Exercise - 1 A

FBO-1) (C) EN of Sb is the lowest

→ order of acid strength

$HNO_3 > H_3PO_3 > H_3AsO_4 > H_3SbO_4$

FBO-2) (B)

FBO-3) (A) diff. of one H^+ b/w CA & CB

FBO-4) (D) difference of one H^+ b/w CA & CB

FBO-5) (C)

$H-O-\overset{\overset{O}{\|}}{S}-O^-$

(acidic H part) (base part)

FBO-6) (C) As we move down the group basic nature increases

FBO-7) (C) The anhydride of an acid is the acidic oxide which on hydration forms the acid.

$Cl_2O_7 + H_2O \rightleftharpoons 2HClO_4$

FBO-8) (A) amphoteric species

FBO-9) (D) $HCl + CH_3COOH \rightleftharpoons Cl^- + CH_3COOH_2^+$

(acid) donates H^+ — (base) accepts H^+ — Conj. base — conj. acid

FBO-10) (D) $[Cr(H_2O)_5 Cl]^{2+} \rightleftharpoons H^+ + [Cr(H_2O)_4 OH Cl]^+$

acid

⇒ donates H^+

See, the charge balance also.

FBO-11) (A) pH initial = 7 (pure water)

pH new = 11

FOB-12) (B, C) pH = 7 not necessary

If temp. ↑, pH of neutral water ↓

FBO-13) (A) $[H^+] = 2[OH^-]$

Also, $[H^+][OH^-] = K_w$

$\Rightarrow [H^+] = \sqrt{\frac{K_w}{2}}$

FBO-14) very dilute basic sol^n. Ionization of water has to
(B) be considered

FBO-15) for $H_2O \rightleftharpoons H^+ + OH^-$ As T ↑, K ↑

i.e. endothermic reaction.

∴ $H^+ + OH^- \rightleftharpoons H_2O$ is exothermic

FBO-16) Strong acids.
(B) $[H^+] = \frac{10^{-3} + 10^{-4}}{2}$

FBO-17) (A) for neutral water $[H^+] = \sqrt{5.5 \times 10^{-13}}$

$pH = 6.06$

$\Rightarrow pH = 6$ is acidic

FBO-18) (A) At $0°C$, $K_w < 10^{-14}$

$pH > 7$ for neutral water

FBO-19) (B) Assuming both strong acid sn[n]

$[H^+] = \frac{10^{-1} + 10^{-2}}{2} \Rightarrow pH = 1.26$

FBO-20) (C) HCl & NaOH neutralize each other.

$[HCl]$ left $= \frac{50 \times 0.4 - 50 \times 0.2}{100} = 0.1$

FBO-21) (D) consider ionization of water

FBO-22) (D) H_2SO_4 is strong acid

FBO-23) (C) ~~KH~~ $\ddot{N}F_3$ is lewis base

FBO-24) (D) CH_3OH is lewis base as O atom has lone pairs to donate

FBO-25) (A) consider ionization of H_2O

FBO-26) (C) $[OH^-]_{initial} = 10^{-7}$

$[OH^-]_{final} = 10^{-2}$

FBO-27) (C)

$[OH^-] = 10^{-2} = \frac{\text{moles}}{\text{vol. (in lit)}}$

$\Rightarrow$ moles of NaOH $= 10^{-2}$

mass of NaOH $= 0.4\ g$

FBO-28) (D)

Assuming soln to be weak acid soln

$[H^+]_1 = 10^{-6} = \sqrt{K_1 C_1}$

$[H^+]_2 = 10^{-4} = \sqrt{K_2 C_2}$

when equal vol. is mixed, conc. gets halve and we have WA + WA soln

$$[H^+]_{new} = \sqrt{\frac{K_1C_1 + K_2C_2}{2}}$$

$$= \sqrt{\frac{10^{-8} + 10^{-12}}{2}}$$

$$\simeq \frac{10^{-4}}{\sqrt{2}}$$

$pH \simeq 4.15$

FBO-29) (C)

FBO-30) (C)

$[H^+]_i = 10^{-1}$

$[H^+]_{new} = 10^{-2}$

FBO-31) (C)

$NH_2 - CH_2 - \overset{O}{\overset{||}{C}} - OH$

NH_2: base part; $-C-OH$: acid part

FBO-32) (B) I^- donates e^- pair

FBO-33) (C) $[H^+]_i = 10^{-3}$

$[H^+]_f = 10^{-6}$

FBO-34) (A) $c\alpha = 10^{-7}$

$\alpha = \frac{10^{-7}}{c} = \frac{10^{-7}}{(1000/18)} = 1.8 \times 10^{-9}$

$= 1.8 \times 10^{-7}\ \%$

FBO-35) (D)

FBO-36) (B) $K_w = [H^+][OH^-] = (c\alpha)(c\alpha)$

$= \frac{1000}{18} \times \frac{1000}{18} \times 1.8\times10^{-9} \times 1.8\times10^{-9}$

$= 10^{-14}$

FBO-37) (B)

HA-2

FBO-38 (1) C is least EN among C, N, O, F

so CH_3^- is strongest Lewis base ⇒ (A)

FBO-39 (2) conjugate acids are.

a) $HClO_3$ (b) $HClO_2$ (c) $HClO_4$ (d) $HClO$

~~So~~ weakest among them is $HClO$

so strongest base is ClO^- ⇒ (D)

FBO-40 (3) pOH of NH_3 soln = pH of a CH_3COOH soln. ($\because$ C is same, $K_{b,NH_3} = K_{a,CH_3COOH}$)

⇒ pOH of NH_3 soln = 3.2

⇒ pH of NH_3 soln = 14 − 3.2 = 10.8

⇒ (D)

FBO-41 (4) $[H^+] = 0.1 \times 0.01 = 10^{-3}$

⇒ pH = 3 ⇒ (C)

FBO-42 (5) $K_{a_1} K_{a_2} = \dfrac{[H^+]^2 [S^{2-}]}{[H_2S]}$

$1 \times 10^{-7} \times 1.3 \times 10^{-13} = \dfrac{10^{-6} \times [S^{2-}]}{0.1}$

$[S^{2-}] = 1.3 \times 10^{-15}$ ⇒ (D)

(6) FBO-43

$[H^+] > 3[A^{3-}]$ $\Rightarrow$ (B)

($\because$ $\alpha_1 >> \alpha_2 >> \alpha_3$)

(7) FBO-44

rxn will shift backwards

$\Rightarrow$ $[H^+]$ will decrease $\Rightarrow$ pH will increase

$\Rightarrow$ (B)

(8) FBO-45

$A^- + H_2O \longrightarrow HA + OH^-$

K_c

$H_2O \rightarrow H^+ + OH^-$ $\quad K_w$

$H^+ + A^- \longrightarrow HA$ $\quad 1/K_a$

$A^- + H_2O \rightarrow HA + OH^-$ $\quad \frac{K_w}{K_a} = 10^8$

$\Rightarrow K_a = 10^{-8}$ $\Rightarrow$ (A)

(9) FBO-46

$[H^+]$ will be lesser for HA

$\Rightarrow$ pH will be higher $\Rightarrow$ (A).

(10) FBO-47

$K_a = \frac{c\alpha^2}{1-\alpha} = \frac{0.1 \times (10^{-5})^2}{1 - 10^{-5}} = 10^{-11}$ $\Rightarrow$ (D).

(11) FBO-48

$[H^+] = \sqrt{cK_a} = 10^{-2}$

$\Rightarrow pH = 2$ $\Rightarrow$ (A).

(12) $[H^+] = \frac{K_a [CH_3COOH]}{[CH_3COO^-]}$

FBO-49

$$10^{-5.74} = \frac{10^{-4.74} \cdot [CH_3COOH]}{[CH_3COO^-]}$$

$\Rightarrow \frac{[CH_3COOH]}{[CH_3COO^-]} = 10^{-1} = \frac{1}{10} \Rightarrow$ (A)

(13) (A) pH = 7

FBO-50

(B) pH > 7 $\Rightarrow$ (C)

(C) pH = ~~13~~14

(D) pH < 7

(14) rxn will proceed to maximum extent when base is strongest (i.e. NH_4OH in the given list) $\Rightarrow$ (D)

FBO-51

(15) $K_b = \frac{K_w}{K_a} = 10^{-9}$

FBO-52

$pK_b = 9 \Rightarrow$ (B)

(16) $[H^+] = \frac{20 + x}{200} = 0.1 + x$

FBO-53

x is very small due to common ion effec

$\Rightarrow pH \simeq 1. \Rightarrow$ (A)

(17) $1.69 \times 10^{-5} = \frac{(0.01\alpha)(0.01\alpha + 0.01)}{0.01(1-\alpha)}$

FBO-54

$1.69 \times 10^{-3} = \frac{\alpha(1+\alpha)}{1-\alpha}$ $\simeq \alpha$ $(\because \frac{1-\alpha}{1+\alpha} \simeq 1)$

=> (C)

(18) By dilution law α will increase on dilution => (C)

FBO-55

(19) $\alpha \simeq 1$ => (D)

FBO-56

(20) $K_h = \frac{K_a}{K_w} = 10^9$ => (B)

FBO-57

(21) $[H_3O^+] = \sqrt{1.8 \times 10^{-6} + 1.8 \times 10^{-6}}$

FBO-58

$= 1.9 \times 10^{-3}$ => (A)

(22) α increases on dilution => (D)

FBO-59

(23) $C = \frac{2.4 \times 0.75}{180} = 0.01$

FBO-60

$[H^+] = \frac{-10^{-2} + \sqrt{5} \times 10^{-2}}{2}$

$pH = 2.2$ => (B)

HA - 3

(1) NO_3^- (Since conj of SA HNO_3) ⇒ (C)

FBO-61

(2) NH_4Cl due to cationic hydrolysis ⇒ (A)

FBO-62

(3) $2.4 \times 10^{-5} = \frac{K_w}{K_b} \Rightarrow K_b = 4.1 \times 10^{-10}$ ⇒ (B)

FBO-63

(4) Al^{3+} cationic hydrolysis makes solution acidic and K^+ can't hydrolyse.

