Solubility Homework Booklet Name Mr B Period________

Show all work in the question booklet.

1. In every solubility equilibrium, the rate of dissolving is
   A. less than the ~~rate of cr~~ystallization
   B. greater than the rate of crystallization
   C. equal to the rate of crystallization
   D. equal to zero

2. Given a saturated solution of $Ca(OH)_2$, which of the following statements is always true?
   A. The $[Ca^{+2}]$ is twice that of $[OH^-]$
   B. The rate of dissolving is greater than the rate of crystallization
   C. The rate of crystallization equals the rate of dissolving
   D. The OH^- precipitates half as fast as the Ca^{+2}

3. Which of the following does not define solubility?
   A. the maximum mass of solute that can dissolve in a given volume of solution
   B. the minimum moles of solute needed to produce one litre of saturated solution
   C. the moles of solute dissolved in a given volume of solution just [ ] not saturated
   D. the concentration of solute in a saturated solution.

4. Which of the following will dissolve in water to produce a molecular solution?
   A. NaOH B. $Sr(OH)_2$ C. $CaCl_2$ D. CH_3OH

5. Which of the following will dissolve to form a molecular solution?
   A. $Ca(OH)_2$ B. $C_6H_{12}O_6$ C. H_2SO_4 D. $AgNO_3$

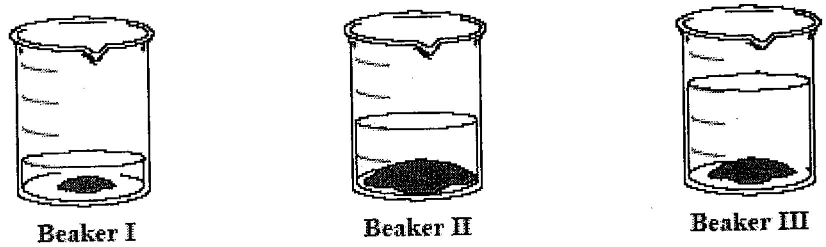
6. Which of the following would best describe the solubility of a solute?
   A. grams per mole B. moles per second C. litres per gram D. moles per litre ✓
   molar mass rate

7. When 100.0 mL of a saturated solution of BaF_2 is heated and all the water is evaporated. 1.753×10^{-2} grams of solute remains. The solubility of BaF_2 is
   A. 1.000×10^{-4} M
   B. 1.753×10^{-2} M
   C. 1.000×10^{-3} M
   D. 1.753×10^{-5} M

$$\frac{1.753 \times 10^{-2} \text{ g of } BaF_2}{100.0 \times 10^{-3} L} \times \frac{1 \text{ mole } BaF_2}{175.3 \text{ g of } BaF_2} = 1 \times 10^{-3}$$

8. Consider the following diagram:

The following three beakers each contain different volumes of a saturated solution of PbI_2 and different masses of solid PbI_2 :



all are saturated

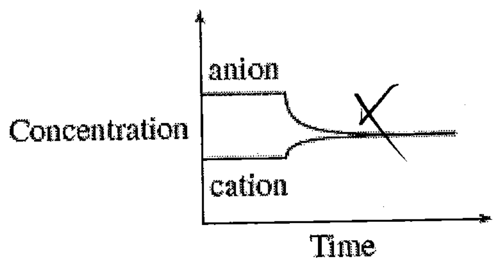
What is the relationship for the $[Pb^{2+}]$ in the solution in the three beakers?

A. I < III < II
B. II < III < I
C. I = II = III
D. I > II > III

9. A saturated solution is prepared by dissolving a salt in water. Which of the following graphs could represent the ion concentrations as the temperature is increased?

$NaCl_{(s)} \rightleftharpoons Na^+ + Cl^-$

A.



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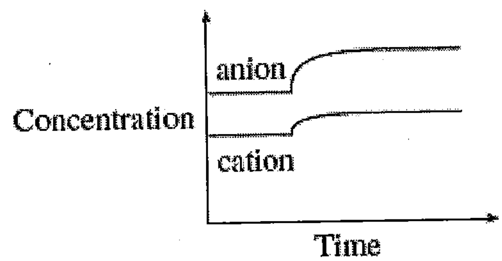

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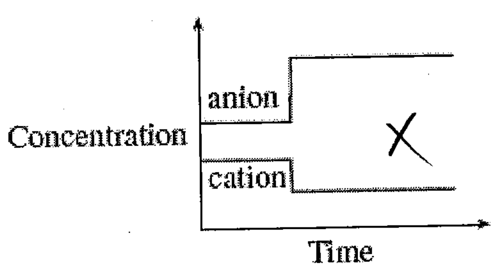

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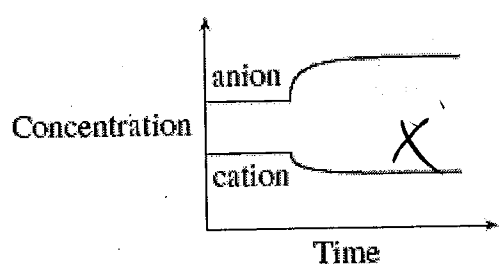


10 min Question

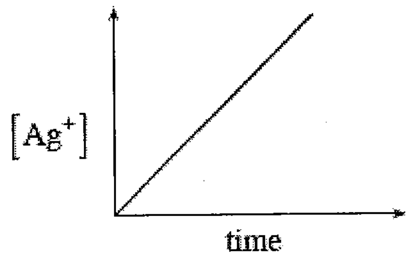
is salt NaCl? K_2SO_4? BaF_2? Na_3PO_4

10. Consider the following equilibrium:

$$AgCl_{(s)} \leftrightarrows Ag^{+}_{(aq)} + Cl^{-}_{(aq)}$$

Which of the following graphs best describes the $[Ag^{+}_{(aq)}]$ after equilibrium has been established?

A.



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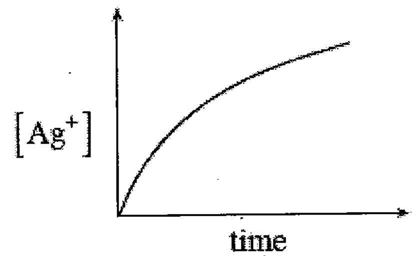

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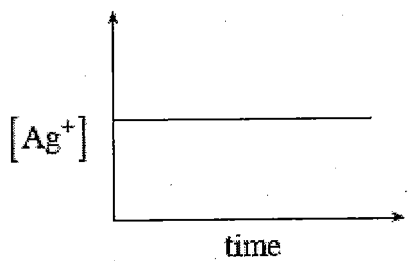

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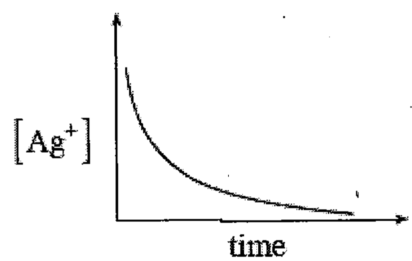


11. The ion concentrations in 3.~~00~~ L of a 0.250 M $Al_2(SO_4)_3$ are

	$[Al^{+3}]$	$[SO_4^{-2}]$
A.	1.50 M	2.25 M
B.	0.750 M	0.750 M
C.	0.500 M	0.750 M
D.	0.250 M	0.250 M

$Al_2(SO_4)_3 \rightarrow 2Al^{+3} + 3SO_4^{-2}$
.250 .500 .750

12. Which of the following solutions would have $[Fe^{+3}] = 0.020$ M?

A. 0.50 L of a 0.010 M $Fe_2(C_2O_4)_3$ solution
B. 0.50 L of a 0.040 M $FeC_6H_5O_7$ solution
C. 0.40 L of a 0.050 M $Fe(NO_3)_3$ solution
D. 0.80 L of a 0.020 M $Fe_2(SO_4)_3$ solution

$Fe_2(C_2O_4)_3 \rightarrow 2Fe^{+3}$ ✓
.010 .020

$FeC_6H_5O_7 \rightarrow Fe^{+3} + C_6H_5O_7^{-3}$
.040 .040

$Fe(NO_3)_3 \rightarrow Fe^{+3} + 3NO_3^{-}$
.050 .050

$Fe_2(SO_4)_3 \rightarrow 2Fe^{+3} + 3SO_4^{-2}$
.020 .040

13. The solubility of $SrCO_3$ is 2.4×10^{-5} M. How many moles of dissolved solute are present in 100.0 mL of saturated $SrCO_3$ solution?

100.0×10^{-3} L $\times \frac{SrCO_3\ 2.4 \times 10^{-5} \text{ moles of } SrCO_3}{L} = 2.4 \times 10^{-6}$ moles

A. 2.4×10^{-5} mol
B. 2.4×10^{-6} mole
C. 5.6×10^{-10} mol
D. 2.4×10^{-4} mol

14. What are the ion concentrations in ~~2.5~~ L of a 0.30 M $CuCl_2$?

$CuCl_2 \rightarrow Cu^{+2} + 2Cl^-$
.30 .30 .60

	$[Cu^{+2}]$	$[Cl^-]$
A.	0.30 M	0.60 M
B.	0.15 M	0.30 M
C.	0.75 M	1.5 M
D.	1.5 M	0.75 M

15. A 3.0 L solution of $BaCl_2$ has a chloride ion concentration of 0.20 M. The barium ion concentration in this solution is

$BaCl_2 \rightarrow Ba^{+2} + 2Cl^-$
? .20

A. 0.10 M
B. 0.60 M
C. 0.067 M
D. 0.20 M

16. What is the $[OH^-]$ in 250 mL of a 0.20 M $Sr(OH)_2$?

$Sr(OH)_2 \rightarrow Sr^{+2} + 2OH^-$
.20M .40M

A. 0.20 M
B. 0.050 M
C. 0.40 M
D. 0.10 M

17. What is the concentration of the ions in 3.0 L of 0.50 M $AgClO_3$?

	$[Ag^+]$	$[ClO_3^-]$
A.	0.50 M	0.50 M
B.	1.5 M	4.5 M
C.	0.17M	0.17M
D.	0.50 M	1.5 M

18. What is the [Cl-] when 1.50 grams of NaCl is dissolved in enough water to make 100.0 mL of solution?

$\frac{1.50 \text{ g of NaCl}}{100.0 \times 10^{-3} L} \times \frac{1 \text{ mole}}{58.5 g} = .25641$ M

A. 0.150 M
B. 0.390 M
C. 0.256 M
D. 15.0 M

need chart.

