

## EXERCISE # (O-I)

## Dissociation of Water &amp; pH of Water

1. Ionic product of water will increase, if:  
(A) Pressure is decreased (B)  $H^+$  is added  
(C)  $OH^-$  is increased (D) Temperature is increased
2. At  $60^\circ C$ , pure water has  $[H_3O^+] = 10^{-6.7}$  mol/lit. what is the value of  $K_W$  at  $60^\circ C$ :  
(A)  $10^{-6}$  (B)  $10^{-12}$  (C)  $10^{-67}$  (D)  $10^{-13.4}$
3. The pH of solution is increased from 3 to 6. Its  $H^+$  ion conc. will be:  
(A) Reduced to half (B) Doubled  
(C) Reduced by 1000 times (D) Increased by 1000 times
4. A solution with pH 2.0 is more acidic than the one with pH 6.0 by a factor of:  
(A) 3 (B) 4 (C) 3000 (D) 10000

## pH of Strong Electrolyte

5. What is the quantity of NaOH present in 250 cc of the solution, so that it gives a pH= 13:  
(A)  $10^{-13}$  g (B)  $10^{-1}$  g (C) 1.0 g (D) 4.0 g
6. An aqueous solution of HCl is  $10^{-9}$  M HCl. The pH of the solution should be:  
(A) 9 (B) Between 6 and 7  
(C) 7 (D) Unpredictable
7. How many moles of HCl must be removed from 1 litre of aqueous HCl solution to change its pH from 2 to 3:  
(A) 1 (B) 0.02 (C) 0.009 (D) 0.01
8. 10 ml of  $\frac{M}{200}$   $H_2SO_4$  is mixed with 40 ml of  $\frac{M}{200}$   $H_2SO_4$ . The pH of the resulting solution is  
(A) 1 (B) 2 (C) 2.3 (D) none of these

## pH of Weak Electrolyte

9. For two monobasic acids A and B,  $pK_{a1} = 1.2$ ,  $pK_{a2} = 2.8$  respectively in value, then which is true:
- (A) A & B both have equal acidic strength  
(B) A is stronger than B  
(C) B is stronger than A  
(D) Depends on concentration
10. When ammonia is added to water it decreases the concentration of which of the following ion
- (A)  $OH^-$                       (B)  $H_3O^+$                       (C)  $NH_4^+$                       (D)  $NH_4^+$  &  $OH^-$
11. Which one of the following has highest pH:
- (A) Distilled water                      (B) 1 M  $NH_3$   
(C) 1 M NaOH                      (D) 1M HCl
12. Degree of dissociation of 0.1 N  $CH_3COOH$  is: (Dissociation constant =  $1 \times 10^{-5}$ )
- (A)  $10^{-5}$                       (B)  $10^{-4}$                       (C)  $10^{-3}$                       (D)  $10^{-2}$
13. The pH of a 0.02 M ammonia solution which is 5% ionised will be:
- (A) 2                      (B) 11                      (C) 5                      (D) 7

## pH of Mixture of More Than One Acid/Base

14. Consider an aqueous solution, 0.1 M each in HOCN, HCOOH,  $(COOH)_2$  and  $H_3PO_4$ . For HOCN, we can write:  $K_a(HOCN) = \frac{[H^+][OCN^-]}{[HOCN]}$ .  $[H^+]$  in this equation is:
- (A)  $H^+$  ions released by HOCN  
(B) Sum of  $H^+$  ions released by all monoprotic acids  
(C) Sum of  $H^+$  ions released only the first dissociation of all the acids.  
(D) Overall  $H^+$  ion concentration in the solution.

15. The pH of the solution produced when an aqueous solution of strong acid pH 5 is mixed with equal volume of an aqueous solution of strong acid of pH 3 is:  
 (A) 3.3 (B) 3.5 (C) 4.5 (D) 4.0
16. What are  $[H^+]$ ,  $[A^-]$  and  $[B^-]$  in a solution that contains 0.03 M HA and 0.1 M HB.  $K_a$  for HA and HB are  $3.0 \times 10^{-4}$  and  $1.0 \times 10^{-10}$  respectively.  
 (A)  $[H^+] = 3 \times 10^{-3}$  M (B)  $[A^-] = 3 \times 10^{-3}$  M  
 (C)  $[B^-] = 3.33 \times 10^{-9}$  M (D) All of these
17. pH of a solution obtained by mixing equal volumes of 0.1 M Triethyl amine ( $K_b = 6.4 \times 10^{-5}$ ) &  $\frac{4}{45}$  M  $NH_4OH$  ( $K_b = 1.8 \times 10^{-5}$ ) will be:  
 (A) 11.3 (B) 10.3 (C) 12.3 (D) 11.45
18. An aqueous solution contains 0.01 M  $RNH_2$  ( $K_b = 2 \times 10^{-6}$ ) &  $10^{-4}$  M NaOH. The concentration of  $OH^-$  is nearly:  
 (A)  $2.414 \times 10^{-4}$  (B)  $10^{-4}$  M (C)  $1.414 \times 10^{-4}$  (D)  $2 \times 10^{-4}$

### Polyprotic Acid Base

19. Approximate pH of 0.10 M aqueous  $H_2S$  solution having  $K_1$  and  $K_2$  for  $H_2S$  at  $25^\circ C$   $10^{-7}$  and  $10^{-13}$  respectively is :  
 (A) 4 (B) 5 (C) 9 (D) 8
20. In a solution containing 0.1 M HCl & 0.1 M  $H_3PO_4$  (having dissociation constants  $K_{a_1}$ ,  $K_{a_2}$  &  $K_{a_3}$ ), assuming  $\alpha \ll 1$  for  $H_3PO_4$ :  
 (A) pH = 1 (B)  $\alpha_{H_3PO_4} = 10 K_{a_1}$   
 (C)  $[HPO_4^{2-}] = 10$  (D) All of these

21. In a solution containing 0.1 M HCl & 0.1 M  $\text{H}_3\text{PO}_4$  (having dissociation constants  $K_{a_1}$ ,  $K_{a_2}$  &  $K_{a_3}$ ), assuming  $x \ll 1$  for  $\text{H}_3\text{PO}_4$ :

(A)  $[\text{PO}_4^{3-}] = 100 K_{a_1} K_{a_2} K_{a_3}$

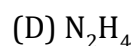
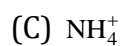
(B)  $[\text{PO}_4^{3-}] = 10 K_{a_1} K_{a_2} K_{a_3}$

(C)  $[\text{PO}_4^{3-}] = 1000 K_{a_1} K_{a_2} K_{a_3}$

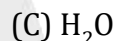
(D)  $[\text{PO}_4^{3-}] = K_{a_1} K_{a_2} K_{a_3}$

### Conjugate Acid Base, Bronsted Theory

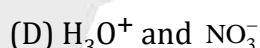
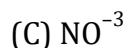
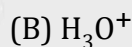
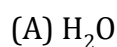
22. The conjugate acid of  $\text{NH}_2^-$  is



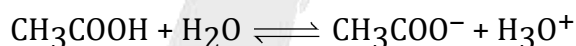
23. Which of the following is not a Bronsted acid:



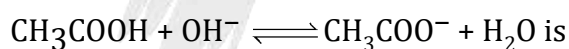
24. In the reaction,  $\text{HNO}_3 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{NO}_3^-$ , the conjugate base of  $\text{HNO}_3$  is:



25. If equilibrium constant of



Is  $1.8 \times 10^{-5}$ , equilibrium constant for



(A)  $1.8 \times 10^{-9}$

(B)  $1.8 \times 10^9$

(C)  $5.55 \times 10^{-9}$

(D)  $5.55 \times 10^{10}$

26. If  $\text{p}K_b$  for fluoride ion at  $25^\circ\text{C}$  is 10.83, the ionisation constant of hydrofluoric acid in water at this temperature is:

(A)  $1.74 \times 10^{-5}$

(B)  $3.52 \times 10^{-3}$

(C)  $6.75 \times 10^{-4}$

(D)  $5.38 \times 10^{-2}$

27. A certain weak acid has  $K_a = 1 \times 10^{-4}$ . Calculate the equilibrium constant for its reaction with strong base -
- (A)  $10^6$  (B)  $10^8$  (C)  $10^{10}$  (D)  $10^{-10}$

**Salt Hydrolysis**

28. pH of an aqueous solution of NaCl at  $85^\circ\text{C}$  should be
- (A) 7 (B)  $> 7$  (C)  $< 7$  (D) 0
29. 1 cc of 0.1 N HCl is added to 99 cc solution of NaCl. The pH of the resulting solution will be
- (A) 7 (B) 3 (C) 4 (D) 1
30. The highest pH value is of:
- (A) 0.1 M NaCl (B) 0.1 M  $\text{NH}_4\text{Cl}$   
(C) 0.1 M  $\text{CH}_3\text{COONa}$  (D) 0.1 M HCl
31. What is the percentage hydrolysis of NaCN in N/80 solution when the dissociation constant for HCN is  $1.3 \times 10^{-9}$  and  $K_w = 1.0 \times 10^{-14}$
- (A) 2.48 (B) 5.26 (C) 8.2 (D) 9.6
32. Degree of Hydrolysis of  $\frac{N}{100}$  solution of KCN is (Given  $K_a = 1.4 \times 10^{-9}$ )
- (A)  $2.7 \times 10^{-3}$  (B)  $2.7 \times 10^{-2}$  (C)  $2.7 \times 10^{-4}$  (D)  $2.7 \times 10^{-5}$

**Salt Hydrolysis of Multivalent Cation or Anion**

33. A solution of  $\text{FeCl}_3$  in water acts as acidic due to:
- (A) Acidic impurities (B) Ionisation  
(C) Hydrolysis of  $\text{Fe}^{3+}$  (D) Dissociation
34. pH of  $\text{K}_2\text{S}$  solution is:
- (A) 7 (B) Less than 7 (C) More than 7 (D) 0

35. For a  $c$  M  $K_3A$  (potassium salt of a tribasic acid  $H_3A$ ) solution:

(Dissociation constants of acid are  $K_{a_1}$ ,  $K_{a_2}$  &  $K_{a_3}$ ;  $h \ll 1$ )

(A)  $pH = \frac{1}{2} (pK_W + pK_{a_3} + \log c)$       (B)  $pH = \frac{1}{2} (pK_W + pK_{a_2} + \log c)$

(C)  $pH = \frac{1}{2} (pK_W + pK_{a_1} + \log c)$       (D)  $pH = \frac{1}{2} (pK_W - pK_{a_3} - \log c)$

### Amphiprotic Salt and Salt of WA + WB

36. The degree of hydrolysis of a salt of weak acid and weak base in its 0.1 M solution is found to be 50%. If the molarity of the solution is 0.2 M, the percentage hydrolysis of the salt should be

- (A) 100%      (B) 50%      (C) 25%      (D) none of these

37. The  $pK_a$  of a weak acid, HA, is 4.80. The  $pK_b$  of a weak base, BOH, is 4.78. The pH of an aqueous solution of the corresponding salt, BA, will be:

- (A) 8.58      (B) 4.79      (C) 7.01      (D) 9.22

38. Out of the following, amphiprotic species in aqueous medium are

I:  $HPO_3^{2-}$       II  $OH^-$       III  $H_2PO_4^-$       IV  $HCO_3^-$

- (A) I, III, IV      (B) I and III      (C) III and IV      (D) All

### Buffer Solution and pH of Buffer Solution

39. The buffer solution play an important role in:

- (A) Increasing the pH value      (B) Decreasing the pH value  
(C) Keeping the pH constant      (D) Solution will be neutral

40. The pH of blood is maintained by  $CO_2$  and  $H_2CO_3$  in the body and chemical constituents of blood. This phenomenon is called:

- (A) Colloidal      (B) Buffer action  
(C) Acidity      (D) Salt balance

41. 1 M NaCl and 1M HCl are present in an aqueous solution. The solution is  
(A) not a buffer solution and with  $\text{pH} < 7$  (B) not a buffer solution with  $\text{pH} > 7$   
(C) a buffer solution with  $\text{pH} < 7$  (D) a buffer solution with  $\text{pH} > 7$
42.  $\text{pK}_b$  for  $\text{NH}_4\text{OH}$  at certain temperature is 4.74. The pH of basic buffer containing equimolar concentration of  $\text{NH}_4\text{OH}$  and  $\text{NH}_4\text{Cl}$  will be:  
(A) 7.74 (B) 4.74 (C) 2.37 (D) 9.26
43. If equal volume of 0.05 M ammonium hydroxide solution and 0.001 M ammonium chloride solution are mixed. What will be the  $\text{OH}^-$  ion concentration of this solution  $K_b(\text{NH}_4\text{OH}) = 1.8 \times 10^{-5}$   
(A)  $3.0 \times 10^{-3}$  (B)  $9.0 \times 10^{-4}$  (C)  $9.0 \times 10^{-3}$  (D)  $3.0 \times 10^{-4}$
44. Calculate the pH of a buffer prepared by mixing 300 cc of 0.3 M  $\text{NH}_3$  and 500 cc of 0.5 M  $\text{NH}_4\text{Cl}$ .  
 $K_b$  for  $\text{NH}_3 = 1.8 \times 10^{-5}$ ,  $\left( \log \left( \frac{25}{16.2} \right) = 0.188 \right)$   
(A) 8.1187 (B) 9.8117 (C) 8.812 (D) 7.812
45. 500 ml of 0.2 M acetic acid are added to 500 ml of 0.30 M sodium acetate solution. If the dissociation constant of acetic acid is  $1.5 \times 10^{-5}$  then pH of the resulting solution is:  
(A) 5.0 (B) 9.0 (C) 3.0 (D) 4.0
46. 50 ml. of 2N acetic acid mixed with 10 ml. of 1N sodium acetate solution will have an approximate pH of ( $K_a = 10^{-5}$ ):  
(A) 4 (B) 5 (C) 6 (D) 7
47.  $K_a$  for HCN is  $5 \times 10^{-10}$  at  $25^\circ\text{C}$ . For maintaining a constant pH of 9, the volume of 5M KCN solution required to be added to 10ml. of 2M HCN solution is-  
(A) 4 ml (B) 7.95 ml (C) 2 ml (D) 9.3 ml

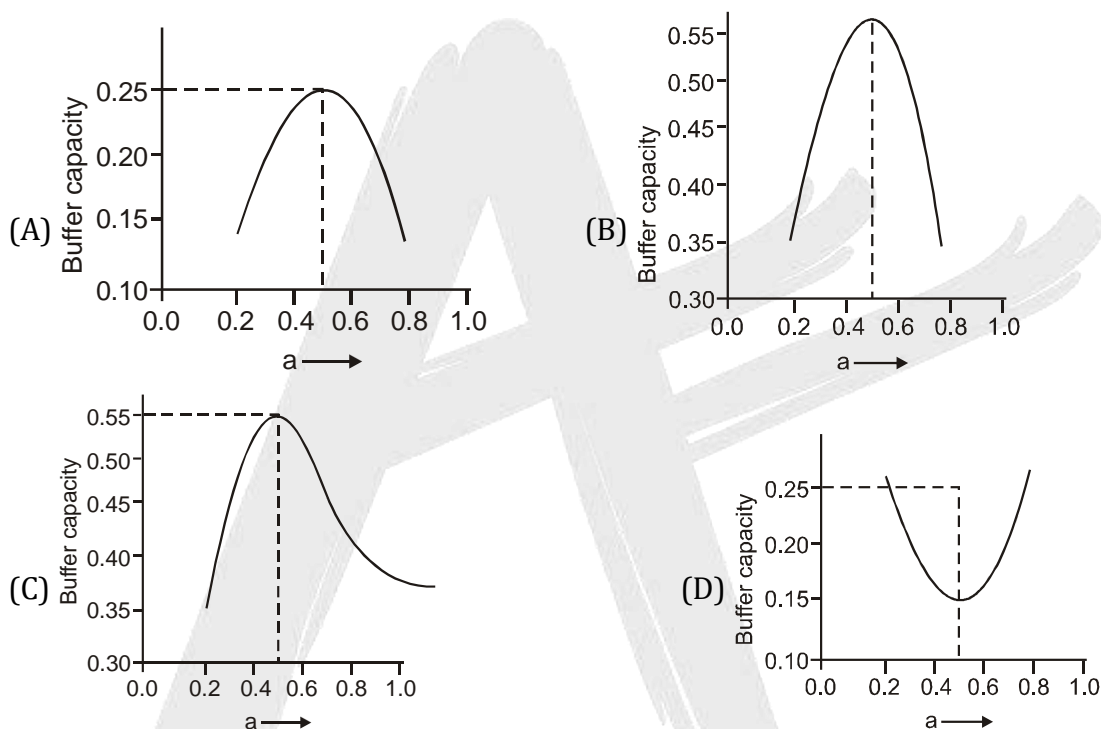
48. What amount of sodium propanoate should be added to one litre of an aqueous solution containing 0.02 mole of propanoic acid ( $K_a = 1.34 \times 10^{-5}$  at  $25^\circ\text{C}$ ) to obtain a buffer solution of pH 4.75 ( $10^{1/4} = 1.78$ )
- (A)  $4.52 \times 10^{-2}$  mol (B)  $3.52 \times 10^{-2}$  mol  
(C)  $2.52 \times 10^{-2}$  mol (D)  $1.5 \times 10^{-2}$  mol
49. To a 50 ml. of 0.05M formic acid how much volume of 0.10M sodium formate must be added to get a buffer solution of pH = 4.0? ( $pK_a$  of the acid is 3.7) ( $\log 2 = 0.3$ )
- (A) 40 ml. (B) 4 ml. (C) 50 ml. (D) 100 ml.
50. In a buffer solution the ratio of concentration of  $\text{NH}_4\text{Cl}$  and  $\text{NH}_4\text{OH}$  is 1: 1 when it changes in 2: 1 what will be the value of pH of buffer:
- (A) Increase (B) Decrease (C) No effect (D) None
51. Henderson equation  $\text{pH} - \text{p}K_a = 5$  will be applicable to an acidic buffer when:
- (A)  $[\text{Acid}] = [\text{Conjugate base}]$  (B)  $[\text{Acid}] \times 10^5 = [\text{Conjugate base}]$   
(C)  $[\text{Acid}] = [\text{Conjugate base}] \times 10^5$  (D)  $[\text{acid}] = 2 [\text{conjugate base}]$

