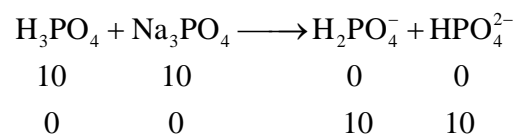


Solutions FOR GET EQUIPPED JEE ADVANCED AND COMPREHENSION

Q.1 [C]

Sol. moles of $\text{H}_3\text{PO}_4 = 0.2 \times 50 = 10$ m moles

moles of $\text{Na}_3\text{PO}_4 = 0.2 \times 50 = 10$ m moles



Buffer of NaH_2PO_4 & Na_2HPO_4

$$\text{pH} = \text{pK}_{a_2} + \log \frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]} = 8 + \log 1 = 8$$

Q.2 [A]

Sol. In one litre initial $\text{pH} = 7$

Final $\text{pH} = 4$; $[\text{H}^+] = 10^{-4}$

$[\text{H}^+]_{\text{by drop}} = 10^{-4} - 10^{-7} = 10^{-4}$

Moles of H^+ in 1L = 10^{-4}

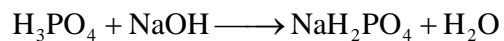
So total moles after 2 drops = 2×10^{-4} in 1L

$\text{pH} = 4 - \log 2 = 3.7$

Q.3 [D]

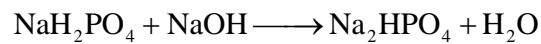
At $\text{pH} = 7.4$ the best buffer is of H_2PO_4^- & HPO_4^{2-}

$$\text{Using } 7.4 = 8 + \log \frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]}$$



5m mole x = 5

0 0 5m moles



5 x

5-x x

Solving, $7.4 = 8 + \log\left(\frac{x}{5-x}\right)$

$$\frac{x}{5-x} = \frac{1}{4}$$

$$x = 1$$

$$\text{total } 5 + 1 = 6 \text{ m moles} = 0.1 \times V \text{ ml}$$

$$V = 60 \text{ ml}$$

Q.4 [A]

Sol. If both MX and M_2Y starts ppting simultaneously then

$$[\text{M}^+] = \frac{K_{sp}}{[\text{X}^-]} = \frac{10^{-10}}{0.1} = 10^{-9}$$

$$\text{then } K_{sp}(\text{M}_2\text{Y}) = [\text{M}^+]^2 [\text{Y}^{-2}]$$

$$= (10^{-9})^2 (0.01) = 10^{-20}$$

In Pure water for M_2Y

$$4s^3 = 10^{-20}$$

$$s = \left(\frac{10^{-20}}{4}\right)^{\frac{1}{3}}$$

Q.5 [B]

Sol. Isoelectric point implies net charge on the species must be zero so considering it as triprotic acid 2nd ionisation of H⁺ must be complete so it will be amphiprotic & $\text{pH} = \frac{\text{Pka}_2 + \text{Pka}_3}{2}$

$$= \frac{8.96 + 10.53}{2}$$

$$= 9.74$$

Comprehensions

Q.13 [A]

Sol. The stronger acid will be more deprotonated than weaker acid at same pH

So it will be less protonated

A & B curves are protonated

Q.14 [C, D]

Sol. for same acid lines must intersect at 0.5 as ordinato, So A & C are pairs & B & D

Q.15 [B]

Sol. $\text{pKa}_{(\text{stronger})} = \text{pH} = 5$ $\text{Ka}_{\text{stronger}} = 10^{-5}$

$\text{pKa}_{(\text{weaker})} = \text{pH} = 7$ $\text{Ka}_{(\text{weaker})} = 10^{-7}$

$$\frac{10^{-5}}{10^{-7}} = 100$$

Q.16 [C]

Sol. First $[\text{Br}^-]$ starts precipitating in the form of $\text{AgBr}_{(s)}$ when $[\text{Ag}^+] = \frac{\text{K}_{\text{sp}}}{[\text{Br}^-]} = \frac{10^{-7}}{10^{-2}} = 10^{-5} \text{M}$

after which $[\text{Ag}^+]_{\text{solution}} [\text{Br}^-]_{\text{solution}} = \text{K}_{\text{sp}}$ remains constant so a hyperbolic curve.

