Biology Magnets Module 13: Properties of Water, Acids and Bases – Teacher and Student Guides

Teacher Information

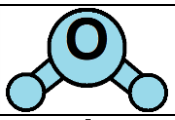
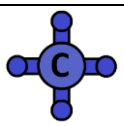
This module uses magnets designed for teacher and student interaction to guide learning acids and bases, buffers, and the properties of water. Contained in this guide are different lesson ideas that can last from 10 minutes each to an entire class period, depending upon teacher preference. Each lesson has both teacher-centered and student-centered activities. The student-centered activities are most effective if students are in small groups. It may be necessary to have multiple magnet sets for large classes. A student handout is provided which can be printed out and given to each student group to help guide their progress as they work with the magnets. If budget or white board space is limited, groups can alternate between using a set of magnets and doing other activities. Teachers can refer to the videos posted at the Biology Magnet web site at Biologymagnets.com for guided teaching instructions.

Magnet Care and Maintenance

Biology magnets are made to last for years. Periodically magnets will fall off or are knocked off the plastic. A piece of magnetic tape is included with each module, which should be able to replace around 10-12 magnets if necessary. Simply cut a new magnet and peel off the back to replace. Magnetic tape can also be purchased from a hobby store to replace magnets lost over time. Laminate may peel off, especially on small pieces. Use transparent tape to re-attach laminate that comes loose, curling the tape over the back of the magnet. The machines used to cut Biology Magnets are not always perfectly accurate. Sometimes a bit of white or black outline on the edges occurs or a cut might be slightly off center. Use scissors to remove extra outline that is unnecessary if desired. Store magnets in the clasp envelopes in which they arrived for easy organization.

Acids and Bases, Buffers, and Properties of Water Copyright and Licensing Information

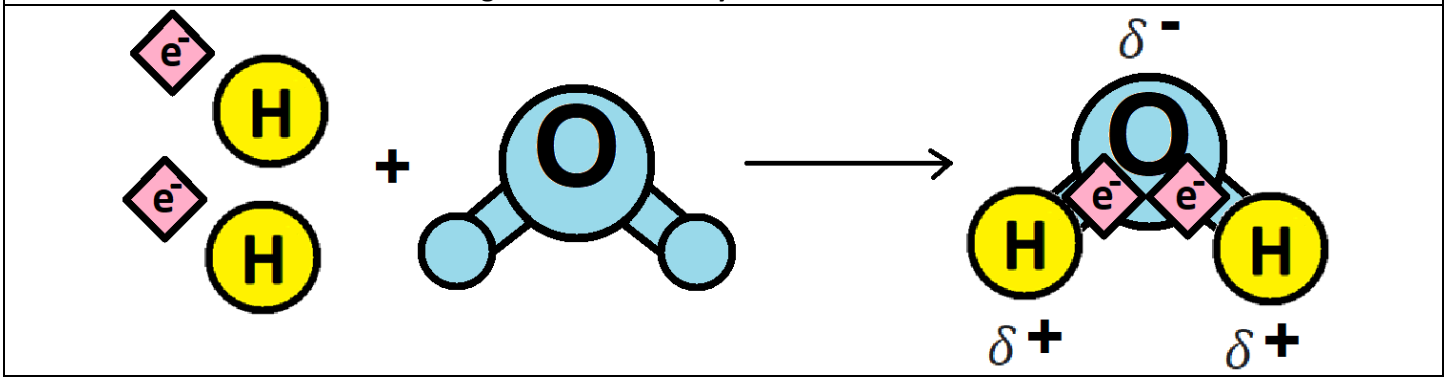
Biology Magnets Module 13 Materials List

Magnet Name	Quantity	Picture
Hydrogen Atom	20	
Oxygen Atom	7	
Electrons	8	
Sodium Atom	2	
Chlorine Atom	2	
Carbon Atom	1	
3” Magnetic Tape Strip	1	
Total Quantity	**41**	

Lesson 13A – Properties of Water (10-50 minutes)

