_2 \text{ is dissolved in } \frac{0.1}{0.556} \text{ L} = 0.1798 \text{ L water.}$$

To make a saturated solution, dissolution of 0.1 g PbCl_2 in 0.1798 L \approx 0.2 L of water will be required.

$$\begin{aligned}37. \quad \Delta_r H^\ominus &= \Delta_r H^\ominus [\text{CaO(s)}] + \Delta_r H^\ominus [\text{CO}_2(\text{g})] - \Delta_r H^\ominus [\text{CaCO}_3(\text{s})] \\ \therefore \Delta_r H^\ominus &= 178.3 \text{ kJ mol}^{-1}\end{aligned}$$

The reaction is endothermic. Hence, according to Le-Chatelier's principle, reaction will proceed in forward direction on increasing temperature.

IV. Matching Type

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|-----------------------------------|------------------------|-------------------------|------------------------|
| 38. (i) \rightarrow (b) | (ii) \rightarrow (d) | (iii) \rightarrow (c) | (iv) \rightarrow (a) |
| 39. (i) \rightarrow (d) | (ii) \rightarrow (c) | (iii) \rightarrow (b) | |
| 40. (i) \rightarrow (d) | (ii) \rightarrow (a) | (iii) \rightarrow (b) | |
| 41. (i) \rightarrow (b) | (ii) \rightarrow (e) | (iii) \rightarrow (c) | (iv) \rightarrow (d) |
| 42. (i) \rightarrow (c) | (ii) \rightarrow (a) | (iii) \rightarrow (b) | |
| 43. (i) \rightarrow (b) and (c) | (ii) \rightarrow (d) | (iii) \rightarrow (a) | |

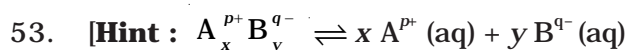
V. Assertion and Reason Type

44. (i) 45. (i) 46. (ii) 47. (iii) 48. (i) 49. (iii)
50. (iv)

VI. Long Answer Type

51. (i) $Q_c < K_c$
(ii) $Q_c > K_c$
(iii) $Q_c = K_c$

where, Q_c is reaction quotient in terms of concentration and K_c is equilibrium constant.



S moles of $A_x B_y$ dissolve to give xS moles of A^{p+} and yS moles of B^{q-} .]

54. $\Delta G = \Delta G^\ominus + RT \ln Q$

ΔG^\ominus = Change in free energy as the reaction proceeds

ΔG = Standard free energy change

Q = Reaction quotient

R = Gas constant

T = Absolute temperature

Since $\Delta G^\ominus = -RT \ln K$

$$\therefore \Delta G = -RT \ln K + RT \ln Q = RT \ln \frac{Q}{K}$$

If $Q < K$, ΔG will be negative. Reaction proceeds in the forward direction.

If $Q = K$, $\Delta G = 0$, no net reaction.

[Hint: Next relate Q with concentration of CO , H_2 , CH_4 and H_2O in view of reduced volume (increased pressure). Show that $Q < K$ and hence the reaction proceeds in forward direction.]