1. Suppose that a molecule has the formula AB3. Sketch and name two different shapes that this molecule may have. For each of the two shapes, give an example of a known molecule that has that shape. For one of the molecules you have named, interpret the shape in the context of a modern bonding theory.

(a) Draw the Lewis electron-dot structures for CO32-, CO2, and CO, including resonance structures where appropriate.

(b) Which of the three species has the shortest C-O bond length? Explain the reason for your answer.

(c) Predict the molecular shapes for the three species. Explain how you arrived at your predictions.

(a) Draw a Lewis electron-dot structure for each of the molecules above and identify the shape of each.

(b) Use the valence shell electron-pair repulsion (VSEPR) model to explain the geometry of each of these molecules.

NO2 NO2- NO2+

Nitrogen is the central atom in each of the species given above.

(a) Draw the Lewis electron-dot structure for each of the three species.

(b) List the species in order of increasing bond angle. Justify your answer.

(c) Select one of the species and give the hybridization of the nitrogen atom in it.

(d) Identify the only one of the species that dimerizes and explain what causes it to do so.

1. Consider the molecules PF3 and PF5.

(a) Draw the Lewis electron-dot structures for PF3 and PF5 and predict the molecular geometry of each.

(b) Is the PF3 molecule polar, or is it nonpolar? Explain.

(c) On the basis of bonding principles, predict whether each of the following compounds exists. In each case, explain your prediction.

(i) NF5

(ii) AsF5

1. Answer the following questions using principles of chemical bonding and molecular structure.

(a) Consider the carbon dioxide molecule, CO2, and the carbonate ion, CO32–.

(i) Draw the complete Lewis electron-dot struc­ture for each species.

(ii) Account for the fact at the carbon-oxygen bond length in CO32– is greater than the car­bon-oxygen bond length in CO2.

(b) Consider the molecules CF4 and SF4.

(i) Draw the complete Lewis electron-dot struc­ture for each molecule.

(ii) In terms of molecular geometry, account for the fact that the CF4 molecule is nonpolar, whereas the SF4 molecule is polar.

CH4*(g)* + 2 Cl2*(g)* → CH2Cl2*(g)* + 2 HCl*(g)*

Methane gas reacts with chlorine gas to form dichloromethane and hydrogen chloride, as represented by the equation above.

(a) A 25.0 g sample of methane is placed in a reaction vessel containing 2.58 mol of Cl2*(g)*.

(i) Identify the limiting reactant when the methane and chlorine gases are combined. Justify your answer with a calculation.

(ii) Calculate the total number of moles of CH2Cl2*(g)* in the container after the limiting reactant has been totally consumed.

Initiating most reactions involving chlorine gas involves breaking the Cl-Cl bond, which has a bond energy of 242 kJ mol-1.

(b) Calculate the amount of energy, in joules, needed to break a single Cl-Cl bond.

(c) Calculate the longest wavelength of light, in meters, that can supply the energy per photon necessary to break the Cl-Cl bond.

The following mechanism has been proposed for the reaction of methane gas with chlorine gas. All species are in the gas phase.

Step 1 Cl2 2 Cl *fast equilibrium*

Step 2 CH4 + Cl → CH3 + HCl *slow*

Step 3 CH3 + Cl2 → CH3Cl + Cl *fast*

Step 4 CH3Cl + Cl → CH2Cl2 + H *fast*

Step 5 H + Cl → HCl *fast*

(d) In the mechanism, is CH3Cl a catalyst, or is it an intermediate? Justify your answer.

(e) Identify the order of the reaction with respect to each of the following according to the mechanism. In each case, justify your answer.

(i) CH4*(g)*

(ii) Cl2*(g)*