1. Write names for the ions
   a. \( \text{CO}_3^{2-} \) _______ carbonate
   b. \( \text{SO}_4^{2-} \) _______ sulfate
   c. \( \text{Sn}^{4+} \) _______ tin (IV)
   d. \( \text{S}^{2-} \) _______ sulfide

2. For the following pairs of ions, predict the formula of the compound that the ions will form and give its name?

<table>
<thead>
<tr>
<th>ions</th>
<th>formula</th>
<th>name of compound</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) ( \text{Pb}^{4+}, \text{CO}_3^{2-} )</td>
<td>( \text{Pb} (\text{CO}_3)_2 )</td>
<td>lead (IV) carbonate</td>
</tr>
<tr>
<td>b) ( \text{PO}_4^{-3}, \text{K}^+ )</td>
<td>( \text{K}_3\text{PO}_4 )</td>
<td>potassium phosphate</td>
</tr>
</tbody>
</table>

3. Identify the following electrolytes as an acid, base, salt or identify as nonelectrolyte
   a) \( \text{HI} (\text{aq}) \) _______ acid
   b) \( \text{CoCl}_3 (\text{aq}) \) _______ salt
   c) \( \text{PbCl}_2 (s) \) nonelectrolyte solid
   d) \( \text{NaOH} (\text{aq}) \) _______ base

4. What net charge will all molecules and ionic compounds have? _______ zero

5. Write the names for each of the following compounds:
   - \( \text{Ca(NO}_3)_2 \) _______ calcium nitrate
   - \( (\text{NH}_4)_2\text{SO}_3 \) _______ ammonium sulfite
   - \( \text{FeBr}_3 \) _______ iron (III) bromide
   - \( \text{N}_2\text{O}_3 \) _______ dinitrogen trioxide
   - \( \text{HClO}_3 (\text{aq}) \) _______ chloric acid
   - \( \text{H}_2\text{O} \) _______ water
   - \( \text{CH}_4 \) _______ methane
6. Write the formula for each of the following compounds:

- sulfur hexafluoride \( \text{SF}_6 \)
- sulfurous acid \( \text{H}_2\text{SO}_3 \)
- nickel (III) carbonate \( \text{Ni}_2(\text{CO}_3)_3 \)
- zinc hydroxide \( \text{Zn(OH)}_2 \)
- hydrobromic acid \( \text{HBr (aq)} \)
- magnesium oxide \( \text{MgO} \)
- nickel (II) sulfite \( \text{NiSO}_3 \)

7. Determine the charge (oxidation number) of the indicated species:

- \( \text{Fe} = +3 \) in \( \text{Fe}_2\text{O}_3 \)
- \( \text{Cu} = +2 \) in \( \text{CuCl}_2 \)
- \( \text{V} = +5 \) in \( \text{VCl}_5 \)
- \( \text{Au} = +1 \) in \( \text{AuNO}_3 \)

**Solubility Rules** for ionic compounds: (fill in the blanks)

*Compounds containing the following ions are generally soluble in water:*

1. **Group 1A** (\( \text{Li}^{+1}, \text{Na}^{+1}, \text{K}^{+1} \)) and **NH\(_4\)\(^{+1}\) cations
2. Nitrates (\( \text{NO}_3^{-1} \)) anion or acetates (\( \text{C}_2\text{H}_3\text{O}_2^{-1} \)) anion
3. Most halide ions \( \text{Cl}^{-1}, \text{Br}^{-1}, \text{I}^{-1} \) are soluble (except \( \text{Ag}^{+1}, \text{Pb}^{+2}, \text{and} \text{Hg}^{+2} \) are insoluble)
4. Most \( \text{SO}_4^{-2} \) anions are soluble (\( \text{CaSO}_4, \text{SrSO}_4, \text{BaSO}_4, \text{Ag}_2\text{SO}_4, \text{Hg}_2\text{SO}_4, \text{and} \text{PbSO}_4 \) are insoluble)