Teacher Centered Activity (10-20 minutes): This lesson utilizes the magnets to demonstrate the properties of water. Start by adding two hydrogen atoms and two electrons to the bond arms of an oxygen atom. The electrons represent the shared electrons forming the covalent bond between the oxygen and hydrogen atoms. Explain that the electrons are held closer to the oxygen than the hydrogen, forming a polar covalent bond. Draw the partial charge symbols on the board to designate the polarity (**Figure 13.A.1).**

Figure 13.A.1: Polarity of a Water Molecule



Demonstrate hydrogen bonds by drawing a dotted line between the oxygen of one water molecule and the hydrogen of a *different* water molecule (**Figure 13.A.2)**. Hydrogen bonds hold together water molecules, which accounts for the cohesive property of water. Add several water molecules and hydrogen bonds to demonstrate cohesiveness. You may find it easier to move the water molecules around if you take off the electrons (**Figure 13.A.3)**.

Figure 13.A.2: Hydrogen Bond

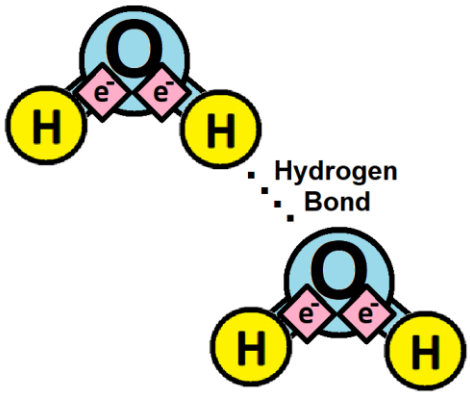
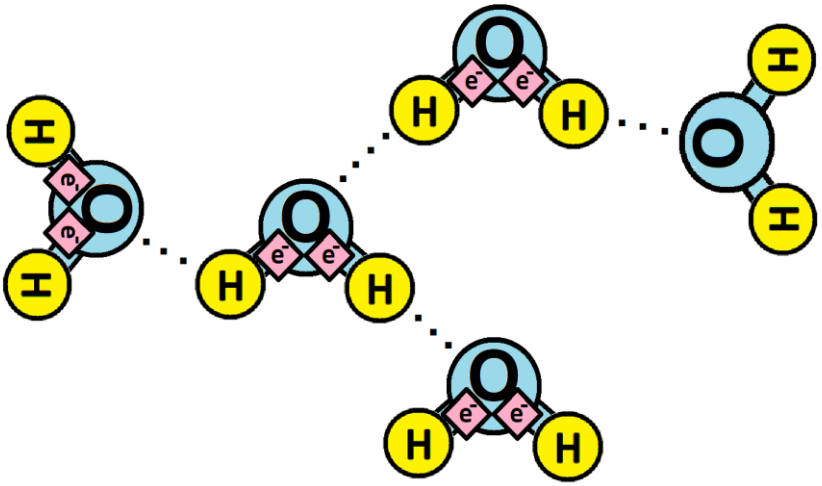
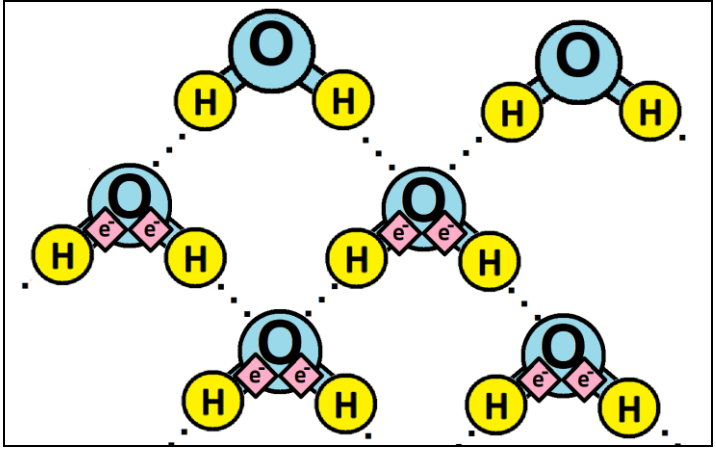