### Change on pH of Buffer Solution & Buffer Capacity

52. How many gm of solid NaOH must be added to 100 ml of a buffer solution which is 0.1 M each w.r.t. Acid HA and salt  $\text{Na}^+ \text{A}^-$  to make the pH of solution 5.5. Given  $\text{p}K_a (\text{HA}) = 5$ .  
(Use antilog (0.5) = 3.16)
- (A)  $2.08 \times 10^{-1}$  (B)  $3.05 \times 10^{-3}$  (C)  $2.01 \times 10^{-2}$  (D) None of these
53. 10 ml. of a solution contains 0.1 M  $\text{NH}_4\text{Cl}$  + 0.01M  $\text{NH}_4\text{OH}$ .  
Which addition would not change the pH of solution:
- (A) Adding 1 ml. water (B) Adding 5 ml. of 0.1 M  $\text{NH}_4\text{Cl}$   
(C) Adding 5 ml. of 0.1 M  $\text{NH}_4\text{OH}$  (D) Adding 10 ml. of 0.1 M  $\text{NH}_4\text{Cl}$



54. When 0.02 moles of NaOH are added to a litre of buffer solution, its pH changes from 5.75 to 5.80. What is its buffer capacity:
- (A) 0.4                      (B) 0.05                      (C) - 0.05                      (D) 2.5
55. A buffer solution is prepared by mixing 'a' moles of  $\text{CH}_3\text{COONa}$  and 'b' moles of  $\text{CH}_3\text{COOH}$  such that  $(a + b) = 1$ , into water to make 1L buffer solution. If the instantaneous (differential) buffer capacity of this buffer solution is plotted against moles of salt  $\text{CH}_3\text{COONa}$  (a), then the plot obtained will be (to the scale) approximately



### Problems related with mixing ... Titration type

56. 8 gm NaOH and 4.9 gm  $\text{H}_2\text{SO}_4$  are present in one litre of the solution. What is its pH
- (A) 1                      (B) 13                      (C) 12                      (D) 2
57. The pH of the solution containing 10 ml of a 0.1M NaOH and 10 ml. of 0.05M  $\text{H}_2\text{SO}_4$  would be (assuming sulphate ion is not hydrolysed)
- (A) Zero                      (B) 1                      (C) < 7                      (D) 7

58. Which of the following solution will have pH close to 1.0?
- (A) 100 ml of M/100 HCl + 100 ml of M/10 NaOH  
(B) 55 ml of M/10 HCl + 45 ml of M/10 NaOH  
(C) 10 ml of M/10 HCl + 90 ml of M/10 NaOH  
(D) 75 ml of M/5 HCl + 25 ml of M/5 NaOH
59. Which can act as buffer:
- (A)  $\text{NH}_4\text{OH} + \text{NaOH}$   
(B)  $\text{HCOOH} + \text{HCl}$   
(C) 40 ml. of 0.1 M NaCN + 20 ml. of 0.1 M HCl  
(D) All of them
60. Which of the following solutions does not act as buffer:
- (A)  $\text{H}_3\text{PO}_4 + \text{NaH}_2\text{PO}_4$  (B)  $\text{NaHCO}_3 + \text{H}_2\text{CO}_3$   
(C)  $\text{NH}_4\text{Cl} + \text{HCl}$  (D)  $\text{CH}_3\text{COOH} + \text{CH}_3\text{COONa}$
61. If 40 ml of 0.2 M KOH is added to 160 ml of 0.1 M HCOOH [ $K_a = 2 \times 10^{-4}$ ], the pOH of the resulting solution is
- (A) 3.4 (B) 3.7 (C) 7 (D) 10.3
62. On addition of NaOH to  $\text{CH}_3\text{COOH}$  solution, 60% of the acid is neutralised. If  $\text{p}K_a$  of  $\text{CH}_3\text{COOH}$  is 4.7 then the pH of the resulting solution is:
- (A) More than 4.7 but less than 5.0 (B) Less than 4.7 but more than 4.0  
(C) More than 5.0 (D) Remains unchanged
63. Half of the formic acid solution is neutralised on addition of a KOH solution to it. If  $K_a (\text{HCOOH}) = 2 \times 10^{-4}$  then pH of the solution is: ( $\log 2 = 0.3010$ )
- (A) 3.6990 (B) 10.3010 (C) 3.85 (D) 4.3010
64.  $\frac{N}{10}$  acetic acid was titrated with  $\frac{N}{10}$  NaOH. When 25%, 50% and 75% of titration is over then the pH of the solution will be: [ $K_a = 10^{-5}$ ]
- (A)  $5 + \log 1/3$ , 5,  $5 + \log 3$  (B)  $5 + \log 3$ , 4,  $5 + \log 1/3$   
(C)  $5 - \log 1/3$ , 5,  $5 - \log 3$  (D)  $5 - \log 1/3$ , 4,  $5 + \log 1/3$

65. 10 mL of  $\frac{M}{5}$   $\text{CH}_3\text{COONa}$  solution is titrated with  $\frac{M}{5}$   $\text{HCl}$  solution. The pH value at equivalence point is: ( $\text{pK}_a(\text{CH}_3\text{COOH}) = 4.76$ )  
 (A) 0.7 (B) 1 (C) 1.88 (D) 2.88
66.  $\text{H}_2\text{A}$  is a diprotic acid for which  $\text{K}_{a_1} = 10^{-7}$  and  $\text{K}_{a_2} = 10^{-11}$ . The solution which will have a pH closest to 9 is:  
 (A) 0.1 M  $\text{H}_2\text{A}$  (B) 0.1 M  $\text{Na}_2\text{A}$   
 (C) 0.1 M  $\text{NaHA}$  (D) 0.1 M  $\text{NaHA}$  + 0.1 M  $\text{Na}_2\text{A}$
67. The total number of different kind of acidic buffers obtained during the titration of  $\text{H}_3\text{PO}_4$  with  $\text{NaOH}$  are:  
 (A) 3 (B) 1 (C) 2 (D) 0
68. 50 mL of 0.1 M  $\text{NaOH}$  is added to 60 mL of 0.15 M  $\text{H}_3\text{PO}_4$  solution ( $\text{K}_1$ ,  $\text{K}_2$  and  $\text{K}_3$  for  $\text{H}_3\text{PO}_4$  are  $10^{-3}$ ,  $10^{-8}$  and  $10^{-13}$  respectively). The pH of the mixture would be about:  
 (A) 3.1 (B) 5.5 (C) 4.1 (D) 6.5

### Indicators & Double Indicator

- 69 The rapid change of pH near the stoichiometric point of an acid-base titration is the basis of indicator detection. pH of the solution is related to ratio of the concentrations of the acid ( $\text{HIn}$ ) and conjugate base ( $\text{In}^-$ ) forms of the indicator by the expression:  
 (A)  $\log \frac{[\text{HIn}]}{[\text{In}^-]} = \text{pK}_{\text{In}} - \text{pH}$  (B)  $\log \frac{[\text{HIn}]}{[\text{In}^-]} = \text{pH} - \text{pK}_{\text{In}}$   
 (C)  $\log \frac{[\text{In}^-]}{[\text{HIn}]} = \text{pH} + \text{pK}_{\text{In}}$  (D)  $\log \frac{[\text{In}^-]}{[\text{HIn}]} = \text{pK}_{\text{In}} - \text{pH}$
- 70 Calculate the pH range in which an acid indicator with  $\text{K}_{\text{acid}}(\text{indicator}) = 1.0 \times 10^{-5}$  changes colour when the concentration of the indicator is  $1 \times 10^{-3} \text{M}$ .  
 (A)  $5 \pm 1$  (B)  $11 \pm 1$  (C)  $3 \pm 1$  (D)  $8 \pm 1$
- 71 pH-range of Methyl red indicator is:  
 (A) 4.2–6.3 (B) 8.5–10.3 (C) 8.3–10 (D) 3.1–4.4

## (Physical Chemistry)

## IONIC EQUILIBRIUM

- 72 Indicator which is used in the titration of  $\text{CH}_3\text{COOH}$  &  $\text{NaOH}$ :  
 (A) Methyl orange (B) Methyl red (C) Phenolphthalein (D) Litmus
- 73 In the volumetric estimation of  $\text{HCl}$ , if we make use of phenolphthalein as an indicator, which base is unsuitable for the titration:  
 (A)  $\text{NaOH}$  (B)  $\text{RbOH}$  (C)  $\text{KOH}$  (D)  $\text{NH}_4\text{OH}$
- 74 What is the suitable indicator for titration of  $\text{NaOH}$  and oxalic acid:  
 (A) Methyl orange (B) Methyl red (C) Phenolphthalein (D) None
- 75 Phenolphthalein does not act as an indicator for the titration between:  
 (A)  $\text{KOH}$  and  $\text{H}_2\text{SO}_4$  (B)  $\text{NaOH}$  and  $\text{CH}_3\text{COOH}$   
 (C) Oxalic acid and  $\text{KMnO}_4$  (D)  $\text{Ba}(\text{OH})_2$  and  $\text{HCl}$
- 76 For weak acid and strong base titration, the indicator used is:  
 (A) Potassium di-chromate (B) Methyl orange  
 (C) Litmus (D) Phenolphthalein
77. 20 ml of 0.2M  $\text{RNH}_2$  ( $K_b = 10^{-5}$ ) is titrated against 0.2 M  $\text{HCl}$ . Which of the following graph is correct-
- (A)

(B)
- (C)

(D)
- 78 An acid-base indicator has a  $K_a = 1.0 \times 10^{-5}$ . The acid form of the indicator is red and the basic form is blue. Calculate the pH change required to change the colour of the indicator from 80% red to 80% blue.  
 (A) 1.20 (B) 0.80 (C) 0.20 (D) 1.40
79. 10gm  $\text{NaHCO}_3(\text{s})$  sample is heated in open to constant weight, the residue is titrated against 0.1M  $\text{HCl}$  in presence of phenolphthalein as an indicator, 500 ml of acid was required to reach end point hence % purity of sample is-  
 (A) 21% (B) 42% (C) 63% (D) 84%

80. A mixture of NaOH &  $\text{Na}_2\text{CO}_3$  when titrated against 0.1N  $\text{H}_2\text{SO}_4$  solution, it requires 30 ml to decolorise the phenolphthalein. Now methyl orange is added to it and further 20 ml of same acid are added it observe methyl orange end point then millimoles of NaOH &  $\text{Na}_2\text{CO}_3$  in mixture respectively -
- (A) 2 & 2                      (B) 2 & 4                      (C) 1 & 2                      (D) 2 & 1

**Solubility and  $K_{sp}$** 

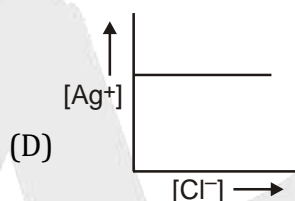
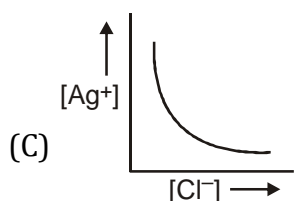
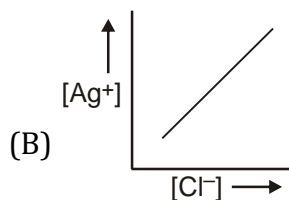
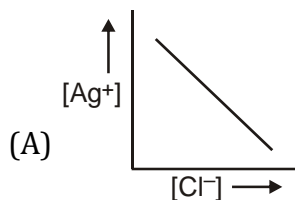
81. The solubility of  $\text{A}_2\text{X}_3$  is  $y \text{ mol dm}^{-3}$ . Its solubility product is
- (A)  $6y^2$                       (B)  $64y^4$                       (C)  $36y^5$                       (D)  $108y^5$
82. If  $K_{sp}$  for  $\text{HgSO}_4$  is  $6.4 \times 10^{-5} \text{ M}^2$  then solubility of this substance in mole per  $\text{m}^3$  is
- (A)  $8 \times 10^{-3}$                       (B)  $6.4 \times 10^{-5}$                       (C)  $8 \times 10^{-6}$                       (D) 8
83. If the solubility of AgCl (formula mass=143) in water at  $25^\circ\text{C}$  is  $1.43 \times 10^{-4} \text{ gm./100 ml.}$  of solution then the value of  $K_{sp}$  will be:
- (A)  $1 \times 10^{-5}$                       (B)  $2 \times 10^{-5}$                       (C)  $1 \times 10^{-10}$                       (D)  $2 \times 10^{-10}$
84. One litre of saturated solution of  $\text{CaCO}_3$  is evaporated to dryness, 7.0 g of residue is left. The solubility product for  $\text{CaCO}_3$  is:
- (A)  $4.9 \times 10^{-3}$                       (B)  $4.9 \times 10^{-5}$                       (C)  $4.9 \times 10^{-9}$                       (D)  $4.9 \times 10^{-7}$
85. Which of the following is most soluble in water?
- (A)  $\text{MnS}$  ( $K_{sp} = 8 \times 10^{-37}$ )                      (B)  $\text{ZnS}$  ( $K_{sp} = 7 \times 10^{-16}$ )
- (C)  $\text{Bi}_2\text{S}_3$  ( $K_{sp} = 1 \times 10^{-72}$ )                      (D)  $\text{Ag}_3(\text{PO}_4)$  ( $K_{sp} = 1.8 \times 10^{-18}$ )
86.  $K_{sp}$  of  $\text{Ag}_2\text{CrO}_4$  at a certain temperature is  $8.64 \times 10^{-13}$ . How many times is its solubility in water greater than in 0.6 M  $\text{Na}_2\text{CrO}_4$  solution?
- (A) 10                      (B) 10                      (C) 1000                      (D) 129

87. Solubility of AgBr will be minimum in:  
(A) Pure water (B) 0.1 M CaBr<sub>2</sub>  
(C) 0.1 M NaBr (D) 0.1 M AgNO<sub>3</sub>
88. SrCO<sub>3</sub> ( $K_{sp} = 10^{-10}$ ) and ZnCO<sub>3</sub> ( $K_{sp} = 1.5 \times 10^{-11}$ ) are dissolved together in a solution. The ratio of  $[Sr^{2+}]/[Zn^{2+}]$  in the solution is:  
(A)  $\frac{10}{3}$  (B)  $\frac{3}{10}$  (C)  $\frac{20}{3}$  (D)  $\frac{3}{20}$

