## Solubility & Solubility product :→
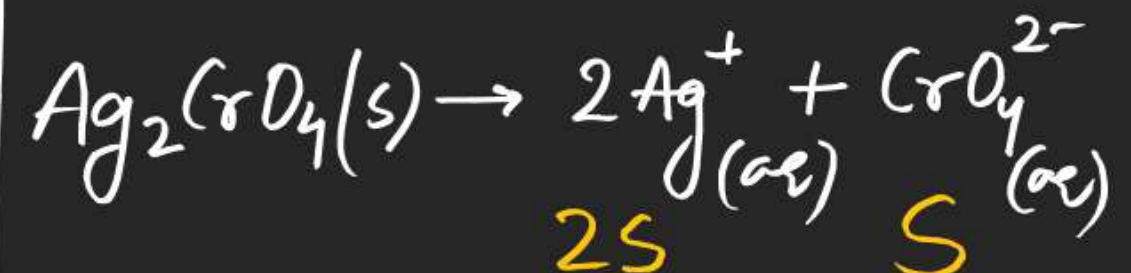
⇓

max $\underset{or}{\underline{molarity}}$ of a solute in a solvent

$\underline{molarity}$ of solute in its saturated solution

$$BA(s) \longrightarrow \underset{S(1-\alpha)}{BA(aq)} \longrightarrow \underset{S\alpha}{B^+(aq)} + \underset{S\alpha}{A^-(aq)}$$

for $\underline{sparingly\ soluble\ salt}$ $(S \ll 1, \alpha = 1)$

$$BA(s) \longrightarrow \underset{S}{B^+(aq)} + \underset{S}{A^-(aq)}$$
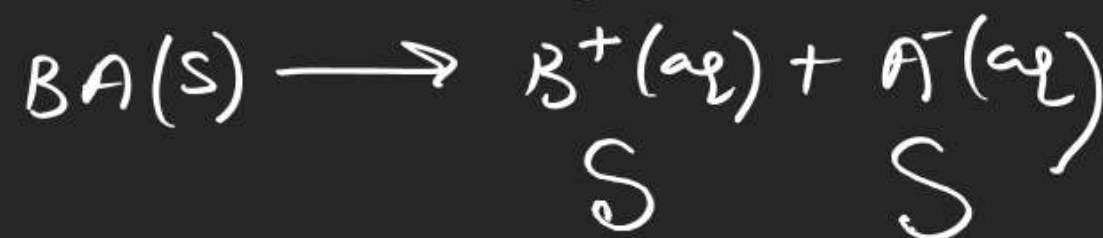
Solubility product $(K_{sp}) = [B^+][A^-]$

$$= S \times S = S^2$$

---

$$Ag_2CrO_4(s) \longrightarrow \underset{2S}{2Ag^+_{(aq)}} + \underset{S}{CrO_4^{2-}}_{(aq)}$$

$$K_{sp} = [Ag^+]^2[CrO_4^{2-}]$$
$$= (2s)^2(s) = 4S^3$$

$$As_2S_3(s) \longrightarrow \underset{2S}{2As^{3+}} + \underset{3s}{3S^{2-}}$$
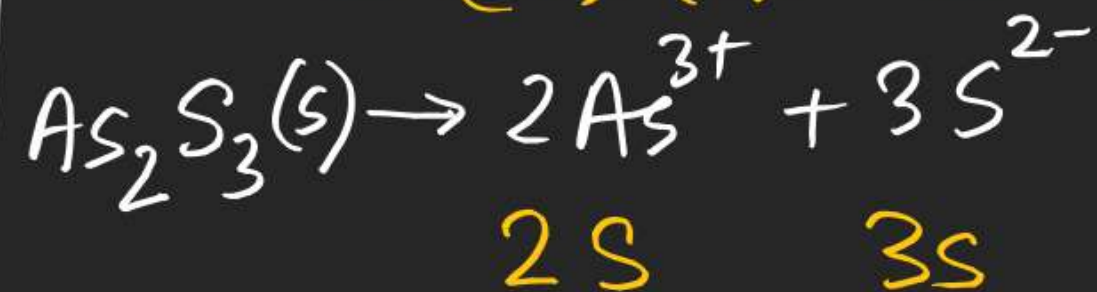
$$K_{sp} = (2s)^2(3s)^3$$
$$= 108\ S^5$$