Q.17 [D]

Sol. When $\text{AgCl}_{(s)}$ starts precipitating

$$[\text{Ag}^+]_{\text{solution}} = \frac{\text{K}_{\text{sp}}}{[\text{Cl}^-]} = \frac{10^{-5}}{10^{-2}} = 10^{-3}$$

$$[\text{Ag}^+]_{\text{ppt}} = [\text{Br}^-]_{\text{ppt}} = 10^{-2} - \frac{10^{-7}}{10^{-3}} = 10^{-2} - 10^{-4}$$

$$[\text{Ag}^+]_{\text{total}} = 10^{-3} + 10^{-2} - 10^{-4} = 0.0109$$

Solutions FOR EXPERTISE ATTAINER SUBJECTIVE

Q.1

Sol. $[\text{OH}^-] = 2.5 \times 10^{-3} \times 2 = 5 \times 10^{-3} \text{ M}$

$$\text{POH} = 3 - \log 5 = 2.3$$

(a) For POH to be doubled

$$[\text{OH}^-]_{\text{final}} = [\text{OH}^-]_{\text{initial}}^2$$

$$= 25 \times 10^{-6} > 10^{-6} \text{ so } [\text{OH}^-]_{\text{water}} \text{ negligible conserving moles of } [\text{OH}^-] \text{ from Ba}[\text{OH}]_2$$

$$25 \times 10^{-6} \times V = 5 \times 10^{-3} \times 1$$

$$V = \frac{5 \times 10^{-3}}{25 \times 10^{-6}} = \frac{10^3}{5} = 200 \text{ L}$$

$$\text{Water added} = 200 - 1 = 199 \text{ L}$$

(b) POH to be tripled

$$[\text{OH}^-]_{\text{final}} = [\text{OH}^-]_{\text{initial}}^3$$

$$= 125 \times 10^{-9} = 1.25 \times 10^{-7} < 10^{-6}$$

So $[\text{OH}^-]_{\text{water}}$ is significant

$$[\text{OH}^-]_{\text{water}} = [\text{H}^+]_{\text{water}} = [\text{H}^+]_{\text{net}} = \frac{10^{-14}}{1.25 \times 10^{-7}} = 8 \times 10^{-8} \text{ M}$$

Conserving moles of $[\text{OH}^-]$ from $\text{Ba}[\text{OH}]_2$

$$(12.5 \times 10^{-8} - 8 \times 10^{-8}) \times V = 5 \times 10^{-3} \times 1$$

$$4.5 \times 10^{-8} \times V = 5 \times 10^{-3}$$

$$V = \frac{5 \times 10^{-3}}{4.5 \times 10^{-8}}$$

$$= \left(\frac{10^6}{9} \right) \text{L}$$

(c) not possible as POH cannot be more than 7

Q.2

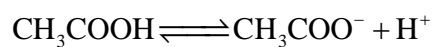
Sol. $\text{pH}_1 = 3 - \log 2 = 2.7$

$$\text{pH}_2 = \frac{1}{2} [\text{pK}_a - \log C] = 2.7$$

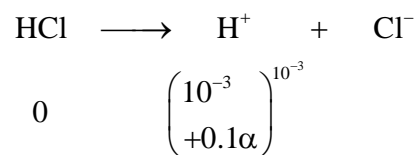
On mixing the new concentration are

$$[\text{CH}_3\text{COOH}] = 0.1\text{M}$$

$$[\text{HCl}] = 10^{-3}\text{M}$$



$$0.1(1-\alpha) \quad 0.1\alpha \quad \begin{pmatrix} 0.1\alpha \\ +10^{-3} \end{pmatrix}$$



0.1α cannot be neglected compared to 10^{-3}

$$\text{K}_a = \frac{(0.1\alpha + 10^{-3})(0.1\alpha)}{0.1(1-\alpha)} = 2 \times 10^{-5}; \quad 1 - \alpha \approx 1$$

$$(0.1\alpha^2) + 10^{-3}\alpha = 2 \times 10^{-5}$$

$$\alpha^2 + 10^{-2}\alpha - 2 \times 10^{-4} = 0$$

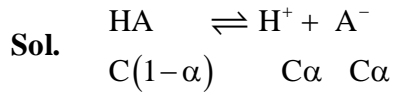
$$\alpha = \frac{-10^{-2} + \sqrt{10^{-4} + 8 \times 10^{-4}}}{2} = \frac{-10^{-2} + 3 \times 10^{-2}}{2} = 10^{-2}$$

$$[\text{H}^+]_{\text{net}} = 0.1 \times 10^{-2} + 10^{-3} = 2 \times 10^{-3}$$

$$\text{pH}_3 = 2.7$$

$$\text{So} \left(\frac{\text{pH}_1 + \text{pH}_2}{\text{pH}_3} \right) = 2$$

Q.3



$$K_a = \frac{\text{C}\alpha^2}{1-\alpha} = \frac{(\text{C}\alpha)(\alpha)}{(1-\alpha)} = [\text{H}^+] \frac{(\alpha)}{(1-\alpha)}$$

$$\text{pKa} = \text{pH} - \log \left(\frac{\alpha}{1-\alpha} \right)$$

$$\log \left(\frac{\alpha}{1-\alpha} \right) = \text{pH} - \text{pKa}$$

$$\frac{\alpha}{1-\alpha} = 10^{\text{pH}-\text{pKa}}$$

$$\alpha = \frac{10^{\text{pH}-\text{pKa}}}{1+10^{\text{pH}-\text{pKa}}} = \frac{1}{1+10^{(\text{pKa}-\text{pH})}}$$

Q.4

Sol.

