

MAINS+ADVANCED

TOPIC

IONIC
EQUILIBRIUM

SOLUTIONS

IONIC EQUILIBRIUM

Exercise-01

9. $\text{pH} = 1$ $\text{pH} = 2$
 $[\text{H}^+] = 0.1$ $[\text{H}^+] = 0.01$
 $V = 50$ $V = 50$
- $[\text{H}^+]$ of mixture is $[\text{H}^+] = \frac{N_1V_1 + N_2V_2}{V_1 + V_2} \Rightarrow \frac{50(0.1 + 0.01)}{100}$
- $[\text{H}^+] \Rightarrow \frac{0.11}{2} \Rightarrow 0.055$
 $\text{pH} = 1.26$
11. $\text{pH} = 7$ $[\text{H}^+] = 10^{-7}$, $[\text{OH}^-] = 10^{-7}$
 new pH after addition of base
 $\text{pH} = 12$ $[\text{H}^+] = 10^{-12}$
 $[\text{OH}^-] = 10^{-2}$
 $[\text{OH}^-]$ concentration increase 10^5 times.
13. Relative strength $= \sqrt{\frac{K_{a1}}{K_{a2}}} = \sqrt{\frac{3 \times 10^{-4}}{1.8 \times 10^{-5}}} \Rightarrow 4 : 1$
16. $\text{HCOOH} + \text{KOH}$
 $40\text{mL}, 0.5(\text{M}) \xrightarrow{50\text{mL}, 0.2\text{M}} \text{HCOOH} + \text{H}_2\text{O}$
 after reaction is forms Buffer solution
- $[\text{HCOOH}] = \frac{10}{90}$ $[\text{HCOOK}] = \frac{10}{90}$
- $\text{pH} = \text{pK}_a + \log \frac{[\text{salt}]}{[\text{acid}]}$ $\text{pH} = \text{pK}_a$
- $\text{pH} = 4 - \log(1.8)$ $\text{pH} = 3.75$
19. Let weak acid is HA its sodium salt is NaA
- $K_a = \frac{K_w}{K_H}$ $K_H = \text{CH}^2 \Rightarrow 0.1 \times (0.03)^2$
- $K_a = \frac{10^{-14}}{9 \times 10^{-5}}$ $K_a = \approx 1 \times 10^{-10}$
22. $\text{CH}_3\text{COOH} + \text{NaOH} \longrightarrow \text{CH}_3\text{COONa} + \text{H}_2\text{O}$
 $100 \text{ mL}, 0.4 \text{ M}$ $100 \text{ mL}, 0.2\text{M}$
 40 20
 After reaction
- $[\text{CH}_3\text{COOH}] = \frac{20}{250}$, $[\text{CH}_3\text{COONa}] = \frac{20}{200}$
- $\text{pH} = \text{pK}_a + \log \frac{[\text{salt}]}{[\text{acid}]}$

- $\text{pH} = \text{pK}_a$ $[\text{H}^+] = K_a = 1.8 \times 10^{-5}$
24. $\text{CH}_3\text{COONa} + \text{HCl} \longrightarrow \text{CH}_3\text{COOH} + \text{NaCl}$
 at equivalence the $[\text{CH}_3\text{COOH}] = \frac{20}{200} \Rightarrow 0.1$
- $\text{pH} = \frac{1}{2} \text{pK}_a - \frac{1}{2} \log C$
 $\text{pH} = \frac{1}{2} [5 \log 2 - \log 10^{-1}]$
 $\text{pH} = \frac{1}{2} [6 - \log 2] \Rightarrow \text{pH} = 3 - \log \sqrt{2}$
28. $\text{pH} = \text{pK}_a + \log \frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}$
 $7 = 7 - \log + \log \frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]} \frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]} = 4$
 $\% \text{HCO}_3^- = \frac{4}{5} \times 100 \Rightarrow 80 \%$
30. $2\text{NaOH} + \text{H}_3\text{PO}_4 \longrightarrow \text{Na}_3\text{PO}_4$
 $50\text{mL}, 0.1\text{M}$ $60\text{mL}, 0.15$
 0 7.33
 $\text{H}_3\text{PO}_4 \rightleftharpoons \text{H}^+ + \text{H}_2\text{PO}_4^-$
 [mass H^+ obtain from first ionization of H_3PO_4]
- $\text{pH} = \frac{1}{2} \text{pK}_a - \frac{1}{2} \log C = \frac{1}{2} \text{pK}_a - \frac{1}{2} \log C$
 $= 1.5 + 1.17 = 2.67$
32. $\text{Mg}(\text{NO}_3)_2 + 2\text{NaF} \longrightarrow \text{MgF}_2 + 2\text{NaNO}_3$
 2.5 5
 0 0 2.5
 $(\text{MgF}_2) = \frac{2.5}{35}$
 $\text{MgF}_2 \longrightarrow \text{Mg}^{+2} + 2 \text{F}$
 Ionic product
41. $\text{AgCNS} \rightleftharpoons \text{Ag}^+ + \text{CNS}$
 $(1-\delta_1)$ $(\delta_1 + \delta_2)$ δ_1
 $\text{AgCl} \rightleftharpoons \text{Ag}^+ + \text{Cl}$
 $(1-\delta_2)$ $(\delta_1 + \delta_2)$ δ_2
 $(K_{sp})_{\text{AgCNS}} = (\delta_1)(\delta_1 + \delta_2)$ (i)
 $(K_{sp})_{\text{AgCl}} = (\delta_2)(\delta_1 + \delta_2)$ (ii)

add equation (i) and (ii)

$$(\delta_1 + \delta_2)^2 = (K_{sp})_{AgCNS} + (K_{sp})_{AgCl}$$

$$(\delta_1 + \delta_2) = \sqrt{(K_{sp})_{AgCNS} + (K_{sp})_{AgCl}} = \sqrt{1.0 \times 10^{-12} + 1.7 \times 10^{-10}}$$

$$(AgT) = (\delta_1 + \delta_2) = 1.3 \times 10^{-5} \text{ divide eq. ii from i}$$

$$\frac{[Cl^-]}{[CNS^-]} = \frac{\delta_2}{\delta_1} = \frac{1.7 \times 10^{-10}}{1.0 \times 10^{-12}} \Rightarrow 1.7 \times 10^2$$

47. $IP > K_{sp}$ I.P. = $(Ca^{+2})(F)^2$
 I.P. $\Rightarrow (10^{-2})(10^{-3})^2 \Rightarrow 10^{-8}$ $IP > K_{sp}$

53. $pH = p^{HIn} + \log \frac{In^-}{HI_A}$ $6 = 5 + \log \frac{In^-}{HI_A}$

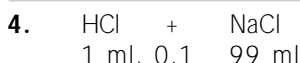
$$\frac{In^-}{HI_A} = 10$$

54. At Half way $[HIn] = In^-$

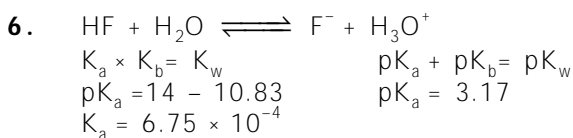
$$pH = 5.5 + \log \frac{[salt]}{[acid]} \quad 5.5 = pK_a + \log \frac{[salt]}{[acid]}$$

$$\log \frac{[salt]}{[acid]} = 0.75 \Rightarrow \frac{[salt]}{[acid]} = 5.62$$

Exercise-02



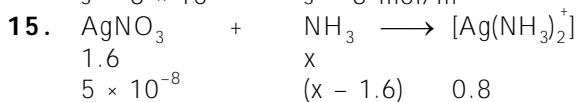
$$[H^+] = \frac{0.1}{100} \Rightarrow 0.001 \quad pH = 3$$



9. $h = \sqrt{\frac{K_h}{C}}$ $h = \sqrt{\frac{K_w}{K_a \times C}}$

$$h = \sqrt{\frac{10^{-14} \times 8.0}{1.3 \times 10^{-9} \times 1}} \quad h = 2.48 \%$$

