1. Calculate the molar mass of Ca(BO$_2$)$_2$·6H$_2$O.
   a. 273.87 g/mol
   b. 233.79 g/mol
   c. 183.79 g/mol
   d. 143.71 g/mol

2. Calculate the mass in grams of 2.35 mol of sodium chloride, or common table salt.
   a. 221 g
   b. 137 g
   c. 93.9 g
   d. 58.4 g

3. Calculate the number of moles in 17.8 g of the antacid magnesium hydroxide, Mg(OH)$_2$.
   a. 3.28 mol
   b. 2.32 mol
   c. 0.431 mol
   d. 0.305 mol

4. Calculate the number of oxygen atoms in 29.34 g of sodium sulfate, Na$_2$SO$_4$.
   a. $1.244 \times 10^{23}$ O atoms
   b. $4.976 \times 10^{23}$ O atoms
   c. $2.915 \times 10^{24}$ O atoms
   d. $1.166 \times 10^{25}$ O atoms

5. Household sugar, sucrose, has the molecular formula C$_{12}$H$_{22}$O$_{11}$. What is the % of carbon in sucrose, by mass?
   a. 26.7
   b. 33.3
   c. 41.4
   d. 42.1
   e. 52.8

6. Sulfur trioxide can react with atmospheric water vapor to form sulfuric acid that falls as acid rain. Calculate the mass in grams of $3.65 \times 10^{20}$ molecules of SO$_3$.
   a. $6.06 \times 10^{-4}$ g
   b. $4.85 \times 10^{-2}$ g
   c. 20.6 g
   d. 1650 g
7. Gadolinium oxide, a colorless powder which absorbs carbon dioxide from the air, contains 86.76 mass % Gd. Determine its empirical formula.
   a. Gd$_2$O$_3$
   b. Gd$_3$O$_2$
   c. Gd$_3$O$_4$
   d. Gd$_4$O$_3$

8. Hydroxylamine nitrate contains 29.17 mass % N, 4.20 mass % H, and 66.63 mass % O. Determine its empirical formula.
   a. HNO
   b. H$_2$NO$_2$
   c. HN$_6$O$_{16}$
   d. HN$_{16}$O$_7$

9. Hydroxylamine nitrate contains 29.17 mass % N, 4.20 mass % H, and 66.63 mass % O. If its molar mass is between 94 and 98 g/mol, what is its molecular formula?
   a. NH$_2$O$_5$
   b. H$_2$N$_2$O$_4$
   c. H$_3$N$_3$O$_3$
   d. H$_8$N$_4$O$_2$

10. Balance the following equation:
    \[ \text{B}_2\text{O}_3(s) + \text{HF}(l) \rightarrow \text{BF}_3(g) + \text{H}_2\text{O}(l) \]
    a. B$_2$O$_3$(s) + 6HF(l) → 2BF$_3$(g) + 3H$_2$O(l)
    b. B$_2$O$_3$(s) + H$_6$F$_6$(l) → B$_2$F$_6$(g) + H$_6$O$_3$(l)
    c. B$_2$O$_3$(s) + 2HF(l) → 2BF$_3$(g) + H$_2$O(l)
    d. B$_2$O$_3$(s) + 3HF(l) → 2BF$_3$(g) + 3H$_2$O(l)

11. Balance the following equation:
    \[ \text{C}_8\text{H}_18\text{O}_3(l) + \text{O}_2(g) \rightarrow \text{H}_2\text{O}(g) + \text{CO}_2(g) \]
    a. C$_8$H$_{18}$O$_3$(l) + 8O$_2$(g) → 9H$_2$O(g) + 8CO$_2$(g)
    b. C$_8$H$_{18}$O$_3$(l) + 11O$_2$(g) → 9H$_2$O(g) + 8CO$_2$(g)
    c. 2C$_8$H$_{18}$O$_3$(l) + 22O$_2$(g) → 9H$_2$O(g) + 16CO$_2$(g)
    d. C$_8$H$_{18}$O$_3$(l) + 13O$_2$(g) → 18H$_2$O(g) + 8CO$_2$(g)
12. Sulfur dioxide reacts with chlorine to produce thionyl chloride (used as a drying agent for inorganic halides) and dichlorine oxide (used as a bleach for wood, pulp and textiles).

\[ \text{SO}_2(g) + 2\text{Cl}_2(g) \rightarrow \text{SOCl}_2(g) + \text{Cl}_2\text{O}(g) \]

If 0.400 mol of Cl\(_2\) reacts with excess SO\(_2\), how many moles of Cl\(_2\)O are formed?

a. 0.800 mol
b. 0.400 mol
c. 0.200 mol
d. 0.100 mol

13. Ammonia will react with fluorine to produce dinitrogen tetrafluoride and hydrogen fluoride (used in production of aluminum, in uranium processing, and in frosting of light bulbs).

\[ 2\text{NH}_3(g) + 5\text{F}_2(g) \rightarrow \text{N}_2\text{F}_4(g) + 6\text{HF}(g) \]

How many moles of NH\(_3\) are needed to react completely with 13.6 mol of F\(_2\)?

a. 34.0 mol
b. 6.80 mol
c. 5.44 mol
d. 2.27 mol

14. Ammonia, an important source of fixed nitrogen that can be metabolized by plants, is produced using the Haber process in which nitrogen and hydrogen combine.