**Q.1** find solubility of $Ag_2CrO_4$. Given $(K_{sp} = 3.2 \times 10^{-11} M^3)$

$$Ag_2CrO_4(s) \longrightarrow 2Ag^+ + CrO_4^{2-}$$

$$K_{sp} = 4S^3 = \overset{8}{\cancel{3}}\cancel{2} \times 10^{-12}$$

$$S = 2 \times 10^{-4} M$$

**Q.2** find $K_{sp}$ of $AgCl$ if its saturated soln contains $1.435$ mg/lit

$AgCl$. (Given $Ag : 108 \qquad Cl : 35.5$)

$$S = \frac{1.435 \times 10^{-3}}{143.5}$$

$$K_{sp} = S^2 = 10^{-10}$$

$$= 10^{-5}$$

# Common ion effect

**Q.** find solubility of $\underline{AgCl}$ in $\underline{\boxed{0.01\,M\,NaCl}}$
$\underline{0.01\,M\,Cl^-\,soln.}$   $K_{sp}(AgCl)=10^{-10}\,M^2$

$$AgCl\,(s) \longrightarrow Ag^+\,(aq) + Cl^-\,(aq)$$
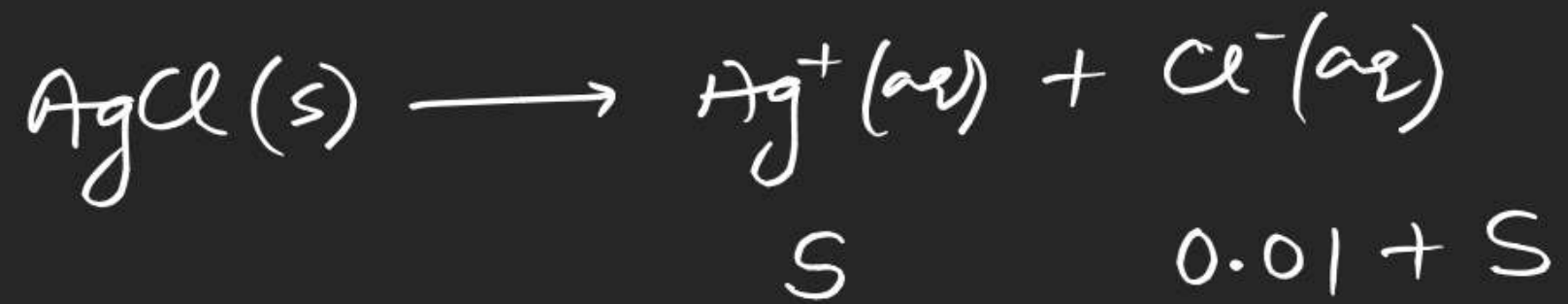
$$\qquad\qquad\qquad S \qquad\qquad 0.01 + S$$

$$K_{sp} = 10^{-10} = S\,(0.01 + \cancel{S})$$

$$\underline{10^{-8} = S}$$

$$NaCl \cancel{\longrightarrow} Na^+ + Cl^-$$

$$\boxed{HCl} \rightarrow H^+ + Cl^-$$
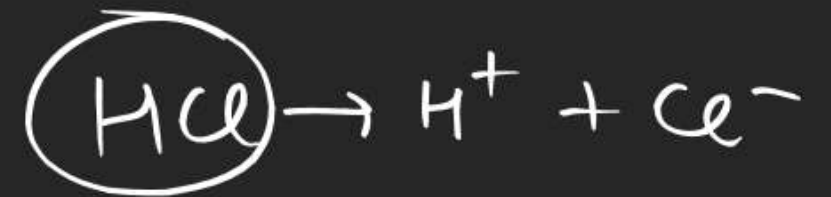
Q. find solubility of $PbI_2$ in $0.01M$ $\underline{NaI}$ $sol^n$

