

8. Consider the reactions, $\text{NO}_2 \rightleftharpoons \frac{1}{2} \text{N}_2 + \text{O}_2$, K_1 $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$, K_2 Give the equilibrium constant for the formation N_2O_4 from N_2 and O_2 .
- a) $\frac{1}{K_1^2} + \frac{1}{K_2}$ b) $\frac{1}{2K_1} + \frac{1}{K_2}$ c) $\sqrt{\frac{1}{K_1 K_2}}$ d) $\frac{K_2}{K_1}$
9. One mole of a compound AB reacts with one mole of a compound CD according to the equation; $\text{AB} + \text{CD} \rightarrow \text{AD} + \text{CB}$. When equilibrium had been established it was found that $\frac{3}{4}$ mole each of reactants AB and CD had been converted to Ad and CB. There is no change in volume. The equilibrium constant for the reaction is
- a) $\frac{9}{16}$ b) $\frac{1}{9}$ c) $\frac{16}{9}$ d) 9
10. If S_1 , S_2 , S_3 and S_4 are the solubilities of AgCl in water, in 0.01 M CaCl_2 , in 0.01 M NaCl and in 0.05 M AgNO_3 respectively at a certain temperature, the correct order of solubilities is
- a) $S_1 > S_2 > S_3 > S_4$ b) $S_1 > S_3 > S_2 > S_4$
c) $S_1 > S_2 = S_3 > S_4$ d) $S_1 > S_3 > S_4 > S_2$.
11. 0.01 mole of lime (CaO) was dissolved in 100 cm^3 of water. Assuming the base is completely ionized in the solution, the pH of the solution will be
- a) 1.3 b) 13.3 c) 12.3 d) 12.0
12. 0.01 M H_2SO_4 is ionized to the extent of 95%. The pH of the solution will be
- a) between 0 and 0.5 b) between 0.5 and 1.0
c) between 1.0 and 1.5 d) between 1.5 and 2.0
13. The pH of an aqueous solution of $\text{Ba}(\text{OH})_2$ is 10. If the K_{sp} of $\text{Ba}(\text{OH})_2$ is 1×10^{-9} , then the conc. of Ba^{+2} ions in the solution in mol L^{-1} is
- a) 1×10^{-2} b) 1×10^{-4} c) 1×10^{-1} d) 1×10^{-5}
14. A solution of an acid has $\text{pH} = 4.70$. Find out the concentration of OH^- ions ($\text{p}K_w = 14$)
- a) 5×10^{-10} M b) 4×10^{-10} M c) 2×10^{-5} M d) 9×10^{-4} M
15. The solubility product of AgI at 25°C is $1.0 \times 10^{-16} \text{ mol}^2 \text{ L}^{-2}$. The solubility of AgI in 10^{-4} N solution of KI at 25°C is approximately (in mol L^{-1})
- a) 1.0×10^{-16} b) 1.0×10^{-12} c) 1.0×10^{-10} d) 1.0×10^{-8}
16. The $\text{p}K_a$ of acetic acid is 4.74. The concentration of CH_3COOH is 0.01 M. The pH of CH_3COOH is
- a) 3.37 b) 4.37 c) 4.74 d) 0.474
17. On adding 0.1 M solution each of Ag^+ , Ba^{2+} , Ca^{2+} ions in a Na_2SO_4 solution, species first precipitated is ($K_{sp} \text{BaSO}_4 = 10^{-11}$, $K_{sp} \text{CaSO}_4 = 10^{-6}$, $K_{sp} \text{Ag}_2\text{SO}_4 = 10^{-5}$)
- a) Ag_2SO_4 b) BaSO_4 c) CaSO_4 d) all of these

18. At 25° C, the value of pK_b (K_b being the dissociation constant of the base) for NH_3 in aqueous solution is 4.7. What is the pH of a 0.1 M aqueous solution of NH_4Cl with 0.01 M NH_3 (approx)?
 a) 8.3 b) 9 c) 9.5 d) 10
19. A solution has 0.05 m Mg^{2+} ions and 0.05 M NH_3 . Calculate the concentration of NH_4Cl required to prevent the formation of $Mg(OH)_2$ in this solution. K_{sp} of $Mg(OH)_2 = 9.0 \times 10^{-12}$ and ionization constant of $NH_3 = 1.8 \times 10^{-5}$.
 a) 0.05 M b) 0.067 M c) 2.0×10^6 M d) 1.8×10^{-10} M
20. What is the equilibrium expression for the reaction, $P_4(s) + 5O_2(g) \rightleftharpoons P_4O_{10}(s)$?
 a) $K_c = \frac{1}{[O_2]^5}$ b) $K_c = [O_2]^5$ c) $K_c = \frac{[P_4O_{10}]}{5[P_4][O_2]}$ d) $K_c = \frac{[P_4O_{10}]}{[P_4][O_2]^5}$
21. The value of K_c for the reaction, $3O_2(g) \rightleftharpoons 2O_3(g)$ is 2.0×10^{-50} at 25°C. If the equilibrium concentration of O_2 in air at 25° C is 1.6×10^{-2} , what is the concentration of O_3 ?
 a) $2.0 \times 10^{-50} \times (1.6 \times 10^{-2})^3$ b) 2.86×10^{-28}
 c) $(1.6 \times 10^{-2})^4$ d) Both (a) and (b)
22. Equilibrium constants K_1 and K_2 for the following equilibria
 $NO(g) + \frac{1}{2} O_2(g) \xrightleftharpoons{K_1} NO_2(g)$ and, $2NO_2(g) \xrightleftharpoons{K_2} 2NO(g) + O_2(g)$ are related as
 a) $K_1 = \frac{1}{K_2}$ b) $K_2 = \frac{1}{K_1}$ c) $K_2 = \frac{1}{K_1^2}$ d) $K_1 = \frac{1}{K_2^2}$
23. What is the effect of pressure by doubling the volume on the following system at 500° C?
 $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
 a) Shift to product side b) Shift to reactant side
 c) Liquefaction of HI d) No effect
24. The ionisation constant of acetic acid is 1.74×10^{-5} . The degree of dissociation of acetic acid in its 0.05 M solution and its pH are respectively
 a) 1.86×10^{-2} , 4 b) 1.24×10^{-3} , 3 c) 1.24×10^{-3} , 4 d) 1.86×10^{-2} , 3
25. $NaOH(aq)$, $HCl(aq)$ and $NaCl(aq)$ concentration of each is 10^{-3} M. Their pH will be respectively
 a) 10, 6, 2 b) 11, 3, 7 c) 10, 2, 6 d) 3, 4, 7
26. 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?
 a) 5.8 b) 6.7 c) 9.3 d) 13