Figure 13.A.3: Cohesion of Water



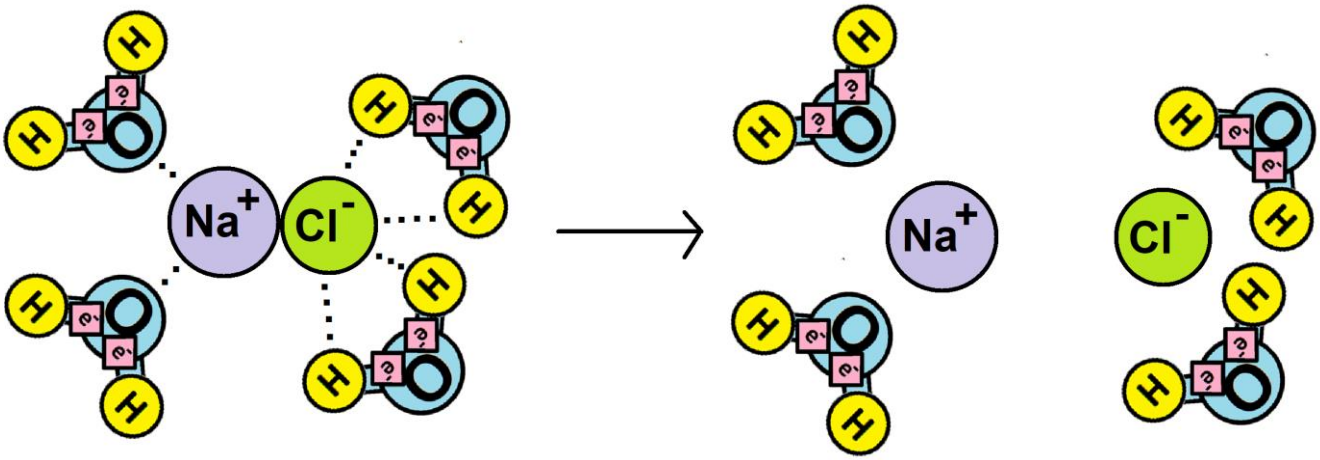
Use the magnets to set up the regular arrangement of water molecules when water freezes. This explains the expansion of ice due to empty spaces that arise in the crystal formation due to hydrogen bonding. The low density causes the water to float (**Figure 13.A.4)**.

Figure 13.A.4: Frozen water configuration



Water is also an excellent solvent. It can pull apart charged molecules such as NaCl to form free ions in solution. Show this with the magnets, drawing a "+" on the Na and a "-" on the Cl with a dry erase marker to indicate the charged nature of the ions (**Figure 13.A.5)**.

Figure 13.A.5: Water as a Solvent



Student Centered Activity (10-30 minutes): After teaching the properties of water, put students into small groups. A copy of the student guide for the lesson may be given to each group if necessary. Have the students take turns demonstrating the different properties of water to one another. Allow the students to correct and help one another. Students can demonstrate for the teacher when they are ready.

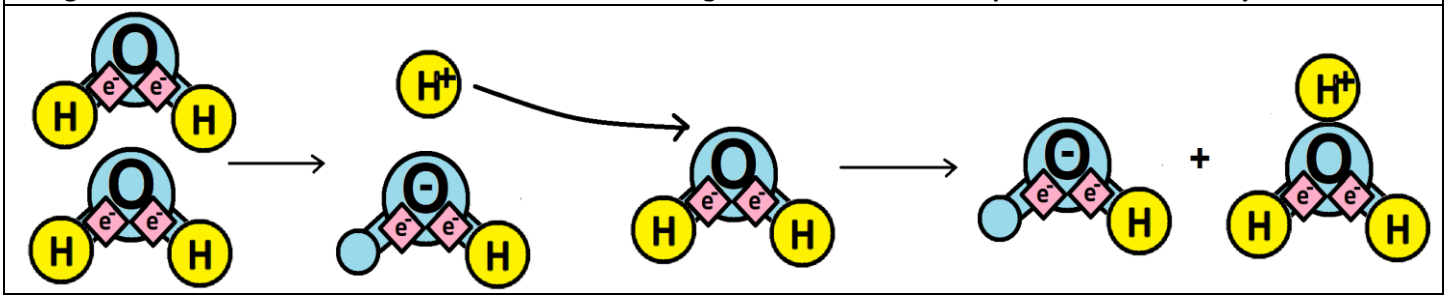
Extra exercises:

Other water properties: Have students research other properties of water such as adhesion, surface tension, capillary action, the meniscus, high heat of vaporization, and high heat capacity. Students can then try to demonstrate and explain the properties using the magnets and the concepts of polarity and hydrogen bonding.