*Compounds containing the following ions are generally insoluble in water:*

5. Most \( \text{CO}_3^{-2} \) are insoluble (see rule 1 exceptions, which are soluble)
6. Most \( \text{CrO}_4^{-2} \) are insoluble (see rule 1 exceptions, which are soluble)
7. Most \( \text{PO}_4^{-3} \) are insoluble (see rule 1 exceptions, which are soluble).
8. Most \( \text{S}^{-2} \) are insoluble (\( \text{CaS}, \text{SrS}, \text{BaS}, \text{and} \) rule 1 exceptions are soluble)
9. Most hydroxides are insoluble (except for \( \text{NH}_4\text{OH} \) and the strong bases which are in group IIA (\( \text{LiOH}, \text{NaOH}, \text{KOH}, \text{RbOH}, \text{CsOH}, \text{FrOH} \)) and in group IIA (\( \text{Ca(OH)}_2, \text{Sr(OH)}_2, \text{Ba(OH)}_2, \text{Ra(OH)}_2 \))

8. List information that can be obtained from a balanced chemical equation?

**Identity of reactants, products, phases, relative stoichiometric amounts, above the arrow you may see reaction conditions or catalyst**
9. **Balance**, identify **driving force**, and **classify** and in as many ways possible the following reactions.

Possible classifications:
- (R) redox or oxidation-reduction
- (SR) single replacement
- (D) decomposition
- (Syn) synthesis or combination
- (C) combustion
- (D-D) double displacement
- (P) precipitation
- (N) neutralization (acid-base)

a) \[ 2 \text{Al} (\text{HCO}_3)_3 \text{(s)} \rightarrow \text{Al}_2(\text{CO}_3)_3 \text{(s)} + 3 \text{CO}_2 \text{(g)} + 3 \text{H}_2\text{O} \text{(l)} \]

Driving force(s) **formation of gas and liquid** Classifications: **D, G**

b) \[ 2 \text{HCl} \text{(aq)} + \text{Mg} \text{(s)} \rightarrow \text{MgCl}_2 \text{(aq)} + \text{H}_2 \text{(g)} \]

Driving force(s) **transfer of electrons, form gas** Classifications: **SR, R, G**

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

Driving force(s) **transfer of electrons, form gas** Classifications: **Syn, R, G**

d) \[ 2 \text{Bi(NO}_3)_3 \text{(aq)} + 3 \text{K}_2\text{S} \text{(aq)} \rightarrow \text{Bi}_2\text{S}_3 \text{(s)} + 6 \text{KNO}_3 \text{(aq)} \]

Driving force(s) **formation of solid** Classifications: **DD, P**

e) \[ \text{Ba(OH)}_2 \text{(aq)} + (\text{NH}_4)_2\text{SO}_4\text{(aq)} \rightarrow 2 \text{NH}_3 \text{(g)} + \text{BaSO}_4 \text{(s)} + 2 \text{H}_2\text{O} \text{(l)} \]

Driving force(s) **formation of gas, solid, and water** Classifications: **DD, G, P**

f) \[ 4 \text{C}_2\text{H}_7\text{N} \text{(s)} + 19 \text{O}_2 \text{(g)} \rightarrow 4 \text{NO}_2 \text{(g)} + 14 \text{H}_2\text{O} \text{(l)} + 8 \text{CO}_2 \text{(g)} \]

Driving force(s) **transfer electrons, form gas, water** Classifications: **C, R, G**
10. Complete and balance the reactions. Indicate states of matter in products and the driving force(s) of the reaction. If there are no driving forces, balance anyway and write NR for no reaction.

a & b are double displacement; c is decomposition; d is combustion.