FBO-64

⇒ (B)

(5) $pH = 7 + \frac{1}{2}\log(0.1) + \frac{1}{2} \times 4.74$.

FBO-65

$= 7 - 0.5 + 2.37$

$= 8.87$ ⇒ (B)

(6) Hydrolysis of Cu^{2+} ions makes the solution acidic

FBO-66

⇒ (A)

(7) CH_3COOK ⇒ $pH > 7$

FBO-67

Na_2CO_3 ⇒ $pH > 7$ ⇒ (C)

NH_4Cl ⇒ $pH < 7$

$NaNO_3$ ⇒ $pH = 7$

(8)

FBO-68

0.01 m H_2S $10^{-7} < [H^+] < 10^{-2}$

0.01 m H_2SO_4 $10^{-2} < [H^+] < 0.02$

0.01 m NaCl $[H^+] = 10^{-7}$

$NaNO_2$ $10^{-14} < [H^+] < 10^{-7}$

so (C)

(9) NaH_2PO_2 ($\because$ H_3PO_2 is monobasic acid)

FBO-69

$\Rightarrow$ (B)

(10) $NaHSO_3$ ($\because$ H_2SO_3 is dibasic acid)

FBO-70

$\Rightarrow$ (C)

(11) $pH = \frac{4.75 + 1}{2} = 2.875 \Rightarrow$ (C)

FBO-71

(12) Basic soln will be due to anionic hydrolysis only. so CH_3COONa or $CaCO_3$

FBO-72

but $CaCO_3$ does not readily dissolve in water so CH_3COONa

$\Rightarrow$ (D)

(18) ~~$8.22 = 7 + \frac{4.75}{2} + \frac{1}{2}\log(10^{-2}n)$~~

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(18) $8.52 = 7 + \frac{4.75}{2} + \frac{1}{2}\log(10^{-2}n)$

FBO-78

$\Rightarrow n = 2 \quad \Rightarrow$ (A)

(19) $R < X < Y < Z \quad \Rightarrow$ (D)

FBO-79

(20) acidic soln due to dominant cationic hydrolysis $\Rightarrow$ II, III, IV

FBO-80

$\Rightarrow$ (B)

(21) $[H^+] = \sqrt{\frac{CK_w}{K_b}} = \sqrt{\frac{10^{-14} \times 0.1}{4 \times 10^{-9}}}$

FBO-81

$[H^+] = \frac{10^{-3}}{2} = 5 \times 10^{-4}$

$\Rightarrow [OH^-] = 2 \times 10^{-11} \quad \Rightarrow$ (B)

(22) $pH = \frac{pK_1 + pK_2}{2} \Rightarrow$ (A)

FBO-82

(13) FBO-73

K_2CO_3 ($\because$ HCO_3^- is WA)

$\Rightarrow$ (D)

(14) FBO-74

$\alpha = \sqrt{\frac{K_w}{cK_b}}$ $\Rightarrow$ (B)

(15)

NH_4Cl	~~pH > 7~~ pH < 7
KCN	pH > 7
$AlCl_3$	pH < 7
CH_3COONa	pH > 7

(15) FBO-75

$pH = 7 + \frac{1}{2}\log 1 + \frac{1}{2} \times 4.7$

$= 9.35$ $\Rightarrow$ (C)

(16) FBO-76

$pH = 7 + \frac{1}{2}\log c + \frac{1}{2} pKa_2$.

$\Rightarrow$ (C)

(17) FBO-77

$\frac{\alpha}{1-\alpha} = \sqrt{\frac{10^{-14}}{3\times10^{-7} \times 3\times10^{-7}}}$ $\Rightarrow$ $\frac{\alpha}{1-\alpha} = \sqrt{\frac{1}{9}}$

$\frac{\alpha}{1-\alpha} = \frac{1}{3}$ $\Rightarrow$ $\alpha = \frac{1}{4}$ $\Rightarrow$ (D)

MA-4.

(1) B

FBO-83

(2) At half pt $pH = pK_a$

FBO-84

$\Rightarrow K_a = 10^{-4.3} = 5\times10^{-5} \Rightarrow$ (A)

(3) $10^{-4} = \dfrac{1.8\times10^{-5}\times 0.1}{C}$

FBO-85

$\Rightarrow C = 1.8\times10^{-2}$

$\Rightarrow w = 1.8\times10^{-2}\times 82 = 1.476\,g \Rightarrow$ (B)

(4) $BC = \dfrac{0.01}{6.832 - 6.745} = 0.115 \Rightarrow$ (B)

FBO-86

(5) $pH = 4.75 + \log\dfrac{6\times10^{-2}}{2\times10^{-2}}$

FBO-87

$= 4.75 + 0.477 = 5.23 \Rightarrow$ (C)

(6) $3.8\times10^{-7} = \dfrac{10^{-6}\times[HCO_3^-]}{[CO_2]}$

FBO-89

$\Rightarrow \dfrac{[HCO_3^-]}{[CO_2]} = 0.38 \Rightarrow$ (B)

(6)

FBO-88 $4 = pK_b + \log \frac{4}{12-4}$

~~$pK_b = 10.3$~~

$\Rightarrow pK_b = 4.3 \quad \Rightarrow$ (B)

(8)

FBO-90 $pH = 4.75 + \log \frac{0.2}{0.1} = 5.05$

$\Rightarrow$ (B)

(9)

FBO-91 $5.05 = 4.75 + \log \frac{0.6-x}{x}$

$2 = \frac{0.6-x}{x} \Rightarrow x = 0.2 \Rightarrow$ (C)

(10)

FBO-92 $pH = 4.75 + \log \frac{0.3+0.2}{0.4-0.2}$

$= 5.148 \Rightarrow$ (B)

(11)

FBO-93 $5.05 = 4.75 + \log \frac{salt}{acid}$

$\Rightarrow \frac{acid}{salt} = \frac{1}{2} \Rightarrow$ (C)

(12) (D) Basic buffer

FBO-94

(13) Due to common ion effect α of HAc

FBO-95 will decrease so $[H^+]$ will dec. so

pH will inc. $\Rightarrow$ (A).

(14) FBO-96 $pH = 6 + \log \frac{0.2}{0.4} = 5.7$ ⇒ (B)

(15) FBO-97 $[H^+] = 1.8 \times 10^{-5} \times \frac{20}{20} = 1.8 \times 10^{-5}$ ⇒ (B)

(16) FBO-98 $pOH = pK_b + \log \frac{\text{Salt}}{\text{base}} = 4.7 + \log 1$

⇒ $pH = 9.3$ ⇒ (D).

(17) FBO-99 (A) SA does not makes a buffer

(18) FBO-100 (A)

(19) FBO-101 (D)

(20) FBO-102 B

(21) FBO-103 For Acidic colour $pH < 5.4 + \log \frac{1}{8}$

⇒ $pH < 5.4 - 0.9$

⇒ $pH < 4.5$

For Base colour $pH > 5.4 + \log 16$

⇒ $pH > 5.4 + 1.2$

⇒ $pH > 6.6$.

⇒ (B)

HA-5

(1) FB0104

$K_{sp} = (2x)^2(5x)^5$ $\quad$ $A_2X_5 \rightarrow 2A^{5+} + 5X^{2-}$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad 2x \quad\; 5x$

$= 1.25 \times 10^4 x^7$

$\Rightarrow$ (D)

(2) FB0105 (B) presence of OH^- in soln deters the hydrolysis of CH_3COO^- which reduces the solubility of CH_3COOAg.

(3) FB0106 A $\left(\frac{10^{-4}}{2}\right)\left(\frac{10^{-4}}{2}\right) > 1.8 \times 10^{-10}$

(4) FB0107

$Ca_3(PO_4)_2 \rightarrow 3Ca^{2+} + 2PO_4^{3-}$

$\qquad\qquad\qquad 3x \qquad 2x$

$K_{sp} = (3x)^3(2x)^2 \quad 108x^5 \Rightarrow$ (D)

(5) FB0108

$CaF_2 \rightarrow Ca^{2+} + 2F^-$

$\qquad\qquad s \qquad 2s + 0.1$

$\qquad\qquad\qquad \approx 0.1$

$s(0.1)^2 = 3.4 \times 10^{-11}$

$s = 34 \times 10^{-9} \Rightarrow$ (C)

(6) FB0109

$[Ca^{2+}][F^-]^2 = K_{sp}$

so (B)

(7) FB0110

$Fe(OH)_3$ is basic so its solubility will be maximum in acid $\Rightarrow$ (D)

(8) D

FBO-111

(9) $K_{sp} = (S)(2S)^2$, eq. $PbI_2 \longrightarrow Pb^{2+} + 2I^-$

S 2S

FBO-112

$[Pb^{2+}] = S = \sqrt[3]{\frac{K_{sp}}{4}}$.

$[Pb^{2+}] = \frac{1}{2}[I^-] \Rightarrow$ (D)

(10) (C) Due to acidic nature of $NaHSO_4$ solubility of $CaCO_3$ will increase since it has ~~basi~~ basic nature.