Lesson 13B – Acids and Bases (10-50 minutes)

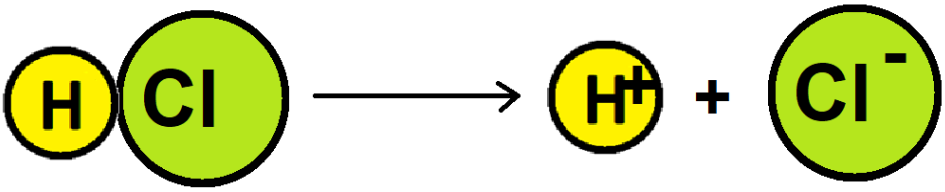
Teacher Centered Activity (10-20 minutes): Use the Biology Magnets to demonstrate acids and bases by first explaining pH. Start with a water molecule dissociating into a hydrogen ion and a hydroxide ion. You can draw a + and a – with a dry erase marker on the magnets if desired. This dissociation happens in about 1 in 10^7 water molecules, thus pure water is pH 7. The free H^+ ion will quickly attach to an unionized water molecule to form the hydronium ion, H_3O^+. The complete formula is $2H_2O \rightarrow H_3O^+ + OH^-$ (**Figure 13.B.1**).

Figure 13.B.1: Dissociation of a water molecule forming H^+ and OH^- and subsequent formation of hydronium ion



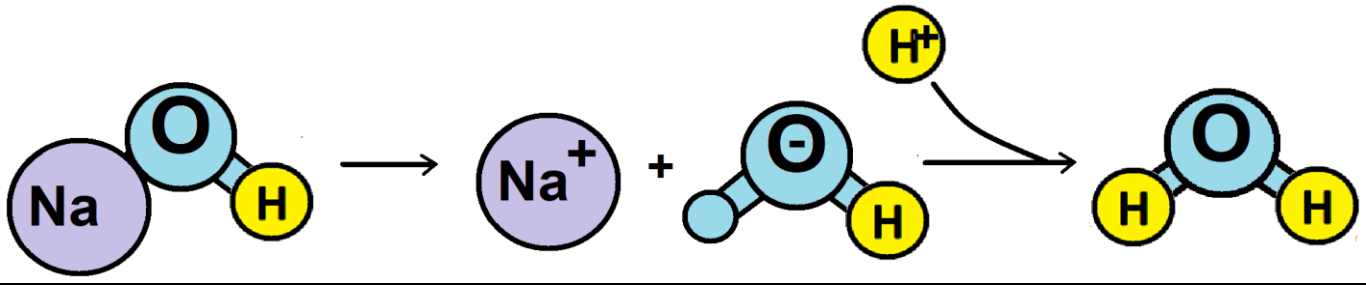
An acid is a substance that increases the hydrogen ion concentration in solution, usually by having its hydrogen atoms dissociate in water. Demonstrate this with the magnets by showing HCl molecules dissociate amongst water molecules to yield hydrogen ions (**Figure 13.B.2**).