### DRIVING FORCE(S) | PRODUCTS
--- | ---
form gas, water | a) \(2 \text{HCl (aq) + Na}_2\text{SO}_3 (aq) \rightarrow 2 \text{NaCl (aq) + H}_2\text{O (l) + SO}_2 (g)\)
No Reaction | b) \(3 \text{LiNO}_3 (aq) + \text{Na}_2\text{PO}_4 (aq) \rightarrow 3 \text{Li}_3\text{PO}_4 (aq) + 3 \text{NaNO}_3 (aq)\)
Transfer e\(^{-1}\), form gas, water | c) \(2 \text{C}_4\text{H}_{10} (l) + 14 \text{O}_2 (g) \rightarrow 8 \text{CO}_2 (g) + 10 \text{H}_2\text{O (g)}\)
Transfer e\(^{-1}\), form gas, water | d) \(2 \text{CH}_3\text{OH (l) + 3 O}_2 (g) \rightarrow 2 \text{CO}_2 (g) + 4 \text{H}_2\text{O (g)}\)

11. Complete and Balance the following chemical reactions. Include the state that the substances are in, (s), (l), (g), or (aq). Identify the driving force for each reaction, if no driving force, write No reaction, but balance it anyway. Practice more by writing the total ionic equation and net ionic equation for each double displacement reaction.

a) Combustion reaction, redox, G: Driving Force(s) Transfer e\(^{-1}\), form gas, water
\[2 \text{C}_8\text{H}_{18} (s) + 25 \text{O}_2 (g) \rightarrow 16 \text{CO}_2 (g) + 18 \text{H}_2\text{O (l)}\]

b) Double Displacement, N, G: Driving Force(s) form gas and water
Aqueous solutions of both hydrochloric acid and ammonium carbonate react
\[2 \text{HCl (aq) + (NH}_4\text{)}_2\text{CO}_3 (aq) \rightarrow 2\text{NH}_4\text{Cl (aq) + CO}_2 (g) + \text{H}_2\text{O (l)}\]

c) Double Displacement, N: Driving Force(s) form water
aqueous nitric acid is added to aqueous strontium hydroxide
\[2 \text{HNO}_3 (aq) + \text{Sr(OH)}_2 (aq) \rightarrow \text{Sr(NO}_3\text{)}_2 (aq) + 2 \text{H}_2\text{O (l)}\]

d) Double Displacement, P: Driving Force(s) form a solid
\[2 \text{K}_3\text{PO}_4 (aq) + 3 \text{Co(NO}_3\text{)}_2 (aq) \rightarrow \text{Co}_3\text{(PO}_4\text{)}_2 (s) + 6 \text{KNO}_3 (aq)\]

e) Double Displacement: Driving Force(s) No reaction
Aqueous ammonium chloride reacts with aqueous iron (III) sulfate
Whole \[6 \text{NH}_4\text{Cl (aq) + Fe}_2\text{(SO}_4\text{)}_3 (aq) \rightarrow 3 \text{(NH}_4\text{)}_2\text{SO}_4 (aq) + 2 \text{FeCl}_3 (aq)\]
Ionic \[6 \text{NH}_4^+ + 6 \text{Cl}^- + 2 \text{Fe}^{3+} + 3 \text{SO}_4^{2-} \rightarrow 6 \text{NH}_4^+ + 3 \text{SO}_4^{2-} + 2 \text{Fe}^{3+} + 6 \text{Cl}^-\]
Net ionic No Reaction
12. A sample of lysine, one of the alpha amino acids found in protein, is found to contain 49.3% carbon, 9.6% hydrogen, 19.3% nitrogen and 21.9% oxygen. The molecular weight of lysine is 146 g/mol. Calculate the empirical formula and the molecular formula of lysine.