(a) For pH to be doubled

$$[\text{H}^+]_{\text{final}} = [\text{H}^+]_{\text{initial}}^2$$

$$\text{C}_f \alpha_f = (\text{C}_i \alpha_i)^2$$

$$= \left(\sqrt{\text{C}_i \text{K}_a} \right)^2 = 0.1 \times 2 \times 10^{-5}$$

$$= 2 \times 10^{-6}$$

Also, $\frac{\text{C}_f \alpha_f^2}{1-\alpha_f} = \frac{\text{C}_i \alpha_i^2}{1-\alpha_i} = 2 \times 10^{-5}$

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

$$2 \times 10^{-6} \times (\alpha_f) = 2 \times 10^{-5}$$

$$\frac{\alpha_f}{1 - \alpha_f} = 10; \alpha_f = \frac{10}{11}$$

$$C_f = 2 \times 10^{-6} \times \frac{11}{10} = 2.2 \times 10^{-6}$$

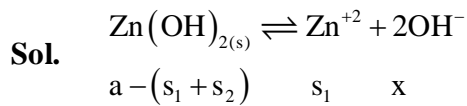
Conserving WA $C_f V_f = C_i V_i$

$$V_f = \frac{10^6}{22}$$

$$V_{\text{water}} = \left(\frac{10^6}{22} - 1 \right) L \approx 45453 L$$

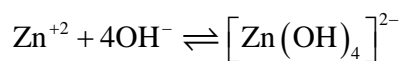
(b) Not possible as pH cannot be > 7

Q.5

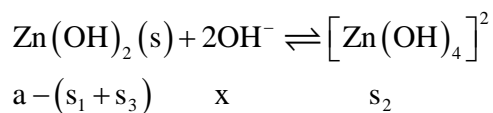


$$K_{sp} = [\text{Zn}^{+2}][\text{OH}^-]^2$$

$$= S_1 x^2 \quad \dots\dots\dots(1)$$



$$K_f = \frac{[\text{Zn(OH)}_4]^{2-}}{[\text{Zn}^{+2}][\text{OH}^-]^4}$$



$$K_{sp} \times K_f = \frac{s_2}{x^2} \quad \dots\dots\dots(2)$$

$$(1) \times (2)$$

$$(K_{sp})^2 \times K_f = s_1 - s_2 \approx s^2 \quad (s_1 \approx s_2)$$

$$s^2 = (1.2 \times 10^{-17})^2 \times 10^{16} = 1.44 \times 10^{-18}$$

$$s = 1.2 \times 10^{-9}$$

Solubility of $Zn(OH)_{2(s)}$ is $s_1 + s_2 \approx 2s = 2.4 \times 10^{-9} M$

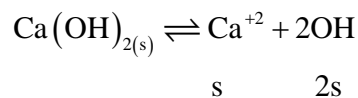
$$[OH^-] = x = \sqrt{\frac{K_{sp}}{s_1}} = \sqrt{\frac{1.2 \times 10^{-17}}{1.2 \times 10^{-9}}} = \sqrt{10^{-8}} = 10^{-4}$$

$$POH = 4$$

$$pH = 10$$

Q.6

Sol. Initially saturated solution of $Ca(OH)_2$ so $Ca(OH)_2$ dissolved is given by



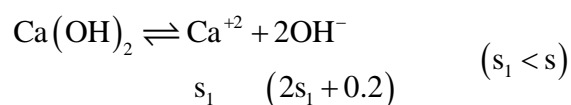
$$K_{sp} = 4s^3 = 4.42 \times 10^{-5}$$

$$S = \sqrt[3]{\frac{4.42 \times 10^{-5}}{4}}$$

$$= 0.022 M$$

$$\text{Moles dissolved} = 0.022 \times \frac{1}{2} = 0.011$$

When NaOH is mixed volume is doubled



$$(s_1)(2s_1 + 0.2)^2 = 4.42 \times 10^{-5}$$

$$(s_1)(s_1 + 0.1)^2 = 1.105 \times 10^{-5}$$

Neglecting s_1

$$s_1 = \frac{1.105 \times 10^{-5}}{0.01} = 1.1 \times 10^{-3}$$

moles of Ca^{+2} dissolved = $1.1 \times 10^{-3} \times 1$ moles

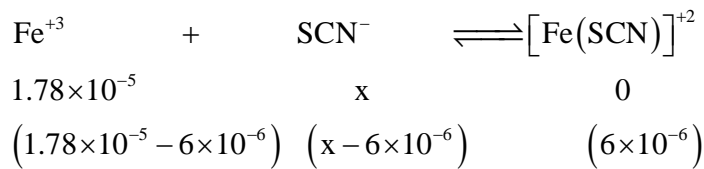
moles of Ca^{+2} deposited = $11 \times 10^{-3} - 1.1 \times 10^{-3} = 9.9 \times 10^{-3}$ moles

moles of $\text{Ca}(\text{OH})_2 = 9.9 \times 10^{-3} \times 74 \text{ gm} = 732.6 \text{ mg}$

