Solubility (no calculator)

(All questions may be completed without the use of a calculator. All answers given were generated without a calculator.)

1) The molar solubility of a compound with the formula M_2X is 0.020. Calculate its K_{sp}.
   (Answer: 3.2 x 10^{-5})

2) The solubility of cobalt(II) carbonate (molar mass = 119 g) is 0.119 mg/100 mL of water. Calculate its K_{sp}.
   (Answer: 1 x 10^{-10})

3) Calculate the molar solubility of Ag_2CrO_4 (K_{sp} = 2.6 x 10^{-12}) in:

   a) 2.6 x 10^{-2} M Na_2CrO_4 **[1 x 10^{-5} M]**
   b) 0.16 M $AgNO_3$ **[1 x 10^{-10} M]**

4) Which compound in each pair is more soluble in water? (Look up the K_{sp} values in your textbook or online.)

   a) Manganese(II) hydroxide or calcium iodate
   b) Strontium carbonate or cadmium sulphide
   c) Silver cyanide or copper(I) iodide
   (Answers: (a) $Ca(IO_3)_2$ is more soluble, (b) $SrCO_3$ is more soluble, (c) CuI is more soluble)

5) Does any solid Ag_2CrO_4 (K_{sp} = 2.6 x 10^{-12}) form when 1.0 mL of 0.10 M $AgNO_3$ is mixed with 999.0 mL of 1 x 10^{-3} M K_2CrO_4?
   (Answer: Yes, a precipitate would form because Q_{sp} > K_{sp}.)

6) When blood is donated, sodium oxalate is used to precipitate out the Ca^{2+} present (Ca^{+2} triggers clotting). A 100 mL sample of blood contains 1.0 x 10^{-4} g Ca/mL blood. A technologist treats this sample with 100 mL of 1.00 M $Na_2C_2O_4$. The K_{sp} of $CaC_2O_4 \cdot H_2O$ is 2.5 x 10^{-9}. Calculate the [Ca^{2+}] and the % Ca^{2+} left in solution after this treatment.
   (Answers: [Ca^{2+}] = 5 x 10^{-9} M and 4 x 10^{-4} % Ca^{2+} left in solution.)

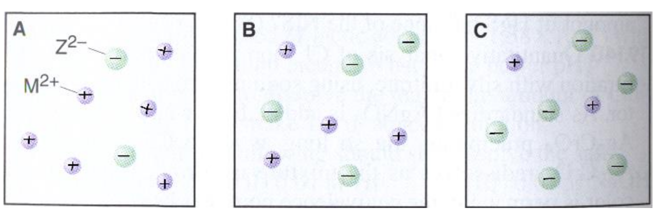
7) 50 mL of 3.2 x 10^{-3} M $Fe(NO_3)_3$ is mixed with 50 mL of 1.44 M $Cd(NO_3)_2$. The K_{sp} of $Fe(OH)_3$ is 1.6 x 10^{-39}, and the K_{sp} of $Cd(OH)_2$ is 7.2 x 10^{-15}

a) If aqueous NaOH is added to the above solution, which ion precipitates first? **(Answer: Fe^{+3})**
b) Describe how the metal ions can be separated using NaOH. **(Answer: As NaOH is added $Fe(OH)_3$ will continue to preciptate until the $[OH^{-1}]$ is sufficiently large to cause the $Cd(OH)_2$ to start to precipitate out.)**
c) Calculate the $[OH^{-1}]$ at which the $Cd(OH)_2$ just begins to precipitate out. **(Answer: $[OH^{-1}]$ = 1 x 10^{-7} M)**
d) Calculate the $[Fe^{+3}]$ left in solution when the $Cd(OH)_2$ just begins to precipitate out of solution. **(Answer: 1.6 x 10^{-19} M)**

8) Gout is caused by the build up of uric acid in body fluids. Crystals of sodium urate ($NaC_5H_3N_4O_3$) are deposited in the joints, particularly in the big toe. The molar solubility of sodium urate is 5 x 10^{-3}. If the $[Na^+]$ in bodily fluids is 0.15 M, at what urate concentration will a deposit of sodium urate occur in the big toe joint? **(Answer: 1.7 x 10^{-4} M)**

9) Scenes A to C represent aqueous solutions of the slightly soluble salt MZ (only the ions of the salt are shown):

$$MZ(s) \rightleftharpoons M^{+2}(aq) + Z^{-2}(aq)$$



a) Which scene represents the solution just after solid MZ is stirred thoroughly in distilled water?
b) If each sphere represents 2.5 x 10^{-6} M of ions, what is the K_{sp} of MZ?
c) Which scene represents the solution after $Na_2Z(aq)$ is added?
d) If Z^{-2} is CO_3^{-2}, which scene represents the solution after the pH has been lowered? **(Answers: (a) B, (b) K_{sp} = 1 x 10^{-10}, (c) C, (d) A)**

10) A solution contains 5.3×10^{-4} M Cu^+ and 1.4×10^{-3} M Pb^{2+}.

a) If a source of I^{-1} is added to this solution, will PbI_2 ($K_{sp} = 1.4 \times 10^{-8}$) or CuI ($K_{sp} = 5.3 \times 10^{-12}$) precipitate first? Specify the concentration of I- necessary to begin precipitation of each compound.
(Answer: CuI will precipitate first since a much lower concentration of I^{-1} would be required. The $[I^{-1}]$ necessary to precipitate the Cu^+ is 1.0×10^{-8} M vs. 1.0×10^{-3} M to precipitate the Pb^{2+}.)

b) Calculate the % of the first ion to precipitate left in solution when the second ion just starts to precipitate.
(Answer: When the PbI_2 just begins to precipitate 0.001% of the Cu^+ will remain in solution.)

11) You are to do a titration of 10.00 mL of 0.1000 M NaCl with 0.1000 M $AgNO_3$. The K_{sp} of AgCl is 1.8×10^{-10} and we will define the pCl scale as:

$$pCl = -\log[Cl^-]$$

(If you've done acids and bases before, this is a similar sort of idea as was used to define the pH scale.)

a) Calculate the pCl at the start of the titration. **(Answer: pCl = 1.0)**

b) Calculate the approximate pCl after 9.00 mL of $AgNO_3$ solution has been added.
(Answer: pCl ≅ 2.3)

c) Calculate the pCl after 10.00 mL of $AgNO_3$ solution has been added.
(Answer: pCl = 4.87)

d) Calculate the approximate pCl after 11 00 mL of $AgNO_3$ solution has been added.
(Answer: pCl ≅ 7.4)