27. K_a for CH_3COOH is 1.8×10^{-5} and K_b for NH_4OH is 1.8×10^{-5} . The pH of ammonium acetate will be
 a) 7.005 b) 4.75 c) 7.0 d) between 6 and 7
28. In Haber's process, 30 L of dihydrogen and 30 L of dinitrogen were taken for reaction which yielded only 50% of the expected product. What will be the composition of gaseous mixture under the aforesaid condition at the end?
 a) 10 L NH_3 , 25 L N_2 , 15 L H_2 b) 20 L NH_3 , 20 L N_2 , 20 L H_2
 c) 20 L NH_3 , 25 L N_2 , 15 L H_2 d) 20 L NH_3 , 10 L N_2 , 30 L H_2
29. Conjugate acid of a weak base is always stronger. The decreasing order of basic strength of the following conjugate bases is OH^- , RO^- , CH_3COO^- , Cl^-
 a) $\text{RO}^- > \text{OH}^- > \text{CH}_3\text{COO}^- > \text{Cl}^-$ b) $\text{OH}^- > \text{RO}^- > \text{CH}_3\text{COO}^- > \text{Cl}^-$
 c) $\text{Cl}^- > \text{RO}^- > \text{OH}^- > \text{CH}_3\text{COO}^-$ d) $\text{CH}_3\text{COO}^- > \text{RO}^- > \text{OH}^- > \text{Cl}^-$
30. What mole of $\text{Ca}(\text{OH})_2$ is dissolved in 250 mL aqueous solution to give a solution of pH 10.65, assuming full dissociation?
 a) 0.47×10^{-4} b) 0.48×10^{-4} c) 0.56×10^{-4} d) 0.68×10^{-4}
31. 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 (mol dm^{-3}) of the salts at temperature T are in the order
 a) $\text{MX} > \text{MX}_2 > \text{M}_3\text{X}$ b) $\text{M}_3\text{X} > \text{MX}_2 > \text{MX}$
 c) $\text{MX}_2 > \text{M}_3\text{X} > \text{MX}$ d) $\text{MX} > \text{M}_3\text{X} > \text{MX}_2$
32. A reaction mixture containing 0.050 atm N_2 , 3.0 atm H_2 and 0.050 atm NH_3 is heated to 450°C . The value of K_p is $4.28 \times 10^{-5} \text{ atm}^{-2}$. $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
 The correct statement (s) is/are
 a) reaction goes towards the left
 b) reaction goes towards the right
 c) N_2 and H_2 combine to form ammonia
 d) ammonia gas decomposes into H_2 and N_2
33. The pH of a 0.1 molar solution of the acid HQ is 3. The value of the ionisation constant, K_a of the acid is
 a) 3×10^{-1} b) 1×10^{-3} c) 1×10^{-5} d) 1×10^{-7}
34. Phosphorus pentachloride dissociates as follows, in a closed reaction vessel,
 $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$
 If Total pressure, at equilibrium, of the reaction mixture is p and degree of dissociation of PCl_5 is z, the partial pressure of PCl_3 will be
 a) $\left(\frac{x}{x+1}\right) p$ b) $\left(\frac{2x}{1-x}\right) p$ c) $\left(\frac{x}{x-1}\right) p$ d) $\left(\frac{x}{1-x}\right) p$

35. The solubility product of a salt having general formula MX_2 , in water is 4×10^{-12} . The concentration of M^{2+} ions in the aqueous solution of the salt is
 a) 4.0×10^{-10} M b) 1.6×10^{-4} M c) 1.0×10^{-4} M d) 2.0×10^{-6} M
36. For the reaction, $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$, the K_p/K_c is equal to
 a) $1/RT$ b) RT c) \sqrt{RT} d) 1.0
37. At a certain temperature, the dissociation constants of formic acid and acetic acid are 1.8×10^{-4} and 1.8×10^{-5} respectively. The concentration of acetic acid solution in
 a) 0.01 M b) 0.04 M c) 0.05 M d) 0.08 M
38. The self ionization constant of pure formic acid $K = [HCOOH_2^+][HCOO^-]$ is 10^{-6} at room temperature. Taking the density of formic acid as 1.22 g/cm^3 , percentage of formic acid molecules in pure formic acid that are converted into formate ions is
 a) 0.4% b) 0.04%
 c) 0.004% d) none of these is correct
39. If to 100 mL of 0.1 M acetic acid solution, 0.82 g of sodium acetate is added, the pH of the solution (assume no dilution factor) becomes
 a) 3.75 b) 4.75 c) 5.25 d) 5.75
40. 100ml of 0.12M HCl and 100ml of 0.1M sodium hydroxide solutions are mixed together. What is the p^H of the resulting solution is
 a) 2 b) 12 c) 10 d) 4
41. At 425°C , for the gaseous reaction $H_2 + I_2 \rightleftharpoons 2HI$; $K_c = 64$. What weight of HI will be formed at equilibrium, if 1 mole of H_2 and 1 mole of iodine are placed in a 1 litre vessel at 425°C
 a) 2048g b) 204.8 g c) 20.48g d) 2.048
42. 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 change to
 a) $\frac{1}{2\sqrt{2}}$ times the original value b) $2\sqrt{2}$ times the original value
 c) $\frac{1}{2}$ of its original value d) $\frac{1}{4}$ of its original value
43. For which of the following sparingly soluble salt, the solubility (S) and solubility product (K_{sp}) are related by the expression: $S = \left[\frac{K_{sp}}{4} \right]^{1/3}$
 a) $BaSO_4$ b) $Ca_3(PO_4)_2$ c) Hg_2Cl_2 d) Ag_3PO_4