**Precipitation**

89. Solid Ba(NO<sub>3</sub>)<sub>2</sub> is gradually dissolved in a  $1.0 \times 10^{-4}$  M Na<sub>2</sub>CO<sub>3</sub> solution. At what concentration of Ba<sup>2+</sup> will a precipitate begin to form?  
( $K_{sp}$  for BaCO<sub>3</sub> =  $5.1 \times 10^{-9}$ )  
(A)  $4.1 \times 10^{-5}$  M (B)  $5.1 \times 10^{-5}$  M (C)  $8.1 \times 10^{-8}$  M (D)  $8.1 \times 10^{-7}$  M
90. Solubility product of Mg(OH)<sub>2</sub> is  $1 \times 10^{-11}$ . At what pH, precipitation of Mg(OH)<sub>2</sub> will begin from 0.1 M Mg<sup>2+</sup> solution:  
(A) 9 (B) 5 (C) 3 (D) 7
91. What will happen if the pH of the solution of 0.001 M Mg(NO<sub>3</sub>)<sub>2</sub> solution is adjusted to pH = 9  
( $K_{sp}$  of Mg(OH)<sub>2</sub> =  $8.9 \times 10^{-12}$ )  
(A) ppt will take place (B) ppt will not take place  
(C) Solution will be saturated (D) None of these
92. 50 litre of a solution containing  $10^{-5}$  mole of Ag<sup>+</sup> is mixed with 50 litre of a  $2 \times 10^{-7}$  M HBr solution.  $[Ag^+]$  in resultant solution is: [Given:  $K_{sp}$  (AgBr) =  $5 \times 10^{-13}$ ]  
(A)  $10^{-5}$  M (B)  $10^{-6}$  M (C)  $10^{-7}$  M (D)  $10^{-8}$  M
93. The remaining molar concentration of Ag<sup>+</sup> ion if 100 ml of 0.1 M AgNO<sub>3</sub> solution is mixed with 400 ml of 0.2 M K<sub>2</sub>Cr<sub>2</sub>O<sub>4</sub> solution is,  
[Given  $K_{sp}$  (Ag<sub>2</sub>CrO<sub>4</sub>) =  $1.5 \times 10^{-11}$  M<sup>3</sup>]  
(A)  $10^{-10}$  (B)  $2.5 \times 10^{-3}$  (C)  $5 \times 10^{-3}$  (D)  $10^{-5}$

94. The moles of  $\text{Ag}^+$  which must be added to decrease the concentration of  $\text{Cl}^-$  from  $4 \times 10^{-5} \text{M}$  to  $10^{-5} \text{M}$  in 100 ml solution, if  $K_{\text{sp}}$  for  $\text{AgCl}$  is  $10^{-10} \text{M}^2$  at  $25^\circ\text{C}$   
 (A)  $4 \times 10^{-5}$  mole (B)  $2 \times 10^{-5}$  mole (C)  $3 \times 10^{-6}$  mole (D)  $4 \times 10^{-6}$  mole
95. In a saturated solution of  $\text{AgCl}$ ,  $\text{NaCl}$  is added gradually. The concentration of  $\text{Ag}^+$  is plotted against the concentration of  $\text{Cl}^-$ . The graph appears as:



### Effect of Complex Formation and Hydrolysis on Solubility

96. What is the effect of pH on the solubility of  $\text{M}(\text{CN})_2$  ?  
 (Neglect hydrolysis of  $\text{M}^{2+}$  ion)  
 (A) As pH decreases, solubility decreases.  
 (B) As pH decreases below 7 or increases above 7, solubility increases in both cases.  
 (C) As pH decreases, solubility increases.  
 (D) No dependence on pH of solution.
97. At  $300^\circ\text{C}$ , In which of the one litre solution, the solubility of  $\text{Ag}_2\text{CO}_3$  (solubility product =  $8 \times 10^{-12}$ ) will be maximum:  
 (A) 0.05 M  $\text{Na}_2\text{CO}_3$  (B) Pure water (C) 0.05 M  $\text{AgNO}_3$  (D) 0.05 M  $\text{NH}_3$
98. 1 mole of  $\text{AgNO}_3$  is added to 10 litre of 1 M  $\text{NH}_3$ . What is the concentration of  $\text{Ag}(\text{NH}_3)^+$  in solution ?  
 [Given : For  $\text{Ag}(\text{NH}_3)_2^+$ ,  $K_{f1} = 2.0 \times 10^3$ ;  $K_{f2} = 10^4$ ]  
 (A)  $8 \times 10^{-5}$  (B)  $1.25 \times 10^{-5}$   
 (C)  $4 \times 10^{-6}$  (D)  $1.25 \times 10^{-4}$
99. pH of a saturated solution of silver salt of monobasic acid HA is found to be 9. Find the  $K_{\text{sp}}$  of sparingly soluble salt  $\text{AgA(s)}$ .  
 Given :  $K_a(\text{HA}) = 10^{-10}$   
 (A)  $1.1 \times 10^{-11}$  (B)  $1.1 \times 10^{-10}$  (C)  $10^{-12}$  (D) None of these

## EXERCISE # (S-I)

## Dissociation of Water, pH of Water

- Calculate the number of  $H^+$  present in one ml of solution whose pH is 13.
- $K_w$  for  $H_2O$  is  $9 \times 10^{-14}$  at  $60^\circ C$ . What is pH of water at  $60^\circ C$ . ( $\log 3 = 0.47$ )
  - What is the nature of solution at  $60^\circ C$  having
    - pH = 6.7
    - pH = 6.35
- Percentage ionisation of water as follows at certain temperature is  $3.6 \times 10^{-7} \%$ . Calculate  $K_w$  and pH of water at this temperature.  $2H_2O \rightleftharpoons H_3O^+ + OH^-$
- At  $-50^\circ C$ , liquid  $NH_3$  has ionic product is  $10^{-30} M^2$ . How many amide ( $NH_2^-$ ) ions are present per  $mm^3$  in pure liquid  $NH_3$ ? (Take  $N_A = 6 \times 10^{23}$ )

## pH of Strong Electrolyte

- Calculate pH of following solutions :
  - 0.1 M HCl
  - $10^{-3}$  mole of KOH dissolved in 100 L of water.
  - Decimolar solution of Baryta ( $Ba(OH)_2$ ), diluted 100 times.
  - $10^{-8} M$  HCl [ $\sqrt{401} = (20.02)$ ] [ $\log 1.051 = 0.03$ ]
  - $10^{-10} M$  NaOH
- 0.1 mole HCl is dissolved in distilled water of volume V. Then, at  $\lim_{V \rightarrow \infty}$ ,  $(pH)_{\text{solution}}$  is equal to
- pH of a dilute solution of HCl is 6.95. Calculate molarity of HCl solution.
 
$$\left[ \begin{array}{l} 10^{-9.5} = 11.22 \times 10^{-8} \\ 10^{-7.05} = 8.90 \times 10^{-8} \end{array} \right]$$

## pH of Weak Electrolyte

- Calculate pH of following solutions :
  - 0.1 M  $CH_3COOH$  ( $K_a = 1.8 \times 10^{-5}$ ) ( $\log \sqrt{1.8} = 0.13$ )
  - 0.1 M  $NH_4OH$  ( $K_b = 1.8 \times 10^{-5}$ )
  - $10^{-7} M$   $CH_3COOH$  ( $K_a = 10^{-5}$ )
  - $10^{-8} M$   $CH_3COOH$  ( $K_a = 1.8 \times 10^{-5}$ ) [ $\sqrt{401} = (20.02)$ ] [ $\log 1.051 = 0.03$ ]



9. Calculate:

(a)  $K_a$  for a monobasic acid whose 0.10 M solution has pH of 4.50.

(b)  $K_b$  for a monoacidic base whose 0.10 M solution has a pH of 10.50.

$$K_b = \frac{10^{-3.5} \times 10^{-3.5}}{0.1 - 10^{-3.5}} = 10^{-6}$$

10. Calculate the ratio of degree of dissociation ( $\alpha_2/\alpha_1$ ) when 1 M acetic acid solution is diluted 100 times. [Given  $K_a = 10^{-5}$  M]

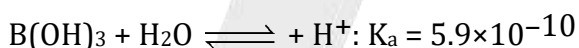
11. Calculate the ratio of degree of dissociation of acetic acid and hydrocyanic acid (HCN) in 1 M their respective solution of acids. [Given  $K_{a(\text{CH}_3\text{COOH})} = 1.8 \times 10^{-5}$ ;  $K_{a(\text{HCN})} = 6.2 \times 10^{-10}$ ]

$$\left[ \sqrt{\frac{18}{6.2}} = 1.704 \right]$$

12. The pH of aqueous solution of ammonia is 10. Find molarity of solution.  $K_b(\text{NH}_4\text{OH}) = 10^{-5}$ .

13. The solution of weak monoprotic acid which is 0.01 M has pH = 3. Calculate  $K_a$  of weak acid.

14. Boric acid is a weak monobasic acid. It ionizes in water as



Calculate pH of 0.3 M boric acid. [  $\log(\sqrt{1.77}) = 0.13$  ]

### pH of Mixture of More Than One Acid/Base

15. Calculate pH if equal volume of HCl solution (PH = 4) + 0.0019 N HCl solution

16. Calculate pH of following solutions:

(a) 0.1 M  $\text{H}_2\text{SO}_4$  (50 ml) + 0.4 M HCl 50 (ml) [  $\log 0.3 = -0.522$  ]

(b) 0.1 M HA + 0.1 M HB [  $K_a(\text{HA}) = 2 \times 10^{-5}$ ;  $K_a(\text{HB}) = 4 \times 10^{-5}$  ] [  $\log = 0.39$  ]

17. Upon passing 0.01 mole HCl gas through 100 mL of 0.05 M Formic acid solution ( $K_a = 1.8 \times 10^{-4}$ ), determine change in pH of solution and  $[\text{HCOO}^-]$  in resulting solution.

18. Calculate  $[\text{H}^+]$  and  $[\text{CHCl}_2\text{COO}^-]$  in a solution that is 0.01 M in HCl and 0.01 M in  $\text{CHCl}_2\text{COOH}$ .  
Take ( $K_a = 3 \times 10^{-2}$ ) ( $\sqrt{30} = 5.5$ )

19. Calculate  $[H^+]$ ,  $[CH_3COO^-]$  and  $[C_7H_5O_2^-]$  in a solution that is 0.02 M in acetic acid and 0.01M in benzoic acid.  $K_a(\text{acetic}) = 1.8 \times 10^{-5}$ ,  $K_a(\text{benzoic}) = 6.4 \times 10^{-5}$ .

### Polyprotic Acid Base

20. What are the concentration of  $H^+$ ,  $H_2C_2O_4$ ,  $HC_2O_4^-$  and  $C_2O_4^{2-}$  in a 0.1 M solution of oxalic acid ?  
 $[K_1 = 10^{-2} \text{ M}$  and  $K_2 = 10^{-5} \text{ M}]$
21. Calculate  $[H^+]$ ,  $[H_2PO_4^-]$ ,  $[HPO_4^{2-}]$  and  $[PO_4^{3-}]$  in a 0.01M solution of  $H_3PO_4$ .  
 Take  $K_1 = 10^{-3}$ ,  $K_2 = 10^{-8}$ ,  $K_3 = 10^{-13}$ .
22. What are the concentrations of  $H^+$ ,  $HSO_4^-$ ,  $SO_4^{2-}$  and  $H_2SO_4$  in a 0.20 M solution of sulphuric acid?  
 Given:  $H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$ ; strong  
 $HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$ ;  $K_2 = 10^{-2} \text{ M}$
23. Calculate the pH of a 0.1M solution of  $H_2NCH_2CH_2NH_2$ ; ethylenediamine (en). Determine the en  $H_2^{2+}$ . Concentration in the solution.  $K_{b1}$  and  $K_{b2}$  values of ethylenediamine are  $8.5 \times 10^{-5}$  and  $7.1 \times 10^{-8}$  respectively.

### Conjugate Acid Base, Bronsted Theory

24. Which of the following ions or compounds in a solution tend to produce an acidic, a basic or a neutral solution ?
- |                 |                 |                 |             |
|-----------------|-----------------|-----------------|-------------|
| (a) $C_2H_5O^-$ | (b) $Cu^{+2}$   | (c) $SO_3^{2-}$ | (d) $F^-$   |
| (e) $NH_4^+$    | (f) $CH_3COONa$ | (g) $KNO_3$     | (h) $NaOCl$ |
| 5(i) $Na_2CO_3$ | (j) $ZnCl_2$    |                 |             |
25. What is ionisation constant of  $HOCl$ , if  $K_b$  of  $OCl^- = 4 \times 10^{-10}$  ? Also find its  $pK_a$ .
26.  $K_{a1}$ ,  $K_{a2}$  and  $K_{a3}$  values for  $H_3PO_4$  are  $10^{-3}$ ,  $10^{-8}$  and  $10^{-12}$  respectively. If  $K_w(H_2O) = 10^{-14}$ , then:
- What is dissociation constant of  $HPO_4^{2-}$  ?
  - What is  $K_b$  of  $HPO_4^{2-}$  ?
  - What is  $K_b$  of  $H_2PO_4^-$  ?
  - What is order of  $K_b$  of  $PO_4^{3-}$  ( $K_{b3}$ ),  $HPO_4^{2-}$  ( $K_{b2}$ ) and  $H_2PO_4^-$  ( $K_{b1}$ ) ?

## Salt Hydrolysis

27. What is the  $\text{OH}^-$  concentration of a 0.08 M solution of  $\text{CH}_3\text{COONa}$ .  
 $[\text{K}_a(\text{CH}_3\text{COOH}) = 1.8 \times 10^{-5}]$
28. Calculate the pH of a 2.0 M solution of  $\text{NH}_4\text{Cl}$ .  $[\text{K}_b(\text{NH}_3) = 1.8 \times 10^{-5}]$
29. 0.25 M solution of pyridinium chloride  $\text{C}_5\text{H}_6\text{N}^+\text{Cl}^-$  was found to have a pH of 2.699. What is  $\text{K}_b$  for pyridine,  $\text{C}_5\text{H}_5\text{N}$ ? ( $\log 2 = 0.3010$ )  $\text{antilog}(0.796) = 6.25$
30. Calculate the percent hydrolysis in a 0.06 M solution of KCN.  
 $[\text{K}_a(\text{HCN}) = 6 \times 10^{-10}]$
31. Calculate the pH of  $1.0 \times 10^{-3}$  M sodium phenolate,  $\text{NaOC}_6\text{H}_5$ .  $\text{K}_a$  for  $\text{HOC}_6\text{H}_5$  is  $1.05 \times 10^{-10}$ .  
 $\frac{\sqrt{43}-1}{21} = 0.26$  &  $\log 26 = 1.43$

## Salt Hydrolysis of Multivalent Cation Or Anion

32. Calculate the  $\text{OH}^-$  concentration and the  $\text{H}_3\text{PO}_4$  concentration of a solution prepared by dissolving 0.1 mol of  $\text{Na}_3\text{PO}_4$  in sufficient water to make 1L of solution.  
 $\text{K}_1 = 7.1 \times 10^{-3}$ ,  $\text{K}_2 = 6.3 \times 10^{-8}$ ,  $\text{K}_3 = 4.5 \times 10^{-13}$ .
33. Calculate the extent of hydrolysis of 0.005 M  $\text{K}_2\text{CrO}_4$ .  $[\text{K}_2 = 3.1 \times 10^{-7}$  for  $\text{H}_2\text{CrO}_4]$   
 (It is essentially strong for first ionization).  
 $\frac{1}{\sqrt{5 \times 3.1}} = 0.26$
34. A 0.010 M solution of  $\text{PuO}_2(\text{NO}_3)_2$  was found to have a pH of 4.0. What is the hydrolysis constant,  $\text{K}_h$ , for  $\text{PuO}_2^{2+}$  and what is  $\text{K}_b$  for  $\text{PuO}_2\text{OH}^+$ ?
35. The acid ionization (hydrolysis) constant of  $\text{Zn}^{2+}$  is  $1.0 \times 10^{-9}$   
 (a) Calculate the pH of a 0.001 M solution of  $\text{ZnCl}_2$   
 (b) What is the basic dissociation constant of  $\text{Zn}(\text{OH})^+$ ?