$$K_{sp}(PbI_2) = 10^{-14}$$

$$PbI_2(s) \longrightarrow Pb^{2+} + 2I^-$$

$$S \qquad\qquad 0.01 + 2S$$
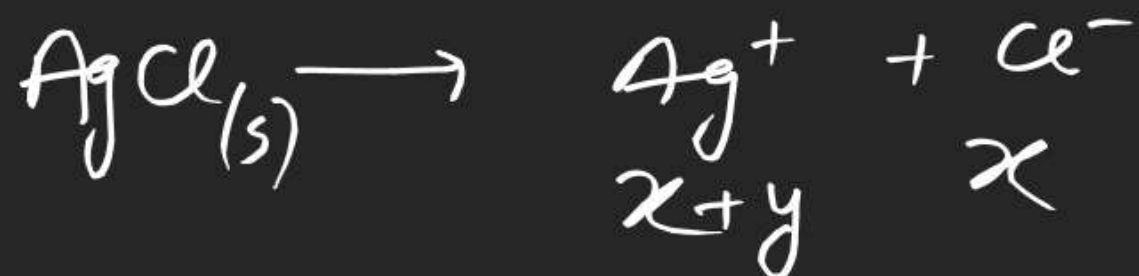
$$K_{sp} = 10^{-14} = S(0.01 + \cancel{2S})^2$$

$$\underline{10^{-10} = S}$$
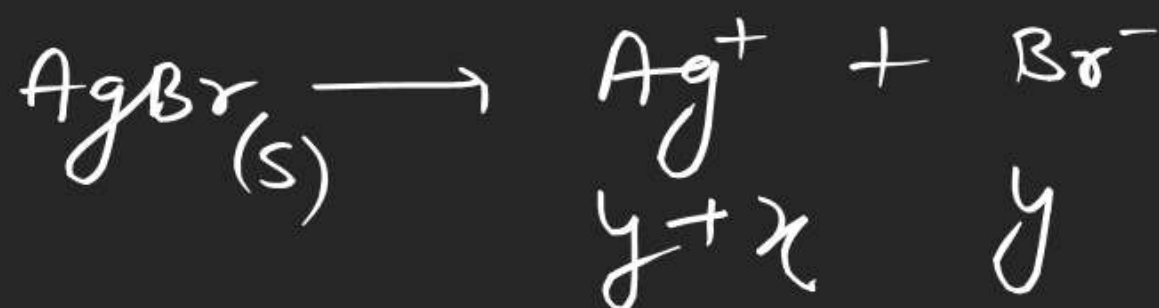
Q. find Simultaneous solubility of $AgCl$ & $AgBr$.

$$K_{sp}(AgCl) = 110 \times 10^{-12} \qquad K_{sp}(AgBr) = 11 \times 10^{-12}$$

$$AgCl_{(s)} \longrightarrow \underset{x+y}{Ag^+} + \underset{x}{Cl^-} \qquad (x+y)\,x = 110 \times 10^{-12}$$

$$AgBr_{(s)} \longrightarrow \underset{y+x}{Ag^+} + \underset{y}{Br^-} \qquad (x+y)(y) = 11 \times 10^{-12}$$

$$(x+y)^2 = 121 \times 10^{-12}$$

$$x+y = 11 \times 10^{-6}$$

$$x = 10^{-5} \qquad y = 10^{-6}$$

$$O-I \qquad 81 - 88$$

$$S-I \qquad 59 - 67$$

$$O-II \qquad 1 - 6, 21, 22$$

⑤ <u>Buffer capacity:</u> → It is equal to the no of moles of $H^+$ or $OH^-$ added to change the pH of 1 lit Buffer sol$^n$ by 1 unit.