Q.7

Sol. Fe^{+3} 1ppm \Rightarrow 1gmin 10^6 gm

$$\Rightarrow \frac{1}{56} \text{ moles in } 10^3 \text{ L} \Rightarrow 1.78 \times 10^{-5} \text{ M}$$



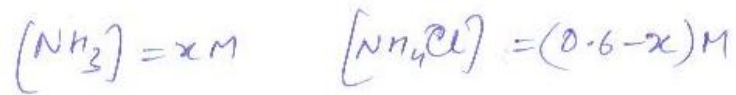
$$\frac{6 \times 10^{-6}}{(1.78 \times 10^{-5} - 6 \times 10^{-6})(x - 6 \times 10^{-6})} = \frac{1}{k_{\text{dissociation}}} = \frac{10^3}{7.142}$$

$$\frac{6 \times 10^{-6}}{(11.8 \times 10^{-6})(x - 6 \times 10^{-6})} = \frac{10^3}{7.142}$$

$$x - 6 \times 10^{-6} = \frac{6 \times 7.142}{11.8 \times 10^3} = 3.61 \times 10^{-3} = 0.0036 \text{ M}$$

Q.8

Sol.



for Basic Buffer

$$\text{pOH} = \text{p}K_b + \log \frac{[\text{NH}_4^+]}{[\text{NH}_4\text{Cl}]}$$

$$14 - 9 = 4.7 + \log \left(\frac{0.6 - x}{x} \right)$$

$$0.3 = \log \left(\frac{0.6 - x}{x} \right)$$

$$\frac{0.6 - x}{x} = 2$$

$$x = 0.2 \text{ M}$$

$$[\text{NH}_3] = 0.2 \text{ M}$$

$$[\text{NH}_4\text{Cl}] = 0.4 \text{ M}$$

$$2 \text{ gm of NaOH} = \frac{2}{40} = 0.05 \text{ moles in } 500 \text{ ml}$$

$$\text{or } [\text{NaOH}] = 0.1 \text{ M}$$

$$[\text{NH}_4^+] = 0.4 - 0.1 = 0.3$$

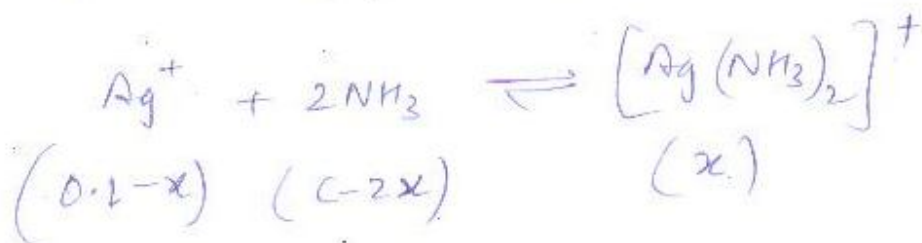
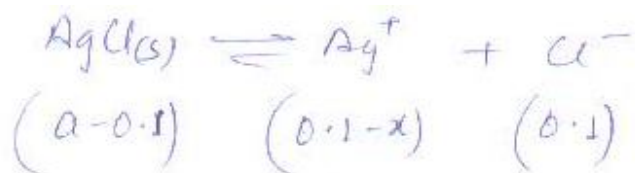
$$[\text{NH}_3] = 0.2 + 0.1 = 0.3$$

$$\text{pOH} = \text{p}K_b = 4.7$$

$$|\Delta \text{pOH}| = 0.3$$

$$|\Delta \text{pH}| = 0.3$$

Q.9
Sol.



two unknowns c & x

$$(0.1-x)(0.1) = 10^{-10}$$

$$(0.1-x) = [\text{Ag}^+] = 10^{-9} \text{ M}$$

$$x \approx 0.1 \text{ M}$$

$$K_f = 1.6 \times 10^7 = \frac{x}{(c-2x)^2 (0.1-x)}$$

$$1.6 \times 10^7 = \frac{0.1}{(c-0.2)^2 (10^{-4})}$$

$$(c-0.2)^2 = \frac{10^8}{1.6 \times 10^7} = \frac{100}{16}$$

$$c-0.2 = \frac{10}{4} = 2.5 \quad \boxed{c = 2.7 \text{ M}}$$

Q.10
Sol.