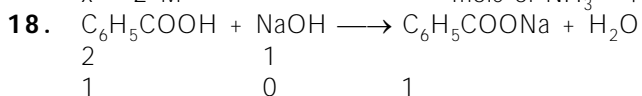
13. $K_{sp} = s^2$ $s = \sqrt{K_{sp}} = \sqrt{6.4 \times 10^{-5}}$
 $s = 8 \times 10^{-3}$ $s = 8 \text{ mol/m}^3$



$$K_s = \frac{[Ag(NH_3)_2]^+}{(AgNO_3)(NH_3)}$$

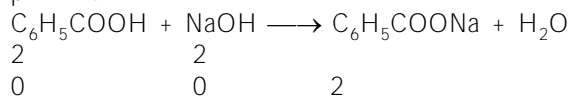
$$10^8 = \frac{0.8}{(5 \times 10^{-8})(x - 1.6)^2} \quad (x - 1.6)^2 = 0.16$$

$$x = 2 \text{ M} \quad \text{mole of } NH_3 = 4$$



$$pH = pK_a + \log \frac{[salt]}{[acid]} \quad pH = 4.2 + \log \frac{1}{1}$$

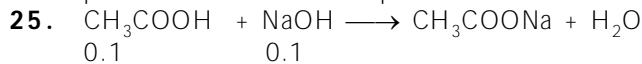
$$pH = 4.2$$



$$pH = 7 + \frac{1}{2} pK_a + \frac{1}{2} \log C$$

$$pH = 7 + 2.1 + \frac{1}{2} \log \frac{2}{200}$$

$$pH = 9.1 - 1 \quad pH = 8.1$$



At 1/3 neutralization
 2/3 1/3

$$pH = pK_a + \log \frac{[salt]}{[acid]}$$

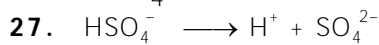
$$pH_1 = pK_a + \log \frac{1/3}{2/3} \quad \dots(1)$$

at 2/3 neutralization

$$pH_2 = pK_a + \log \frac{2/3}{1/3} \quad \dots(2)$$

$$pH_1 - pH_2 = \log \frac{1}{2} - \log 2$$

$$= \log \frac{1}{4} = -2 \log 2$$



$$(1 - \alpha) \quad \alpha \quad \alpha$$

$$10^{-2} = \frac{\alpha^2}{1 - \alpha} \quad \alpha \Rightarrow 0.09 \quad pH = 1.02$$

Exercise-03

COMPREHENSION BASED QUESTIONS

Comprehension # 1

1. Suppose volume of $HCO_3^- = V$ mL
 millimoles of $HCO_3^- = 5V$
 millimoles of $H_2CO_3 = 20$

$$pH = pK_a + \log \frac{[HCO_3^-]}{[H_2CO_3]}$$

$$7.40 = 6.11 + \log \frac{V}{4}, \quad V = 78 \text{ mL}$$

3. If CO_2 escapes, $[H^+]$ decreases, hence pH increases.
 (In CO_2 eq. $[H^+] \propto \sqrt{p}$ $pH \propto \frac{1}{2} \log p$)

Comprehension # 2

1. Phosphoric acid with three ionisable hydrogens ions is a tribasic acid. H-atoms are attached to O-atoms,

(O) (K) (j) (d) (v) (y) (r) (u) (v) (k); (u) (d) (r) (g) (l) (o) (m) (s) (t) (u) (v) (k); (u) (l) (e) (d) (s) (l) (k) (f) (k) (j) (h); (v) (e) (y) (g) (a) (i) (j) (e) (k) (q) (v) (l) (i) (h) (t) (u) (i) (j) (e) (k) (q) (l) (s) (t) (u) (v) (g) (r) (s) (g) (a))

2. If first step is only taken (; f n d o y i f k e i n d i s s y ; k t k ; A)

$$\text{pH} = \frac{1}{2} [\text{p}K_{a_1} - \log c] \quad c = [\text{H}_3\text{PO}_4] = 0.05 \%$$

$$= \frac{0.05 \times 10}{98} \text{ mol L}^{-1} (\text{M}) = 5.1 \times 10^{-3} \text{ M}$$

$$-\log c = 2.3, \text{p}K_{a_1} = 2.12 \quad \text{pH} = 2.21$$

3. $\frac{[\text{H}^+]^3 [\text{PO}_4^{3-}]}{[\text{H}_3\text{PO}_4]} = K_{a_1} K_{a_2} K_{a_3}$

$$3 \log [\text{H}^+] + \log [\text{PO}_4^{3-}] = \log K_{a_1} + \log K_{a_2} + \log K_{a_3} - \log [\text{H}_3\text{PO}_4]$$

$$3 \text{pH} - \log [\text{PO}_4^{3-}] = \log [\text{H}_3\text{PO}_4] = \text{p}K_{a_1} + \text{p}K_{a_2} + \text{p}K_{a_3}$$

$$21 - \log [\text{PO}_4^{3-}] - 3 = 2.12 + 7.21 + 12.32$$

$$\log [\text{PO}_4^{3-}] = -3.65$$

$$[\text{PO}_4^{3-}] = 2.24 \times 10^{-4} \text{ M}$$

4. $\text{Zn}_3(\text{PO}_4)_2 \rightleftharpoons 3\text{Zn}^{2+} + 2\text{PO}_4^{3-}$

$$\therefore K_{sp} = [\text{Zn}^{2+}]^3 [\text{PO}_4^{3-}]^2$$

$$9.1 \times 10^{-33} = [\text{Zn}^{2+}]^3 (2.2 \times 10^{-4})^2$$

$$[\text{Zn}^{2+}]^3 = 1.88 \times 10^{-25} \quad [\text{Zn}^{2+}] = 5.73 \times 10^{-9} \text{ M}$$

Exercise-4(A)

- 1.(i) $\text{H}_2\text{O} \xrightleftharpoons{K_a} \text{H}^+ + \text{OH}^-$
 $10^{-7} \quad 10^{-7}$

$$K_a = \frac{[\text{H}^+][\text{OH}^-]}{[\text{H}_2\text{O}]} = \frac{10^{-7} \times 10^{-7}}{1000/8} = \frac{10^{-14}}{55.5} = 1.8 \times 10^{-16}$$

- (ii) $K_a \times K_b = 10^{-14}$

2. $K_a = C\alpha^2 \Rightarrow \frac{\alpha_2}{\alpha_1} = \sqrt{\frac{C_1}{C_2}} = \sqrt{\frac{1}{1/100}} = 10$

3. $K_a = C\alpha^2$

$$\frac{\alpha_1}{\alpha_2} = \sqrt{\frac{K_{a_1}}{K_{a_2}}} = \sqrt{\frac{1.8 \times 10^{-5}}{6.2 \times 10^{-10}}}$$

4.(a) $\text{pH} = \frac{1}{2} \text{p}K_a - \frac{1}{2} \log C$

$$4.50 \times 2 = \text{p}K_a - \log (0.1)$$

$$9 - 1 = \text{p}K_a \quad \text{p}K_a = 8 \quad K_a = 10^{-8}$$

- 5.(c) $[\text{H}^+] = \sqrt{K_a C} = \sqrt{1.8 \times 10^{-6}} = 3 - \log 1.8 = 2.87$

(e) $[\text{H}^+] = 10^{-8} + 10^{-7} = 10^{-7} [0.1 + 1]$

$$\text{pH} = 7 - \log 1.1 = 6.95$$

(f) $[\text{OH}^-] = 10^{-10} + 10^{-7} = 10^{-7} [1.001]$

$$\text{POH} = 7 - \log 1.001 = 6.99$$

$$\text{pH} = 7.0004$$

(g) $[\text{H}^+] = \sqrt{K_a C} = \sqrt{1.8 \times 10^{-5} \times 10^{-6}}$

$$[\text{H}^+] = \sqrt{1.8 \times 10^{-11}} = \sqrt{18 \times 10^{-12}} = 4.24 \times 10^{-6}$$

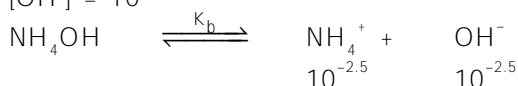
$$\text{pH} = 6 - \log 4.24 = 5.37$$

6. $\text{p}K_w = 14 - \log 2.56 = 13.59 \approx 13.6$

$$\text{pH} = \frac{\text{p}K_w}{2} = 6.795$$

10. $\text{pH} = 11.5 \quad [\text{H}^+] = 10^{-11.5}$

$$[\text{OH}^-] = 10^{-2.5}$$



$$\frac{10^{-5}}{C} = 1.8 \times 10^{-5} \quad C = \frac{1}{1.8} = 0.556 \text{ M}$$

11. $C = 10^{-2}, [\text{H}^+] = 10^{-3}$

$$K_a = \frac{10^{-3} \times 10^{-3}}{10^{-2} - 10^{-3}} = \frac{10^{-3}}{9} = 1.1 \times 10^{-4}$$