## Amphiprotic Salt and Salt of WA + WB

36. Calculate the extent of hydrolysis & the pH of 0.02 M  $\text{CH}_3\text{COONH}_4$ .

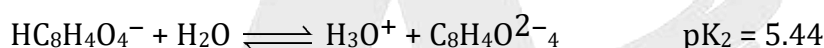
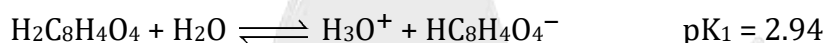
$$[\text{K}_b(\text{NH}_3) = 1.8 \times 10^{-5}, \text{K}_a(\text{CH}_3\text{COOH}) = 1.8 \times 10^{-5}]$$

37. What is the pH of 0.1M  $\text{NaHCO}_3$ ?

$$\text{K}_1 = 4.5 \times 10^{-7}, \text{K}_2 = 4.5 \times 10^{-11} \text{ for carbonic acids.}$$

$$\log(4.5) = 0.66$$

38. Calculate pH of 0.05M potassium hydrogen phthalate,  $\text{KHC}_8\text{H}_4\text{O}_4$ .



## pH of buffer solution and Change on pH of Buffer Solution

39. Determine  $[\text{OH}^-]$  of a 0.050 M solution of ammonia to which sufficient  $\text{NH}_4\text{Cl}$  has been added to make the total  $[\text{NH}_4^+]$  equal to 0.100.  $[\text{K}_b(\text{NH}_3) = 1.8 \times 10^{-5}]$
40. A buffer of pH 9.26 is made by dissolving x moles of ammonium sulphate and 0.1 mole of ammonia into 100 mL solution. If  $\text{pK}_b$  of ammonia is 4.74, calculate value of x.
41. (a) Determine the pH of a 0.2 M solution of pyridine  $\text{C}_5\text{H}_5\text{N}$ .  $\text{K}_b = 1.5 \times 10^{-9}$   
 (b) Predict the effect of addition of pyridinium ion  $\text{C}_5\text{H}_5\text{NH}^+$  on the position of the equilibrium. Will the pH be raised or lowered?  
 (c) Calculate the pH of 1.0 L of 0.10 M pyridine solution to which 0.3 mol of pyridinium chloride  $\text{C}_5\text{H}_5\text{NH}^+\text{Cl}$ , has been added, assuming no change in volume.
42. Calculate the pH of 0.5 L of a 0.2 M  $\text{NH}_4\text{Cl}$  – 0.2 M  $\text{NH}_3$  buffer before and after addition of (a) 0.05 mole of  $\text{NaOH}$  and (b) 0.05 mole of  $\text{HCl}$ . Assume that the volume remains constant. [Given:  $\text{pK}_b$  of  $\text{NH}_3 = 4.74$ ]

**Problems Related with mixing... Titration type**

43. Calculate the pH of the resulting solution formed by mixing the following solutions:
- (a) 20 mL of 0.2 M  $\text{Ba}(\text{OH})_2$  + 30 mL of 0.1 M HCl
  - (b) 2 mL of 0.1 M HCl + 10 mL of 0.01 M  $\text{Sr}(\text{OH})_2$
  - (c) 10 mL of 0.1 M  $\text{H}_2\text{SO}_4$  + 10 mL of 0.1 M KOH.
44. How many of the following statement(s) is/are correct for making a buffer solution ?
- (i) It can be formed by mixing equal moles of HCl and  $\text{CH}_3\text{COONa}$
  - (ii) It can be formed by mixing equal moles of  $\text{HNO}_3$  and  $\text{NH}_3$
  - (iii) It can be formed by mixing equal moles of HCN and Aniline.
  - (iv) It can be formed by mixing unequal moles of  $\text{NH}_4\text{OH}$  and HCl.
  - (v) It can be formed by mixing unequal moles of HCN and KOH.
45. Calculate the pH of a solution prepared by mixing 50.0 mL of 0.200 M  $\text{HC}_2\text{H}_3\text{O}_2$  and 50.0 mL of 0.100 M NaOH. [ $K_{\text{a}}(\text{CH}_3\text{COOH}) = 1.8 \times 10^{-5}$ ]
46. 50 mL of 0.1 M NaOH is added to 75 mL of 0.1 M  $\text{NH}_4\text{Cl}$  to make a basic buffer. If  $\text{p}K_{\text{a}}$  of  $\text{NH}_4^+$  is 9.26, calculate pH.
47. Calculate the pH of a solution which results from the mixing of 50.0 ml of 0.3 M HCl with 50.0 ml of 0.4 M  $\text{NH}_3$ . [ $K_{\text{b}}(\text{NH}_3) = 1.8 \times 10^{-5}$ ]
48. Calculate the pH of a solution made by mixing 50.0 ml of 0.2M  $\text{NH}_4\text{Cl}$  & 75.0 ml of 0.1 M NaOH. [ $K_{\text{b}}(\text{NH}_3) = 1.8 \times 10^{-5}$ ]
49. Calculate  $\text{OH}^-$  concentration at the equivalent point when a solution of 0.2 M acetic acid is titrated with a solution of 0.2 M NaOH.  $K_{\text{a}}$  for the acid =  $10^{-5}$ .
50. Calculate the hydronium ion concentration and pH at the equivalence point in the reaction of 22.0 mL of 0.10M acetic acid,  $\text{CH}_3\text{COOH}$ , with 22.0 mL of 0.10 M NaOH. [ $K_{\text{a}} = 1.8 \times 10^{-5}$ ]  
( $10^{+0.29} = 1.95$ )

51. Calculate the hydronium ion concentration and the pH at the equivalence point in a titration of 50.0 mL of 0.40 M  $\text{NH}_3$  with 0.40M  $\text{HCl}$ . [ $K_b = 1.8 \times 10^{-5}$ ]  
 $10^{0.02} = 1.05$
52.  $\text{CH}_3\text{COOH}$  (50 ml, 0.1 M) is titrated against 0.1 M  $\text{NaOH}$  solution. Calculate the pH at the addition of 0 ml, 10 ml 20 ml, 25 ml, 40 ml, 50 ml of  $\text{NaOH}$ .  $K_a$  of  $\text{CH}_3\text{COOH}$  is  $2 \times 10^{-5}$ .  
 $[\log 2 = 0.3010, \log 3 = 0.4771]$

### Indicators

53. For the acid indicator thymol blue, pH is 2.0 when half the indicator is in unionised form. Find the % of indicator in unionised form in the solution with  $[\text{H}^+] = 4 \times 10^{-3}$  M.
54. An acid indicator has a  $K_a$  of  $3 \times 10^{-5}$ . The acid form of the indicator is red & the basic form is blue. By how much must the pH change in order to change the indicator form 75% red to 75 % blue?  $[\log 3 = 0.4771]$
55. Bromophenol blue is an acid indicator with a  $K_a$  value of  $6 \times 10^{-5}$ . What % of this indicator is in its basic form at a pH of 5 ?
56. At what pH does an indicator change colour if the indicator is a weak acid with  $K_{\text{ind}} = 4 \times 10^{-4}$ . For which one(s) of the following neutralizations would the indicator be useful? Explain.  
 (a)  $\text{NaOH} + \text{CH}_3\text{COOH}$                       (b)  $\text{HCl} + \text{NH}_3$                       (c)  $\text{HCl} + \text{NaOH}$
57. What indicator should be used for the titration of 0.10 M  $\text{KH}_2\text{BO}_3$  with 0.10 M  $\text{HCl}$  ?  
 $K_a (\text{H}_3\text{BO}_3) = 7.2 \times 10^{-10}$ .  $[\log \left( \frac{20}{7.2} \right) = 0.44]$

### Double Indicator, Solubility and $K_{\text{sp}}$

58. 100 ml solution containing  $\text{Na}_2\text{CO}_3$  &  $\text{NaHCO}_3$  is titrated with 0.1 M solution of triprotic strong acid then following results were obtained  
 (i) 25 ml solution required 10 ml of acid using phenolphthalein as indicator  
 (ii) 20 ml solution required 20 ml of acid using methyl orange indicator  
 What will be the value of sum of millimoles of  $\text{Na}_2\text{CO}_3$  &  $\text{NaHCO}_3$  in original solution.

59. Calculate the solubility of  $A_2X_3$  in pure water, assuming that neither kind of ion reacts with water. For  $A_2X_3$ ,  $[K_{sp} = 1.08 \times 10^{-23}]$
60. The solubility of  $PbSO_4$  in water is 0.038 g/L. Calculate the solubility product constant of  $PbSO_4$ .  
Molar mass  $PbSO_4 = 304$  g/mole,  $\frac{380}{304} = 1.25$   $(1.25)^2 = 1.56$
61. A solution of saturated  $CaF_2$  is found to contain  $4.1 \times 10^{-4}$  M fluoride ion. Calculate the  $K_{sp}$  of  $CaF_2$ . Use  $4\left(\frac{4.1}{2}\right)^3 \approx 34$ .
62. The solubility of  $ML_2$  (formula weight, 60 g/mol) in water is  $2.4 \times 10^{-5}$  g/100 mL solution. Calculate the solubility product constant for  $ML_2$ .
63. The values of  $K_{sp}$  for the slightly soluble salts  $MX$  and  $QX_2$  are each equal to  $4.0 \times 10^{-18}$ . Which salt is more soluble? Explain your answer fully.

### SOLUBILITY IN PRESENCE OF COMMON ION

64. How many mol  $CuI$  ( $K_{sp} = 5 \times 10^{-12}$ ) will dissolve in 1.0 L of 0.10 M  $NaI$  solution?
65. Determine the solubility of  $AgCl$  in 0.1 M  $BaCl_2$ . [ $K_{sp}$  for  $AgCl = 1 \times 10^{-10}$ ]
66. Calculate the Simultaneous solubility of  $AgSCN$  and  $AgBr$ .  
 $K_{sp}(AgSCN) = 1.1 \times 10^{-12}$ ,  $K_{sp}(AgBr) = 5 \times 10^{-13}$ .  $\left(\frac{1.1}{1.26} \approx 0.9, \frac{5}{1.26} \approx 4\right)$
67. Calculate  $F^-$  in a solution saturated with respect of both  $MgF_2$  and  $SrF_2$ .  $K_{sp}(MgF_2) = 9.5 \times 10^{-9}$ ,  $K_{sp}(SrF_2) = 4 \times 10^{-9}$ .

### Precipitation

68. A solution has a  $Mg^{2+}$  concentration of 0.0010 mol/L. Will  $Mg(OH)_2$  precipitate if the  $OH^-$  concentration of the solution is [ $K_{sp} = 1.2 \times 10^{-11}$ ]  
(a)  $10^{-5}$  mol/L (b)  $10^{-3}$  mol/L?



69.  $8 \times 10^{-6}$  M  $\text{AgNO}_3$  solution is gradually added in 1 L of  $10^{-4}$  M  $\text{KCl}$  solution. Up to what volume  $\text{AgNO}_3$  solution being added (in L), precipitation of  $\text{AgCl}$  will not take place? ( $K_{\text{sp}}$  of  $\text{AgCl} = 2 \times 10^{-10}$ )
70. Solubility of  $\text{Ag}_2\text{CrO}_4$  in water at  $25^\circ\text{C}$  is  $10^{-3}$  M. If 0.1 moles of  $\text{K}_2\text{CrO}_4$  are added to 1 litre saturated solution of  $\text{Ag}_2\text{CrO}_4$ . Then find moles of  $\text{Ag}_2\text{CrO}_4$  precipitated at  $25^\circ\text{C}$ .  
If your answer is  $x \times 10^y$  then fill 'x' in OMR. Where 'x' is single digit number.
71. What mass of  $\text{Pb}^{2+}$  ion is left in solution when 50.0 mL of 0.20 M  $\text{Pb}(\text{NO}_3)_2$  is added to 50.0 mL of 1.5 M  $\text{NaCl}$ ? [Given  $K_{\text{sp}}$  for  $\text{PbCl}_2 = 1.7 \times 10^{-4}$ ]  
[ $5.6 \times 208 = 1.2 \times 10^3$ ] [Atomic mass of  $\text{Pb} = 208$ ,  $\frac{1.7}{(0.55)^2} = 5.6$ ]
72. The solubility of  $\text{CaCO}_3$  is 7 mg/litre. Calculate the solubility of  $\text{BaCO}_3$  (in mol/L) from this information and from the fact that when  $\text{Na}_2\text{CO}_3$  is added slowly to a solution containing equimolar concentration of  $\text{Ca}^{+2}$  and  $\text{Ba}^{+2}$ , no precipitate of  $\text{CaCO}_3$  is formed until 90% of  $\text{Ba}^{+2}$  has been precipitated as  $\text{BaCO}_3$ . (Assume no hydrolysis of  $\text{CO}_3^{2-}$  ion).

### Effect of Complex Formation And Hydrolysis on Solubility

73. A recent investigation of the complexation of  $\text{SCN}^-$  with  $\text{Fe}^{3+}$  led of 130, 16, and 1.0 for  $K_1$ ,  $K_2$ , and  $K_3$ , respectively. What is the overall formation constant of  $\text{Fe}(\text{SCN})_3$  from its component ions, and what is the dissociation constant of  $\text{Fe}(\text{SCN})_3$  into its simplest ions on the basis of these data?
74. How much  $\text{AgBr}$  could dissolve in 1.0 L of 0.40 M  $\text{NH}_3$ ? Assume that  $\text{Ag}(\text{NH}_3)_2^+$  is the only complex formed.  
[ $K_f(\text{Ag}(\text{NH}_3)_2^+) = 1 \times 10^8$ ;  $K_{\text{sp}}(\text{AgBr}) = 5 \times 10^{-13}$ ] [ $\sqrt{50} \approx 7$ ] S
75. At  $25^\circ\text{C}$ , the solubility of  $\text{Ag}_2\text{CO}_3$  ( $K_{\text{sp}} = 4.3 \times 10^{-13}$ ) would be in what order in the following solutions?
- (a) 0.01 M  $\text{AgNO}_3$  (b) 0.04 M  $\text{K}_2\text{CO}_3$   
(c) pure water (d) in a buffer (pH = 4)



## EXERCISE # (O-II)

1. If  $K_1$  &  $K_2$  be first and second ionisation constant of  $H_3PO_4$  and  $K_1 \gg K_2$  which is correct.  
(A)  $[H^+] = [H_2PO_4^-]$  (B)  $[H^+] = \sqrt{K_1[H_3PO_4]}$  (C)  $[HPO_4^{2-}] = K_2$  (D)  $[H^+] = 3[PO_4^{3-}]$
2. Choose the correct statement(s)  
(A)  $K_a$  for an acid HA is  $1 \times 10^{-6}$ .  $K_b$  for  $A^-$  would be  $10^{-8}$   
(B) The value of  $K_w$  increases with increase in temperature  
(C) Larger the value of  $pK_a$  weaker is the acid.  
(D) Salts of strong acids and weak bases undergo cationic hydrolysis.
3. Choose the correct statement(s)  
(A) pH of 0.1M  $CH_3COOH$  solution decreases with increase in temperature  
(B) pOH of 0.1M  $NH_4OH$  solution decreases with increase in temperature  
(C)  $10^{-4}M$  HCl solution is more acidic than 0.1M HCN ( $K_{a_{HCN}} = 10^{-5}$ ) solution.  
(D) On dilution degree of dissociation of weak electrolytes increases.
4. Choose the incorrect statement(s)  
(A) When a solution of a weak monoprotic acid is titrated against a strong base, at half-neutralization point,  $pH = \frac{1}{2}pK_a$ .  
(B) The pH of a solution which is 0.1 M in sodium acetate and 0.01 M in acetic acid ( $pK_a = 4.74$ ) would be 5.74.  
(C) In a mixture of weak acid and its salt, the ratio of concentration of salt to acid is increased Ten times. The pH of the solution would Increase by one unit.  
(D) A buffer has maximum buffer capacity when the ratio of salt to acid is 10.
5. Select the correct statement(s):  
(A) If pOH of aq. solution at  $70^\circ C$  is 7, then solution will be acidic  
(B) If  $[H^+]$  concentration is decreases 100 times, pH of solution increases by 2 units  
(C) If solution of  $CH_3COONa(aq.)$  is diluted then pH increases.  
(D) Buffer capacity remains constant with dilution.