FBO-113

(11) $S = \sqrt{K_{sp}} = 10^{-1}\,M = 10^{-1} \times 100$ g/L

FBO-114

$= 10$ g/L $\Rightarrow$ (C)

(12) (B) $Q_{sp} > K_{sp}$

FBO-115

(13) $S(10^{-10})^3 = 10^{-33}$

FBO-116

$S = 10^{-3} \Rightarrow$ (A)

(14) $Li_3Na_3[(AlF_6)_2] \longrightarrow 3Li^+ + 3Na^+ + 2AlF_6^{3-}$

3S 3S 2S

FBO-117

$K_{sp} = (3S)^3(3S)^3(2S)^2$

$= 2916\,S^8 \Rightarrow$ (D)

(15) B

FBO-118

(16) a) $S = \sqrt[5]{\frac{10^{-70}}{108}}$

FBO-119

b) $S = \sqrt{7 \times 10^{-16}}$ $\Rightarrow$ (B)

c) $S = \sqrt{8 \times 10^{-37}}$

d) $S = \sqrt[3]{\frac{6 \times 10^{-51}}{4}}$

(17) $[Ba^{2+}]_{max} = \frac{2.4 \times 10^{-10}}{6 \times 10^{-4}}$ $\Rightarrow$ (A)

FBO-120

$= 0.4 \times 10^{-6}$

(18)

FBO-121) (A) for an added amt. of H_2S i.e. S^{2-} ions if As_2S_3 ppt. first then it has lower solubility product

FBO-122) (A)

$s^2 = K_{sp}$

$s = 5 \times 10^{-5}$

moles $= 5 \times 10^{-5}$

mass $= 5 \times 10^{-5} \times 128$ g

FBO-123) (C)

$2s = 1.5 \times 10^{-4}$

$s = 0.75 \times 10^{-4}$

$K_{sp} = 4s^3$

FBO-124) (C)

$AgSCN \rightleftharpoons Ag^+ + SCN^-$

$\quad\quad\quad x+y \quad\quad x$

$AgBr \rightleftharpoons Ag^+ + Br^-$

$\quad\quad\quad y+x \quad\quad y$

$(x+y)x = 1.2 \times 10^{-12}$

$(y+x)y = 5 \times 10^{-13}$

FBO-125) (B) more ppt. will happen

FBO-126) (B)

$PbCl_2 \rightleftharpoons Pb^{2+} + 2Cl^-$

$\quad\quad\quad s \quad\quad 2s + 0.2$

$(s)(2s+0.2)^2 = 4 \times (0.01)^3$

FBO-127) (B) Solubility of both the salts decrease due to common ion effect.

Charge balance is still valid

FBO-128) (B) $PbI_2 \rightleftharpoons Pb^{2+} + 2I^-$

$s+0.1 \quad 2s$

$(s+0.1)(2s)^2 = 7.1\times10^{-9}$

FBO-129) (B) $[M^{2+}][OH^-]^2 = K_{sp, M(OH)_2}$ for ppt.

$[OH^-]$ required for ppt. of $M(OH)_2$ $= 2\times10^{-5}$

$[X^{3+}][OH^-]^3 = K_{sp, X(OH)_3}$ for ppt.

$[OH^-]$ required for ppt. of $X(OH)_3$ $= 3\times10^{-5}$

FBO-130) (C) $s = \frac{1}{0.8}\times\sqrt[3]{\frac{8\times10^{-5}}{4}}$

FBO-131) (D) For similar salts, salt with lowest K_{sp} gets ppt. first

FBO-132) (B) common ion effect

FDO-133) (C) $Hg_2I_2 \rightleftharpoons Hg_2^{2+} + 2I^-$

EXERCISE - 1 [C]

1. (36)

$$\underset{0.1(1-\alpha)}{HAc} \xrightleftharpoons{K_a} \underset{0.4\alpha}{H^+} + \underset{(b\times 0.4\alpha)}{Ac^-}$$

$0.4\alpha = 2\times10^{-4}$

$\alpha = 5\times10^{-4}$

$K_a = \dfrac{b\times 0.4\alpha}{0.4}$

$b = \dfrac{1.8\times10^{-5}}{5\times10^{-4}}$

2. (2)

$4S^3 = 3.2\times10^{-11}$

$4S^3 = 32\times10^{-12}$

$S = 2\times10^{-4}\,\text{mole}/\text{mL}$

$= .02\,\text{mg}/\text{ml}$

$= 2\,\text{mg per}\,100\,\text{mL}$

3. (4)

(a), (b), (c), (f)

4. (2)

For pptn. Of $Fe(OH)_3, [OH^-] = \sqrt[3]{\dfrac{4\times10^{-28}}{0.05}} = 2\times10^{-9}$

For pptn. Of $Fe(OH)_2, [OH^-] = \sqrt{\dfrac{8\times10^{-16}}{0.02}} = 2\times10^{-7}$

$\Delta(pH) = 9-7 = 2$

5. (3)

(a), (b), (d)

6. (6 and 2)

At isoelectric point $pH = \dfrac{1}{2}[pKa_1 + pKa_2] = \dfrac{1}{2}[2.3+9.7] = 6$

$[H^+] = \sqrt{5\times10^{-3}M\times0.2} = \sqrt{10\times10^{-5}} = 10^{-2}$

$pH = -\log[H^+] = 2$

7. (3)

$KCN,\ K_2CO_3, LiCN$ are all salts of WA and SB.

8. (7)

$[Cl^-] = \sqrt{K_{sp}(CuCl)} = 10^{-3}M$

$$\left[Ag^+\right]=\frac{1.6\times10^{-10}}{10^{-3}}=1.6\times10^{-7}\,M\Rightarrow x=7$$

9. (768)

$$K_{sp}\left(AgCl\right)=10^{-4}\times10^{-6}=10^{-10}$$

$$K_{sp}\left(Ag_2CrO_4\right)=\left(10^{-4}\right)^2\times8\times10^{-4}=8\times10^{-12}$$

No. of moles of Cl^- remaining in solution

$$=10\times10^{-7}-8\times10^{-7}$$

$$=2\times10^{-7}$$

$$\Rightarrow\left[Ag^+\right]=\frac{10^{-10}}{2\times10^{-7}}=5\times10^{-4}$$

$$\therefore\left[CrO_4^{2-}\right]=\frac{8\times10^{-12}}{25\times10^{-8}}=3.2\times10^{-5}$$

$\therefore$ No of moles of CrO_4^{2-} pptd

$$=80\times10^{-5}-3.2\times10^{-5}$$

$$=76.8\times10^{-5}$$

10. (810)

$$\underset{\substack{0.2V\\ \sim0=10^{-6}}}{Ag^+}+\underset{\substack{1\times V\\ V-0.4V}}{2CN^-}\rightleftharpoons\underset{0.2V}{Ag\left[CN\right]_2^-}$$

$$K_{f_1}=\frac{\left(\frac{0.2V}{2V}\right)}{10^{-6}\times\left(\frac{0.6V}{2V}\right)^2}=\frac{10^7}{9}$$

$$\underset{\substack{0.2V\\ \sim0}}{Zn^{2+}}+\underset{\substack{1\times V\\ V-0.8V}}{4CN^-}\rightleftharpoons\underset{\substack{-\\ 0.2V}}{Zn\left(CN\right)_4^{2-}}$$

$$=10^{-12}\quad=0.2V$$

$$K_{f_2}=\frac{\left(\frac{0.2V}{2}\right)}{10^{-12}\times\left(\frac{0.2V}{2V}\right)^4}=10^{15}$$

$$K_{f\left(question\right)}=\frac{Kf_2}{\left(Kf_1\right)^2}=\frac{10^{15}}{10^{14}}\times81=810$$

1. (A)

Conc. of $Na_2CO_3 = 1.0\times10^{-4}M$

$\therefore \left[CO_3^{2-}\right] = 1.0\times10^{-4}M$

i.e., $s = 1.0\times10^{-4}M$

At equilibirum , $\left[Ba^{2+}\right]\left[CO_3^{2-}\right] = K_{sp}$ of $BaCO_3$

$$\left[Ba^{2+}\right] = \frac{K_{sp}}{\left[CO_3^{2-}\right]} = \frac{5.1\times10^{-9}}{1.0\times10^{-4}} = 5.1\times10^{-5}M$$

2. (A)

Metal halide on hydrolysis with water form correc-sponding hydroxides.
The basic strength of hydroxide increases as we move down in a group.
Hence, $Be(OH)_2$ will have lowest pH.

3. (D)

Given as 330 K, $K_w = 10^{-13.6}$

$pK_w = pH + pOH \Rightarrow 13.6 = pH + pOH$

$pOH = -\log 10^{-4} \Rightarrow pOH = 4$

$\therefore pOH = 13.6 - 4 = 9.6$

4. (C)

Higher the value of K_a, higher will be acidic nature. Further, since CN^-, F^- and NO_2^- are conjugate base of the acids HCN and HNO_2 respectively, hence the correct order of base strength will be: $F^- < NO_2^- < CN^-$

($\because$ stringer the acid, weaker will be its conjugate base)

5. (B)

$N_3H \rightleftharpoons N_3^- + H^+$

Hydrazoic acid

6. (C)

$2HNO_3(aq) + \left[Ag(NH_3)_2\right]^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)\uparrow + 2NH_4^+(aq) + 2NO_3^-(aq)$

When nitric acid is added to amine solution, solution is made acidic and the complex ion dissociates and liberate silver ion to recombine with chloride ion.
This is the conformatory test for silver in group 1.

7. (D)

$NH_3 + HCl \longrightarrow NH_4Cl$

Moles of $HCl = 0.2\times25\times10^{-3} = 0.005$

Moles of $NH_3 = 0.2\times50\times10^{-3} = 0.01$

Excess $NH_3 = 0.01 - 0.005 = 0.005 moles$

1 mole ammonia =1 mole NH_4Cl

$0.005 NH_3 \equiv 0.005 NH_4Cl$

Total volume $= V_{HCl} + V_{NH_3} = 25 + 50 = 75 mL$

$$[NH_3] = [NH_4Cl] = \frac{0.005 mole}{75 \times 10^{-3} L} = 0.066 M$$

$$pOH = pK_b + \log\frac{[NH_4Cl]}{[NH_3]}$$

$$pOH = 4.75 + \log\frac{[0.066]}{[0.066]}$$

$pOH = 4.75$

$pH = 14 - pOH \Rightarrow pH = 9.25$

8. (B)

$$75 mL \frac{M}{5} HCl + 25 mL \frac{M}{5} NaOH$$

$25 mL \frac{M}{5} NaOH$ will neitralise 25 mL $\frac{M}{5} HCl$

$75 - 25 = 50 mL \frac{M}{5} HCl$ will remain.

