1. Balance the following equations:
   a. \( \text{Cr(s) + O}_2(g) \rightarrow \text{Cr}_2\text{O}_3(s) \)
   b. \( \text{Cu}_2\text{S(s) + O}_2(g) \rightarrow \text{Cu(s) + SO}_2(g) \)
   c. \( \text{C}_6\text{H}_5\text{CH}_3(l) + \text{O}_2(g) \rightarrow \text{H}_2\text{O}(l) + \text{CO}_2(g) \)

2. Balance the following equations and name each reactant and product:
   a. \( \text{Fe}_2\text{O}_3(s) + \text{Mg(s) \rightarrow MgO(s) + Fe(s) \)
   b. \( \text{AlCl}_3(s) + \text{NaOH(aq) \rightarrow Al(OH)_3(s) + NaCl(aq) \)
   c. \( \text{NaNO}_3(s) + \text{H}_2\text{SO}_4(l) \rightarrow \text{Na}_2\text{SO}_4(s) + \text{HNO}_3(l) \)
   d. \( \text{NiCO}_3(s) + \text{HNO}_3(aq) \rightarrow \text{Ni(NO}_3)_2(aq) + \text{CO}_2(g) + \text{H}_2\text{O}(l) \)

3. Like many metals, aluminum reacts with a halogen to give a metal halide.
   \[ 2 \text{Al(s) + 3 Br}_2(l) \rightarrow \text{Al}_2\text{Br}_6(s) \]
   What mass of \( \text{Br}_2 \), in grams, is required for complete reaction with 2.56 g of \( \text{Al} \)? What mass of white, solid \( \text{Al}_2\text{Br}_6 \) is expected?

4. Aluminum chloride, \( \text{AlCl}_3 \), is made by treating scrap aluminum with chlorine.
   \[ 2 \text{Al(s) + 3 Cl}_2(g) \rightarrow 2 \text{AlCl}_3(s) \]
   If you begin with 2.70 g of \( \text{Al} \) and 4.05 g of \( \text{Cl}_2 \),
   a. Which reactant is limiting?
   b. What mass of \( \text{AlCl}_3 \) can be produced?
   c. What mass of the excess reactant remains when the reaction is completed?

5. The deep blue compound \( \text{Cu(NH}_3)_4\text{SO}_4 \) is made by the reaction of copper(II) sulfate and ammonia:
   \[ \text{CuSO}_4(aq) + 4 \text{NH}_3(aq) \rightarrow \text{Cu(NH}_3)_4\text{SO}_4(aq) \]
   a. If you use 10.0 g of \( \text{CuSO}_4 \) and excess \( \text{NH}_3 \), what is the theoretical yield of \( \text{Cu(NH}_3)_4\text{SO}_4 \)?
   b. If you isolate 12.6 g of \( \text{Cu(NH}_3)_4\text{SO}_4 \), what is the percent yield of \( \text{Cu(NH}_3)_4\text{SO}_4 \)?

6. A sample of limestone and other soil materials is heated, and the limestone decomposes to give calcium oxide and carbon dioxide:
   \[ \text{CaCO}_3(s) \rightarrow \text{CaO(s) + CO}_2(g) \]
   A 1.506 g sample of limestone-containing material gives 0.558 g of \( \text{CO}_2 \), in addition to \( \text{CaO} \), after being heated at a high temperature. What is the mass percent of \( \text{CaCO}_3 \) in the original sample?

7. Styrene, the building block of polystyrene, consists of only C and H. If 0.438 g of styrene is burned in oxygen and produces 1.481 g of \( \text{CO}_2 \) and 0.303 g of \( \text{H}_2\text{O} \), what is the empirical formula of styrene?

8. Nickel forms a compound with carbon monoxide, \( \text{Ni}_x(\text{CO})_y \). To determine its formula, you carefully heat a 0.0973 g sample in air to convert the nickel to 0.0426 g of \( \text{NiO} \) and the CO to 0.100 g of \( \text{CO}_2 \). What is the empirical formula of \( \text{Ni}_x(\text{CO})_y \)?
9. Menthol, from oil of mint, has a characteristic odor. The compound contains only C, H, and O. If 95.6 mg of menthol burns completely in O2, and gives 269 mg of CO2 and 110 mg of H2O, what is the empirical formula of menthol?

10. An unknown compound has the formula CxH2Oz. You burn 0.0956 g of the compound and isolate 0.1356 g of CO2 and 0.0833 g of H2O. What is the empirical formula of the compound? If the molar mass is 62.1 g/mol, what is the molecular formula?

11. Which compound or compounds in each of the following groups is (are) expected to be soluble in water?
   a. CuO, CuCl2, FeCO3
   b. AgI, Ag3PO4, AgNO3
   c. K2CO3, KI, KMnO4

12. The following compounds are water-soluble. What ions are produced by each compound in aqueous solution?
   a. KOH
   b. LiNO3
   c. K2SO4
   d. (NH4)2SO4

13. Decide whether each of the following is water-soluble. If soluble, tell what ions are produced.
   a. Na2CO3
   b. NiS
   c. CuSO4
   d. BaBr2

14. Predict the products of each precipitation reaction. Balance the completed equation, and then write the net ionic equation.
   a. NiCl2(aq) + (NH4)2S(aq) →
   b. Mn(NO3)2(aq) + Na3PO4(aq) →

