b. After two days of sitting on the counter, some liquid has evaporated from the solution. Did $[Ba^{2+}]$ increase, decrease, or remain the same? Justify your answer.

Remain the same! Although less liquid is present, the sol'n was already saturated, thus $[Ba^{2+}]$ cannot increase.

c. The chemist adds 3.00 g of solid $(NH_4)_3PO_4$ to the original saturated solution of $Ba_3(PO_4)_2$. Did $[Ba^{2+}]$ increase, decrease, or remain the same? Justify your answer.

Decrease, b/c adding a common ion, PO_4^{3-}, to sol'n will increase [products], + so the rxn will shift left to re-establish equilibrium. This means more $Ba_3(PO_4)_2$ (s) will form, removing some Ba^{2+} from sol'n.

2. A solution containing lead (II) nitrate is mixed with one containing sodium bromide to form a solution that is 0.0150 M in $Pb(NO_3)_3$ and 0.00350 M NaBr. Does a precipitate form in this newly mixed solution? (K_{sp} of $PbBr_2$ = 4.67×10^{-6})

$$Q = [Pb^{2+}][Br^-]^2 = (0.0150)(0.00350)^2 = 1.84 \times 10^{-7}$$

$K > Q$ $\quad$ $K > Q$ so no precipitate will form.

$4.67E-6 > 1.84E-7$

3. The K_{sp} value for lead (II) bromide, $PbBr_2$, is 4.6×10^{-6} at 25°C. What is the maximum mass, in grams, of $PbBr_2$ that can dissolve in 1.50 L of water?

$$K_{sp} = [Pb^{2+}][Br^-]^2 = x(2x)^2 = 4x^3 = 4.6E-6$$

$$x = \sqrt[3]{\frac{4.6E-6}{4}} = 0.01048 \text{ M } PbBr_2 \times 1.50 \text{ L} = 0.016 \text{ mol} \times \frac{367 \text{ g } PbBr_2}{1 \text{ mol}}$$

$$= \boxed{5.8 \text{ g } PbBr_2}$$

4. A student mixes $\boxed{\text{15.0 mL of 0.015 M sodium iodide}}$ solution, NaI, with $\boxed{\text{5.00 mL of 0.0025 M } Pb(NO_3)_2}$. The K_{sp} of $\boxed{PbI_2}$ is 8.5×10^{-9} M. What will the student observe? Justify your answer with calculations.

$$[I^-] = \frac{mmol}{mL} = \frac{(15.0\,mL)(0.015\,M)}{(20.0\,mL)} = 0.01\underline{1}25\,M$$

$$[Pb^{2+}] = \frac{mmol}{mL} = \frac{(5.00\,mL)(0.0025\,M)}{(20.0\,mL)} = 6.\underline{2}5E{-4}\,M$$

$$Q = [Pb^{2+}][I^-]^2 = (6.25E{-4})(0.01\underline{1}25)^2$$
$$= 7.9E{-8}$$

$K < Q$

$8.5E{-9} < 7.9E{-8}$

Since $K < Q$, the student will observe a precipitate forming b/c the rxn will shift left to reach equilibrium.

5. Sodium carbonate is added to a $\boxed{\text{0.0024 M}}$ solution of the $\boxed{\text{nickel (II) ion}}$. If $[Na_2CO_3] = \boxed{1.0 \times 10^{-4}\,M}$, will a precipitate form? (The K_{sp} of $\boxed{\text{nickel (II) carbonate}}$ is 6.6×10^{-9}.)

$NiCO_3$

$$Q = [Ni^{2+}][CO_3^{2-}] = (0.0024)(1.0E{-4}) = 2.4E{-7}$$

$K < Q$

$6.6E{-9} < 2.4E{-7}$

Since $K < Q$, a precipitate will form: the rxn will shift left to reduce the # of ions in sol'n to reach equilibrium, thus forming solid $NiCO_3$.

6. Calculate the molar solubility of $Ba_3(PO_4)_2$, which has a $K_{sp} = 6.0 \times 10^{-39}$.

$$K_{sp} = [Ba^{2+}]^3[PO_4^{3-}]^2 = (3x)^3(2x)^2 = 108x^5 = 6.0E{-39}$$

$$x = \sqrt[5]{\frac{6.0E{-39}}{108}} = \boxed{8.9 \times 10^{-9}\,M}$$

Multiple Choice Practice!

7. 150 mL of saturated SrF_2 solution is present in a 250 mL beaker at room temperature. If some of the solution evaporates overnight, which of the following will occur?

   a. The mass of the solid and the concentration of the ions will remain the same.

   b. The mass of the solid and the concentration of the ions will increase.

   c. The mass of the solid will decrease, and the concentration of the ions will remain the same.

   d. The mass of the solid will increase, and the concentration of the ions will remain the same.

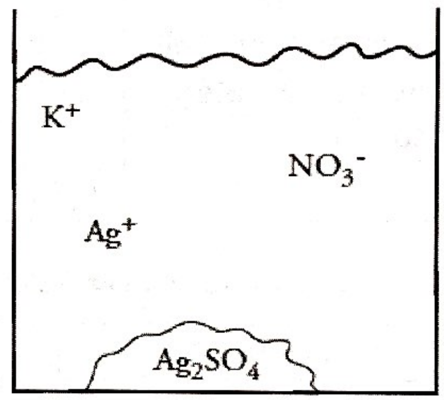
8. A student added 1 liter of a 1.0 M KCl solution to 1 liter of a 1.0 M $Pb(NO_3)_3$ solution. A lead chloride precipitate formed, and nearly all of the lead ions disappeared from solution. Which of the following lists the ions remaining in the solution in order of decreasing concentration?

   a. $[NO_3^-] > [K^+] > [Pb^{2+}]$ c. $[K^+] > [Pb^{2+}] > [NO_3^-]$

   b. $[NO_3^-] > [Pb^{2+}] > [K^+]$ d. $[K^+] > [NO_3^-] > [Pb^{2+}]$

Use the following information to answer questions 8–10.

Silver sulfate, Ag_2SO_4, has a solubility product constant of 1.0×10^{-5}. The diagram to the right shows the products of a precipitation reaction in which some silver sulfate was formed.



9. What is the identity of the excess reactant?

   a. $AgNO_3$ c. $NaNO_3$

   b. Ag_2SO_4 d. Na_2SO_4

10. If the beaker above was left uncovered for several hours:

    × I. Some of the Ag_2SO_4 would dissolve.
    ✓ II. Additional Ag_2SO_4 would precipitate.
    ✓ III. $[Ag^+]$ would remain constant.

    a. I only b. II only c. II and III d. I and III

11. Which ion concentration below would have led the precipitate to form?

    a. $[Ag^+] = 0.01$ M, $[SO_4^{2-}] = 0.01$ M

    b. $[Ag^+] = 0.10$ M, $[SO_4^{2-}] = 0.01$ M

    c. $[Ag^+] = 0.01$ M, $[SO_4^{2-}] = 0.10$ M

    d. It is impossible to determine without knowing the total volume of the solution.

$Q = [Ag^+]^2[SO_4^{2-}]$
$= (0.1)^2(0.01) = 1.4E{-}4$

Want $K < Q$ for precipitate to form $\Rightarrow$ need $Q > 1E{-}5$ (K)