13. $\text{CHCl}_2\text{COOH} \rightleftharpoons \text{H}^+ + \text{CHCl}_2\text{COO}^-$

$$0.01$$

$$0.01 - x \quad 0.01 + x \quad x$$

$$\frac{x(0.01 + x)}{0.01 - x} = 2.55 \times 10^{-2}$$

$$0.01x + x^2 = 2.55 \times 10^{-4} - 2.55 \times 10^{-2}x$$

$$x^2 + 0.355x - 0.000255 = 0$$

$$x = \frac{-0.355 \pm \sqrt{0.04775}}{2} = 1.1 \times 10^{-2}$$

$$\text{CHCl}_2\text{COO}^- = 6.126 \times 10^{-2}$$

14. For weak acid

$$[\text{H}^+] = \sqrt{K_1 C_1 + K_2 C_2 + \dots + K_w}$$

$$= \sqrt{1.8 \times 10^{-5} \times 0.02 + 6.4 \times 10^{-5} \times 0.01 + 10^{-14}}$$

$$= \sqrt{100 \times 10^{-8}}$$

$$[\text{H}^+] = 10^{-3} \quad K_a = \frac{[\text{H}^+][\text{ACO}^-]}{[\text{ACOH}]_2}$$

$$[\text{ACO}^-] = 3.6 \times 10^{-4}$$

$$\text{same } [\text{C}_2\text{H}_5\text{O}_2^-] = 6.4 \times 10^{-4}$$

15. HCN is a weak acid so H^+ due to it can neglect

As comparison to HF

$$[\text{H}^+] = \sqrt{K C} = \sqrt{6.7 \times 10^{-4} \times 0.1} = \sqrt{67 \times 10^{-6}}$$

$$= 8.18 \times 10^{-3}$$

$$\text{pH} = -\log [8.18 \times 10^{-3}] = 3 - \log [8.18]$$

$$\text{pH} = 2.087$$

16. $\text{H}_2\text{S} \rightleftharpoons 2\text{H}^+ + \text{S}^{2-}$

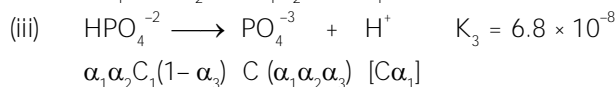
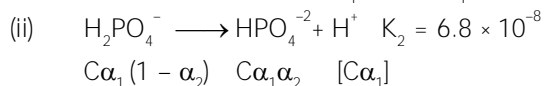
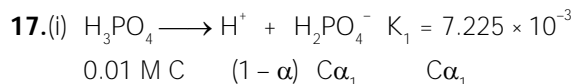
$$[\text{H}^+] = 2 \times 10^{-4}, \quad [\text{H}_2\text{S}] = 0.1 \text{ M}$$

$$K = K_1 \times K_2 \quad K = 10^{-7} \times 10^{-7}$$

$$K = 10^{-21}$$

$$\Rightarrow 10^{-21} = \frac{[2 \times 10^{-4}]^2 [S^{-2}]}{[0.1]} \quad 10^{-21} = 4 \times 10^{-8} [S^{-2}]$$

$$\frac{1}{4} \times 10^{-14} = [S^{-2}] \quad 2.5 \times 10^{-15} = [S^{-2}]$$



$$7.225 \times 10^{-3} = \frac{C \alpha_1^2}{(1 - \alpha_1)} = \frac{0.01 \times \alpha_1^2}{1 - \alpha_1}$$

RxN. (i)

$$(1 - \alpha) \times 0.7225 = \alpha_1^2$$

$$\alpha_1^2 + 0.7225 \alpha - 0.7225 = 0$$

$$\alpha_1 = 0.562$$

$$\Rightarrow [H^+] = 0.01 \times 0.562 \quad [H^+] = 5.6 \times 10^{-3}$$

$$[H_2PO_4^-] \approx 5.6 \times 10^{-3} \quad \text{RxN. (ii)}$$

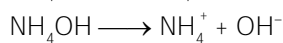
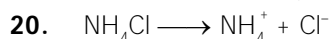
$$6.8 \times 10^{-8} = \frac{[HPO_4^{2-}][H^+]}{[H_2PO_4^-]} \text{ from [i] reaction.}$$

$$\Rightarrow [HPO_4^{2-}] = 6.8 \times 10^{-8} M \quad \text{RxN. (iii)}$$

$$4.5 \times 10^{-13} = \frac{[PO_4^{3-}][H^+]}{[HPO_4^{2-}]}$$

$$\frac{4.5 \times 10^{-13} \times 6.8 \times 10^{-8}}{5.6 \times 10^{-3}} = [PO_4^{3-}]$$

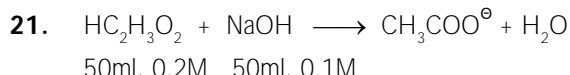
$$5.464 \times 10^{-18} = [PO_4^{3-}]$$



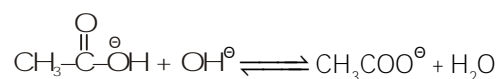
$$K_b = \frac{[NH_4^+][OH^-]}{[NH_4OH]}$$

$[NH_4^+]$ = is due to salt because NH_4OH ionise in less amount due to common ions effect

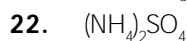
$$1.8 \times 10^{-5} = \frac{0.1 \times [OH^-]}{0.05} \quad 9 \times 10^{-6} = [OH^-]$$



10m mol 5m mol



$$pH = pK_a = 5 - \log 1.8 \quad pH = 4.74$$



$$\text{Molarity } (NH_4)_2SO_4 = \left(\frac{x}{100} \right)$$

$$\text{Molarity of } NH_4^+ = \left(\frac{2x}{100} \right)$$

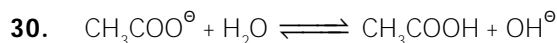
$$\text{Molarity of } NH_4OH = \left(\frac{0.1}{100} \right) = 10^{-3}$$

$$14 - 9.26 = 4.24 + \log \left(\frac{2x/100}{0.1/100} \right)$$

$$0 = \log (20x) \Rightarrow 1 = 20x$$

$$x = 1/20 \text{ mole}$$

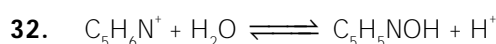
$$x = 0.05 \text{ mole}$$



$$0.08 \quad K_b = \frac{10^{-14}}{1.8 \times 10^{-5}}$$

$$\frac{x^2}{0.08} = \frac{10}{1.8} \times 10^{-10} \quad x^2 = \frac{0.8}{1.8} \times 10^{-10}$$

$$x^2 = 0.44 \times 10^{-10} \quad x = 0.66 \times 10^{-5}$$



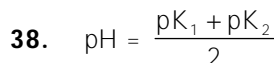
$$pH = \frac{1}{2} [pK_w - pK_b - \log C]$$