19. Which of the following has the lowest solubility?

A. FeS(s) B. CuS (s) C. CaS(aq) D. MgS(aq)

Can't do until after Ksp calculations

So (aq)

20. Which of the following compounds could be used to prepare a solution with a [S^{-2}] greater than 0.1 M?

A. Ag_2S B. Rb_2S C. ZnS D. PbS

21. Which of the following compounds could be used to prepare a solution with a [SO_3^{-2}] greater than 0.10 M?

A. Ag_2SO_3 B. H_2SO_3 C. $CuSO_3$ D. $CaSO_3$

22. Which of the following would form a saturated solution when 0.0100 mol of the solid solute is added to 100.0 mL of water? = .100 M 100.0×10⁻³ L low solubility

A. NaCN (aq) B. $BaCO_3$ (s) C. $Pb(NO_3)_2$ (aq) D. $FeSO_4$ (aq)

23. Which compound will have the greatest solubility in water?

A. $CaSO_4$ (s) B. AgCl (s) C. $BaCO_3$ (s) D. $CuCl_2$ (aq)

24. When equal volumes of 0.2 M solutions are mixed, which of the following combinations will form a single precipitate?

A. H_2SO_3 and $Fe(CH_3COO)_3$ → $Fe_2(SO_3)_3$ + HCH_3COO
B. $(NH_4)_2SO_4$ and K_2CO_3 → Na_2CO_3 + K_2SO_4
C. Na_2S and RbOH → Rb_2S + NaOH
D. $ZnSO_4$ and $MgCl_2$ → $MgSO_4$ + $ZnCl_2$

25. Which of the following would be true when equal volumes of 0.2 M $(NH_4)_2SO_4$ and 0.2 M BaS are combined?

A. no precipitate forms
B. precipitates of both $(NH_4)_2S$ and $BaSO_4$ form
C. a precipitate of $BaSO_4$ forms
D. a precipitate of $(NH_4)_2S$ forms

26. Which of the following would be true when equal volumes of 0.2 M CaS and 0.2 M $Fe_2(SO_4)_3$ are combined?

A. precipitates of both Fe_2S_3 and $CaSO_4$ form
B. a precipitate of $CaSO_4$ forms
C. no precipitate forms
D. a precipitate of Fe_2S_3 forms

27. Which of the following will **not** form a precipitate when mixed with an equal amount of 0.2 M $Ca(NO_3)_2$?

A. 0.2 M Na_2SO_3 (s)
B. 0.2 M NaBr
C. 0.2 M NaOH
D. 0.2 M Na_2CO_3

28. Which of the following will **not** form a precipitate when mixed with an equal amount of 0.2 M $Cu(NO_3)_2$?

A. 0.2 M NaCl — $CuCl_2$ (aq)
B. 0.2 M Na_2CO_3 — $CuCO_3$
C. 0.2 M Na_2SO_3 — $CuSO_3$
D. 0.2 M Na_2S — CuS

29. Equal volumes of 0.20 M BaS and 0.20 M $FeCl_3$ are mixed.

a. Write the formula equation for the above reaction.

$$3BaS + 2FeCl_3 \rightarrow 3BaCl_2 + Fe_2S_3$$

b. Write the complete ionic equation for the above reaction.

$$3Ba^{+2} + 3S^{-2} + 2Fe^{+3} + 6Cl^- \rightarrow 3Ba^{+2} + 6Cl^- + Fe_2S_3(s)$$

c. Write the net ionic equation for the above reaction.

$$3S^{-2} + 2Fe^{+3} \rightarrow Fe_2S_3(s)$$

30. Equal volumes of 0.20 M $CaCl_2$ and 0.20 M $Pb(NO_3)_4$ are mixed.

a. Write the formula equation for the above reaction.

$$2CaCl_2 + Pb(NO_3)_4 \rightarrow PbCl_4 + 2Ca(NO_3)_2$$

b. Write the complete ionic equation for the above reaction.

$$2Ca^{+2} + 4Cl^- + Pb^{+4} + 4NO_3^- \rightarrow Pb^{+4} + 4Cl^- + 2Ca^{+2} + 4NO_3^-$$

c. Write the net ionic equation for the above reaction.

none.

31. Equal volumes of 0.20 M strontium hydroxide and 0.20 M chromium (III) sulphate are mixed.

a. Write the formula equation for the above reaction.

$3Sr(OH)_2 + Cr_2(SO_4)_3 \rightarrow 2Cr(OH)_3 + 3SrSO_4$

b. Write the complete ionic equation for the above reaction.

$3Sr^{+2} + 6OH^- + 2Cr^{+3} + 3SO_4^{-2} \rightarrow 2Cr(OH)_{3\,(s)} + 3SrSO_{4\,(s)}$

c. Write the net ionic equation for the above reaction.

$3Sr^{+2} + 6OH^- + 2Cr^{+3} + 3SO_4^{-2} \rightarrow 2Cr(OH)_{3\,(s)} + 3SrSO_{4\,(s)}$

32. Equal volumes of 0.20 M barium dichromate and 0.20 M sodium phosphate are mixed.

a. Write the formula equation for the above reaction.

$3BaCr_2O_7 + 2Na_3PO_4 \rightarrow 3Na_2Cr_2O_7 + Ba_3(PO_4)_2$

b. Write the complete ionic equation for the above reaction.

$3Ba^{+2} + 3Cr_2O_7^{-2} + 6Na^+ + 2PO_4^{-3} \rightarrow 6Na^+ + 3Cr_2O_7^{-2} + Ba_3(PO_4)_{2\,(s)}$

c. Write the net ionic equation for the above reaction.

$3Ba^{+2} + 2PO_4^{-3} \rightarrow Ba_3(PO_4)_{2\,(s)}$

33. Equal volumes of 0.20 M $Mg(HCO_3)_2$ and 0.20 M H_2SO_3 are mixed.

a. Write the formula equation for the above reaction.

$Mg(HCO_3)_2 + H_2SO_3 \rightarrow 2H_2CO_3 + MgCO_3$

b. Write the complete ionic equation for the above reaction.

$Mg^{+2} + 2HCO_3^- + 2H^+ + SO_3^{-2} \rightarrow \underbrace{(4H^+ + 2CO_3^{-2})}_{\text{or } 2H^+ + 2HCO_3^-} + MgCO_{3\,(s)}$

c. Write the net ionic equation for the above reaction.

$Mg^{+2} + SO_3^{-2} \rightarrow MgCO_{3\,(s)}$

34. A solution contains both Ag^{+} and Mg^{+2} ions. During selective precipitation, these ions are removed one at a time by adding

A. SO_4^{-2} followed by Cl^{-}
B. I^{-} followed by OH^{-}
C. NO_3^{-} followed by PO_4^{-3}
D. OH^{-} followed by S^{-2}

Ag^{+}	Mg^{+2}	
(s) (s)	(aq) (aq)	X
(s) (s)	(aq) (s)	✓
(aq) (s)	(aq) (s)	X
(s) (s)	(s) (aq)	X

35. A solution contains both Pb^{+2} and Mg^{+2} ions. During selective precipitation, these ions are removed one at a time by adding

A. SO_4^{-2} followed by Cl^{-}
B. Cl^{-} followed by PO_4^{-3}
C. S^{-2} followed by SO_4^{-2}
D. OH^{-} followed by S^{-2}

Pb^{+2}	Mg^{+2}	
(s) (s)	(aq) (aq)	X
(s) (s)	(aq) (s)	✓
(s) (s)	(aq) (aq)	X
(s) (s)	(s) (aq)	X

36. A solution contains both 0.2 M $Mg^{+2}_{(aq)}$ and 0.2 M $Sr^{+2}_{(aq)}$. These ions can be removed separately through precipitation by adding equal volumes of 0.2 M solutions of

A. CO_3^{-2} and then SO_4^{-2}
B. SO_4^{-2} and then S^{-2}
C. OH^{-} and then SO_4^{-2}
D. Cl^{-} and then OH^{-}

Mg^{+2}	Sr^{+2}	
(s) (aq)	(s) (s)	X
(aq) (aq)		X
(s) (aq)	(aq) (s)	✓
(aq) (s)	(aq) (aq)	X

37. Using the solubility table, determine which of the following ions could **not** be used to separate S^{-2} from SO_4^{-2} by precipitation.

A. NH_4^{+}
B. Cu^{+2}
C. Ca^{+2}
D. Zn^{+2}

S^{-2}	SO_4^{-2}	
(aq)	(aq)	X
(s)	(aq)	✓
(aq)	(s)	✓
(s)	(aq)	✓

38. Using the solubility table, determine which of the following ions could **not** be used to separate OH^{-1} from SO_4^{-2} by precipitation.

A. Cu^{+2}
B. Sr^{+2}
C. Ba^{+2}
D. Zn^{+2}

OH^{-}	SO_4^{-2}	
(s)	(aq)	✓
(aq)	(s)	✓
(s)	(s)	X
(s)	(aq)	✓

39. Using the solubility table, determine which of the following ions could be used to separate OH^{-1} from SO_3^{-2} by precipitation.

A. Cu^{+2}
B. Ba^{+2}
C. Sr^{+2}
D. Zn^{+2}

OH^{-}	SO_3^{-2}	
(s)	(s)	X
(s)	(s)	X
(aq)	(s)	✓
(s)	(s)	X

40. A solution is prepared containing both 0.2 M S^{2-} and 0.2 M $PO_4{}^{3-}$ ions. An equal volume of a second solution is added in order to precipitate only one of these two anions. The second solution must contain which of the following?