$$\text{at } [\text{In}^-] = 4 \times 10^{-5} \text{ M}$$

$$\text{pH} = 5 - \log 4 = 4.4$$

$$\text{pH} = \text{pK}_a + \log (1)$$

$$\boxed{\text{pK}_a = 4.4} \quad \boxed{\text{K}_a = 4 \times 10^{-5}}$$

for acidic color (A)

$$[\text{A}] > 8[\text{B}]$$

$$[\text{HIn}] > 8[\text{In}^-] \quad \frac{[\text{In}^-]}{[\text{HIn}]} < \frac{1}{8}$$

$$\text{pH} = 4.4 + \log \left(\frac{1}{8} \right)$$

$$= 4.4 - 0.9 = \boxed{3.5}$$

for Basic color B

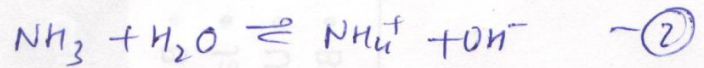
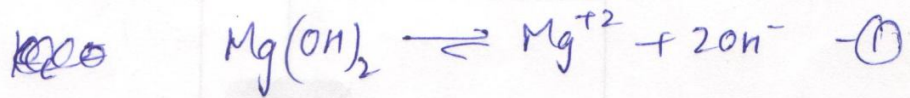
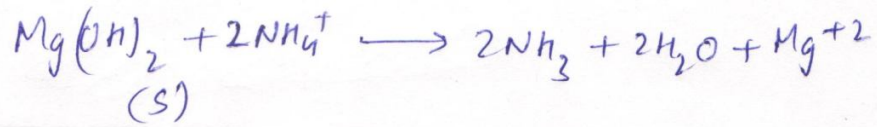
$$[\text{In}^-] > 20[\text{HIn}]$$

$$\text{pH} = 4.4 + \log(20)$$

$$\boxed{\text{pH} = 5.7}$$

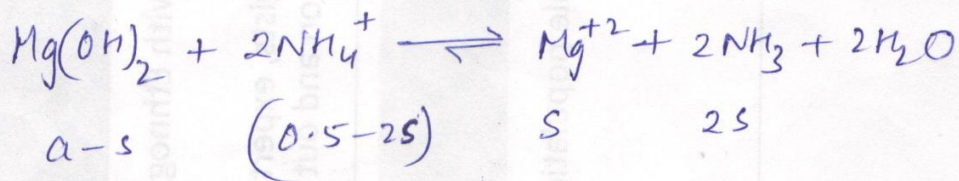
$$\text{pH}_{\text{range}} = 3.5 \text{ to } 5.7$$

Q.12
Sol.



Main reaction = (1) - 2 × (2)

$$K_c = \frac{K_{sp}}{K_b^2} = \frac{10^{-11}}{(1.8 \times 10^{-5})^2} = \frac{10^{-11} \times 10^{+10}}{(1.8)^2} = \underline{\underline{3.08 \times 10^{-2}}}$$



$$\frac{(2s)^2(s)}{(0.5-2s)^2} = 3.08 \times 10^{-2}$$

$$\frac{4 \times 4s^3}{(1-4s)^2} = 3.08 \times 10^{-2}$$

INCORRECT
ASSUMPTION
~~1-4s~~

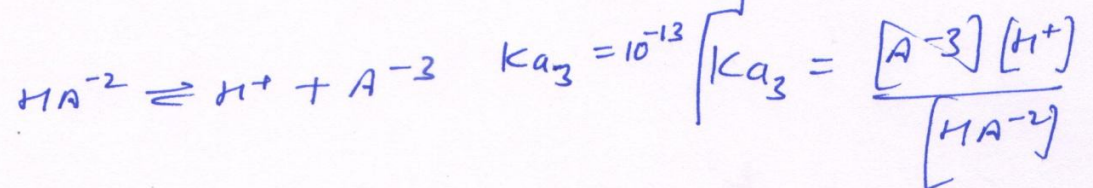
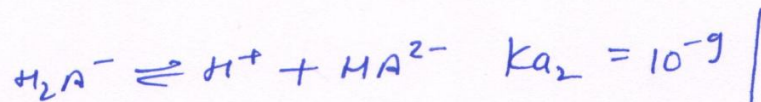
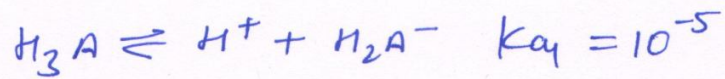
$$\underline{1-4s \approx 1}$$

$$s^3 = 0.1925 \times 10^{-2}$$

$$\boxed{s = 0.124}$$

Q.13
Sol.

$$K_{a_1} = 10^{-5} \quad K_{a_2} = 10^{-9} \quad K_{a_3} = 10^{-13}$$



$$X = \frac{[A^{3-}]}{[HA^{2-}]} = \frac{K_{a_3}}{[H^+]}$$

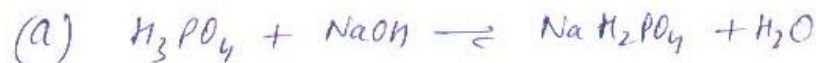
$$[H^+] = \sqrt{C K_{a_1}} = 10^{-3}$$

$$X = \frac{10^{-13}}{10^{-3}} = 10^{-10}$$

$$\boxed{pX = 10}$$

Answer verification

Q.14
Sol.