15. Balance the following equations, and then write the net ionic equation.
   a. (NH4)2CO3(aq) + Cu(NO3)2(aq) → CuCO3(s) + NH4NO3(aq)
   b. Pb(OH)2(s) + HCl(aq) → PbCl2(s) + H2O(l)
   c. BaCO3(s) + HCl(aq) → BaCl2(aq) + H2O(l) + CO2(g)
Answers to the Practice Problem Set:

1. **Answers:**
   a. $4 \text{Cr(s)} + 3 \text{O}_2(\text{g}) \rightarrow 2 \text{Cr}_2\text{O}_3(\text{s})$
   b. $\text{Cu}_2\text{S(s)} + \text{O}_2(\text{g}) \rightarrow 2 \text{Cu(s)} + \text{SO}_2(\text{g})$
   c. $\text{Cs}_3\text{H}_3\text{CH}_3(\ell) + 9 \text{O}_2(\text{g}) \rightarrow 4 \text{H}_2\text{O}(\ell) + 7 \text{CO}_2(\text{g})$

2. **Answers:**
   a. $\text{Fe}_2\text{O}_3(\text{s}) + 3 \text{Mg}(\text{s}) \rightarrow 3 \text{MgO}(\text{s}) + 2 \text{Fe}(\text{s})$
      iron(III) oxide, magnesium, magnesium oxide, iron
   b. $\text{AlCl}_3(\text{s}) + 3 \text{NaOH}(\text{aq}) \rightarrow \text{Al(OH)}_3(\text{s}) + 3 \text{NaCl}(\text{aq})$
      aluminum chloride, sodium hydroxide, aluminum hydroxide, sodium chloride
   c. $2 \text{NaNO}_3(\text{s}) + \text{H}_2\text{SO}_4(\ell) \rightarrow \text{Na}_2\text{SO}_4(\text{s}) + 2 \text{HNO}_3(\ell)$
      sodium nitrate, hydrogen sulfate (sulfuric acid), sodium sulfate, hydrogen nitrate (nitric acid)
   d. $\text{NiCO}_3(\text{s}) + 2 \text{HNO}_3(\text{aq}) \rightarrow \text{Ni(NO}_3)_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\ell)$
      nickel(II) carbonate, hydrogen nitrate (nitric acid), nickel(II) nitrate, carbon dioxide, water

3. 22.7 g Br₂; 25.3 g Al₂Br₆

4. a. Cl₂ b. 5.09 g c. 1.67 g Al

5. a. 14.3 g b. 88.3%

6. 84.3%

7. CH

8. Ni(CO)₄

9. C₁₀H₁₉O

10. EF = CH₃O, MF = C₂H₆O₂

11. a. CuCl₂ b. AgNO₃ c. all three compounds

12. a. K⁺ and OH⁻ ions  b. Li⁺ and NO₃⁻ ions  c. K⁺ and SO₄²⁻ ions  d. NH₄⁺ and SO₄²⁻ ions

13. a. soluble, Na⁺ and CO₃²⁻ ions  b. insoluble  c. soluble, Cu²⁺ and SO₄²⁻ ions  d. soluble, Ba²⁺ and Br⁻ ions

14. **Answers:**
   a. $\text{NiCl}_2(\text{aq}) + (\text{NH}_4)_2\text{S}(\text{aq}) \rightarrow \text{NiS(s)} + 2 \text{NH}_4\text{Cl}(\text{aq})$
      $\text{Ni}^{2+}(\text{aq}) + \text{S}^{2-}(\text{aq}) \rightarrow \text{NiS(s)}$
   b. $3 \text{Mn(NO}_3)_2(\text{aq}) + 2 \text{Na}_2\text{PO}_4(\text{aq}) \rightarrow \text{Mn}_3(\text{PO}_4)_2(\text{s}) + 6 \text{NaNO}_3(\text{aq})$
      $3 \text{Mn}^{2+}(\text{aq}) + 2 \text{PO}_4^{3-}(\text{aq}) \rightarrow \text{Mn}_3(\text{PO}_4)_2(\text{s})$

15. **Answers:**
   a. $(\text{NH}_4)_2\text{CO}_3(\text{aq}) + \text{Cu(NO}_3)_2 \rightarrow \text{CuCO}_3(\text{s}) + 2 \text{NH}_4\text{NO}_3(\text{aq})$
      $\text{CO}_3^{2-}(\text{aq}) + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{CuCO}_3(\text{s})$
   b. $\text{Pb(OH)}_2(\text{s}) + 2 \text{HCl}(\text{aq}) \rightarrow \text{PbCl}_2(\text{s}) + 2 \text{H}_2\text{O}(\ell)$
      $\text{Pb(OH)}_2(\text{s}) + 2 \text{H}^+(\text{aq}) + 2 \text{Cl}^-(\text{aq}) \rightarrow \text{PbCl}_2(\text{s}) + 2 \text{H}_2\text{O}(\ell)$
   c. $\text{BaCO}_3(\text{s}) + 2 \text{HCl}(\text{aq}) \rightarrow \text{BaCl}_2(\text{aq}) + \text{H}_2\text{O}(\ell) + \text{CO}_2(\text{g})$
      $\text{BaCO}_3(\text{s}) + 2 \text{H}^+(\text{aq}) \rightarrow \text{Ba}^{2+}(\text{aq}) + \text{H}_2\text{O}(\ell) + \text{CO}_2(\text{g})$