87. An equal number of moles of Na_2CO_3 is added to four different 10.0 mL samples.

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. **(1**

A. Ba^{2+}
B. Ca^{2+}
C. Mg^{2+}
D. Sr^{2+}

88. What is the net ionic equation for the reaction between $BaS_{(aq)}$ and $Sr(OH)_{2(aq)}$?

A. $Sr^{2+}_{(aq)} + S^{2-}_{(aq)} \rightarrow SrS_{(s)}$
B. $Ba^{2+}_{(aq)} + 2OH^{-}_{(aq)} \rightarrow Ba(OH)_{2(s)}$
C. $Ba^{2+}_{(aq)} + S^{2-}_{(aq)} + Sr^{2+}_{(aq)} + 2\,OH^{-}_{(aq)} \rightarrow Ba(OH)_{2(s)} + SrS_{(s)}$
D. $Ba^{2+}_{(aq)} + S^{2-}_{(aq)} + Sr^{2+}_{(aq)} + 2\,OH^{-}_{(aq)} \rightarrow Ba(OH)_{2(s)} + Sr^{2+}_{(aq)} + S^{2-}_{(aq)}$

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

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

90. The solubility of $ZnCO_3$ is 6.4×10^{-9} M . What is the value of K_{sp} for $ZnCO_3$?

A. 4.1×10^{-17}
B. 6.4×10^{-9}
C. 1.3×10^{-8}
D. 8.0×10^{-5}

91. When equal volumes of 0.20 M NaOH and 0.20 M CaS are mixed together,

A. a precipitate forms and the Trial K_{sp} would be less than K_{sp}.
B. no precipitate forms and the Trial K_{sp} would be less than K_{sp}.
C. a precipitate forms and the Trial K_{sp} would be greater than K_{sp}.
D. no precipitate forms and the Trial K_{sp} would be greater than K_{sp}.

92. Which of the following solutes will produce a molecular solution?

A. HCl
B. Fe_3S_3
C. HNO_3
D. CH_3OH

93. Which of the following would best describe the solubility of a solute?

A. litres per gram
B. moles per litre
C. grams per mole
D. moles per second

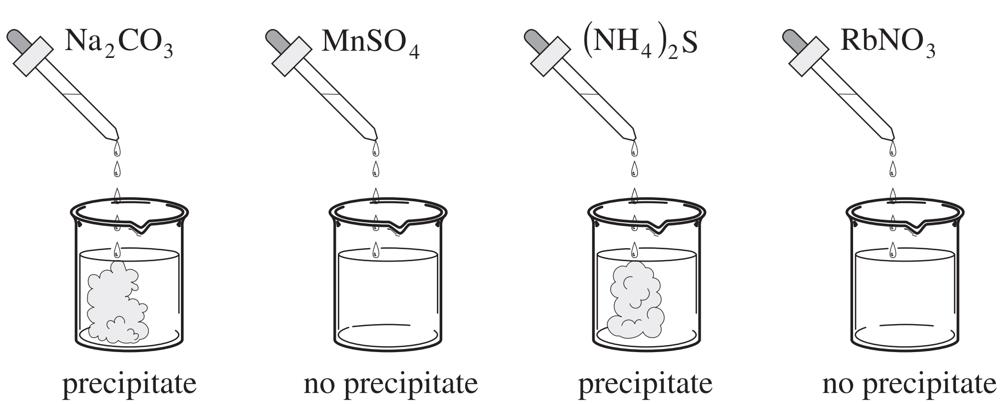
94. Which compound will have the lowest solubility?

A. FeS
B. $CaSO_4$
C. $AgBrO_3$
D. $Fe(NO_3)_3$

95. Which of the following precipitates may form when equal volumes of 0.3M $AgNO_3$, 0.3M $SrCl_2$ and 0.3M Na_2CO_3 are mixed together?

A. $SrCO_3$ and $AgCl$
B. Ag_2CO_3 and $AgCl$
C. $SrCO_3$ and Ag_2CO_3
D. $SrCO_3$, Ag_2CO_3 and $AgCl$

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



Which of the following could be the unknown cation?

