

**I. Multiple Choice Questions (Type-I)**

1. We know that the relationship between  $K_c$  and  $K_p$  is

$$K_p = K_c(RT)^{\Delta n}$$

What would be the value of  $\Delta n$  for the reaction



- (i) 1
- (ii) 0.5
- (iii) 1.5
- (iv) 2

**Solution:**

Option (iv) is the answer.

2. For the reaction  $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightarrow 2\text{HI (g)}$ , the standard free energy is  $\Delta G > 0$ .

The equilibrium constant ( $K$ ) would be \_\_\_\_\_.

- (i)  $K = 0$
- (ii)  $K > 1$
- (iii)  $K = 1$
- (iv)  $K < 1$

**Solution:**

Option (iv) is the answer.

3. Which of the following is not a general characteristic of equilibria involving physical processes?

- (i) Equilibrium is possible only in a closed system at a given temperature.
- (ii) All measurable properties of the system remain constant.
- (iii) All the physical processes stop at equilibrium.
- (iv) The opposing processes occur at the same rate and there is dynamic but stable condition.

**Solution:**

Option (iii) is the answer.

4.  $\text{PCl}_5$ ,  $\text{PCl}_3$  and  $\text{Cl}_2$  are at equilibrium at 500K in a closed container and their concentrations are  $0.8 \times 10^{-3} \text{ mol L}^{-1}$ ,  $1.2 \times 10^{-3} \text{ mol L}^{-1}$  and  $1.2 \times 10^{-3} \text{ mol L}^{-1}$  respectively. The value of  $K_c$  for the reaction  $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$  will be

- (i)  $1.8 \times 10^3 \text{ mol L}^{-1}$
- (ii)  $1.8 \times 10^{-3}$
- (iii)  $1.8 \times 10^{-3} \text{ L mol}^{-1}$
- (iv)  $0.55 \times 10^4$

**Solution:**

Option (ii) is the answer.

5. Which of the following statements is incorrect?

- (i) In equilibrium mixture of ice and water kept in perfectly insulated flask

mass of ice and water does not change with time.

(ii) The intensity of red colour increases when oxalic acid is added to a solution containing iron (III) nitrate and potassium thiocyanate.

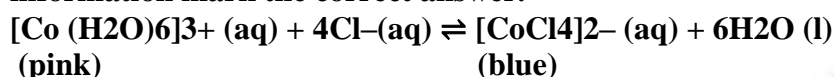
(iii) On addition of the catalyst, the equilibrium constant value is not affected.

(iv) The equilibrium constant for a reaction with negative  $\Delta H$  value decreases as the temperature increases.

**Solution:**

Option (ii) is the answer.

**6. When hydrochloric acid is added to cobalt nitrate solution at room temperature, the following reaction takes place and the reaction mixture becomes blue. On cooling the mixture it becomes pink. Based on this information mark the correct answer.**



(i)  $\Delta H > 0$  for the reaction

(ii)  $\Delta H < 0$  for the reaction

(iii)  $\Delta H = 0$  for the reaction

(iv) The sign of  $\Delta H$  cannot be predicted based on this information.

**Solution;**

Option (i) is the answer.

**7. The pH of neutral water at 25°C is 7.0. As the temperature increases, ionization of water increases, however, the concentration of  $\text{H}^+$  ions and  $\text{OH}^-$  ions are equal. What will be the pH of pure water at 60°C?**

(i) Equal to 7.0

(ii) Greater than 7.0

(iii) Less than 7.0

(iv) Equal to zero

**Solution:**

Option (iii) is the answer.