A. 0.2 M Pb^{+2}
B. 0.2 Sr^{+2}
C. 0.2 M Cs^{+}
D. 0.2 M Zn^{+2}

	S^{-2}	$PO_4{}^{-3}$	
A	(s)	(s)	X
B	(aq)	(s)	✓
C	(aq)	(aq)	X
D	(s)	(s)	X

41. A solution is found to contain $NaBr_{(aq)}$, $K_2SO_4{}_{(aq)}$ and $Li_2SO_3{}_{(aq)}$ in solution. Devise a procedure by which each of the anions in the solution can be removed, one at a time. The solutions that are available to use are:

$Ca(NO_3)_2$ NH_4NO_3 $AgNO_3$ $Mg(NO_3)_2$

	Br^-	$SO_4{}^{-2}$	$SO_3{}^{-2}$
Ca^{+2}	(aq)	(s)	(s)
Ag^+	(s)	(s)	(s)
Mg^{+2}			

1. First you would add $Mg(NO_3)_2$. The precipitate formed would be $MgSO_3$. Filter out the precipitate.
2. To the remaining solution add $Ca(NO_3)_2$. The precipitate formed would be $CaSO_4$. Filter out the precipitate.
3. To the remaining solution add $AgNO_3$. The precipitate formed would be $AgBr$. FIlter out the precipitate.

42. A solution is found to contain $Ca(NO_3)_2{}_{(aq)}$, $AgNO_3{}_{(aq)}$, $Fe(NO_3)_3{}_{(aq)}$ in solution. Devise a procedure by which each of the cations in the solution can be removed, one at a time. The solutions that are available to use are:

NaI KNO_3 Li_2SO_4 KOH

	Ca^{+2}	Ag^+	Fe^{+3}
I^-	(aq)	(s)	(aq)
$SO_4{}^{-2}$			
OH^-			

1. First you would add NaI. The precipitate formed would be AgI. Filter out the precipitate.
2. To the remaining solution add Li_2SO_4. The precipitate formed would be $CaSO_4$. Filter out the precipitate.
3. To the remaining solution add KOH. The precipitate formed would be $Fe(OH)_3$. FIlter out the precipitate.

43. A solution is found to contain $CuSO_{4\,(aq)}$ in solution. Devise a procedure by which each of the cations in the solution can be removed, one at a time. The solutions that are available to use are:

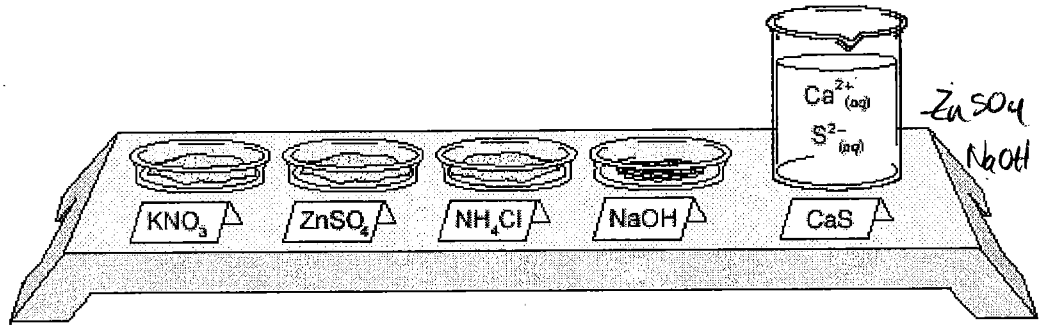
BaI_2 CaS $Pb(NO_3)_4$ NH_4Cl

	Cu^{+2}	SO_4^{-2}
BaI_2	(aq)	(s)
CaS	(s)	(s)
$Pb(NO_3)_4$	(aq)	(aq)
NH_4Cl	(aq)	(aq)

1. First you would add BaI_2. The precipitate formed would be $BaSO_4$
   Filter out the precipitate.

2. To the remaining solution add CaS. The precipitate formed would be CuS. Filter out the precipitate.

Consider the following:



	Ca^{+2}	S^{-2}
$ZnSO_4$	(s)	(s)
NaOH	(s)	(aq)

44.

a. Fill in the blanks below that would separate the Ca^{+2} ions from the S^{-2} ions using the solids samples. Indicate which sample you would add first, and the precipitate that would form. Indicate which sample you would add second and the precipitate that would form then.

First, add NaOH. The precipitate formed would be $Ca(OH)_2$

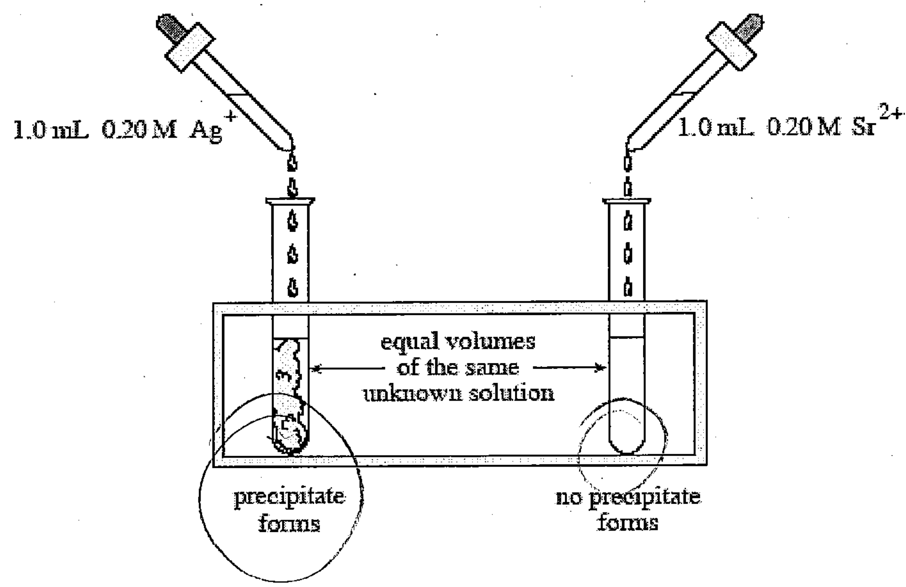
Second, add $ZnSO_4$. The precipitate formed would be ZnS.

b. Write the net ionic equations for one of the precipitation reactions in part (a)

$2OH^- + Ca^{+2} \rightarrow Ca(OH)_{2\,(s)}$

$Zn^{+2} + S^{-2} \rightarrow ZnS_{(s)}$

45. Consider the following:

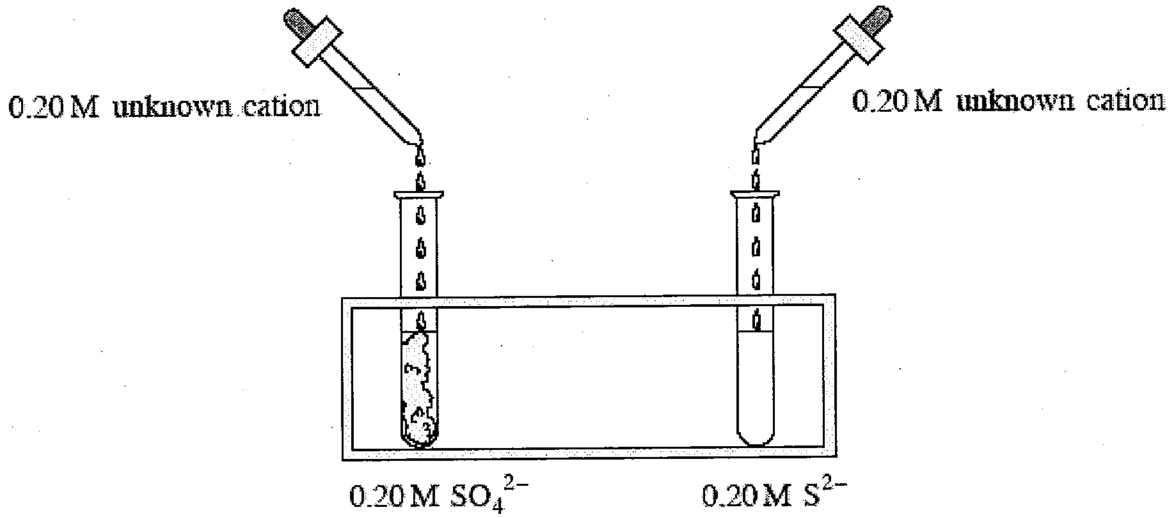


Which of the following could be the unknown solution?

A. 0.20 M KOH ✓
B. 0.20 M Na_2SO_4 both
C. 0.20 M K_3PO_4 both
D. 0.20 M $NaNO_3$ neither

46.

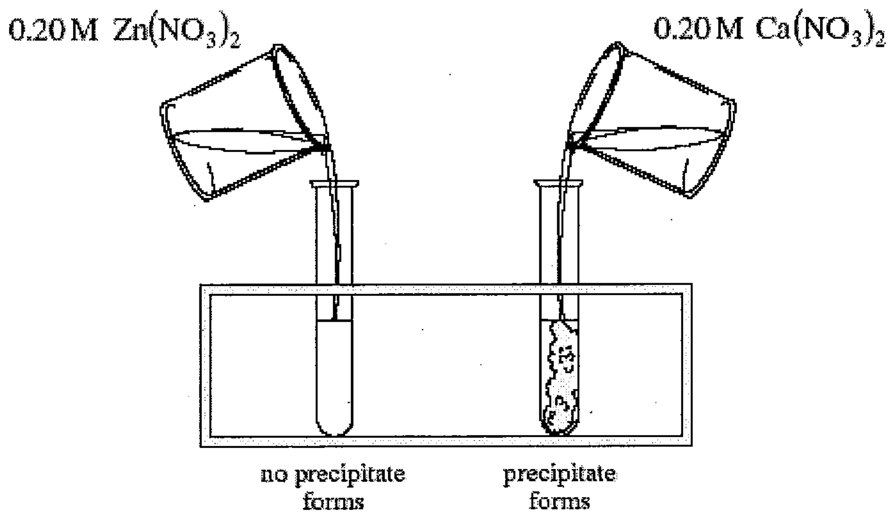
A precipitate forms when a 0.20 M solution containing an unknown cation is added to SO_4^{2-}, but not when an equal volume is added to S^{2-}. **(2 marks)**



The unknown cation is

A. Ba $^{+2}$
B. Mg $^{+2}$ neither
C. Pb $^{+2}$ both
D. Zn $^{+2}$ ~~bet~~ S^{-2} but not SO_4^{-2}

When 10.0 mL of 0.20 M $Zn(NO_3)_2$ is added to a 10.0 mL sample of 0.20 M unknown solution, no precipitate forms. When the same volume of 0.20 M $Ca(NO_3)_2$ is added to a separate 10.0 mL sample of the unknown solution, a precipitate does form. (2 marks)



47. The unknown solution could be

A. KOH
B. K_2S
C. Na_2CO_3
D. Na_2SO_4

48. Which anion would be most effective in removing the cations responsible for hard water?
A. S^{-2}
B. SO_3^{-2}
C. SO_4^{-2}
D. Cl^-

What is hard water?
so get rid of as many cations as possible

49. For a saturated solution, the K_{sp} expression does not contain any solid solute term. What is the reason for this?
A. The solid solute continues to change in amount.
B. The solid solute is a product.
C. The solid solute does not change in concentration.
D. The solid solute is a reactant.