44. A mixture of SO_2 , SO_3 and O_2 is taken in a 10 litre flask at a temperature at which
 $K_c = 100$ for the reaction $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$
 If the number of moles of SO_3 in the flask is double the number of moles of SO_2 , the number of moles of O_2 in the flask is
 a) 0.2 b) 0.4 c) 4 d) 2.0
45. Solution of 0.1 M NH_4OH and 0.1 M NH_4Cl has pH 9.25. Then pK_b of NH_4OH is
 a) 9.25 b) 4.75 c) 3.75 d) 8.25
46. 100 mL of 0.2 N HCl is added to 100 mL of 0.18 N NaOH and the whole volume is made one litre. The pH of the resulting solution is
 a) 1 b) 2 c) 3 d) 4
47. The first and second dissociation constants of an acid, H_2A , are 1.0×10^{-5} and 5.0×10^{-10} respectively. The overall dissociation constant of the acid will be
 a) 0.2×10^5 b) 5.0×10^{-5} c) 5.0×10^{-15} d) 5.0×10^{15}
48. The solubility products of MA, MB, MC and MD are 1.8×10^{-10} , 4×10^{-8} , 4×10^{-8} and 6×10^{-5} respectively. If a 0.01 M solution of MX is added drop wise to a mixture containing A^- , B^- , C^- and D^- ions, then the one to be precipitated first will be
 a) MA b) MB c) MC d) MD
49. Silver ions are added to the solution with $[\text{Br}^-] = [\text{Cl}^-] = [\text{CO}_3^{2-}] = [\text{AsO}_4^{3-}] = 0.1\text{M}$
 Which compound will precipitate at the lowest $[\text{Ag}^+]$?
 a) AgBr ($K_{\text{sp}} = 5 \times 10^{-13}$) b) AgCl ($K_{\text{sp}} = 1.8 \times 10^{-10}$)
 c) Ag_2CO_3 ($K_{\text{sp}} = 8.1 \times 10^{-12}$) d) Ag_3AsO_4 ($K_{\text{sp}} = 10^{-22}$)
50. The solubility of PbCl_2 in water is 0.01M at 25°C . It's solubility in 0.1M NaCl will be
 a) $2 \times 10^{-3}\text{M}$ b) $1 \times 10^{-4}\text{M}$
 c) $1.6 \times 10^{-2}\text{M}$ d) $4 \times 10^{-4}\text{M}$

solutions

1. Ans (b)

	$\text{N}_{2(\text{g})}$	+	$3\text{H}_{2(\text{g})}$	\rightleftharpoons	$2\text{NH}_{3(\text{g})}$
Initial Moles	1		3		0
At equilibrium	1-0.0025		3-0.0075		2 x 0.0025
Eq. conc	$\frac{1 - 0.0025}{4}$		$\frac{3 - 0.0075}{4}$		$\frac{2 \times 0.0025}{4}$

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

Since 0.0025 and 0.0075 are very small, $1 - 0.0025$ and $3 - 0.0075$ may be taken as 1 and 3.

$$\therefore K_c = \frac{\left(\frac{2 \times 0.0025}{4}\right)^2}{\left(\frac{1}{4}\right)\left(\frac{3}{4}\right)^3} = \frac{0.0025 \times 0.0025}{4} \times \frac{4 \times 4 \times 4 \times 4}{3 \times 3 \times 3}$$

$$= 1.48 \times 10^{-5} \text{ litre}^2 \text{ mol}^{-2}$$

For the equilibrium, $\frac{1}{2} \text{N}_{2(g)} + \frac{3}{2} \text{H}_{2(g)} \rightleftharpoons \text{NH}_{3(g)}$

$$K_c' = \frac{[\text{NH}_3]}{[\text{N}_2]^{1/3}[\text{H}_2]^{3/2}} = \sqrt{K_c} = \sqrt{1.48 \times 10^{-5}} = 3.82 \times 10^{-3} \text{ litre mol}^{-1}$$

2. Ans (d)

Firstly find ΔS .

$$\Delta S = \Delta_f S (\text{XY}_3) - \left[\frac{1}{2} \Delta_f S (\text{X}_2) + \frac{3}{2} \Delta_f S (\text{Y}_2) \right]$$

$$\Delta S = 50 - \left[\frac{1}{2} \times 60 + \frac{3}{2} \times 40 \right] = -40 \text{ J K}^{-1} \text{ mol}^{-1}$$