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightarrow 2\text{NH}_3(g) \]

How many grams of nitrogen are needed to produce 325 grams of ammonia?

a. 1070 g
b. 535 g
c. 267 g
d. 178 g

15. Aluminum reacts with oxygen to produce aluminum oxide which can be used as an adsorbent, desiccant or catalyst for organic reactions.

\[ 4\text{Al}(s) + 3\text{O}_2(g) \rightarrow 2\text{Al}_2\text{O}_3(s) \]

A mixture of 82.49 g of aluminum (\(M = 26.98 \text{ g/mol}\)) and 117.65 g of oxygen (\(M = 32.00 \text{ g/mol}\)) is allowed to react. Identify the limiting reactant and determine the mass of the excess reactant present in the vessel when the reaction is complete.

a. oxygen is the limiting reactant; 19.81 g of aluminum remain
b. oxygen is the limiting reactant; 35.16 g of aluminum remain
c. aluminum is the limiting reactant; 16.70 g of oxygen remain
d. aluminum is the limiting reactant; 44.24 g of oxygen remain
16. A 0.150 \textit{M} sodium chloride solution is referred to as a physiological saline solution because it has the same concentration of salts as normal human blood. Calculate the mass of solute needed to prepare 275.0 mL of a physiological saline solution.

a. 31.9 g  
b. 16.1 g  
c. 8.77 g  
d. 2.41 g

17. Lithium hydroxide is used in alkaline batteries. Calculate the molarity of a solution prepared by dissolving 35.8 g of LiOH (\textit{M} = 23.95 \text{ g/mol}) in enough water to give a final volume of 750.0 mL.

a. 1.99 \textit{M}  
b. 1.50 \textit{M}  
c. 1.12 \textit{M}  
d. 0.502 \textit{M}

18. How many milliliters of 1.58 \textit{M} HCl are needed to react completely with 23.2 g of NaHCO\textsubscript{3} (\textit{M} = 84.02 \text{ g/mol})?

\[
\text{HCl}(aq) + \text{NaHCO}_3(s) \rightarrow \text{NaCl}(s) + \text{H}_2\text{O}(l) + \text{CO}_2(g)
\]

a. 638 mL  
b. 572 mL  
c. 536 mL  
d. 175 mL

19. How many moles of ions are released when 0.27 mol of cobalt(II) chloride, CoCl\textsubscript{2}, is dissolved in water?

a. 0.81 mol  
b. 0.54 mol  
c. 0.27 mol  
d. 0.090 mol

20. Which of the following solutions will be the poorest conductor of electrical current?

a. sucrose, C\textsubscript{12}H\textsubscript{22}O\textsubscript{11}(aq)  
b. sodium chloride, NaCl(aq)  
c. potassium nitrate, KNO\textsubscript{3}(aq)  
d. lithium hydroxide, LiOH(aq)

21. Which of the following solutions will be the best conductor of electrical current?

a. methyl alcohol, CH\textsubscript{3}OH(aq)  
b. glucose, C\textsubscript{6}H\textsubscript{12}O\textsubscript{6}(aq)  
c. potassium chloride, KCl(aq)  
d. bromine, Br\textsubscript{2}(aq)
22. Select the spectator ions for the following reaction.

$$\text{Pb(NO}_3\text{)}_2(aq) + 2\text{NaCl}(aq) \rightarrow \text{PbCl}_2(s) + 2\text{NaNO}_3(aq)$$

a. Pb\(^{2+}\)(aq), Cl\(^{-}\)(aq)
b. Na\(^{+}\)(aq), NO\(_3\)\(^{-}\)(aq)
c. Pb\(^{2+}\)(aq), NO\(_3\)\(^{-}\)(aq)
d. Na\(^{+}\)(aq), Cl\(^{-}\)(aq)

23. Select the precipitate that forms when the following reactants are mixed.

$$\text{Na}_2\text{CO}_3(aq) + \text{BaCl}_2(aq) \rightarrow$$

a. Ba\(_2\)CO\(_3\)
b. BaCO\(_3\)
c. NaCl
d. NaCl\(_2\)

24. Select the net ionic equation for the reaction between sodium chloride and silver nitrate.

$$\text{NaCl}(aq) + \text{AgNO}_3(aq) \rightarrow \text{NaNO}_3(aq) + \text{AgCl}(s)$$

a. Na\(^{+}\)(aq) + NO\(_3\)\(^{-}\)(aq) \rightarrow NaNO\(_3\)(aq)
b. Ag\(^{+}\)(aq) + Cl\(^{-}\)(aq) \rightarrow AgCl(s)
c. NaCl(aq) \rightarrow Na\(^{+}\)(aq) + Cl\(^{-}\)(aq)
d. AgNO\(_3\)(aq) \rightarrow Ag\(^{+}\)(aq) + NO\(_3\)\(^{-}\)(aq)

