1) In aqueous solution, boric acid behaves as a weak acid ($pK_a = 9.1$) and the following equilibrium is established:

$$B(OH)_3(aq) + 2H_2O(l) \rightleftharpoons [B(OH)_4]^- (aq) + [H_3O]^+ (aq)$$

(a) Draw the structures of $B(OH)_3$ and $[B(OH)_4]^-$.

(b) How would you classify the acidic behavior of $B(OH)_3$?

(c) The formula for boric acid may also be written as $H_3BO_3$; compare the acidic behavior of this acid with that of $H_3PO_3$.

2) When NaCN dissolves in water, the resulting solution is basic. Account for this observation given that $pK_a$ for HCN is 9.31.

3) Which of the following oxides are likely to be acidic, basic or amphoteric in aqueous solution: (a) MgO; (b) SnO; (c) CO$_2$; (d) P$_2$O$_5$; (e) Sb$_2$O$_5$; (f) SO$_2$; (g) Al$_2$O$_3$; (h) BeO?
4. Give products of the following reactions and classify the reaction according to acid-base concepts (Lewis, Arrhenius, etc.)

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a) \( \text{NaOH} \text{ (aq)} + \text{HNO}_3 \text{ (aq)} \rightarrow \) __________________

b) \( \text{H}_2\text{SO}_4 \text{ (aq)} + \text{H}_2\text{O} \rightarrow \) __________________

c) \( \text{2 BrF}_3 \text{ (liq)} \rightarrow \) __________________

d) \( \text{KF} + \text{BF}_3 \rightarrow \) __________________

e) \( \text{CO}_2 \text{ (g)} + \text{K}_2\text{O} \text{ (s)} \rightarrow \) __________________

f) \( \text{NH}_4\text{Cl} \text{ (aq)} + \text{H}_2\text{O} \rightarrow \) __________________

g) \( \text{2 Na}^0 + \text{2 NH}_3 \xrightarrow{\text{(liq NH}_3)} \text{2 Na} + \text{2 NH}_2^- + \text{H}_2 \)

\( \text{NH}_4\text{Cl} + \text{Na}^+\text{NH}_2^- \rightarrow \) __________________

5. For 4c) above, give the Lewis structure, geometry, and point group assignment for reactant and products.

6. For 4b) above, identify the conjugate acid/base pairs.
1. Write out the ionization equilibrium for each of the following acids in water. In each case, give the Lewis structure and predicted geometric structure of the conjugate base. Give the oxidation state of the central atom in each oxyacid and each conjugate base.

   **Acid**

   a) Perchloric, HClO₄

   b) Sulfuric, H₂SO₄

   c) Nitric, HNO₃

   d) Sulfurous, H₂SO₃

   e) Phosphoric, H₃PO₄

   f) Carbonic, H₂CO₃

   g) Boric, H₃BO₃

   h) Dihydrogen Phosphate

   i) Monohydrogen Phosphate

2. According to Pauling’s rules, the pKₐ of oxoacids is \( pK_a = 8 - 5p \) (where \( p \) = the number of non-protonated oxygens in the formula \( O_pE(OH)_q \)).

   a) What is the predicted pKₐ of each of the above acids?

   b) What is the predicted pKₐ of (h) and (i) above?