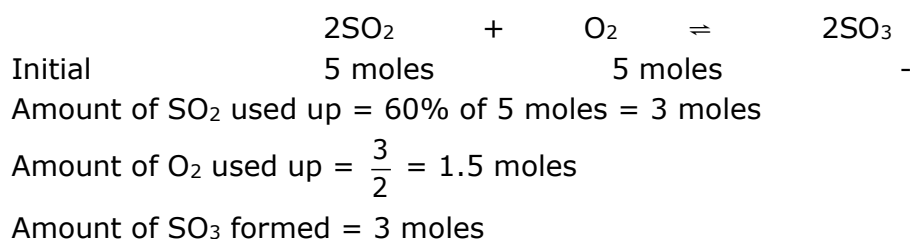
Now $\Delta G = \Delta H - T\Delta S$

For eqbm conditions, $\Delta G = 0$

$$\therefore T\Delta S = \Delta H$$

$$\text{or } T = \frac{\Delta H}{\Delta S} = \frac{-30,000}{-40} = 750 \text{ K}$$

3. Ans (a)



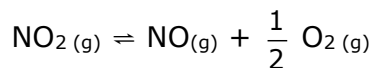
Thus, number of moles of SO_2 , O_2 and SO_3 at equilibrium are:

$[\text{SO}_2] = 5 - 3 = 2$ moles; $[\text{O}_2] = 5 - 1.5 = 3.5$ moles; $[\text{SO}_3] = 3$ moles

Total number of moles = $2 + 3.5 + 3 = 8.5$ moles

4. Ans (a)

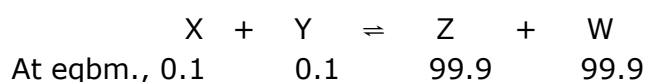
For the reverse reaction,



$$K = \frac{1}{K_1} \text{ and for the reaction, } 2\text{NO}_{2(g)} \xrightleftharpoons{K_2} 2\text{NO}_{(g)} + \text{O}_{2(g)}$$

$$K_2 = \left[\frac{1}{K_1} \right]^2$$

5. Ans (c)



$$\therefore K_c = \frac{99.9 \times 99.9}{0.1 \times 0.1} \approx 10^6$$

6. Ans (c)

$$K_c = \frac{[\text{NO}]^2}{[\text{N}_2][\text{O}_2]}$$

$$= \frac{[2.8 \times 10^{-3} \text{ M}]^2}{[3 \times 10^{-3} \text{ M}][4.2 \times 10^{-3} \text{ M}]} = 0.622$$

7. Ans (d)

$$\Delta n = 3 - 2 = 1$$

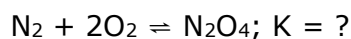
$$K_p = K_c (RT)^{\Delta n}$$

$$= 3 \times 10^{-6} \times (0.0821 \times 700)$$

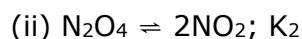
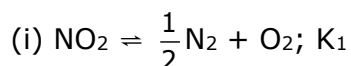
$$= 1.72 \times 10^{-4}$$

8. Ans (a)

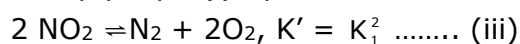
The required equation is:



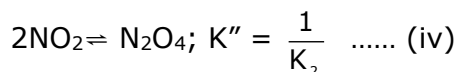
The given equations are



Multiply eqn. (i) by 2



Invert eqn. (ii)



9. Ans (d)

	AB	+	CD	→	Ad	+	CB
Initial conc ;	$\frac{1}{V} \text{ M}$		$\frac{1}{V} \text{ M}$		0		0
At eqm;	$\frac{1 - \frac{3}{4}}{V} \text{ M}$		$\frac{1 - \frac{3}{4}}{V} \text{ M}$		$\frac{3}{V} \text{ M}$		$\frac{3}{V} \text{ M}$
	$= \frac{1}{4V} \text{ M}$		$= \frac{1}{4V} \text{ M}$				
	$K_c = \frac{[\text{AD}][\text{CB}]}{[\text{AB}][\text{CD}]} = \frac{\frac{3}{4V} \times \frac{3}{4V}}{\frac{1}{4V} \times \frac{1}{4V}} = 9$						

10. Ans: (b)

$0.01 \text{ M CaCl}_2 \rightleftharpoons 0.02 \text{ M Cl}^-$, $0.01 \text{ M nAcL} \rightleftharpoons 0.01 \text{ m Cl}^-$, $0.05 \text{ M AgNO}_3 \rightleftharpoons 0.05 \text{ M Ag}^+$

$[\text{Ag}^+][\text{Cl}^-] = K_{sp} (\text{const.})$. Hence,

$S_2 = K_{sp}/0.02 = 50 K_{sp}$,

$$S_3 = K_{sp}/0.01 = 100 K_{sp},$$

$$S_4 = K_{sp}/0.05 = 20 K_{sp} (S_1 = \sqrt{K_{sp}} = \text{maximum}).$$

11. Ans: (b)

$$[\text{Ca}(\text{OH})_2] = 0.01 \text{ mole in } 100 \text{ c.c.} = 0.1 \text{ mol L}^{-1}$$

$$= 0.1 \text{ M. Assuming complete ionization, } [\text{OH}^-] = 0.2 \text{ M, } [\text{H}^+] = \frac{10^{-14}}{0.2} = 5 \times 10^{-14}$$