6. Which of the following is correct for 0.1 M BOH solution ( $K_b = 10^{-5}$ )
- (A) pH of solution is 11  
(B)  $\text{OH}^-$  concentration is  $10^{-3}$  mol/L  
(C) it's salt with HCl (i.e., BCl) form the acidic solution in water  
(D) Phenolphthalein indicator can be used during the titration of BOH with HCl
7. When equal volumes of the following solutions are mixed, precipitation of AgCl ( $K_{sp} = 1.8 \times 10^{-10}$ ) will occur
- (A)  $10^{-4}$  M ( $\text{Ag}^+$ ) and  $10^{-4}$  M ( $\text{Cl}^-$ )                      (B)  $10^{-5}$  M ( $\text{Ag}^+$ ) and  $10^{-5}$  M ( $\text{Cl}^-$ )  
(C)  $10^{-6}$  M ( $\text{Ag}^+$ ) and  $10^{-6}$  M ( $\text{Cl}^-$ )                      (D)  $10^{-10}$  M ( $\text{Ag}^+$ ) and  $10^{-10}$  M ( $\text{Cl}^-$ )
8. Choose the correct statement(s)
- (A) From an equimolar solution of  $\text{Cl}^-$  and  $\text{Br}^-$  ions, the addition of  $\text{Ag}^+$  will precipitates  $\text{Br}^-$  ion first ( $K_{sp}$  of AgCl & AgBr are  $1 \times 10^{-10}$  &  $1 \times 10^{-13}$  respectively).  
(B) If the salts  $\text{M}_2\text{X}$ ,  $\text{QY}_2$  and  $\text{PZ}_3$  have same solubilities ( $\ll 1$ ), their  $K_{sp}$  values are related as  $\text{M}_2\text{X} = \text{QY}_2 > \text{PZ}_3$   
(C) If the solubility of the salt  $\text{Li}_3\text{Na}_3(\text{AlF}_6)_2$  is x, then its solubility product would be  $2916 x^8$ .  
(D)  $K_{sp}$  of  $\text{Fe}(\text{OH})_3$  in aqueous solution is  $3.8 \times 10^{-38}$  at 298K. The concentration of  $\text{Fe}^{3+}$  will increase when  $[\text{H}^+]$  ion concentration decreases
9. Choose the correct statement(s)
- (A) AgCl is less soluble in aqueous sodium chloride solution than in pure water.  
(B) In the presence of a common ion (incapable of forming complex ion), the solubility of salt decreases.  
(C) The solubility of  $\text{CH}_3\text{COOAg}$  in water considering hydrolysis of  $\text{CH}_3\text{COO}^-$  ions would be Greater than that ignoring the hydrolysis.  
(D) The solubility of AgCl in  $\text{NH}_3$  is greater than the solubility in pure water because of complex ion,  $[\text{Ag}(\text{NH}_3)_2]^+$  formation.

## Paragraph for Question 10 to 12

1 litre of 1M  $\text{CH}_3\text{COOH}$  (very weak acid) taken in a container initially. Now this solution is diluted upto volume  $V$  (litre) so that pH of the resulting solution becomes the twice of the original value. ( $K_a(\text{CH}_3\text{COOH}) = 10^{-6}$ ). Now equal volume of  $0.5 \times 10^{-6}\text{M}$   $\text{NaOH}$  solution is added to this resulting solution. So that a buffer solution is obtained.

$$\text{pH (acidic buffer)} = \text{p}K_a + \log_{10} \left( \frac{[\text{Anion}]}{[\text{Acid}]} \right) \quad \& \quad \text{pOH (Basic buffer)} = \text{p}K_b + \log_{10} \left( \frac{[\text{Cation}]}{[\text{Base}]} \right)$$

10. Find  $[\text{H}^+]$  in original solution

- (A) 1 M                      (B)  $10^{-3}\text{M}$                       (C)  $10^{-7}\text{M}$                       (D)  $10^{-11}\text{M}$

11. Find value of  $V$  (litre)

- (A)  $5 \times 10^5$  litre                      (B) 1 litre  
(C) 2 litre                      (D)  $2 \times 10^{-6}$  litre

12. Find pH of final solution ( $\log 3 = 0.477$ )

- (A) 6                      (B) 6.477                      (C) 5.523                      (D) 3

## Paragraph for Q.13 to Q.15

100ml of 1M  $\text{Na}_3\text{PO}_4$  is titrated with 1M  $\text{HCl}$  the following observation were made

Stage of titration	pH
I half equivalence point	12
I equivalence point	10
II equivalence point	6

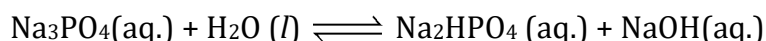
13. pH at III equivalence point should be -

- (A) 4                      (B)  $4 - \log 2$                       (C)  $3 - \log 5$                       (D)  $2 - \log 5$

14. pH at II half equivalence point will be -

- (A) 4                      (B) 8                      (C) 11                      (D) 12

15. What is the value of equilibrium constant for the reaction -



- (A)  $10^{-2}$                       (B)  $10^{-4}$                       (C)  $10^{-6}$                       (D)  $10^{-8}$

## Paragraph for Question 16 to 17

A solution contains one mole each of HA & HB (both are weak acids) in one litre solution. Now one mole of NaOH is added to this solution so that both the acids are partially neutralised. Heat of neutralisation of HA & HB are  $-11.8$  and  $-12.4$  kcal per mole respectively and heat produced during partial neutralisation of HA & HB is  $-12.25$  kcal.

16. Mole ratio of neutralisation of HA & HB is -  
 (A) 1: 4 (B) 1: 2 (C) 1: 3 (D) 1: 5
17. pH of solution containing mixture of 1 mol of HA & 1 mole of HB in 1 litre solution is  
 $K_a(\text{HA}) = 1 \times 10^{-5}$ ,  $K_a(\text{HB}) = 9 \times 10^{-5}$   
 (A) 2 (B) 3 (C) 4 (D) 5

## Paragraph for question nos. 18 to 20

To find the  $K_{sp}$  of  $\text{AgBrO}_3$  a student prepared one litre of a just saturated solution by adding  $\text{AgBrO}_3$  at  $27^\circ\text{C}$ . He found that a copper wire left in the solution overnight became covered with silver and  $\text{Cu}^{+2}(\text{aq})$  ions were also formed in solution. The wire was cleaned, dried, and found to weight 7.04 mg less than it did originally. ( $R = 8 \text{ J/mol/K}$ ;  $\ln x = 2.3 \log x$ )

Given :  $\text{Cu(s)} + 2\text{Ag}^+(\text{aq}) \rightleftharpoons \text{Cu}^{+2}(\text{aq}) + 2\text{Ag(s)}$   $\Delta G^\circ = 110.4 \text{ kJ}$ .

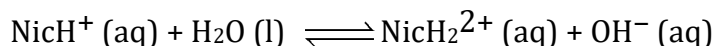
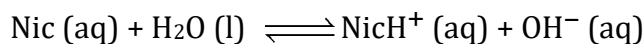
18. The number of moles of Cu which reacted was  
 (A)  $1.1 \times 10^{-4}$  (B) 1.1 (C) 0.11 (D)  $1.1 \times 10^{-3}$
19. The  $[\text{Ag}^+(\text{aq})]$  in the original saturated solution have been  
 (A)  $1.1 \times 10^{-2}$  (B)  $1.1 \times 10^{-4}$  (C)  $2.2 \times 10^{-4}$  (D)  $5.5 \times 10^{-5}$
20. The  $K_{sp}$  for  $\text{AgBrO}_3$  as calculated from the above data is about  
 (A)  $1.21 \times 10^{-8}$  (B)  $3.025 \times 10^{-9}$  (C)  $1.7 \times 10^{-4}$  (D)  $4.84 \times 10^{-8}$
21. Match the effect of addition of 1 M NaOH to 100 mL 1 M  $\text{CH}_3\text{COOH}$  (in Column I) with pH (in Column II):

Column-I	Column-II
(A) 25 mL of NaOH	(P) $\text{pK}_a$
(B) 50 mL of NaOH	(Q) $\text{pK}_a + \log 3$
(C) 75 mL of NaOH	(R) $\text{pK}_a - \log 3$
(D) 100 mL of NaOH	(S) $\frac{1}{2} [\text{pK}_w + \text{pK}_a - \log 2]$

22.	Column-I PH	Column-II Solution
(A)	3	(P) When equal volumes of 0.2M $\text{NH}_4\text{OH}$ ( $K_b = 10^{-5}$ ) & 0.2M HCl are mixed
(B)	5	(Q) When equal volumes of 0.2M $\text{CH}_3\text{COONa}$ & 0.2M HCl are mixed ( $K_a(\text{CH}_3\text{COOH}) = 10^{-5}$ )
(C)	8	(R) 0.1M $\text{Na}_2\text{HPO}_4$ (for $\text{H}_3\text{PO}_4$ ; $K_{a1} = 10^{-4}$ ; $K_{a2} = 10^{-6}$ ; $K_{a3} = 10^{-10}$ )
(D)	9	(S) At 1 <sup>st</sup> half equivalence point of $\text{H}_2\text{CO}_3$ when titrated against 0.1M NaOH , $K_{a1} = 10^{-5}$ , $K_{a2} = 10^{-9}$ (T) $\text{Mg}(\text{OH})_2$ ; $K_{sp} = 5 \times 10^{-16}$

## EXERCISE # (S-II)

- Determine the  $[S^{2-}]$  in a saturated (0.1M)  $H_2S$  solution to which enough HCl has been added to produce a  $[H^+]$  of  $2 \times 10^{-4}$ .  $K_1 = 10^{-7}$ ,  $K_2 = 10^{-14}$ .
- Nicotine,  $C_{10}H_{14}N_2$ , has two basic nitrogen atoms and both can react with water to give a basic solution a



$K_{b1}$  is  $7 \times 10^{-7}$  and  $K_{b2}$  is  $10^{-10}$ . Calculate the approximate pH of a 0.020 M solution.

$$\left[ (\log \sqrt{1.4} = 0.07) \right]$$

- Calculate the pH of 0.1 M solution of (i)  $NaHCO_3$ , (ii)  $Na_2HPO_4$  and (iii)  $NaH_2PO_4$ . Given that:



- Calculate the pH of the following solutions.

$$[K_1 = 7.5 \times 10^{-3} \text{ M} ; K_2 = 6.2 \times 10^{-8} \text{ M} ; K_3 = 1.0 \times 10^{-12} \text{ M}]$$

(a) 50 ml of 0.12 M  $H_3PO_4$  + 20 ml of 0.15 M NaOH;

(b) 50 ml of 0.12 M  $H_3PO_4$  + 40 ml of 0.15 M NaOH;

(c) 40 ml of 0.12 M  $H_3PO_4$  + 40 ml of 0.18 M NaOH;

(d) 40 ml of 0.10 M  $H_3PO_4$  + 40 ml of 0.25 M NaOH.

- A buffer solution was prepared by dissolving 0.02 mol propionic acid & 0.015 mol sodium propionate in enough water to make 1.00 L of solution. ( $K_a$  for propionic acid is  $1.34 \times 10^{-5}$ )
  - What is the pH of the buffer?
  - What would be the pH if  $1.0 \times 10^{-5}$  mol HCl were added to 10 ml of the buffer ?
  - What would be the pH if  $1.0 \times 10^{-5}$  mol NaOH were added to 10 ml of the buffer.
  - Also report the percent change in pH of original buffer in cases (b) and (c).

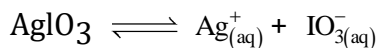
6. A weak base (50.0 mL) was titrated with 0.1 M HCl. The pH of the solution after the addition of 10.0 mL and 25.0 mL were found to be 9.84 and 9.24, respectively. Calculate  $K_b$  of the base and pH at the equivalence point. [ $\log 2 = 0.3$ ]
7. The indicator phenol red is half in the ionic form when pH is 7.2. If the ratio of the undissociated form to the ionic form is 1: 5, find the pH of the solution. With the same pH for solution, if indicator is altered such that the ratio of undissociated form to dissociated form becomes 1: 4, find the pH when 50 % of the new indicator is in ionic form.
8. What  $[H_3O^+]$  must be maintained in a saturated  $H_2S$  solution (0.1 M) to precipitate  $Pb^{2+}$ , but not  $Zn^{2+}$  from a solution in which each ion is present at a concentration of 0.01 M ? ( $K_1K_2$  of  $H_2S = 1.1 \times 10^{-21}$  ;  $K_{sp}$  of  $ZnS = 1.0 \times 10^{-21}$  ;  $\sqrt{11} = 3.3$ )
9. What minimum pH must be maintained in a saturated  $H_2S$  solution (0.1 M) to cause precipitation of both  $Mn^{2+}$  &  $Fe^{2+}$  from a solution, in which each ion is present at a concentration of 0.01 M? ( $K_1K_2$  of  $H_2S = 9.6 \times 10^{-21}$  ;  $K_{sp}$  of  $MnS = 2.5 \times 10^{-13}$  ;  $K_{sp}$  of  $FeS = 6.4 \times 10^{-18}$ )
10. 2M solution of  $Na_2CO_3$  is boiled in a closed container with excess of  $CaF_2$ . Very little amount of  $CaCO_3$  and  $NaF$  are formed. If the solubility product ( $K_{sp}$ ) of  $CaCO_3$  is x and molar solubility of  $CaF_2$  is y, find the molar concentration of  $F^-$  in resulting solution after equilibrium is attained.
11. Determine the concentration of  $NH_3$  solution whose 1 L can dissolve 0.1 mole  $CuCO_3$ . Given:  $K_{sp}$  of  $CuCO_3 = 1.4 \times 10^{-10}$  and  $K_f$  of  $[Cu(NH_3)_4]^{2+} = 2 \times 10^{13}$ .  
Take  $\sqrt[4]{\frac{1000}{2.8}} = 4.4$ . Assume no other reaction to take place.
12. Calculate solubility of  $MnS$  in a buffer solution of given pH. Solubility constant of  $MnS$  is  $K_{sp}$  and dissociation constants of  $H_2S$  are  $K_1$  &  $K_2$  respectively.

## EXERCISE # JEE-MAINS

1. The solubility in water of a sparingly soluble salt  $AB_2$  is  $1.0 \times 10^{-5} \text{ mol L}^{-1}$ . Its solubility product will be [AIEEE-2003]  
(A)  $1 \times 10^{-15}$  (B)  $1 \times 10^{-10}$  (C)  $4 \times 10^{-15}$  (D)  $4 \times 10^{-10}$
2. The solubility of  $Mg(OH)_2$  is  $x$  mole/lit. then its solubility product is: [AIEEE-2002]  
(A)  $x^3$  (B)  $5x^3$  (C)  $4x^3$  (D)  $2x^2$
3. The molar solubility in  $\text{mol L}^{-1}$  of a sparingly soluble salt  $MX_4$  is 's'. The corresponding solubility product is  $K_{sp}$  's' is given in terms of  $K_{sp}$  by relation: [AIEEE-2004]  
(A)  $s = (K_{sp} / 128)^{1/4}$  (B)  $s = (128K_{sp})^{1/4}$  (C)  $s = (256K_{sp})^{1/5}$  (D)  $s = (K_{sp}/256)^{1/5}$
4. The conjugate base of  $H_2PO_4^-$  is [AIEEE-2004]  
(A)  $H_3PO_4$  (B)  $P_2O_5$  (C)  $PO_4^{3-}$  (D)  $HPO_4^{2-}$
5. Hydrogen ion concentration in mol/L in a solution of  $pH = 5.4$  will be: [AIEEE-2005]  
(A)  $3.88 \times 10^6$  (B)  $3.98 \times 10^8$  (C)  $3.98 \times 10^{-6}$  (D)  $3.68 \times 10^{-6}$
6. The solubility product of a salt having general formula  $MX_2$ , in water is:  $4 \times 10^{-12}$ . The concentration of  $M^{2+}$  ions in the aqueous solution of the salt is: [AIEEE-2005]  
(A)  $1.0 \times 10^{-4} M$  (B)  $2.0 \times 10^{-6} M$  (C)  $4.0 \times 10^{-10} M$  (D)  $1.6 \times 10^{-4} M$
7. What is the conjugate base of  $OH^-$ ? [AIEEE-2005]  
(A)  $O^{2-}$  (B)  $O^-$  (C)  $H_2O$  (D)  $O_2$
8. The first and second dissociation constants of an acid  $H_2A$  are  $1.0 \times 10^{-5}$  and  $5.0 \times 10^{-10}$  respectively. the overall dissociation constant of the acid will be [AIEEE-2007]  
(A)  $0.2 \times 10^5$  (B)  $5.0 \times 10^{-5}$  (C)  $5.0 \times 10^{15}$  (D)  $5.0 \times 10^{-15}$
9. The  $pK_a$  of a weak acid (HA) is 4.5. The  $pOH$  of an aqueous buffer solution of HA in which 50% of the acid is ionised is [AIEEE-2007]  
(A) 7.0 (B) 4.5 (C) 2.5 (D) 9.5



10. In a saturated solution of the sparingly soluble strong electrolyte  $\text{AgIO}_3$  (molecular mass = 283) the equilibrium which sets in is: [AIEEE-2007]



If the solubility product constant  $K_{\text{sp}}$  of  $\text{AgIO}_3$  at a given temperature is  $1.0 \times 10^{-8}$ , what is the mass of  $\text{AgIO}_3$  contained in 100 ml of its saturated solution?