Figure 13.B.2: Dissociation of an acid in solution raises H^+ concentration



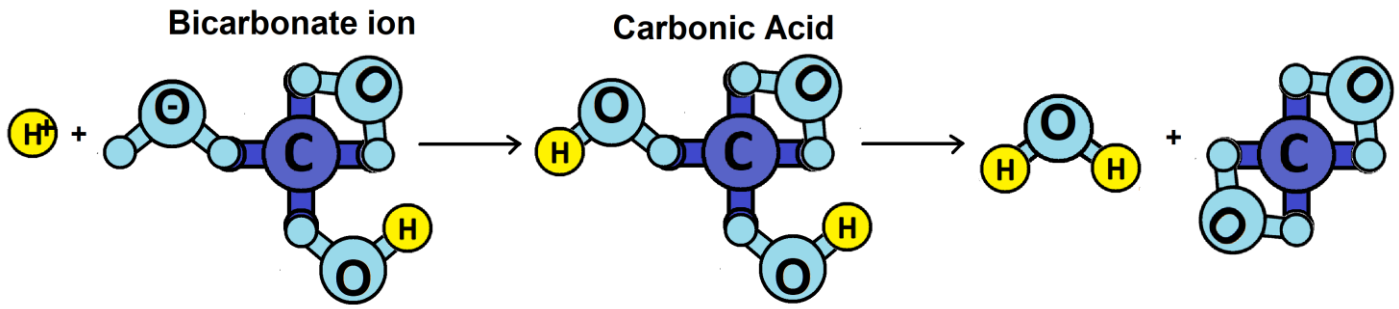
A base is a substance that decreases the hydrogen ion concentration in solution, usually by absorbing or binding to free hydrogen ions. Demonstrate this with the magnets by showing NaOH molecules dissociate amongst water molecules to yield hydroxide ions. The hydroxide ions then bind with free hydrogen ions to form water. This drives the pH up since there are less free H^+ ions in solution (**Figure 13.B.3**).

Figure 13.B.3: Dissociation of NaOH (a base) yields OH^- ions which bind H^+ ions to form water



Buffers are molecules which absorb H^+ or OH^- ions to keep the pH relatively constant. The carbonic acid-bicarbonate buffer system in the blood can be demonstrated using the Biology Magnets. If the pH is too high, carbonic acid will dissociate and release H^+ ions, forming bicarbonate. The extra H^+ ions in solution lowers the pH. If the pH is too low, carbonic acid will dissociate into H_2O and CO_2. The CO_2 can be breathed out from the lungs, essentially getting rid of carbonic acid and raising pH (**Figure 13.B.4**).

Figure 13.B.4: The carbonic acid-bicarbonate buffer system



Student Centered Activity (10-30 minutes): After teaching acids and bases, put students into small groups. A copy of the student guide for the lesson may be given to each group if necessary. Have the students take turns demonstrating acids, bases and buffers to one another using the Biology Magnets. Have them discuss if pH levels go up or down based upon each reaction. Allow the students to correct and help one another. Students can demonstrate for the teacher when they are ready.

Extra exercises:

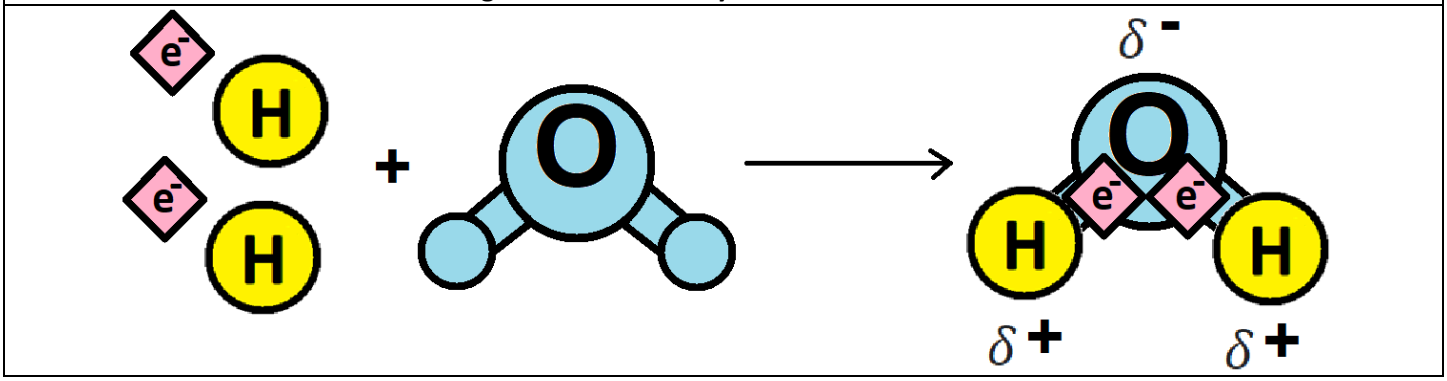
Antacids and Acid Rain: Have the students research antacids and acid rain either online or using textbooks and model its effects on pH using the Biology Magnets. If available, students can use index cards and magnetic tape to make atoms not contained in this module.

