SECTION 2

SHORT ANSWER Answer the following questions in the space provided.

1. a. Write the two equations that show the two-stage ionization of sulfurous acid in water.
   
   stage 1: \( \text{H}_2\text{SO}_3(aq) + \text{H}_2\text{O}(l) \rightleftpararrow \text{H}_3\text{O}^+(aq) + \text{HSO}_3^-(aq) \)

   stage 2: \( \text{HSO}_3^-(aq) + \text{H}_2\text{O}(l) \rightleftpararrow \text{H}_3\text{O}^+(aq) + \text{SO}_3^{2-}(aq) \)

   b. Which stage of ionization usually produces more ions? Explain your answer.
   Stage 1; for most polyprotic acids, the concentration of ions formed in the first ionization is the greatest.

   A Lewis base is a species that donates an electron pair to form a covalent bond. Yes, \( \text{OH}^- \) is a Lewis base. It has an electron pair available to donate. For example,
   \( \text{OH}^-(aq) + \text{H}^+(aq) \rightarrow \text{H}_2\text{O}(l) \).

   b. Define a Lewis acid. Can \( \text{H}^+ \) function as a Lewis acid? Explain your answer.
   A Lewis acid is a species that accepts an electron pair to form a covalent bond.
   \( \text{H}^+ \) is a Lewis acid because it can accept an electron pair from a base. For example,
   \( \text{H}^+(aq) + \text{OH}^-(aq) \rightarrow \text{H}_2\text{O}(l) \).

3. Identify the Brønsted-Lowry acid and the Brønsted-Lowry base on the reactant side of each of the following equations for reactions that occur in aqueous solution. Explain your answers.
   a. \( \text{H}_2\text{O}(l) + \text{HNO}_3(aq) \rightarrow \text{H}_3\text{O}^+(aq) + \text{NO}_3^-(aq) \)
   \( \text{HNO}_3 \) is the Brønsted-Lowry acid because it donates a proton to the \( \text{H}_2\text{O} \). The \( \text{H}_2\text{O} \) is the Brønsted-Lowry base because it is the proton acceptor.

   b. \( \text{HF}(aq) + \text{HS}^-(aq) \rightarrow \text{H}_2\text{S}(aq) + \text{F}^-(aq) \)
   \( \text{HF} \) is the Brønsted-Lowry acid because it donates a proton to the \( \text{HS}^- \). The \( \text{HS}^- \) is the Brønsted-Lowry base because it is the proton acceptor.
SECTION 2 continued

4. a. Write the equation for the first ionization of H₂CO₃ in aqueous solution. Assume that water serves as the reactant that attaches to the hydrogen ion released from the H₂CO₃. Which of the reactants is the Brønsted-Lowry acid, and which is the Brønsted-Lowry base? Explain your answer.

\[ H_2CO_3(aq) + H_2O(l) \rightarrow HCO_3^-(aq) + H_3O^+(aq) \]. The H₂CO₃ is the Brønsted-Lowry acid because it donates a proton to the H₂O. The H₂O is the Brønsted-Lowry base because it accepts the proton.

b. Write the equation for the second ionization, that of the ion that was formed by the H₂CO₃ in the reaction you described above. Again, assume that water serves as the reactant that attaches to the hydrogen ion released. Which of the reactants is the Brønsted-Lowry acid, and which is the Brønsted-Lowry base? Explain your answer.

\[ HCO_3^-(aq) + H_2O(l) \rightarrow CO_3^{2-}(aq) + H_3O^+(aq) \]. The HCO₃⁻ is the Brønsted-Lowry acid because it donates a proton to the H₂O. The H₂O is the Brønsted-Lowry base because it accepts the proton.

c. What is the name for a substance, such as H₂CO₃, that can donate two protons?

a diprotic acid

5. a. How many electron pairs surround an atom of boron (B, element 5) bonded in the compound BCl₃?

three

b. How many electron pairs surround an atom of nitrogen (N, element 7) in the compound NF₃?

four

c. Write an equation for the reaction between the two compounds above. Assume that they react in a 1:1 ratio to form one molecule as product.

\[ BCl_3 + NF_3 \rightarrow BCl_3NF_3 \]

d. Assuming that the B and the N are covalently bonded to each other in the product, which of the reactants is the Lewis acid? Is this reactant also a Brønsted-Lowry acid? Explain your answers.

BCl₃ is the Lewis acid because it accepts an electron pair in forming a covalent bond. It is not a Brønsted-Lowry acid, because it is not donating a proton.

e. Which of the reactants is the Lewis base? Explain your answer.

NF₃ is the Lewis base because it donates an electron pair in forming a covalent bond.