$$\text{or pH} = -\log(5 \times 10^{-14}) = 14 - 0.699 = 13.3$$

12. Ans: (d)

$$[\text{H}^+] = 0.02 \times 95/100 = 1.90 \times 10^{-2}$$

$$\text{or pH} = -\log(1.9 \times 10^{-2}) = 2 - 0.28 = 1.72$$

13. Ans: (c)



$$\text{pH} = 10 \text{ means } [\text{H}^+] = 10^{-10}$$

$$\text{or } [\text{OH}^-] = 10^{-4}$$

$$K_{sp} = [\text{Ba}^{2+}] [\text{OH}^-]^2$$

$$\text{Or } 10^{-9} = [\text{Ba}^{2+}] [10^{-4}]^2$$

$$\text{Or } [\text{Ba}^{2+}] = 10^{-1} \text{ M.}$$

14. Ans: (a)

$$\text{pH} = 4.70 \text{ means } -\log [\text{H}^+] = 4.70$$

$$\text{i.e. } \log [\text{H}^+] = -4.70 = 5.30$$

$$\text{or } [\text{H}^+] = 1.995 \times 10^{-5} \approx 2 \times 10^{-5}$$

$$\text{pK}_w = 14 \text{ means } [\text{H}^+] [\text{OH}^-] = 10^{-14}$$

$$\therefore [\text{OH}^-] = \frac{10^{-14}}{2 \times 10^{-5}} = 0.5 \times 10^{-9} = 5 \times 10^{-10}$$

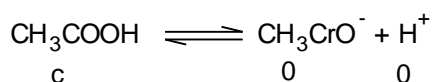
15. Ans: (a)

$$\text{Total } [\text{I}^-] = 10^{-4} + 10^{-16} - 10^{-4} \text{ M}$$

$$[\text{Ag}^+] [\text{I}^-] = K_{sp} \therefore [\text{Ag}^+] (10^{-4}) = 1.0 \times 10^{-16}$$

$$\text{or } [\text{Ag}^+] = 10^{-12}.$$

16. Ans: (a)



$$K_a = \frac{c\alpha \cdot c\alpha}{c(1-\alpha)} = \frac{c\alpha^2}{1-\alpha} \approx c\alpha^2, \alpha = \sqrt{K_a/c}$$

$$[\text{H}^+] = c\alpha = c \cdot \sqrt{K_a/c} = \sqrt{K_a \cdot c}$$

$$\text{pH} - \log [\text{H}^+] = -\log (K_a c)^{1/2}$$

$$= \frac{1}{2} [-\log K_a - \log c] = \frac{1}{2} [\text{pK}_a - \log c] = \frac{1}{2} [4.74 - \log 10^{-2}]$$

$$= \frac{1}{2} \times 6.74 = 3.37$$

17. Ans: (b)

$$K_{sp} \text{ for } \text{Ag}_2\text{SO}_4 = [\text{Ag}^+]^2 [\text{SO}_4^{2-}]$$

$$\therefore [\text{SO}_4^{2-}] \text{ for precipitation of } \text{Ag}_2\text{SO}_4 > \frac{K_{sp}}{[\text{Ag}^+]^2} = \frac{10^{-5}}{(0.1)^2} = 10^{-3} \text{ M}$$

Similarly, $[\text{SO}_4^{2-}]$ for precipitation of

$$\text{BaSO}_4 > \frac{K_{sp}}{[\text{Ba}^{2+}]} = \frac{10^{-11}}{0.1} = 10^{-10} \text{ M}$$

$$[\text{SO}_4^{2-}] \text{ for precipitation of } \text{CaSO}_4 > \frac{K_{sp}}{[\text{Ca}^{2+}]} = \frac{10^{-6}}{0.1} = 10^{-5} \text{ M}$$

Thus, minimum $[\text{SO}_4^{2-}]$ required for precipitation is for BaSO_4 .

18. Ans: (a)

$$\begin{aligned} \text{pOH} &= \text{p}K_b + \log \frac{[\text{conjugate acid, NH}_4^+]}{\text{weak base, NH}_3} \\ &= 4.7 + \log \frac{0.1}{0.01} = 4.7 + \log 10 = 5.7 \\ \therefore \text{pH} &= 14 - \text{pOH} = 14 - 5.7 = 8.3. \end{aligned}$$

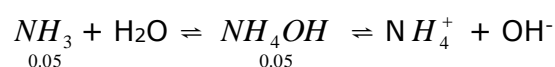
19. Ans: (b)

The maximum concentration of OH^- ions that will precipitate $\text{Mg}(\text{OH})_2$ is given by

$$\begin{aligned} K_{sp} &= [\text{Mg}^{2+}] [\text{OH}^-]^2 \\ [\text{OH}^-]^2 &= \frac{K_{sp}}{[\text{Mg}^{2+}]} = \frac{9.0 \times 10^{-12}}{0.05} = 1.8 \times 10^{-10} \end{aligned}$$

$$\text{Or } [\text{OH}^-] = 1.34 \times 10^{-5} \text{ M}$$

NH_3 is present in solution in the form of NH_4OH

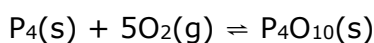


The ionisation NH_4OH is suppressed by the addition of strong electrolyte, NH_4Cl .

$$\begin{aligned} K_{\text{NH}_3} &= K_{\text{NH}_4\text{OH}} = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_4\text{OH}]} \\ [\text{NH}_4^+] &= \frac{K_{\text{NH}_4\text{OH}} \times [\text{NH}_4\text{OH}]}{[\text{OH}^-]} = \frac{1.8 \times 10^{-5} \times 0.05}{1.34 \times 10^{-5}} = 0.067 \text{ M} \end{aligned}$$

$$\text{i.e., } [\text{NH}_4\text{Cl}] = 0.067 \text{ M}$$

20. Ans: (a)

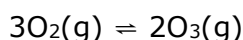


$$K_c = \frac{[\text{P}_4\text{O}_{10}(\text{s})]}{[\text{P}_4(\text{s})][\text{O}_2(\text{g})]^5}$$

We know that concentration of a solid component is always taken as unity.

