Name: ________________________________

Solubility Problems – Need to look at page 802 – Solubility constants

1. Write balanced chemical equations and the K_{sp} expressions for the dissolving of the following compounds in water.
   a) sodium sulfide
   b) calcium iodide
   c) lithium carbonate
   d) iron(II) sulfate
   e) cobalt(II) nitrate
   f) barium phosphate

2. What are the concentrations of the resulting ions in saturated aqueous solutions of the following compounds?
   a) lead (II) sulfate [Pb^{2+}=1.3x10^{-4} M, SO_4^{2-}= 1.3x10^{-4} M]
   b) silver carbonate [Ag^{+}=2.6x10^{-4} M, CO_3^{2-}= 1.3x10^{-4} M]
   c) magnesium hydroxide [Mg^{2+}=1.1x10^{-4} M, OH^{-}= 2.2x10^{-4} M]

3. Calculate the K_{sp} values of the following substances from their solubilities in water.
   a) silver chloride with a solubility of 1.6x10^{-3}g/L [1.2x10^{-10}]
   b) lithium carbonate with a solubility of 13.0 g/L [2.2x10^{-2}]

4. Calculate the concentrations of ions in saturated aqueous solutions of the following.
   a) silver iodide [Ag^{+}=9.2x10^{-17} M, I^{-}= 9.2x10^{-17} M]
   b) strontium carbonate [Sr^{2+}=2.4x10^{-5} M, CO_3^{2-}= 2.4x10^{-5} M]

5. What are the ion concentrations in saturated solutions of the following:
   a) lead(II) iodide [Pb^{2+}=1.3x10^{-3} M, I^{-}= 2.6x10^{-3} M]
   b) silver sulfate [Ag^{+}=2.8x10^{-2} M, SO_4^{2-}= 1.4x10^{-2} M]
   c) iron(III) hydroxide [Fe^{3+}=9.9x10^{-11} M, OH^{-}= 3.0x10^{-10} M]

6. Calculate the K_{sp} values of the substances below from their solubilities in water:
   a) thallium(I) chloride, 3.4 g/L at 25°C [2.0x10^{-4}]
   b) silver bromide, 1.3x10^{-4} g/L at 20°C [4.8x10^{-13}]
   c) calcium fluoride, 1.6x10^{-2} g/L at 20°C [3.4x10^{-11}]

7. Calculate the maximum iodide ion concentration for lead(II) iodide dissolved in a 1.00x10^{-2} M solution of lead(II) nitrate. [9.2x10^{-4} M]

8. Calculate the maximum barium ion concentration in a 0.010 M aqueous solution of sodium sulfate. The K_{sp} of barium sulfate is 1.1x10^{-11}. [1.1x10^{-9}]

9. Calculate the maximum magnesium ion concentration in a 0.020 M aqueous solution of barium hydroxide. The K_{sp} of magnesium hydroxide is 1.2x10^{-11}. [7.9x10^{-9}]

10. Upon addition of hydroxide ions to sea water, $Mg(OH)_2$ precipitates. If the magnesium ion concentration in sea water is 5.3x10^{-2} M, calculate the maximum hydroxide ion concentration in sea water. [1.0x10^{-5}]

11. A sample of sea water contains 0.53 M of Cl^{-} ions and 8.4x10^{-4} M of Br^{-} ions. What concentration of added Ag^{+} ions would cause precipitation of AgCl and AgBr? Which of these two halides would precipitate first? The K_{sp} for AgCl is 1.6x10^{-3} and the K_{sp} for AgBr is 6.5x10^{-13}. [Cl^{-}:3.0x10^{-3} Br^{-}:7.7x10^{-10}, AgBr precipitates first]

12. How many mg of Pb^{2+} must be present in 10.0 mL of 0.135 M NaCl solution for $PbCl_2$ to precipitate? [1.4 mg]

13. Will a precipitate of CaF_2 form when 0.084 g of sodium fluoride is dissolved in 1.00 L of a 0.010 M aqueous solution of calcium chloride. K_{sp} for calcium fluoride is 3.9x10^{-11}. [Q=4.0x10^{-8}, yes a ppt will form]

14. In which of the following reactions does a precipitate form?
    a) 10.0 mL of 0.010 M $AgNO_3$ and 10.0 mL of 0.10 M Na_2SO_4. (K_{sp} for Ag_2SO_4=$1.2x10^{-5}$) [Q=$1.25x10^{-6}$]
    b) 1.0 mL of 0.10 M $Ca(NO_3)_2$ and 1.0 L of 0.010 M NaF. [Q=$1.0x10^{-8}$]
    c) 5.0 mL of 0.0040 M $AgNO_3$ and 15 mL of a solution containing 1.5 mg of Br^- ions. [Q=$9.5x10^{-7}$]