$$2.699 = \frac{1}{2} [14 - pK_b + 0.6]$$

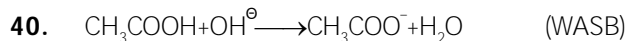
$$2.398 = 14.6 - pK_b$$

$$pK_b = 14.6 - 5.398 = 9.802$$

$$K_b = 10^{-9.802}$$



$$pH = \frac{11 + 7 - 2 \log 4.5}{2} = 9 - \log 4.5 = 8.54$$



$$pH = \frac{1}{2} [pK_w + pK_a + \log C]$$

$$= \frac{1}{2} [14 + 5 - \log 1.9 + \log \frac{1}{20}]$$

$$= \frac{1}{2} [19 - \log 1.9 - \log 20]$$

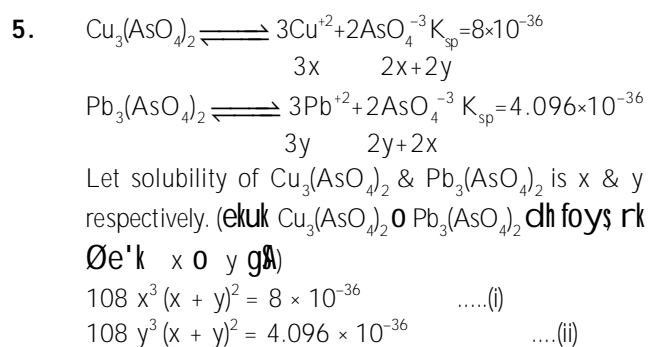
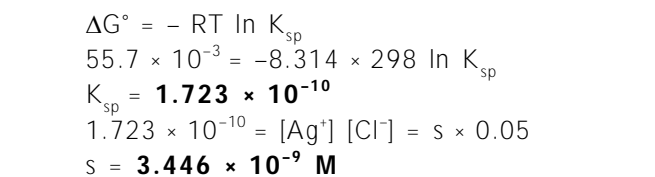
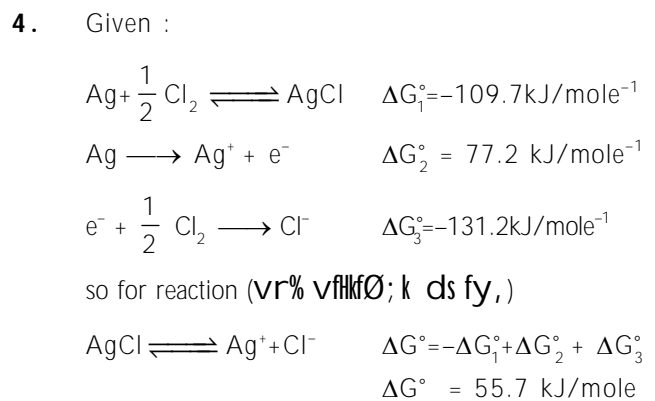
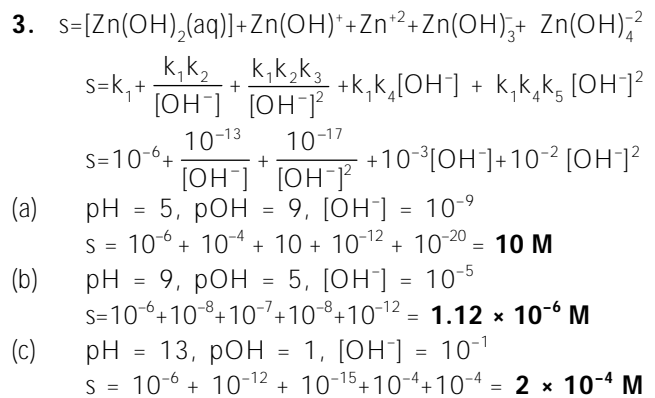
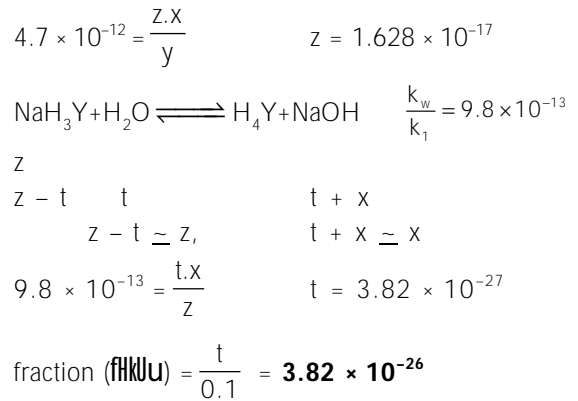
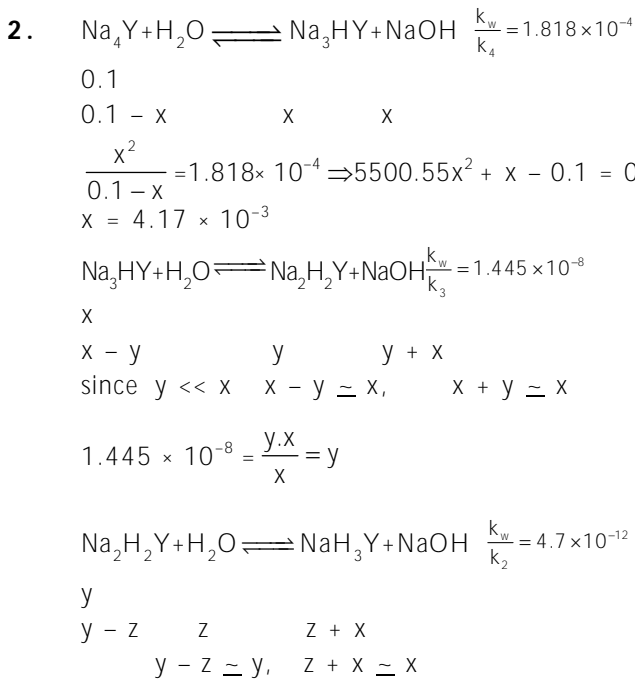
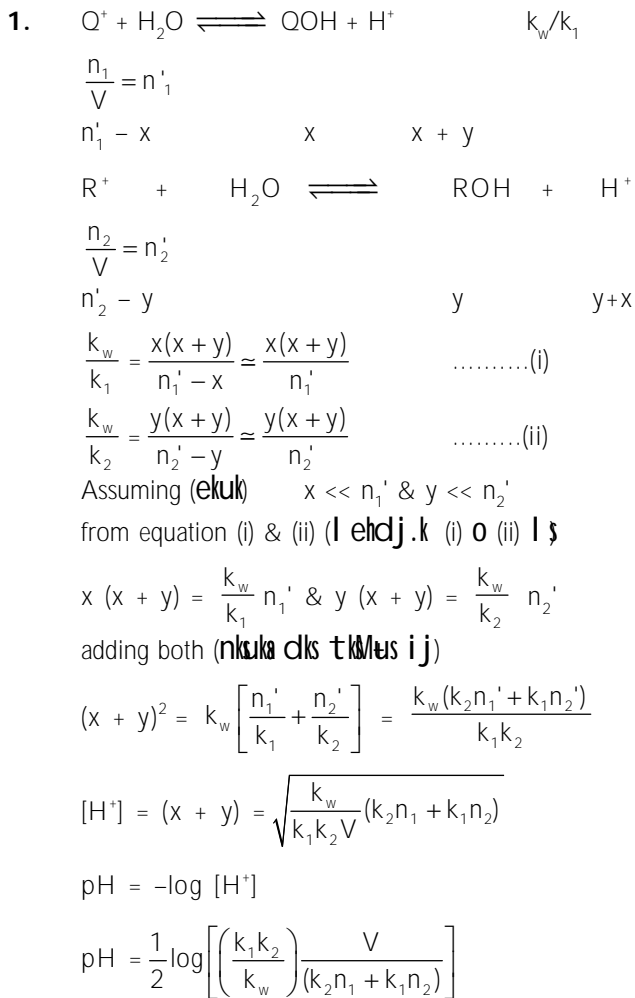
$$pH = \frac{1}{2} [19 - \log 20 \times 1.9] = 8.78$$

$$pOH = 5.28$$

$$[OH^\ominus] = 10^{-5.28}$$

$$[OH^\ominus] = 10^{-6} \times 10^{0.72} \quad [OH^\ominus] = 5.24 \times 10^{-6}$$

Exercise-4(B)



$$\frac{(i)}{(ii)} \Rightarrow \frac{x^3}{y^3} = \frac{8}{4.096} \Rightarrow x = 1.25 y$$

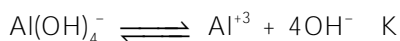
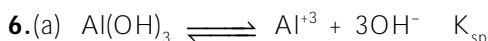
putting this in equation (ii) (bl sl eh dj . k(ii) eaj [kusi j])

$$108 y^3 (2.25 y)^2 = 4.096 \times 10^{-36}$$

$$y = 2.3 \times 10^{-8} \quad x = 1.25 y = 2.875 \times 10^{-8}$$

$$[Cu^{+2}] = 3x = \mathbf{8.825 \times 10^{-8}}$$

$$[Pb^{+2}] = 3y = \mathbf{7.1 \times 10^{-8}}$$



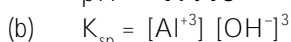
$$Al(OH)_3 + OH^- \rightleftharpoons Al(OH)_4^- \quad \frac{K_{sp}}{K} = 38.46$$

$$38.46 = \left[\frac{Al(OH)_4^-}{[OH^-]} \right] = \frac{10^{-3}}{[OH^-]}$$

$$[OH^-] = 2.6 \times 10^{-5}$$

$$pOH = 4.585$$

$$pH = \mathbf{9.415}$$

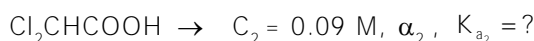
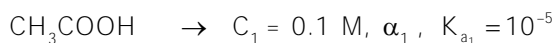


$$5 \times 10^{-33} = [1 \times 10^{-3}][OH^-]^3$$

$$[OH^-] = 1.7 \times 10^{-10}$$

$$pOH = 9.767$$

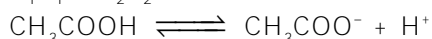
$$pH = \mathbf{4.23}$$



$$pH = 1, [H^+] = 0.1$$

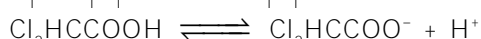
$$0.1 = 0.09 + C_1\alpha_1 + C_2\alpha_2$$

$$C_1\alpha_1 + C_2\alpha_2 = 0.01 \quad \dots\dots(i)$$



$$C_1$$

$$C_1 - C_1\alpha_1 \quad C_1\alpha_1 \quad 0.1$$



$$C_2$$

$$C_2 - C_2\alpha_2 \quad C_2\alpha_2 \quad 0.1$$

$$K_{a1} = \frac{(C_1\alpha_1)(0.1)}{C_1(1-\alpha_1)} \simeq \alpha_1 \times 0.1 = 10^{-5}$$

$$\alpha_1 = 10^{-4}$$

putting this in equation (i) (bl sl eh dj . k (i) eaj [kusi j])

$$10^{-4} \times 0.1 + 0.09\alpha_2 = 0.01$$

$$\alpha_2 = 0.111$$

$$K_{a2} = \frac{(C_2\alpha_2)(0.1)}{C_2(1-\alpha_2)} = \frac{(0.111)(0.1)}{1-0.111} = \mathbf{1.248 \times 10^{-2}}$$