Change % to grams, divide by atomic mass to get moles, divide by smallest # moles

\[
\begin{align*}
49.3 \text{ g C} & \rightarrow 4.105 \text{ mole C} \rightarrow 3 \text{ C} \\
9.6 \text{ g H} & \rightarrow 9.52 \text{ mole H} \rightarrow 7 \text{ H} \\
19.3 \text{ g N} & \rightarrow 1.38 \text{ mole N} \rightarrow 1 \text{ N} \\
21.9 \text{ g O} & \rightarrow 1.37 \text{ mol O} \rightarrow 1 \text{ O}
\end{align*}
\]

Empirical formula: \( \text{C}_3\text{H}_7\text{NO} \)

Empirical weight = 73.0 g/mol

\[
\frac{\text{MW}}{\text{EW}} = n \quad \frac{146 \text{ g/mol}}{73.0 \text{ g/mol}} = 2
\]

Molecular Formula: \( \text{C}_6\text{H}_{14}\text{N}_2\text{O}_2 \)
13. a) Calculate the molar mass of aluminum dichromate, Al₂(Cr₂O₇)₃

\[ 702.0 \text{ g/mol} \]

a) Determine the mass percent composition of only the O in Al₂(Cr₂O₇)₃

\[ 47.9\% \text{ O} \]

b) Calculate the number of moles in 35.4 g of Al₂(Cr₂O₇)₃

\[ 0.0504 \text{ mol} \]

c) Calculate the number of formula units in 35.4 g of Al₂(Cr₂O₇)₃

\[ 3.04 \times 10^{22} \text{ molecules} \]

d) Calculate the number of oxygen atoms in 35.4 g of Al₂(Cr₂O₇)₃

\[ 6.34 \times 10^{23} \text{ atoms O} \]

e) Calculate the mass of \( 2.51 \times 10^{24} \) molecules of Al₂(Cr₂O₇)₃

\[ 2926 \text{ g} \ \rightarrow \ 2.93 \times 10^3 \text{ g} \]
14. a) **Balance** the following unbalanced equation:

\[
\text{C}_3\text{H}_8 \text{(g)} + 5 \text{O}_2 \text{(g)} \rightarrow 3 \text{CO}_2 \text{(g)} + 4 \text{H}_2\text{O} \text{(l)}
\]

a) Calculate the theoretical **mass in grams** of CO\(_2\) produced from 5.00 grams C\(_3\)H\(_8\) and 8.00 g oxygen.

**Limiting reactant problem**

Molar masses: C\(_3\)H\(_8\) = 44.09 g/mol, O\(_2\) = 32.00 g/mol, CO\(_2\) = 44.01 g/mol

5.00 g C\(_3\)H\(_8\) can produce 15.0 g CO\(_2\)
8.00 g O\(_2\) can produce 6.60 g CO\(_2\)

**The maximum CO\(_2\) is the lowest theoretical value, 6.60 g CO\(_2\)**

b) What is the limiting reactant in the reaction above?

O\(_2\)

c) What is the % yield of the reaction above if 4.22 grams of CO\(_2\) were experimentally produced in a lab starting with the given amounts above?

**63.9% yield**

15. For the following double-displacement reaction:

a) **Complete** the whole equation by including the products and **balance** the equation. Include the physical states in all the equations.

\[
\text{K}_2\text{CO}_3 \text{(aq)} + \text{NiF}_2 \text{(aq)} \rightarrow 2 \text{KF} \text{(aq)} + \text{NiCO}_3 \text{(s)}
\]

b) Write the **balanced total ionic equation** for the above reaction. Include charges on ions and states of matter.

\[
2\text{K}^{+} \text{(aq)} + \text{CO}_3^{2-} \text{(aq)} + \text{Ni}^{2+} \text{(aq)} + 2\text{F}^{-} \text{(aq)} \rightarrow 2\text{K}^{+} \text{(aq)} + 2\text{F}^{-} \text{(aq)} + \text{NiCO}_3 \text{(s)}
\]

c) Circle the **spectator ions** in part b?

d) Write the **balanced net ionic equation** for this reaction. Include charges on ions and states of matter.

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

e) What is/are the driving force(s) for this reaction?

**Formation of solid**