$$K_c = \frac{1}{[\text{O}_2]^5}$$

21. Ans: (b)



Equilibrium Conc. $1.6 \times 10^{-2} ?$

$$K = \frac{[\text{O}_3]^2}{[\text{O}_2]^3}$$

$$2.0 \times 10^{-50} = \frac{[O_3]^2}{[1.6 \times 10^{-2}]^3}$$

$$[O_3]^2 = 2.0 \times 10^{-50} \times [1.6 \times 10^{-2}]^3$$

$$[O_3]^2 = 8.192 \times 10^{-56}$$

$$[O_3] = 2.86 \times 10^{-28} \text{ mol L}^{-1}$$

22. Ans:(c)

$$K_1 = \frac{[NO_2]}{[NO][O_2]^{1/2}} \quad \dots\dots\dots (i)$$

$$K_2 = \frac{[NO]^2[O_2]}{[NO_2]^2} \quad \dots\dots\dots (ii)$$

$$\therefore \frac{1}{K_2} = \frac{[NO_2]^2}{[BO]^2[O_2]}$$

$$\text{Or, } \frac{1}{\sqrt{K_2}} = \frac{[NO_2]}{[NO][O_2]^{1/2}} \quad \dots\dots\dots (iii)$$

$$\text{From Eqs. (i) and (iii), } K_1 = \frac{1}{\sqrt{K_2}}$$

$$\therefore K_2 = \frac{1}{K_1^2}$$

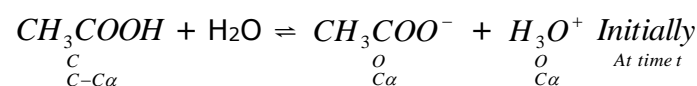
23. Ans:(d)

We know that $pV = nRT$

p become $\frac{1}{2} p$ and V becomes $2V$, so $\frac{1}{2} p \times 2V = pV = nRT$

Hence, there is no effect in equation.

24. Ans:(d)



$$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$$

Given, $K_a = 1.74 \times 10^{-5}$, $[CH_3COOH] = 0.05 \text{ M}$

$$[CH_3COO^-] = [H_3O^+] = \sqrt{K_a \cdot [CH_3COOH]}$$

$$[CH_3COO^-] = [H_3O^+] = \sqrt{1.74 \times 10^{-5} \times 0.05}$$

$$[CH_3COO^-] = [H_3O^+] = \sqrt{17.4 \times 10^{-6} \times 5.0 \times 10^{-2}} = 9.33 \times 10^{-4} \text{ M}$$

$$[CH_3COO^-] = [H_3O^+] = C.\alpha$$

$$\text{Degree of dissociation, } \alpha = \frac{[H_3O^+]}{C} = \frac{9.33 \times 10^{-4}}{0.05} = 1.86 \times 10^{-2}$$

$$pH = -\log [H_3O^+]$$

$$pH = -\log [9.33 \times 10^{-4}]$$

$$pH = 4 - 0.9699 = 3.0301$$

25. Ans:(b)

$$\begin{aligned} \text{NaOH} &= [\text{OH}^-] = 10^{-3} \\ [\text{H}^+][\text{OH}^-] &= 10^{-14} \\ [\text{H}^+] &= 10^{-11} \\ \text{pH} &= -\log [\text{H}^+] \\ &= -\log [10^{-11}] = 11 \\ \text{HCl (aq)} &= [\text{H}^+] = 10^{-3} \\ \text{pH} &= -\log [10^{-3}] = 3 \\ \text{NaCl (aq)} &= \text{Neutral}; [\text{H}^+] = [\text{OH}^-] = 10^{-7} \\ \text{i.e.,} \quad \text{pH} &= 7 \end{aligned}$$

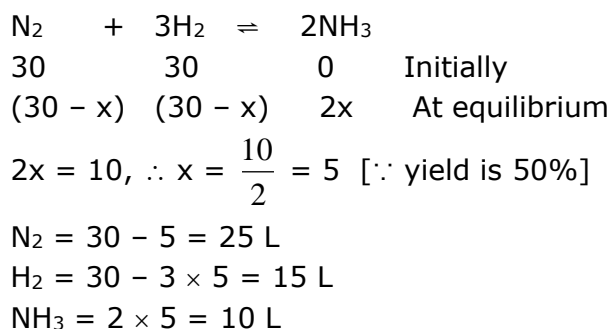
26. Ans:(b)

$$\begin{aligned} \text{pH} &= 5 \\ [\text{H}^+] &= 10^{-5} \text{ mol L}^{-1} \\ \text{On diluting the solution 100 times, } [\text{H}^+] &= \frac{10^{-5}}{100} = 10^{-7} \text{ mol L}^{-1} \\ \text{Total H}^+ \text{ ion concentration} &= \text{H}^+ \text{ ions from acid} + \text{H}^+ \text{ ions from water} \\ [\text{H}^+] &= 10^{-7} + 10^{-7} = 2 \times 10^{-7} \text{ M} \\ \text{pH} &= -\log [2 \times 10^{-7}] \\ \text{pH} &= 7 - 0.3010 = 6.699 \end{aligned}$$

27. Ans:(c)

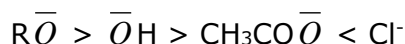
Ammonium acetate is a salt of weak acid and weak base. For such salts,

$$\begin{aligned} \text{pH} &= 7 + \frac{pK_a - pK_b}{2} = 7 + \frac{[-\log 1.8 \times 10^{-5}] - [-\log 1.8 \times 10^{-5}]}{2} \\ &= 7 + \frac{4.74 - 4.74}{2} = 7.00 \end{aligned}$$