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

97. Given the equilibrium reaction:

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

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

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

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

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

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

98. Two salt solutions were mixed and a Trial K_{sp} was calculated to be 2.0×10^{-9}. The K_{sp} value is 1.0×10^{-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 $K_{sp} > K_{sp}$	precipitate forms
C.	Trial $K_{sp} < K_{sp}$	no precipitate forms
D.	Trial $K_{sp} > K_{sp}$	no precipitate forms

99. A saturated solution of $SrSO_4$ has a $[SO_4^{2-}]$ of 1.0×10^{-4} M. What is the $[Sr^{2+}]$?

A. 3.4×10^{-3} M
B. 5.8×10^{-4} M
C. 1.0×10^{-4} M
D. 3.4×10^{-7} M

100. Which of the following would form a saturated solution when 0.010 mol of the solid solute is added to 100 mL of water?

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

101. Which net ionic equation best describes the reaction that exists in a solution prepared by mixing equal volumes of 0.20 M $Ca(NO_3)_2$ and 0.20 M Na_2CO_3 ?

A. $Ca^{2+}_{(aq)} + CO_{3\,(aq)}^{2-} \rightleftarrows CaCO_{3(s)}$
B. $Na^{+}_{(aq)} + NO_{3\,(aq)}^{-} \rightleftarrows NaNO_{3(s)}$
C. $Ca(NO_3)_{2(aq)} + Na_2CO_{3(aq)} \rightleftarrows 2NaNO_{3(s)} + CaCO_{3(s)}$
D. $Ca(NO_3)_{2(aq)} + Na_2CO_{3(aq)} \rightleftarrows 2NaNO_{3(aq)} + CaCO_{3(s)}$

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

A. CuCl
B. $FeCO_3$
C. $MgSO_4$
D. $Cu_3(PO_4)_2$

103. Which cation below can be used to separate SO_4^{2-} from S^{2-} ions by precipitation?

A. Sr^{2+}
B. Pb^{2+}
C. Cs^{+}
D. Be^{2+}

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

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

105. 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 is a product.
B. The solid solute is a reactant.
C. The solid solute continues to change in amount.
D. The solid solute does not change in concentration.

106. Which of the statements below describes the K_{sp} expression for the salt barium phosphate?

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

107. What is the solubility of $Fe(OH)_2$?

A. 4.9×10^{-17} M
B. 1.2×10^{-17} M
C. 3.7×10^{-6} M
D. 2.3×10^{-6} M

108. Which of the following ions would have the highest concentration in $0.1M\ CO_3^{2-}$?

A. Ba^{2+}
B. Ca^{2+}
C. Sr^{2+}
D. Mg^{2+}

109. Which of the solutes below can form an ionic solution with the highest conductivity?

A. PbS
B. CH_3Cl
C. $NaNO_3$
D. CH_3COOH

110. The following data was collected to determine the solubility of a substance:

Mass of solute dissolved	5.00 g
Volume of solvent	250.0 mL
Molar mass of solute	100.0 g/mol
Molar mass of solvent	20.0 g/mol

Which of the following best describes its solubility?

A. 2.00×10^{-2} g/mL
B. 5.00×10^{-2} mol
C. 0.250 mol
D. 1.00 mol/L

111. Which value best represents the total ion concentration when 0.10 moles of K_3PO_4 is present in 0.5 L of solution?

A. 0.1 M
B. 0.2 M
C. 0.4 M
D. 0.8 M

112. What will happen when equal volumes of 0.20 M $(NH_4)_2S$ and 0.20 M $Sr(OH)_2$ are mixed?

A. SrS precipitates.
B. NH_4OH precipitates.
C. Both NH_4OH and SrS precipitate.
D. No precipitate forms.

113. Which anion would be most effective in removing the cations responsible for hard water?

A. S^{2-}

B. Cl^-

C. PO_4^{3-}

D. SO_4^{2-}

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

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

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

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

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

115. The solubility of $Mg(OH)_2$ is found to be 1.2×10^{-4} M. What is its K_{sp} ?

A. 6.9×10^{-12}
B. 1.7×10^{-12}
C. 1.4×10^{-8}
D. 1.2×10^{-4}

116. Which of the following is true for the salt SrF_2 at 25°C ?

A. It has a high solubility.
B. It will not dissolve at all.
C. Its solubility is 1.6×10^{-3} M.
D. Its solubility is 1.0×10^{-3} M.

