Solubility equilibrium

8.

Which salts will be more soluble in an acidic solution than in pure water?

- $CsClO_4$
- CuI
- $CaCO_3$
- $Zn(OH)_2$
- Ag_2SO_4

10.

The K_{sp} of $PbBr_2$ is 6.60×10^{-6}.

What is the molar solubility of $PbBr_2$ in pure water?

Number _____ M

What is the molar solubility of $PbBr_2$ in 0.500 M KBr solution?

Number _____ M

What is the molar solubility of $PbBr_2$ in a 0.500 M $Pb(NO_3)_2$ solution?

Number _____ M

12.

Given the equation

Map

$$Ag^+(aq) + 2NH_3(aq) \longrightarrow \left[Ag\left(NH_3\right)_2\right]^+(aq) \qquad K_f = 2.00\times10^7$$

determine the concentration of $NH_3(aq)$ that is required to dissolve 597 mg of AgCl(s) in 100.0 mL of solution. The K_{sp} of AgCl is 1.77×10^{-10}.

Number _____ M

13.

The generic metal A forms an insoluble salt AB(*s*) and a complex $AC_5(aq)$.

The equilibrium concentrations in a solution of AC_5 were found to be [A] = 0.100 M, [C] = 0.0190 M, and $[AC_5]$ = 0.100 M. Determine the formation constant, K_f, of AC_5.

K_f = Number

The solubility of AB(*s*) in a 1.000-M solution of C(*aq*) is found to be 0.158 M.
What is the K_{sp} of AB?

K_{sp} = Number

14.

A 0.170-mole quantity of $NiCl_2$ is added to a liter of 1.20 M NH_3 solution. What is the concentration of Ni^{2} M ions at equilibrium? Assume the formation constant* of $Ni(NH_3)_6^{2+}$ is 5.5×10^8.

Number M

15.

Consider an amphoteric hydroxide, $M(OH)_2(s)$, where M is a generic metal.

$$M(OH)_2(s) \rightleftharpoons M^{2+}(aq) + 2OH^-(aq) \qquad K_{sp} = 3 \times 10^{-16}$$

$$M(OH)_2(s) + 2OH^-(aq) \rightleftharpoons [M(OH)_4]^{2-}(aq) \qquad K_f = 0.05$$

Estimate the solubility of $M(OH)_2$ in a solution buffered at pH = 7.0, 10.0, and 14.0.

pH = 7.0
Number M

pH = 10.0
Number M

pH = 14.0
Number M

19.

Sodium sulfate is slowly added to a solution containing 0.0500 M $Ca^{2+}(aq)$ and 0.0280 M $Ag^+(aq)$.
What will be the concentration of $Ca^{2+}(aq)$ when $Ag_2SO_4(s)$ begins to precipitate?
Solubility-product constants, K_{sp}, can be found here.

$[Ca^{2+}]$ = Number M

What percentage of the $Ca^{2+}(aq)$ can be precipitated from the $Ag^+(aq)$ by selective precipitation?

Number %

20.

Suppose you have a solution that contains 0.0410 M Ca^{2+} and 0.0910 M Ag^{+}. If solid Na_3PO_4 is added to this mixture, which of the following phosphate species would precipitate out of solution first?

- $Ca_3(PO_4)_2$
- Ag_3PO_4
- Na_3PO_4

When the second cation just starts to precipitate, what percentage of the first cation remains in solution?

Number ____ %

21.

Consider the following Gibbs energies at 25 °C.

Substance	$\Delta G°_f$ (kJ· mol^{-1})
$Ag^+(aq)$	77.1
$Cl^-(aq)$	−131.2
$AgCl(s)$	−109.8
$Br^-(aq)$	−104.0
$AgBr(s)$	−96.9

(a) Calculate $\Delta G°_{rxn}$ for the dissolution of AgCl(*s*).

Number ____ $kJ \cdot mol^{-1}$

(b) Calculate the solubility-product constant of AgCl.

$K =$ Number ____

(c) Calculate $\Delta G°_{rxn}$ for the dissolution of AgBr(*s*).

Number ____ $kJ \cdot mol^{-1}$

(d) Calculate the solubility-product constant of AgBr.

$K =$ Number ____

22.

A solution containing a mixture of metal cations was treated as follows.

1. Dilute HCl was added and a precipitate formed. The precipitate was filtered off.
2. H_2S was bubbled through the acidic solution. Again, a precipitate formed and was filtered off.
3. The pH was raised to about 9 and H_2S was again bubbled through the solution. No precipitate formed.
4. Finally, sodium carbonate was added and no precipitate formed.

What can be said about the presence of each of these groups of cations in the original solution?

Cation Group	Description	Present in the original solution?
Ag^+, Pb^{2+}, Hg_2^{2+}	form insoluble chlorides	
Bi^{3+}, Cd^{2+}, Cu^{2+}, Hg^{2+}, Pb^{2+}, Sb^{3+}, Sn^{2+}, Sn^{4+}	form acid-insoluble sulfides	
Al^{3+}, Co^{2+}, Cr^{3+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}	form base-insoluble sulfides or hydroxides	
Ba^{2+}, Ca^{2+}, Mg^{2+}, Sr^{2+}	form insoluble carbonates	
Li^+, Na^+, K^+, NH_4^+	completely soluble	

At least one of these ions was present.
unknown
None of these ions were present.
All of these ions were present.

23.

A student was given a solid containing a mixture of nitrate salts. The sample completely dissolved in wat Map and upon addition of dilute HCl, no precipitate formed. The pH was lowered to about 1 and H_2S was bubbled through the solution. No precipitate formed. The pH was adjusted to 8 and H_2S was again bubbled in. This time, a precipitate formed.

Which compounds might have been present in the unknown?

- $Ca(NO_3)_2$
- $Pb(NO_3)_2$
- $Cu(NO_3)_2$
- $Zn(NO_3)_2$
- $Ni(NO_3)_2$
- KNO_3
- $AgNO_3$
- $Cr(NO_3)_3$