Common acids and bases: Have the students research common acids and bases either online or using textbooks and try to model their activity/dissociation using the Biology Magnets. If available, students can use index cards and magnetic tape to make atoms not contained in this module.

Lesson 13A – Properties of Water - Student Handout

Student Centered Activity: (10-20 minutes): This lesson utilizes the magnets to demonstrate the properties of water. Start by adding two hydrogen atoms and two electrons to the bond arms of an oxygen atom. The electrons represent the shared electrons forming the covalent bond between the oxygen and hydrogen atoms. Electrons are held closer to the oxygen than the hydrogen, forming a polar covalent bond. Draw the partial charge symbols on the board to designate the polarity (**Figure 13.A.1).**

Figure 13.A.1: Polarity of a Water Molecule



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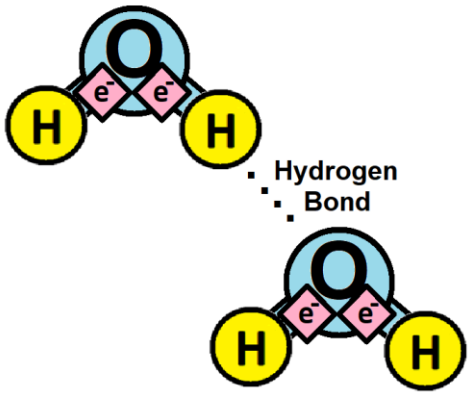

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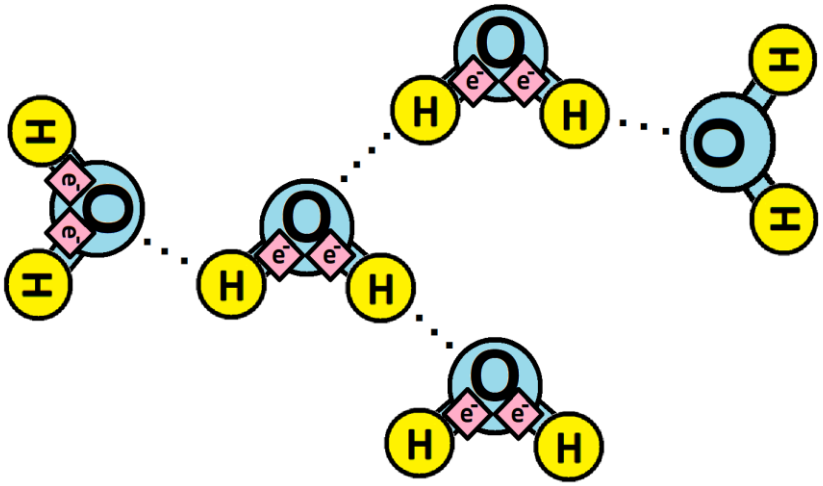

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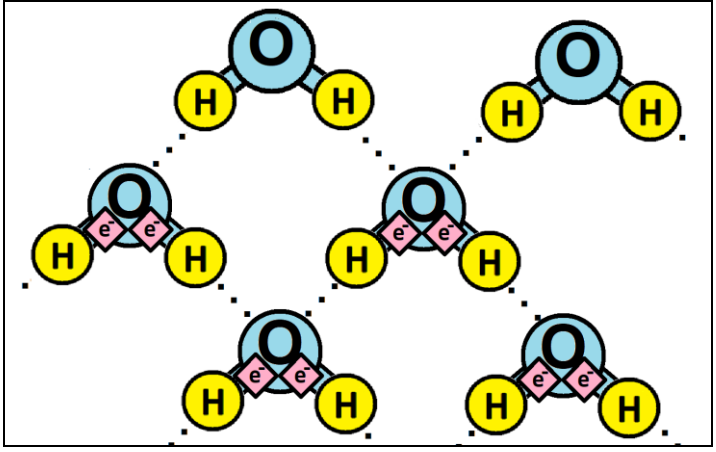