~~50x0.12~~

$$50 \times 0.12 \quad 20 \times 0.15$$

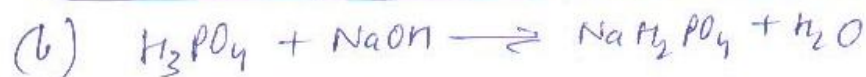
$$= 6 \quad = 3$$

$$\boxed{3 \quad 0 \quad 3}$$

$$[\text{H}_3\text{PO}_4] = \frac{3}{V} \quad [\text{NaH}_2\text{PO}_4] = \frac{3}{V}$$

$$\text{pH} = \text{p}K_{a1} + \log(1)$$

$$= 3 - \log 7.5 = \boxed{2.12}$$



$$6 \quad 6 \quad 6$$

$$0 \quad 0 \quad 0$$

$$\text{pH} = \frac{\text{p}K_{a1} + \text{p}K_{a2}}{2} = \frac{2.12 + 7.2}{2} = \boxed{4.66}$$



$$40 \times 0.12 \quad 40 \times 0.18$$

$$= 4.8 \quad = 7.2$$

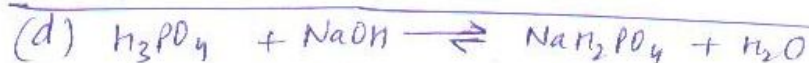
~~40~~ ~~20~~ ~~40~~



$$4.8 \quad 2.4 \quad 0$$

$$2.4 \quad 0 \quad 2.4$$

$$\text{pH} = \text{p}K_{a2} + \log(1) = \boxed{7.2}$$



$$4 \quad 10 \quad 0$$

$$0 \quad 6 \quad 4$$

continued

Continued



4 6 0

0 2 4

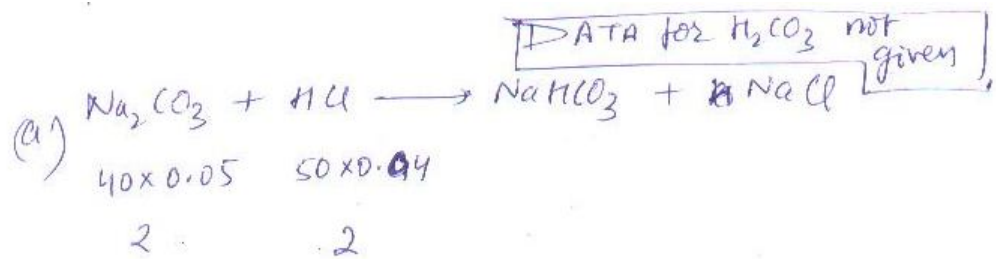


4 2 0

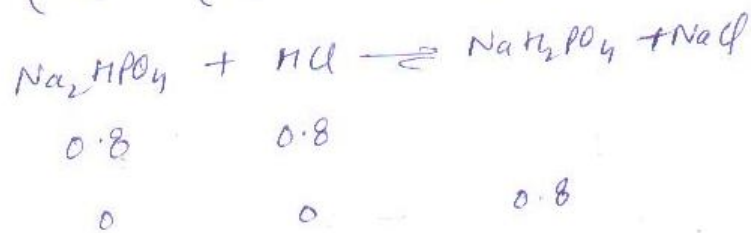
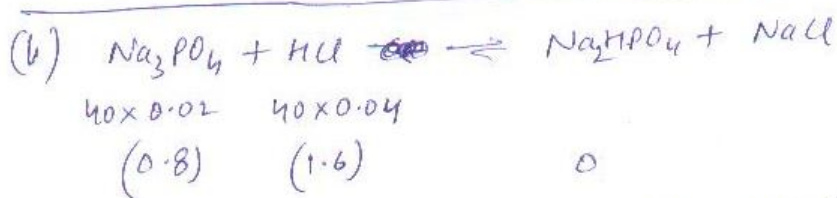
2 0 2

$$\boxed{\text{pH} = \text{pK}_a_3 = 12}$$

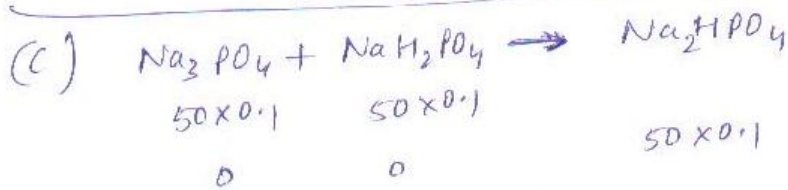
Q.15
Sol.