**8. The ionisation constant of an acid,  $K_a$ , is the measure of the strength of an acid. The  $K_a$  values of acetic acid, hypochlorous acid and formic acid are  $1.74 \times 10^{-5}$ ,  $3.0 \times 10^{-8}$  and  $1.8 \times 10^{-4}$  respectively. Which of the following orders of pH of 0.1 mol  $\text{dm}^{-3}$  solutions of these acids are correct?**

(i) acetic acid > hypochlorous acid > formic acid

(ii) hypochlorous acid > acetic acid > formic acid

(iii) formic acid > hypochlorous acid > acetic acid

(iv) formic acid > acetic acid > hypochlorous acid

**Solution:**

Option (iv) is the answer.

**9.  $K_a$ ,  $2K_a$  and  $3K_a$  is the respective ionisation constants for the following reactions.**





The correct relationship between  $K_{a1}$ ,  $K_{a2}$  and  $K_{a3}$  is

(i)  $K_{a3} = K_{a1} \times K_{a2}$

(ii)  $K_{a3} = K_{a1} + K_{a2}$

(iii)  $K_{a3} = K_{a1} - K_{a2}$

(iv)  $K_{a3} = K_{a1} / K_{a2}$

**Solution:**

Option (i) is the answer.

10. The acidity of  $\text{BF}_3$  can be explained based on which of the following concepts?

(i) Arrhenius concept

(ii) Bronsted Lowry concept

(iii) Lewis concept

(iv) Bronsted Lowry as well as Lewis concept.

**Solution:**

Option (iii) is the answer.

11. Which of the following will produce a buffer solution when mixed in equal volumes?

(i) 0.1 mol  $\text{dm}^{-3}$   $\text{NH}_4\text{OH}$  and 0.1 mol  $\text{dm}^{-3}$   $\text{HCl}$

(ii) 0.05 mol  $\text{dm}^{-3}$   $\text{NH}_4\text{OH}$  and 0.1 mol  $\text{dm}^{-3}$   $\text{HCl}$

(iii) 0.1 mol  $\text{dm}^{-3}$   $\text{NH}_4\text{OH}$  and 0.05 mol  $\text{dm}^{-3}$   $\text{HCl}$

(iv) 0.1 mol  $\text{dm}^{-3}$   $\text{CH}_3\text{COONa}$  and 0.1 mol  $\text{dm}^{-3}$   $\text{NaOH}$

**Solution:**

Option (iii) is the answer.

12. In which of the following solvents is silver chloride most soluble?

(i) 0.1 mol  $\text{dm}^{-3}$   $\text{AgNO}_3$  solution

(ii) 0.1 mol  $\text{dm}^{-3}$   $\text{HCl}$  solution

(iii)  $\text{H}_2\text{O}$

(iv) Aqueous ammonia

**Solution:**

Option (iv) is the answer.

13. What will be the value of pH of 0.01 mol  $\text{dm}^{-3}$   $\text{CH}_3\text{COOH}$  ( $K_a = 1.74 \times 10^{-5}$ )?

(i) 3.4

(ii) 3.6

(iii) 3.9

(iv) 3.0

**Solution:**

Option (i) is the answer.

14.  $K_a$  for  $\text{CH}_3\text{COOH}$  is  $1.8 \times 10^{-5}$  and  $K_b$  for  $\text{NH}_4\text{OH}$  is  $1.8 \times 10^{-5}$ . The pH of ammonium acetate will be

(i) 7.005

- (ii) 4.75
- (iii) 7.0
- (iv) Between 6 and 7

**Solution:**

Option (iii) is the answer.

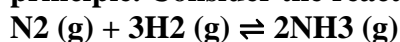
**15. Which of the following options will be correct for the stage of half completion of the reaction  $A \rightleftharpoons B$**

- (i)  $\Delta G^\circ = 0$
- (ii)  $\Delta G^\circ > 0$
- (iii)  $\Delta G^\circ < 0$
- (iv)  $\Delta G^\circ = -RT \ln 2$ .

**Solution:**

Option (i) is the answer.