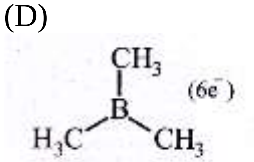
Total volume will be $75 + 25 = 100 mL$

When 50 mL $\frac{M}{5} HCl$ is diluted to 100mL, molarity will reduce to half, i.e., $\frac{M}{10}$.

$$[H^+] = [HCl] = \frac{1}{10}$$

$$pH = -\log_{10}[H^+ = -\log_{10}]\frac{1}{10} = 1$$

9. (D)



Due to incomplete octet of B, it can act as a Lewis acid.

10. (D)

$$Cd(OH)_2 \rightleftharpoons Cd^{2+} + 2OH^-$$

At equilibrium , $K_{sp} = s(2s)^2 = 4s^3$

$$\Rightarrow K_{sp} = 4 \times (1.84 \times 10^{-5})^3$$

Solubility in buffer solution having $pH = 12$

$[OH^-] 10^{-2}$

$$Cd(OH)_2 \rightleftharpoons Cd^{2+} + 2OH^-$$

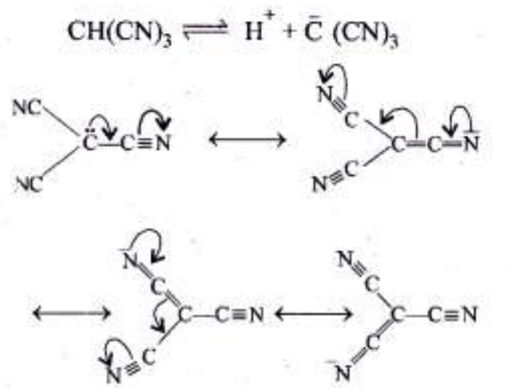
$$s' \qquad 2s + 10^{-2} \approx 10^{-2}$$

$$\therefore K_{sp} = 4 \times (1.84 \times 10^{-5})^3 = s'(10^{-2})^2$$

$$\Rightarrow s' = \frac{24.9\times10^{-15}}{10^{-4}} = 2.49\times10^{-10}\,M$$

11. (C)

Due to the resonance stabilisation of the conjugate base, $CH(CN)_3$ is the strongest acid amongst the given compounds.



The conjugate bases of $CHBr_3$ and CHI_3 are stabilised by inductive effect of halogens. This is why, they are less stable. Also, the conjugate base of $CHCl_3$ involves backbonding between 2p and 3p orbitals.

12. (B)

m.mol of $H_2SO_4 = 20\times0.1 = 2$

m.mol of $NH_4OH = 30\times0.2 = 6$

$H_2SO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + 2H_2O$

Initial	2m mol	6m mol	0
Final	(0)	$(6-2\times2)$	2m mol

$= 0\text{m mol} = 2\text{m mol}$

+

$[NH_4](\text{from}\,(NH_4)_2SO_4) = 2\times2 = 4\text{m mol}$

Total volume $= 30+20 = 50\text{mL}$

$$pOH = pK_b + \log\left[\frac{\text{Salt}}{\text{Base}}\right] = 4.7 + \log\frac{4/50}{2/50} = 4.7 + \log 2 = 5$$

$pH = 14 - pOH$

$pH = 14 - 5 = 9$

13. (B)

Let s be the solubility of $Ca(OH)_2$ in water

$$Ca(OH)_2 \rightleftharpoons Ca^{2+} + 2OH^-$$

s 2s

$$K_{sp} = [Ca^{2+}][OH^-]^2 = s\times(2s)^2$$

$$\Rightarrow 5.5\times10^{-6} = 4s^3 \Rightarrow s^3 = \frac{5.5}{4}\times10^{-6}$$

$$s = \left[\frac{5.5}{4}\right]^{\frac{1}{3}} \times 10^{-2} = 1.11 \times 10^{-2}$$

14. (D)

$$HCl + CH_3COONa \longrightarrow CH_3COOH + NaCl$$

	HCl	CH_3COONa	CH_3COOH	NaCl
Millimoles (initial)	10	20	0	0
Millimoles (Final)	0	10	10	10

Buffer solution contains CH_3COONa (10 millimole) and CH_3COOH (10 millimole) which is a acidic buffer.

15. (B)

$$Cr(OH)_3 \rightarrow Cr^{3+} + 3OH^-$$

$$\quad\quad s \quad\quad 3s$$

$$K_{sp} = s.(3s)^3$$

$$\Rightarrow 6 \times 10^{-31} = 27.s^4; s = \left(\frac{6}{27} \times 10^{-31}\right)^{1/4}$$

$$\left[OH^-\right] = 3s = 3 \times \left(\frac{6}{27} \times 10^{-31}\right)^{1/4} = \left(18 \times 10^{-31}\right)^{1/4} M$$

16. (B)

Temperature plays a significant role on pH measurements. As the temperature rises, molecular vibrations increase which results in greater ability of water to ionise and form more hydrogen ions. As a result, the pH will drop. So assertion is incorrect.

The dissociation of water molecules into ions is bond breaking and is therefore an endothermic process. So reason is also incorrect.

17. (A)

$$AgCN \rightleftharpoons Ag^+ + CN^-$$

Solubility of AgCN is x.

$$pH = 3 \Rightarrow \left[H^+\right] = 10^{-3}$$

$$HCN \rightleftharpoons H^+ + CN^-$$

$$K_a = \frac{\left[H^+\right]\left[CN^-\right]}{[HCN]} \Rightarrow \frac{\left[10^{-3}\right]\left[CN^-\right]}{[HCN]} = 6.2 \times 10^{-10}$$

$$\Rightarrow \frac{\left[CN^-\right]}{[HCN]} = 6.2 \times 10^{-7}$$

Each $CN-$ hydrolyses to give one HCN as:

$$CN^- + H_2O \rightleftharpoons HCN + OH^-$$

HCN is a weak acid, thus, $[HCN] >> \left[CN^-\right]$

$$x = \left[Ag^+\right] = \left[CN^-\right] + [HCN]$$

$$\Rightarrow x = \left[Ag^+\right] \approx [HCN] \Rightarrow \left[CN^-\right] = x \times 6.2 \times 10^{-7}$$

$$K_{sp}(AgCN) = \left[Ag^+\right]\left[CN^-\right]$$

$$\Rightarrow 2.2 \times 10^{-16} = (x)\left(x \times 6.2 \times 10^{-7}\right)$$

$$= x^2 = 3.55 \times 10^{-10} \Rightarrow x = 1.88 \times 10^{-5}$$

18. (C)

Phenolphathalein have colour change range between pH 8.3 and 10.5.

19. (B)

$$\left[H^+\right] = \frac{\left(n_{H^+}\right)_{HCl} + \left(n_{H^+}\right)_{H_2SO_4}}{\text{Total volume}}$$

$$\frac{\left[M_{HCl} \times n_{factor,HCl} \times V_{HCl}\right] + M_{H_2SO_4} \times n_{f_{H_2SO_4}} \times V_{H_2SO_4}}{600}$$

$$\left[H^+\right] = \frac{(0.01 \times 1 \times 200) + (0.01 \times 2 \times 400)}{600}$$

$$= \frac{2+8}{600} = \frac{10}{600} = \frac{1}{60}$$

$$pH = -\log\left[\frac{1}{60}\right] = 1.78$$

20. (C)

$$pH + pOH = 14$$

$$pOH = 14 - 8.26$$

$$pOH = pK_b + \log\frac{\left[NH_4^+\right]}{\left[NH_3\right]}$$

$$\Rightarrow 5.74 = 4.74 + \log\frac{\left[NH_4^+\right]}{0.2} \Rightarrow \left[NH_4^+\right] = 2M$$

Molar mass of $NH_4Cl = 53.5 g\, mol^{-1}$

Amount of $NH_4Cl = 2 \times 53.5 = 107g$

21. (C)

C-concn. of salt, NH_4Cl, produced by neutralization of NH_4OH and HCl.

NH_4Cl, no. of moles $= 2m\,mol = 2 \times 10^{-3} mol$

$$\left[NH_4Cl\right] = \frac{2m\,mol}{(20+40)ml} = \frac{1}{30}M$$

$$pH7 - \frac{1}{2}pK_b - \frac{1}{2}\log C$$

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

22. (D)

$$H_2C_2O_4 \rightleftharpoons H^+ + HC_2O_4^- \; K_{a_1} \qquad \ldots\ldots \text{(i)}$$
$$H_2C_2O_4^- \rightleftharpoons H^+ + C_2O_4^{2-} K_{a_2} \qquad \ldots\ldots \text{(ii)}$$
$$H_2C_2O_4 \rightleftharpoons 2H^+ + C_2O_4^{2-} K_{a_3} \qquad \ldots\ldots \text{(iii)}$$

Adding of equation (i) with equation (ii) gives equation (iii),

So $K_{a_3} = K_{a_1} \times K_{a_2}$

23. (D)

In deionized water no common ion effect will take place so solubility of AgCl will be maximum in it.

$$KCl \longrightarrow K^+ + Cl^-$$
$$HCl \longrightarrow H^+ + Cl^-$$
$$AgNO_3 \longrightarrow Ag^+ + NO_3^-$$

24. (B)

According to Henderson-Hasselbalch equation

$$pH = pK_a + \log\frac{[Salt]}{[Acid]}$$
$$4 = 5 - \log 1.3 + \log\frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$$
$$\log\frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]} = \log 1.3 - 1 = \log\frac{1.3}{10}$$
$$\therefore \log A - \log(B) = \log\left(\frac{A}{B}\right)$$
$$\frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]} = 0.13$$

25. (A)

$$Bi_2S_3 \rightleftharpoons 2Bi^{3+} + 3S^{2-}$$
$$\qquad\qquad 2s \qquad 3s$$
$$K_{sp} = (2s)^2(3s)^3 = 108(s)^5$$
$$(s)^5 = \frac{1.08 \times 10^{-73}}{108} \Rightarrow s = 10^{-15}$$

