Ksp Problems – SCH 4U

1. Calculate the Ksp for each of the salts whose solubility is listed below.

(a) $CaSO_4$ = 5.0 X 10^{-3} kmol/m^3
(b) MgF_2 = 2.7 X 10^{-3} kmol/m^3
(c) $AgC_2H_3O_2$ = 1.02 g/l00 mL
(d) SrF_2 = 12.2 mg/100 mL

2. Calculate (a) the solubility in kmol/m^3 of each of these salts and (b) the concentration of the cations in mg/mL in each of the saturated solutions

(a) AgCN Ksp = 2 X 10^{-12}
(b) $BaSO_4$ Ksp = 1.5 X 10^{-9}
(c) FeS Ksp = 3.7 X 10^{-19}
(d) $Mg(OH)_2$ Ksp = 9 X 10^{-12}
(e) Ag_2S Ksp = 1.6 X 10^{-49}
(f) CaF_2 Ksp = 4.9 X 10^{-11}

3. Consider these slightly soluble salts:

(1) PbS Ksp = 8.4 X 10^{-28}
(2) $PbSO_4$ Ksp = 1.6 X 10^{-8}
(3) $Pb(IO_3)_2$ Ksp = 2.6 X 10^{-13}
(a) Which is the most soluble?
(b) Calculate the solubility in kmol/m^3 of $PbSO_4$
(c) How many grams of $PbSO_4$ dissolve in one litre of solution?
(d) How can you decrease the concentration of Pb^{2+}(aq) in a saturated $PbSO_4$ solution?
(e) What is the concentration in kmol/m^3 of PbS in a saturated solution of the salt?

4. For each of these substances, calculate the milligrams of metallic ion per mL that can remain at equilibrium in a solution having a [OH^{1-}] = 1.0 X 10^{-4} kmol/m^3

(a) $Cu(OH)_2$ Ksp = 1.6 X 10^{-19}
(b) $Fe(OH)_3$ Ksp = 6.0 X 10^{-38}
(c) $Mg(OH)_2$ Ksp = 9.0 X 10^{-12}

5. Calculate the [Ag+] needed to begin precipitation of each of these anions from solutions containing one mg of anion per mL of solution.

(a) Br^{1-}
(b) S^{2-}
(c) BrO_3^{1-}
(d) CrO_4^{2-}
(e) IO_3^{1-}

6. How many mg of TlI can dissolve in 500 mL of
(a) water,
(b) 0.1 kmol/m^3 $TlNO_3$
(c) 0.02 kmol/m^3 KI

7. What is the solubility in kmol/m^3 AgBr in a solution resulting from the addition of 50.0 mL of 0.01 kmol/m^3 $CaBr_2$ to 50.0 mL of 0.008 kmol/m^3 $AgNO_3$?

8. Fifty mL of 0.10 kmol/m^3 $AgNO_3$ is added to 150 mL of 0.10 kmol/m^3 $CaCl_2$. What is the concentration of each ion in the resulting solution?

9. In which of these reactions does a precipitate form?

9. In which of these reactions does a precipitate form?
(a) 10.0 mL of 0.01 kmol/m^3 $AgNO_3$ + 10.0 mL of 0.10 kmol/m^3 Na_2SO_4
(b) 1 mg of $MgCl_2$+ 1 L of 0.01 kmol/m^3 $Na_2C_2O_4$
(c) 1 mL of 0.1 kmol/m^3 $Ca(NO_3)_2$ + 1 L of 0.01 kmol/m^3 HF
(d) 1 mL of 0.1 kmol/m^3 $Ca(NO_3)_2$ + 1 L of 0.01 kmol/m^3 NaF
(e) 5 mL of 0.004 kmol/m^3 $AgNO_3$ + 15 mL of a solution containing 1.5 mg Br^{1-} ions

10. How many mg of Pb^{2+} must be present in 10.0 mL of a 0.135 kmol/m^3 NaCl solution for $PbCl_2$ to precipitate?

11. A solution contains 0.01 kmol/m^3 $TINO_3$ and 0.01 kmol/m^3 $AgNO_3$.
(a) Which compound precipitates first when Nal is slowly added to 100 mL of this solution?
(b) How many mg of this ion remain unprecipitated when the second compound begins to precipitate?

12. A litre of solution contains 100 mg of Ba^{2+} and 10.0 g of Sr^{2+}. Within what range must the concentration of CrO_4^{2-} be to precipitate Ba^{2+} without precipitating any Sr^{2+}?

13. Does a precipitate of $Mg(OH)_2$ form when 10.0 mL of a 0.10 kmol/m^3 NH_3 solution containing 3.0 g of NH_4CI is mixed with 10.0 mL of 0.10 kmol/m^3 $MgCl_2$ solution?

14. Does a precipitate of $Mg(OH)_2$ form when 10.0 mL of 0.050 kmol/m^3 aqueous NH_3 is mixed with 10.0 mL of 0.15 kmol/m^3 $MgCl_2$

15. Barium nitrate reacts with potassium sulfate solution and forms insoluble $BaSO_4$. What volume of 0.40 kmol/m^3 $Ba(NO_3)_2$ solution is required to precipitate effectively the sulfate ions in 25 mL of 0.80 kmol/m^3 of K_2SO_4 solution?

16. What volume of 0.25 kmol/m^3 KCl solution is required to precipitate effectively the silver ions from 160.0 mL sample of 0.60 kmol/m^3 $AgNO_3$ solution?