**16. On increasing the pressure, in which direction will the gas-phase reaction proceed to re-establish equilibrium, is predicted by applying Le Chatelier's principle. Consider the reaction.**



**Which of the following is correct, if the total pressure at which the equilibrium is established, is increased without changing the temperature?**

- (i) K will remain the same
- (ii) K will decrease
- (iii) K will increase
- (iv) K will increase initially and decrease when pressure is very high

**Solution:**

Option (i) is the answer.

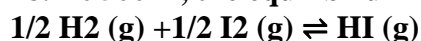
**17. What will be the correct order of vapour pressure of water, acetone and ether at 30°C. Given that among these compounds, water has a maximum boiling point and ether have a minimum boiling point?**

- (i) Water < ether < acetone
- (ii) Water < acetone < ether
- (iii) Ether < acetone < water
- (iv) Acetone < ether < water

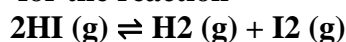
**Solution:**

Option (ii) is the answer.

**18. At 500 K, the equilibrium constant,  $K_c$ , for the following reaction is 5.**



**What would be the equilibrium constant  $K_c$  for the reaction**



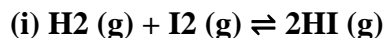
- (i) 0.04
- (ii) 0.4
- (iii) 25

(iv) 2.5

**Solution:**

Option (I) is the answer.

**19. In which of the following reactions, the equilibrium remains unaffected on addition of small amount of argon at constant volume?**



(iv) The equilibrium will remain unaffected in all the three cases.

**Solution:**

Option (iv) is the answer.

## II. Multiple Choice Questions (Type-II)

In the following questions, two or more options may be correct.

**20. For the reaction  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$ , the value of K is 50 at 400 K and 1700 at 500 K. Which of the following options is correct?**

(i) The reaction is endothermic

(ii) The reaction is exothermic

(iii) If  $\text{NO}_2(\text{g})$  and  $\text{N}_2\text{O}_4(\text{g})$  are mixed at 400 K at partial pressures 20 bar and 2 bar respectively, more  $\text{N}_2\text{O}_4$

(g) will be formed.

(iv) The entropy of the system increases.

**Solution:**

Option (i) (iii) and (iv) are the answers.

**21. At a particular temperature and atmospheric pressure, the solid and liquid phases of a pure substance can exist in equilibrium. Which of the following Does the term define this temperature?**

(i) Normal melting point

(ii) Equilibrium temperature

(iii) Boiling point

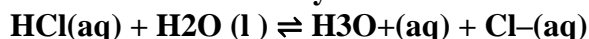
(iv) Freezing point

**Solution:**

Option (i) and (iv) are the answers.

## III. Short Answer Type

**22. The ionisation of hydrochloric in water is given below:**



**Label two conjugate acid-base pairs in this ionisation.**

**Solution:**

The two conjugate acid-base pairs in the ionisation of HCl are (HCl-Cl<sup>-</sup>) in which HCl is the conjugate acid and Cl<sup>-</sup> is the conjugate base similarly the second pair is (H<sub>2</sub>O-H<sub>3</sub>O<sup>+</sup>) in which H<sub>2</sub>O is the conjugate base and H<sub>3</sub>O<sup>+</sup> is the conjugate acid.

**23. The aqueous solution of sugar does not conduct electricity. However, when sodium chloride is added to water, it conducts electricity. How will you explain this statement on the basis of ionization and how is it affected by the concentration of sodium chloride?**

**Solution;**

The aqueous solution of sugar does not conduct electricity because they exist as a molecule in water. They don't have free ions to conduct electricity but in the case of NaCl, free ions of Na<sup>+</sup> and Cl<sup>-</sup> are present to conduct electricity. Conductance depends on the no. of ions present in the solution. More will the no. of ions of NaCl in water more will be the conductivity.

**24. BF<sub>3</sub> does not have proton but still acts as an acid and reacts with NH<sub>3</sub>. Why is it so? What type of bond is formed between the two?**

**Solution:**

According to Lewis concept e<sup>-</sup> deficient species are called lewis acid so BF<sub>3</sub> will act as a lewis acid while NH<sub>3</sub> (N=1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>3</sup>) has a lone pair so it will act as a lewis base and it will donate its lone pair to the empty p-orbital of Boron through a coordinate bond to form an adduct.