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

A. I^-
B. Br^-
C. BrO_3^-
D. CO_3^{2-}

118. Which of the solutes below is both ionic and most soluble?

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

119. Which of the following is commonly used to describe the solubility of a solute?

A. mass of solute/moles of solute
B. moles of solution/mass of solute
C. mass of solute/volume of solution
D. mass of solution/volume of solute

120. 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 OH^- precipitates half as fast as the Ca^{2+}.
C. The rate of crystallization equals the rate of dissolving.
D. The rate of dissolving is greater than the rate of crystallization.

121. What happens when equal volumes of $0.20\,M\ BaCl_2$ and $0.20\,M\ Pb(NO_3)_2$ are mixed?

A. Only $PbCl_2$ precipitates.

B. Only $Ba(NO_3)_2$ precipitates.

C. Both $PbCl_2$ and $Ba(NO_3)_2$ precipitate.

D. No precipitate forms.

122. Which of the following best represents the net ionic reaction resulting from the mixing of equal volumes of $0.2\,M\ Ca(NO_3)_2$ and $0.2\,M$ NaOH ?

A. $Ca^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Ca(OH)_{2(s)}$

B. $Ca(NO_3)_{2(aq)} + 2NaOH_{(aq)} \rightarrow Ca(OH)_{2(s)} + 2NaNO_{3(aq)}$

C. $Ca^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2Na^+_{(aq)} + 2OH^-_{(aq)} \rightarrow Ca(OH)_{2(s)} + 2NaNO_{3(aq)}$

D. $Ca^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2Na^+_{(aq)} + 2OH^-_{(aq)} \rightarrow Ca(OH)_{2(s)} + 2Na^+_{(aq)} + 2NO_3^-{}_{(aq)}$

123. What is the K_{sp} expression for the precipitate formed when solutions of $Fe(NO_3)_3$ and $Sr(OH)_2$ are mixed?

A. $K_{sp} = [Sr^{2+}][OH^-]^2$

B. $K_{sp} = [Fe^{3+}][OH^-]^3$

C. $K_{sp} = [Sr^{2+}][2NO_3^-]$

D. $K_{sp} = [Fe^{3+}][3OH^-]$

124. At some temperature greater than 25°C, the K_{sp} for lead(II) sulphate becomes 1.0×10^{-7}. What is the solubility of the lead(II) sulphate at this temperature?

A. 1.0×10^{-14} M

B. 5.0×10^{-8} M

C. 2.0×10^{-7} M

D. 3.2×10^{-4} M

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

A. 1.2×10^{-5} M

B. 6.0×10^{-5} M

C. 1.2×10^{-3} M

D. 3.0×10^{-3} M

126. Which of the ions below could be used in a precipitation reaction to determine the $[SO_4^{2-}]$ in a water sample?

A. H^+

B. Cs^+

C. Sr^{2+}

D. NH_4^+

127. Write the balanced complete ionic equation for the reaction that occurs when $0.20\,M$ of $Ba(NO_3)_2$ is added to an equal volume of $0.20\,M$ Na_2CO_3.

128. Calculate the minimum number of moles of $Pb(NO_3)_2$ required to start precipitation in $50.0\,mL$ of $0.15\,M$ ZnI_2 .