8. $C = \frac{10 \times 0.935 \times 1000}{17 \times 100} = 5.5 M$

$$K_a = C\alpha^2 \Rightarrow 5.5 \times 10^{-6} = 5.5 \alpha^2$$

$$\alpha = 10^{-3}$$

$$[OH^-] = C\alpha = 5.5 \times 10^{-3}$$

$$pOH = 2.26, \quad pH = \mathbf{11.74}$$

9. $\ln \frac{k_{w2}}{k_{w1}} = \frac{\Delta H}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$

$$\ln \frac{5.474 \times 10^{-14}}{1.08 \times 10^{-14}} = \frac{\Delta H}{8.314} \left(\frac{1}{298} - \frac{1}{323} \right)$$

$$\Delta H = \mathbf{51952.6 J = 51.95 kJ/mole}$$

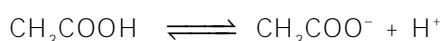
10. In beginning $[H^+] = \sqrt{K_a C}$

$$[H^+] = \sqrt{1.8 \times 10^{-5}} = 0.004242$$

$$pH = 2.372$$

On doubling pH, new pH (pH nakh djusti j) u; h pH) = 4.744

$$[H^+] = 1.8 \times 10^{-5}$$



$$C$$

$$C - C\alpha \quad C\alpha \quad C\alpha$$

$$K_a = \frac{(C\alpha)^2}{C(1-\alpha)}, \quad C\alpha = [H^+] = 1.8 \times 10^{-5}$$

$$1.8 \times 10^{-5} = \frac{(1.8 \times 10^{-5})^2}{C - C\alpha}$$

$$C - C\alpha = 1.8 \times 10^{-5}$$

$$C = 3.6 \times 10^{-5}$$

$$V = \frac{1}{C} = \mathbf{2.77 \times 10^4 L}$$

11.(a) $PV = nRT$

$$1 \times 0.959 = n \times 0.0821 \times 298$$

$$n = 0.03919$$

volume of $H_2O = 1 mL$ (per volume of H_2O)

(H_2O dk vk; ru = 1 mL (H_2O dk ifr vk; ru))

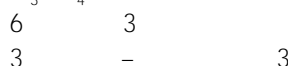
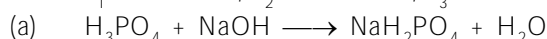
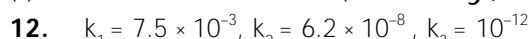
$$C = \frac{n}{V} = \frac{0.03919}{10^{-3}} = 39.19 M$$

$$pk_b = 3.39 \Rightarrow k_b = 4 \times 10^{-4}$$

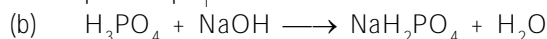
$$[OH^-] = \sqrt{K_b C} = 0.1252 M$$

$$pOH = 0.9023$$

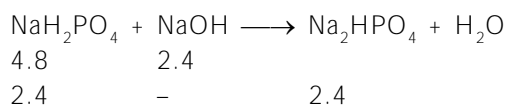
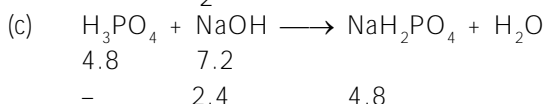
$$pH = \mathbf{13.097}$$



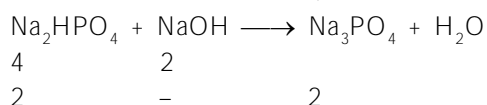
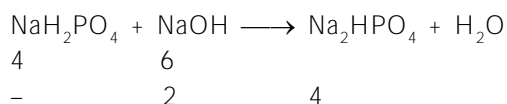
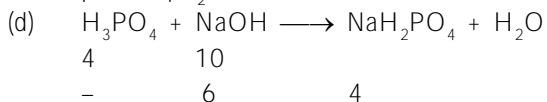
$$pH = pk_1 = \mathbf{2.12}$$



$$pH = \frac{pk_1 + pk_2}{2} = 4.66$$

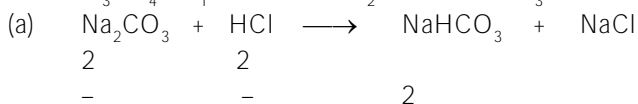


$$pH = pk_2 = 7.2$$

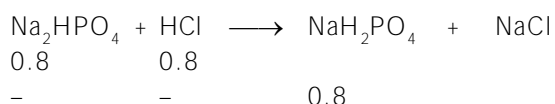
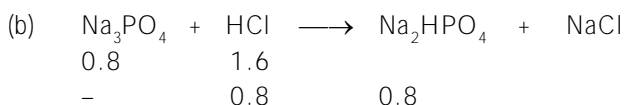


$$pH = pk_3 = 12$$

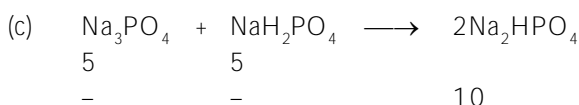
13. For $H_2CO_3 \rightarrow k_1 = 4.2 \times 10^{-7}$, $k_2 = 4.8 \times 10^{-11}$
 $H_3PO_4 \rightarrow k_1 = 7.5 \times 10^{-3}$, $k_2 = 6.2 \times 10^{-8}$, $k_3 = 10^{-12}$



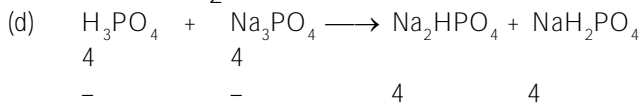
$$pH = \frac{pk_1 + pk_2}{2} = 8.347$$



$$pH = \frac{pk_1 + pk_2}{2} = 4.66$$



$$pH = \frac{pk_2 + pk_3}{2} = 9.6$$



$$pH = pk_2 = 7.2$$



At end point m moles of BOH = m moles of HCl (vllr fclnq ij BOH ds m moles)

$$0.16 \times V = 4 \qquad V = 25 \text{ mL}$$

$$\text{Total volume (dy vk; ru)} = 40 + 25 = 65 \text{ mL}$$

$$[BCl] = \frac{4}{65}$$

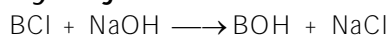
since BCl is SAWB

$$pH = 7 - \frac{1}{2}pk_b - \frac{1}{2}\log C$$

$$5.23 = 7 - \frac{1}{2}pk_b - \frac{1}{2}\log \frac{4}{65}$$

$$pk_b = 4.75$$

Now on further adding NaOH vc iφ NaOH dks feykus ij



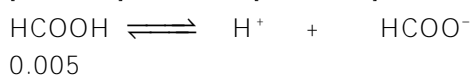
$$pOH = pk_b + \log \frac{2.2}{1.8} = 4.837 \Rightarrow pH = 9.1628$$

15.(a) $pH = pK_a + \log \frac{0.06}{0.05}$

$$pH = 3.744 + \log 1.2 = 3.823$$

(b) On diluting solution 10 times (foy; u dks 10 xqk ruq djus ij)

$$[HCOOH] = 0.005, [HCOONa] = 0.006$$



$$0.005(1 - \alpha) \qquad 0.005\alpha \qquad 0.005\alpha + 0.006$$

$$K_a = 1.8 \times 10^{-4} = \frac{(0.005\alpha + 0.006)(0.005\alpha)}{0.005(1 - \alpha)}$$