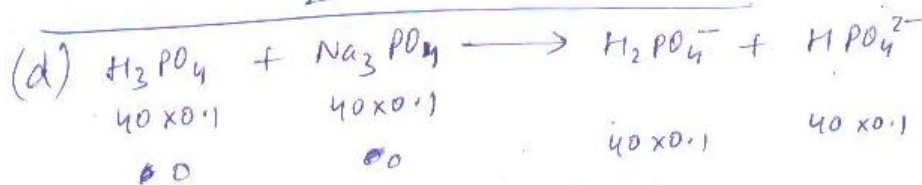
$$pH = \frac{pK_{a1} + pK_{a2}}{2} = \text{---}$$



$$pH = \frac{pK_{a1} + pK_{a2}}{2} = [4.66]$$

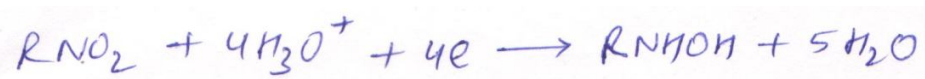


$$pH = \frac{pK_{a2} + pK_{a3}}{2} = [9.6]$$



$$pH = pK_{a2} + \log(1) = [7.2]$$

Q.16
Sol.



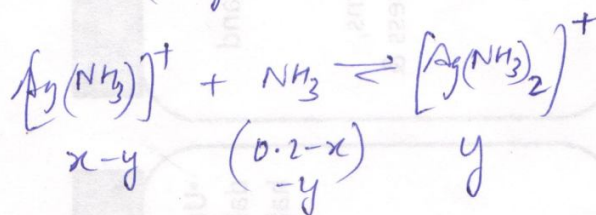
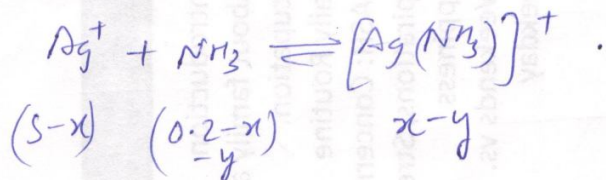
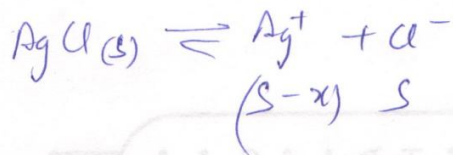
300 ml

0.01 M

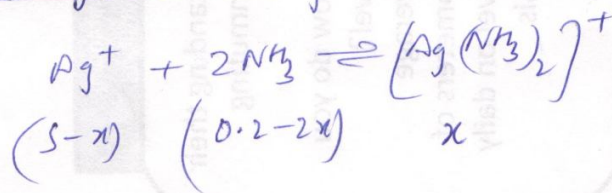
3 mmoles

Ka of acetic acid required

Q.17
Sol.



x ≈ y so adding last 2 equations



$$K_{sp} = 1.7 \times 10^{-10} = (S-x)(S)$$

$$K_f = 16.6 \times 10^6 = \frac{x}{(S-x)(0.2-2x)^2}$$

$$\frac{(S)(x)}{(0.2-2x)^2} = 1.7 \times 16.6 \times 10^{-4} = 28.28 \times 10^{-4}$$

$$\frac{x \approx S}{(0.2-2S)^2} = 28.28 \times 10^{-4}$$

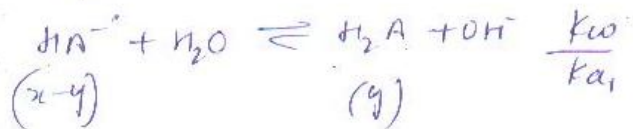
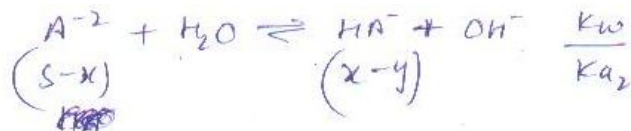
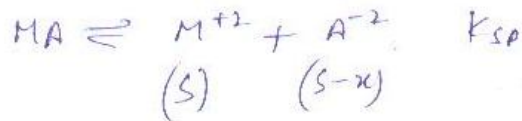
$$\frac{S}{(0.2-2S)} = 5.3 \times 10^{-2}$$

$$\frac{S}{0.1-S} = 1.06 \times 10^{-1} = 0.106$$

$$\frac{S}{0.1} = \frac{0.106}{1.06} = 0.09$$

$$\boxed{S = 9.6 \times 10^{-3}}$$

Q.18
Sol.



$$\frac{(y) [OH^{-}]}{(x-y)} = \frac{K_w}{K_{a1}} \quad \left[\frac{y}{(x-y)} = \frac{K_w}{K_{a1}} \times \frac{1}{[OH^{-}]} = \frac{[H^{+}]}{K_{a1}} \right] \text{--- (1)}$$

$$\frac{(x-y) [OH^{-}]}{(s-x)} = \frac{K_w}{K_{a2}} \quad \left[\frac{(x-y)}{(s-x)} = \frac{[H^{+}]}{K_{a2}} \right] \text{--- (2)}$$