129. In a titration, $25.00\,mL$ of $NaCl_{(aq)}$ reacts completely with $42.20\,mL$ of $0.100\,M$ $AgNO_3$. What is the $[Cl^-]$ in the original solution? **(3 ma**

130. The following data was obtained when $20.0\,mL$ of a saturated solution of PbI_2 was evaporated to dryness.

Mass of evaporating dish	30.250 g
Mass of evaporating dish and residue	30.262 g

Use this information to determine the K_{sp} of PbI_2. **(4 marks)**

131. Calculate the molar solubility of SrF_2.

132. Does a precipitate form when $3.0\,mL$ of $1.0 \times 10^{-3}\,M$ NaBr is added to $2.0\,mL$ of $1.0 \times 10^{-3}\,M$ $Pb(NO_3)_2$?

133. Hard water, containing Ca^{2+} ions, forms a precipitate with sodium stearate $(NaC_{18}H_{35}O_2)$.

a) Write the net ionic reaction that represents this precipitation. **(2 marks)**

b) Identify another compound that could be used to remove Ca^{2+} from hard water.

134. Calculate the mass of $SrCO_3$ dissolved in $1.00\,L$ of a saturated solution of $SrCO_3$.

135. When equal volumes of $0.20\,M$ $Pb(NO_3)_2$ and $0.20\,M$ KCl are mixed, a precipitate of $PbCl_2$ forms.

a) Write the formula equation for the above reaction.

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

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

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

137. 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:

Volume of solution	$30.00\ mL$
Mass of evaporating dish	$32.125\ g$
Mass of evaporating dish and solid Ag_2SO_4	$32.260\ g$

Calculate the K_{sp} value for Ag_2SO_4 .

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

139. A $100.0\ mL$ saturated solution of FeF_2 contains $0.0787\ g$ of solute. Determine $[Fe^{2+}]$ and $[F^-]$ in the solution.

140. Consider the following information and accompanying diagram:

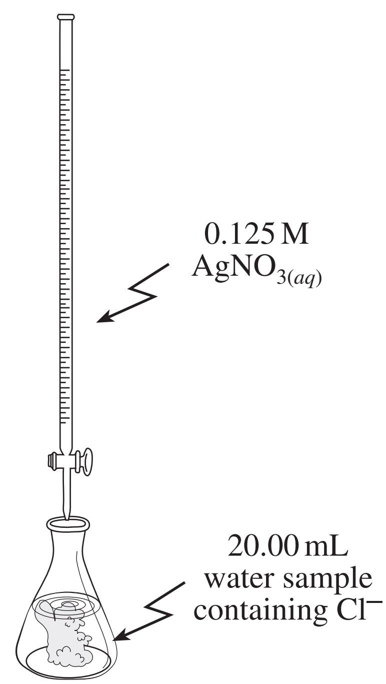
In a titration experiment, $AgNO_{3(aq)}$ was used to determine the $[Cl^-]$ in a water sample and the following data were recorded:

$[AgNO_3] = 0.125\ M$

Volume of water sample containing $Cl^- = 20.00\ mL$

Initial buret reading of $AgNO_3 = 5.15\ mL$

Final buret reading of $AgNO_3 = 37.15\ mL$



The equation for this reaction is

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

Using the above data, determine the $[Cl^-]$ in the water sample. **(3 marks)**

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

142. When a solution of $Na_2CO_{3(aq)}$ is mixed with a solution of $Ca(NO_3)_{2(aq)}$ a precipitate forms.

a) Write the net ionic equation for the precipitation reaction.

b) Explain what happens to the precipitate when HCl is added.

143. a) Write the net ionic equation for the reaction between $Pb(NO_3)_{2(aq)}$ and $NaCl_{(aq)}$.

b) Determine, with calculations, whether a precipitate will form when 15.0 mL of 0.050 M $Pb(NO_3)_2$ is added to 35.0 mL of 0.085 M NaCl.

144. After a 50.0 mL sample of a saturated solution of Ag_2SO_4 was heated to dryness, 7.2×10^{-4} g of solid Ag_2SO_4 remained. What is the value of K_{sp} for Ag_2SO_4 ?

145. Calculate the maximum mass of $BaCl_{2(s)}$ that can be added to 250 mL of 0.50 M $Pb(NO_3)_{2(aq)}$ without forming a precipitate of $PbCl_{2(s)}$.