28. Ans:(a)**29. Ans:(a)**

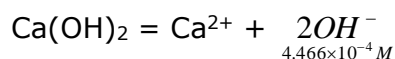
Conjugate acids of the given bases are, H_2O , ROH , CH_3COOH and HCl . Order of acidic strength is $\text{HCl} > \text{CH}_3\text{COOH} > \text{H}_2\text{O} > \text{ROH}$

Hence, order of basic strength of their conjugate bases is

**30. Ans:(c)**

$$\begin{aligned} \text{pOH} &= 14 - \text{pH} = 14 - 10.65 = 3.35 \\ \text{pOH} &= -\log [\text{OH}^-] \\ -3.35 &= \log [\text{OH}^-] \end{aligned}$$

$$\therefore [\text{OH}^-] = 4.466 \times 10^{-4} \text{ M}$$



$$\frac{[\text{OH}^-]}{2} = [\text{Ca(OH)}_2] = 2.2335 \times 10^{-4} \text{ M}$$

Hence, in 250 mL, moles of

$$\text{Ca(OH)}_2 = \frac{2.2335 \times 10^{-4} \times 250}{1000} = 0.56 \times 10^{-4}$$

31. Ans:(a)

Salt	Solubility product	solubility
MX	$S_1^2 = 4.0 \times 10^{-8}$	$S_1 = 2 \times 10^{-4}$
MX ₂	$4S_2^3 = 3.2 \times 10^{-14}$	$S_2 = 2 \times 10^{-5}$
M ₃ X	$27S_3^4 = 2.7 \times 10^{-15}$	$S_3 = 1 \times 10^{-4}$

Thus, solubility order is $\text{MX} > \text{M}_3\text{X} > \text{MX}_2$.

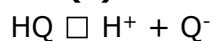
32. Ans:(d)

$$\text{Reaction quotient} = \frac{P_{\text{NH}_3}^2}{P_{\text{N}_2} \cdot P_{\text{H}_2}^3} = \frac{(0.05 \text{ atm})^2}{(0.05 \text{ atm})(3.0 \text{ atm})^3}$$

$$= 1.85 \times 10^{-3} \text{ atm}^{-2}$$

The value of K_p is $4.28 \times 10^{-5} \text{ atm}^{-2}$. The numerical value of Q_p is more than that of K_p . The reaction goes towards the left and thus, ammonia decomposes into H_2 and N_2 .

33. Ans:(c)



$$[\text{H}^+] = \sqrt{K_a C} \quad (\text{by Ostwald's dilution law})$$

$$[\text{H}^+] = 10^{-\text{pH}} = 10^{-3} \text{ M}$$

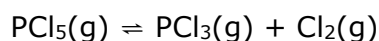
$$C = 0.1 \text{ M}$$

$$\text{Thus, } 10^{-3} = \sqrt{K_a \times 0.1}$$

$$10^{-6} = K_a \times 0.1$$

$$\therefore K_a = 10^{-5}$$

34. Ans: (c)



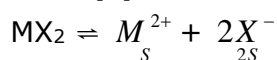
$$\text{Initially} \quad 1 \quad 0 \quad 0$$

$$\text{At equilibrium} \quad (1-x) \quad x \quad x$$

$$\text{Total pressure at equilibrium} = (1-x) + x + x = 1+x$$

$$P_{\text{PCl}_3} = \left[\frac{x}{1+x} \right] \times p$$

35. Ans: (c)



$$K_{sp} = [M^{2+}][X^-]^2$$

If solubility be S, then $K_{sp} = (S)(2S)^2 = 4S^3$

$$4S^3 = 4 \times 10^{-12}$$

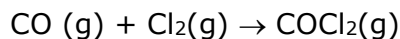
$$\therefore S = 1 \times 10^{-4} \text{ M}$$

$$\therefore M^{2+} = S = 1 \times 10^{-4} \text{ M}$$

36. Ans:(a)

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

Δn_g = Sum of coefficients of gaseous products – sum of coefficients of gaseous reactants.

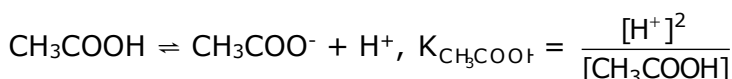
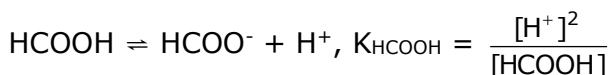


$$\therefore \Delta n_g = 1 - 2 = -1$$

$$\therefore K_p = K_c (RT)^{-1}$$

$$\therefore \frac{K_p}{K_c} = (RT)^{-1} = \frac{1}{(RT)}$$

37. Ans:(a)



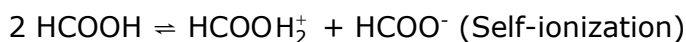
As $[\text{H}^+]$ in both cases are equal, $\frac{[\text{CH}_3\text{COOH}]}{[\text{HCOOH}]} = \frac{K_{\text{HCOOH}}}{K_{\text{CH}_3\text{COOH}}}$

$$\text{Or } [\text{CH}_3\text{COOH}] = \frac{1.8 \times 10^{-4}}{1.8 \times 10^{-5}} \times 10^{-3} = 10^{-2} \text{ M} = 0.01 \text{ M.}$$

