Ionic Equilibria Problems

1) **The solubility of lead(II) chloride is 0.064 g/100. mL at 25° C. What is its solubility product?**

2) **The K_{sp} for barium sulfate is 1.1×10^{-10}. Calculate the molar solubility of barium sulfate.**

3) **What is the fluoride concentration in a saturated barium fluoride solution? The $K_{sp} = 1.7 \times 10^{-6}$.**

4) **Will a precipitate form when 0.15 L of a 3.0×10^{-2} M lead(II) nitrate solution is added to 300. mL of a 8.0×10^{-2} M sodium chloride solution? The $K_{sp} = 2.4 \times 10^{-4}$.**

5) **What is the solubility of silver phosphate in a 0.20 M silver nitrate solution? The $K_{sp} = 1.1 \times 10^{-16}$.**

6) **What is the solubility of Fe^{2+} in a solution with a pH of 9.00? The $K_{sp} = 7.9 \times 10^{-15}$.**

Solutions

1) **s = 0.064 g/100. mL**

$[PbCl_2]$ = 0.064 ~~g PbI_2~~/100. ~~mL~~ x 1000 ~~mL~~/L x 1 mol PbI_2/461.00 ~~g PbI_2~~

$[PbCl_2] = 1.4 \times 10^{-3}$ M

	$PbI_2(s)$ ↔	$Pb^{2+}(aq)$ +	$2I^-(aq)$
$[\ ]_i$		0	0
$[\ ]_c$		$+1.4 \times 10^{-3}$	$+2.8 \times 10^{-3}$
$[\ ]_e$		1.4×10^{-3}	2.8×10^{-3}

$K_{sp} = [Pb^{2+}] \times [Cl^-]^2$

$K_{sp} = 1.4 \times 10^{-3} \times (2.8 \times 10^{-3})^2 =$ 1.1×10^{-8}

2) **$K_{sp} = 1.1 \times 10^{-10}$**

	$BaSO_4(s)$ ↔	$Ba^{2+}(aq)$ +	$SO_4^{2-}(aq)$
$[\ ]_i$		0	0
$[\ ]_c$		+x	+x
$[\ ]_e$		x	x

$K_{sp} = [Ba^{2+}] \times [SO_4^{2-}]$

$1.1 \times 10^{-10} = x \cdot x = x^2$

s = x = **1.0×10^{-5} M**

3) $K_{sp} = 1.7 \times 10^{-6}$

	$BaF_2(s)$	$\leftrightarrow$	$Ba^{2+}(aq)$	+	$2F^-(aq)$
$[\ ]_i$			0		0
$[\ ]_c$			+x		+2x
$[\ ]_e$			x		2x

$K_{sp} = [Ba^{2+}] \times [F^-]^2$

$1.7 \times 10^{-6} = x \cdot (2x)^2 = 4x^3$

$s = x = 7.5 \times 10^{-3}$ M

$[F^-] = 2 \times 7.5 \times 10^{-3}$ M = 1.5×10^{-2} M

4) $[Pb(NO_3)_2]_1 = 3.0 \times 10^{-2}$ M $\quad\quad$ $[NaCl]_2 = 8.0 \times 10^{-2}$ M

$V_1 = 0.15$ L $\quad\quad$ $V_2 = 300.$ mL

$K_{sp} = 2.4 \times 10^{-4}$

$[\ ] = n/V$

$n = [\ ] \times V$

$n_1 = 3.0 \times 10^{-2}$ mol $Pb(NO_3)_2/\cancel{L} \times 0.15\ \cancel{L} = 4.5 \times 10^{-3}$ mol $Pb(NO_3)_2$

$n_2 = 8.0 \times 10^{-2}$ mol NaCl/$\cancel{L} \times 300.\ \cancel{mL} \times 1\ \cancel{L}/10^3\ \cancel{mL} = 2.4 \times 10^{-2}$ mol NaCl

$[Pb^{2+}] = n/V$

$[Pb^{2+}] = 4.5 \times 10^{-3}\ \cancel{\text{mol } Pb(NO_3)_2}/0.45$ L $\times$ 1mol $Pb^{2+}/1\ \cancel{\text{mol } Pb(NO_3)_2} = 0.010$ M

$[Cl^-] = n/V$

$[Cl^-] = 2.4 \times 10^{-2}\ \cancel{\text{mol NaCl}}/0.45$ L $\times$ 1mol $Cl^-/1\ \cancel{\text{mol NaCl}} = 0.053$ M

	$PbCl_2(s)$	$\leftrightarrow$	$Pb^{2+}(aq)$	+	$2Cl^-(aq)$
$[\ ]_i$			0		0
$[\ ]_c$			+0.010		+0.053
$[\ ]_e$			0.010		0.053

$P = [Pb^{2+}] \times [Cl^-]^2$

$P = 0.010 \times 0.053^2 =$ **2.8 x 10^{-5}**

No precipitate forms because $P < K_{sp}$.

5) $[AgNO_3] = [Ag^+] = 0.20\ M$

$K_{sp} = 1.1 \times 10^{-16}$

	$Ag_3PO_4(s)$	$\leftrightarrow$	$3Ag^+(aq)$	+	$PO_4^{3-}(aq)$
$[\ ]_i$			0.20		0
$[\ ]_c$			+3x		+x
$[\ ]_e$			0.20 + 3x		x

$K_{sp} = [Ag^+]^3 \times [PO_4^{3-}]$

$1.1 \times 10^{-16} = (0.20 + 3x)^3 \cdot x$

$(0.20 + 3x) \approx (0.20)$

$1.1 \times 10^{-16} = (0.20)^3 \cdot x$

$s = x = 1.4 \times 10^{-14}\ M$

6) **pH = 9.00**

$K_{sp} = 7.9 \times 10^{-15}$

pH + pOH = 14.00

pOH = 14.00 – 9.00 = 5.00

$[OH^-] = 10^{-pOH} = 10^{-5.00} = 1.0 \times 10^{-5}$ M

	$Fe(OH)_2(s)$	↔	$Fe^{2+}(aq)$	+	$2OH^-(aq)$
$[\ ]_i$			0		1.0×10^{-5}
$[\ ]_c$			+x		+2x
$[\ ]_e$			x		$2x + 1.0 \times 10^{-5}$

$K_{sp} = [Fe^{2+}] \times [OH^-]^2$

$7.9 \times 10^{-15} = x \cdot (2x + 1.0 \times 10^{-5})^2$

$(2x + 1.0 \times 10^{-5}) \approx (1.0 \times 10^{-5})$

$7.9 \times 10^{-15} = x \cdot (1.0 \times 10^{-5})^2$

s = x = 7.9×10^{-5} mol Fe^{2+}/L