146. Sufficient $Na_2SO_{4(s)}$ is added to 0.10 M $Ba(NO_3)_2$ to cause a precipitate to form.

a) Write the net ionic equation for the precipitate formation.

b) Calculate the $[SO_4^{2-}]$ at the moment the precipitate starts to form.

147. Calculate the mass of solid $AgNO_3$ that can be added to 2.0 L of a 0.10 M K_2CrO_4 solution in order to just start precipitation.

148. a) How would a saturated solution be prepared at room temperature?

b) Write a chemical equation to illustrate the equilibrium that exists in a saturated solution of $Be_3(PO_4)_2$.

149. Calculate the iodate ion concentration in a saturated copper (II) iodate solution at 25°C.

Multiple Choice Answers

1	C	6	D	11	C	16	D	21	A	26	D	31	C	36	C	41	A	46	B
2	B	7	C	12	A	17	A	22	C	27	C	32	B	37	B	42	A	47	C
3	B	8	D	13	B	18	B	23	A	28	B	33	A	38	D	43	C	48	C
4	C	9	D	14	A	19	C	24	D	29	B	34	D	39	A	44	B	49	B
5	B	10	A	15	C	20	A	25	A	30	A	35	C	40	B	45	B	50	B

51	C	56	C	61	B	66	C	71	C	76	B	81	B	86	C	91	C	96	B
52	C	57	B	62	B	67	D	72	B	77	A	82	C	87	D	92	D	97	A
53	D	58	A	63	A	68	C	73	B	78	D	83	A	88	B	93	B	98	B
54	B	59	C	64	A	69	D	74	D	79	C	84	D	89	B	94	A	99	A
55	B	60	D	65	B	70	D	75	A	80	D	85	A	90	A	95	D	100	A

101	A	111	D	116	D	121	A	126	C										
102	C	112	D	117	A	122	A												
103	A	113	C	118	A	123	B												
104	C	114	B	119	C	124	C												
105	D	115	A	120	C	125	C												

Written Answers

127.

$$\underbrace{Ba^{2+}_{(aq)} + 2NO_{3\,(aq)}^{-}}_{\frac{1}{2}\text{ mark}} + \underbrace{2Na^{+}_{(aq)} + CO_{3\,(aq)}^{2-}}_{\frac{1}{2}\text{ mark}} \rightarrow \underbrace{BaCO_{3(s)}}_{\frac{1}{2}\text{ mark}} + \underbrace{2Na^{+}_{(aq)} + 2NO_{3\,(aq)}^{-}}_{\frac{1}{2}\text{ mark}}$$

128.

$$\left[ZnI_2\right] = 0.15\,M$$

$$\therefore \left[I^-\right] = 2 \times 0.15\,M$$

$$= 0.30\,M$$

$$PbI_{2(s)} \rightleftarrows Pb^{2+} + 2I^-$$

$$K_{sp} = \left[Pb^{2+}\right]\left[I^-\right]^2$$

$$8.5 \times 10^{-9} = (x)(0.30)^2$$

$$x = 9.44 \times 10^{-8}\text{ mol/L}$$

$$\text{moles} = 9.44 \times 10^{-8}\text{ mol/L} \times 0.0500\,L$$

$$= 4.7 \times 10^{-9}\text{ mol}$$

129. $Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$

$$\text{mol } Ag^+ = (0.100\ \text{mol/L})(0.04220\ \text{L})$$
$$= 0.00422\ \text{mol}$$
$$\text{mol } Cl^- = \text{mol } Ag^+$$
$$[Cl^-] = \frac{0.00422\ \text{mol}}{0.02500\ \text{L}}$$
$$= 0.169\ \text{M}$$

