RESEARCH TRIANGLE NANOTECHNOLOGY NETWORK

Forces & Attractions: Falling Water

Overview

Students will be able to determine the forces at play in water molecules through different exercises pertaining to water and its adhesive properties. They will observe water accumulate on a penny and gather evidence as to why water is accumulating on the surface without overflowing. Once students grasp the concept of the demonstration, they will dive into their own activity. Students will be tasked with finding the item that can hold the most water without spilling whenever the sample gets flipped over. They will have three items: a test tube, a doll house teacup, and a bottle cap to test this. Once they have gathered their information on which of the three works best, they will complete a lab summary on the activity they have conducted.

Key Search Words

Chemical bonds, compounds, cohesion, surface tension, secondary science, elementary science, adhesion, polar, gravity, physical science

Learning Objectives

- Students can describe how ionic, covalent and metallic bonds form and provide examples of substances that exhibit each type of bonding.
- Students can explain the different types of forces at play within a molecule

Curriculum Alignment

NGSS Standard:

- ***HS-PS1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.***
- ***HS-PS-2 Communicates scientific and technical information about why the molecular-level structure is important in the functioning of designed practices.***

NC Essential Standard:

- ***PSc.2.2.2: Infer the type of chemical bond that occurs, whether covalent, ionic or metallic, in a given substance***

Classroom time required

- 60-90 minutes

Materials & Technology

Materials needed include resources used by both teacher and students, including books and websites, handouts, paper and pencils, art supplies, and so on.

- Pencil/Pen
- Paper
- Plastic pipette
- Science Journals
- Test tube(s)
- Small tea cups (Dollhouse tea cup set)
- Bottle caps
- 8-inch baking pan
- Pennies

Safety

- Students will be provided with safety glasses if requested in order for them to avoid getting any water in their eyes. They will also be offered the following PPE: lab aprons and gloves.

Teacher Preparation for Activity

- The teacher will need to make sure that their classroom is divided into small groups, as the materials will be spread evenly throughout the classroom. Materials need to be numbered and accounted for so that all students are able to participate in the activity.
- The teacher should have the video link of the second part of the activity up on the board for supporting instruction

Student Preparation for Activity

- Students should know the following terms when participating in the activity: polar, covalent bond, hydrogen bonding, hydrogen, elements, molecules, surface tensions, gravity, density, cohesion, and adhesion.
- Students should have gone over the different types of bonding that atoms undergo in a chemical reaction. They should be able to understand the concepts of friction, adhesion, cohesion, and surface tension as they relate to molecules.
- Students should have a refresher prior to the activity (hold a mini-lesson or review session before diving into the activity).

Procedure

- Step 1: Introduce the activity by posing a probing question to the students. The teacher will have a few coins and a pipette of water at hand. The teacher will place 5 drops of water on the penny and ask the students why the water is collecting on the surface of this penny (could be any type of coin). Ask the students, “If you kept adding water droplets to the penny, what would happen?” Most of them will answer that it will pour over the penny as it is metal and slippery. To their surprise, they find that the water did not spill over the penny.
- Step 2: Ask the students why the water is collecting on the surface of the penny. Students will then participate in a small group discussion section where they collaborate on what occurred. Have students find or explain their reasoning as to why they believe the water stayed (possibly remind them of the properties of water and how the molecule is structured).
- Step 3: Once all groups have shared their idea, have them do a round robin type of sharing, where they go to another group and share their ideas. Explain the properties of water and the adhesive nature of water. Water has an unseen force where it attracts other water molecules and does not want to let go, hence why we see water beads on top of certain surfaces like cars, houses, a leaf, coins, and more.
- Step 4: Once students have discussed their ideas and possibilities with different groups, have them return to their original groups. Students will be tasked with performing a similar activity of the one that was demonstrated. Students will have a bottle cap, a medium sized test tube (bigger than the one you had), and a small doll teacup.
- Step 5: Explain the challenge is to still login to see which one of the three items can hold the most water without overflowing. Each item has to be filled with water until full. Once they have filled their item with water, they are to test and see (over a bowl or something to catch the water) which item can hold the most water.
- Step 6: As the students conclude, have them write up a lab report or lab summary of the activity that was conducted. The lab report should be about a one page full length and written in the three paragraph format (introduction, body paragraphs, and conclusion). Students should provide different methods that could have been different in the activity.
- Step 7: As they are completing the lab reports, have students exchange them with someone in their group to perform a peer review. Once they have completed the peer reviews students can make changes to their lab reports.
- Step 8: Students turn in the lab report for a grade.

Differentiation

- English Language Learners- Provide some handouts through Canvas and make sure that the immersive reader and translation software is active.
- Academically Gifted Students- Have students draw out the molecular structure of the water molecules and illustrate what is occurring within the test tube or sample items. Have them identify where the bonds are holding together or being broken apart.
- Students with Learning Disabilities- Provide some extra supporting material (i.e., handouts of the vocabulary or pictures of water structure) to possibly help the students understand the content better. Also utilize student led small groups to assist.