50. The Ksp expression for a saturated solution of $Mg(OH)_2$ is

A. $K_{sp} = \dfrac{[Mg^{+2}][OH^-]^2}{[Mg(OH)_2]}$

B. $K_{sp} = [Mg^{+2}][OH^-]^2$ ✓

C. $K_{sp} = [Mg^{+2}][2OH^-]$

D. $K_{sp} = [Mg^{+2}][2OH^-]^2$

51. The K_{sp} expression for a saturated solution of $Ba_3(AsO_4)_2$ would be

A. $Ksp = [3Ba^{+2}]^3 [2AsO_4^{-3}]^2$

B. $Ksp = [3Ba^{+2}] [2AsO_4^{-3}]$

C. $Ksp = \dfrac{[Ba^{+2}]^3 [AsO_4^{-3}]^2}{Ba_3(AsO_4)_2}$

D. $Ksp = [Ba^{+2}]^3 [AsO_4^{-3}]^2$

52. The K_{sp} expression for a saturated solution of Ag_2SO_3 is

A. $K_{sp} = [2Ag^+]^2[SO_3^{-2}]$

B. $K_{sp} = [Ag_2^{+2}][SO_3^{-2}]$

C. $K_{sp} = [2Ag^+][SO_3^{-2}]$

D. $K_{sp} = [Ag^+]^2[SO_3^{-2}]$

53. Which of the following expressions represents $[Fe^{+3}]$ in a saturated $Fe(OH)_3$ solution?

A. $[Fe^{+3}] = \dfrac{Ksp}{3[OH^-]}$

B. $[Fe^{+3}] = \dfrac{Ksp}{[OH^-]^3}$

C. $[Fe^{+3}] = \dfrac{Ksp}{3[OH^-]}$

D. $[Fe^{+3}] = Ksp \times [OH^-]^3$

54. Which of the following is the K_{sp} expression for barium phosphate?

A. $K_{sp} = [3Ba^{+2}][2PO_4^{-3}]$

B. $K_{sp} = [3Ba^{+2}]^3[2PO_4^{-3}]^2$

C. $K_{sp} = [Ba^{+2}][PO_4^{-3}]$

D. $K_{sp} = [Ba^{+2}]^3[PO_4^{-3}]^2$

55. The solubility of CdS is 2.8×10^{-14} M. The value of Ksp is

$CdS_{(s)} \rightleftharpoons Cd^{+2} + S^{-2}$ $(2.8\times10^{-14})^2$

A. 1.7×10^{-7}

B. 5.6×10^{-14}

C. 2.8×10^{-14}

D. 7.8×10^{-28}

56. In a saturated solution of $Ag_2C_2O_4$ the $[Ag^+] = 2.2 \times 10^{-4}$ M. What is the K_{sp} of $Ag_2C_2O_4$ in this solution?

$Ag_2C_2O_4 \rightleftharpoons 2Ag^+ + C_2O_4^{-2}$

2.2×10^{-4} 1.1×10^{-4}

$K_{sp} = [2.2\times10^{-4}]^2[1.1\times10^{-4}]$

A. 4.8×10^{-8}

B. 5.3×10^{-12}

C. 4.3×10^{-11}

D. 1.1×10^{-4}

57. The solubility of $CdCO_3$ is 2.5 x 10^{-6} M. Calculate the K_{sp} value for $CdCO_3$.

A. 5.0 x 10^{-6}

B. 1.6 x 10^{-3}

C. 2.5 x 10^{-6}

D. 6.3 x 10^{-12}

s^2

58. What is the value of K_{sp} for $Zn(OH)_2$ if the solubility of $Zn(OH)_2$ is equal to 4.2 x 10^{-6}M?

A. 1.8 x 10^{-11}

B. 3.0 x 10^{-16}

C. 1.0 x 10^{-2}

D. 4.0 x 10^{-3}

$4(4.2\times10^{-6})^3 = 2.96253\times10^{-16}$

59. The solubility of $NiCO_3$ is 4.4 x 10^{-2} g/L. Determine the K_{sp} value for $NiCO_3$.

A. 1.9 x 10^{-3}

B. 2.1 x 10^{-1}

C. 3.7 x 10^{-4}

D. 1.4 x 10^{-7}

$\frac{4.4\,g\times10^{-2}\ NiCO_3}{L} \times \frac{1\ mole\ NiCO_3}{118.7\ g\ NiCO_3} = \frac{3.7\times10^{-4}\ moles}{L}$

$K_{sp} = (3.7\times10^{-4})^2$

$= 1.374\times10^{-7}$

60. A saturated solution of nickel carbonate, $NiCO_3$, contains 0.090 g in 2.0 L of solution. Calculate the K_{sp} for $NiCO_3$.

(6.6×10^{-9})

$NiCO_{3(s)} \rightleftarrows Ni^{+2} + CO_3^{-2}$ $\frac{1}{2}$

$K_{sp} = [Ni^{+2}][CO_3^{-2}]$ $\frac{1}{2}$

/4

$= (3.791\times10^{-4})(3.791\times10^{-4}) = 1.43722\times10^{-7}$

$= 1.4\times10^{-7}$ (1)

$\frac{.090\,g\ NiCO_3}{2.0L} \times \frac{1\ mole\ NiCO_3}{118.7\,g\ NiCO_3} = 3.791\times10^{-4}$ (1)

(1)

61. After a 50.0 mL sample of a saturated solution of Cu_2SO_3 was heated to dryness, 7.2 x 10 $^{-4}$ g of solid Cu_2SO_3 remained. What is the value of K_{sp} for Cu_2SO_3

$$\frac{7.2 \times 10^{-4} \text{ g of } Cu_2SO_3}{50.0 \times 10^{-3} L} \times \frac{1 \text{ mole } Cu_2SO_3}{207.1 \text{ g of } Cu_2SO_3} = 6.9531... \times 10^{-5} \; (1)$$

(1)

$$Cu_2SO_{3(s)} \rightleftharpoons 2Cu^+ + SO_3^{-2} \; (\tfrac{1}{2})$$

$$K_{sp} = [Cu^+]^2[SO_3^{-2}] \; (\tfrac{1}{2})$$

$$= (1.39062 \times 10^{-5})^2(6.9531 \times 10^{-5})$$

$$= 1.34464 \times 10^{-12}$$

$$= 1.3 \times 10^{-12} \; (1)$$

62. A 30.00 mL sample of a saturated solution of Ag_2SO_4 was heated in an evaporating dish until all the water was evaporated. The following data were recorded:

Mass of solution and evaporating dish	62.260 g
Mass of evaporating dish	32.125 g
Mass of evaporating dish and solid Ag_2SO_4	32.260 g change 7

Calculate the K_{sp} value for the Ag_2SO_4

$$Ag_2SO_{4(s)} \rightleftharpoons 2Ag^+ + SO_4^{-2} \; (\tfrac{1}{2})$$

$$K_{sp} = [Ag^+]^2[SO_4^{-2}]$$

$$\frac{\overset{(.135)}{(32.260 - 32.125)} \text{ g of } Ag_2SO_4}{30.00 \times 10^{-3} L} \times \frac{1 \text{ mole } Ag_2SO_4}{311.9 \text{ g } Ag_2SO_4} = 1.44... \times 10^{-2}$$

$$K_{sp} = (2.88... \times 10^{-2})^2(1.44... \times 10^{-2})$$

$$= 1.20129... \times 10^{-5}$$

$$= 1.20 \times 10^{-5}$$

63. Consider the following saturated solutions:

$CuSO_4$, $BaSO_4$, $CaSO_4$
(aq) (s) (s)

$BaSO_4$ $s = \sqrt{1.1 \times 10^{-10}} = 1.0 \times 10^{-5}$
$CaSO_4$ $s = \sqrt{3.4 \times 10^{-7}} = 5.9 \times 10^{-4}$

the order of cation concentration, from highest to lowest is

A. $[\cancel{Ba}^{+2}] > [Ca^{+2}] > [\cancel{Cu}^{+2}]$
B. $[Cu^{+2}] > [Ba^{+2}] > [\cancel{Ca}^{+2}]$
C. $[Cu^{+2}] > [Ca^{+2}] > [Ba^{+2}]$
D. $[\cancel{Ca}^{+2}] > [Cu^{+2}] > [Ba^{+2}]$

64. Calculate the solubility of $PbSO_4$

$PbSO_{4(s)} \rightleftharpoons Pb^{+2} + SO_4^{-2}$

$s^2 = 1.8 \times 10^{-8}$
$s = \sqrt{1.8 \times 10^{-8}}$
$= 1.3 \times 10^{-4}$

A. 3.6×10^{-8} M
B. 1.8×10^{-8} M
C. 3.2×10^{-16} M
D. 1.3×10^{-4} M

65. How many moles of dissolved solute are present in 100.0 mL of a saturated $SrCO_3$ solution?

A. 2.4×10^{-5} mol
B. 2.3×10^{-4} mol
C. 5.6×10^{-11} mol
D. 2.4×10^{-6} mol

$SrCO_{3(s)} \rightleftharpoons Sr^{+2} + CO_3^{-2}$
$s^2 = 5.6 \times 10^{-10}$
$s = \sqrt{5.6 \times 10^{-10}} = 2.366 \times 10^{-5} \frac{\text{moles}}{L} \times 100.0 \times 10^{-3} L$

66. Which of the following saturated solutions will have the lowest $[S^{-2}]$?

A. $BaS_{(aq)}$
B. $ZnS_{(s)}$ $\sqrt{2.0 \times 10^{-25}}$
C. $CuS_{(s)}$ $\sqrt{6.0 \times 10^{-37}}$
D. $CaS_{(aq)}$

67. ~~Which of~~ the following saturated solutions will have the lowest $[IO_3^{-1}]$?