By (1) $\frac{y}{x-y} = \frac{[H^{+}]}{K_{a1}} \quad \frac{y}{x} = \frac{[H^{+}]}{K_{a1} + [H^{+}]}$ $\left[y = \frac{[H^{+}] x}{K_{a1} + [H^{+}]} \right]$

Substituting in (2) $\frac{x}{s-x} = \frac{K_{a1} [H^{+}] + [H^{+}]^2}{K_{a1} K_{a2}}$

$$\frac{x}{s} = \frac{[H^{+}] K_{a1} + [H^{+}]^2}{K_{a1} K_{a2} + K_{a1} [H^{+}] + [H^{+}]^2}$$

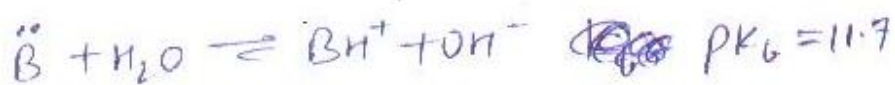
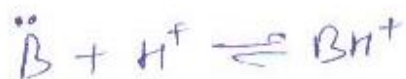
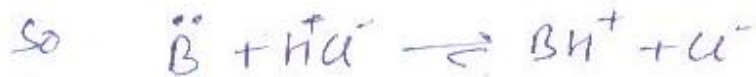
$$(s) (s-x) = (s) \left(s - s \left(\frac{[H^{+}] K_{a1} + [H^{+}]^2}{K_{a1} K_{a2} + K_{a1} [H^{+}] + [H^{+}]^2} \right) \right) = K_{sp}$$

$$s^2 \left(\frac{K_{a1} K_{a2} + K_{a1} [H^{+}] + [H^{+}]^2 - [H^{+}] K_{a1} - [H^{+}]^2}{K_{a1} K_{a2} + K_{a1} [H^{+}] + [H^{+}]^2} \right) = K_{sp}$$

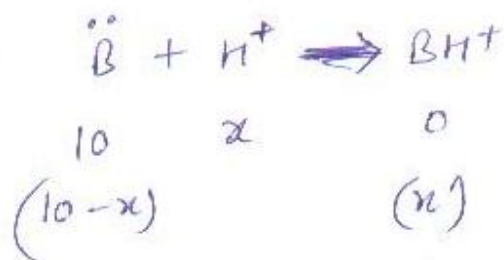
$$\boxed{s = \sqrt{K_{sp} \left(1 + \frac{[H^{+}]}{K_2} + \frac{[H^{+}]^2}{K_1 K_2} \right)}}$$

Q.19
Sol.

with HCl it behaves as base



Let x m moles of HCl added



$$\text{pOH} = \text{p}K_b + \log \frac{[\text{BH}^+]}{[\ddot{\text{B}}]}$$

$$14 - 2.6 = 11.7 + \log \left(\frac{x}{10-x} \right)$$

$$-0.3 = \log \left(\frac{x}{10-x} \right)$$

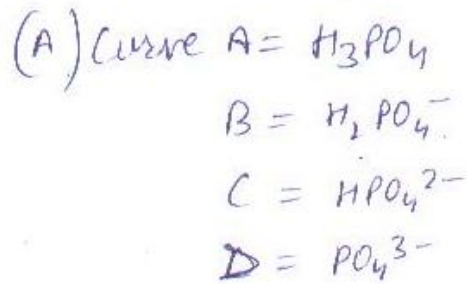
$$\frac{10-x}{x} = 2$$

$$10 = 3x$$

$$\boxed{x = 3.33 \text{ mmoles}}$$

Q.20
Sol.

as pH \uparrow acidic forms \downarrow
subsequent basic forms \uparrow



(B) at intersection of A & B
 $[\text{H}_3\text{PO}_4] = [\text{H}_2\text{PO}_4^-]$

$$\text{pH} = \text{p}K_{a1} = 4.7$$
$$\boxed{K_{a1} = 2 \times 10^{-5}}$$

Similarly $\text{pH} = \text{p}K_{a2} = 7.7$
 $\boxed{K_{a2} = 2 \times 10^{-8}}$

& $\text{pH} = \text{p}K_{a3} = 10.4$
 $\boxed{K_{a3} = 4 \times 10^{-11}}$

(C) $\text{pH} = \frac{1}{2} \left\{ \text{p}K_w + \text{p}K_{a3} + \log c \right\}$

$$= \frac{1}{2} \left\{ 14 + 11 - \log 4 + \log \frac{0.5}{3} \right\}$$
$$= \frac{1}{2} \left\{ 22.92 \right\} = 11.46$$

$c = \frac{0.1 \times V}{3V}$
 $\boxed{c = 0.1/3}$

