Super Models

Chemistry of Water

Molecular Model Kit

Ryler Enterprises, Inc.

Recommended for ages 10 - adult.

Caution: Atom centers and vinyl tubing are a choking hazard. Do not eat or chew model parts.

Kit Contents:

13 red 4-peg oxygen atom centers (1 spare)
1 green 6-peg atom center (Cl^-)
1 silver 6-peg atom center (Na^+)
61 magnets (1 spare)
38-0.87" clear tubes for lone pairs (2 spares)
26-0.87" white tubes for H atoms (2 spares)

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ASSEMBLING THE WATER KIT

1. Place two white and two clear tubes on each of 12 4-peg, red oxygen atom centers (see Fig. 1).

Fig. 1 An assembled water molecule without magnets.

2. Push a cylindrical magnet into each white tube of each water molecule.

PLEASE MAKE SURE THAT ALL THE MAGNETS HAVE THE SAME N/S ORIENTATION. ONCE IN A TUBE, A MAGNET IS VERY DIFFICULT TO REMOVE WITHOUT DESTROYING THE TUBE.

3. Push a cylindrical magnet into each clear tube of the 12 water molecules.

PLEASE MAKE SURE THAT THE MAGNETS HAVE A N/S ORIENTATION OPPOSITE TO THE MAGNETS IN THE WHITE TUBES.

You might test the polarity of each magnet by seeing that it is attracted to a magnet in a white tube, before inserting completely.

4. Place six clear tubes on the pegs of the silver-sodium ion.

5. Place an unattached magnet on a magnet already inserted in a clear tube of a water molecule. This will insure the correct alignment of the magnet to be inserted into a clear tube of the sodium ion (see Fig. 2).

Fig. 2 Free magnet on clear tube.

6. Now insert the free magnet into a clear tube of the sodium ion (see Fig. 3).

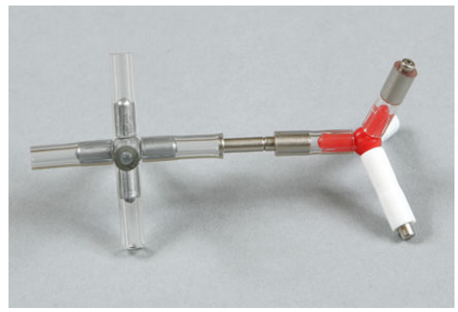

Fig. 3 Sodium ion before complete insertion of first magnet.

7. Repeat steps 5 and 6 five more times.

8. Place an unattached magnet on a magnet already inserted in a white tube of a water molecule (see Fig. 4).

Fig. 4 A free magnet on a white tube.

This will insure the correct alignment of the magnet to be inserted into a clear tube of the chloride ion.

9. Now insert the free magnet into a clear tube of the chloride ion (see Fig. 5).

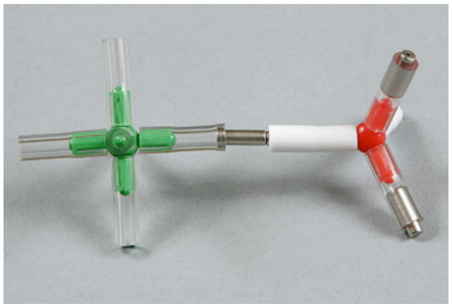

Fig. 5 A chloride ion before complete insertion of the first magnet.

10. Repeat steps 8 and 9 five more times.

LAB ACTIVITIES

A. How many drops of water can a penny hold?

1. Have each group of students write down an estimate of the number of drops of water that can be carefully delivered from a standard eyedropper (pipette) onto a penny. Have them make the estimate in terms of milliliters of water too.

2. After ten drops have been placed on the penny, have students make a new hypothesis concerning the possible amount of water which can be loaded onto the penny.

3. After 30+ drops have been successfully put on the penny, have the students explain the large amount of water which can be placed on the coin.

4. After drying the penny, students will smear a thin layer of dish soap on it. Step 1 is then repeated, and the new results are interpreted.

B. How do temperature and a surfactant (wetting agent) affect surface tension?

1. Students float a paper clip on water at room temperature. The procedure is repeated with water at as high a temperature as is comfortable and with water near freezing.

2. Students predict the effect of adding a surfactant to the water. After adding a few drops of liquid dish soap to the water samples, students attempt to float the paper clip again.

C. Why does water stick to itself and other materials: Tension and cohesion?

1. Test the cohesion property of water (the Coanda effect) by filling just the two end depressions in an ice tray with water. Red food coloring can be added for clarity (see Fig. 6). Then, very carefully and slowly, tilt the end of the tray with the water upright to a vertical position (see Fig. 7).