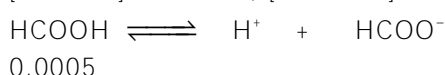
$$\frac{0.005\alpha^2 + 0.006\alpha}{1 - \alpha} = 1.8 \times 10^{-4}$$

$$\Rightarrow 27.77\alpha^2 + 34.33\alpha - 1 = 0 \qquad \alpha = 0.0285$$

$$[H^+] = 0.005\alpha = 1.425 \times 10^{-4} \qquad pH = 3.846$$

(c) On further diluting solution by 10 times (foy; u dks iφ 10 xqk ruq djus ij)

$$[HCOOH] = 0.0005, [HCOONa] = 0.0006$$



$$0.0005(1 - \alpha) \qquad 0.0005\alpha \qquad 0.0005\alpha + 0.0006$$

$$K_a = 1.8 \times 10^{-4} = \frac{(0.0005\alpha + 0.0006)(0.0005\alpha)}{0.0005(1 - \alpha)}$$

$$= \frac{0.0005\alpha^2 + 0.0006\alpha}{1 - \alpha} = 1.8 \times 10^{-4}$$

$$2.77\alpha^2 + 4.33\alpha - 1 = 0 \Rightarrow \alpha = 0.2047$$

$$[H^+] = 0.0005\alpha = 1.0235 \times 10^{-4}$$

$$pH = 3.9899$$

16. Initial (ikjElk ex) $pOH = pK_b = 4.744$

Let x mole of NaOH has been added so (ekuk NaOH ds x ekv feyk; s gS vr)

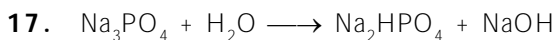
$$[NH_4^+] = 0.1 + x, [NH_3] = 0.1 - x$$

$$pOH = 5.744$$

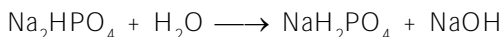
$$5.744 = 4.744 + \log \frac{0.1 + x}{0.1 - x}$$

$$1 = \log \frac{0.1 + x}{0.1 - x}$$

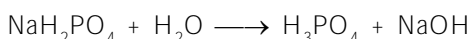
$$\frac{0.1 + x}{0.1 - x} = 10 \Rightarrow x = \frac{0.9}{11} = 0.0818 \text{ moles}$$



$$K = \frac{K_w}{K_3} = 0.0222$$



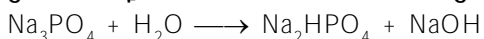
$$K = \frac{K_w}{K_2} = 1.58 \times 10^{-7}$$



$$K = \frac{K_w}{K_1} = 1.4 \times 10^{-12}$$

since equilibrium constant of 2nd & 3rd reaction is very less, [OH⁻] will mainly come from 1st reaction.

(*prid 2nd o 3rd vflkfØ; k dk l kE; fu; rkdacgr de gS [OH⁻] e[; r 1st vflkfØ; k l s i klr glxkA*)



$$\begin{array}{ccc} 0.1 & & \\ 0.1-x & x & x \end{array}$$

$$\frac{x^2}{0.1-x} = 0.0222 \Rightarrow 45x^2 + x - 0.1 = 0$$

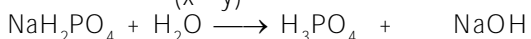
$$x = 3.73 \times 10^{-2}$$

$$[\text{OH}^-] = x = \mathbf{3.73 \times 10^{-2} \text{ M}}$$



$$\begin{array}{ccc} x & & \\ x-y & y & y+x \\ x-y \simeq x, & y+x \simeq x, & \text{so} \end{array}$$

$$1.58 \times 10^{-7} = \frac{(y+x)y}{(x-y)} \simeq y$$

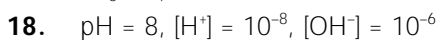


$$\begin{array}{ccc} y & & \\ y-z & z & z+x \\ y-z \simeq y, & z+x \simeq x \end{array}$$

$$1.4 \times 10^{-12} = \frac{z(x+z)}{(y-z)} = \frac{z \times x}{y} = \frac{z \times 3.73 \times 10^{-2}}{1.58 \times 10^{-7}}$$

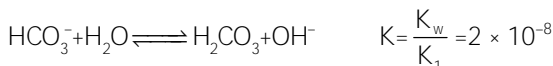
$$z = 5.93 \times 10^{-18}$$

$$[\text{H}_3\text{PO}_4] = z = \mathbf{5.93 \times 10^{-18} \text{ M}}$$



$$0.0005$$

$$0.0005-y-z \quad 10^{-8} \quad y$$



$$0.0005$$

$$0.0005-y-z \quad z \quad 10^{-6}$$

since equilibrium constant for first reaction is very less *y << z* (*prid i kE dkV vflkfØ; k dsfy, l kE; fu; rkdacgr de gS y << z*)

$$2 \times 10^{-8} = \frac{z(10^{-6})}{0.0005-z}$$

$$51z = 0.0005, \Rightarrow z = \mathbf{9.8 \times 10^{-6}}$$

$$[\text{H}_2\text{CO}_3] = 9.8 \times 10^{-6} \text{ M}$$

$$[\text{HCO}_3^-] = 0.0005 - 9.8 \times 10^{-6} = \mathbf{4.9 \times 10^{-4} \text{ M}}$$

$$5 \times 10^{-3} = \frac{10^{-8} \times y}{4.9 \times 10^{-4}}$$

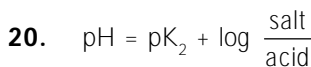
$$[\text{CO}_3^{2-}] = y = \mathbf{2.45 \times 10^{-8} \text{ M}}$$



$$\begin{array}{ccc} x & & \\ 0.95x & 0.05x & 0.05x \end{array}$$

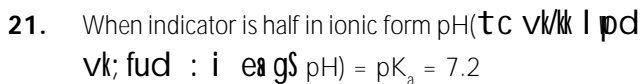
$$6.5 \times 10^{-3} = \frac{(0.05)^2 x}{0.95} \quad x = 2.47$$

$$[\text{H}^+] = 0.05x = 0.1235 \quad \text{pH} = \mathbf{0.908}$$



$$6.7 = 7.2 + \log \frac{y}{0.005}$$

$$y = 1.58 \times 10^{-3} \text{ mole}$$



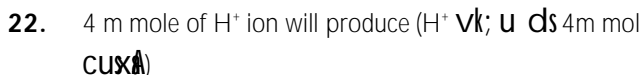
$$\text{pH} = 7.2 + \log 5 = \mathbf{7.898}$$

now with this pH (*vc bl pH ep*)

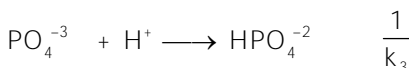
$$7.898 = \text{p}K_{a1} + \log 4 = \text{p}K_{a1} = 7.2959$$

again when 50% of new indicator is in ionic form (*i p tc u; k l pd 50% vk; fud : i ea gA*)

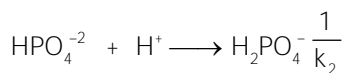
$$\text{pH} = \text{p}K_{a1} = \mathbf{7.2959}$$



$$[\text{H}^+] = \frac{4 \times 10^{-3}}{0.1} = 0.04$$



$$\begin{array}{ccc} 0.02 & 0.04 & 0.08 \\ - & 0.02 & 0.1 \end{array}$$



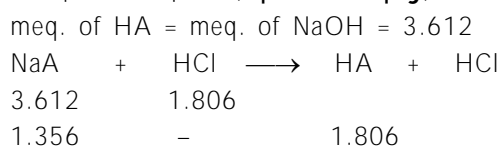
$$\begin{array}{ccc} 0.1 & & 0.02 \\ 0.08 & - & 0.02 \end{array}$$

so now they form a buffer solution of HPO_4^{-2} & H_2PO_4^- (vr%vc ; g HPO₄⁻² o H₂PO₄⁻ dk cQj foy; u cukrs gA)

$$\text{pH} = \text{pk}_2 + \log \frac{0.08}{0.02} \quad (k_2 = 6.3 \times 10^{-8})$$

$$\text{pH} = 7.2 + \log 4 = \mathbf{7.8}$$

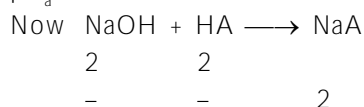
23. At equivalence point (rv; kd fclnq ij)



$$\text{pH} = \text{pK}_a + \log \frac{[\text{S}]}{[\text{A}]}$$

$$4.92 = \text{pK}_a + \log \frac{1.356}{1.806}$$

$$\text{pK}_a = 5.044$$

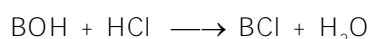


$$[\text{NaA}] = \frac{2}{20} = 0.1$$

$$\text{pH} = 7 + \frac{1}{2}\text{pK}_a + \frac{1}{2}\log C = 7 + \frac{5.044}{2} + \frac{1}{2}\log 0.1$$