26. (C)

Phenolphthalein dissociate in basic medium

$$HPh(aq) \rightleftharpoons H^+ + Ph^-$$

(colourless) (Pink)

27. (D)

Assertion: The amphoteric nature of water can be explained by Bronsted-Lowry concept

Reason: $H_2S + H_2O \rightleftharpoons H_3O^+ + HS^-$

Acid Base

$$H_2O + NH_3 \rightleftharpoons NH_4^+ + \overline{O}H$$

28. (37)

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

30 bar ………. 1 mol/L

3 bar ……….. 0.1 mol/L

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

$t = 0$ 0.1 0 0

at Equb. $0.1(1-\alpha)$ 0.1α 0.1α

$$4.0\times10^{-7} = \frac{0.1\alpha^2}{1-\alpha}$$

As $(1-\alpha)\approx 1 \Rightarrow \alpha^2 = 4\times10^{-6} \Rightarrow \alpha = 2\times10^{-3}$

$$\left[H^+\right] = C\alpha = 2\times10^{-4}\,M$$

$$pH = 4\times\log 2 = 3.7 \simeq 37\times10^{-1}$$

29. (5.22)

No. of moles $= \dfrac{\text{Mass}}{\text{Molar mass}}$

$$3g\,CH_3COOH = \frac{3}{60} = 0.05\,mol = 50\,m\,mol$$

No. of millimoles = Molarity $\times$Volume in mL

250 mL of 0.1 $M\,HCl = 250\times0.1 = 25\,m\,mol$

500mL solution = 50 m mol CH_3COOH

20 mL solution $= \dfrac{50}{500}\times20 = 2m$ mol CH_3COOH

500 mL solution contains $= 25m$ mol HCl

20 mL solution contains $= \dfrac{25}{500}\times20 = 1m$ mol HCl

$\dfrac{1}{2}$mL of $5MNaOH = \dfrac{1}{2}\times5 = 2.5$ m mol NaOH

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

Remaining $NaOH = 2.5 - 1 = 1.5m$ mol

$$CH_3COOH + NaOH(\text{remaining}) \rightarrow CH_3COONa + \text{Water}$$

2	1.5	0	0
0.5	0	1.5	–

$$pH = pK_a + \log\frac{1.5}{0.5} = 4.74 + \log 3 = 4.74 + 0.48 = 5.22$$

30. (4)

Let moles of NH_3 added $= a$

$$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq)$$

$t = 0$ 0.8 $\left(\dfrac{a}{2}\right)$ 0

$t = \infty \quad 5\times10^{-8} \quad \left(\frac{a}{2}-1.6\right) \quad 0.8$

$$K_f = \frac{0.8}{\left(5\times10^{-8}\right)\left(\frac{a}{2}-1.6\right)} = 10^8$$

$$\Rightarrow \frac{a}{2}-1.6 = 0.4 \Rightarrow a = 4$$

31. (1)

k_{a_1} of $H_2SO_3 >> k_{a_2}$ of H_2SO_4

$\therefore$ The contribution of H^+ from 2nd dissociation of H_2SO_3 can be neglected.

$$H_2SO_3 \rightleftharpoons H^+ + HSO_3^-$$

t=0   c   0   0

t=t $c(1-\alpha)$ $c\alpha$ $c\alpha$

$$\frac{c\alpha^2}{1-\alpha} = 1.7\times10^{-2} \Rightarrow \frac{0.588\alpha^2}{1-\alpha} = 1.7\times10^{-2}$$

$$\Rightarrow 58.8\alpha^2 + 1.7\alpha - 1.7 = 0$$

$$\alpha = \frac{-1.7+\sqrt{1.7^2+4\times1.7\times58.8}}{2\times58.8} = 0.156$$

$$\left[H^+\right] = c\alpha = 0.156\times0.588 = 0.092$$

$$pH = -\log\left[H^+\right] = 1.036 \approx 1$$

32. (2)

$$Zn(OH)_2(s) \rightleftharpoons Zn^{2+}(aq) + 2OH^-(aq)$$

s $(0.1+2s) \simeq 0.1$

$$K_{sp} = s(0.1)^2$$

$$2\times10^{-20} = s\times10^{-2} \Rightarrow s = 2\times10^{-18}$$

Therefore, $x = 2$

33. (108)

$$A_3B_2 \rightleftharpoons 3A^{2+}(aq) + 2B^{3-}(aq)$$

3s   2s

$$K_{sp} = (3s)^3(2s)^2 = 108s^5$$

$$K_{sp} = 108\left(\frac{x}{M}\right)^5 \qquad \left(\because \frac{x}{M} = s\right)$$

$$(\text{Given})\ K_{sp} = a\left(\frac{x}{M}\right)^5$$

On comparing, $a = 108$

34. (3)

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

$\left[NH_3\right] = 2\times 0.0210 = 0.042 m\,mol$

$NH_4Cl \longrightarrow NH_4^+ + Cl^-$

$\left[NH_4Cl\right] = 5\times 0.0504 = 0.252\, m\,mol$

By Henderson- Hasselbalch equation,

$$pOH = pK_b + \log\frac{[Salt]}{[Base]}$$

$$= -\log\left(1.8\times 10^{-5}\right) + \log\left(\frac{0.252}{0.042}\right) = 4.74 + 0.77$$

$$pOH = 5.51$$

$$\left[OH^-\right] = 10^{-5.51} = 3.09\times 10^{-6} \simeq 3\times 10^{-6}$$

35. (6021)

	$HCl(aq)$	$+\ NaOH(aq)$	$\rightarrow NaCl(aq)$	$+\ H_2O(\ell)$
Initial	50mm	30mm	-	-
Final	20 mm		20	20

$$[HCl] = \frac{20}{80} = \frac{1}{4}M = 2.5\times 10^{-1}M$$

$$pH = -\log 2.15\times 10^{-1} = 1 - 0.33979 = 0.6021$$

$$\Rightarrow pH = 6021\times 10^{-4}$$

36. (10)

Henderson $-$Hasselbalch equation,

$$pH = pK_a + \log\frac{[Salt]}{[Acid]}$$

$$\Rightarrow 5074 = 4.74 + \log\frac{[CH_3COONa]}{1}$$

$$5.74 - 4.74 = \log[CH_3COONa] - \log 1$$

$$= 1\log[CH_3COONa] = 10^1 \approx 10M$$

37. (64)

In pure water, $s = 8\times 10^{-4}$

$$K_{sp} = s^2 = \left(8\times 10^{-4}\right)^2 = 64\times 10^{-8}$$

In 0.01 $M\,H_2SO_4$,

$$CdSO_4 \longrightarrow \underset{s}{Cd^{2+}} + \underset{s}{SO_4^{2-}}$$

Total conc. of $SO_4^{2-} = 0.01 + s$

$$K_{sp} = s(s + 0.01)$$

$$K_{sp} = s.(0.01)\left(\text{neglecting } s^2\right)$$

$$s = \frac{64\times 10^{-8}}{0.01} = 64\times 10^{-6}$$

38. (50)

For $A_2X, A_2X \longrightarrow 2A^+ + X^{2-}$

$$2s_1 \quad s_1$$

$$K_{sp} = 4s_1^3 \Rightarrow s_1 = \sqrt[3]{\frac{K_{sp}}{4}} = 10^{-4}$$

For $MX, MX \longrightarrow M^{2+} + X^{2-}$

$$s_2 \quad s_2$$

$$K_{sp} = s_2^2 \Rightarrow s_2 = \sqrt{K_{sp}} = 2\times10^{-6}$$

$$\frac{s_1}{s_2} = \frac{s(A_2X)}{s(MX)} = \frac{10^{-4}}{2\times10^{-6}} = 50$$

39. (141)

Given: $[K_{sp}]_{PbI_2} = 8\times10^{-9}$

At $t=0$ 0.1 M - -

At $t=t$ − 0.1 M 0.2 M

(II) $PbI_2 \rightleftharpoons Pb^{+2}(aq) + 2I^-(aq)$

$$s \quad 2s$$

$$[Pb^{2+}] = s + 0.1 \simeq 0.1$$

Now: $K_{sp} = 8\times10^{-9} = [Pb^{+2}][I^-]^2$

$$\Rightarrow 8\times10^{-9} = 0.1\times(2s)^2 \Rightarrow 8\times10^{-8} = 4s^2 \Rightarrow s = \sqrt{2}\times10^{-4}$$

$$\Rightarrow s = 141\times10^{-6}M \Rightarrow x = 141.$$

40. (282)

$$K_{sp} = S^2$$

$$S = \sqrt{K_{sp}} = \sqrt{8\times10^{-28}} = 2\sqrt{2}\times10^{-14} = 2.82\times10^{-14}$$

$$= 282\times10^{-16}$$

41. (0)

Solubility of $CaF_2 = 2.34\times10^{-3}\times10\,g/L$

$$s = \frac{2.34}{78}\times10^{-2}mol/L$$

$$s = 3\times10^{-4}mol/L$$

$$CaF_2 \rightleftharpoons Ca^{2+} + 2F^-$$

$$s \quad s$$

$$K_{sp} = s(2s)^2 = 4(3\times10^{-4})^3 = 0.0108\times10^{-8}(mol/L)^3$$

42. (11)

0.001M NaOH

$$[OH^-] = 10^{-3}$$

$pOH = -\log\left[OH^-\right] \Rightarrow pOH = 3$

$pH + pOH = 14 \Rightarrow pH = 11$

43. (476)

Moles of $CH_3COOH = 50 \times 0.1 = 5m$ mole

$NaOH$	$+\ CH_3COOH$	$\longrightarrow$	$CH_3COONa + H_2O$
2.5 m mole	5 m mole		
0	2.5 m mole		2.5 mole

Total volume of this buffer solution $= 75mL$

$$pH = pK_a + \log\left(\frac{2.5/75}{2.5/78}\right) \Rightarrow pH = 4.76 = 476 \times 10^{-2}$$

44. (10.02)

H_2CO_3 is a weak dibasic acid. Since $NaOH$ is a srong acid H_2CO_3 reacts completely as a monobasic acid.