15. Would you expect a precipitate of silver bromate (K_{sp}=$1.2x10^{-11}$) to form when 50.0 mL of 0.0020 M silver nitrate is added to 250.0 mL of 0.020 M potassium bromate. [Q=$5.6x10^{-6}$]

16. Will a precipitate of $Mg(OH)_2$ form when 1.00 mL of 0.010 M $Ca(OH)_2$ is added to 1.0 L of 0.20 M $Mg(NO_3)_2$. You may ignore the volume change caused by the addition of 1.00 mL. [Q=$8.0x10^{-11}$]

17. One litre of solution has 100.0 mg of Ba^{2+} and 10.0 g of Sr^{2+}. Within what range must the [CrO_4^{2-}] be to precipitate barium without precipitating strontium. (K_{sp} $SrCrO_4$ =$3.6x10^{-5}$) [$1.6x10^{-7}$ M < [CrO_4^{2-}] < $3.2x10^{-4}$M]

18. A 0.010 M aqueous solution of Na_2SO_4 is added one drop at a time to 1.00 L of 0.0010 M lead(II) nitrate. What is the minimum volume of sodium sulfate that must be added to form a precipitate of lead(II) sulfate. The K_{sp} for lead(II) sulfate is $1.3x10^{-8}$. [1.3 mL]

19. Compare the molar solubility of PbI_2 in a) pure water and b) in 0.10 M NaI. [a) $1.3x10^{-3}$, b) $8.5x10^{-7}$]

20. How many grams of $SrCO_3$ will dissolve in 250 mL of 0.080 mol/L $SrNO_3$? [$2.6x10^{-7}$ g]

21. For each of the following substances, calculate the milligrams per millilitre of metallic ion that can remain at equilibrium in a solution having a [OH^-]=$1.0x10^{-4}$.
    a) $Zn(OH)_2$, K_{sp}=$4.3x10^{-17}$ [$2.8x10^{-7}$mg/mL]
    b) $Fe(OH)_3$, K_{sp}=$2.6x10^{-39}$ [$1.5x10^{-25}$ mg/mL]
    c) $Mg(OH)_2$, K_{sp}=$5.6x10^{-12}$ [$1.4x10^{-2}$ mg/mL]

22. Calculate the [Ag^+] needed to begin precipitation of each of the following anions from solutions containing 1 mg of anion per mL of solution.
    a) Br^- [$4.3x10^{-11}$]
    b) S^{2-} (K_{sp}=$1.8x10^{-50}$) [$7.6x10^{-25}$]
    c) BrO_3^- [$6.8x10^{-3}$]
    d) CrO_4^{2-} [$1.2x10^{-5}$]

23. What is the solubility in mol/L of AgBr in a solution resulting from the addition of 50.0 mL of 0.010 $CaBr_2$ to 50.0 mL of 0.0080 M $AgNO_3$? (K_{sp}=$5.4x10^{-13}$) [$9.0x10^{-11}$]

24. If 50.0 mL of 0.10 M $AgNO_3$ is added to 150 mL of 0.10 M $CaCl_2$, what is the resulting concentration of each ion in the final solution? (K_{sp}=$1.8x10^{-10}$) [Ag^+ =$1.4x10^{-9}$M, Cl^-=0.125 M, NO_3^-=0.025M, Ca^{2+}=0.075 M]

25. What volume of 0.10 M $CaBr_2$ must be added to 100.0 mL of 0.10 M of $Pb(NO_3)_2$, before a precipitate of $PbBr_2$ (K_{sp}=$1.4x10^{-8}$) starts to form. Assume the total volume remains at 100.0 mL. [0.19 mL]

26. How many litres of water at 25°C must be added to mercury(II) sulfide (K_{sp}=$3.0x10^{-54}$) in order for 1 mercury atom to be present in solution? (HINT: You will need Avogadro's number) [1000 L]

27. A 100.0 mL sample of 1.00 M Na_2SO_4 is added to 200.0 mL of 1.00 M $BaCl_2$. Determine the mass of $BaCl_2$ that precipitates from solution and the concentration of all ions at equilibrium. [m=23.3 g, Ba^{2+} =0.333 M, Cl^-=1.33 M, SO_4^{2-}= 3.33 X10^{-10} M, Na^+=0.667 M]

28. A 1.50 L sample of 0.250 M NaOH is added to 1.00 L of 0.150 M $Mg(NO_3)_2$. Calculate the mass of $Mg(OH)_2$ that precipitates and the concentration of all ions in solution at equilibrium. [m=8.75 g, Mg^{2+} =$6.22x10^{-9}$ M, OH^-=0.0300 M, NO_3^-= 0.120 M, Na^+=0.150 M]