$$\text{pH} = \mathbf{9}$$

24. In beginning let x m mole of BOH are present (i kjEHk ea ekuk BOH ds x m mole mi fLFkr gA)



$$\begin{array}{ccc} x & & \\ \frac{3x}{4} & & \frac{x}{4} \end{array}$$

$$\text{pOH} = \text{pk}_b + \log \frac{1}{3}$$

$$14 - 9.24 = \text{pk}_b - \log 3$$

$$\text{pk}_b = 5.237$$

$$k_b = 5.8 \times 10^{-6}$$



$$\begin{array}{ccc} \frac{x}{4} & & 6 \\ - & - & x \end{array}$$

$$\frac{x}{4} = 6, \Rightarrow x = 24$$

$$[\text{BOH}] = \frac{24}{50} = 0.48$$

$$[\text{OH}^-] = \sqrt{k_b \times C} = 1.668 \times 10^{-3}$$

$$\text{pOH} = 2.77$$

$$\text{pH} = \mathbf{11.22}$$

25. (a) pH at one fourth neutralization (, d pkFkkbz mnkl hhdj.k ij pH)

$$(\text{pH})_1 = \text{pk}_a + \log \frac{x/4}{3x/4} = \text{pk}_a + \log \frac{1}{3}$$

pH at three fourth neutralization (rhu pkFkkbz mnkl hhdj.k ij pH)

$$(\text{pH})_2 = \text{pk}_a + \log \frac{3x/4}{x/4} = \text{pk}_a + \log 3$$

$$\Delta\text{pH} = (\text{pH})_2 - (\text{pH})_1 = 2 \log 3 = \mathbf{0.9542}$$

(b) $4.45 = \text{pk}_a + \log \frac{x/3}{2x/3} = \text{pk}_a - \log 2$

$$\text{pk}_a = \mathbf{4.751}$$

(c) $\Delta\text{pH} = 2$ i.e.

$$(\text{pH})_1 = \text{pk}_a + 1, (\text{pH})_2 = \text{pk}_a - 1$$

$$\text{For } \text{pk}_a + 1 \Rightarrow \frac{[\text{S}]}{[\text{A}]} = 10$$

$$\frac{x}{a-x} = 10 \Rightarrow x = 10a - 10x$$

$$x = \frac{10a}{11}$$

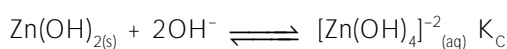
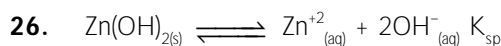
$$\text{i.e. } \frac{10^{\text{th}}}{11} \text{ stage}$$

$$\text{For } \text{pk}_a - 1 \Rightarrow \frac{[\text{S}]}{[\text{A}]} = \frac{1}{10}$$

$$\frac{x}{a-x} = \frac{1}{10}$$

$$x = \frac{a}{11}$$

$$\text{i.e. } \frac{1}{11}^{\text{th}} \text{ stage}$$



dissolved Zn(OH)_2 is present in form of Zn^{+2} & $[\text{Zn(OH)}_4]^{-2}$

so solubility $s = [\text{Zn}^{+2}] + [\text{Zn(OH)}_4]^{-2}$

(Myr Zn(OH)_2 . Zn^{+2} o $[\text{Zn(OH)}_4]^{-2}$ ds: i eami fLFkr gA)

vr% foyr rk $s = [\text{Zn}^{+2}] + [\text{Zn(OH)}_4]^{-2}$

$$s = \frac{K_{sp}}{[\text{OH}^-]^2} + K_C[\text{OH}^-]^2$$

For min. solubility (d; ure foyş rk ds fy,)

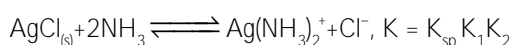
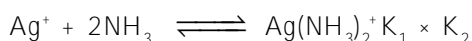
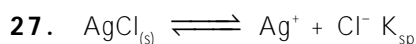
$$\frac{ds}{d[\text{OH}^-]} = 0 \Rightarrow \frac{-2K_{sp}}{[\text{OH}^-]^3} + 2K_c [\text{OH}^-] = 0$$

$$[\text{OH}^-] = \left(\frac{K_{sp}}{K_c} \right)^{1/4}$$

$$[\text{OH}^-] = 9.8 \times 10^{-5}$$

$$\text{pOH} = 4.00869$$

$$\text{pH} = \mathbf{9.9913}$$



$$0.2$$

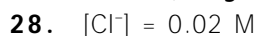
$$0.2 - 2x \qquad \qquad x \qquad \qquad x$$

$$K = \frac{x^2}{(0.2 - 2x)} = K_{sp} K_1 K_2 = 0.002828$$

$$\frac{x}{0.2 - 2x} = 0.05318$$

$$x = 0.009613$$

$$\text{Solubility (foyş rk)} = \mathbf{9.6 \times 10^{-3} \text{ M}}$$



$$0.05$$

$$0.05 - x = 0.05 \quad x \quad 2x$$

$$4 \times 10^{-19} = \frac{x \cdot (2x)^2}{0.05}$$

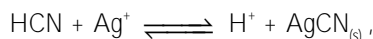
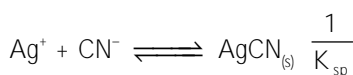
$$\frac{4x^3}{0.05} = 4 \times 10^{-19} \Rightarrow x = 1.7 \times 10^{-7}$$

$$[\text{Ag}][\text{Cl}] = 1.7 \times 10^{-7} \times 0.02 = 3.4 \times 10^{-9} > K_{sp}$$

so **AgCl will precipitate. (vr AgCl vo{kfi r gkxkA)**

29. After mixing with equal volume (l eku vk; ru dsl kfk feykus ds i' pkr)

$$[\text{Ag}^+] = 0.01 \text{ M}, \text{HCN} = 0.01 \text{ M}$$



$$K = \frac{K_a}{K_{sp}} = 2.25 \times 10^6$$

$$0.01 \qquad \qquad 0.01$$

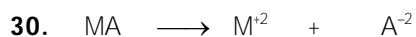
$$x \qquad \qquad x \qquad 0.01$$

since K value is very high almost all of reactant will convert into product

(pfd k eku cgr mPp gSyxHkx l Hk fØ; kdkjd mRi kn ea i jofr r gkxkA)

$$\frac{0.01}{x^2} = 2.25 \times 10^6 \quad X = 6.6 \times 10^{-5}$$

$$[\text{Ag}^+] = \mathbf{6.66 \times 10^{-5} \text{ M}}$$

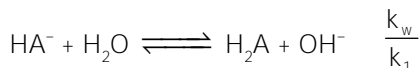
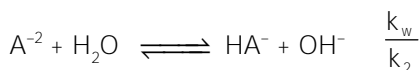


$$s \qquad \qquad s$$

Let solubility is s. (ekuk foyş rk s gA)

But some amount of A^{2-} will undergo hydrolysis. Let x is the amount of A^{2-} left in solution.

(yfd u A^{2-} dh dñ ek=k ty vi?kfv r gkxkA ekuk x foy; u ea 'k k A^{2-} dh ek=k gş)



$$\frac{k_w}{k_2} = \frac{[\text{HA}^-][\text{OH}^-]}{[\text{A}^{2-}]} \Rightarrow [\text{HA}^-] = \frac{k_w [\text{A}^{2-}]}{k_2 [\text{OH}^-]}$$

$$\frac{k_w}{k_1} = \frac{[\text{H}_2\text{A}][\text{OH}^-]}{[\text{HA}^-]} \Rightarrow [\text{H}_2\text{A}] = \frac{k_w [\text{HA}^-]}{k_1 [\text{OH}^-]}$$

$$[H_2A] = \frac{k_w^2 [A^{-2}]}{k_1 k_2 [OH^{-}]^2}$$

From mass balance (æ0; eku I Ugyu I)

$$s = x + \frac{k_w [A^{-2}]}{k_2 [OH^{-}]} + \frac{k_w^2 [A^{-2}]}{k_1 k_2 [OH^{-}]^2}$$

$$s = x + \frac{[H^+]x}{k_2} + \frac{[H^+]^2 x}{k_1 k_2}$$

$$x = \frac{s}{1 + \frac{[H^+]}{k_2} + \frac{[H^+]^2}{k_1 k_2}}$$

$$K_{sp} = [M^{+2}] [A^{-2}] = s \cdot x = \frac{s^2}{1 + \frac{[H^+]}{k_2} + \frac{[H^+]^2}{k_1 k_2}}$$

$$s = \sqrt{K_{sp} \left(1 + \frac{[H^+]}{k_2} + \frac{[H^+]^2}{k_1 k_2} \right)}$$