- (A)  $28.3 \times 10^{-2}$  g      (B)  $2.83 \times 10^{-3}$  g      (C)  $1.0 \times 10^{-7}$  g      (D)  $1.0 \times 10^{-4}$  g

11. The  $\text{pK}_a$  of a weak acid, HA, is 4.80. The  $\text{pK}_b$  of a weak base, BOH, is 4.78. The pH of an aqueous solution of the corresponding salt, BA, will be: [AIEEE-2008]

- (A) 9.58      (B) 4.79      (C) 7.01      (D) 9.22

12. Solid  $\text{Ba}(\text{NO}_3)_2$  is gradually dissolved in a  $1.0 \times 10^{-4}$  M  $\text{Na}_2\text{CO}_3$  solution. At what concentration of  $\text{Ba}^{2+}$  will a precipitate begin to form? ( $K_{\text{sp}}$  for  $\text{BaCO}_3 = 5.1 \times 10^{-9}$ ) [AIEEE-2009]

- (A)  $8.1 \times 10^{-8}$  M      (B)  $8.1 \times 10^{-7}$  M      (C)  $4.1 \times 10^{-5}$  M      (D)  $5.1 \times 10^{-5}$  M

13. Solubility product of silver bromide is  $5.0 \times 10^{-13}$ . The quantity of potassium bromide (molar mass taken as  $120 \text{ g mol}^{-1}$ ) to be added to 1 litre of 0.05 M solution of silver nitrate to start the precipitation of AgBr is: [AIEEE-2010]

- (A)  $5.0 \times 10^{-8}$  g      (B)  $1.2 \times 10^{-10}$  g      (C)  $1.2 \times 10^{-9}$  g      (D)  $6.2 \times 10^{-5}$  g

14. In aqueous solution the ionization constants for carbonic acid are [AIEEE-2010]

$$K_1 = 4.2 \times 10^{-7} \text{ and } K_2 = 4.8 \times 10^{-11}$$

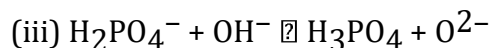
Select the correct statement for a saturated 0.034 M solution of the carbonic acid:

- (A) The concentration of  $\text{H}^+$  is double that of  $\text{CO}_3^{2-}$   
(B) The concentration of  $\text{CO}_3^{2-}$  is 0.034 M  
(C) The concentration of  $\text{CO}_3^{2-}$  is greater than that of  $\text{HCO}_3^-$   
(D) The concentrations of  $\text{H}^+$  and  $\text{HCO}_3^-$  are approximately equal

15. At 25° C, the solubility product of  $\text{Mg}(\text{OH})_2$  is  $1.0 \times 10^{-11}$ . At which pH, will  $\text{Mg}^{2+}$  ions start precipitating in the form of  $\text{Mg}(\text{OH})_2$  from a solution of 0.001 M  $\text{Mg}^{2+}$  ions ? [AIEEE-2010]

- (A) 8 (B) 9 (C) 10 (D) 11

16. Three reactions involving  $\text{H}_2\text{PO}_4^-$  are given below: [AIEEE-2010]



In which of the above does  $\text{H}_2\text{PO}_4^-$  act as an acid?

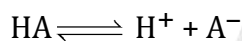
- (A) (ii) only (B) (i) and (ii) (C) (iii) only (D) (i) only

17. The  $K_{\text{sp}}$  for  $\text{Cr}(\text{OH})_3$  is  $1.6 \times 10^{-30}$ . The molar solubility of this compound in water is:

[AIEEE-2011]

- (A)  $\sqrt[3]{1.6 \times 10^{-30}}$  (B)  $\sqrt[4]{1.6 \times 10^{-30}}$  (C)  $\sqrt[4]{1.6 \times 10^{-30} / 27}$  (D)  $1.6 \times 10^{-30} / 27$

18. An acid HA ionises as



The pH of 1.0 M solution is 5. Its dissociation constant would be:

[AIEEE-2011]

- (A)  $1 \times 10^{-10}$  (B) 5 (C)  $5 \times 10^{-8}$  (D)  $1 \times 10^{-5}$

19. If  $K_{\text{sp}}$  of  $\text{CaF}_2$  at 25°C is  $1.7 \times 10^{-10}$ , the combination amongst the following which gives a precipitate of  $\text{CaF}_2$  is: [JEE-MAIN(online)-2012]

- (A)  $1 \times 10^{-2}$  M  $\text{Ca}^{2+}$  and  $1 \times 10^{-5}$  M  $\text{F}^-$  (B)  $1 \times 10^{-4}$  M  $\text{Ca}^{2+}$  and  $1 \times 10^{-4}$  M  $\text{F}^-$   
(C)  $1 \times 10^{-3}$  M  $\text{Ca}^{2+}$  and  $1 \times 10^{-5}$  M  $\text{F}^-$  (D)  $1 \times 10^{-2}$  M  $\text{Ca}^{2+}$  and  $1 \times 10^{-3}$  M  $\text{F}^-$

20. The pH of a 0.1 molar solution of the acid HQ is 3. The value of the ionization constant,  $K_a$  of this acid is: [AIEEE-2012]

- (A)  $1 \times 10^{-7}$  (B)  $3 \times 10^{-7}$  (C)  $1 \times 10^{-3}$  (D)  $1 \times 10^{-5}$

21. Solid  $\text{Ba}(\text{NO}_3)_2$  is gradually dissolved in a  $1.0 \times 10^{-4}$  M  $\text{Na}_2\text{CO}_3$  solution. At which concentration of  $\text{Ba}^{2+}$ , precipitate of  $\text{BaCO}_3$  begins to form?

( $K_{\text{sp}}$  for  $\text{BaCO}_3 = 5.1 \times 10^{-9}$ )

[JEE-MAIN(Online)-2013]

- (A)  $5.1 \times 10^{-5}$  M (B)  $8.1 \times 10^{-7}$  M (C)  $4.1 \times 10^{-5}$  M (D)  $7.1 \times 10^{-8}$  M

22. NaOH is a strong base. What will be pH of  $5.0 \times 10^{-2} \text{M}$  NaOH solution? ( $\log 2 = 0.3$ )

[JEE-MAIN(Online)-2013]

- (A) 13.70 (B) 13.00 (C) 14.00 (D) 12.70

23. Which one of the following arrangements represents the correct order of solubilities of sparingly soluble salts  $\text{Hg}_2\text{Cl}_2$ ,  $\text{Cr}_2(\text{SO}_4)_3$ ,  $\text{BaSO}_4$  and  $\text{CrCl}_3$  respectively ?

[JEE-MAIN(Online)-2013]

- (A)  $\left(\frac{K_{sp}}{4}\right)^{\frac{1}{3}}, \left(\frac{K_{sp}}{108}\right)^{\frac{1}{8}}, (K_{sp})^{\frac{1}{2}}, \left(\frac{K_{sp}}{27}\right)^{\frac{1}{4}}$  (B)  $(K_{sp})^{\frac{1}{2}}, \left(\frac{K_{sp}}{4}\right)^{\frac{1}{3}}, \left(\frac{K_{sp}}{27}\right)^{\frac{1}{4}}, \left(\frac{K_{sp}}{108}\right)^{\frac{1}{3}}$   
(C)  $(K_{sp})^{\frac{1}{2}}, \left(\frac{K_{sp}}{108}\right)^{\frac{1}{3}}, \left(\frac{K_{sp}}{27}\right)^{\frac{1}{4}}, \left(\frac{K_{sp}}{4}\right)^{\frac{1}{3}}$  (D)  $\left(\frac{K_{sp}}{108}\right)^{\frac{1}{3}}, \left(\frac{K_{sp}}{27}\right)^{\frac{1}{4}}, (K_{sp})^{\frac{1}{2}}, \left(\frac{K_{sp}}{4}\right)^{\frac{1}{3}}$

24. What would be the pH of a solution obtained by mixing 5 g of acetic acid and 7.5 g of sodium acetate and making the volume equal to 500 mL?

[JEE-MAIN(Online)-2013]

( $K_a = 1.75 \times 10^{-5}$ ,  $pK_a = 4.76$ )

- (A)  $4.76 < \text{pH} < 5.0$   
(B)  $\text{pH} < 4.70$   
(C) pH of solution will be equal to pH of acetic acid  
(D)  $\text{pH} = 4.70$

25. How many litres of water must be added to 1 litre of an aqueous solution of HCl with a pH of 1 to create an aqueous solution with pH of 2 ?

[JEE-MAIN(Online)-2013]

- (A) 0.1 L (B) 0.9 L (C) 2.0 L (D) 9.0 L

26. In some solutions, the concentration of  $\text{H}_3\text{O}^+$  remains constant even when small amounts of strong acid or strong base are added to them. These solutions are known as:

[JEE-MAIN(Online)-2014]

- (A) Colloidal solutions (B) True solutions (C) Ideal solutions (D) Buffer solutions

27. Zirconium phosphate  $[\text{Zr}_3(\text{PO}_4)_4]$  dissociates into three zirconium cations of charge +4 and four phosphate anions of charge -3. If molar solubility of zirconium phosphate is denoted by  $S$  and its solubility product by  $K_{\text{sp}}$  then which of the following relationship between  $S$  and  $K_{\text{sp}}$  is correct? [JEE-MAIN(Online)-2014]

- (A)  $S = \{K_{\text{sp}}/144\}^{1/7}$  (B)  $S = \{K_{\text{sp}}/(6912)\}^{1/7}$   
 (C)  $S = (K_{\text{sp}}/6912)^{1/7}$  (D)  $S = \{K_{\text{sp}}/6912\}^7$

28.  $\text{pK}_a$  of a weak acid (HA) and  $\text{pK}_b$  of a weak base (BOH) are 3.2 and 3.4, respectively. The pH of their salt (AB) solution is [JEE-MAIN-2017]

- (A) 7.2 (B) 6.9 (C) 7.0 (D) 1.0

29. An alkali is titrated against an acid with methyl orange as indicator, which of the following is a correct combination? [JEE-MAIN-2018]

	Base	Acid	End Point
(A)	Strong	Strong	Pink to colourless
(B)	Weak	Strong	Colourless to pink
(C)	Strong	Strong	Pinkish red to yellow
(D)	Weak	Strong	Yellow to Pinkish red

30. An aqueous solution contains an unknown concentration of  $\text{Ba}^{2+}$ . When 50 mL of a 1 M solution of  $\text{Na}_2\text{SO}_4$  is added,  $\text{BaSO}_4$  just begins to precipitate. The final volume is 500 mL. The solubility product of  $\text{BaSO}_4$  is  $1 \times 10^{-10}$ . What is the original concentration of  $\text{Ba}^{2+}$ ? [JEE-MAIN-2018]

- (A)  $1.0 \times 10^{-10} \text{ M}$  (B)  $5 \times 10^{-9} \text{ M}$  (C)  $2 \times 10^{-9} \text{ M}$  (D)  $1.1 \times 10^{-9} \text{ M}$

31. An aqueous solution contains 0.10 M  $\text{H}_2\text{S}$  and 0.20 M  $\text{HCl}$ . If the equilibrium constants for the formation of  $\text{HS}^-$  from  $\text{H}_2\text{S}$  is  $1.0 \times 10^{-7}$  and that  $\text{S}^{2-}$  from  $\text{HS}^-$  ions is  $1.2 \times 10^{-13}$  then the concentration of  $\text{S}^{2-}$  ions in aqueous solution is [JEE-MAIN-2018]

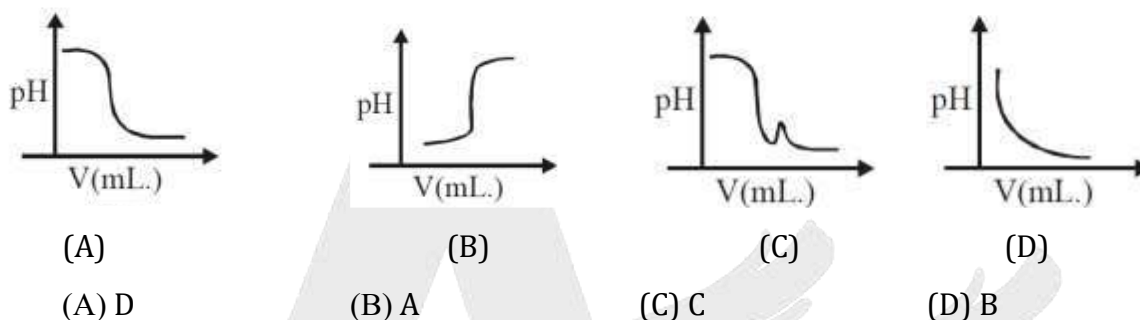
- (A)  $5 \times 10^{-19}$  (B)  $5 \times 10^{-8}$  (C)  $3 \times 10^{-20}$  (D)  $6 \times 10^{-21}$

32. Which of the following salts is the most basic in aqueous solution? **[JEE-MAIN-2018]**  
(A)  $\text{Pb}(\text{CH}_3\text{COO})_2$  (B)  $\text{Al}(\text{CN})_3$  (C)  $\text{CH}_3\text{COOK}$  (D)  $\text{FeCl}_3$
33. The minimum volume of water required to dissolve 0.1 g lead (II) chloride to get a saturated solution ( $K_{\text{sp}}$  of  $\text{PbCl}_2 = 3.2 \times 10^{-8}$ ; atomic mass of Pb = 207 u) is: **[JEE Main-2018 Online]**  
(A) 0.36 L (B) 0.18 L (C) 17.98 L (D) 1.798 L
34. Following four solutions are prepared by mixing different volumes of NaOH and HCl of different concentrations, pH of which one of them will be equal to 1? **[JEE Main-2018 Online]**  
(A)  $75\text{mL } \frac{\text{M}}{5} \text{HCl} + 25\text{mL } \frac{\text{M}}{5} \text{NaOH}$  (B)  $100\text{mL } \frac{\text{M}}{10} \text{HCl} + 100\text{mL } \frac{\text{M}}{10} \text{NaOH}$   
(C)  $55\text{mL } \frac{\text{M}}{10} \text{HCl} + 40\text{mL } \frac{\text{M}}{10} \text{NaOH}$  (D)  $60\text{mL } \frac{\text{M}}{10} \text{HCl} + 40\text{mL } \frac{\text{M}}{10} \text{NaOH}$
35. 20 mL of 0.1 M  $\text{H}_2\text{SO}_4$  solution is added to 30 mL of 0.2 M  $\text{NH}_4\text{OH}$  solution. The pH of the resultant mixture is: [ $\text{p}K_{\text{b}}$  of  $\text{NH}_4\text{OH} = 4.7$ ]. **[JEE Main-2019 (Jan)]**  
(A) 9.4 (B) 5.0 (C) 9.0 (D) 5.2
36. A mixture of 100 mmol of  $\text{Ca}(\text{OH})_2$  and 2 g of sodium sulphate was dissolved in water and the volume was made up to 100 mL. The mass of calcium sulphate formed and the concentration of  $\text{OH}^-$  in resulting solution, respectively, are: (Molar mass of  $\text{Ca}(\text{OH})_2$ ,  $\text{Na}_2\text{SO}_4$  and  $\text{CaSO}_4$  are 74, 143 and 136 g  $\text{mol}^{-1}$ , respectively;  $K_{\text{sp}}$  of  $\text{Ca}(\text{OH})_2$  is  $5.5 \times 10^{-6}$ ) **[JEE Main-2019 (Jan)]**  
(A) 13.6 g, 0.14  $\text{mol L}^{-1}$  (B) 1.9 g, 0.14  $\text{mol L}^{-1}$   
(C) 1.9 g, 0.28  $\text{mol L}^{-1}$  (D) 13.6 g, 0.28  $\text{mol L}^{-1}$
37. If  $K_{\text{sp}}$  of  $\text{Ag}_2\text{CO}_3$  is  $8 \times 10^{-12}$ , the molar solubility of  $\text{Ag}_2\text{CO}_3$  in 0.1M  $\text{AgNO}_3$  is: **[JEE Main-2019 (Jan)]**  
(A)  $8 \times 10^{-10} \text{ M}$  (B)  $8 \times 10^{-13} \text{ M}$   
(C)  $8 \times 10^{-12} \text{ M}$  (D)  $8 \times 10^{-11} \text{ M}$

38. If solubility product of  $\text{Zr}_3(\text{PO}_4)_4$  is denoted by  $K_{\text{sp}}$  and its molar solubility is denoted by  $S$ , then which of the following relation between  $A$  and  $K_{\text{sp}}$  is correct? [JEE Main-2019 (Apr)]

(A)  $S = \left(\frac{K_{\text{sp}}}{6912}\right)^{\frac{1}{7}}$  (B)  $S = \left(\frac{K_{\text{sp}}}{144}\right)^{\frac{1}{6}}$  (C)  $S = \left(\frac{K_{\text{sp}}}{929}\right)^{\frac{1}{9}}$  (D)  $S = \left(\frac{K_{\text{sp}}}{216}\right)^{\frac{1}{7}}$

39. In an acid-base titration, 0.1 M HCl solution was added to the NaOH solution of unknown strength. Which of the following correctly shows the change of pH of the titration mixture in this experiment? [JEE Main-2019 (Apr)]



40. Consider the following statements [JEE Main-2019 (Apr)]
- (a) The pH of a mixture containing 400 mL of 0.1 M  $\text{H}_2\text{SO}_4$  and 400 mL of 0.1 M NaOH will be approximately 1.3.
  - (b) Ionic product of water is temperature dependent.
  - (c) A monobasic acid with  $K_a = 10^{-5}$  has a pH = 5. The degree of dissociation of this acid is 50%.
  - (d) The Le Chatelier's principle is not applicable to common-ion effect.