$$a \mp x \qquad s \pm x$$

no. of moles of $H^+$ or $OH^-$ added $=$ change in no of moles of acid or base $=$ change in no. of moles of salt $(ds)$

$$1 \text{ lit}$$

$$dS \longrightarrow dpH$$
$$dpH \longrightarrow dS$$
$$1 \text{ unit} \longrightarrow \left(\frac{dS}{dpH}\right) = \text{Buffer Capacity}$$

$$PH = pka + \log \frac{s}{a}$$

$$a + s = c$$

$$pH = pka + \frac{1}{2 \cdot 303} \ln \frac{s}{c-s}$$

$$\frac{dpH}{ds} = 0 + \frac{1}{2 \cdot 303} \frac{c-s}{s} \frac{1 \times (c-\cancel{s}) - \cancel{s}(-1)}{(c-s)^2}$$

$$= \frac{1}{2 \cdot 303} \frac{c}{s(c-s)}$$

$$\boxed{\frac{ds}{dpH} = 2 \cdot 303 \frac{s \times a}{a+s}}$$

$$pH = pka + \log \frac{s}{a}$$

$$pH' = pka + \log \frac{s \pm x}{a \mp x}$$

$$a + s = 10$$

| a | s |
|---|---|
| 1 | 9 |
| 2 | 8 |
| 3 | 7 |
| 5 | 5 |

for max
Buffer cap
$$a = s$$
if total moles are
const

$$\begin{array}{c|c|c} & a & 5 \\ B-1 & 10 & 15 \\ B-2 & 5 & 5 \\ B-3 & 2 & 8 \end{array}$$

$$\frac{ds}{dpH} = 2.303 \times \frac{10 \times 15}{25} = 2.303 \times 6$$

$$\frac{ds}{dpH} = 2.303 \times \frac{5 \times 5}{10} = 2.303 \times 2.5$$
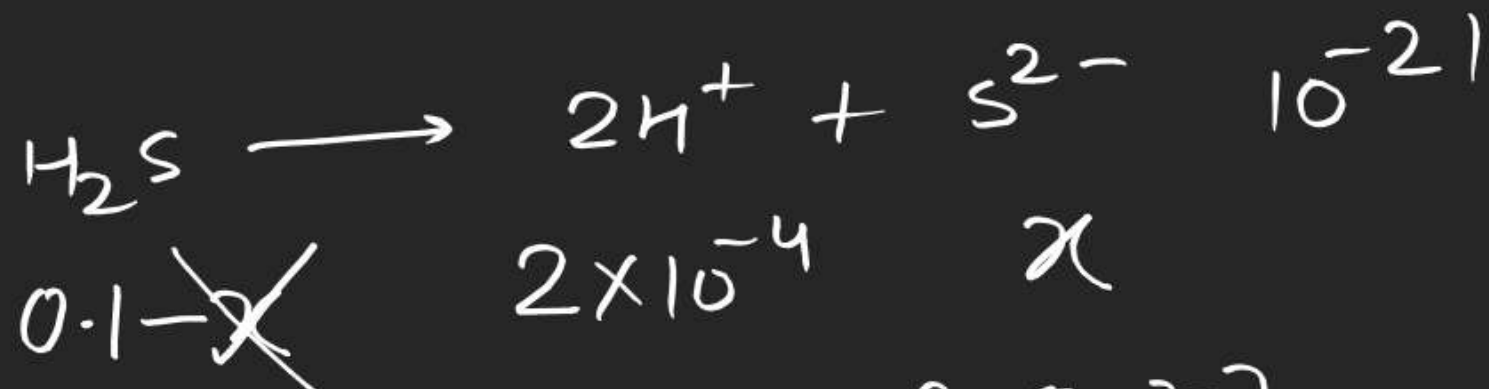
$$\boxed{pH = 5}$$
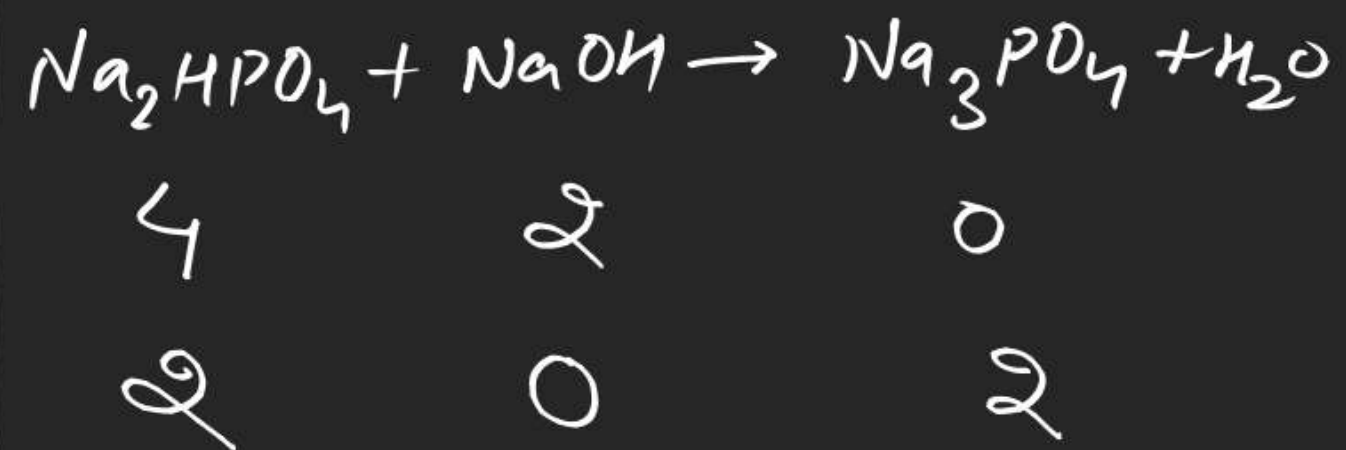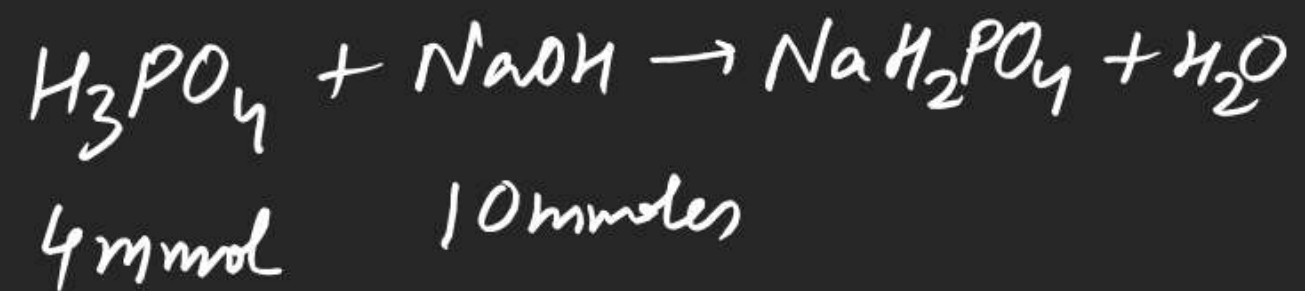
① HA

