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Name:________________________

SCH 4U

K_{sp} Test

1. Using the K_{sp} value for PbI_2 found in the attached table, calculate:
   a) the solubility in mol/L for PbI_2
   b) the concentration of Pb^{2+} ion in a saturated solution of lead iodide in parts per million (Note: Parts per million or p.p.m. is a common unit for expressing small amounts of solute, ionic or otherwise. The unit p.p.m is a short form of the composite unit mg/L)

a) $PbI_2(s) \rightleftharpoons Pb^{2+} + 2I^{1-}$ ✓

Let s represent the solubility ✓

∴ $[Pb^{2+}] = s$ ✓

$[I^{1-}] = 2s$ ✓

$K_{sp} = [Pb^{2+}][I^{1-}]^2$ ✓

$7.1 \times 10^{-9} = s(2s)^2$ ✓

$7.1 \times 10^{-9} = 4s^3$

$s = 1.21 \times 10^{-3}$ mol/L ✓

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b) $\frac{1.21 \times 10^{-3} \text{ mol } PbI_2}{1 L} \times \frac{1 \text{ mol } Pb^{2+}}{1 \text{ mol } PbI_2} \times \frac{207.2 \text{ g } Pb^{2}}{1 \text{ mol } Pb^{2}} \times \frac{1000 \text{ mg}}{1 g}$ ✓ ✓ ✓

$= \frac{251 \text{ mg}}{1 L}$ ✓

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∴ 251 p.p.m. Pb^{2+} ✓

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2. Determine the $[Ag^{1+}]$ in M needed to just begin precipitate formation in a solution that has an carbonate ion concentration equal to 0.0001 M (i.e. $[CO_3^{2-}]$ = 0.0001 M)

$$ag_2CO_{3(s)} \rightleftharpoons 2ag^{1+} + CO_3^{2-} \checkmark$$

$$Ksp = [ag^{1+}]^2[CO_3^{2-}] \checkmark$$

$$[ag^+] = \sqrt{\frac{ksp}{[CO_3^{2-}]}} \checkmark$$

$$[ag^+] = \sqrt{\frac{8.2\times10^{-12}}{0.0001}}$$

$$[ag^+] = 2.86\times10^{-4}\,M \checkmark$$

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3. Calculate the K_{sp} value for $Fe(OH)_3$ given that the solubility of ferric hydroxide is 2.17 x 10^{-10} mol/L. *Use the table of K_{sp} values for confirmation purposes only.*

$$Fe(OH)_{3\,(s)} \rightleftharpoons Fe^{3+} + 3OH^{1-} \checkmark$$

$$[Fe^{3+}] = 2.17\times10^{-10}M \checkmark$$

$$[OH^-] = 3(2.17\times10^{-10}M)$$

$$= 6.51\times10^{-10}M \checkmark$$

$$Ksp = [Fe^{3+}][OH^-]^3 \checkmark$$

$$Ksp = (2.17\times10^{-10})(6.51\times10^{-10})^3$$

$$Ksp = 5.98\times10^{-38} \checkmark$$

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4. Determine the solubility of $CaCO_3$ in a solution of 0.100 M Na_2CO_3. Given your answer, determine the mass of $CaCO_3$ in mg that would be required to saturated 750 mL of the sodium carbonate solution.

✓ $\underset{0.100M}{Na_2CO_3(s)} \rightarrow 2Na^{1+} + \underset{0.100M}{CO_3^{2-}}$ ← common ion ✓

✓ $CaCO_3(s) \rightleftharpoons Ca^{2+} + CO_3^{2-}$

Let s represent the solubility of $CaCO_3$ ✓

$\therefore [Ca^{2+}] = s$ ✓

$[CO_3^{2-}] = s + 0.1$ ✓

$K_{sp} = [Ca^{2+}][CO_3^{2-}]$ ✓

$4.8 \times 10^{-9} = s(s + 0.1)$ ✓

assume $s << 0.1$

$\therefore 4.8 \times 10^{-9} = s(0.1)$

$s = 4.8 \times 10^{-8}$ mol/L ✓✓ ∴ assumption was valid

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$750 mL \times \frac{1 L}{1000 mL} \times \frac{4.8 \times 10^{-8} mol\ CaCO_3}{1 L} \times \frac{100.09 g\ CaCO_3}{1 mol\ CaCO_3} \times \frac{1000 mg}{1 g}$ ✓ ✓ ✓ ✓

$= 0.0036$ mg ✓

or $3.6\ \mu g$

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0.00024 M Pb(NO$_3$)$_2$. May I suggest use of a table for your solution.

✓ $\overset{0.0006\,M}{Na_2SO_{4(s)}} \rightarrow 2Na^{+} + \overset{0.0006\,M}{SO_4^{2-}}$ 250 mL

✓ $\overset{0.00024\,M}{Pb(NO_3)_{2(s)}} \rightarrow \overset{0.00024\,M}{Pb^{2+}} + 2NO_3^{1-}$ 500 mL

✓✓ $PbSO_{4(s)} \rightleftharpoons Pb^{2+} + SO_4^{2-}$ ✓

	$PbSO_{4(s)}$	Pb^{2+}	SO_4^{2-}
initial [ ]	N.A.	/	/
Initial Amount	0 ✓	n = CV n = 0.00024 × 0.5 n = 0.00012 mol ✓	n = CV n = 0.0006 × 0.25 n = 0.00015 mol
Final amount	x ✓	0.00012 − x	✓ 0.00015 − x
Final [ ]	N.A.	$\frac{0.00012 - x}{0.75}$	✓ $\frac{0.00015 - x}{0.75}$

750 mL → 0.75 L ✓

Let x represent the amount of $PbSO_4$ that forms ✓

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$K_{sp} = [Pb^{2+}][SO_4^{2-}]$ ✓

$1.6 \times 10^{-8} = \left(\frac{0.00012 - x}{0.75}\right)\left(\frac{0.00015 - x}{0.75}\right)$ ✓

$9 \times 10^{-9} = 1.8 \times 10^{-8} - 2.7 \times 10^{-4}x + x^2$

$0 = x^2 - 2.7 \times 10^{-4}x + 9 \times 10^{-9}$

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

$x = \frac{2.7 \times 10^{-4} \pm \sqrt{(2.7 \times 10^{-4})^2 - 4(1)(9 \times 10^{-9})}}{2(1)}$

$x = \frac{2.7 \times 10^{-4} \pm 1.92 \times 10^{-4}}{2}$

∴ $x =$ ~~2.3 × 10⁻⁴ mol~~ extraneous (too large)

or $x = 3.895 \times 10^{-5}$ mol ✓✓

3.895×10^{-5} mol $PbSO_4$

$\times \frac{303.27\,g\,PbSO_4}{1\,mol\,PbSO_4}$ ✓

$\times \frac{1000\,mg}{1\,g}$ ✓

$= 11.81$ mg $PbSO_4$ ✓

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