Exercise-4(B)

- $\therefore \text{pH} = 1 ; H^+ = 10^{-1} = 0.1 \text{ M}$
 $\text{pH} = 2 ; H^+ = 10^{-2} = 0.01 \text{ M}$
 $\therefore M_1 = 0.1 \quad V_1 = 1$
 $M_2 = 0.01 \quad V_2 = ?$
 From
 $M_1 V_1 = M_2 V_2$
 $0.1 \times 1 = 0.01 \times V_2$
 $V_2 = 10 \text{ litre}$
 $\therefore \text{volume of water added} = 10 - 1 = 9 \text{ litre.}$
- $H^+ = C\alpha ; \alpha = \frac{[H^+]}{C} \quad \text{or} \quad \alpha = \frac{10^{-3}}{0.1} = 10^{-2}$
 $K_a = C \alpha^2 = 0.1 \times 10^{-2} \times 10^{-2} = 10^{-5}$
- $\text{Cr(OH)}_3(s) \rightleftharpoons \text{Cr}^{3+}(aq.) + 3\text{OH}^-(aq.)$
 $27S^4 = K_{sp}$
 $S = \left(\frac{K_{sp}}{27} \right)^{1/4} = \left(\frac{1.6 \times 10^{-30}}{27} \right)^{1/4}$
- $\text{pH} = 5 \text{ means}$
 $[H^+] = 10^{-5}$
 $\text{HA} \rightleftharpoons \text{H}^+ + \text{A}^-$
 $t = 0 \quad c \quad 0 \quad 0$
 $\text{teq} \quad c(1 - \alpha) \quad c\alpha \quad c\alpha$
 $K_a = \frac{[H^+][A^-]}{[HA]} = \frac{(c\alpha)^2}{c(1 - \alpha)} = \frac{[H^+]^2}{c - [H^+]}$
 But, $[H^+] \ll c$

- $\therefore K_a = (10^{-5})^2 = 10^{-10}$
 $\text{AgBr} \rightleftharpoons \text{Ag}^+ + \text{Br}^-$
 $K_{sp} = [\text{Ag}^+][\text{Br}^-]$
 For precipitation to occur
 Ionic product > Solubility product
 $[\text{Br}^-] = \frac{K_{sp}}{[\text{Ag}^+]} = \frac{5 \times 10^{-13}}{0.05} = 10^{-11}$
 i.e., precipitation just starts when 10^{-11} moles of KBr is added to 1 l AgNO₃ solution
 \therefore Number of moles of Br⁻ needed from KBr = 10^{-11}
 \therefore Mass of KBr = $10^{-11} \times 120 = 1.2 \times 10^{-9} \text{ g}$
- $\text{H}_2\text{CO}_3(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{HCO}_3^-(aq) + \text{H}_3\text{O}^+(aq)$
 $0.034 - x \quad \quad \quad x \quad \quad x$
 $K_1 = \frac{[\text{HCO}_3^-][\text{H}_3\text{O}^+]}{[\text{H}_2\text{CO}_3]} = \frac{x \times x}{0.034 - x}$
 $\Rightarrow 4.2 \times 10^{-7} \approx \frac{x^2}{0.034} \Rightarrow x = 1.195 \times 10^{-4}$
 As H₂CO₃ is a weak acid so the concentration of H₂CO₃ will remain 0.034 as $0.034 \gg x$.
 $x = [H^+] = [\text{HCO}_3^-] = 1.195 \times 10^{-4}$
 Now, $\text{HCO}_3^-(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{CO}_3^{2-}(aq) + \text{H}_3\text{O}^+(aq)$
 $\quad \quad \quad x - y \quad \quad \quad y \quad \quad y$
 As HCO₃⁻ is again a weak acid (weaker than H₂CO₃) with $x \gg y$.

$$K_2 = \frac{[\text{CO}_3^{2-}][\text{H}_3\text{O}^+]}{[\text{HCO}_3^-]} = \frac{y \times (x+y)}{(x-y)}$$

Note : $[\text{H}_3\text{O}^+] = \text{H}^+$ from first step(x) and from second step(y) = (x + y)

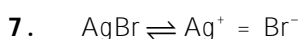
[As $x \gg y$ so $x + y \approx x$ and $x - y \approx x$]

$$\text{So, } K_2 \approx \frac{y \times x}{x} = y$$

$$\Rightarrow K_2 = 4.8 \times 10^{-11} = y = [\text{CO}_3^{2-}]$$

So the concentration of $[\text{H}^+] \approx [\text{HCO}_3^-]$ = concentrations obtained from the first step. As the first step. As the dissociation will be very low in second step so there will be no change in these concentrations.

$$[\text{H}^+] = [\text{HCO}_3^-] = 1.195 \times 10^{-4} \text{ \& } [\text{CO}_3^{2-}] = 4.8 \times 10^{-11}$$



$$K_{sp} = [\text{Ag}^+][\text{Br}^-]$$

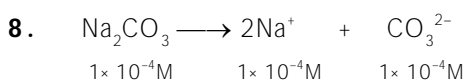
For precipitation to occur Ionic product > Solubility product

$$[\text{Br}^-] = \frac{K_{sp}}{[\text{Ag}^+]} = \frac{5 \times 10^{-13}}{0.05} = 10^{-11}$$

i.e., precipitation just starts when 10^{-11} moles of KBr is added to 1 l AgNO₃ solution

\therefore Number of moles of Br⁻ needed from KBr = 10^{-11}

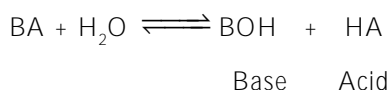
\therefore Mass of KBr = $10^{-11} \times 120 = 1.2 \times 10^{-9}$ g



$$K_{sp}(\text{BaCO}_3) = [\text{Ba}^{2+}][\text{CO}_3^{2-}]$$

$$[\text{Ba}^{2+}] = \frac{5.1 \times 10^{-9}}{1 \times 10^{-4}} = 5.1 \times 10^{-5} \text{ M}$$

9. In corresponds to choice (c) which is correct answer.



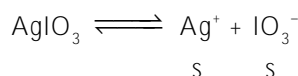
Now pH is given by

$$\text{pH} = \frac{1}{2} \text{p}K_w + \frac{1}{2} \text{p}K_a - \frac{1}{2} \text{p}K_b$$

Substituting given values, we get

$$\text{pH} = \frac{1}{2} (14 + 4.80 - 4.78) = 7.01$$

10. Let s = solubility



$$K_{sp} = [\text{Ag}^+][\text{IO}_3^-] = s \times s = s^2$$

$$\text{Given } K_{sp} = 1 \times 10^{-8}$$

$$\therefore s = \sqrt{K_{sp}} = \sqrt{1 \times 10^{-8}}$$

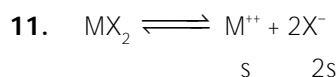
$$= 1.0 \times 10^{-4} \text{ mol/lit}$$

$$= 1.0 \times 10^{-4} \times 283 \text{ g/lit}$$

(\therefore Molecular mass of Ag IO₃ = 283)

$$= \frac{1.0 \times 10^{-4} \times 283 \times 100}{1000} \text{ gm/100ml}$$

$$= 2.83 \times 10^{-3} \text{ gm/100 ml}$$



Where s is the solubility of MX₂

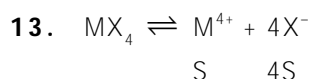
then $K_{sp} = 4s^3$; $(2s)^2 = 4 \times 10^{-12} = 4s^3$; $s = 1 \times 10^{-4}$

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

12. $\text{pH} = -\log[\text{H}^+] = \log \frac{1}{[\text{H}^+]}$

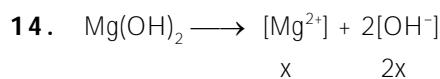
$$5.4 = \log \frac{1}{[\text{H}^+]}$$

On solving, $[\text{H}^+] = 3.98 \times 10^{-6}$

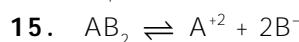


$$K_{sp} = [s][4s]^4 = 256 s^5$$

$$\therefore s = \left(\frac{K_{sp}}{256} \right)^{1/5}$$



$$K_{sp} = [\text{Mg}][\text{OH}]^2 = [x][2x]^2 = x \cdot 4x^2 = 4x^3$$



$$[\text{A}] = 1.0 \times 10^{-5}, [\text{B}] = [2.0 \times 10^{-5}],$$

$$K_{sp} = [\text{B}]^2[\text{A}] = [2 \times 10^{-5}]^2 [1.0 \times 10^{-5}] = 4 \times 10^{-15}$$