Learning Partners Strong vs Weak Acids

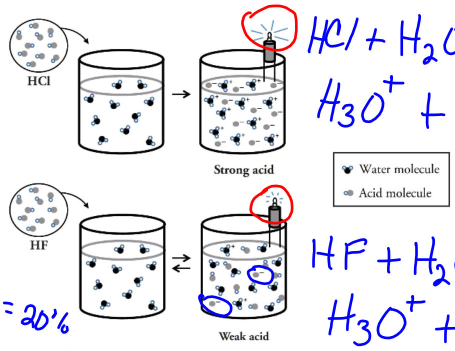
Strong versus Weak Acids

What makes a strong acid strong?

Why?

Acids are substances that surround us in our everyday life. The uses of acids range from providing essential nutrients for our bodies to dissolving metals. Some acids are safe to handle with our bare hands or even use in food preparation. Other acids will severely burn human skin. It is important to understand how these substances can all be acids and yet have such different properties.

Model 1 – Acid Strength and Conductivity



20

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

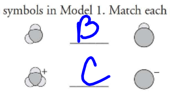
20

2/10 = 20%

$HF + H_2O \rightleftharpoons H_3O^+ + F^-$

Note: Excess water molecules in the solutions are not shown.

1. Examine the symbols in Model 1. Match each symbol with its correct meaning.



A, B, D, C

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 product do the solutions have in common?

   b. Use a complete sentence to explain the formation of the product in part *a* from an acid molecule and a water molecule.

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

	Solution	Initial number of acid molecules	Number of acid molecules that reacted	Molecules reacted / Initial number of molecules	Percent ionization
A	0.06 M HCl	40	40	40/40	100%
B	0.06 M HF	40	8	8/40	20%
C	0.03 M HCl	20	20	20/20	100%
D	0.03M HF	20	4	4/20	20%

Strong
weak

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 is ionic (like salt), or because the substance reacts with water to produce ions (as is the case with acids). The more ions that are formed in solution, the stronger the electrolyte. **Nonelectrolytes** 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.

Learning Partners Strong vs Weak Acids

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 electrolyte (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 reaction there is a double arrow (⇄). What do these symbols imply:
   a. about the extent to which the reaction occurs?

   b. about the strength of the acid?

9. A student states "A solution of 4 M sulfuric acid (H_2SO_4) is a stronger acid than a 1 M solution of sulfuric acid." Construct a well-thought out response to help this student improve his understanding.

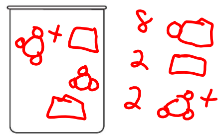
10 x .20 / 2   8 H_2O

10. In the beaker below, draw a representation to show 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.

Molecular acid = (H⁺)[A⁻]

Water =

H^+ A^-



11. You have conductivity meters in 1 M solutions of HNO_3, HNO_2, and $HC_2H_3O_2$. The 1 M HNO_3 light bulb is bright, the 1 M HNO_2 light bulb is giving off some light, and the 1 M $HC_2H_3O_2$ is very dim. Rank the solutions in order of acid strength based on this information.

$HNO_3 > HNO_2 > HC_2H_3O_2$

12. Based on your answer to Question 11, write balanced chemical equations for HNO_3 and HNO_2 reacting with water as they are mixed into an aqueous solution. Use single or double arrows as appropriate.

$HNO_3 + H_2O \rightarrow NO_3^- + H_3O^+$

$HNO_2 + H_2O \rightleftharpoons NO_2^- + H_3O^+$

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Extension Questions

Model 2 – The Meaning of K_a

$$HA(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + A^-(aq) \qquad K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

13. In Model 2, does HA represent a weak acid or a strong acid? What evidence found in the model supports your answer?

14. Compare the equation above that starts out "K_a =" to other equilibrium constant expressions you have seen.
    a. Is K_a calculated in the same manner as other K_{eq} 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 extent to 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_4^+ using Model 1 as your guide. Pay close attention to the arrow (single or double) you use.
    b. Write the K_a expression for HF using Model 2 and your equation above as a guide.