ANSWERS

1. (a) What compound precipitates when solutions of Fe$_2$(SO$_4$)$_3$ and LiOH are mixed? (b) Write a balanced equation for the reaction. (c) Will a precipitate form when solutions of Ba(NO$_3$)$_2$ and KOH are mixed?

Answers: (a) Fe(OH)$_3$; (b) Fe$_2$(SO$_4$)$_3$(aq) + 6 LiOH(aq) → 2 Fe(OH)$_3$(s) + 3 Li$_2$SO$_4$(aq); (c) no (both possible products are water soluble)

2. Write the net ionic equation for the precipitation reaction that occurs when solutions of calcium chloride and sodium carbonate are mixed.

\[
\text{CaCl}_2(aq) + \text{Na}_2\text{CO}_3(aq) \rightarrow \text{CaCO}_3(s) + 2 \text{NaCl}(aq)
\]

\[
\text{Ca}^{2+}(aq) + 2 \text{Cl}^-(aq) + 2 \text{Na}^+(aq) + \text{CO}_3^{2-}(aq) \rightarrow \text{CaCO}_3(s) + 2 \text{Na}^+(aq) + 2 \text{Cl}^-(aq)
\]

\(\text{Cl}^-\) and \(\text{Na}^+\) are spectator ions. Canceling them gives the following net ionic equation:

\[
\text{Ca}^{2+}(aq) + \text{CO}_3^{2-}(aq) \rightarrow \text{CaCO}_3(s)
\]

3. Write the net ionic equation for the precipitation reaction that occurs when aqueous solutions of silver nitrate and potassium phosphate are mixed.

Answers: 3 Ag$^+(aq) + \text{PO}_4^{3-}(aq) \rightarrow $Ag$_3$PO$_4$(s)

4. (a) Write a balanced molecular equation for the reaction between aqueous solutions of acetic acid (CH$_3$COOH) and barium hydroxide, Ba(OH)$_2$. (b) Write the net ionic equation for this reaction.

\[
\text{CH}_3\text{COOH}(aq) + \text{Ba(OH)}_2(aq) \rightarrow \text{H}_2\text{O}(l) + \text{Ba(CH}_3\text{COO})_2(aq)
\]

\[
2\text{CH}_3\text{COOH}(aq) + \text{Ba(OH)}_2(aq) \rightarrow 2\text{H}_2\text{O}(l) + \text{Ba(CH}_3\text{COO})_2(aq)
\]

\[
2\text{CH}_3\text{COOH}(aq) + \text{Ba}^{2+}(aq) + 2\text{OH}^-(aq) \rightarrow 2\text{H}_2\text{O}(l) + \text{Ba}^{2+}(aq) + 2\text{CH}_3\text{COO}^-(aq)
\]

\[
2\text{CH}_3\text{COOH}(aq) + 2\text{OH}^-(aq) \rightarrow 2\text{H}_2\text{O}(l) + 2\text{CH}_3\text{COO}^-(aq)
\]

\[
\text{CH}_3\text{COOH}(aq) + \text{OH}^-(aq) \rightarrow \text{H}_2\text{O}(l) + \text{CH}_3\text{COO}^-(aq)
\]
5. (a) Write a balanced molecular equation for the reaction of carbonic acid (H\(_2\)CO\(_3\)) and potassium hydroxide (KOH). (b) Write the net ionic equation for this reaction.

**Answers:** (a) H\(_2\)CO\(_3\)(aq) + 2 KOH(aq) → 2 H\(_2\)O(l) + K\(_2\)CO\(_3\)(aq);

(b) H\(_2\)CO\(_3\)(aq) + 2 OH\(^-\)(aq) → 2 H\(_2\)O(l) + CO\(_3^{2-}\)(aq). (H\(_2\)CO\(_3\) is a weak acid and therefore a weak electrolyte, whereas KOH, a strong base, and K\(_2\)CO\(_3\), an ionic compound, are strong electrolytes.)

6. Determine the oxidation number of sulfur in each of the following: (a) H\(_2\)S, (b) S\(_8\), (c) SCl\(_2\), (d) Na\(_2\)SO\(_3\), (e) SO\(_4^{2-}\).

(a) S has an oxidation number of -2.
(b) Because this is an elemental form of sulfur, the oxidation number of S is 0 (rule 1).
(c) the oxidation number of S must be +2.
(d) the oxidation number of S in this compound is +4.
(e) the oxidation number of S in this ion is +6.

7. What is the oxidation state of the boldfaced element in each of the following: (a) P\(_2\)O\(_5\), (b) NaH, (c) Cr\(_2\)O\(_7^{2-}\), (d) SnBr\(_4\), (e) BaO\(_2\)?

**Answers:** (a) +5, (b) -1, (c) +6, (d) +4, (e) -1

8. Write the balanced molecular and net ionic equations for the reaction of aluminum with hydrobromic acid.

\[
2 \text{Al(s)} + 6 \text{HBr(aq)} \rightarrow 2 \text{AlBr}_3(aq) + 3 \text{H}_2(g)
\]

Both HBr and AlBr\(_3\) are soluble strong electrolytes. Thus, the complete ionic equation is

\[
2 \text{Al}(s) + 6 \text{H}^+(aq) + 6 \text{Br}^-(aq) \rightarrow 2 \text{Al}^{3+}(aq) + 6 \text{Br}^- (aq) + 3 \text{H}_2(g)
\]

Because Br\(^-\) is a spectator ion, the net ionic equation is

\[
2 \text{Al}(s) + 6 \text{H}^+(aq) \rightarrow 2 \text{Al}^{3+}(aq) + 3 \text{H}_2(g)
\]

9. (a) Write the balanced molecular and net ionic equations for the reaction between magnesium and cobalt(II) sulfate. (b) What is oxidized and what is reduced in the reaction? **Answers:** (a) Mg(s) + CoSO\(_4\)(aq) → MgSO\(_4\)(aq) + Co(s); Mg(s) + Co\(^{2+}\)(aq) → Mg\(^{2+}\)(aq) + Co(s) (b) Mg is oxidized and Co\(^{2+}\) is reduced.