130. Mass of $PbI_2 = 30.262\ \text{g} - 30.250\ \text{g} = 0.012\ \text{g}$

$$\text{Moles } PbI_2 = 0.012\ \text{g} \times \frac{1\ \text{mol}}{461.0\ \text{g}} = 2.60 \times 10^{-5}\ \text{mol}$$
$$[Pb^{2+}] = \frac{2.60 \times 10^{-5}\ \text{mol}}{0.0200\ \text{L}} = 1.3 \times 10^{-3}\ \text{M}$$
$$[I^-] = \frac{2 \times 2.60 \times 10^{-5}\ \text{mol}}{0.0200\ \text{L}} = 2.6 \times 10^{-3}\ \text{M}$$
$$K_{sp} = [Pb^{2+}][I^-]^2 = (1.3 \times 10^{-3})(2.6 \times 10^{-3})^2 = 8.8 \times 10^{-9}$$

131. $SrF_2 \rightleftarrows Sr^{2+} + 2F^-$

$$\qquad\qquad s \qquad 2s$$

$$K_{sp} = [Sr^{2+}][F^-]^2$$
$$= (s)(2s)^2$$
$$= 4.3 \times 10^{-9}$$
$$s = 1.0 \times 10^{-3}\ \text{mol/L}$$

132. $PbBr_{2(s)} \rightleftarrows Pb^{2+}_{(aq)} + 2Br^-_{(aq)}$

$$[Pb^{2+}] = \frac{2.0\ \text{mL}}{5.0\ \text{mL}} \times 1.0 \times 10^{-3}\ \text{M} = 4.0 \times 10^{-4}\ \text{M}$$
$$[Br^-] = \frac{3.0\ \text{mL}}{5.0\ \text{mL}} \times 1.0 \times 10^{-3}\ \text{M} = 6.0 \times 10^{-4}\ \text{M}$$
$$\text{Trial } K_{sp} = [Pb^{2+}][Br^-]^2$$
$$= (4.0 \times 10^{-4})(6.0 \times 10^{-4})^2$$
$$= 1.4 \times 10^{-10}$$

Since Trial K_{sp} is less than $K_{sp}(6.6 \times 10^{-6})$ no precipitate forms.

133. a) $Ca^{2+}_{(aq)} + 2C_{18}H_{35}O^{-}_{2(aq)} \rightarrow Ca(C_{18}H_{35}O_2)_{2(s)}$ b) Na_2CO_3

134. $SrCO_{3(s)} \rightleftarrows Sr^{2+}_{(aq)} + CO_3{}^{2-}_{(aq)}$

$$K_{sp} = [Sr^{2+}][CO_3{}^{2-}] = 5.6 \times 10^{-10}$$

$$[Sr^{2+}] = [CO_3{}^{2-}] = 2.36 \times 10^{-5}$$

$$\text{Mass of } SrCO_3 \text{ dissolved in } 1.00\,L = 2.36 \times 10^{-5}\text{ mol} \times \frac{147.6\text{ g}}{\text{mol}}$$

$$= 3.5 \times 10^{-3}\text{ g}$$

135. a) $Pb(NO_3)_{2(aq)} + 2KCl_{(aq)} \rightarrow PbCl_{2(s)} + 2KNO_{3(aq)}$

b) $Pb^{2+}_{(aq)} + 2NO_3{}^{-}_{(aq)} + 2K^{+}_{(aq)} + 2Cl^{-}_{(aq)} \rightarrow PbCl_{2(s)} + 2K^{+}_{(aq)} + 2NO_3{}^{-}_{(aq)}$

c) $Pb^{2+}_{(aq)} + 2Cl^{-}_{(aq)} \rightarrow PbCl_{2(s)}$

136. $K_{sp}\ MgCO_3 = 6.8 \times 10^{-6}$

$$MgCO_{3(s)} \rightleftarrows Mg^{2+}_{(aq)} + CO_3{}^{2-}_{(aq)}$$

$$1.0 \times 10^{-3}\text{ M} \qquad x$$

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

$$= \frac{6.8 \times 10^{-6}}{1.0 \times 10^{-3}}$$

$$= 6.8 \times 10^{-3}\text{ M}$$

137. Mass of Ag_2SO_4 collected is $32.260\text{ g} - 32.125\text{ g} = 0.135\text{ g}$

$$\text{Solubility of } Ag_2SO_4 = \frac{0.135\text{ g } Ag_2SO_4}{0.03000\text{ L}} \times \frac{1\text{ mol}}{311.9\text{ g}}$$

