15.83 Classify the following oxides by filling in this table:

<table>
<thead>
<tr>
<th>Oxide</th>
<th>Metallic or non-metallic oxide</th>
<th>Acidic or basic oxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) CO₂</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) K₂O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) MgO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) N₂O₅</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) SO₃</td>
<td></td>
<td></td>
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<tr>
<td>(f) BaO</td>
<td></td>
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</tr>
</tbody>
</table>

15.87 Zn(OH)₂ is an amphoteric hydroxide. Write balanced equations to show its reaction with HCl and with NaOH.

(a) With HCl:
Molecular Eq: \(2\text{HCl}(aq) + \text{Zn(OH)}_2(s) \rightarrow\)
Net Ionic Eq:

(b) With NaOH: \(2\text{OH}^- (aq) + \text{Zn(OH)}_2(s) \rightarrow\)

15.88 Although Al(OH)₃ is insoluble, it dissolves in excess NaOH. Write a balanced net ionic equation for its reaction with NaOH. This is a Lewis Acid-base reaction. Show an arrow for the transfer of electrons and label the Lewis Acid and the Lewis Base.

Rxn: \(\text{Al(OH)}_3(s) + \text{OH}^- (aq) \rightarrow\)

15.90 What must be present for a molecule/ion to act as a Lewis acid? A Lewis Base?

- To be a Lewis acid, a molecule/ion must have ....
- To be a Lewis base, a molecule/ion must have ....

15.92 Draw the Lewis Dot structures for each substance in the following Lewis Acid-Base reaction.
\(\text{AlCl}_3(s) + \text{Cl}^- (aq) \rightarrow \text{AlCl}_4^- (aq)\)
Then, show the arrow for the electron transfer and label the Lewis Acid and the Lewis Base.

a) Why is the Lewis Acid a good Lewis acid?

b) Why is the Lewis Base a good Lewis base?

A. Would you expect Fe²⁺ or Fe³⁺ to be a stronger Lewis Acid? ________ Why?
B. For this Lewis Acid-Base reaction, draw the arrow to show the electron transfer and label the Lewis Acid and Lewis Base.

\[ \text{Ag}^+ \text{(aq)} + 2 \text{NH}_3 \text{(aq)} \rightleftharpoons \text{Ag(NH}_3)_2^+ \text{(aq)} \]

C. Reaction #1 and Reaction #2 below can both be considered Bronsted Acid-Base reactions and Lewis Acid-Base reactions. Draw arrows and label acids and bases as asked in table.

<table>
<thead>
<tr>
<th></th>
<th>Draw arrow to show transfer of H⁺ Label Bronsted Acid and Bronsted Base</th>
<th>Draw arrow to show transfer of electrons Label Lewis Acid and Lewis Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rxn #1: HF (aq) + H₂O(l) ⇌ H₃O⁺ (aq) + F⁻ (aq)</td>
<td>HF (aq) + H₂O(l) ⇌ H₃O⁺ (aq) + F⁻ (aq)</td>
<td></td>
</tr>
<tr>
<td>Rxn #2: NH₃(aq) + H₂S(aq) ⇌ NH₄⁺(aq) + HS⁻ (aq)</td>
<td>NH₃(aq) + H₂S(aq) ⇌ NH₄⁺(aq) + HS⁻ (aq)</td>
<td></td>
</tr>
</tbody>
</table>

D. A 0.25 g sample of lime (CaO) is dissolved in enough water to make 1.5 L of solution.

1. Is CaO an acidic or basic oxide? ____________________________
2. Determine the products of the reaction that occurs: \( \text{CaO(s) + H}_2\text{O(l) } \rightarrow \) ____________________________
3. What is the pH of the solution that forms? (Assume that all of the CaO dissolves. Also, you should know that the rxn goes 100% to the right. How do you know this? ____________________________)

E. Burning coal often produces SO₂ gas which can react with water to form acid rain.

\[ \text{SO}_2 \text{(g) + H}_2\text{O(l) } \rightarrow \text{H}_2\text{SO}_3 \text{(aq)} \]

1. Draw the Lewis Dot structures for all substances in the reaction written above.
   *Hint: Both H’s in H₂SO₃ are bonded to oxygens.*

2. Now, using your Lewis Dot structures above, **draw arrows** to show how electrons must move to transform the reactants into the product given. **Label the Lewis Acid and the Lewis Base.**

3. Put in all **oxidation numbers** into the original chemical equation above. State why the reaction is not an oxidation-reduction reaction. ____________________________

4. H₂SO₃ is an Arrhenius acid, a Bronsted acid and a Lewis Acid. Determine the products of the reaction of H₂SO₃ and water and explain in what way H₂SO₃ is each of the three types of acids.

   \[ \text{H}_2\text{SO}_3 \text{ (aq) + H}_2\text{O(l) } \rightleftharpoons \] ________________

   *An Arrhenius Acid because...*