**25. Ionization constant of a weak base MOH is given by the expression**

$$K_b = \frac{[M^+][OH^-]}{[MOH]}$$

**Values of ionisation constant of some weak bases at a particular temperature are given below:**

**Base Di-methylamine Urea Pyridine Ammonia**

**K<sub>b</sub>  $5.4 \times 10^{-4}$   $1.3 \times 10^{-14}$   $1.77 \times 10^{-9}$   $1.77 \times 10^{-5}$**

**Arrange the bases in decreasing order of the extent of their ionisation at Equilibrium. Which of the above base is the strongest?**

**Solution:**

The decreasing order of bases based on the ionisation constant at Equilibrium will be;-

Di-methylamine > Ammonia > Pyridine > Urea

The strongest base will be Di-methyl amine as its pK<sub>b</sub> value is 3.29 and we know that the less the pK<sub>b</sub> value strong is the base.

**26. The conjugate acid of a weak base is always stronger. What will be the decreasing order of basic strength of the following conjugate bases?**

**OH<sup>-</sup>, RO<sup>-</sup>, CH<sub>3</sub>COO<sup>-</sup>, Cl<sup>-</sup>**

**Solution:**

The conjugate base of a strong acid is weak therefore the decreasing order of basic strength will be;  
 RO<sup>-</sup> > OH<sup>-</sup> > CH<sub>3</sub>COO<sup>-</sup> > Cl<sup>-</sup>

**28. Arrange the following in increasing order of pH**

**KNO<sub>3</sub> (aq), CH<sub>3</sub>COONa (aq), NH<sub>4</sub>Cl (aq), C<sub>6</sub>H<sub>5</sub>COONH<sub>4</sub> (aq)**

**Solution:**

The increasing order of pH will be;

CH<sub>3</sub>COONa < KNO<sub>3</sub> < C<sub>6</sub>H<sub>5</sub>COONH<sub>4</sub> < NH<sub>4</sub>Cl

CH<sub>3</sub>COONa is a salt of a weak acid (CH<sub>3</sub>COOH) and strong base (NaOH)

KNO<sub>3</sub> is a salt of strong acid (HNO<sub>3</sub>)-strong base (KOH)



$C_6H_5COONH_4$  is a salt of a weak acid (benzoic acid) and weak base ( $NH_4OH$ )  
 $NH_4Cl$  is a salt of a strong acid ( $HCl$ ) and a weak base ( $NH_4OH$ )

**28. The value of  $K_c$  for the reaction  $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$  is  $1 \times 10^{-4}$**

**At a given time, the composition of the reaction mixture is**

**$[HI] = 2 \times 10^{-5}$  mol,  $[H_2] = 1 \times 10^{-5}$  mol and  $[I_2] = 1 \times 10^{-5}$  mol. In which direction will the reaction proceed?**

**Solution:**

Given that  $K_c = 1 \times 10^{-4}$

$$K_c = \frac{[H_2][I_2]}{[HI]^2}$$

$Q_c$  expresses the relative ratio of products to reactants at a given instant.

$$Q_c = \frac{[H_2][I_2]}{[HI]^2} \\ = \frac{(1 \times 10^{-5})(1 \times 10^{-5})}{(2 \times 10^{-5})^2}$$

$$Q_c = 1/4 = 0.25$$

Here;  $Q_c > K_c$  Reaction will proceed in reverse direction.

**29. Based on the equation  $pH = -\log [H^+]$ , the pH of  $10^{-8}$  mol  $dm^{-3}$  solution of  $HCl$  should be 8. However, it is observed to be less than 7.0. Explain the reason.**

**Solution:**

The solution is very dilute here and we know that  $HCl$  reacts with water to form hydronium ion. A decrease in pH can be observed as a result of a large concentration of  $H^+$ . Hydronium ion concentration also to be considered here.