$$= 0.0144\text{ mol/L}$$

$$Ag_2SO_{4(s)} \rightleftarrows 2Ag^{+}_{(aq)} + SO_4{}^{2-}_{(aq)}$$

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

$$= (0.0288)^2(0.0144)$$

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

138. $$SrSO_{4(s)} \rightleftarrows Sr^{2+}_{(aq)} + SO_4{}^{2-}_{(aq)}$$

$$\qquad\qquad\qquad s \qquad\qquad s$$

$$K_{sp} = [Sr^{2+}][SO_4{}^{2-}] = 3.4 \times 10^{-7}$$

$$s^2 = 3.4 \times 10^{-7}$$

$$\text{Solubility} = s = 5.8 \times 10^{-4}\ M$$

$$\text{Solubility in g/L} = 5.8 \times 10^{-4}\ \text{mol/L} \times \frac{183.7\ g}{\text{mol}}$$

$$= 0.11\ g/L$$

139. $$[FeF_2] = 0.0787\ g \times \frac{1\ \text{mol}}{93.8\ g} \times \frac{1}{0.1000\ L}$$

$$= 8.39 \times 10^{-3}\ M$$

$$FeF_{2(aq)} \rightarrow Fe^{2+}_{(aq)} + 2F^-_{(aq)}$$

$$[Fe^{2+}] = 8.39 \times 10^{-3}\ M$$

$$[F^-] = 1.68 \times 10^{-2}\ M$$

140. $$\text{Volume } AgNO_3 \text{ used} = 37.15\ mL - 5.15\ mL = 32.00\ mL$$

$$\text{mol } Ag^+ = 0.125\ \text{mol/L} \times 0.03200\ L$$

$$= 0.00400\ \text{mol}$$

$$\text{mol } Cl^- = \text{mol } Ag^+$$

$$= 0.00400\ \text{mol}$$

$$[Cl^-] = \frac{0.00400\ \text{mol}}{0.02000\ L}$$

$$= 0.200\ M$$

141. $$CuI_{(s)} \rightleftarrows Cu^+_{(aq)} + I^-_{(aq)}$$

$$K_{sp} = [Cu^+][I^-] = 1.3 \times 10^{-12}$$

$$[I^-] = \frac{K_{sp}}{[Cu^+]} = \frac{1.3 \times 10^{-12}}{0.010} = 1.3 \times 10^{-10}\ M$$

$$= [NaI]$$

$$\text{mass of NaI} = 1.3 \times 10^{-1}\ \text{mol/L} \times \frac{149.9\ g}{\text{mole}} \times 0.250\ L$$

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

142. a) $Ca^{2+}_{(aq)} + CO_{3\,(aq)}^{2-} \rightarrow CaCO_{3(s)}$

b) Addition of HCl provides $H^{+}_{(aq)}$ which reacts with the $CO_{3\,(aq)}^{2-}$.

$$H^{+}_{(aq)} + CO_{3\,(aq)}^{2-} \rightarrow HCO_{3\,(aq)}^{-}$$

This reduces the $\left[CO_{3\,(aq)}^{2-}\right]$ in the solubility equilibrium,

$$CaCO_{3(s)} \rightleftarrows Ca^{2+}_{(aq)} + CO_{3\,(aq)}^{2-}$$

causing more solid to dissolve to offset the stress caused by the reduction in concentration.

143. a) $Pb^{2+}_{(aq)} + 2Cl^{-}_{(aq)} \rightarrow PbCl_{2(s)}$

b)
$$\left[Pb^{2+}\right] = 0.050\,\text{M} \times \frac{15.0\,\text{mL}}{50.0\,\text{mL}} = 0.015\,\text{M}$$

$$\left[Cl^{-}\right] = 0.085\,\text{M} \times \frac{35.0\,\text{mL}}{50.0\,\text{mL}} = 0.0595\,\text{M}$$

$$\text{Trial } K_{sp} = \left[Pb^{2+}\right]\left[Cl^{-}\right]^2 = (0.015)(0.0595)^2 = 5.3 \times 10^{-5}$$

K_{sp} for $PbCl_2 = 1.2 \times 10^{-5}$

Since Trial $K_{sp} > K_{sp}$, a precipitate does form.