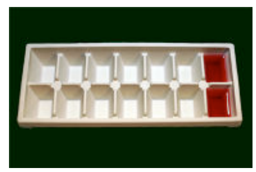

Fig. 6 Colored water in 2 depressions.

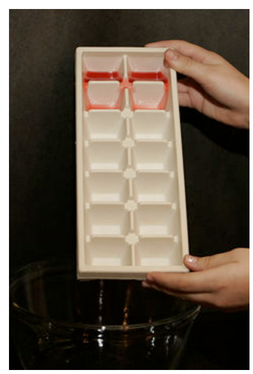

Fig. 7 Starting to tilt up the tray.

You should see the water move in and out of each depression as the flow continues to the bottom of the tray (see Fig. 8).

Fig. 8 The tray is vertical.

2. The cohesion of water can be modeled by attaching several water models to each other, and then suspending them in a chain.

3. To model the tension property, put the mass of the models on a vertical magnetic surface. Point out that there is an equilibrium between the tension force and the mass of the water that can be supported. This also explains capillarity. To show that water does not stick to all surfaces, repeat with a nonmagnetic surface.

D. How do plants move water from roots to great heights?

The Tension, Cohesion, Transpiration theory that explains how water is pulled to the tops of tall trees can be demonstrated as in section C-3 above.

E. Does water "wet" all surfaces? How will a surfactant, (detergent) affect wetting?

If water "creeps" along a surface, the water is said to "wet" the material.

1. Put a drop of water on a piece of wax paper: look for wetting. Add a drop of detergent to the water and observe again.

2. Put some water in a beaker. Insert a variety of materials (with flat surfaces if possible) into the water and look for wetting.

F. How do water molecules associate in the liquid state?

1. The simplest aggregate of water molecules would be bimolecular. Each group uses two water models, bonding them in as many configurations they can come up with. The following are illustrations of five of the 10 possible structures(see Fig. 9).

1 and 2 are "open", 3 is "cyclic", 4 is "bifurcated", and 5 is "triple H bonded".

1

2

3

4

5

Fig. 9 Five possible configurations for H bonding of two water molecules.

G. Which freezes faster, cold or hot water?

Students can test this controversial subject themselves at home. Discuss with them the procedure they will use. The cold water must not be near freezing (e.g. 0.9º C). Use two containers with the same volume of water to start.

H. Why does ice float?

This can be demonstrated with the water molecule models by bunching all 12 models together in one hand to simulate liquid water. Then six models can be bonded in a hexagon to show the open structure of ice, which is less dense than the liquid and hence floats.

I. How does water dissolve things?

1. First the sodium ion from the water kit is bonded (attracted) to the chloride ion.

2. Next, the hydrogen ends of five water molecules are attached to five pegs of the chloride ion, and five other water molecules have a lone pair of electrons bonded to the pegs of the sodium ion.

3. Now the sodium and chloride ions dissociate, and another water molecule bonds to each ion (see Figs. 10 and 11).

Fig. 10 A hydrated chloride ion.

Fig. 11 A hydrated sodium ion.

K. What does, " Like dissolves like," mean?

In procedure I, we saw polar water dissolving two charged species. In order to demonstrate water's inability to dissolve a nonpolar substance, anything that is not magnetic can be used; e.g., put all twelve water molecules in a glass beaker along with some glass marbles which will not be attracted to the magnets and will, therefore, fall to the bottom as a separate layer.

K. How does water move up a paper towel?

1. Compare the rates of movement of water into paper products of various kinds, and then examine the materials under a microscope. The papers with the more abundant and smaller interfiber spaces (capillary spaces) should have the fastest rates of movement of water.

2. Glass tubes with varying diameters can be compared on the basis of raising a column of water. The smaller the diameter, the higher the column. This is due to the equilibrium of the weight of the water and the tension force between the glass and the water (see C-3 above).

L. A good topic for discussion, debate, opinion poll, research paper, science fair project, etc.: Are any of the specialty bottled waters all that manufacturers claim them to be?

M. References.

1. www.lsbu.ac.uk/water/hbond.html
2. www.lsbu.ac.uk/water/anmlies.html
3. www.lsbu.ac.uk/water/explan4.html #mpemba
4. www.eurekalert.org/pub_releases/ 2004.04/sa-wmc040204.php
5. www.chemist.ca/ncw/experiments/
6, www.biologylessons.sdsu.edu/classes/ lab1/lab.html

7. http://enews.lbl.gov/ Then scroll down to "Water Fight."
8. www.chem1.com/acid/sci/aboutwater.html
9. www.randi.org Then do a search for Penta water.

A final word (from Mark Twain): "Whiskey is for drinking; water is for fighting over."