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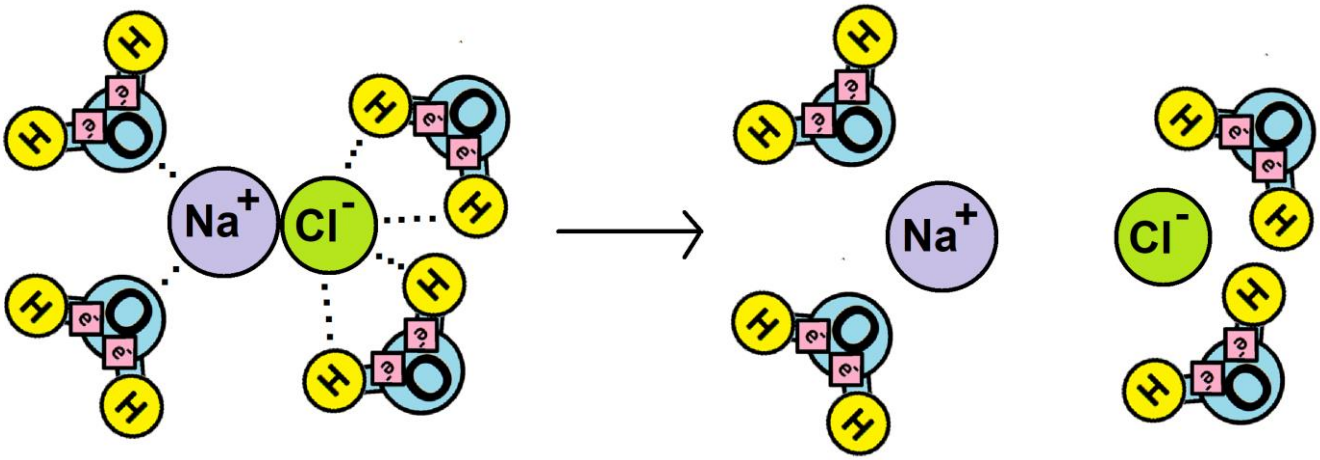

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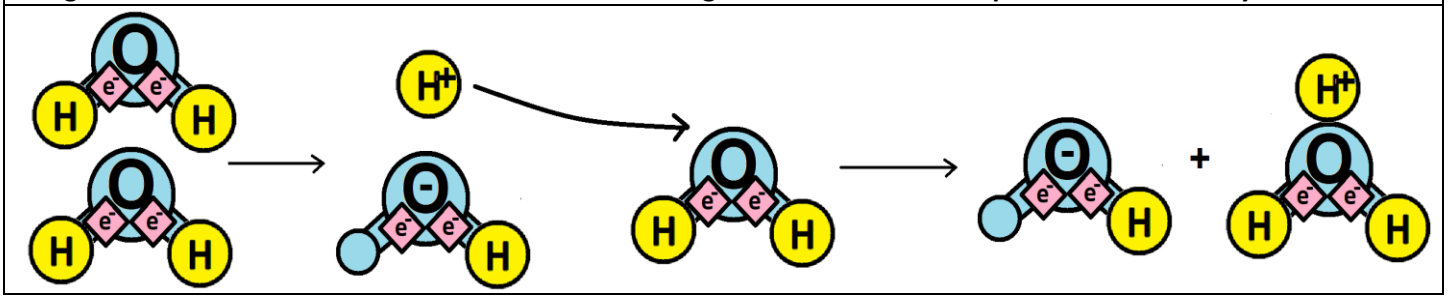
Lesson 13B – Acids and Bases – Student Handout

Student Centered Activity: Use the Biology Magnets to demonstrate acids and bases. Start with a water molecule dissociating into a hydrogen ion and a hydroxide ion. You can draw a + and a – with a dry erase marker on the magnets if desired. This dissociation happens in about 1 in 10^7 water molecules, thus pure water is pH 7. The free H^+ ion will quickly attach to an unionized water molecule to form the hydronium ion, H_3O^+. The complete formula is $2H_2O \rightarrow H_3O^+ + OH^-$ (**Figure 13.B.1**).