pKa = 4

② HB

pKa = 5 ✓

③ HC

pKa = 5.5

① $[H^+] = 2 \times 10^{-4}$

$$H_2S \longrightarrow 2H^+ + S^{2-} \qquad 10^{-21}$$

$0.1 - \cancel{x} \qquad\qquad 2 \times 10^{-4} \qquad x$

$$10^{-21} = \frac{(2 \times 10^{-4})^2 \, [S^{2-}]}{0.1}$$

$$Na_3PO_4 + HCl \longrightarrow$$

④

$$H_3PO_4 + NaOH \longrightarrow NaH_2PO_4 + H_2O$$

4 mmol          10 mmoles

$$Na_2HPO_4 + NaOH \longrightarrow Na_3PO_4 + H_2O$$

| 4 | 2 | 0 |
|---|---|---|
| 2 | 0 | 2 |

$$pH = pKa_3 + \log \frac{2}{2}$$

①      $pKa_3$

$$\frac{1}{2}\left(pKa_3 + pKa_2\right)$$

$pKa_2$

$$\frac{1}{2}\left(pKa_2 + pKa_1\right)$$

$pKa_1$

$c = \underline{[H_3PO_4]} = \frac{1}{40}$    $Ka_1 = \dfrac{x^2}{c-x}$

CIE    $HCl + H_3PO_4$

            $\frac{1}{50}M$     $\frac{1}{50}M$