A. $Pb(IO_3)_2$ $4s^3 = 3.7 \times 10^{-13}$ $s = 4.5 \times 10^{-5} \times 2 =$ 9.0×10^{-5} M
B. $Cu(IO_3)_2$ $4s^3 = 6.9 \times 10^{-8}$ $s = 2.58 \times 10^{-3} \times 2 =$ 5.1×10^{-2} M
C. $NaIO_{3}$ (aq)
D. $AgIO_3$ $s^2 = 3.2 \times 10^{-8}$ $s = 1.788 \times 10^{-4} =$ 1.8×10^{-4}

68. Which of the following saturated solutions will have the lowest $[CO_3^{-2}]$?

A. $CaCO_3$ $s^2 = 5.0 \times 10^{-9}$ $s = 7.1$
B. $SrCO_3$ $s^2 = 5.6 \times 10^{-10}$ $s = 2.4 \times 10^{-5}$
C. Ag_2CO_3 $4s^3 = 8.5 \times 10^{-12}$ $s = 1.3 \times 10^{-4}$
D. $BaCO_3$ $s^2 = 2.6 \times 10^{-9}$ $s = 5.1 \times 10^{-5}$

Note $4s^3$ vs s^2

69. What is the solubility of SrF_2?

A. 4.3×10^{-9} M

B. 1.8×10^{-17} M

C. 6.6×10^{-5} M

D. 1.0×10^{-3} M

$SrF_{2(s)} \rightleftharpoons Sr^{+2} + 2F^-$

$K_{sp} = 4s^3$

$4.3\times10^{-9} = 4s^3$

$s^3 = 1.075 \times 10^{-9}$ $s = 1.0\times10^{-3}$

70. Which of the following compounds is the least soluble in water?

A. $PbCl_2$ $4s^3 = 1.2 \times 10^{-5}$ $s = 1.4\times10^{-2}$

B. PbI_2 $4s^3 = 8.5\times10^{-9}$ $s = 1.3\times10^{-3}$

C. CuI_2 (aq)

D. CsI (aq)

71. Calculate the solubility of $SrSO_4$ in grams per litre.

$SrSO_{4(s)} \rightleftharpoons Sr^{+2} + SO_4^{-2}$

$K_{sp} = [Sr^{+2}][SO_4^{-2}]$

$K_{sp} = s^2 = 3.4\times10^{-7}$

$s = 5.83095\ldots\times10^{-4}$ M

$\frac{5.83095\times10^{-4} \text{ moles}}{L} \times \frac{183.7 \text{ g of } SrSO_4}{1 \text{ mole } SrSO_4} = .10711\ldots \frac{g}{L} \text{ of } SrSO_4$

$= 1.1$ g/L of $SrSO_4$

72. Which would have a higher mass of solute: 25 L of a saturated $Pb(IO_3)_2$ solution or 25 L of a saturaed CaC_2O_4 solution

$Pb(IO_3)_2$

$Pb(IO_3)_{2(s)} \rightleftharpoons Pb^{+2} + 2IO_3^-$

$K_{sp} = [Pb^{+2}][IO_3^-]^2$

$4s^3 = 3.7\times10^{-13}$

$s = 4.52252\times10^{-5}$ M

$CaC_2O_{4(s)} \rightleftharpoons Ca^{+2} + C_2O_4^{-2}$

$K_{sp} = [Ca^{+2}][C_2O_4^{-2}]$

$s^2 = 2.3\times10^{-9}$

$s = 4.79583\times10^{-5}$ M

$\frac{4.52252\times10^{-5} \text{ moles of } Pb(IO_3)_2}{L} \times 25 L \times \frac{557.0}{1 \text{ mole } Pb(IO_3)_2} = .63 \text{ g of } Pb(IO_3)_2$ ✓

$\frac{4.79583\times10^{-5} \text{ mol of } CaC_2O_4}{L} \times 25 L \times \frac{128.1 g}{1 \text{ mole } CaC_2O_4} = .15 \text{ g of } CaC_2O_4$

73. Calculate the iodate ion concentration in a saturated copper(II) iodate solution.

$Cu(IO_3)_{2\,(s)} \rightleftharpoons Cu^{+2} + 2IO_3^-$

$K_{sp} = [Cu^{+2}][IO_3^-]^2$

$6.9\times10^{-8} = 4s^3$

$2.58382\times10^{-3}\,M = s$

$\therefore [IO_3^-] = 5.167649\times10^{-3}\,M$

$= 5.2\times10^{-3}\,M$

---

74. 15.0 mL of a 0.020 M $AgNO_3$ is added to 35.0 mL of a 0.0040 M $KBrO_3$. Will a precipitate form?

A. A precipitate will ~~form~~ because the Trial K_{sp} < K_{sp}.

B. A precipitate will not form because the Trial K_{sp} < K_{sp}.

C. A precipitate will ~~form~~ because the Trial K_{sp} ~~>~~ K_{sp}.

D. A precipitate will not form because the Trial K_{sp} ~~>~~ K_{sp}.

$AgBrO_{3\,(s)} \rightleftharpoons Ag^+ + BrO_3^-$ .0040

$K_{Trial} = \left(\frac{15.0\times10^{-3}\,L \times .020\,mol/L}{50.0\times10^{-3}\,L}\right) \times \left(\frac{35.0\times}{50.0\times}\right)$

$\underset{5.3\times10^{-5}}{K_{sp}} > \underset{1.7\times10^{-5}}{K_T} = (6.0\times10^{-3})(2.8\times10^{-3})$

$= 1.68\times10^{-5}$

75. What happens when equal volumes of 0.2 M BaS and 0.2 M Na_2CO_3 are combined?

do in class

A. A precipitate forms because the trial ion product ~~<~~ K_{sp}.

B. A precipitate forms because the trial ion product > K_{sp}.

C. No ~~precipitate~~ forms because the trial ion product ~~<~~ K_{sp}.

D. No ~~precipitate~~ forms because the trial ion product > K_{sp}.

$BaCO_{3\,(s)} \rightleftharpoons Ba^{+2} + CO_3^{-2}$

$K_{Trial} = [Ba^{+2}][CO_3^{-2}]$

$= (.1)^2 = .01$

$K_{sp} < K_T$ so ppte

76. What happens when equal volumes of 0.2 M BaS and 0.2 M $CuSO_4$ are combined?

A. A precipitate forms because the trial ion product ≥ K_{sp}.

B. No ~~precipitate~~ forms because the trial ion product ~~<~~ K_{sp}.

C. A precipitate forms because the trial ion product ~~<~~ K_{sp}.

D. No ~~precipitate~~ forms because the trial ion product > K_{sp}.

$BaSO_{4\,(s)} \rightleftharpoons Ba^{+2} + S^{-2}$

$K_T = [Ba^{+2}][SO_4]$

$= (.1)^2 = .01$

$CuS_{(s)} \rightleftharpoons Cu^{+2} + S^{-2}$

$K_{Trial} = [Cu^{+2}][S^{-2}]$

$= (.1)^2 = .01$

$BaSO_4$ < .01

CuS < .01

77. Two salt solutions were mixed and a Trial K_{sp} was calculated to be 2.0 x 10^{-9}. The Ksp value is 1.0 x 10^{-10}. From this information, which of the following is a true statement?

	K_{sp} comparison	Outcome
A.	Trial $K_{sp} > K_{sp}$	precipitate forms
B.	Trial $K_{sp} > K_{sp}$	no precipitate forms
C.	Trial K_{sp} < K_{sp}	precipitate forms
D.	Trial K_{sp} < K_{sp}	no precipitate forms

$K_{sp} < K_T$

1.0×10^{-10} 2.0×10^{-9}

78. 25.0 mL of a 0.0012 M $NaIO_3$ solution is added to 75.0 mL of a 0.0016 M $Cu(NO_3)_2$ solution. Will a precipitate form? Support your answer with calculations.

$Cu(IO_3)_{2(s)} \rightleftarrows Cu^{+2} + 2IO_3^-$

$K_{sp} = K_{Trial} = [Cu^{+2}][IO_3^-]^2$

$[Cu^{+2}] = \left(\dfrac{75.0 \times 10^{-3} L \times .0016 \text{ moles of } Cu^{+2}/L}{(75.0 + 25.0) \times 10^{-3} L}\right) = 1.2 \times 10^{-3} M$

$= (1.2 \times 10^{-3})(3.0 \times 10^{-4})^2$

$K_T = 1.08 \times 10^{-10}$

$[IO_3^-] = \left(\dfrac{25.0 \times 10^{-3} L \times .0012 \text{ moles of } IO_3^-/L}{(25.0 + 75.0) \times 10^{-3} L}\right) = 3.0 \times 10^{-4} M$

$K_{sp} > K_T$

6.9×10^{-8} 1.08×10^{-10}

so no precipitate forms

79. 25.0 mL of a 0.0012 M $Mg(IO_3)_2$ solution is added to 25.0 mL of a 0.0016 M $AgNO_3$ solution. Will a precipitate form? Support your answer with calculations.

$AgIO_{3(s)} \rightleftarrows Ag^+ + IO_3^-$

$K_{Trial} = [Ag^+][IO_3^-]$

$[Ag^+] = \left(\dfrac{25.0 \times 10^{-3} L \times .0016 \text{ mol of } Ag^+/L}{(25.0 + 25.0) \times 10^{-3} L}\right) = .00080 M$

$= (.00080)(.0012)$

$K_{Trial} = 9.6 \times 10^{-7}$

$[IO_3^-] = \left(\dfrac{25.0 \times 10^{-3} L \times .0024 M}{(25.0 + 25.0) \times 10^{-3} L}\right) = .0012 M$

$K_{sp} < K_T$

3.2×10^{-8} 9.6×10^{-7}

so a precipitate forms

80. 25.0 mL of a 0.0024 M CaI_2 solution is added to 35 mL of a 0.0012 M $Pb(NO_3)_2$ solution. Will a precipitate form? Support your answer with calculations.