Now total pH will be;  $[H_3O^+] = 10^{-8} + 10^{-7} M = 7$

Hence the solution will be acidic.

**30. The pH of a solution of a strong acid is 5.0. What will be the pH of the solution obtained after diluting the given solution 100 times?**

**Solution:**

As we dilute the solution, the concentration of the solution will reduce by how much times we are diluting it.

When diluted 100 times  $[H^+] = 10^{-5}/100 = 10^{-7} \text{ mol/L}$

And, pH Value will be =  $pH = -\log [H^+]$

$$= -\log [10^{-7}] = 7$$

Hence the pH after diluting solution a hundred times will be 7.

**31. A sparingly soluble salt gets precipitated only when the product of the concentration of its ions in the solution ( $Q_{sp}$ ) becomes greater than its solubility product. If the solubility of  $BaSO_4$  in water is  $8 \times 10^{-4}$  mol  $dm^{-3}$ , calculate its solubility in 0.01 mol  $dm^{-3}$  of  $H_2SO_4$ .**

**Solution:**

Given, the solubility of  $BaSO_4$  in water =  $8 \times 10^{-4}$  g/L

The equation of disassociation of  $BaSO_4$  will be-



( $S'$  is the solubility of  $Ba^{2+}$  in 0.01  $HCl$ )

$S \ll 0.01$ , so it can be neglected

We know that  $K_{sp} = S^2$

$$K_{sp} = (8 \times 10^{-8})^2$$

$$= 64 \times 10^{-8}$$

$$\text{Now, } K_{sp} = (S')^2 \text{ (0.01)}$$

$$S' = 64.8 \times 10^{-8} / 0.01 = 6.4 \times 10^{-5}$$

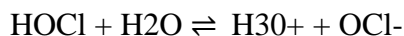
Hence solubility of  $\text{BaSO}_4$  in  $0.01 \text{ mol dm}^{-3}$  of  $\text{H}_2\text{SO}_4$  is  $6.4 \times 10^{-5}$

**32. pH of  $0.08 \text{ mol dm}^{-3}$  HOCl solution is 2.85. Calculate its ionisation constant.**

**Solution:**

Given,  $\text{pH} = 2.85$  and  $C = 0.08 \text{ mol dm}^{-3}$

Now since HOCl is a weak acid its dissociation will be given as-



We know that;

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

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

$$[\text{H}^+] = \text{antilog} (-2.85)$$

$$[\text{H}^+] = 1.41 \times 10^{-3}$$

We also know that, for a weak mono basic acid-

$$\text{(On squaring both sides)} [\text{H}^+]^2 = K_a C$$

$$K_a = (1.41 \times 10^{-3})^2 / 0.08 = 2.5 \times 10^{-5}$$

Hence the ionization constant of HOCl will be  $2.5 \times 10^{-5}$

**33. Calculate the pH of a solution formed by mixing equal volumes of two solutions A and B of a strong acid having  $\text{pH} = 6$  and  $\text{pH} = 4$  respectively.**

**Solution:**

Given,  $\text{pH}$  of solution A = 6

$[\text{H}^+]$  of solution A =  $10^{-6} \text{ mol/lit}$ .

$\text{pH}$  of solution B = 4

$[\text{H}^+]$  of solution B =  $10^{-4} \text{ mol/lit}$ .

On mixing 1L of each solution we will get total 2L of Solution.