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-; HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

$$pK_{a_1} = 6.37 \qquad pK_{a_2} = 10.32$$

$$H_2CO_3 + NaOH \longrightarrow NaHCO_3 + H_2O$$

	H_2CO_3	$NaOH$	$NaHCO_3$
Initial:	0.01 mol	0.01 mol	
After mixing	$-$	-	0.01 mol

Final components in mixtture:

$NaHCO_3 = 0.01mol + 0.01mol = 0.02mol$

$Na_2CO_3 = 0.01mol$

Now, $HCO_3^- + H_2O \rightleftharpoons H_3O^+ + CO_3^{2-}$

Acid conjugated base

Applying Henderson $-$ Hasselbatch equation

$$pH = pK_{a_2} + \log\frac{\left[CO_3^{2-}\right]}{\left[HCO_3^-\right]} = 10.32 + \log\frac{0.01/0.1}{0.02/0.1}$$

$$= 10.32 + \log\frac{1}{2} = 10.32 - 0.3 = 10.02$$

EXERCISE - 2 [A]

Q.1 **[C]**

Sol. moles of $H_3PO_4 = 0.2 \times 50$ = 10 m moles

moles of $Na_3PO_4 = 0.2 \times 50$ = 10 m moles

$$\begin{array}{cccc} H_3PO_4 + & Na_3PO_4 \longrightarrow & H_2PO_4^- + & HPO_4^{2-} \\ 10 & 10 & 0 & 0 \\ 0 & 0 & 10 & 10 \end{array}$$

Buffer of NaH_2PO_4 & Na_2HPO_4

$$pH = Pka_2 + \log \frac{[HPO_4^{2-}]}{[H_2PO_4^-]} = 8 + \log 1 = 8$$

Q.2 **[A]**

Sol. In one litre initial pH=7

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

$[H^+]$ 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

pH = 4 – log 2 = 3.7

Q.3 **[D]**

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

Using $7.4 = 8 + \log \frac{[HPO_4^{2-}]}{[H_2PO_4]}$

$$H_3PO_4 + NaOH \longrightarrow NaH_2PO_4 + H_2O$$
$$\begin{array}{llll} 5\text{m mole} & x = 5 & & \\ 0 & 0 & & 5\text{m moles} \end{array}$$

$$NaH_2PO_4 + NaOH \longrightarrow Na_2HPO_4 + H_2O$$
$$\begin{array}{lll} 5 & x & \\ 5-x & & x \end{array}$$

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

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

x = 1

total 5 + 1 = 6 m moles $= 0.1 \times V\,ml$

V = 60 ml

Q.4 [A]

Sol. If both MX and M_2Y starts ppting simultaneously then

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

then $K_{sp}\left(M_2Y\right) = \left[M^+\right]^2\left[Y^{-2}\right]$

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

In Pure water for M_2Y

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

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

Q.5 [B]

Sol. Isoelectronic 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 & $pH = \frac{Pka_2 + Pka_3}{2}$

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

= 9.74

11. (A, B, C, D)

$$AgCl(s) \longrightarrow \underset{x}{Ag^+} + \underset{s}{Cl^-}(aq) \qquad K_{sp} = S \times x$$

$$\underset{x}{Ag^+} + \underset{0.2}{2NH_3} \rightleftharpoons \underset{s}{Ag(NH_3)_2^+} \qquad 10^8 = \frac{s}{(0.2)^2 \times x}$$

$$10^{-2} = \frac{s^2}{(0.2)^2}$$

$$[Cl^-] = s = 2 \times 10^{-2} M = [Ag(NH_3)_2^+]$$

$$x = [Ag^+] = \frac{10^{-10}}{2 \times 10^{-2}} = 5 \times 10^{-9} M$$

$$Ag^+ + NH_3 \rightleftharpoons Ag(NH_3)^+ \qquad K = 10^3 = \frac{[Ag(NH_3)^+]}{5 \times 10^{-9} \times 0.2}$$

$$[Ag(NH_3)^+] = 10^{-6} M$$

12. (A, B, D)

For ppt^n of AgCl, $[Ag^+] = \frac{10^{-10}}{5 \times 10^{-2}} = 2 \times 10^{-9} M$

For ppt^n of AgI, $[Ag^+] = \frac{4 \times 10^{-18}}{5 \times 10^{-2}} = 8 \times 10^{-17} M$

13. (A, B, C, D)

$$10 = \frac{1}{2}\left[14 + 6 + \log \frac{\frac{12.2}{M}}{0.1}\right]$$

$$20 = 20 + \log \frac{122}{M} \Rightarrow M = 122$$

14. (A, C, D)

15. (A, B, C, D)

After dilution $[H^+] = 10^{-2} \Rightarrow pH = 2$

Let V litre solution of pH = 2 is added in original solution so that pH remains fixed.

$$\therefore \quad [H^+] = \frac{10^{-2} \times 10 + V \times 10^{-2}}{10 + V} = 10^{-2}$$

This result is independent of volume taken.

Exercise - 2C

Q.1 (i) $H_2O \rightleftharpoons H^+ + OH^-$

$$K_a = \frac{(H^+)(OH^-)}{(H_2O)} = \frac{K_w}{(H_2O)}$$

$$K_a = \frac{10^{-14}}{1000/18} = 18\times10^{-17}$$

$$K_a = 1.8\times10^{-16}$$

(ii) $$K_b = \frac{K_w}{K_a} = \frac{10^{-14}}{6\times10^{-10}} = \frac{10}{6}\times10^{-5}$$

$$K_b = 1.67\times10^{-5}$$

(iii) $$K_a = \frac{K_w}{K_b} = \frac{10^{-14}}{2.5\times10^{-5}} = \frac{10\times10^{-15}}{2.5\times10^{-5}}$$

$$K_a = 4\times10^{-10}.$$

Q.2 $$K_a = c_1\alpha_1^2 = c_2\alpha_2^2$$

$$1(\alpha_1^2) = \frac{1}{1000}\alpha_2^2$$

$$\left(\frac{\alpha_2}{\alpha_1}\right)^2 = 1000 \Rightarrow \frac{\alpha_1}{\alpha_2} = 0.0316$$

Q.3 $$\frac{\alpha_1}{\alpha_2} = \sqrt{\frac{K_{a_1}}{K_{a_2}}} = \sqrt{\frac{1.8\times10^{-5}}{6.2\times10^{-10}}} = \sqrt{\frac{18}{6.2}\times10^{4}}$$

$$= 170.4$$

Q.4 $$pH = \frac{1}{2}(pK_a - \log c)$$

$$4.5 = \frac{1}{2}(pK_a + 1)$$

$$pK_a = 8$$

$$K_a = 10^{-8}$$

$$pOH = \frac{1}{2}(pK_b - \log c)$$

$$3.5 = \frac{1}{2}(pK_b + 1)$$

$$pK_b = 6$$

$$K_b = 10^{-6}.$$

Q.6 $(H^+) = \sqrt{2.56 \times 10^{-14}}$

$(H^+) = 1.6 \times 10^{-7} = 16 \times 10^{-8}$

$pH = -\log(16 \times 10^{-8})$

$pH = 8 - 4\log 2$, $pH = 8 - 4(0.301)$

$= 8 - 1.204$

$pH = 6.796$

Q.7 $(H^+) = 10^{-13}$ M

(H^+) Moles $= 10^{-16}$

No. of $H^+ = 6.022 \times 10^{23} \times 10^{-16}$

$= 6.022 \times 10^{7}$

Q.8 Change in (H^+) ion

$= (1.6 \times 10^{-7}) - (10^{-7})$

$= 0.6 \times 10^{-7} = 6 \times 10^{-8}$ M

Q.9 (i) $(H^+) = \sqrt{K_w} = 3.1 \times 10^{-7}$

$pH = 7 - \log 3.1$

$= 6.51$

(ii) (a) Basic (b) Acidic

Q.10 Let $[HCl] = c$

$(c+x)x = 10^{-14}$ — ①

$-\log(c+x) = 6.95$ — ②

from Eq. ① and ②

$c = 2.31 \times 10^{-8}$ M

(g) 10^{-6}M CH_3COOH

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$
$$c(1-\alpha) \quad c\alpha \quad c\alpha$$

$$K_a = \frac{c\alpha^2}{1-\alpha} = \frac{10^{-6}\alpha^2}{1-\alpha} = 1.8\times10^{-5}$$

$$\frac{\alpha^2}{1-\alpha} = 18, \quad \alpha^2+18\alpha-18=0$$

$$\alpha = \frac{-18+\sqrt{324+72}}{2}$$

$$\alpha = \frac{-18+19.899}{2} = 0.95$$

$$10^{-6}(0.95) = [CH_3COO^-]$$

$$[CH_3COO^-] = 9.5\times10^{-7}$$

$$(H^+) = (CH_3COO^-) + (OH^-)$$

$$(H^+) = 9.5\times10^{-7} + \frac{10^{-14}}{(H^+)}$$

$$(H^+)^2 - 9.5\times10^{-7}(H^+) - 10^{-14} = 0$$

$$(H^+) = \frac{9.5\times10^{-7} + \sqrt{(90.25)\times10^{-14} + 4\times10^{-14}}}{2}$$

$$(H^+) = 9.6\times10^{-7}$$

$$pH = 7 - \log 9.6$$
$$= 7 - 0.9824 = 6.01$$

(i) $(H^+) = \sqrt{C_1K_{a_1} + C_2K_{a_2}}$

$$= \sqrt{2\times10^{-6} + 4\times10^{-6}}$$

$$= \sqrt{6\times10^{-6}}, \quad pH = \frac{1}{2}(6-\log 6) = \frac{1}{2}(6-0.778)$$
$$= 2.61$$

