Show your work on numerical problems to receive full credit for them.

1. (10 points) Balance each of the following chemical equations by writing the appropriate coefficient on the underline. You may omit any coefficients that are “1”.

\[ \underline{\text{___ } \text{C}_6\text{H}_{12}\text{O}_6} \ + \ 6 \ \underline{\text{O}_2} \ \rightarrow \ 6 \ \underline{\text{CO}_2} \ + \ 6 \ \underline{\text{H}_2\text{O}} \]

\[ \underline{\text{___ } \text{BaCl}_2} \ + \ \underline{\text{___ } \text{Na}_2\text{SO}_4} \ \rightarrow \ \underline{\text{___ } \text{BaSO}_4} \ + \ 2 \ \underline{\text{NaCl}} \]

\[ 2 \ \underline{\text{NaNO}_3} \ \rightarrow \ 2 \ \underline{\text{NaNO}_2} \ + \ \underline{\text{O}_2} \]

\[ 2 \ \underline{\text{Pb(NO}_3)_2} \ \rightarrow \ 2 \ \underline{\text{PbO}} \ + \ 4 \ \underline{\text{NO}_2} \ + \ \underline{\text{O}_2} \]

\[ \underline{\text{___ } \text{H}_3\text{PO}_4} \ + \ 3 \ \underline{\text{KOH}} \ \rightarrow \ \underline{\text{___ } \text{K}_3\text{PO}_4} \ + \ 3 \ \underline{\text{H}_2} \]

\[ 8 \ \underline{\text{Al}} \ + \ 3 \ \underline{\text{Fe}_3\text{O}_4} \ \rightarrow \ 4 \ \underline{\text{Al}_2\text{O}_3} \ + \ 2 \ \underline{\text{Fe}} \]

\[ 2 \ \underline{\text{Al}} \ + \ 6 \ \underline{\text{HCl}} \ \rightarrow \ 3 \ \underline{\text{H}_2} \ + \ 2 \ \underline{\text{AlCl}_3} \]

\[ 2 \ \underline{\text{SO}_2} \ + \ \underline{\text{___ } \text{O}_2} \ \rightarrow \ 2 \ \underline{\text{SO}_3} \]

\[ 6 \ \underline{\text{HCl}} \ + \ \underline{\text{___ } \text{Al}_2\text{(CO}_3)_3} \ \rightarrow \ 3 \ \underline{\text{H}_2\text{CO}_3} \ + \ 2 \ \underline{\text{AlCl}_3} \]

\[ \underline{\text{___ } \text{Sr}} \ + \ 2 \ \underline{\text{H}_2\text{O}} \ \rightarrow \ \underline{\text{___ } \text{Sr(OH)}_2} \ + \ \underline{\text{H}_2} \]

2. (4 points) A person working with a chemical solution found it has a pH of 5.4, but wants it to have a pH of 7.2. Which of the following chemicals could be added to raise the pH of the solution? Explain your reasoning.

\[ \underline{\text{HCl}} \quad \underline{\text{KOH}} \quad \underline{\text{H}_2\text{SO}_4} \quad \underline{\text{HBr}} \]

To raise the pH, you need to add a base. A base typically contains an –OH (the others are all acids) so KOH is the choice.
3. (8 points) Draw a structural formula meeting each of the following criteria.

   a. an alkene containing at least five carbons
      \[
      \begin{array}{cccccc}
      & H & H & H & H & H \\
      | & | & | & | & | \\
      H & -C & = & C & - & C - H \\
      | & | & | & | & | \\
      H & H & H & H & H \\
      \end{array}
      \]

   b. an amine containing at least four carbons and two amine groups
      \[
      \begin{array}{cccccc}
      & H & H & H & H & H \\
      | & | & | & | & | \\
      H_2N & - & C & - & C & - C & - C & - NH_2 \\
      | & | & | & | & | & | & | \\
      H & H & H & H & H \\
      \end{array}
      \]

   c. an alkyl bromide containing at least six carbons and two bromines
      \[
      \begin{array}{cccccc}
      Br & H & H & H & H \\
      | & | & | & | & | \\
      H & -C & - C & - C & - C & - H \\
      | & | & | & | & | \\
      H & H & Br & H & H \\
      \end{array}
      \]

   d. an alcohol containing at least five carbons and two alcohol groups
      \[
      \begin{array}{cccccc}
      & OH & H & H & H \\
      | & | & | & | & | \\
      H & -C & - C & - C & - C & - H \\
      | & | & | & | & | \\
      H & H & OH & H & H \\
      \end{array}
      \]

4. (4 points) The mean distance from Neptune to the Sun is 30.11 AU. Use Kepler’s Third Law to find the period of revolution of Neptune. **SHOW YOUR WORK.**

   \[ T^2 = kR^3 \]

   \[ T^2 = \left(\frac{1 \text{ yr}^2}{\text{AU}^3}\right) (30.11 \text{ AU})^3 = 27298 \text{ yr}^2 \]

   \[ T = \text{square root} (27298 \text{ yr}^2) = 165 \text{ years} \]
5. (8 points) Consider the H-R diagram below to answer the following questions.

![Hertzsprung-Russell Diagram]

a. Our Sun is considered to be a class G star. What is the expected temperature range of the Sun?
   
   Class G stars are about 5000 K – 6000 K

b. What type of star has the lowest temperature but the highest level of brightness on the H-R diagram?
   
   giants/supergiants

c. A particular star has an absolute magnitude of 2.5. What type(s) of star could this star be?
   
   main sequence or giant

d. Suppose the star in part c is also found to have a temperature of 3500 K. What type of star is this?
   
   giant
6. (10 points) An old manuscript is found and carbon-14 dating is used to estimate its age. Carbon-14 decays to N-14 with a half-life of 5730 years. A measurement of the abundance of these two nuclides indicates there is 4 parts of carbon-14 to 12 parts of nitrogen-14.

a. How many parts of carbon-14 were in the original sample?

\[ 4 \text{ parts} + 12 \text{ parts} = 16 \text{ parts} \]

b. What fraction of the original carbon-14 remains now?

\[ 4 \text{ parts remain} \rightarrow \text{fraction remaining is } \frac{4}{16} \text{ (or } \frac{1}{4} \text{) of the original} \]

c. How many half-lives have transpired for the carbon-14?

\[ \frac{1}{4} \text{ corresponds to two half-lives } (\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}) \]

d. Approximately how old is the sample?

\[ 2 \text{ half-lives} \times 5730 \text{ years} = 11460 \text{ years} \]

Things that may be useful:

\[ T^2 = k R^3 \quad k = 1 \text{ yr}^2/\text{AU}^3 \]

Functional Groups:

Alcohol \(-\text{OH}\)
Amine \(-\text{NH}_2\)
Carboxylic acid \(-\text{C} - \text{OH}\)