AP CHEMISTRY

TOPIC 12: SOLUTIONS, PART A,

Day 134:

- Solubility Equilibria
- Common Ion Effect

1. Lead(II) sulfate dissociates in water and has a $K_{sp} = 1.3 \times 10^{-8}$ at 25^0C

   a) Write the chemical dissociation equation for the above dissociation.

   $$PbSO_4 \rightleftharpoons Pb^{+2} + SO_4^{-2}$$

   b) Write the equilibrium expression

   $$K_{sp} = [\,Pb^{+2}\,][\,SO_4^{-2}\,]$$

   c) Calculate the concentration, in mol L^{-1} of the lead(II) ions in a saturated solution of lead(II) sulfate at 25^0C.

	$PbSO_4$	$\rightleftharpoons$	Pb^{+2}	+	SO_4^{-2}
I	-		0		0
C	-		$+x$		$+x$
E	-		x		x

$$1.3 \times 10^{-8} = [\,Pb^{+2}\,][\,SO_4^{-2}\,]$$

$$1.3 \times 10^{-8} = [\,x\,][\,x\,] = x^2$$

$$x = \sqrt{1.3\times10^{-8}} = 1.14 \times 10^{-4}\ M = [\,Pb^{+2}\,] = [\,SO_4^{-2}\,]$$

   d) Calculate the maximum mass, in grams, of lead(II) sulfate that can dissolve in 1500 mL of water at 25^0C.

$$\frac{1500\ mL}{} \times \frac{1\ L}{1000\ mL} \times \frac{1.14\times10^{-4}\ mol\ Pb^{+2}}{L} \times \frac{1\ mol\ PbSO_4}{1\ mol\ Pb^{+2}} \times \frac{303.26\ g}{1\ mol\ PbSO_4} = 5.19\times10^{-2}\ g$$

_OR_

$$\frac{1500\ mL}{} \times \frac{1\ L}{1000\ mL} \times \frac{1.14\times10^{-4}\ mol\ SO_4^{-2}}{L} \times \frac{1\ mol\ PbSO_4}{1\ mol\ SO_4^{-2}} \times \frac{303.26\ g}{1\ mol\ PbSO_4} = 5.19\times10^{-2}\ g$$

   e) A 0.20 mol sample of solid sodium sulfate is added to a 1.00 L saturated solution of lead(II) sulfate. Assuming no volume change, determine what will happen to the concentration of the lead ions once equilibrium has been established again.

According to Le Chatlier's principle, an increase in cations or anions will cause the reaction to shift away from those cations or anions. In this case, Na_2SO_4 will dissociate 100% (sodium sulfate is a STRONG salt) causing an INCREASE in sulfate anions within the solution AT EQUILIBRIUM (be sure to say this part "at equilibrium). This addition of anions will cause the reaction to shift to the left forming more solid in the solution. Therefore, since the sulfate is being introduced into the solution the lead ions will DECREASE from its original concentration at equilibrium. NO MATH is needed to answer this!

2. Zinc carbonate dissociates in water and has a $K_{sp} = 2.0 \times 10^{-10}$ at 25^0C

a) Write the chemical dissociation equation for the above dissociation.

$$ZnCO_3 \rightleftharpoons Zn^{+2} + CO_3^{-2}$$

b) Write the equilibrium expression

$$K_{sp} = [\ Zn^{+2}\ ]\ [\ CO_3^{-2}\ ]$$

c) Calculate the concentration, in mol L^{-1} of the carbonate ions in a saturated solution of zinc carbonate at 25^0C.

	$ZnCO_3$	$\rightleftharpoons$	Zn^{+2}	+	CO_3^{-2}
I	-		0		0
C	-		$+ x$		$+ x$
E	-		x		x

$$2.0 \times 10^{-10} = [\ Zn^{+2}\ ]\ [\ CO_3^{-2}\ ]$$

$$2.0 \times 10^{-10} = [\ x\ ]\ [\ x\ ] = x^2$$

$$x = 1.41 \times 10^{-5}\ M = [\ Zn^{+2}\ ] = [\ CO_3^{-2}\ ]$$

d) Calculate the maximum mass, in grams, of zinc carbonate that can dissolve in 1500 mL of water at 25^0C.

$$\frac{1500\ mL}{} \times \frac{1\ L}{1000\ mL} \times \frac{1.41 \times 10^{-5}\ mol\ Zn^{+2}}{L} \times \frac{1\ mol\ ZnCO_3}{1\ mol\ Zn^{+2}} \times \frac{125.39\ g}{1\ mol\ ZnCO_3} = 2.65 \times 10^{-3}\ g\ ZnCO_3$$

OR

$$\frac{1500\ mL}{} \times \frac{1\ L}{1000\ mL} \times \frac{1.41 \times 10^{-5}\ mol\ CO_3^{-2}}{L} \times \frac{1\ mol\ ZnCO_3}{1\ mol\ CO_3^{-2}} \times \frac{125.39\ g}{1\ mol\ ZnCO_3} = 2.65 \times 10^{-3}\ g\ ZnCO_3$$

3. In a saturated solution of $Ca_3(PO_4)_2$ at 25^0C, the concentration of PO_4^{-3} (*aq*) is 3.2895×10^{-7} *M*. The equilibrium constant expression for the dissolving of $Ca_3(PO_4)_2$ in water is shown below:

$$K_{sp} = [\,Ca^{+2}\,]^3\,[\,PO_4^{-3}\,]^2$$

a) Write the balanced equation for the dissolving of $Ca_3(PO_4)_2$ in water.

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

b) Calculate the value of K_{sp} for $Ca_3(PO_4)_2$ at 25^0C.

	$Ca_3(PO_4)_2$	$\rightleftharpoons$	$3\ Ca^{+2}$	+	$2\ PO_4^{-3}$
I	-		0		0
C	-		+ 3*x*		+ 2*x*
E	-		3*x*		2*x*

$$[\,PO_4^{-3}\,] = 3.2895 \times 10^{-7}\ M$$

$$[\,Ca^{+2}\,] = \frac{3.2895\times10^{-7}\ mol\ PO_4^{-3}}{L} \times \frac{3\ mol\ Ca^{+2}}{2\ mol\ PO_4^{-3}} = 4.93\times10^{-7}\ M\ \left[Ca^{+2}\right]$$

$$K_{sp} = (\,4.93 \times 10^{-7}\,)^3\ (\,3.2895 \times 10^{-7}\,)^2 = 1.3 \times 10^{-32}$$

c) A 1.00 L sample of saturated $Ca_3(PO_4)_2$ is allowed to evaporate at 25^0C to a final volume of 500 mL. What is the [PO_4^{-3}] in the solution? Justify your answer.

SATURATED SOLUTION means that the solution can no longer dissolve (dissociate) any additional solute for "that" volume of solution. IF a saturated solution has water evaporate the solute stays behind. When water leaves the system, the solute that was once dissolved in that water volume MUST NOW come out of solution and form a precipitate (a solid). The key statement in this question is SATURATED SOLUTION. The concentration WILL NOT CHANGE if saturated.