(j) $Ba(OH)_2 = \frac{0.1M}{100}$, $(OH^-) = 2\times10^{-3}$, $pOH = 3-\log 2$

$$pH = 11+\log 2 = 11.301$$

Q.5 (a) 0.1M HCl

$(H^+) = 0.1M$

$pH = -\log(0.1) = 1$

(b) $(H^+) = \frac{(100 \times 0.1) + (50 \times 0.1)}{100} = \frac{15}{100}$

$pH = -\log\left(\frac{15}{100}\right)$, $pH = 2 - \log 3 - \log 5$

$pH = 2 - 0.477 - 0.699$

$pH = 0.977$

(c) $pH = \frac{1}{2}(pK_a - \log C) = \frac{1}{2}(4.75 - (-1))$

$pH = 2.875$

(d) $pOH = \frac{1}{2}(pK_b - \log C) = 2.875$

$pH = 14 - 2.875 = 11.13$

(e) 10^{-8}M HCl

$pH \simeq -\log(10^{-8} + 10^{-7})$

$= -\log(1.1 \times 10^{-7}) = 7 - \log 1.1$

$pH = 6.97$

(f) 10^{-10}M NaOH

$pOH = -\log(10^{-7} + 10^{-10})$

$= -\log(1.001 \times 10^{-7})$

$= 7 - \log 1.001$

$pH = 7 + \log 1.001$

Q.11

$pOH = \frac{1}{2}(pK_b - \log c)$

$2.5 = \frac{1}{2}(4.75 - \log c)$

$-\log c = 0.25$

$\log c = -0.25$

$c = \text{Antilog}(-1 + 0.75)$

$C = 0.556$

Q.12

$pH = \frac{1}{2}(pK_a - \log c)$

$3 = \frac{1}{2}(pK_a + 2)$

$pK_a = 4, \quad K_a = 10^{-4}$

Q.12 $[H^+] = 0.01\alpha$

$\alpha = 0.1$

$K_a = \frac{C\alpha^2}{1-\alpha} = \frac{10^{-2} \times 10^{-2}}{0.9}$

$= 1.11 \times 10^{-4}$

Q.13

$pH = \frac{1}{2}(10 - \log 5.9 - \log(0.3))$

$= \frac{1}{2}(10 - 0.2479)$

$= 4.87$

Q.14

$HCl \rightleftharpoons H^+ + Cl^-$

$\quad\quad\quad c \quad c$

$CHCl_2COOH \rightleftharpoons CHCl_2COO^- + H^+$

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

$\frac{C\alpha(C\alpha + C)}{C(1-\alpha)} = K_a$

$\frac{C\alpha(1+\alpha)}{1-\alpha} = 2.55 \times 10^{-2}$

$\alpha + \alpha^2 = 2.55 - 2.55\alpha$

$\alpha^2 + 3.55\alpha - 2.55 = 0$

$\alpha = \frac{-3.55 + 4.77}{2} = 0.612$

Q.15

$10^{-6}M$ NaOH

$$x(x+10^{-6}) = 10^{-14}$$

$$x^2 + 10^{-6}x - 10^{-14} = 0$$

$$x = \frac{-10^{-6} + \sqrt{10^{-12} + 4\times10^{-14}}}{2}$$

$$x = 0.098\times10^{-7}M$$

$$x = 0.98\times10^{-8}M$$

If ionisation of H_2O is neglected, $(H^+) = 10^{-8}M$

$$\% \text{ Error} = \frac{10^{-8} - 0.98\times10^{-8}}{0.98\times10^{-8}}\times100$$

$$= \frac{0.01\times10^{-8}}{0.98\times10^{-8}}\times100$$

$$= \frac{1}{0.98} = 1.01\%$$

Q.16:-

$$(H^+) = \sqrt{(0.02\times1.8\times10^{-5}) + (0.01\times6.4\times10^{-5})}$$

$$(H^+) = \sqrt{(3.6+6.4)\times10^{-7}}$$

$$(H^+) = 10^{-3}\ M$$

$$[CH_3COO^-] = \frac{1.8\times10^{-5}\times0.02}{10^{-3}} = 3.6\times10^{-4}M$$

$$[C_7H_5O_2^-] = \frac{6.4\times10^{-5}\times0.01}{10^{-3}} = 6.4\times10^{-4}M$$

Q.17 ~~(H+)=~~ $\sqrt{}$ ~~...~~ x+

Dissociation of HF can be neglected

$$pH = \frac{1}{2}(4 - \log 6.7 + 1) = \frac{1}{2}(5 - 0.8267) = 2.08$$

Only One Option Correct

1. (A)

2. (C)

3. (A)

4. (C)

5. (D)

6. (C)

7. (B)

8. (A)

9. (A)

10. (B)

11. (C)

12. (B)

13. (A)

14. (A)

15. (D)

16. (D)

17. (B)

$$Ag_2CrO_4 \rightleftharpoons 2Ag^+ + CrO_4^{2-}$$

$$K_{sp} = 1.1\times10^{-12} = \left[Ag^+\right]^2\left[CrO_4^{2-}\right]$$

$$1.1\times10^{-12} = [0.1]^2[s]; s = 1.1\times10^{-10}$$

18. (A)

As ester hydrolysis is first order with respect $\left[H^+\right]$

$$R_{HA} = K\left[H^+\right]_{HA}[ester]$$

$$R_{HX} = K\left[H^+\right]_{HX}[ester]$$

$$\therefore \frac{R_{HA}}{R_{HX}} = \frac{[H^+]_{HA}}{[H^+]_{HX}}; \frac{1}{100} = [H^+]_{HA} = 0.01$$

$$HA \rightleftharpoons H^+ + A^-$$

$1 - 0.01$ 0.01 0.01

≈ 1

$$K_a = \frac{0.01 \times 0.01}{1} = 10^{-4}$$

19. (B)

Initially, on increasing temperature, rate of reaction will increase, so % yield will also increase with time. But at equilibrium, % yield at high temperature (T_2) would be less than at T_1 as reaction is exothermic so the graph is represented by option (b).

One or More than One Correct Answer

1. (B, C)

2. (A, C)

3. (C, D)

Any solution of a weak acid and its salt with strong base acts as an acidic buffere solution.
If volume of HNO_3 solution added is less as compared to that of CH_3COONa solution, it results in the formation of an acidic buffer solition.

$$CH_3COONa + HNO_3 \longrightarrow CH_3COOH + NaNO_3$$

CH_3COONa	HNO_3	CH_3COOH	$NaNO_3$
Excess	limiting reagent		
MV	MV'	$-$	$-$
$M(V - V')$	0	MV'	$MV'(V' < V)$

4. (A, C, D)

Comprensions Type

1. (A)

Let the h cat capacity of insultated beaker be C. Mass of aqueous content in expt.

$1 = (100 + 100) \times 1 = 200g$

$\Rightarrow \pm$ Total heat capacity $= (C + 200 \times 4.2) J/K$

Moles of acid, base neutrakised in expt.

$= 1 = 0.1 \times 1 = 0.1$

$\Rightarrow$ Heat released in expt. $1 = 0.1 \times 57 = 5.7kJ = 5.7 \times 1000J$

$\Rightarrow 5.7 \times 1000 = (C + 200 \times 4.2) \times \Delta' T$

$5.7 \times 1000 = (C + 200 \times 4.2) \times 5.7$

$5.7 \times 1000 = (C + 200 \times 4.2) \times 5.7$

$\Rightarrow (C + 200 \times 4.2) = 1000$

In second experiment, $n_{CH_3COOH} = 0.2, n_{NaOH} = 0.1$

Total mass of aqueous content $= 200g$

$\Rightarrow$ Total heat capacity $= (C + 200 \times 4.2) = 1000$

$\Rightarrow$ Heat released $= 1000 \times 5.6 = 5600J$

Overall, only 0.1 mol of CH_3COOH undergo neutralization

$$\Rightarrow \Delta H_{neutralization} \text{ of } CH_3COOH = \frac{-5600}{0.1}$$

$$= -56000\, J/mol = -56\, KJ/mol$$

$$\Rightarrow \Delta H_{dissociation} \text{ of } CH_3COOH = 57 - 56 = 1 kJ/mol$$

2. (B)

Final solution contain 0.1 mole of CH_3COOH and CH_3COONa each.

Hence, it is a buffer solution.

$$pH = pK_a + \log \frac{[CH_3COO^-]}{[CH_3COOH]} = 5 - \log 2 + \log \frac{0.1}{0.1} = 4.7$$

3. (B)

	$X_2(g)$	$\rightleftharpoons$	$2X(g)$
Initial mole:	1		0
Moles at equilibrium:	$\left(1 - \frac{\beta_{eqbm}}{2}\right)$		β_{eqbm}
Partial pressure:	$\frac{1 - \frac{B_{eqbm}}{2}}{\left(1 + \frac{\beta_{eqbm}}{2}\right)} \times P$		$\frac{\beta_{eqbm}}{\left(1 + \frac{\beta_{eqbm}}{2}\right)} + P$

$$\therefore K_P = \frac{(P_x)^2}{P_{x_2}} = \frac{\beta_{eqbm}^2 P}{\left(1 - \frac{\beta_{eqbm}^2}{4}\right)} \Rightarrow K_p = \frac{4\beta_{eqbm}^2 P}{(4 - \beta_{eqbm}^2)}$$

Since, $P = 2$ bar So, $\boxed{K_P = \frac{8\beta_{eqbm}^2}{(4 - \beta_{eqbm}^2)}}$

4. (C)

(A) Correct statement

As on decrease in pressure, reactions moves in direction where no. of gaseous molecules increase.

(B) Correct statement

At the start of reaction, $Q_P > K_P$ so diddociation of X_2 take place spontaneously.

$\Delta G0^\circ > 0$ but at start $\Delta G << 0$.