Amount of  $[\text{H}^+]$  in 1L: solution A =  $10^{-6} \times 1\text{L} = 10^{-6}$

: Solution B =  $10^{-4} \times 1\text{L} = 10^{-4}$

Total  $[\text{H}^+]$  in Solution =  $10^{-6} + 10^{-4} / 2$

$$= 10^{-4} (1 + 0.01/2) = 10^{-4} \times 1.01/2$$

$$= 5 \times 10^{-5} \text{ mol/L}$$

$$\text{pH} = -\log [\text{H}^+] = -\log [5 \times 10^{-5}]$$

$$= -\log(5) + (-5 \log 10)$$

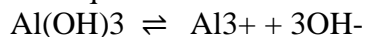
$$= -\log 5 + 5 = 4.3$$

The  $\text{pH}$  of the Solution formed by mixing will be 4.

**34. The solubility product of  $\text{Al}(\text{OH})_3$  is  $2.7 \times 10^{-11}$ . Calculate its solubility in  $\text{g L}^{-1}$  and also find out the  $\text{pH}$  of this solution. (Atomic mass of Al = 27 u).**

**Solution:**

The equation of disassociation of  $\text{Al}(\text{OH})_3$  will be-



We know that,



$$\begin{aligned}
 K_{sp} &= [Al^{3+}] [OH^-]^3 \\
 &= (s) \times (3s)^3 = 27s^4 \\
 s^4 &= K_{sp}/27 \\
 &= 2.7 \times 10^{-11}/27 \\
 s^4 &= 10^{-12} \\
 s &= (10^{-12})^{1/4} = 10^{-3} \text{ mol/L} \\
 \text{Now, molar mass of } Al(OH)_3 &= 78 \\
 \text{Solubility} &= \text{molar mass} \times s \\
 &= 78 \times 10^{-3} \\
 &= 7.8 \times 10^{-2} \text{ g/L} \\
 \text{NOW, we know that-} \\
 \text{pH} &= 14 - \text{pOH} \\
 [OH^-] &= 3s = 3 \times 10^{-3} \\
 \text{pOH} &= 3 - \log 3 \\
 \text{pH} &= 14 - 3 + \log 3 \\
 &= 11.4771
 \end{aligned}$$

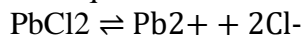
Hence the pH of the solution will be 11.4771 and solubility in g/L will be  $7.8 \times 10^{-2}$  g/L.

**35. Calculate the volume of water required to dissolve 0.1 g lead (II) chloride to get a saturated solution. ( $K_{sp}$  of  $PbCl_2 = 3.2 \times 10^{-8}$ , atomic mass of Pb = 207 u).**

**Solution:**

Given,  $K_{sp}$  of  $PbCl_2 = 3.2 \times 10^{-8}$

The equation of disassociation of  $PbCl_2$  will be-



$$K_{sp} = [Pb^{2+}] [Cl^-]^2$$

$$= (x) \times (2x)^2 = 4x^3$$

$$4x^3 = 3.2 \times 10^{-8}$$

$$x = 2 \times 10^{-3} \text{ mol/L}$$

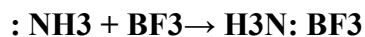
$$\text{Solubility} = \text{molar mass } (PbCl_2) \times 2 \times 10^{-3}$$

$$= 556 \times 10^{-3} = 0.556 \text{ g/L}$$

0.1g of  $PbCl_2$  will dissolve in  $0.1/0.556 = 0.1798$  L

The required volume to get a saturated solution of  $PbCl_2$  is 0.1798 L

**36. A reaction between ammonia and boron trifluoride is given below:**



**Identify the acid and base in this reaction. Which theory explains it? What is the hybridisation of B and N in the reactants?**

**Solution:**

Lewis acid in this reaction is  $NH_3$  ( $N=1s^2 2s^2 2p^1$ ) as it has a lone pair of  $e^-$  to donate in its p-orbital and Lewis base is  $BF_3$  as p-orbital of Boron is empty ( $B=1s^2 2s^2 2p^1$ ) so it will accept lone pair from N and form a dative bond. This is explained by Lewis electronic theory. The Hybridisation of N is  $sp^3$  and B is  $sp^2$ .

