1. The empirical and molecular formulas of a hydrocarbon are determined by combustion analysis.

   a. Combustion of a 1.214 g sample of a hydrocarbon results in 4.059 g of carbon dioxide and 0.9494 g of water.
      i. How many moles of carbon are contained in the sample? 0.09225 moles
      ii. How many moles of hydrogen are contained in the sample? 0.1055 mol
      iii. What is the empirical formula of the hydrocarbon? CH

   b. The mass spectrum of the hydrocarbon shows a peak at 184 mass units.
      i. Predict the molar mass of the hydrocarbon. 184 g
      ii. What is the molecular formula of the hydrocarbon? C\(_{14}\)H\(_{14}\)
      iii. Write and balance a chemical equation for the complete combustion of the hydrocarbon. 2C\(_{14}\)H\(_{14}\) + 35 O\(_2\) \(\rightarrow\) 28 CO\(_2\) + 14 H\(_2\)O

2. In an experiment, a hydrocarbon and carbon tetrachloride were each found not to dissolve in water.

   a. Draw the Lewis structure and the line-angle representation for carbon tetrachloride.
   b. What is the molecular geometry of carbon tetrachloride? tetrahedral
   c. Does the molecule have polar bonds? yes Explain. Is the molecule polar or nonpolar? Nonpolar Explain. Polarity is based on two factors, the polarity of the bonds and the symmetry of the molecule. Carbon tetrachloride is tetrahedral so the bond polarities will cancel and the center of positive and negative charge coincides.
   d. Explain the fact that carbon tetrachloride does not dissolve in water. Carbon tetrachloride is a nonpolar substance with London Dispersion forces, and water is a polar substance with hydrogen bonding. The differences in the properties does not allow these two substances to dissolve.
   e. What principal intermolecular force(s) is (are) acting in the carbon tetrachloride solution? London Dispersion forces

3. In the laboratory, you are to determine the identity of a pure unknown white solid.

   a. A 19.2 g sample of the volatile compound decomposes upon heating to yield 6.80 g of ammonia, 8.80 g of carbon dioxide gas, and some water. Calculate the empirical formula of the compound in the form C\(_{m}\)H\(_n\)N\(_y\)O\(_z\). CH\(_3\)N\(_2\)O\(_3\)

   b. When a sample of the compound is dissolved in water and made basic with sodium hydroxide, wetted pH paper held above the solution indicates a pH of about 9 and the solution gives off a distinct odor of ammonia. Write and balance a net ionic equation that could explain this result. NH\(_4^+\) + OH\(^-\) \(\rightarrow\) NH\(_3\) + H\(_2\)O

   c. When another sample is dissolved in water and made acidic with hydrochloric acid, the solution effervesces (bubbles). Write and balance a net ionic equation that could explain this result. CO\(_3^{2-}\) + H\(^+\) \(\rightarrow\) CO\(_2\) + H\(_2\)O
d. Based on your answers to Parts b and c, rearrange the simplest formula you determined in Part a to identify this compound. Name the compound. \((\text{NH}_4)_2\text{CO}_3\)

e. Use principles of intermolecular forces and polarity to explain why effervescence was observed in Part c but not in Part b. Ammonia is polar and capable of hydrogen bonding with the water. Carbon Dioxide is nonpolar and has a weaker force of dispersion forces. The carbon dioxide produced does not easily dissolve in water where the ammonia gas does dissolve in the water more easily with hydrogen bonding. Therefore, the carbon dioxide will bubble out of the solution.

4.

![Photo Electron Spectra](image)

a. Write the complete electron configurations for boron and fluorine. B: \(1s^22s^22p^1\) F: \(1s^22s^22p^5\)

b. Why are the fluorine peaks to the left of the boron peaks? Fluorine has 4 more protons in the nucleus than boron, so it has a greater force of attraction for the electrons. A greater attraction indicates a greater amount of energy is necessary to remove the electron.

c. Why is there one peak in fluorine that is so much taller than all the others? That peak represents the 2p orbital with five electrons. It is taller because it represents the most number of electrons in the two elements.

5. Below is shown the PES spectrum of sulfur (atomic number = 16).

a. Write the full electron configuration of sulfur. \(1s^22s^22p^63s^23p^4\)

b. Label each peak in the spectrum to show which subshell it represents (i.e., 1s, 2s, etc.)

c. On the spectrum, sketch in the relative locations and correct peak heights for the spectrum of aluminum (atomic number = 13). By relative location, I mean correctly to the left or right of the same subshell peak in the sulfur spectrum. Aluminum has 13 protons in the nucleus so the peaks will be to the right of sulfur. It will take less energy to remove electrons is the corresponding orbitals as sulfur with 16 protons.
6. Equal masses (0.500 g each) of hydrogen and oxygen are placed in an evacuated 4.00 L flask at 25.0°C. The mixture is allowed to react to completion and the flask is returned to 25.0°C and allowed to come to equilibrium. The equilibrium vapor pressure of water at 25°C is 23.76 mmHg.

a. Write and balance a chemical equation for the reaction
b. What is the total pressure inside the flask before the reaction begins?
c. What is the mass of water vapor in the flask at equilibrium?
d. How many grams of which reactant gas remains at equilibrium?
e. What is the total pressure inside the flask at equilibrium?
f. After the reaction, is there any liquid water present? If so, how many grams. If not, why?

7. A 2.00 L flask at 27°C contains 3.00 g of each Ar(g), SO₂(g), and He (g). Answer the following questions about the gases, and in each case, explain your reasoning.

a. Which gas has particles with the highest average kinetic energy?
b. Which gas has particles with the highest average velocity?
c. Which gas will deviate the most from ideal behavior?
d. Which gas has the highest partial pressure?
e. Which substance will have the highest boiling point.
f. What changes in temperature and pressure will increase the deviations of all the gases from ideal behavior?

8. Consider the following solids: LiF, NaF, and KF.
a. Rank these in order of increasing lattice energy and explain according to Coulomb's Law.

KF < NaF < LiF  The difference in the solids is the ionic radius of the cation. As the radius increases, the distance between the ions increases so the force of attraction decreases. Li and F has the greatest Lattice Energy.

b. Predict whether ScN will have a higher or lower lattice energy than the three solids. Explain according to Coulomb's Law.  ScN will have a higher lattice energy than the three solids due to the charges on the ions being greater. Sc +3, N-3 compared to +1, -1 will have a greater force of attraction therefore, a greater lattice energy.

c. Explain why these ionic solids are hard and have high melting points when molecular solids are soft and have low melting points. The cations and anions in an ionic substance forms a crystal lattice (hard) structure where the columbic forces in an ionic compound are much stronger than the intermolecular forces in a molecular solid. Melting points are based upon the attraction and so the greater the attraction, the higher the melting point.

d. Rank the following in order of increasing melting point. LiF, CF4, & OF2. Explain.

    CF4 < OF2 < LiF  Melting points are based upon the strength of the intermolecular forces. The weaker the forces, the lower the melting points. CF4 has weak dispersion forces, OF2 is polar so it has dipole-dipole forces, and LiF has very strong columbic forces.