Assessment/Check for Understanding

- Summative assessment- Students will be checked for understanding through the lab write-up they will perform at the end of the activity

Required resources

- Failing Test Tube (also found in the appendix)

Author comments

- *Please try the activity out for yourself and feel free to try different items than the ones described above. There are multiple ways in which this activity can be performed.*

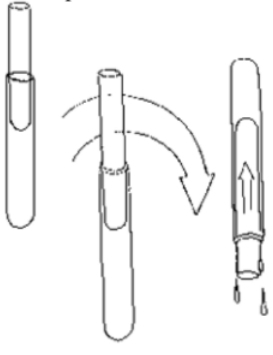
Sources

- ncnaturalsciences. (2020, July 29). *Science at home: Gravity-Defying Water Experiment*. YouTube. Retrieved June 29, 2022, from https://www.youtube.com/watch?v=ozHDhqab0g8
- Mid-Continent Research for Education and Learning. (2012, January). Falling Test Tubes.

Appendix

6. FALLING TEST TUBES

Description:



Two glass test tubes and water are used to create a discrepant event demonstrating adhesion and cohesion.

Science process skills:

1. observation
2. inference
3. prediction

Complex reasoning strategies:

1. induction

Standards:
K-4:

- Employ simple equipment and tools to gather data and extend the senses (Standard A.1.3).
- The position of an object can be described by locating it relative to another object or the background (Standard B.2.1).
- An object's motion can be described by tracing and measuring its position over time (Standard B.2.2).

5-8:

- Unbalanced forces will cause changes in the speed or direction of an object's motion (Standard B.2.3).

9-12:

- The physical properties of compounds reflect the nature of the interactions among its molecules (Standard B.2.4).

Above Standards from the National Science Education Standards.

Content topics:

1. adhesion
2. cohesion
3. molecular attraction
4. surface tension

You will need:

1. a large glass test tube
2. a smaller glass test tube
3. water
4. a pan or bucket

Instructions:
Glass test tubes work best for this activity. It does not matter what size test tubes are used. However, the smaller test must *just fit* into the larger tube. You may need to try different combinations of sizes to determine which pair works best.

Make certain the test tubes are clean, especially free of soap or detergent. Fill each test tube full with water. Holding both over the catch pan, lower and release the small test tube into the larger. Invert the larger tube. The smaller test tube does not fall out. Instead, water drips out of both tubes and the smaller tube rises up into the larger tube, seeming to defy gravity!

While rehearsing this activity, you may need to vary the amount of water in either tube to improve results. You may need to adjust the amount of water placed in the smaller tube if it sinks rather than floats on the water in the larger tube. Ideally, the smaller tube will float half way out of the larger tube.

To prevent breakage, you may want to place a sponge or some paper towels in the catch pan in case the small tube falls.

Presentation:

When presenting this activity, proceed at a moderate rate. Allow plenty of time at each step of the activity to elicit questions and model analytical thought.

Pour the established amount of water into each test tube. Before lowering the smaller into the larger, elicit predictions from your students. When they offer predictions, ascertain on what experiences they base their prediction (lowering themselves into a bathtub).

Inform students that you are going to invert the test tube system. Elicit predictions.

Before inverting the tubes, allow students to make careful observation of the two tubes. Some might notice a "bulge" of water around the lip of the larger tube. Ask students if that bulge of water has any significance. Might it give a clue to what is going to happen when the tubes are inverted? (It does.)

Slowly, but without hesitation invert the tubes. The smaller should rise up into the larger tube. Ask students to explain the discrepant event. Suggest that they use drawings to indicate all of the forces involved (gravity, adhesion, cohesion, air pressure, etc.).

Reinforce to your students that experience, very careful observations, and analytical thinking provide a basis for good predictions.

Content:
The polar nature of water molecules causes them to be attracted to each other. That is why water forms beads, drops, and the skin on the surface of a pool of water called surface tension. This type of intermolecular attraction is called cohesion.

An attraction between dissimilar types of molecules, such as glass and water, is called adhesion. Both forces are responsible for the bulge of water hanging out over the edge of the glass lip on the test tube.

The bulge is an indicator that there is an attraction between the water and the glass, and the water and itself. In this case, the attractive forces are stronger than the pull of gravity.

Assessment:
Type: small group or individual.
Content/Process: Surface tension (#1), adhesion, cohesion, and surface tension (#2).
Age/Level: all.

#1: Fill a small glass with water until it is full to the brim. Kneel and look at the top of the glass to assure that the water is filled to the top. Predict how many pennies you can drop into the glass before the water runs over. Record your prediction. Add one penny at a time to the glass. Carefully slide it in from the edge. Observe the glass from the side as you add more pennies. Draw the water in the glass at the beginning, after several pennies, and at the end. Record the number of pennies added until the water runs down the side. Describe what happened to the water as more pennies were added. What properties of the water allowed you to add so many pennies before the water spilled out? What gives water these properties?

Assess this concept based on the age of the child. The elementary student should discuss the rounded shape of the surface of the water and that water sticks together at the surface. Older students should discuss the polarity of the water molecule that gives water this characteristic.

#2: These three concepts are at play as water moves up the xylem of a plant. Following a study of plant physiology, students should use these terms along with transpiration to describe how water moves from the root of the plant out the leaf.

Notes: