

# Solubility Practice Questions

(A)

1.  $V_{\text{soln}} = 0.01 \text{ mL}$

$$[\text{CaF}_2] = \frac{m}{M \cdot V}$$

$m_{\text{CaF}_2} = 0.0016 \text{ g}$

$$= 0.0016 \text{ g CaF}_2 \times \frac{1 \text{ mol CaF}_2}{78.08 \text{ g CaF}_2} \times \frac{1}{0.00001 \text{ L}}$$

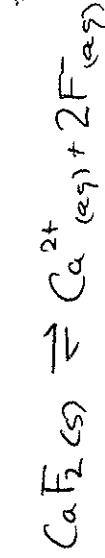
$$= 2.05 \frac{\text{mol CaF}_2}{\text{L}}$$

Solubility  $\text{CaF}_2 = [\text{Ca}^{2+}] = \frac{1}{2}[\text{F}^-] = 2.05 \frac{\text{mol}}{\text{L}}$

$[\text{Ca}^{2+}]_{\text{eqm}} = 2.05 \frac{\text{mol}}{\text{L}}$

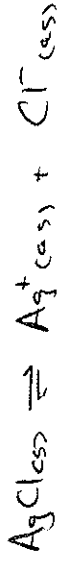
$[\text{F}^-]_{\text{eqm}} = 4.10 \frac{\text{mol}}{\text{L}}$

$$K_{sp} = [\text{Ca}^{2+}][\text{F}^-]^2 = (2.05)(4.1)^2 = 34.46$$



$K_{sp} = 34$

2.



|   |    |        |        |
|---|----|--------|--------|
| I |    | 0      | 0.01   |
| C | +x | +x     |        |
| E | x  | 0.01+x | ~ 0.01 |

$$[\text{Cl}^-]_{\text{I}} = 0.010 \frac{\text{mol}}{\text{L}}$$

check

$$\frac{[\text{Cl}^-]_{\text{I}}}{K_{sp}} = \frac{0.01}{1.8 \times 10^{-10}} \gg 100$$

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

$$1.8 \times 10^{-10} = (x)(0.01)$$

$$x = 1.8 \times 10^{-8}$$

Solubility  $\text{AgCl} = [\text{Ag}^+]$

$$= 1.8 \times 10^{-8} \frac{\text{mol}}{\text{L}}$$

proof

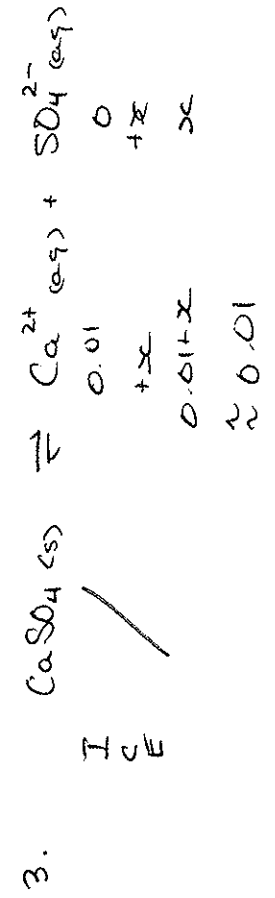
$$\frac{x}{[\text{Cl}^-]_{\text{I}}} \times 100\%$$

$$\frac{1.8 \times 10^{-8}}{0.01} \times 100$$

$$= 1.8 \times 10^{-4} \%$$

assumption is valid

(B)



$$[\text{Ca}^{2+}]_I = 0.0100 \frac{\text{mol}}{\text{L}}$$

check

$$\frac{[\text{Ca}^{2+}]_I}{K_{sp}} = \frac{0.01}{7.1 \times 10^{-5}} \gg 100$$

$$K_{sp} = [\text{Ca}^{2+}][\text{SO}_4^{2-}]$$

$$7.1 \times 10^{-5} = (0.01)(x)$$

$$x = 7.1 \times 10^{-3}$$

$$7.5 \times 10^{-5} = (0.01+x)(x)$$

$$7.5 \times 10^{-5} = 0.01x + x^2$$

$$0 = x^2 + 0.01x - 7.5 \times 10^{-5}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-0.01 \pm \sqrt{(0.01)^2 - 4(1)(-7.5 \times 10^{-5})}}{2(1)}$$

$$= \frac{-0.01 \pm \sqrt{4 \times 10^{-4}}}{2} = \frac{-0.01 \pm 0.02}{2}$$

$$x = -0.015$$

$$x = 0.005$$

$$\therefore x = 0.005$$

solubility  $\text{CaSO}_4 = [\text{SO}_4^{2-}]$   
 $= 0.005 \frac{\text{mol}}{\text{L}}$

Proof

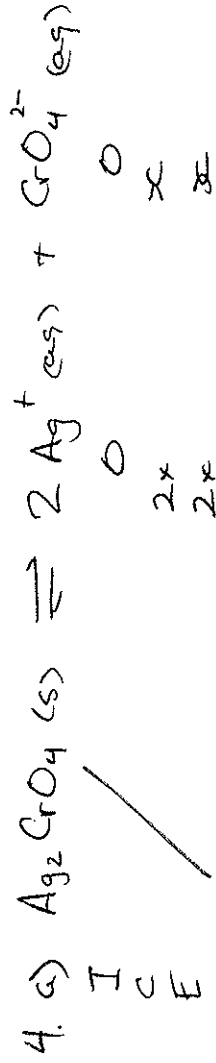
$$\frac{x}{[\text{Ca}^{2+}]_I} \times 100\%$$

$$= \frac{7.1 \times 10^{-3}}{0.01} \times 100\%$$

$$= 71\%$$

$\therefore$  assumption not valid.

©



$$K_{sp} = [\text{Ag}^+]^2 [\text{CrO}_4^{2-}]$$

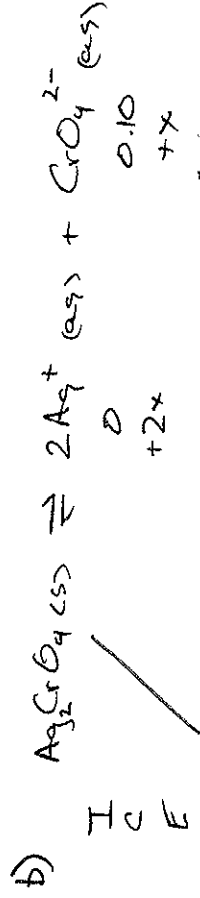
solubility  $\text{Ag}_2\text{CrO}_4 = \frac{1}{2}[\text{Ag}^+] = [\text{CrO}_4^{2-}]$

$$1.12 \times 10^{-12} = (2x)^2 (x) = 6.54 \times 10^{-5} \frac{\text{mol}}{\text{L}}$$

$$4x^3 = 1.12 \times 10^{-12}$$

$$x = 6.54 \times 10^{-5}$$

$$x = 6.54 \times 10^{-5}$$



$$[\text{CrO}_4^{2-}]_I = 0.1 \frac{\text{mol}}{\text{L}}$$

check

$$\frac{0.1}{K_{sp}} = \frac{0.1}{1.12 \times 10^{-12}} \gg 100$$

$$K_{sp} = [\text{Ag}^+]^2 [\text{CrO}_4^{2-}]$$

$$1.12 \times 10^{-12} = (2x)^2 (0.1)$$

$$(2x)^2 = 1.12 \times 10^{-11}$$

$$x = 1.67 \times 10^{-6}$$

proof

$$\frac{x}{[\text{CrO}_4^{2-}]_I} \times 100\%$$

$$= \frac{1.67 \times 10^{-6}}{0.1} \times 100\%$$

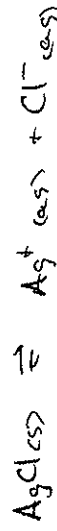
$$= 1.67 \times 10^{-3} \%$$

∴ assumption valid

Solubility  $\text{Ag}_2\text{CrO}_4 = \frac{1}{2}[\text{Ag}^+] = 1.67 \times 10^{-6} \frac{\text{mol}}{\text{L}}$

①

5. a)



$$[\text{Ag}^+] = [\text{AgNO}_3] \times \text{mol ratio} \times \frac{V_{\text{AgNO}_3}}{V_T}$$

$$= \frac{0.010 \text{ mol AgNO}_3}{\text{L}} \times \frac{1 \text{ mol Ag}^+}{1 \text{ mol AgNO}_3} \times \frac{25.0 \text{ mL}}{50.0 \text{ mL}}$$

$$= 0.005 \frac{\text{mol Ag}^+}{\text{L}}$$

$$[\text{Cl}^-] = [\text{KCl}] \times \text{mol ratio} \times \frac{V_{\text{KCl}}}{V_T}$$

$$= \frac{0.0050 \text{ mol KCl}}{\text{L}} \times \frac{1 \text{ mol Cl}^-}{1 \text{ mol KCl}} \times \frac{25.0 \text{ mL}}{50.0 \text{ mL}}$$

$$= 0.0025 \frac{\text{mol Cl}^-}{\text{L}}$$

$$Q_{\text{sp}} = [\text{Ag}^+][\text{Cl}^-]$$

$$= (0.005)(0.0025)$$

$$= 1.25 \times 10^{-5}$$

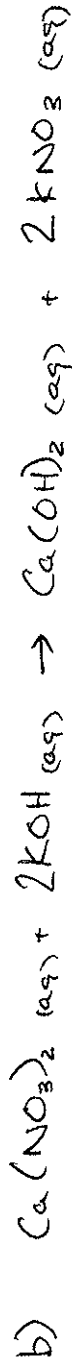
$$Q_{\text{sp}} > K_{\text{sp}}$$

$$1.25 \times 10^{-5}$$

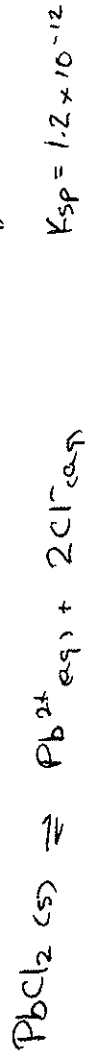
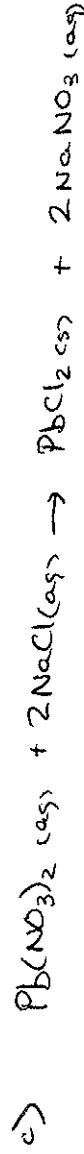
$$1.8 \times 10^{-10}$$

$\therefore$  ppt will form

(E)



→ no ppt formed



$$\begin{aligned}
 [\text{Pb}^{2+}] &= [\text{Pb}(\text{NO}_3)_2] \times \text{mol ratio} \times \frac{V}{V_T} \\
 &= 0.010 \frac{\text{mol Pb}(\text{NO}_3)_2}{\text{L}} \times \frac{1 \text{ mol Pb}^{2+}}{1 \text{ mol Pb}(\text{NO}_3)_2} \times \frac{2}{2x} \\
 &= 0.005 \frac{\text{mol Pb}^{2+}}{\text{L}}
 \end{aligned}$$

$$= 0.005 \frac{\text{mol Pb}^{2+}}{\text{L}}$$

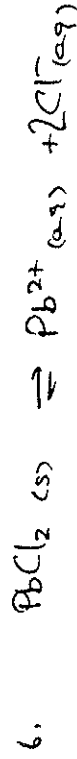
$$[\text{Cl}^-] = [\text{NaCl}] \times \text{mol ratio} \times \frac{V}{V_T}$$

$$= 0.010 \frac{\text{mol NaCl}}{\text{L}} \times \frac{1 \text{ mol Cl}^-}{1 \text{ mol NaCl}} \times \frac{2}{2x}$$

$$= 0.005 \frac{\text{mol Cl}^-}{\text{L}}$$

$Q_{sp} < K_{sp}$

∴ no ppt



$$[\text{Cl}^-] = [\text{NaCl}] \times \text{mol ratio}$$

$$= 0.010 \frac{\text{mol Cl}^-}{\text{L}}$$

$$\begin{aligned}
 Q_{sp} &= [\text{Pb}^{2+}][\text{Cl}^-]^2 \\
 &= (0.015)(0.01)^2 \\
 &= 1.51 \times 10^{-6}
 \end{aligned}$$

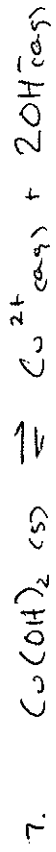
$$[\text{Pb}^{2+}] = \frac{m \text{ Pb}(\text{NO}_3)_2}{M \text{ Pb}(\text{NO}_3)_2 \times V} \times \text{mol ratio}$$

$$= 5.00 \text{g Pb}(\text{NO}_3)_2 \times \frac{1 \text{ mol Pb}(\text{NO}_3)_2}{331.20 \text{g Pb}(\text{NO}_3)_2} \times \frac{1}{1.0 \text{L}} \times \frac{1 \text{ mol Pb}^{2+}}{1 \text{ mol Pb}(\text{NO}_3)_2}$$

$$= 0.0151 \frac{\text{mol Pb}^{2+}}{\text{L}}$$

$Q_{sp} < K_{sp}$

∴ no ppt



$$K_{sp} =$$

$$[\text{OH}^-] = [\text{NaOH}] \times \text{mol ratio} \times \frac{V_{\text{NaOH}}}{V_T}$$

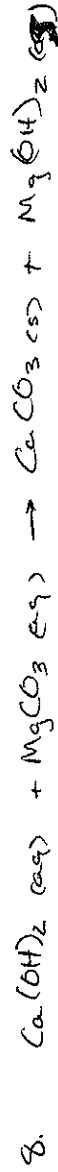
$$= 0.010 \frac{\text{mol NaOH}}{\text{L}} \times \frac{[\text{mol OH}^-]}{[\text{mol NaOH}]} \times \frac{0.010 \text{ L}}{1.01 \text{ L}}$$

$$= 9.90 \times 10^{-5} \frac{\text{mol OH}^-}{\text{L}}$$

$$[\text{Ca}^{2+}] = [\text{CaCl}_2] \times \text{mol ratio} \times \frac{V_{\text{CaCl}_2}}{V_T}$$

$$= 0.010 \frac{\text{mol CaCl}_2}{\text{L}} \times \frac{[\text{mol Ca}^{2+}]}{[\text{mol CaCl}_2]} \times \frac{1.0 \text{ L}}{1.01 \text{ L}}$$

$$= 9.90 \times 10^{-3} \frac{\text{mol Ca}^{2+}}{\text{L}}$$



$$[\text{Ca(OH)}_2] = \frac{m}{MV} = \frac{56 \text{ g Ca(OH)}_2}{74.10 \text{ g Ca(OH)}_2} \times \frac{1 \text{ mol Ca(OH)}_2}{520 \text{ L}}$$

$$= 0.00145 \frac{\text{mol Ca(OH)}_2}{\text{L}}$$

$$\therefore [\text{Ca}^{2+}] = 0.00145 \frac{\text{mol Ca}^{2+}}{\text{L}}$$

$$[\text{OH}^-] = 0.00290 \frac{\text{mol OH}^-}{\text{L}}$$

$$[\text{MgCO}_3] = \frac{m}{MV} = \frac{45 \text{ g}}{84.32 \text{ g MgCO}_3} \times \frac{1 \text{ mol MgCO}_3}{520 \text{ L}}$$

$$= 0.00103 \frac{\text{mol MgCO}_3}{\text{L}}$$

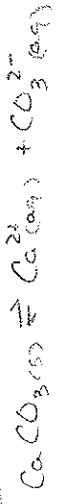
$$\therefore [\text{Mg}^{2+}] = 0.00103 \frac{\text{mol Mg}}{\text{L}}$$

$$[\text{CO}_3^{2-}] = 0.00103 \frac{\text{mol CO}_3^{2-}}{\text{L}}$$

$$Q_{sp} = [\text{Ca}^{2+}][\text{OH}^-]^2$$

$$= (9.90 \times 10^{-3})(9.90 \times 10^{-5})^2$$

$$= 9.70 \times 10^{-11}$$



$$K_{sp} = 5.0 \times 10^{-9}$$

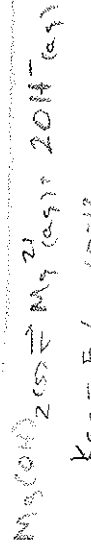
$$Q_{sp} = [\text{Ca}^{2+}][\text{CO}_3^{2-}]$$