10. Which of the following metals will be oxidized by Pb(NO\(_3\))\(_2\): Zn, Cu, Fe?

**Answer:** Zn and Fe
11. Calculate the molarity of a solution made by dissolving 23.4 g of sodium sulfate (Na$_2$SO$_4$) in enough water to form 125 mL of solution.

\[
\text{Moles Na}_2\text{SO}_4 = \left( \frac{23.4 \text{ g Na}_2\text{SO}_4}{142 \text{ g Na}_2\text{SO}_4} \right) \left( \frac{1 \text{ mol Na}_2\text{SO}_4}{1 \text{ mol Na}_2\text{SO}_4} \right) = 0.165 \text{ mol Na}_2\text{SO}_4
\]

\[
\text{Liters soln} = \left( \frac{125 \text{ mL}}{1000 \text{ mL/L}} \right) = 0.125 \text{ L}
\]

\[
\text{Molarity} = \frac{0.165 \text{ mol Na}_2\text{SO}_4}{0.125 \text{ L soln}} = 1.32 \text{ mol Na}_2\text{SO}_4/\text{L soln} = 1.32 \text{ M}
\]

12. Calculate the molarity of a solution made by dissolving 5.00 g of glucose (C$_6$H$_{12}$O$_6$) in sufficient water to form exactly 100 mL of solution.

Answer: 0.278 M

13. What are the molar concentrations of each of the ions present in a 0.025 M aqueous solution of calcium nitrate?

\[
\text{mol NO}_3^-/\text{L} = \left( \frac{0.025 \text{ mol Ca(NO}_3)_2}{\text{L}} \right) \left( \frac{2 \text{ mol NO}_3^-}{1 \text{ mol Ca(NO}_3)_2} \right) = 0.050 \text{ M}
\]

14. What is the molar concentration of K$^+$ ions in a 0.015 M solution of potassium carbonate?

Answer: 0.030 M K$^+$

15. How many grams of Na$_2$SO$_4$ are required to make 0.350 L of 0.500 M Na$_2$SO$_4$?

\[
M_{\text{Na}_2\text{SO}_4} = \frac{\text{moles Na}_2\text{SO}_4}{\text{liters soln}}
\]

\[
\text{moles Na}_2\text{SO}_4 = \text{liters soln} \times M_{\text{Na}_2\text{SO}_4}
\]

\[
= (0.350 \text{ L soln}) \left( \frac{0.500 \text{ mol Na}_2\text{SO}_4}{1 \text{ L soln}} \right)
\]

\[
= 0.175 \text{ mol Na}_2\text{SO}_4
\]

\[
\text{grams Na}_2\text{SO}_4 = (0.175 \text{ mol Na}_2\text{SO}_4) \left( \frac{142 \text{ g Na}_2\text{SO}_4}{1 \text{ mol Na}_2\text{SO}_4} \right) = 24.9 \text{ g Na}_2\text{SO}_4
\]
16. (a) How many grams of Na$_2$SO$_4$ are there in 15 mL of 0.50 M Na$_2$SO$_4$? (b) How many milliliters of 0.50 M Na$_2$SO$_4$ solution are needed to provide 0.038 mol of this salt?

**Answers:** (a) 1.1 g, (b) 76 mL

17. How many milliliters of 3.0 M H$_2$SO$_4$ are needed to make 450 mL of 0.10 M H$_2$SO$_4$?

\[
\text{moles H}_2\text{SO}_4 \text{ in dilute solution} = (0.450 \text{ L soln}) \left( \frac{0.10 \text{ mol H}_2\text{SO}_4}{1 \text{ L soln}} \right) = 0.045 \text{ mol H}_2\text{SO}_4
\]

\[
\text{L conc soln} = (0.045 \text{ mol H}_2\text{SO}_4) \left( \frac{1 \text{ L soln}}{3.0 \text{ mol H}_2\text{SO}_4} \right) = 0.015 \text{ L soln}
\]

\[
(3.0 \text{ M})(V_{\text{conc}}) = (0.10 \text{ M})(450 \text{ mL})
\]

\[
V_{\text{conc}} = \frac{(0.10 \text{ M})(450 \text{ mL})}{3.0 \text{ M}} = 15 \text{ mL}
\]

18. (a) What volume of 2.50 M lead(II) nitrate solution contains 0.0500 mol of Pb$^{2+}$? (b) How many milliliters of 5.0 M K$_2$Cr$_2$O$_7$ solution must be diluted to prepare 250 mL of 0.10 M solution? (c) If 10.0 mL of a 10.0 M stock solution of NaOH is diluted to 250 mL, what is the concentration of the resulting stock solution?

**Answers:** (a) 0.0200 L = 20.0 mL, (b) 5.0 mL, (c) 0.40 M