**Student Page**

**Title: K'Nex Hydrogen Bonding**

**Introduction:** Matter is held together by both strong and weak attractions. One strong attraction is the covalent bond. Covalent bonding involves sharing of electrons between nuclei of two atoms, which can be of the same or different elements. Breaking strong attractions requires quite a bit of energy. Weak attractions occur between positive and negative regions of chemical species, usually molecules. One of the most common weak attractions is the hydrogen bond. The name here is unfortunate because it is not really a bond. Hydrogen bonds are responsible for water being a liquid at room temperature and also hold together the two strands of DNA. These attractions can come and go fairly easily— you have probably heard of the evaporation of water and the replication of DNA! In this Activity, you will discover the fundamental difference between strong covalent bonds and weak hydrogen bonds. You will make models from K'Nex toy components and Velcro and then use the models in your investigation. All models are only representations of real items, so they are not identical. Keep this limitation in mind as you work through the activity.

**Prediction/Hypothesis**

If water molecules have two types of bonding, a model will show differences by

changing ______________________________________________ and measuring

*[INDEPENDENT VARIABLE]*

____________________________________________________________, I predict that

*[DEPENDENT VARIABLE]*

______________________________________________________________________.

*[Prediction of results. Be specific. Do not simply state that there will be an effect]*

Because ________________________________________________________________

______________________________________________________________________

______________________________________________________________________.

*[Scientific phenomenon to support your prediction. Cite evidence from your textbook.]*

**Procedures:**

You will need: K'Nex pieces: 14 3/4-in. rods, 7 spoked green connectors, 14 dark gray horseshoe-shaped connectors; 14 adhesive patches of black circular Velcro loop; 14 adhesive patches of white Velcro hook; large plastic container with lid; protractor.

1. Draw a Lewis structure of water below.

Adapted from Nature of hydrogen bonding, Schultz, Emeric. *J. Chem. Educ.* **2005** *82* 400A.

2. Make a K'Nex model of your step 1 structure: take a spoked green connector and add a rod to each of the two outermost connect points. Connect a dark gray horseshoe-shaped connector to each of the rods. What does each of these pieces represent?

3. At this point, your water-molecule model is incomplete because it does not show all of the electrons in a water molecule nor the polarity in the water molecule caused by the electronegativity difference between oxygen and hydrogen. Attach two circular adhesive patches of black loop (softer) Velcro to the model in the places where you would find the two pairs of unshared electrons on the oxygen atom in water.
4. Add two small adhesive patches of white hook Velcro to the hydrogen ends of the water molecule. It is easier to remove the backing and then cut the pieces to fit over the ends. Trim the pieces so they just cover the ends. You have now made a model of water that indicates its approximate polarity and shape.
5. Repeat steps 2–4 to make six more water-molecule models.
6. Place the seven water-molecule models in a large plastic container such as an empty five-quart ice cream bucket. Make sure the models are not touching each other. Gently swirl and shake the container so the models come into contact with each other.
7. Describe what you observe. Pick up the connected array of water-molecule models and spread it out on a flat surface without breaking the Velcro connections. Are there any connections that shouldn't occur? If so, how can they be explained in terms of limitations of the model and how it was built?

8. Return the connected array of water-molecule models to the plastic container. Place the lid on the container.

Adapted from Nature of hydrogen bonding, Schultz, Emeric. *J. Chem. Educ.* **2005** *82* 400A.

9. Shake the container vigorously for several seconds. Open the container and describe what you observe.

10. Repeat steps 6 though 8 two or three more times.
11. Connect the water-molecule models in a fixed pattern so that each of the Velcro patches on a central water molecule model is connected to a complementary Velcro patch on another water-molecule model.

**Analysis**

1. Using a protractor, measure the bond angle in the model. How does it compare to the actual bond angle in water?

2. What do these model parts represent: rods; black loop Velcro patches; white hook Velcro patches?

3. Between what two parts of this model are the model's representative hydrogen bonds formed?

4. What physical change is modeled when individual waters are allowed to connect to each other by gentle stirring?

5. What does vigorously shaking the container represent and what physical change of water is being modeled?

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6. What would have to change in the model for water to have had a chemical change? How would you do this? Could this change occur if you shook really hard? What does this suggest about the quantity of energy needed to break a hydrogen bond versus the energy needed to break a covalent bond?

7. Are the connections the same after each round of shaking and bringing the water molecules back together again?

8. How does this relate to the idea of equilibrium?

**9.** What state of water is modeled in step 10?

**Conclusion:**

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