$$= (0.00145)(0.00103)$$

$$= 1.49 \times 10^{-6}$$

$$Q_{sp} > K_{sp}$$

$\therefore \text{CaCO}_3$  will ppt



$$K_{sp} = 5.6 \times 10^{-12}$$

$$Q_{sp} = [\text{Mg}^{2+}][\text{OH}^-]^2$$

$$= (0.00103)(0.00290)^2$$

$$= 8.66 \times 10^{-9}$$

$$Q_{sp} > K_{sp}$$

$\therefore \text{Mg(OH)}_2$  will ppt

### Exe. 1



$$m_{\text{Zn}} = 0.094 \text{ g}$$

$$V = 100 \text{ mL}$$

$$a) \quad n_{\text{Zn}} = \frac{m}{M} = 0.094 \text{ g Zn} \times \frac{1 \text{ mol Zn}}{65.38 \text{ g Zn}} = 0.00144 \text{ mol Zn}$$

$$b) \quad n_{\text{Pb}^{2+}} = n_{\text{Zn}} \times \text{mol ratio} \\ = 0.00144 \text{ mol Zn} \times \frac{1 \text{ mol Pb}^{2+}}{1 \text{ mol Zn}} \\ = 0.00144 \text{ mol Pb}^{2+}$$

$$[\text{Pb}^{2+}] = \frac{0.00144 \text{ mol Pb}^{2+}}{0.1 \text{ L}} = 0.0144 \frac{\text{mol Pb}^{2+}}{\text{L}}$$

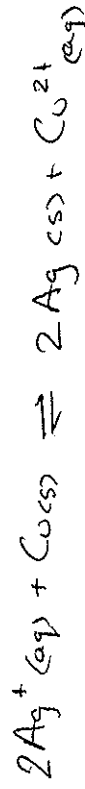
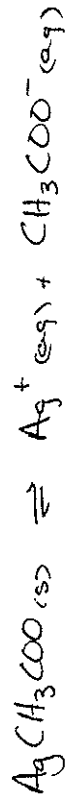
$$\hookrightarrow \text{solubility PbCl}_2 = [\text{Pb}^{2+}] = \frac{1}{2} [\text{Cl}^-]$$

$$\frac{1}{2} [\text{Cl}^-] = [\text{Pb}^{2+}] = 0.0144 \frac{\text{mol Pb}^{2+}}{\text{L}}$$

$$[\text{Cl}^-] = 0.0288 \frac{\text{mol Cl}^-}{\text{L}}$$

$$K_{sp} = [\text{Pb}^{2+}] [\text{Cl}^-]^2 \\ = (0.0144)(0.0288)^2 \\ = 1.2 \times 10^{-5}$$

Ex 2



$$m_{\text{Cu}} = 0.16\text{g}$$
$$V = 100\text{mL}$$

$$a) \quad n_{\text{Cu}} = \frac{m}{M} = 0.16\text{g Cu} \times \frac{1\text{mol Cu}}{63.55\text{g Cu}}$$

$$= 0.00252\text{ mol Cu}$$

$$b) \quad n_{\text{Ag}^+} = n_{\text{Cu}} \times \text{mol ratio}$$

$$= 0.00252\text{ mol Cu} \times \frac{2\text{mol Ag}^+}{1\text{mol Cu}}$$

$$= 0.00504\text{ mol Ag}^+$$

$$c) \quad [\text{Ag}^+] = \frac{n}{V} = \frac{0.00504\text{ mol Ag}^+}{0.1\text{L}}$$

$$= 0.0504 \frac{\text{mol Ag}^+}{\text{L}}$$

solubility  $\text{Ag}_2\text{C}_2\text{H}_3\text{O}_2 = [\text{Ag}^+] = [\text{C}_2\text{H}_3\text{O}_2^-]$

$$[\text{Ag}^+] = [\text{C}_2\text{H}_3\text{O}_2^-] = 0.0504 \frac{\text{mol}}{\text{L}}$$

$$K_{sp} = [\text{Ag}^+][\text{C}_2\text{H}_3\text{O}_2^-]$$
$$= (0.0504)(0.0504)$$

$$K_{sp} = 2.5 \times 10^{-3}$$