(C) Incorrect statement as

$$K_P = \frac{8\beta_{eq2}^2}{4-\beta_{eq}^2} = \frac{8\times(0.7)^2}{4-(0.7)^2} > 1$$

At equilibrium, $\Delta G^\circ = -RT\ln K_P$

If $K_P > 1$, then ΔG° is negative.

But it is given that, ΔG° is positive.

(D) $K_P < 1$ and $K_P = K_C(RT)^{\Delta n}; \Delta n = 1$

$$\Rightarrow K_C = \frac{K_P}{RT} \Rightarrow K_C < 1; RT > 1$$

Match the Following

1. (D)

(P) $NaOH + CH_3COOH \longrightarrow CH_3COONa + H_2O$

M mole $10\times0.1 = 1$m.mol $20\times0.1 = 2$m.mol

$\therefore$ Solution contains 1m. mol CH_3COOH & 1m, mol CH_3COONa in 30 mL solution.

It is a Buffer solution. Hence, pH does not change with dilution.

m mole $20\times0.1 = 2$m.mol $20\times0.1 - 2$m.mol

$\therefore$ Solution contains 2m. mol of CH_3COONa in 40 mL solution(salt of weak acid and strong base)

For salts of weak acid and strong basic:

$$\left[H^+\right]_{initial} = \sqrt{\frac{K_wK_a}{C}}$$

On dilution up to 80 mL, new conc. will be $= \frac{C}{2}$

$$\therefore \left[H^+\right]_{new} = \sqrt{\frac{K_wK_a}{C/2}} = \left[H^+\right]_{initial}\sqrt{2}$$

(R)

$HCl + NH_3 \longrightarrow NH_4Cl$ `

m mole $20\times0.1 = 2$m.mol $20\times0.1 = 2$m.mol

$\therefore$ Solution contains 2m.mol of NH_4Cl in 40 mL solution

(salt of strong acid and weak base)

For salts of strong acid and weak base, $\left[H^+\right]_{initial} = \sqrt{\frac{K_wC}{K_b}}$

On dilution upto 80 mL, new conc. will be $= \frac{C}{2}$

$$\therefore \left[H^+\right]_{new} = \sqrt{\frac{K_wC}{K_b2}} = \frac{\left[H^+\right]_{initial}}{\sqrt{2}}$$

(S) $Ni(OH)_2(s) \longrightarrow Ni^{2+} + 2OH^-$

$\because$ it is sparingly soluble salt

$\therefore$ On dilution $\left[OH^-\right]$ conc. in saturated solution of $Ni(OH)_2$ remains constant

$\therefore [H^+]_{new} = [H^+]_{initial}$

Integer / Numerical Answer Type

1. **(6.5)**

2. **(11.5)**

3. **(2)**

4. (4.86)

Amount of SO_2 in atmosphere $= \frac{10}{10^6} = 10 \times 10^{-6}$

Molar concentration of SO_2 present in water

$=$ Amount of SO_2 $\times$ Solubility of SO_2 in water

$= 10 \times 10^{-6} \times 1.3653 \text{ mole L}^{-1} = 1.3653 \times 10^{-5} \text{ M}$

Writing the concerned chemical equation

	$H_2SO_3 \longrightarrow$	H^+	+	HSO_3^-
Initial conc.	1.3653×10^{-5}	0		0
Molar conc. at equb	$1.3653 \times 10^{-5} - x$	x		x

Threfore $K_a = \frac{x^2}{(1.3653 \times 10^{-5} - x)}$

$\Rightarrow 10^{-1.92} = \frac{x^2}{(1.3653 \times 10^{-5} - x)}$

$(pK_a = 1.92, \therefore K_a = 10^{-1.92})$

$\Rightarrow 1.2 \times 10^{-2} = \frac{x^2}{(1.3653 \times 10^{-5} - x)}$

$x^2 = 1.2 \times 10^{-2} (1.3653 \times 10^{-5} - x)$

On solving, $x = 1.364 \times 10^{-5}$

Therefore, $pH = -\log(1.364 \times 10^{-5}) = 4.865$

5. (9)

6. (8)

7. (3)

8. (6)

9. (7)

Let the solubility of AgCl is $x \text{ mol litre}^{-1}$ and that of CuCl is $y \text{ mol litre}^{-1}$

$AgCl \rightleftharpoons Ag^+ + Cl^-$

$\qquad\qquad x \qquad x$

$CuCl \rightleftharpoons Cu^{+} + Cl^{-}$

$\quad\quad\quad\quad y \quad\quad y$

$\therefore K_{sp}$ of $AgCl = [Ag^{+}][Cl^{-}]$

$1.6\times10^{-10} = x(x+y)$ ……(i)

Similarly, K_{sp} of $CuCl = [Cu^{+}][Cl^{-}]$

$1.6\times10^{-6} = y(x+y)$ …….(ii)

On solving , (i) and (ii)

$[Ag^{+}] = 1.6\times10^{-7} \therefore x = 7$

10. (4.47)

$$S = \sqrt{K_{sp}\left(\frac{[H^{+}]}{K_a}+1\right)} = \sqrt{20\times10^{-10}\left(\frac{10^{-3}}{10^{-8}}+1\right)} \simeq \sqrt{2\times10^{-5}} = 4.47\times10^{-3}M$$

Alternate solution:

Let the solubility of salt AB be x.

$AB \rightleftharpoons A^{+} + B^{-}$

$\quad\quad\quad x \quad x-y$

$K_{sp} = 2\times10^{-10} = x(x-y)$ ….. (i)

Association constant of weak acid HA,

$K_a^{'} = 1/K_a = 10^{8}$

$H^{+} + B^{-} \rightleftharpoons HB$

$10^{-3} \quad x-y \quad y$

Let concentration of HB at equilibirum be y. It is given that pH of solution is 3 which mean $[H^{+}] = 10^{-3}$

$$10^{8} = \frac{y}{10^{-3}\times(x-y)} \quad \text{….. (ii)}$$

$$\Rightarrow y = \frac{x}{1+10^{-5}}$$

Putting value of y in equation (i):

$$x\left(x-\frac{x}{1+10^{-5}}\right) = 2\times10^{-10}$$

$\Rightarrow x^{2} = 2\times10^{-5} + 2\times10^{-10} \Rightarrow x^{2} \approx 2\times10^{-5}$

$\Rightarrow x = \sqrt{20\times10^{-6}} \Rightarrow x = 4.47\times10^{-3}$

Hence, $Y = 4.47$

11. (3)

$B + HA \longrightarrow BH^{+} + A^{-}$

Volume of HA used till equivalent point $= 6mL$

At half of equivalence point, solution will be basic buffer with B and BH^{+}

$$\therefore pOH = pK_b + \log\frac{[BH^{+}]}{[B]}$$

At half equivalence point $\left[BH^+\right]=[B]$

$\therefore pOH = pK_b = 14-11 = 3$

12. (0.20)

$ZnS(s) \rightleftharpoons Zn^{2+}(aq) + S^{2-}(aq)$

$\left[S^{2-}\right]_{max}$ to prevent precipitation is given by

$$\left[S^{2-}\right]_{max} = \frac{1.25\times10^{-22}}{0.05} = 2.5\times10^{-21}M$$

$H_2S \rightleftharpoons 2H^+ + S^{-2}$

$$K_1.K_2 = \frac{\left[H^+\right]\left[S^{2-}\right]}{[H_2S]}$$

$$K_{Net} = 10^{-21} = \frac{\left[H^+\right]^2\times2.5\times10^{-21}}{0.1}$$

$$\left[H^+\right]^2 = \frac{1}{25} \Rightarrow \left[H^+\right] = \frac{1}{5}M = 0.2M$$

13. (6)

$H_2SO_4(aq) \longrightarrow H^+(aq) + HSO_4^-(aq)$

1M 1M

(As K_{a_1} is very large)

$Na_2SO_4(aq) \longrightarrow 2Na^+(aq) + SO_4^{2-}(aq)$

0.018M

(As Na_2SO_4 is a salt)

Now, due to common ion effect, dissociation of HSO_4^- will be suppressed.

$HSO_4^-(aq) \rightleftharpoons H^+(aq) = SO_4^{2-}(aq)$

1M 1M 0.018 M (at start)

$$Q_C = \frac{\left[H^+\right]\left[SO_4^{2-}\right]}{\left[HSO_4^-\right]} \Rightarrow Q_C = \frac{1\times0.018}{1} = 0.018$$

$K_C = K_{a_2} = 1.2\times10^{-2} = 0.012$

Thus, $Q_C > K_C$ and the reaction will remove in backward direction.

$HSO_4^-(aq) \rightleftharpoons H^+(aq) + SO_4^{2-}(aq)$

$(1+x)$ $(1-x)$ $(0.018-x)$

$$K_{a_2} = \frac{(1-x)(0.018-x)}{(1+x)} = 0.012$$

Assuming x to be very small, $1-x\approx1$ and $1+x\approx1$.

$\Rightarrow 0.018-x = 0.012 \Rightarrow x = 0.006$

$\left[SO_4^{2-}\right] = 0.018 - x = 0.012 mol/L$

$PbSO_4(s) \rightleftharpoons Pb^{2+}(aq) + SO_4^{2-}(aq)$

0 0.012

$$S \qquad S+0.012$$

$K_{sp} = S(S+0.012)$

Since, S is very small $S+0.012 \approx 0.012$

$\Rightarrow 1.6\times10^{-8} = S\times0.012$

$\Rightarrow S = 1.33\times10^{-6} = X\times10^{-y} \Rightarrow Y = 6$

Subjective Type

1. (78.36 ml)

2. (0.983)

3. 7.5×10^{-18} M

4. I_2

5. Ag^+; Na^+ has no tendency to accept electron

6. $K_{sp} = 1.71 \times 10^{-10}$

7. 0.0538 M

8. 1.203×10^{-3} mol litre^{-1}

9. 7.71×10^{-10}

10. (a) 0.0175% (b) 4.757

11. It will not be