$PbI_{2(s)} \rightleftharpoons Pb^{+2} + 2I^-$ $K_T = [Pb^{+2}][I^-]^2$

$[Pb^{+2}] = \dfrac{(35.0 \times 10^{-3} L \times .0012 \frac{mol}{L})}{(35.0 + 25.0) \times 10^{-3} L} = 7.0 \times 10^{-4} M$ $= (7.0 \times 10^{-4})(2.0 \times 10^{-3})^2$

$= 2.8 \times 10^{-9}$

$[I^-] = \dfrac{(25.0 \times 10^{-3} L \times .0048 \frac{mol}{L})}{(35.0 + 25.0) \times 10^{-3} L} = 2.0 \times 10^{-3} M$

$\underset{8.5 \times 10^{-9}}{K_{eq}} > \underset{2.8 \times 10^{-9}}{K_T}$ ∴ no precipitate

81. What is the maximum $[Ag^+]$ that can exist in a solution of 0.010 M $NaIO_3$?

A. 1.8×10^{-4} M
B. 3.2×10^{-6} M
C. 3.2×10^{-10} M
D. 3.2×10^{-8} M

$AgIO_{3(s)} \rightleftharpoons Ag^+ + IO_3^-$
$K_{sp} = [Ag^+][IO_3^-]$
$3.2 \times 10^{-8} = [Ag^+][.010]$

82. Determine the maximum $[Na_2CO_3]$ that can exist in 1.0 L of a 0.0010 M $Ba(NO_3)_2$ without forming a precipitate.

A. 2.6×10^{-9} M
B. 5.1×10^{-5} M
C. 2.6×10^{-12} M
D. 2.6×10^{-6} M

$BaCO_{3(s)} \rightleftharpoons Ba^{+2} + CO_3^{-2}$
$K_{sp} = [Ba^{+2}][CO_3^{-2}]$
$2.6 \times 10^{-9} = (.0010)[CO_3^{-2}]$

83. What is the maximum number of moles of Cl^- that can exist in 500.0 mL of 2.0 M $AgNO_3$?

A. 1.8×10^{-8}
B. 4.5×10^{-11}
C. 1.8×10^{-9}
D. 9.0×10^{-11}

$AgCl_{(s)} \rightleftharpoons Ag^+ + Cl^-$ $9.0 \times 10^{-11} \frac{moles}{L} \times 500.0 \times 10^{-3} L$
$K_{sp} = [Ag^+][Cl^-]$
$1.8 \times 10^{-10} = (2.0)[Cl^-]$ $= 4.5 \times 10^{-11}$ moles

84. Which of the following ions would have the highest concentration in 0.1 M Ag^+?

A. Cl^-
B. Br^-
C. CrO_4^{-2}
D. CO_3^{-2}

$1.8 \times 10^{-10} = (.10)[Cl^-]$ 1.8×10^{-9}
$5.4 \times 10^{-13} = (.10)[Br^-]$ 5.4×10^{-12}
$1.1 \times 10^{-12} = (.01)[CrO_4^{-2}]$ 1.4×10^{-10}
$8.5 \times 10^{-12} = (.01)[CO_3^{-2}]$ 8.5×10^{-10}

85. Which of the following ions could be used in the lowest concentration to remove 0.0050 M Ag^+ ions from a polluted water sample?

A. BrO_3^- $\quad 5.3\times10^{-5} = (.0050)[BrO_3^-] \quad 1.1\times10^{-2}\ M$

B. CO_3^{-2} $\quad 8.5\times10^{-12} = (2.5\times10^{-5})[CO_3^{-2}] \quad 3.4\times10^{-7}\ M$

C. I^- $\quad 8.5\times10^{-17} = (.0050)[I^-] \quad 1.7\times10^{-14}$

D. Br^- $\quad 5.4\times10^{-13} = (.0050)[Br^-] \quad 1.1\times10^{-10}$

86. Which of the following ions could be used in the lowest concentration to remove 0.0010M Pb^{+2} ions from a polluted water sample?

A. SO_4^{-2} $\quad 1.8\times10^{-8} = (.0010)[SO_4^{-2}] = 1.8\times10^{-5}\ M$

B. Cl^- $\quad 1.2\times10^{-5} = (.0010)[Cl^-]^2 = .11\ M$

C. I^- $\quad 8.5\times10^{-9} = (.0010)[I^-]^2 \quad 2.9\times10^{-3}\ M$

D. Br^- $\quad 6.6\times10^{-6} = (.0010)[Br^-]^2 \quad .081\ M$

87. Calculate the maximum $[CO_3^{-2}]$ that can exist in a 0.0010 M $Mg(NO_3)_2$

$$MgCO_{3(s)} \rightleftharpoons Mg^{+2} + CO_3^{-2}$$

$$K_{sp} = [Mg^{+2}][CO_3^{-2}]$$

$$6.8\times10^{-6} = (.0010)[CO_3^{-2}]$$

$$[CO_3^{-2}] = 6.8\times10^{-3}$$

88. Calculate the maximum [$CO_3{}^{-2}$] that can exist in a 0.0010 M $AgNO_3$

$$Ag_2CO_{3(s)} \rightleftharpoons 2Ag^+ + CO_3^{-2}$$

$$K_{sp} = [Ag^+]^2[CO_3^{-2}]$$

$$8.5 \times 10^{-12} = (.0010)^2 [CO_3^{-2}]$$

$$8.5 \times 10^{-6}\ M = [CO_3^{-2}]$$

89. Calculate the mass of NaI necessary to begin precipitation of Cu^+ from a 250.0 mL sample of 0.010 M $CuNO_3$.

$$CuI_{(s)} \rightleftharpoons Cu^+ + I^-$$

$$K_{sp} = [Cu^+][I^-]$$

$$1.3 \times 10^{-12} = (.010)[I^-]$$

$$[I^-] = 1.3 \times 10^{-10}\ M$$

$$250.0 \times 10^{-3} L \times \frac{1.3 \times 10^{-10} \text{ moles of } I^-}{L} \times \frac{1 \text{ mole NaI}}{1 \text{ mole } I^-} \times \frac{149.95 \text{ g NaI}}{1 \text{ mole NaI}}$$

$$= 4.87175 \times 10^{-9} g$$

$$= 4.9 \times 10^{-9} g$$

90. Calculate the mass of NaCl necessary to begin precipitation of Ag^+ from a 250.0 mL sample of 0.010 M $AgNO_3$.

$$AgCl_{(s)} \rightleftharpoons Ag^+ + Cl^-$$

$$K_{sp} = [Ag^+][Cl^-]$$

$$1.8\times10^{-10} = (.010)[Cl^-]$$

$$1.8\times10^{-8} = [Cl^-]$$

$$250.0\times10^{-3}\,L \times \frac{1.8\times10^{-8}\text{ mol of }Cl^-}{L} \times \frac{1\text{ mole NaCl}}{1\text{ mole }Cl^-} \times \frac{58.5\text{ g of NaCl}}{1\text{ mole NaCl}}$$

$$= 2.6325\times10^{-7}\text{ g of NaCl} = 2.6\times10^{-7}\text{ g of NaCl}$$

91. Calculate the maximum mass of $BaCl_2(s)$ that can be added to 250 mL of 0.50 M $Pb(NO_3)_2$ **without** forming a precipitate of $PbCl_2$.

$$PbCl_{2\,(s)} \rightleftharpoons Pb^{+2} + 2Cl^{-1}$$

$$K_{sp} = [Pb^{+2}][Cl^-]^2$$

$$1.2\times10^{-5} = (.50)[Cl^-]^2 \qquad \sqrt{2.4\times10^{-5}} = \sqrt{[Cl^-]^2}$$

$$4.8989...\times10^{-3}M = [Cl^-]$$

$$250\times10^{-3}\,L \times \frac{4.89...\times10^{-3}\text{ moles of }Cl^-}{L} \times \frac{1\text{ mole }BaCl_2}{2\text{ moles }Cl^-} \times \frac{208.3\text{ g of }BaCl_2}{1\text{ mole }BaCl_2}$$

$$= .127557\text{ g of }BaCl_2 = .13\text{ g of }BaCl_2$$

92. Consider the following equilibrium:

$$Fe(OH)_{2(s)} \leftrightarrows Fe^{+2}{}_{(aq)} + 2OH^-{}_{(aq)}$$

Which of the following will cause the equilibrium to shift to the right?

A. adding $Fe(OH)_2$
B. adding Na_2S
C. adding KOH
D. adding $Fe(NO_3)_2$

secondary precipitate

93. Consider the following equilibrium:

$$AgIO_{3\,(s)} \leftrightarrows Ag^{+}{}_{(aq)} + IO_3^{-}{}_{(aq)}$$

A few crystals of $NaIO_3$ are added to the above equilibrium. When equilibrium is re-established, how do the new ion concentrations compare with the original equilibrium concentrations?

	$[Ag^+]$	$[IO_3^-]$
A.	increased	increased
B.	increased	decreased
C.	decreased	decreased
D.	decreased	increased

94. Consider the following equilibrium:

$$CaSO_{4(s)} \leftrightarrows Ca^{+2}{}_{(aq)} + SO_4^{-2}{}_{(aq)}$$

Which of the following would shift the above equilibrium to the left?

A. removing some $Ca^{+2}{}_{(aq)}$

B. removing some $SO_4^{-2}{}_{(aq)}$

C. adding $CaSO_{4(s)}$

D. adding $MgSO_{4(s)}$ so $[SO_4^{-2}]\uparrow$

95. Which of the following is true when solid $Cu(NO_3)_2$ is added to a saturated solution of CuS and equilibrium is reestablished?

A. $[Cu^{+2}]$ increases

B. $[Cu^{+2}]$ does not change

C. $[S^{-2}]$ increases

D. $[S^{-2}]$ does not change

$CuS_{(s)} \rightleftharpoons Cu^{+2} + S^{-2}$

add Cu^{+2}

96. Which of the following is true when solid NaOH is added to a saturated solution of CuS and equilibrium is reestablished?

A. $[S^{-2}]$ does not change

B. $[Cu^{+2}]$ does not change

C. $[Cu^{+2}]$ increases

D. $[S^{-2}]$ increases

$CuS_{(s)} \rightleftharpoons Cu^{+2} + S^{-2}$

$+OH^-$

$\downarrow$

$Cu(OH)_{2(s)}$

97. Solid NaI is added to a saturated AgCl solution. How have $[Ag^+]$ and $[Cl^-]$ changed when equilibrium has been reestablished?