The correct statements are:

- (A) (a), (b) and (c) (B) (a) and (b) (C) (b) and (c) (D) (a), (b) and (d)
41. The pH of a 0.02 M  $\text{NH}_4\text{Cl}$  solution will be [given  $K_b(\text{NH}_4\text{OH}) = 10^{-5}$  and  $\log 2 = 0.301$ ]

[JEE Main-2019 (Apr)]

- (A) 5.35 (B) 4.65 (C) 4.35 (D) 2.65

42. What is the molar solubility of  $\text{Al}(\text{OH})_3$  in 0.2 M NaOH solution? Given that, solubility product of  $\text{Al}(\text{OH})_3 = 2.4 \times 10^{-24}$ .

[JEE Main-2019 (Apr)]

- (A)  $12 \times 10^{-23}$  (B)  $3 \times 10^{-22}$  (C)  $12 \times 10^{-21}$  (D)  $3 \times 10^{-19}$

43. The molar solubility of  $\text{Cd}(\text{OH})_2$  is  $1.84 \times 10^{-5}$  M in water. The expected solubility of  $\text{Cd}(\text{OH})_2$  in a buffer solution of pH = 12 is: [JEE Main-2019 (Apr)]

(A)  $6.23 \times 10^{-11}$  M (B)  $2.49 \times 10^{-10}$  M (C)  $1.84 \times 10^{-9}$  M (D)  $10^{-9}$  M

44. Arrange the following solutions in the decreasing order of pOH: [Jee Main, 2020]

(A) 0.01 M HCl (B) 0.01 M NaOH  
(C) 0.01 M  $\text{CH}_3\text{COONa}$  (D) 0.01 M NaCl  
(A) (B) > (C) > (D) > (A) (B) (A) > (C) > (D) > (B)  
(C) (B) > (D) > (C) > (A) (D) (A) > (D) > (C) > (B)

45. An acidic buffer is obtained on mixing : [Jee Main, 2020]

(A) 100 mL of 0.1 M HCl and 200 mL of 0.1 M NaCl  
(B) 100 mL of 0.1 M HCl and 200 mL of 0.1 M  $\text{CH}_3\text{COONa}$   
(C) 100 mL of 0.1 M  $\text{CH}_3\text{COOH}$  and 100 mL of 0.1 M NaOH  
(D) 100 mL of 0.1 M  $\text{CH}_3\text{COOH}$  and 200 mL of 0.1 M NaOH

46. Given below are two statements. [JEE Main, August 2021]

**Statement I:** In the titration between strong acid and weak base methyl orange is suitable as an indicator.

**Statement II:** For titration of acetic acid with NaOH phenolphthalein is not a suitable indicator.

In the light of the above statements, choose the most appropriate answer from the options given below:

(A) Statement I is false but Statement II is true  
(B) Statement I is true but Statement II is false  
(C) Both Statement I and Statement II are true  
(D) Both Statement I and Statement II are false

47. The solubility of  $\text{Ca}(\text{OH})_2$  in water is: [JEE Main, Feb 2021]

[Given : The solubility product of  $\text{Ca}(\text{OH})_2$  in water =  $5.5 \times 10^{-6}$ ]

(A)  $1.77 \times 10^{-6}$  (B)  $1.11 \times 10^{-6}$  (C)  $1.11 \times 10^{-2}$  (D)  $1.77 \times 10^{-2}$

48. When 35 mL of 0.15 M lead nitrate solution is mixed with 20 mL of 0.12 M chromic sulphate solution, \_\_\_\_\_  $\times 10^{-5}$  moles of lead sulphate precipitate out. (Round off to the Nearest Integer) [JEE Main, March 2021]



49. The solubility of AgCN in a buffer solution of pH=3 is x. The value of x is: (Assume : No cyano complex is formed;  $K_{sp}(\text{AgCN}) = 2.2 \times 10^{-16}$  and  $K_a(\text{HCN}) = 6.2 \times 10^{-10}$ ) [JEE Main, Feb 2021]
- (A)  $0.625 \times 10^{-6}$  (B)  $1.9 \times 10^{-5}$   
(C)  $2.2 \times 10^{-16}$  (D)  $1.6 \times 10^{-6}$
50. The number of moles of  $\text{NH}_3$ , that must be added to 2 L of 0.80 M  $\text{AgNO}_3$  in order to reduce the concentration of  $\text{Ag}^+$  ions to  $5.0 \times 10^{-8}$  M ( $K_{\text{formation}}$  for  $[\text{Ag}(\text{NH}_3)_2]^+ = 1.0 \times 10^8$ ) is \_\_\_\_\_. (Nearest integer) [Assume no volume change on adding  $\text{NH}_3$ ] [JEE Main, August 2021]
51.  $K_a$  for butyric acid ( $\text{C}_3\text{H}_7\text{COOH}$ ) is  $2 \times 10^{-5}$ . The pH of 0.2 M solution of butyric acid is \_\_\_\_\_  $\times 10^{-1}$ . (Nearest integer) [Given  $\log 2 = 0.30$ ] [JEE Main, July 2022]
52. 200 mL of 0.01 M HCl is mixed with 400 mL of 0.01M  $\text{H}_2\text{SO}_4$ . The pH of the mixture is \_\_\_\_\_. [JEE Main, July 2022]
- (A) 1.14 (B) 1.78 (C) 2.34 (D) 3.02
53. Class XII students were asked to prepare one litre of buffer solution of pH 8.26 by their chemistry teacher. The amount of ammonium chloride to be dissolved by the student in 0.2 M ammonia solution to make one litre of the buffer is [JEE Main, July 2022]
- (Given  $\text{p}K_b(\text{NH}_3) = 4.74$ ; Molar mass of  $\text{NH}_3 = 17 \text{ g mol}^{-1}$ ; Molar mass of  $\text{NH}_4\text{Cl} = 53.5 \text{ g mol}^{-1}$ )
- (A) 53.5 g (B) 72.3 g (C) 107.0 g (D) 126.0 g
54. In base vs. Acid titration, at the end point methyl orange is present as [JEE Main, July 2022]
- (A) quinonoid form (B) heterocyclic form (C) phenolic form (D) benzenoid form
55. The solubility of AgCl will be maximum in which of the following? [JEE Main, June 2022]
- (A) 0.01 M KCl (B) 0.01 M HCl  
(C) 0.01 M  $\text{AgNO}_3$  (D) De-ionised water



## EXERCISE # JEE-ADVANCED

- What will be the resultant pH when 200 ml of an aqueous solution of HCl (pH = 2.0) is mixed with 300 ml of an aqueous solution of NaOH (pH = 12.0) ? **[JEE 1998]**
- The solubility of  $\text{Pb}(\text{OH})_2$  in water is  $6.7 \times 10^{-6} \text{ M}$ . Calculate the solubility of  $\text{Pb}(\text{OH})_2$  in a buffer solution of pH = 8. **[JEE 1999]**
- A buffer solution can be prepared from a mixture of **[JEE 1999]**
  - sodium acetate and acetic acid in water
  - sodium acetate and hydrochloric acid in water
  - ammonia and ammonium chloride in water
  - ammonia and sodium hydroxide in water.
- The pH of 0.1 M solution of the following salts increases in the order **[JEE 1999]**
  - $\text{NaCl} < \text{NH}_4\text{Cl} < \text{NaCN} < \text{HCl}$
  - $\text{HCl} < \text{NH}_4\text{Cl} < \text{NaCl} < \text{NaCN}$
  - $\text{NaCN} < \text{NH}_4\text{Cl} < \text{NaCl} < \text{HCl}$
  - $\text{HCl} < \text{NaCl} < \text{NaCN} < \text{NH}_4\text{Cl}$
- The average concentration of  $\text{SO}_2$  in the atmosphere over a city on a certain day is 10 ppm, when the average temperature is 298 K. Given that the solubility of  $\text{SO}_2$  in water at 298 K is  $1.3653 \text{ moles litre}^{-1}$  and the  $\text{pK}_a$  of  $\text{H}_2\text{SO}_3$  is 1.92, estimate the pH of rain on that day. **[JEE 2000]**
- An aqueous solution of 6.3 g oxalic acid dihydrate is made up to 250 mL. The volume of 0.1 N NaOH required to completely neutralise 10 mL of this solution is **[JEE 2001]**
  - 40 mL
  - 20 mL
  - 10 mL
  - 4 mL
- For sparingly soluble salt  $\text{ApBq}$ , the relationship of its solubility product ( $L_s$ ) with its solubility ( $S$ ) is: **[JEE 2001]**
  - $L_s = S^{p+q}, p^p, q^q$
  - $L_s = S^{p+q}, p^p, q^p$
  - $L_s = S^{pq}, p^p, q^q$
  - $L_s = S^{pq}, (p \cdot q)^{p+q}$
- 500 ml of 0.2 M aqueous solution of acetic acid is mixed with 500 mL of 0.2 M HCl at  $25^\circ\text{C}$ .
  - Calculate the degree of dissociation of acetic acid in the resulting solution and pH of the solution.
  - If 6 g of NaOH is added to the above solution, determine final pH. Assume there is no change in volume on mixing.  $K_a$  of acetic acid is  $1.75 \times 10^{-5} \text{ M}$ . **[JEE 2002]**

## (Physical Chemistry)

## IONIC EQUILIBRIUM

9. Will the pH of water be same at 4°C and 25°C? Explain. [JEE 2003]
10. A solution which is  $10^{-3}$  M each in  $\text{Mn}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Zn}^{2+}$  and  $\text{Hg}^{2+}$  is treated with  $10^{-16}$  M sulphide ion. If  $K_{\text{sp}}$ ,  $\text{MnS}$ ,  $\text{FeS}$ ,  $\text{ZnS}$  and  $\text{HgS}$  are  $10^{-15}$ ,  $10^{-23}$ ,  $10^{-20}$  and  $10^{-54}$  respectively, which one will precipitate first? [JEE 2003]  
 (A)  $\text{FeS}$  (B)  $\text{MnS}$  (C)  $\text{HgS}$  (D)  $\text{ZnS}$
11.  $\text{HX}$  is a weak acid ( $K_a = 10^{-5}$ ). It forms a salt  $\text{NaX}$  (0.1 M) on reacting with caustic soda. The degree of hydrolysis of  $\text{NaX}$  is [JEE 2004]  
 (A) 0.01% (B) 0.0001% (C) 0.1% (D) 0.5%
12. 0.1 M of  $\text{HA}$  is titrated with 0.1 M  $\text{NaOH}$ , calculate the pH at end point. Given  $K_a(\text{HA}) = 5 \times 10^{-6}$  and  $h \ll 1$ . [JEE 2004]
13.  $\text{CH}_3\text{NH}_2$  (0.1 mole,  $K_b = 5 \times 10^{-4}$ ) is added to 0.08 moles of  $\text{HCl}$  and the solution is diluted to one litre, resulting hydrogen ion concentration is [JEE 2005]  
 (A)  $1.6 \times 10^{-11}$  (B)  $8 \times 10^{-11}$  (C)  $5 \times 10^{-5}$  (D)  $2 \times 10^{-2}$
14. The species present in solution when  $\text{CO}_2$  is dissolved in water: [JEE 2006]  
 (A)  $\text{CO}_2$ ,  $\text{H}_2\text{CO}_3$ ,  $\text{HCO}_3^{2-}$  (B)  $\text{H}_2\text{CO}_3$ ,  $\text{CO}_3^{2-}$   
 (C)  $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$  (D)  $\text{CO}_2$ ,  $\text{H}_2\text{CO}_3$
15. Solubility product constants ( $K_{\text{sp}}$ ) of salts of types  $\text{MX}$ ,  $\text{MX}_2$  and  $\text{M}_3\text{X}$  at temperature 'T' are  $4.0 \times 10^{-8}$ ,  $3.2 \times 10^{-14}$  and  $2.7 \times 10^{-15}$ , respectively. Solubilities ( $\text{mol dm}^{-3}$ ) of the salts at temperature 'T' are in the order: [JEE 2008]  
 (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)  $\text{MX} > \text{M}_3\text{X} > \text{MX}_2$
16. 2.5 mL of  $\frac{2}{5}$  M weak monoacidic base ( $K_b = 1 \times 10^{-12}$  at 25°C) is titrated with  $\frac{2}{15}$  M  $\text{HCl}$  in water at 25°C. The concentration of  $\text{H}^+$  at equivalence point is ( $K_w = 1 \times 10^{-14}$  at 25°C) [JEE 2008]  
 (A)  $3.7 \times 10^{-13}$  M (B)  $3.2 \times 10^{-7}$  M (C)  $3.2 \times 10^{-2}$  M (D)  $2.7 \times 10^{-2}$  M

17. The dissociation constant of a substituted benzoic acid at  $25^{\circ}\text{C}$  is  $1.0 \times 10^{-4}$ . The pH of a 0.01 M solution of its sodium salt is [JEE 2009]
18. Aqueous solutions of  $\text{HNO}_3$ ,  $\text{KOH}$ ,  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{COONa}$  of identical concentrations are provided. The pair(s) of solutions which form a buffer upon mixing is(are) – [JEE -2010]  
(A)  $\text{HNO}_3$  and  $\text{CH}_3\text{COOH}$  (B)  $\text{KOH}$  and  $\text{CH}_3\text{COONa}$   
(C)  $\text{HNO}_3$  and  $\text{CH}_3\text{COONa}$  (D)  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{COONa}$
19. In 1 L saturated solution of  $\text{AgCl}$  [ $K_{\text{sp}}(\text{AgCl}) = 1.6 \times 10^{-10}$ ], 0.1 mol of  $\text{CuCl}$  [ $K_{\text{sp}}(\text{CuCl}) = 1.0 \times 10^{-6}$ ] is added. The resultant concentration of  $\text{Ag}^+$  in the solution is  $1.6 \times 10^{-x}$ . The value of 'x' is. [JEE -2011]
20. The  $K_{\text{sp}}$  of  $\text{Ag}_2\text{CrO}_4$  is  $1.1 \times 10^{-12}$  at 298 K. The solubility (in mol/L) of  $\text{Ag}_2\text{CrO}_4$  in a 0.1 M  $\text{AgNO}_3$  solution is ( $K_{\text{w}} = 1 \times 10^{-14}$  at  $25^{\circ}\text{C}$ ) [JEE 2013]  
(A)  $1.1 \times 10^{-11}$  (B)  $1.1 \times 10^{-10}$  (C)  $1.1 \times 10^{-12}$  (D)  $1.1 \times 10^{-9}$
21. The initial rate of hydrolysis of methyl acetate (1M) by a weak acid ( $\text{HA}$ , 1M) is  $1/100^{\text{th}}$  of that of a strong acid ( $\text{HX}$ , 1M), at  $25^{\circ}\text{C}$ . The  $K_{\text{a}}$  of  $\text{HA}$  is [JEE 2013]  
(A)  $1 \times 10^{-4}$  (B)  $1 \times 10^{-5}$  (C)  $1 \times 10^{-6}$  (D)  $1 \times 10^{-3}$

**Paragraph For Questions 22 and 23**

When 100 mL of 1.0 M  $\text{HCl}$  was mixed with 100 mL of 1.0 M  $\text{NaOH}$  in an insulated beaker at constant pressure, a temperature increase of  $5.7^{\circ}\text{C}$  was measured for the beaker and its contents. (Expt-1). Because the enthalpy of neutralisation of a strong acid with a strong base is a constant ( $-57.0 \text{ kJ mol}^{-1}$ ), this experiment could be used to measure the calorimeter constant. In a second experiment (Expt-2), 100 mL of 2.0 M acetic acid ( $K_{\text{a}} = 2.0 \times 10^{-5}$ ) was mixed with 100 mL of 1.0M  $\text{NaOH}$  (under identical conditions to (Expt-1)) where a temperature rise of  $5.6^{\circ}\text{C}$  was measured.

