### Why?

Acids are substances that are used in our everyday life. They are present in our bodies in various forms. Some acids are used in the body to help in the body's natural processes. For example, stomach acid helps break down food. It is important to understand how these substances can be acids and what properties they have.

### Model 1 – Acid Strength and Conductivity

**Strong acid**:

\[ \text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^- \]

**Weak acid**:  

\[ \text{HF} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{F}^- \]

New! Four water molecules in the solutions are not shown.

1. Label each solution in Model 1. Match each symbol with its correct meaning.
   - A. Water molecule
   - B. Acid molecule
   - C. Conjugate base ion
   - D. Hydronium ion

### 2. Examine the strong and weak acid solutions in Model 1.

   a. What property do the solutions have in common?

   A. Conductivity

3. Assume that solutions of HCl and HF, similar to those in Model 1, are prepared, and identical small samples are collected and analyzed to determine the extent of dissociation that occurs. Based on the data below, calculate the percent ionization for each acid solution. Solutions A and B have been completed for you.

<table>
<thead>
<tr>
<th>Solution</th>
<th>Initial number of acid molecules</th>
<th>Number of acid molecules that reacted</th>
<th>Percent ionization</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 0.10 M HCl</td>
<td>40</td>
<td>40</td>
<td>100%</td>
</tr>
<tr>
<td>B 0.10 M HF</td>
<td>40</td>
<td>8</td>
<td>20%</td>
</tr>
<tr>
<td>C 0.01 M HCl</td>
<td>20</td>
<td>20</td>
<td>100%</td>
</tr>
<tr>
<td>D 0.015 M HF</td>
<td>20</td>
<td>4</td>
<td>20%</td>
</tr>
</tbody>
</table>

### Read This:

Electrolytes are substances that dissolve in water to produce ions in solution. The presence of ions allows a solution to conduct an electrical current. ions may be produced because the substance that dissolves in ions (ionic solids), or because the substance mixes with water to produce ions (as is the case with acids). The ions that are formed in solutions, the stronger the electrical. Non-electrolytes are substances whose aqueous solutions do not contain ions and therefore do not conduct an electrical current.

4. Which solution in Model 1, the strong or weak acid, is a better conductor of electricity? Provide evidence from Model 1 for your answer.
5. Based on the data in Model 1 and the table in Question 3, describe the relationship between:
   a. the percent ionization of the acid and the conductivity of the solution.
   b. the conductivity of the solution and the strength of the dissolved acid strength.

6. Consider the conductivity data shown in Model 1 and the ionization data in Question 3.
   a. Is HCl a strong acid or a weak acid? Explain in terms of percent ionization.
   b. Is HF a strong acid or a weak acid? Explain in terms of percent ionization.

7. Does a change in concentration affect the strength of an acid? Use the information in Question 3 to provide specific evidence to support your answer.

8. In one of the reactions in Model 1 there is a single arrow (⇒). In the other reactions there is a double arrow (↔). What do these symbols imply?
   a. About the nature of the reaction that occurs.
   b. About the strength of the acid?

9. A student states: “A solution of 4 M sulfuric acid (H₂SO₄) is a stronger acid than a 1 M solution of sulfuric acid.” Construct a well-thought-out response to help the student improve his understanding.

10. In the Lewis below, draw a representation for three 10 molecules of a weak acid dissolved in water with 20% ionization. Include only the water molecules that react, not the excess water molecules in the solution.

11. You have conductivity testing to 1 M solutions of HNO₃, H₂SO₄, and HCl. Three solutions are tested. The 1 M HNO₃ light bulb is bright, the 1 M H₂SO₄ light bulb is dimly lit, and the 1 M HCl light bulb is very dim. Rank the solutions in order of acid strength based on this information.

12. Based on your answer to Question 11, write balanced chemical equations for HNO₃ and H₂SO₄ reacting with water as they are mixed into an aqueous solution. Use single or double arrows as appropriate.
Learning Partners Strong vs Weak Acids

Extension Questions

Model 2 – The Meaning of $K_a$

$$\text{H}_2\text{CO}_3(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_3\text{O}^+(aq) + \text{CO}_3^{2-}(aq) \quad K_a = \frac{[\text{H}_3\text{O}^+][\text{CO}_3^{2-}]}{[\text{H}_2\text{CO}_3]}$$

15. In Model 2, does HCO$_3^-$ represent a weak acid or a strong acid? What evidence found in the model supports your answer?

16. Compare the equation above that starts with "HCO$_3^-$" to other equilibrium constant expressions you have seen:
   a. Is $K_a$ calculated in the same manner as other $K_e$ values?
   b. What molecule in the reaction has been left out of the $K_a$ expression? Give a reason why this molecule was ignored in calculating $K_a$.

15. Consider what you learned in Model 1 about the reaction in which weak acids react with water. Is the value of $K_a$ for a weak acid likely to be greater than or less than 1? Explain your answer in terms of the numbers that might be used in the equation in Model 2.

16. Is the value of $K_a$ for a strong acid greater than or less than 1? Explain your answer in terms of the numbers that might be used in the equation.

17. Consider the weak acid ammonium (NH$_4^+$).
   a. Write the acid dissociation reaction for NH$_3$ using Model 1 as your guide. Pay close attention to the arrow (single or double) you use.
   b. Write the $K_a$ expression for NH$_3$ using Model 2 and your equation above as a guide.