25. Which of the following is a weak acid?

a. H\(_2\)SO\(_4\)
b. HNO\(_3\)
c. HF
d. HBr

26. Which of the following is a weak base?

a. NH\(_3\)
b. Ca(OH)\(_2\)
c. Ba(OH)\(_2\)
d. NaOH

27. Select the correct set of products for the following reaction.

$$\text{Ba(OH)}_2(aq) + \text{HNO}_3(aq) \rightarrow$$

a. BaN\(_2\)(s) + H\(_2\)O(l)
b. Ba(NO\(_3\))\(_2\)(aq) + H\(_2\)O(l)
c. Ba(s) + H\(_2\)(g) + NO\(_2\)(g)
d. No reaction occurs
28. Select the net ionic equation for the reaction between lithium hydroxide and hydrobromic acid.

\[
\text{LiOH (aq)} \rightarrow \text{Li}^{+}(aq) + \text{OH}^{-}(aq)
\]

\[
\text{HBr(aq)} \rightarrow \text{H}^{+}(aq) + \text{Br}^{-}(aq)
\]

\[
\text{H}^{+}(aq) + \text{OH}^{-}(aq) \rightarrow \text{H}_{2}O(l)
\]

\[
\text{Li}^{+}(aq) + \text{Br}^{-}(aq) \rightarrow \text{LiBr}(aq)
\]

29. Automobile batteries use 3.0 M H\text{H}_2\text{SO}_4 as an electrolyte. How much 1.20 M NaOH will be needed to neutralize 225 mL of battery acid?

\[
\text{H}_2\text{SO}_4(aq) + 2\text{NaOH(aq)} \rightarrow 2\text{H}_2\text{O(l)} + \text{Na}_2\text{SO}_4(aq)
\]

- a. 0.045 L
- b. 0.28 L
- c. 0.56 L
- d. 1.1 L

30. Calculate the oxidation number of the chlorine in perchloric acid, HClO\text{\textsubscript{4}}, a strong oxidizing agent.

- a. -1
- b. +4
- c. +5
- d. +7

31. Calculate the oxidation number of sulfur in sodium metabisulfite, Na\text{\textsubscript{2}}S\text{\textsubscript{2}}O\text{\textsubscript{5}}.

- a. -2
- b. +2
- c. +4
- d. +5

32. Sodium thiosulfate, Na\text{\textsubscript{2}}S\text{\textsubscript{2}}O\text{\textsubscript{3}}, is used as a “fixer” in black and white photography. Identify the oxidizing agent in the reaction of thiosulfate with iodine.

\[
2\text{S}_2\text{O}_3^{2-}(aq) + \text{I}_2(aq) \rightarrow \text{S}_4\text{O}_6^{2-}(aq) + 2\Gamma(aq)
\]

- a. I\textsubscript{2}(aq)
- b. I\textsubscript{2}(aq)
- c. S\textsubscript{2}O\textsubscript{3}\textsuperscript{2-}(aq)
- d. S\textsubscript{4}O\textsubscript{6}\textsuperscript{2-}(aq)
33. Balance the following redox equation using the smallest integers possible and select the correct coefficient for the hydrogen sulfite ion, HSO$_3^-$.

\[ \text{MnO}_4^{-}(aq) + \text{HSO}_3^{-}(aq) + \text{H}^+(aq) \rightarrow \text{Mn}^{2+}(aq) + \text{SO}_4^{2-}(aq) + \text{H}_2\text{O}(l) \]

a. 1  
b. 2  
c. 5  
d. 10

34. Select the classification for the following reaction.

\[ 2\text{Na}(s) + 2\text{H}_2\text{O}(l) \rightarrow 2\text{NaOH}(aq) + \text{H}_2(g) \]

a. precipitation  
b. neutralization  
c. redox  
d. none of the above

35. Select the classification for the following reaction.

\[ \text{KOH}(aq) + \text{HCl}(aq) \rightarrow \text{KCl}(aq) + \text{H}_2\text{O}(l) \]

a. precipitation  
b. neutralization  
c. redox  
d. none of the above

36. Select the classification for the following reaction.

\[ \text{BaCl}_2(aq) + \text{K}_2\text{SO}_4(aq) \rightarrow \text{BaSO}_4(s) + 2\text{KCl}(aq) \]

a. precipitation  
b. neutralization  
c. redox  
d. none of the above

37. Predict the product(s) for the following reaction.

\[ \text{H}_2\text{SO}_4(aq) + \text{KOH}(aq) \rightarrow \]

a. \( \text{K}_2\text{SO}_4(aq) + \text{H}_2\text{O}(l) \)  
b. \( \text{K}_2\text{S}(aq) + \text{H}_2\text{O}(l) \)  
c. \( \text{K}(s) + \text{H}_2(g) + \text{SO}_3(g) \)  
d. No reaction occurs