**37. Following data is given for the reaction:  $CaCO_3 (s) \rightarrow CaO (s) + CO_2 (g)$**

$$\Delta_f H^\ominus [CaO (s)] = -635.1 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\ominus [\text{CO}_2(\text{g})] = -393.5 \text{ kJ mol}^{-1}$$

$$\Delta_f H^\ominus [\text{CaCO}_3(\text{s})] = -1206.9 \text{ kJ mol}^{-1}$$

**Predict the effect of temperature on the Equilibrium constant of the above reaction.**

**Solution:**

$$\Delta_f H^\ominus = \Delta_f H^\ominus_{\text{products}} - \Delta_f H^\ominus_{\text{reactants}}$$

$$\Delta_f H^\ominus = \Delta_f H^\ominus [\text{CaO}(\text{s})] + \Delta_f H^\ominus [\text{CO}_2(\text{g})] - \Delta_f H^\ominus [\text{CaCO}_3(\text{s})]$$

$$= -635.1 - 393.5 + 1206.9 = 178.3 \text{ kJ mol}^{-1}$$

=positive

i.e. the reaction is exothermic.

Hence according to Le Chatelier's Principle on increasing the temperature, the reaction will shift to forward direction.

#### IV. Matching Type

**38. Match the following equilibria with the corresponding condition**

(i) Liquid $\rightleftharpoons$ Vapour	(a) Saturated solution
(ii) Solid $\rightleftharpoons$ Liquid	(b) Boiling point
(iii) Solid $\rightleftharpoons$ Vapour	(c) Sublimation point
(iv) Solute (s) $\rightleftharpoons$ Solute (solution)	(d) Melting point
	(e) Unsaturated solution

**Solution:**

(i) is b

(ii) is d

(iii) is c

(iv) is a

**39. For the reaction :  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$**

**Equilibrium constant  $K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$**

**Some reactions are written below in Column I and their equilibrium constants in terms of  $K_c$**

**are written in Column II. Match the following reactions with the corresponding equilibrium constant**

Column I (Reaction)	Column II (Equilibrium constant)
(i) $2\text{N}_2(\text{g}) + 6\text{H}_2(\text{g}) \rightarrow 4\text{NH}_3(\text{g})$	(a) $2K_c$
(ii) $2\text{NH}_3(\text{g}) \rightarrow \text{N}_2(\text{g}) + 3\text{H}_2(\text{g})$	(b) $K_c/2$
(iii) $2\text{N}_2(\text{g}) + 3/2\text{H}_2(\text{g}) \rightarrow \text{NH}_3(\text{g})$	(c) $1/K_c$
	(d) $K_c^2$

**Solution:**

(i) is d

(ii) is c

(iii) is b

**40. Match standard free energy of the reaction with the corresponding Equilibrium constant**

(i) $\Delta G^\circ > 0$ (ii) $\Delta G^\circ < 0$ (iii) $\Delta G^\circ = 0$	(a) $K > 1$ (b) $K = 1$ (c) $K = 0$ (d) $K < 1$
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**Solution:**

- (i) is d  
(ii) is a  
(iii) is b

**41. Match the following species with the corresponding conjugate acid**

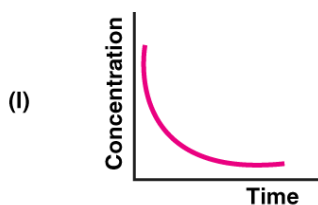
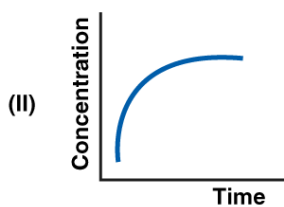
**Species Conjugate acid**