17. What mass of silver chloride can be precipitated from a silver nitrate solution by 200 mL of a solution of 0.50 kmol/m^3 $CaCl_2$

18. A sample of an unknown chloride with a mass of 0.210 g is treated with 30.00 mL of 0.100 kmol/m^3 $AgNO_3$. The precipitate is filtered and the excess silver in the filtrate is titrated with 5.65 mL of 0.0900 kmol/m^3 KSCN. What is the percentage of Cl in the sample?

19. A solution of KI contains 0.200 g KI in 50.00 mL of solution. If 25.00 mL of 0.1 00 kmol/m^3 $AgNO_3$ is added to the KI solution, how many mL of 0.110 kmol/m^3 KSCN are needed for back titration?

Answers for Ksp Problems

1. a) 2.5×10^{-5}
   b) 7.87×10^{-8}
   c) 3.73×10^{-3}
   d) 3.66×10^{-9}

2. a) $s = 1.41 \times 10^{-6}$ mol/L
   $[Ag^+] = 1.41 \times 10^{-6}$ M
   $[CN^-] = 1.41 \times 10^{-6}$ M

   b) $s = 3.87 \times 10^{-5}$ mol/L
   $[Ba^{2+}] = 3.87 \times 10^{-5}$ M
   $[SO_4^{2-}] = 3.87 \times 10^{-5}$ M

   c) $s = 6.08 \times 10^{-10}$ mol/L
   $[Fe^{2+}] = 6.08 \times 10^{-10}$ M
   $[S^{2-}] = 6.08 \times 10^{-10}$ M

   d) $s = 1.31 \times 10^{-4}$ mol/L
   $[Mg^{2+}] = 1.31 \times 10^{-4}$ M
   $[OH^-] = 2.62 \times 10^{-4}$ M

   e) $s = 3.42 \times 10^{-17}$ mol/L
   $[Ag^+] = 6.84 \times 10^{-17}$ M
   $[S^{2-}] = 3.42 \times 10^{-17}$ M

   f) $s = 2.31 \times 10^{-4}$ mol/L
   $[Ca^{2+}] = 2.31 \times 10^{-4}$ M
   $[F^-] = 4.61 \times 10^{-4}$ M

4. a) $[Cu^{2+}] = 1.02 \times 10^{-9}$ mg/mL
   b) $[Fe^{3+}] = 3.35 \times 10^{-24}$ mg/mL
   c) $[Mg^{2+}] = 2.19 \times 10^{-2}$ mg/mL

5. a) $[Ag^+] = 6.15 \times 10^{-11}$ M
   b) $[Ag^+] = 2.26 \times 10^{-24}$ M
   c) $[Ag^+] = 7.67 \times 10^{-3}$ M
   d) $[Ag^+] = 1.13 \times 10^{-5}$ M
   e) $[Ag^+] = 5.42 \times 10^{-6}$ M

6. a) 49.4 mg TlI
   b) 0.149 mg TlI
   c) 0.737 mg TlI

7. $s = \varnothing$

8. $[Ag^+] = 1.44 \times 10^{-9}$ M
   $[Cl^-] = 0.125$ M
   (very tough problem)

9. a) & b) no ppte
   c), d) & e) ppte forms

10. more than 1.82 mg Pb^{2+}

11. Tl^+ ppte first
    1×10^{-7} mg Ag^+ remain

Solubility Product Constants

$AgC_2H_3O_2$	2.5×10^{-3}	Cu_2S	1.6×10^{-48}
$AgBr$	7.7×10^{-13}	FeS	3.7×10^{-19}
$AgBrO_3$	6×10^{-5}	$Fe(OH)_3$	6.0×10^{-38}
Ag_2CO_3	8.2×10^{-12}	HgS	3×10^{-53}
$AgCl$	1.8×10^{-10}	$MgCO_3$	2.5×10^{-5}
Ag_2CrO_4	1.1×10^{-12}	MgC_2O_4	8.6×10^{-5}
$AgCN$	2.0×10^{-12}	$Mg(OH)_2$	9.0×10^{-12}
AgI	8.3×10^{-17}	MnS	1.4×10^{-15}
$AgIO_3$	3.1×10^{-8}	NiS	1.8×10^{-21}
Ag_2S	1.6×10^{-49}	$PbCl_2$	1.6×10^{-5}
$AgSO_4$	1.2×10^{-5}	$PbCrO_4$	1.8×10^{-14}
$Al(OH)_3$	3×10^{-33}	$Pb(IO_3)_2$	2.6×10^{-13}
$BaCO_3$	4.9×10^{-9}	PbI_2	7.1×10^{-9}
$BaCrO_4$	1.2×10^{-10}	$PbSO_4$	1.6×10^{-8}
$BaSO_4$	1.5×10^{-9}	PbS	8.4×10^{-28}
$CaCO_3$	4.8×10^{-9}	$SrCO_3$	7×10^{-10}
CaC_2O_4	2.3×10^{-9}	$SrCrO_4$	3.6×10^{-5}
CaF_2	4.9×10^{-11}	$SrSO_4$	7.6×10^{-7}
$CaSO_4$	2.6×10^{-5}	$TlBr$	3.6×10^{-6}
CdS	1.0×10^{-28}	$TlCl$	1.9×10^{-4}
CoS	1.0×10^{-21}	TlI	8.9×10^{-8}
$CuCl$	3.2×10^{-7}	$Zn(OH)_2$	2×10^{-14}
$Cu(OH)_2$	1.6×10^{-19}	ZnS	4.5×10^{-24}
CuS	8.5×10^{-45}		