	$[Ag^+]$	$[Cl^-]$
A.	increased	increased
B.	decreased	increased
C.	increased	decreased
D.	stayed the same	stayed the same

$Ag_{(s)} \rightleftharpoons Ag^+ + Cl^-$

$+$

I^-

$\downarrow$

$AgI_{(s)}$

$BaSO_{4(s)}$

Ba^{+2}

98. Consider the following equilibrium:

$$CaSO_{4\,(s)} \leftrightarrows Ca^{2+}\,(aq) + SO_4{}^{2-}\,(aq)$$

When $Ba(NO_3)_2$ is added to this solution, which of the following will occur in regards to the equilibrium and $[Ca^{2+}]$?

	Equilibrium	$[Ca^{2+}]$
A.	shifts right	increases
B.	shifts left	decreases
C.	shifts left	increases
D.	shifts right	decreases

99. Consider the following equilibrium:

$$\text{energy} + AgCl_{(s)} \leftrightarrows Ag^+{}_{(aq)} + Cl^-{}_{(aq)}$$

Addition of which of the following will increase the solubility of AgCl?

A. $AgNO_3$
B. heat
C. a catalyst
D. HCl

100. Consider the following equilibrium:

$$\text{energy} + AgCl_{(s)} \leftrightarrows Ag^+{}_{(aq)} + Cl^-{}_{(aq)}$$

Addition of which of the following will increase the solubility of AgCl?

A. $AgNO_3$
B. NaBr
C. decrease the volume
D. HCl

101. In which of the following would $PbCl_{2(s)}$ be the **least** soluble?

A. 1 M K_2SO_4
B. 1 M $BaCl_2$
C. 1 M HCl
D. 1 M $Pb(NO_3)_2$

do in class.

102. What will be the effect of adding some solid $AgNO_3$ to a saturated solution of AgCl?

A. More AgCl will dissolve.
B. The $AgNO_3$ will not affect the AgCl equilibrium.
C. The $AgNO_3$ will not dissolve.
D. More AgCl will be produced.

103. What will be the effect of adding some solid K_2SO_4 to a saturated solution of AgCl?

A. More AgCl will dissolve.
B. The K_2SO_4 will not affect the AgCl equilibrium.
C. The K_2SO_4 will not dissolve.
D. More AgCl will be produced.

$AgCl_{(s)} \rightleftharpoons Ag^+ + Cl^-$

SO_4^{-2}

Ag_2SO_4

104. What will be the effect of adding some solid $Cu(NO_3)_2$ to a saturated solution of AgCl?

A. More AgCl will be produced.
B. The $Cu(NO_3)_2$ will not affect the AgCl equilibrium.
C. The $Cu(NO_3)_2$ will not dissolve.
D. More AgCl will dissolve.

$AgCl_{(s)} \rightleftharpoons Ag^+ + Cl^-$

$+ Cu^{+2}$

$Cu^{+2} + 2Cl^-$

I8 - Review

105. Which of the following is both ionic and most soluble?

A. $Ca(OH)_2$ B. $Fe(OH)_3$ C. RbOH D. ~~CH_3OH~~

106. What is the concentration of the ions in ~~3.0~~ L of 0.50 M $Fe_2(SO_4)_3$? $\rightarrow 2Fe^{+3} + 3SO_4^{-2}$

.50 1.0 1.5

	$[Fe^{+3}]$	$[SO_4^{-2}]$
A.	1.0 M	1.5 M
B.	3.0 M	4.5 M
C.	0.33M	0.50M
D.	1.5 M	1.5 M

107. In a solubility equilibrium, the

A. concentration of solute and solvent are equal
B. Ksp = solubility
C. concentration of anion and cation are always equal
D. rate of dissolving equals the rate of crystallization

108. A compound has a solubility of 7.1 x 10^{-5} M at 25°C. The compound is

A. CuS s^2
B. ~~$CaSO_4$~~
C. $CaCO_3$ s^2
D. AgBr s^2

∴ solubility not Ksp

∴ $K_{sp} = (7.1 \times 10^{-5})^2 = 5.0 \times 10^{-9}$

109. At 25°C, what is the [Cl^-] in a saturated solution of $PbCl_2$?

A. 2.3 x 10^{-2} M
B. 4.6 x 10^{-2} M
C. 1.4 x 10^{-2} M
D. 2.9 x 10^{-2} M

$PbCl_{2(s)} \rightleftharpoons Pb^{+2} + 2Cl^-$

$K_{sp} = [Pb^{+2}][Cl^-]^2$

$1.2 \times 10^{-5} = 4y^3$

$y = 0.014422$

∴ $[Cl^-] = 2y = .028844$

(change next year to 1.1×10^{-3} M)

110. The solubility of CaF_2 is 3.3×10^{-4} M. Determine the K_{sp} for CaF_2. (actually $K_{sp} = 5.3 \times 10^{-9}$)

A. 1.1×10^{-7}
B. 3.3×10^{-4}
C. 1.4×10^{-10}
D. 3.6×10^{-11}

$$CaF_{2(s)} \rightleftharpoons Ca^{+2} + 2F^-$$
$$K_{sp} = [Ca^{+2}][F^-]^2$$
$$= (3.3 \times 10^{-4})(6.6 \times 10^{-4})^2 = 1.4 \times 10^{-10}$$

111. In a saturated solution of $Ag_2C_2O_4$ the $[Ag^+] = 2.2 \times 10^{-4}$ M. What is the solubility of $Ag_2C_2O_4$ in this solution?

A. 2.2×10^{-4} M
B. 4.4×10^{-4} M
C. 5.2×10^{-12} M
D. 1.1×10^{-4} M

$$\underset{?}{Ag_2C_2O_{4(s)}} \rightleftharpoons \underset{2.2 \times 10^{-4}}{2Ag^+} + C_2O_4^{-2}$$

112. A solution is prepared containing both 0.2 M $SO_4^{\ 2-}$ and 0.2 M $PO_4^{\ 3-}$ ions. An equal volume of a second solution is added in order to precipitate only one of these two anions. The second solution must contain which of the following?

A. 0.2 M Pb^{+2}
B. 0.2 Sr^{+2}
C. 0.2 M Cs^+
D. 0.2 M Zn^{+2}

	SO_4^{-2}	PO_4^{-3}
Pb^{+2}	(s)	(s)
Sr^{+2}	(s)	(s)
Cs^+	(aq)	(aq)
Zn^{+2}	(aq)	(s)

113. Consider the following equilibrium:

$$CaSO_{4\,(s)} \rightleftharpoons Ca^{+2}\,(aq) + SO_4^{\ 2-}\,(aq)$$

When $Ca(NO_3)_2$ is added to this solution, which of the following will occur in regards to the equilibrium and $[SO_4^{\ 2-}]$

	Equilibrium	$[SO_4^{\ 2-}]$
A.	shifts left	~~increases~~
B.	shifts left	decreases
C.	shifts ~~right~~	~~increases~~
D.	shifts ~~right~~	decreases

114. Consider the following equilibrium:

$$Fe(OH)_{2(s)} \rightleftharpoons Fe^{+2}\,_{(aq)} + 2OH^-\,_{(aq)}$$

Which of the following will cause the equilibrium to shift to the right?

A. adding $\cancel{Fe(OH)_2}$
B. adding $\cancel{KOH}$
C. adding $\cancel{NaNO_3}$
D. adding Na_2S

115. An equal number of moles of Na_2CO_3 is added to four different 10.0 mL testtubes.

Sample 1	Sample 2	Sample 3	Sample 4
0.50 M $Ba^{2+}_{(aq)}$	0.50 M $Ca^{2+}_{(aq)}$	0.50 M $Mg^{2+}_{(aq)}$	0.50 M $Sr^{2+}_{(aq)}$

A precipitate forms in only one of the samples. Identify the cation which is present in the precipitate.

$\therefore$ lowest solubility

A. Ba^{+2} $BaCO_3$ y^2 $y^2 = 2.6 \times 10^{-9}$

B. Mg^{+2} $MgCO_3$ y^2 $y^2 = 6.8 \times 10^{-6}$

C. Ca^{+2} $CaCO_3$ y^2 $\therefore$ $y^2 = 5.0 \times 10^{-9}$

D. Sr^{+2} $SrCO_3$ y^2 $y^2 = 5.6 \times 10^{-10}$ ✓

116. 25.0 mL of a 4.5 x 10^{-3} M NaF solution is added to 35.0 mL of a 3.6 x 10^{-3} M $Sr(NO_3)_2$ solution. Will a precipitate form?

$$SrF_{2(s)} \rightleftarrows Sr^{+2} + 2F^- \qquad K_T = [Sr^{+2}][F^-]^2$$

$$[Sr^{+2}] = \left(\frac{35.0 \times 10^{-3} L \times 3.6 \times 10^{-3} M}{(35.0 + 25.0) \times 10^{-3} L}\right) = 2.1 \times 10^{-3} M$$

$$[F^-] = \left(\frac{25.0 \times 10^{-3} L \times 4.5 \times 10^{-3} M}{(25.0 + 35.0) \times 10^{-3} L}\right) = 1.875 \times 10^{-3} M$$

$$K_T = (2.1 \times 10^{-3})(1.875 \times 10^{-3})^2$$

$$= 7.3828125 \times 10^{-9}$$

$$\begin{matrix} K_{sp} & & K_T \\ 4.3 \times 10^{-9} & < & 7.38 \times 10^{-9} \end{matrix}$$

$\therefore$ precipitate forms

117. Calculate the mass of NaCl necessary to begin precipitation of Pb^{+2} from a 250.0 mL sample of 0.010 M $Pb(NO_3)_2$.

$PbCl_{2\,(s)} \rightleftarrows Pb^{+2} + 2Cl^-$

$K_{sp} = [Pb^{+2}][Cl^-]^2$

$1.2 \times 10^{-5} = (.010)[Cl^-]^2$

$1.2 \times 10^{-3} = [Cl^-]^2$

$.034641\,M = [Cl^-]$

$250.0 \times 10^{-3}\,L \times \frac{.034641 \text{ mol of } Cl^-}{L} \times \frac{1 \text{ mole NaCl}}{1 \text{ mole } Cl^-} \times \frac{58.5\,g \text{ NaCl}}{1 \text{ mole NaCl}}$

$= .506625\,g = .51\,g$ of NaCl.