Figure 13.B.1: Dissociation of a water molecule forming H^+ and OH^- and subsequent formation of hydronium ion



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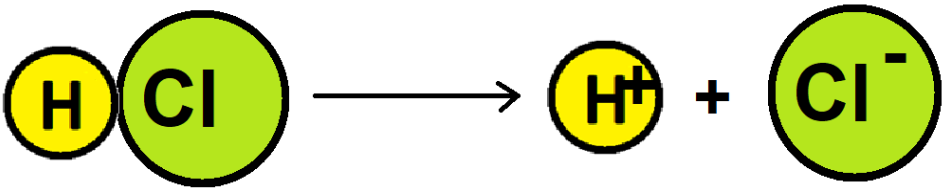

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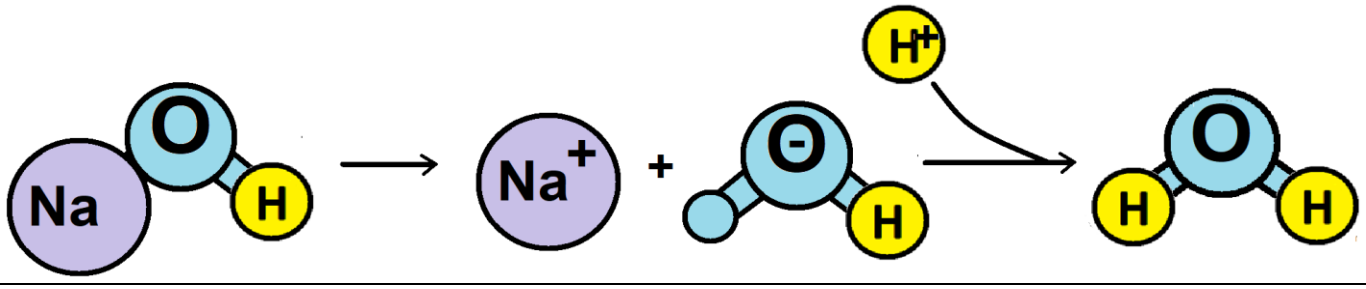

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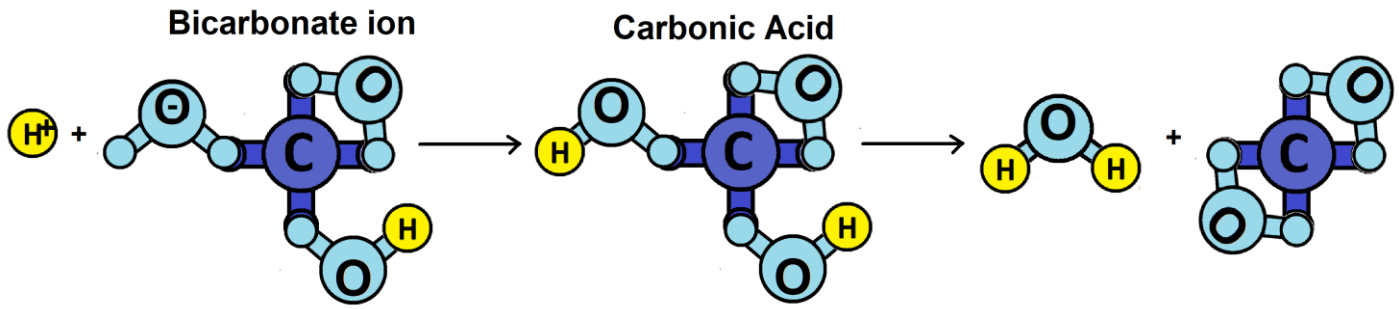

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