

Answer the following questions about a pure compound that contains only carbon, hydrogen, and oxygen.

- (a) A 0.7549 g sample of the compound burns in  $O_2(g)$  to produce 1.9061 g of  $CO_2(g)$  and 0.3370 g of  $H_2O(g)$ .
- Calculate the individual masses of C, H, and O in the 0.7549 g sample.
  - Determine the empirical formula for the compound.
- (b) A 0.5246 g sample of the compound was dissolved in 10.0012 g of lauric acid, and it was determined that the freezing point of the lauric acid was lowered by  $1.68^\circ C$ . The value of  $K_f$  of lauric acid is  $3.90^\circ C m^{-1}$ . Assume that the compound does not dissociate in lauric acid.
- Calculate the molality of the compound dissolved in the lauric acid.
  - Calculate the molar mass of the compound from the information provided.
- (c) Without doing any calculations, explain how to determine the molecular formula of the compound based on the answers to parts (a)(i) and (b)(ii).
- (d) Further tests indicate that a 0.10 M aqueous solution of the compound has a pH of 2.6 . Identify the organic functional group that accounts for this pH.

A solution of  $CuSO_4$  was electrolyzed using platinum electrodes by passing a current through the solution. As a result, there was a decrease in both  $[Cu^{2+}]$  and the solution pH; one electrode gained in weight a gas was evolved at the other electrode.

- Write the cathode half reaction that is consistent with the observations above.
- Write the anode half reaction that is consistent with the observations above.
- Sketch an apparatus that can be used for such an experiment and label its necessary components.
- List the experimental measurements that would be needed in order to determine from such an experiment the value of the faraday.

1989 B



At  $25^\circ C$  the equilibrium constant,  $K_p$ , for the reaction above is 0.281 atmosphere.

- What is the  $\Delta G^\circ_{298}$  for this reaction?
- It takes 193 joules to vaporize 1.00 gram of  $Br_2(l)$  at  $25^\circ C$  and 1.00 atmosphere pressure. What are the values of  $\Delta H^\circ_{298}$  and  $\Delta S^\circ_{298}$  for this reaction?
- Calculate the normal boiling point of bromine. Assume that  $\Delta H^\circ$  and  $\Delta S^\circ$  remain constant as the temperature is changed.
- What is the equilibrium vapor pressure of bromine at  $25^\circ C$ ?

Propane,  $C_3H_8$ , is a hydrocarbon that is commonly used as fuel for cooking.

- Write a balanced equation for the complete combustion of propane gas, which yields  $CO_2(g)$  and  $H_2O(l)$ .
- Calculate the volume of air at  $30^\circ C$  and 1.00 atmosphere that is needed to burn completely 10.0 grams of propane. Assume that air is 21.0 percent  $O_2$  by volume.
- The heat of combustion of propane is  $-2,220.1 \text{ kJ/mol}$ . Calculate the heat of formation,  $\Delta H_f^\circ$ , of propane given that  $\Delta H_f^\circ$  of  $H_2O(l) = -285.3 \text{ kJ/mol}$  and  $\Delta H_f^\circ$  of  $CO_2(g) = -393.5 \text{ kJ/mol}$ .
- Assuming that all of the heat evolved in burning 30.0 grams of propane is transferred to 8.00 kilograms of water (specific heat =  $4.18 \text{ J/g}\cdot K$ ), calculate the increase in temperature of water.

Solid aluminum hydroxide is added to a concentrated solution of potassium hydroxide.

Solid calcium carbonate is added to a solution of ethanoic (acetic) acid.

Lithium metal is strongly heated in nitrogen gas

A solution of copper(II) sulfate is spilled onto a sheet of freshly polished aluminum metal

A solution of potassium phosphate is mixed with a solution of calcium acetate.

Explain each of the following observations in terms of the electronic structure and/or bonding of the compounds involved.

- At ordinary conditions, HF (normal boiling point =  $20^\circ C$ ) is a liquid, whereas HCl (normal boiling point =  $-114^\circ C$ ) is a gas.
- Molecules of  $AsF_3$  are polar, whereas molecules of  $AsF_5$  are nonpolar.
- Draw the Lewis electron-dot structures for  $PF_3$  and  $PF_5$  and predict the molecular geometry of each.
- Is the  $PF_3$  molecule polar, or is it nonpolar? Explain.