(Consider heat capacity of all solutions as  $4.2 \text{ J g}^{-1} \text{ K}^{-1}$  and density of all solutions as  $1.0 \text{ g mL}^{-1}$ )

22. Enthalpy of dissociation (in  $\text{kJ mol}^{-1}$ ) of acetic acid obtained from the Expt-2 is  
 $(K_W = 1 \times 10^{-14}$  at  $25^\circ\text{C}$ ) [JEE 2015]  
 (A) 1.0 (B) 10.0 (C) 24.5 (D) 51.4
23. The pH of the solution after Expt-2 [JEE 2015]  
 (A) 2.8 (B) 4.7 (C) 5.0 (D) 7.0
24. The solubility of a salt of weak acid (AB) at pH 3 is  $Y \times 10^{-3} \text{ mol L}^{-1}$ . The value of Y is \_\_\_\_.  
 (Given that the value of solubility product of AB ( $K_{sp}$ ) =  $2 \times 10^{-10}$  and the value of ionization constant of HB ( $K_a$ ) =  $1 \times 10^{-8}$ ) [JEE 2018]
25. Dilution processes of different aqueous solutions, with water, are given in LIST-I. The effects of dilution of the solutions on  $[\text{H}^+]$  are given in LIST-II.  
 (Note: Degree of dissociation ( $\alpha$ ) of weak acid and weak base is  $\ll 1$ ; degree of hydrolysis of salt  $\ll 1$ ;  $[\text{H}^+]$  represents the concentration of  $\text{H}^+$  ions) [JEE Advance 2018]

## LIST-I

## LIST-II

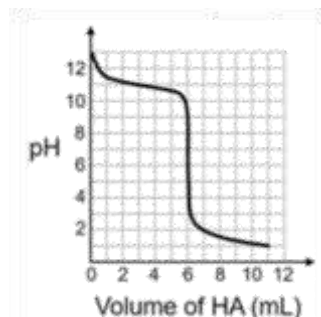
- |  |  |
|--|--|
| (P) (10 mL of 0.1 M NaOH + 20 mL of 0.1 M acetic acid) diluted to 60 mL  | (1) the value of $[\text{H}^+]$ does not change on dilution  |
| (Q). (20 mL of 0.1 M NaOH + 20 mL of 0.1 M acetic acid) diluted to 80 mL   | (2) the value of $[\text{H}^+]$ changes to half of its initial value on dilution                       |
| (R) (20 mL of 0.1 M HCl + 20 mL of 0.1 M ammonia solution) diluted to 80 mL  | (3) the value of $[\text{H}^+]$ changes to two times of its initial value on dilution                  |
| (S) 10 mL saturated solution of $\text{Ni}(\text{OH})_2$ in equilibrium with excess solid $\text{Ni}(\text{OH})_2$ is diluted to 20 mL (solid $\text{Ni}(\text{OH})_2$ is still present after dilution). | (4) the value of $[\text{H}^+]$ changes to $\frac{1}{\sqrt{2}}$ times of its initial value on dilution |
|  | (5) the value of $[\text{H}^+]$ changes to $\sqrt{2}$ times of its initial value on dilution           |

Match each process given in LIST-I with one or more effect(s) in LIST-II. The correct option is

- (A)  $P \rightarrow 4$ ;  $Q \rightarrow 2$ ;  $R \rightarrow 3$ ;  $S \rightarrow 1$  (B)  $P \rightarrow 4$ ;  $Q \rightarrow 3$ ;  $R \rightarrow 2$ ;  $S \rightarrow 3$   
 (C)  $P \rightarrow 1$ ;  $Q \rightarrow 4$ ;  $R \rightarrow 5$ ;  $S \rightarrow 3$  (D)  $P \rightarrow 1$ ;  $Q \rightarrow 5$ ;  $R \rightarrow 4$ ;  $S \rightarrow 1$

26. A solution of 0.1M weak base (B) is titrated with 0.1M of a strong acid (HA). The variation of pH of the solution with the volume of HA added is shown in the figure below. What is the  $pK_b$  of the base? The neutralization reaction is given by

[JEE Advance 2020]



27. An acidified solution of  $0.05M Zn^{2+}$  is saturated with  $0.1M H_2S$ . What is the minimum molar concentration (M) of  $H^+$  required to prevent the precipitation of  $ZnS$ ?  
Use  $K_{sp}(ZnS) = 1.25 \times 10^{-22}$  and overall dissociation constant of  $H_2S$ ,  
 $K_{NET} = K_1K_2 = 1 \times 10^{-21}$ .
28. A solution is prepared by mixing 0.01 mol each of  $H_2CO_3$ ,  $NaHCO_3$ ,  $Na_2CO_3$ , and  $NaOH$  in 100 mL of water. pH of the resulting solution is  
[Given  $pK_{a1}$  and  $pK_{a2}$  of  $H_2CO_3$  are 6.37 and 10.32, respectively;  $\log 2 = 0.30$ ]
29. Concentration of  $H_2SO_4$  and  $Na_2SO_4$  in a solution is 1M and  $1.8 \times 10^{-2}M$ , respectively. Molar solubility of  $PbSO_4$  in the same solution is  $X \times 10^{-Y}M$  (expressed in scientific notation). The value of Y is  
[Given: Solubility product of  $PbSO_4 (K_{sp}) = 1.6 \times 10^{-8}$ . For  $H_2SO_4$ ,  $K_{a1}$  is very large and  $K_{a2} = 1.2 \times 10^{-2}$ ]
30. On decreasing the pH from 7 to 2, the solubility of a sparingly soluble salt (MX) of a weak acid (HX) increased from  $10^{-4} mol L^{-1}$  to  $10^{-3} mol L^{-1}$ . The  $pK_a$  of HX is

[JEE Advance 2020]

[JEE Advance 2022]

[JEE Advance 2023]

(A)3

(B)4

(C)5

(D) 2

ANSWER KEY

EXERCISE # O-I

1. (D) 2. (D) 3. (C) 4. (D) 5. (C) 6. (B) 7. (C)
8. (B) 9. (A) 10. (B) 11. (C) 12. (D) 13. (B) 14. (D)
15. (A) 16. (D) 17. (A) 18. (D) 19. (A) 20. (D) 21. (A)
22. (A) 23. (B) 24. (C) 25. (B) 26. (C) 27. (C) 28. (C)
29. (B) 30. (C) 31. (A) 32. (B) 33. (C) 34. (C) 35. (A)
36. (B) 37. (C) 38. (C) 39. (C) 40. (B) 41. (A) 42. (D)
43. (B) 44. (C) 45. (A) 46. (A) 47. (D) 48. (D) 49. (C)
50. (B) 51. (B) 52. (A) 53. (A) 54. (A) 55. (B) 56. (B)
57. (D) 58. (D) 59. (C) 60. (C) 61. (D) 62. (A) 63. (A)
64. (A) 65. (A) 66. (C) 67. (A) 68. (A) 69. (A) 70. (A)
71. (A) 72. (C) 73. (D) 74. (C) 75. (C) 76. (D) 77. (D)
78. (A) 79. (D) 80. (C) 81. (D) 82. (D) 83. (C) 84. (A)
85. (D) 86. (A) 87. (B) 88. (C) 89. (B) 90. (A) 91. (B)
92. (C) 93. (D) 94. (D) 95. (C) 96. (C) 97. (D) 98. (B)
99. (A)

EXERCISE # S-I

1.  $6.022 \times 10^7$  2. (i) 6.53 ; (ii) (a) Basic , (b) Acidic 3.  $K_w = 4 \times 10^{-14}$ , pH = 6.7
4. 600 ions /mm<sup>3</sup> 5. (a) + 1, (b) 9 (c) 11.30 (d) 6.97, (e) 7,
6. 7 7.  $2.32 \times 10^{-8}$  M 8. (b) 2.87, (c) 11.13 (f) 6.78, (g) 6.97
9. (a)  $K_a = 10^{-8}$ , (b)  $K_b = 10^{-6}$  10. 10 11. 170.14
12.  $1.1 \times 10^{-3}$  M 13.  $1.11 \times 10^{-4}$  14. 4.87
15. 3 16. 2.61 17.  $9 \times 10^{-5}$  M
18.  $[H^+] = 1.75 \times 10^{-2}$  M,  $[CHCl_2COO^-] = 0.75 \times 10^{-2}$  M
19.  $[H^+] = 10^{-3}$  M,  $[CH_3COO^-] = 3.6 \times 10^{-4}$  M,  $[C_7H_5O_2^-] = 6.4 \times 10^{-4}$  M
20. 0.027M, 0.073M, 0.027M,  $10^{-5}$  M
21.  $[H^+] = [H_2PO_4^-] = 2.7 \times 10^{-3}$ ,  $[HPO_4^{2-}] = 10^{-8}$ ,  $[PO_4^{3-}] = 3.7 \times 10^{-19}$
22.  $[H^+] = 0.209$  M  
 $[SO_4^{2-}] = 0.009$  M  
 $[HSO_4^-] = 0.191$  M

23.  $\text{pH} = 11.46, [\text{enH}_2^{2+}] = 7.1 \times 10^{-8}\text{M}$
24. (a) Basic (b) acidic (c) basic (d) basic (e) acidic (f) basic  
(g) neutral (h) basic (i) basic (j) acidic
25.  $2.5 \times 10^{-5}; 4.6$
26. (i)  $10^{-12}$ , (ii)  $10^{-6}$ , (iii)  $10^{-11}$ , (iv)  $K_{b_1} < K_{b_2} < K_{b_3}$
27.  $[\text{OH}^-] = 6.664 \times 10^{-6}$
28.  $\text{pH} = 4.477$
29.  $K_b = 6.25 \times 10^{-10}$
30. 1.66 %
31.  $\text{pH} = 10.43$
32.  $[\text{OH}^-] = 3.73 \times 10^{-2}\text{M}, [\text{H}_3\text{PO}_4] = 6 \times 10^{-18}\text{M}$
33. 4.19
34.  $10^{-6}; 10^{-8}$
35. (a) 6, (b)  $1 \times 10^{-5}$
36. 0.56%,  $\text{pH} = 7$
37. 8.34
38. 4.19
39.  $[\text{OH}^-] = 9.0 \times 10^{-6}$
40. 0.05 mol
41. (a)  $\text{pH} = 9.239$  (b) lowered (c)  $\text{pH} = 4.699$
42.  $\text{pH} = 9.26$ ; (a)  $\text{pH} = 9.74$ ;
43. (a) 13 ; (b) 7 ; (c) 1.3.
44. 3
45. 4.74
46. 9.56
47. 8.7782
48. 9.7324
49.  $10^{-5}\text{M}$
50. 8.71,  $[\text{H}_3\text{O}^+] = 1.95 \times 10^{-9}\text{M}$
51. 4.98,  $1.05 \times 10^{-5}\text{M}$
52. (i) 2.85, (ii) 4.0969, (iii) 4.5229, (iv) 4.699, (v) 5.301, (vi) 8.699
53.  $[\text{HI}_n] = 28.57\%$
54.  $\Delta\text{pH} = 0.954$
55. 85.71%

56. (b), (c)
57. one with  $pK_{In} = 5.22$ , methyl orange
58. (018)
59.  $1.0 \times 10^{-5} \text{ mol/lit}$
60.  $1.56 \times 10^{-8}$
61.  $3.4 \times 10^{-11}$
62.  $2.6 \times 10^{-16}$
63.  $QX_2$  is more soluble
64.  $[Cu^+] = 5 \times 10^{-11} \text{ M}$
65.  $5 \times 10^{-10} \text{ M}$
66.  $4 \times 10^{-7} \text{ mol/LAgBr}$ ,  $9 \times 10^{-7} \text{ mol/LAgSCN}$
67.  $[F^-] = 3 \times 10^{-3} \text{ M}$
68. (a) no precipitation will occur, (b) a precipitate will form
69. 1
70.  $(9 \times 10^{-4})$ ; OMR ANS (9)
71. 12 mg
72.  $4.9 \times 10^{-10}$
73.  $69K_d = 1/K_f = 4.8 \times 10^{-4}$  Q. 700.444M
74.  $2.82 \times 10^{-3} \text{ mole}$
75. (d) > (c) > (b) > (a)

EXERCISE # O - II

- |                                  |           |                                |          |          |            |
|----------------------------------|-----------|--------------------------------|----------|----------|------------|
| 1. (ABC)                         | 2. (ABCD) | 3. (A,B,D)                     | 4. (A,D) | 5. (A,B) | 6. (A,B,C) |
| 7. (A)                           | 8. (ABC)  | 9. (ABCD)                      | 10. (B)  | 11. (A)  | 12. (C)    |
| 13. (C)                          | 14. (B)   | 15. (A)                        | 16. (C)  | 17. (A)  | 18. (A)    |
| 19. (C)                          | 20. (D)   | 21. (A)→R; (B)→P; (C)→Q; (D)→S |          |          |            |
| 22. (A)-Q, (B)-P,S, (C)-R, (D)-T |           |                                |          |          |            |



EXERCISE: S-II

1.  $[S^{2-}] = 2.5 \times 10^{-15}$
2. 10.07
3. 8.35, 9.60, 4.66
4. (a) 2.12 (b) 4.66 (c) 7.2 (d) 12
5. (a) 4.7525 (b) 4.697, (c) 4.798  
(d) 1.134 % on acid addition 0.96 % on base addition.
6.  $K_b = 1.8 \times 10^{-5}$ , 5.27
7. pH = 7.3; pH = 7.898, pH = 7.29
8.  $3.3 \times 10^{-2}$
9. (5.21)
10.  $[F^-] = \sqrt{\frac{8y^3}{x}}$
11. 0.444 M
12.  $s = \sqrt{K_{sp} \left( 1 + \frac{[H^+]}{K_2} + \frac{[H^+]^2}{K_1 K_2} \right)}$

EXERCISE # JEE-MAINS

- |         |          |         |         |         |           |         |
|---------|----------|---------|---------|---------|-----------|---------|
| 1. (C)  | 2. (C)   | 3. (D)  | 4. (D)  | 5. (C)  | 6. (A)    | 7. (A)  |
| 8. (D)  | 9. (D)   | 10. (B) | 11. (C) | 12. (D) | 13. (C)   | 14. (D) |
| 15. (C) | 16. (A)  | 17. (C) | 18. (A) | 19. (D) | 20. (D)   | 21. (A) |
| 22. (D) | 23. (A)  | 24. (A) | 25. (D) | 26. (D) | 27. (C)   | 28. (B) |
| 29. (D) | 30. (D)  | 31. (C) | 32. (C) | 33. (B) | 34. (A)   | 35. (C) |
| 36. (C) | 37. (A)  | 38. (A) | 39. (B) | 40. (A) | 41. (A)   | 42. (B) |
| 43. (B) | 44. (D)  | 45. (B) | 46. (B) | 47. (C) | 48. (525) | 49. (B) |
| 50. (4) | 51. (27) | 52. (2) | 53. (C) | 54. (A) | 55. (D)   |         |

EXERCISE # JEE-ADVANCED

- |                           |                                       |                  |
|---------------------------|---------------------------------------|------------------|
| 1. pH = 11.3010           | 2. $s = 1.203 \times 10^{-3} M$       | 3. (A, B, C)     |
| 4. (B)                    | 5. pH = 4.86                          | 6. (A) 7. (A)    |
| 8. (a) 0.0175%, (b) 4.757 | 9. No it will be > 7                  | 10. (C) 11. (A)  |
| 12. pH = 9                | 13. (B)                               | 14. (A) 15. (D)  |
| 16. (D)                   | 17. (8)                               | 18. (CD) 19. (7) |
| 20. (A)                   | 21. (A)                               | 22. (A) 23. (B)  |
| 24. (4.47)                | 25. (D)                               | 26. 3.3          |
| 27. $[H^+] \geq 0.2$      | 28. $\therefore pH = 10.0229$ . Y = 6 | 30. (B)          |