38. Ans: (c)

Mass of 1 L of HCOOH = $1000 \times 1.22 \text{ g}$

$$\therefore [\text{HCOOH}] = \frac{1000 \times 1.22}{46} = 26.5 \text{ M}$$



$$[\text{HCOOH}_2^+] = [\text{HCOO}^-]$$

$$K = [\text{HCOOH}_2^+] = [\text{HCOO}^-]$$

$$= x \times x = x^2 = 10^{-6} \text{ (Given)}$$

$$\therefore x \text{ or } [\text{HCOO}^-] = 10^{-3} \text{ M}$$

$$\% \text{ dissociation} = \frac{10^{-3}}{26.5} \times 100 = 0.004\%$$

39. Ans: (b)

$$M(\text{CH}_3\text{COONa}) = 82 \text{ g mol}^{-1}$$

$$n(\text{CH}_3\text{COONa}) = m/M = 0.82 \text{ g}/82 \text{ g mol}^{-1} = 0.01 \text{ mol}$$

$$c(\text{CH}_3\text{COONa}) = n/V = 0.01 \text{ mol}/0.1 \text{ L} = 0.1 \text{ M}$$

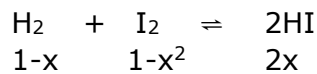
$$\text{pH} = \text{p}K_a + \log [\text{salt}]/[\text{acid}] = \log (1.8 \times 10^{-5}) + \log (0.1/0.1) = 4.75$$

40. Ans: (a)

$$N = \frac{100 \times 0.12100 \times 0.1}{200} = \frac{100(0.02)}{200} = 0.01$$

$$\text{pH} = -\log(0.01) = -\log(10^{-2}) = 2$$

41. Ans: (b)



$$1-x \quad 1-x^2 \quad 2x$$

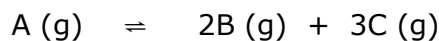
$$K_C = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} = \frac{(2x)^2}{(1-x)(1-x)} = \frac{(2x)^2}{(1-x)^2} = 64$$

$$\therefore \frac{2x}{1-x} = 8 \Rightarrow 2x = 8 - 8x \Rightarrow 10x = 8 \Rightarrow x = 0.8$$

$$\therefore \text{No of moles of HI} = 2x = 2 \times 0.8 = 1.6$$

$$\text{Mass of HI} = 1.6 \times 128 = 2048 \text{ g}$$

42. Ans: (a)



$$K = \frac{[\text{B}]^2[\text{C}]^3}{[\text{A}]} \Rightarrow K = \frac{(x^2)(y)^3}{(z)}$$

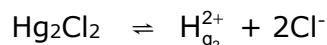
When y becomes 2y, to keep K constant the concentration of x decreases

$$K = \frac{(x)^2(2y)^3 \left(\frac{1}{8}\right)}{z}$$

$$\therefore \text{Concentration of x should decrease by } \frac{1}{2\sqrt{2}}$$

$$\therefore K = \frac{\left(\frac{1}{2\sqrt{2}}x\right)^2(2y)^3}{z} = \frac{x^2y^2z}{z}$$

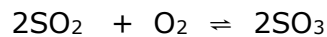
43. Ans: (c)



$$K_s = \frac{3}{[\text{Hg}_2^{2+}]} \frac{2s}{[\text{Cl}^-]^2} = s \times (2s)^2 = 4s^3$$

$$\therefore s = \left(\frac{K_s}{4}\right)^{\frac{1}{3}}$$

44. Ans: (b)



No. of moles of SO_2 , O_2 and SO_3 be x, y and z respectively. But $z = 2x$

$$\therefore y = ?$$

$$K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]} = \frac{\left(\frac{z}{10}\right)^2}{\left(\frac{x}{10}\right)^2 \left(\frac{y}{10}\right)} = \frac{\left(\frac{2x}{10}\right)^2}{\left(\frac{x}{10}\right)^2 \left(\frac{y}{10}\right)} = 100$$

$$\frac{4}{\frac{y}{10}} = 100 \Rightarrow \frac{40}{y} = 100 \Rightarrow y = \frac{40}{100} = 0.4$$

45. Ans: (b)

$$\text{pOH} = \text{pK}_b + \log \frac{[\text{salt}]}{[\text{Base}]}$$

$$\text{pH} = 9.25 \Rightarrow \text{pOH} = 4.75$$

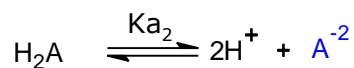
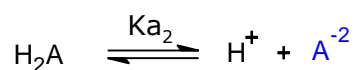
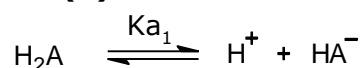
$$4.75 = \text{pK}_b + \log \left(\frac{0.1}{0.1} \right)$$

46. Ans: (b)

$$\left(\frac{100 \times 0.2 - 100 \times 0.18}{200} \right) = \frac{100(0.02)}{200} = 0.01$$

$$\text{pH} = -\log (10^{-2}) = 2$$

47. Ans: (b)



$$K_a = K_{a_1} \times K_{a_2} = 1 \times 10^{-5} \times 5 \times 10^{-10} = 5 \times 10^{-15}$$

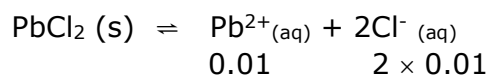
48. Ans: (a)

Lower the solubility product, higher is case of precipitation i.e., MA.

49. Ans: (a)

$$[\text{Ag}^+] [\text{Br}^-] = [\text{Ag}^+] = \frac{5 \times 10^{-13}}{0.1} = 5 \times 10^{-12} \text{ m}$$

50. Ans: (d)



$$[\text{Cl}^-] = 0.02 + 0.1 = 0.12 \approx 0.1$$

$$K_s = 4s^3 = 4 \times 10^{-6}$$

$$\therefore \text{In } 0.1 \text{ m NaCl, } [S] [0.12]^2 = 4 \times 10^{-6} \quad \therefore S = \frac{4 \times 10^{-6}}{(0.1)^2} = 4 \times 10^{-4} \text{ m}$$