118. A solution is found to contain $\overset{+2}{Sr}(NO_3)_2\,(aq)$, $\overset{+}{Cu}NO_3\,(aq)$, $\overset{+2}{Ba}(NO_3)_2\,(aq)$ in solution. Devise a procedure by which each of the cations in the solution can be removed, one at a time. The solutions that are available to use are:

NaI   KNO3 $Li_2SO_4^{-2}$ KOH^-

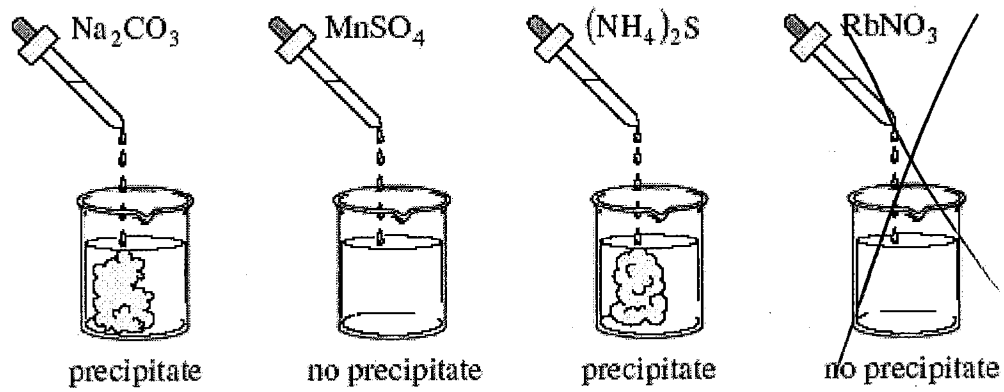
1. First you would add NaI. The precipitate formed would be CuI. Filter out the precipitate.

2. To the remaining solution add KOH. The precipitate formed would be $Ba(OH)_2$. Filter out the precipitate.

3. To the remaining solution add Li_2SO_4. The precipitate formed would be $SrSO_4$. FIlter out the precipitate.

	Sr^{+2}	Cu^+	Ba^{+2}
I^-	(aq)	(s)	(aq)
SO_4^{-2}	(s)	(s)	(s)
OH^-	(aq)	(s)	(s)

An experiment is conducted to identify an unknown cation that is present in each of four beakers.



119.
Which of the following is the unknown cation?

A. Fe^{+3}
B. Be^{+2}
C. Ag^{+1}
D. Ba^{+2}

	CO_3^{-2}	SO_4^{-2}	S^{-2}
Fe^{+3}	(s)	(aq)	(s)
Be^{+2}	(s)	(aq)	~~(aq)~~
Ag^{+}	(s)	~~(s)~~	(s)
Ba^{+2}	(s)	~~(s)~~	(aq)

120. A solution is found to contain $ZnSO_{4\,(aq)}$ in solution. Devise a procedure by which each of the ions in the solution can be removed, one at a time. The solutions that are available to use are:

$Sr(OH)_2$ BaS NH_4Cl $Pb(NO_3)_2$ FeI_3

1. First you would add $Pb(NO_3)_2$. The precipitate formed would be $PbSO_4$
Filter out the precipitate.

2. To the remaining solution add BaS / $Sr(OH)_2$. The precipitate formed would be
ZnS / $Zn(OH)_2$ Filter out the precipitate.

	Zn^{+2}	SO_4^{-2}
Sr^{+2} / OH^-	(s)	(s)
Ba^{+2} / S^{-2}	(s)	(s)
NH_4^+ / Cl^-	(aq)	(aq)
Pb^{+2} / NO_3^{-2}	(aq)	(s)
Fe^{+3} / I^-	(aq)	(aq)

121. A solution is found to contain one of the following solutions: $NaCl_{(aq)}$, $K_2SO_{4\,(aq)}$ and $Li_2CO_{3\,(aq)}$. Fill in the following blanks to determine the identity of the unknown solution. The solutions that are available to use are:

$\overset{+2}{Sr}(NO_3)_2$ ~~NH_4NO_3~~ $\overset{+4}{Pb}(NO_3)_4$ $\overset{+3}{Cr}(NO_3)_3$

1. First you would add $Pb(NO_3)_4$. The precipitate formed would be $Pb(CO_3)_2$
   No precipitate formed. What does this tell you? Not K_2SO_4.

2. To the remaining solution add $Sr(NO_3)_2$ The precipitate formed would be $SrSO_4$.
   A precipitate forms. What does this tell you? solution is K_2SO_4.

3. To the remaining solution add —. The precipitate formed would be nothing.
   A precipitate does not form. What does this tell you? ______.

For the reaction that formed a precipitate:

	Cl^-	SO_4^{-2}	CO_3^{-2}
Sr^{+2}	(aq)	(s)	(s)
Pb^{+4}	(aq)	(aq)	(s)
Cr^{+3}	(aq)	(aq)	(s)

Write a balanced formula equation.

$$Sr(NO_3)_2 + K_2SO_4 \rightarrow 2KNO_3 + SrSO_4$$

Write a balanced complete ionic equation.

$$Sr^{+2} + 2NO_3^- + 2K^+ + SO_4^{-2} \rightarrow 2K^+ + 2NO_3^- + SrSO_{4(s)}$$

Write a balanced net ionic equation.

$$Sr^{+2} + SO_4^{-2} \rightarrow SrSO_{4(s)}$$

122. Given the equilibrium reaction:

$$2NaNO_{3\,(aq)} + Ag_2S_{(s)} \leftrightarrows 2\,AgNO_{3\,(aq)} + Na_2S_{(aq)}$$

Which K_{sp} expression best describes the net ionic reaction?

A. $K_{sp} = \dfrac{[Ag^+][S^{-2}]}{\cancel{[Ag_2S]}}$

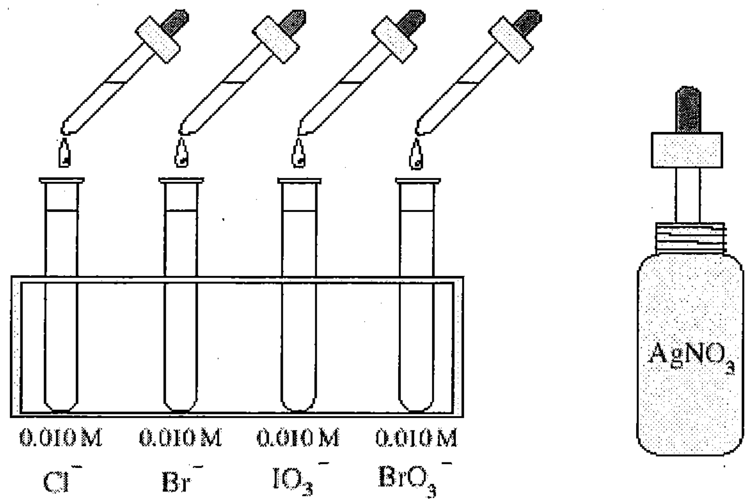
B. $K_{sp} = \dfrac{[AgNO_3]^2[Na_2S]}{\cancel{[NaNO_3]^2}}$

C. $K_{sp} = \dfrac{1}{[Ag^+]^2[S^{-2}]}$

D. $K_{sp} = [Ag^+]^2[S^{-2}]$

123.

Consider the following 10.0 mL solutions:



Equal moles of $AgNO_3$ are added to each solution. It is observed that a precipitate forms in all but one solution. Which solution does not form a precipitate? the most soluble!

A. IO_3^- $y^2 = 3.2 \times 10^{-8}$

B. Cl^- $y^2 = 1.8 \times 10^{-10}$

C. BrO_3^- $y^2 = 5.3 \times 10^{-5}$

D. Br^- $y^2 = 5.4 \times 10^{-13}$

124. How many moles of Pb^{2+} are there in 500.0 mL of a saturated solution of $PbSO_4$.

A. 1.3×10^{-4}

B. 6.7×10^{-5}

C. 3.2×10^{-16}

D. 9.0×10^{-9}

$PbSO_{4(s)} \rightleftharpoons Pb^{+2} + SO_4^{-2}$

$K_{sp} = [Pb^{+2}][SO_4^{-2}]$ $1.8 \times 10^{-8} = y^2$

$1.34 \times 10^{-4}\,M = y \times 500.0 \times 10^{-3}\,L = 6.7 \times 10^{-5}$ moles

125. 25.0 mL of a 0.020 M $Ca(NO_3)_2$ is added to 75.0 mL of a 0.0030 M K_2SO_4. Will a precipitate form?

A. A precipitate will ~~form~~ because the Trial $K_{sp} < K_{sp}$.

B. A precipitate will not form because the Trial $K_{sp} < K_{sp}$.

C. A precipitate will ~~form~~ because the Trial $K_{sp} \cancel{>} K_{sp}$.

D. A precipitate will not form because the Trial $K_{sp} \cancel{>} K_{sp}$.

$CaSO_{4(s)} \rightleftharpoons Ca^{+2} + SO_4^{-2}$

$K_T = [Ca^{+2}][SO_4^{-2}]$

$= \left(\frac{25.0 \times 10^{-3}\,L \times .020\,M}{100.0 \times 10^{-3}\,L}\right)\left(\frac{75.0 \times 10^{-3}\,L \times .0030}{100.0}\right)$

$= (.0050)(2.25 \times 10^{-3})$

$K_T = 1.125 \times 10^{-5}$

K_{sp} 7.1×10^{-5} $>$ K_T 1.125×10^{-5}

126. What is the maximum $[Pb^{+2}]$ possible in a 0.10 M NaCl solution?

A. 1.2×10^{-3} M

B. 3.0×10^{-3} M

C. 1.2×10^{-5} M

D. 6.0×10^{-5} M

$PbCl_{2(s)} \rightleftharpoons Pb^{+2} + 2Cl^-$

$K_{sp} = [Pb^{+2}][Cl^-]^2$

$1.2 \times 10^{-5} = [Pb^{+2}](.10)^2$

$1.2 \times 10^{-3} = [Pb^{+2}]$