Salts, Solutions and K_{sp} Worksheet

(adapted from Glencoe Chapter 23 Study Guide and Chapter 24 Concept Review)

Key

Name: _____ Date: _____

Complete the sentence of answer the question.

1. Ions present in a solution but not involved in the reaction are called spectator ions.

molecular → 2. State the general rule that must be observed when writing net ionic equations.

(1) Write balanced molecular equation (double replacement)

complete ionic → (2) Break up anything (aq) into component ions. Leave(s) intact

(3) Eliminate spectator ions (appear same on right + left side of arrow) ← net ionic

3. Convert the following balanced chemical equations first into ionic form, then to net ionic form and finally identify the spectator ions.

green = cation blue = anion

a. $BaCl_2\,(aq) + Na_2SO_4\,(aq) \rightarrow BaSO_4\,(s) + 2\,NaCl\,(aq)$

($Ba^{+1}\,Cl^{-1}$; $Na^{+1}\,SO_4^{2-}$; leave intact; $Na^{+1}\,Cl^{-1}$)

complete ionic: $Ba^{+2}(aq) + 2Cl^-(aq) + 2Na^+(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s) + 2Na^+(aq) + 2Cl^-(aq)$

net ionic: $Ba^{+1}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

b. $Na_2CO_3\,(aq) + 2\,HCl\,(aq) \rightarrow 2\,NaCl\,(aq) + CO_2\,(g) + H_2O\,(l)$

($Na^{+1}\,CO_3^{2-}$; $H^+\,Cl^-$; $Na^+\,Cl^-$)

complete ionic: $2Na^+(aq) + CO_3^{2-}(aq) + 2H^+(aq) + 2Cl^-(aq) \rightarrow 2Na^+(aq) + 2Cl^-(aq) + CO_2(g) + H_2O(l)$

net ionic: $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$

c. $Ca(OH)_2\,(aq) + Na_2CO_3\,(aq) \rightarrow CaCO_3\,(s) + 2\,NaOH\,(aq)$

complete ionic: $Ca^{+2}(aq) + 2OH^-(aq) + 2Na^+(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s) + 2Na^+(aq) + 2OH^-(aq)$

net ionic: $Ca^{+2}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$

Solubility Product

When an ionic compound is in a solution so concentrated that the solid is in equilibrium with its ions the solution is saturated. Because the concentration of a solid is constant, K_{sp} can be calculated. The solubility product constant expression does not contain the concentration of the solid.

Example: The solubility product constant of silver iodide is 1.50×10^{-16}. What is the $[I^-]$ in the solution at equilibrium?

Solving process:
$AgI\ (cr) \rightleftharpoons Ag^+\ (aq) + I^-\ (aq)$
For every silver ion, there is one iodide ion. $[Ag^+] = [I^-]$

$K_{sp} = [Ag^+][I^-]$
$1.50 \times 10^{-16} = (x)(x)$
$1.50 \times 10^{-16} = x^2$
$1.22 \times 10^{-8}\ M = x$

Solve each of the following problems.

4. The solubility constant for iron (II) sulfide is 3.70×10^{-19}. What is the $[S^{2-}]$ in the solution at equilibrium? $FeS(s) \rightleftharpoons Fe^{+2}(aq) + S^{2-}(aq)$
   $1x \quad : \quad 1x$
   $K_{sp} = [Fe^{+2}] \cdot [S^{2-}]$
   $3.70 \times 10^{-19} = [x] \cdot [x]$
   $\sqrt{3.70 \times 10^{-19}} = \sqrt{x^2}$
   $x = 6.08 \times 10^{-10}\ M$
5. The solubility product constant of lead (II) iodide is 1.39×10^{-8}. What is the $[I^-]$ in the solution at equilibrium? $PbI_2(s) \rightleftharpoons Pb^{+2}(aq) + 2I^-(aq)$
   $x \quad : \quad 2x$
   $K_{sp} = [Pb^{+2}][I^-]^2$
   $1.39 \times 10^{-8} = [x][2x]^2$
   $1.39 \times 10^{-8} = x \cdot 4x^2$
   $\frac{1.39 \times 10^{-8}}{4} = \frac{4x^3}{4}$
   $\sqrt[3]{3.0 \times 10^{-9}} = \sqrt[3]{x^3}$
   $x = 0.00151$
   $[I^-] = 2x = 2(0.00151) = 0.00302$
6. If the concentration of IO_3^- is 1.18×10^{-3} M at equilibrium, what is the K_{sp} for $Cu(IO_3)_2$?
   $Cu(IO_3)_2(s) \rightleftharpoons Cu^{+2}(aq) + 2IO_3^-(aq)$
   $x \quad\quad 2x = 1.18 \times 10^{-3}$
   $2x = 1.18 \times 10^{-3}$
   $x = \div 2 = 0.00059$
   $K_{sp} = [Cu^{+2}][IO_3^-]^2$
   $K_{sp} = [x][2x]^2 = (0.00059)(1.18 \times 10^{-3})^2 = 8.22 \times 10^{-10}$
7. A saturated solution of $Al(OH)_3$ has an aluminum ion concentration of 2.61×10^{-9} M. What is the K_{sp} of $Al(OH)_3$? $Al(OH)_3(s) \rightleftharpoons Al^{+3}(aq) + 3OH^-(aq)$
   $x \quad\quad 3x$
   $x = 2.61 \times 10^{-9}$
   $K_{sp} = [Al^{+3}] \cdot [OH^-]^3$
   $K_{sp} = [x] \cdot [3x]^3 = [2.61 \times 10^{-9}] \cdot [(3)(2.61 \times 10^{-9})]^3 = 1.25 \times 10^{-33}$
8. The K_{sp} of Ag_2CrO_4, silver chromate, is 1.12×10^{-12}.
   Determine the solubility of Ag_2CrO_4 in g/dm^3.
   $Ag_2CrO_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^{2-}(aq)$
   $2x \quad\quad x$
   $K_{sp} = [Ag^+]^2 \cdot [CrO_4^{2-}]$
   $1.12 \times 10^{-12} = [2x]^2 \cdot [x]$
   $\frac{1.12 \times 10^{-12}}{4} = \frac{4x^3}{4}$
   $\sqrt[3]{2.80 \times 10^{-13}} = \sqrt[3]{x^3}$
   $6.54 \times 10^{-5}\ M = x$
   6.54×10^{-5} moles (multiply by gfm)