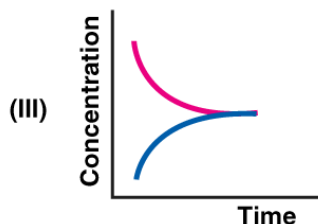
(i) $\text{NH}_3$ (ii) $\text{HCO}_3^-$ (iii) $\text{H}_2\text{O}$ (iv) $\text{HSO}_4^-$	(a) $\text{CO}_3^{2-}$ (b) $\text{NH}_4^+$ (c) $\text{H}_3\text{O}^+$ (d) $\text{H}_2\text{SO}_4$ (e) $\text{H}_2\text{CO}_3$
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**Solution:**

- (i) is b  
(ii) is e  
(iii) is c  
(iv) is d

**42. Match the following graphical variation with their description**





(a) Variation in product concentration with time

(b) Reaction at equilibrium

(c) Variation in reactant concentration with time

**Solution:**

(i) is c

(ii) is a

(iii) is b

**43. Match Column (I) with Column (II).**

Column I	Column II
(i) Equilibrium	(a) $\Delta G > 0$ , $K < 1$
(ii) Spontaneous reaction	(b) $\Delta G = 0$
(iii) Non spontaneous reaction	(c) $\Delta G^\circ = 0$
	(d) $\Delta G < 0$ , $K > 1$

**Solution:**

(i) are b and c

(ii) is d

(iii) is a

### V. Assertion and Reason Type

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

**44. Assertion (A):** Increasing order of acidity of hydrogen halides is  $\text{HF} < \text{HCl} < \text{HBr} < \text{HI}$

**Reason (R):** While comparing acids formed by the elements belonging to the same group of the periodic table, H–A bond strength is a more

**an important factor in determining the acidity of acid than the polar nature of the bond.**

- (i) Both A and R are true and R is the correct explanation of A.
- (ii) Both A and R are true but R is not the correct explanation of A.
- (iii) A is true but R is false.
- (iv) Both A and R are false.

**Solution:**

Option (i) is correct

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

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

- (i) Both A and R are true and R is the correct explanation of A.
- (ii) Both A and R are true but R is not the correct explanation of A.
- (iii) A is true but R is false.
- (iv) Both A and R are false.

**Solution:**

Option (i) is correct.

**46. Assertion (A): The ionisation of hydrogen sulphide in water is low in the presence of hydrochloric acid.**

**Reason (R): Hydrogen sulphide is a weak acid.**

- (i) Both A and R are true and R is the correct explanation of A.
- (ii) Both A and R are true but R is not the correct explanation of A.
- (iii) A is true but R is false
- (iv) Both A and R are false

**Solution:**

Option (iii) is the answer.

**47. Assertion (A): For any chemical reaction at a particular temperature, the equilibrium constant is fixed and is a characteristic property.**

**Reason (R): Equilibrium constant is independent of temperature.**

- (i) Both A and R are true and R is the correct explanation of A.
- (ii) Both A and R are true but R is not the correct explanation of A.
- (iii) A is true but R is false.
- (iv) Both A and R are false.

**Solution:**

Option (iii) is correct.

**48. Assertion (A): Aqueous solution of ammonium carbonate is basic.**

**Reason (R): Acidic/basic nature of a salt solution of a salt of a weak acid and weak base depends on  $K_a$  and  $K_b$  value of the acid and the base forming it.**

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

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

(iii) A is true but R is false.

(iv) Both A and R are false.

**Solution:**

Option (i) is the answer.

**49. Assertion (A):** An aqueous solution of ammonium acetate can act as a buffer.

**Reason (R):** Acetic acid is a weak acid and  $\text{NH}_4\text{OH}$  is a weak base.

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

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

(iii) A is false but R is true.

(iv) Both A and R are false.

**Solution:**

Option (iii) is the answer.

**50. Assertion (A):** In the dissociation of  $\text{PCl}_5$  at constant pressure and temperature addition of helium at equilibrium increases the dissociation of  $\text{PCl}_5$ .

**Reason (R):** Helium removes  $\text{Cl}_2$  from the field of action.

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

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

(iii) A is true but R is false.

(iv) Both A and R are false.

**Solution:**

Option (iv) is the answer.