144. $Ag_2SO_{4(s)} \rightleftarrows 2Ag^{+}_{(aq)} + SO_{4\,(aq)}^{2-}$

$$\left[Ag_2SO_4\right] = \frac{7.2 \times 10^{-4}\,\text{g}}{0.0500\,\text{L}} \times \frac{1\,\text{mole}}{311.9\,\text{g}} = 4.62 \times 10^{-5}\,\text{M}$$

$$\left[Ag^{+}\right] = 2 \times 4.62 \times 10^{-5}\,\text{M} = 9.23 \times 10^{-5}\,\text{M}$$

$$\left[SO_4^{2-}\right] = 4.62 \times 10^{-5}\,\text{M}$$

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

$$= \left(9.23 \times 10^{-5}\right)^2\left(4.62 \times 10^{-5}\right)$$

$$= 3.9 \times 10^{-13}$$

145. $PbCl_{2(s)} \rightleftarrows Pb^{2+}_{(aq)} + 2Cl^-_{(aq)}$

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

$$1.2 \times 10^{-5} = (0.50)[Cl^-]^2$$

$$[Cl^-] = 4.90 \times 10^{-3}\ M$$

In 250 mL:

$$\text{moles } Cl^- = 4.90 \times 10^{-3}\ \text{mol/L} \times 0.25\ L = 1.22 \times 10^{-3}\ \text{mol } Cl^-$$

$$\text{moles } BaCl_2 = \tfrac{1}{2}\ \text{mol } Cl^-$$

$$= \tfrac{1}{2} \times 1.22 \times 10^{-3}\ \text{mol}$$

$$= 6.12 \times 10^{-4}\ \text{mol}$$

$$\text{Mass } BaCl_2 = 6.12 \times 10^{-4}\ \text{mol} \times \frac{208.3\ g}{1\ \text{mol}}$$

$$= 0.13\ g\ BaCl_2$$

146. a) $Ba^{2+}_{(aq)} + SO_4{}^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)}$

b)

$$[SO_4{}^{2-}] = \frac{K_{sp}}{[Ba^{2+}]}$$

$$= \frac{1.1 \times 10^{-10}}{0.10}$$

$$= 1.1 \times 10^{-9}\ M$$

147. $Ag_2CrO_{4(s)} \rightleftarrows 2Ag^+_{(aq)} + CrO_4{}^{2-}{}_{(aq)}$

$$K_{sp} = [Ag^+]^2[CrO_4{}^{2-}] = 1.1 \times 10^{-12}$$

$$[CrO_4{}^{2-}] = 0.10\ M$$

$$[Ag^+]^2 = \frac{1.1 \times 10^{-12}}{0.10}$$

$$[Ag^+] = 3.3 \times 10^{-6}\ M$$

$$\text{Mass of } AgNO_3 = 3.3 \times 10^{-6}\ \frac{\text{mol}}{L} \times 2.0\ L \times \frac{169.9\ g}{1\ \text{mol}}$$

$$= 1.1 \times 10^{-3}\ g$$

148. a) Add solute to solvent until no more solute dissolves.

b) $Be_3(PO_4)_{2(s)} \rightleftarrows 3Be^{2+}_{(aq)} + 2PO_4{}^{3-}_{(aq)}$

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

$$K_{sp} = [Cu^{2+}][IO_3{}^-]^2 = 6.9 \times 10^{-8}$$

$$6.9 \times 10^{-8} = (x)(2x)^2$$

$$4x^3 = 6.9 \times 10^{-8}$$

$$x = 2.6 \times 10^{-3}\ \text{M}$$

$$[IO_3{}^-] = 2 \times 2.6 \times 10^{-3}\ \text{M}$$

$$= 5.2 \times 10^{-3}\ \text{M}$$