The Shape of an Ice Cube Affects Rate of Melting

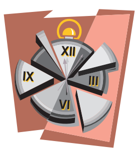
Topic

The shape of a mass of ice affects the rate at which it melts.

Introduction

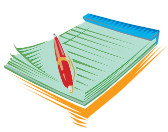
When you ask for a soft drink or glass of water at a restaurant, you expect to find ice in the beverage. Ice cools drinks by absorbing some of the heat they contain. As a result of this transfer of heat, the ice melts. Once all of the ice in a beverage has melted, the temperature of the drink rises until it reaches room temperature. Very small pieces of ice will cool a drink quickly, but they also melt quickly. Large pieces of ice do not chill a drink as rapidly as small ones, but they will remain frozen for a longer period of time. The more slowly an ice cube melts, the longer it will keep a drink cool.

Ice cubes are simply small pieces of water in the solid form. When water is cooled below its freezing point (32 degrees Fahrenheit [°F] or 0 degrees Celsius [°C]), it crystallizes into ice. As with all liquids, water takes the form of the container in which it is placed. Therefore, ice cubes can easily be formed into many different shapes and sizes. In this experiment, you will test ice cubes made from the same volume of water in different shapes to determine if shape affects rate of melting.



Time Required

15 minutes on day 1
overnight for ice cubes to form
60 minutes on day 2



Materials

- 300 milliliters (ml) distilled water
- graduated cylinder

- access to a freezer
- 6 different small plastic molds (for making shaped ice cubes or gelatin)
- plastic wrap
- 6 small bowls
- 12 labels
- waterproof labeling pen
- graph paper
- science notebook

Safety Note **Please review and follow the safety guidelines.**

Procedure, Day 1

1. Measure 50 ml of distilled water. (The volume can be altered depending on the size of the plastic molds, as long as it is constant for all molds.)
2. Pour the water into a plastic mold, ensuring that none spills.
3. Cover the mold with plastic wrap.
4. Repeat steps 1 through 3 with the remaining 5 molds. Label each mold with a letter (A through F).
5. Place the molds in the freezer and allow them to solidify overnight. Be careful not to spill any water while transporting the molds.
6. Answer Analysis questions 1 and 2.

Procedure, Day 2

1. Label the six bowls with a letter (A through F).
2. Remove the molds from the freezer.
3. Remove each ice cube from its mold by turning it upside down over the bowl labeled with the corresponding letter. Press gently on the bottom of the tray until the ice cube pops out.
4. After all of the ice cubes are placed in their bowls, record the experiment “Start time” on the data table.

5. Allow the ice cubes to melt completely. After an ice cube has melted completely, record the time on the data table.
6. Answer Analysis questions 3 through 8.

Data Table

Ice shape	Start time	Finish time	Time required to melt (Finish time – Start time)
A			
B			
C			
D			
E			
F			

Analysis

1. Which shapes did you choose for your ice cubes?
2. Write a hypothesis predicting which of your ice cubes will melt the fastest and which one will melt the slowest. Justify your choices.
3. Which ice cube melted first? Last?
4. Create a bar graph comparing the amount of time (in minutes) it took for each ice cube to melt completely.
5. What factors do you think affected the speed at which the ice cubes melted?

6. Why was it important to use the same volume of water in each mold?
7. If you were going to produce a type of ice cube that would be advertised as "the slowest melting ice cube," what shape would it be?
8. Describe some sources of error in this experiment that may have affected your experimental results.

What's Going On?

The rate at which ice melts depends on the ratio of its *surface area* to its volume. The surface area of an object is the amount of area that is exposed to the outside atmosphere. The surface area of a regular-shaped object can be found by adding the areas of each side of the object. All the ice cubes in this experiment had the same volume, so the rate of melting depended solely on the surface area of each cube. An ice cube with a small surface area will remain frozen for a longer period of time than one of the same volume with a large surface area.

Ice melts because it absorbs heat from its surroundings. When solid water absorbs heat energy, the water molecules begin moving. This motion dislodges the molecules from their solid crystalline form (see Figure 1). Therefore, there is a direct relationship between the number of molecules exposed to warm air or water and the rate at which heat is absorbed.

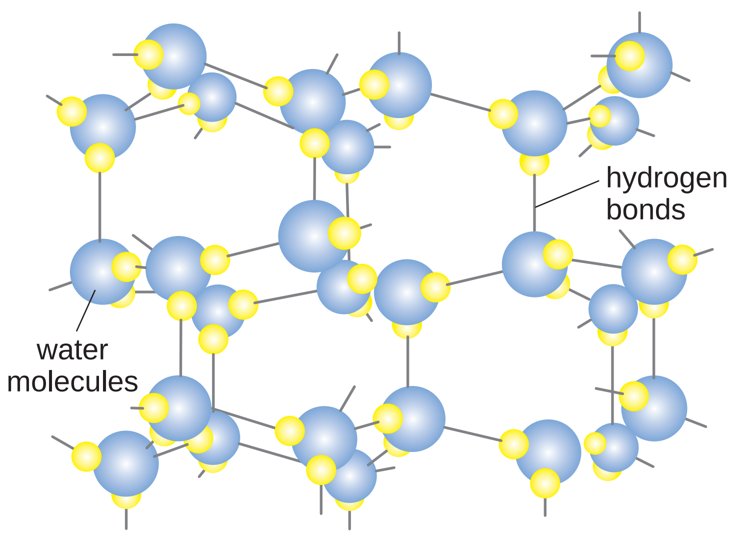


Figure 1

Crystalline form of ice

Connections

Water is continuously recycled on Earth through a series of events known as the *water cycle* (see Figure 2). Water *evaporates* from the land and surface water, *condenses* in the air to form clouds, then falls as *precipitation*. Most of the water on Earth is saltwater, leaving only 3 percent freshwater, the water on which all living things rely. Three-quarters of the freshwater is frozen as polar ice, thick sheets found at the north and south poles. At the north pole, floating pack ice covers about 108 million square feet (million ft^2) (10 million square kilometers [million km^2]). Antarctica, the land mass at the south pole, is covered by a thick ice sheet that covers about 151 million ft^2 (14 million km^2) of ice. Despite the fact that these regions are gigantic, very old, tightly packed masses of ice, they have been melting in recent years due to increased global temperatures. Thickening layers of carbon dioxide and other *greenhouse gases*, the products of fossil fuel combustion, are trapping heat near the Earth and raising air and water temperatures.

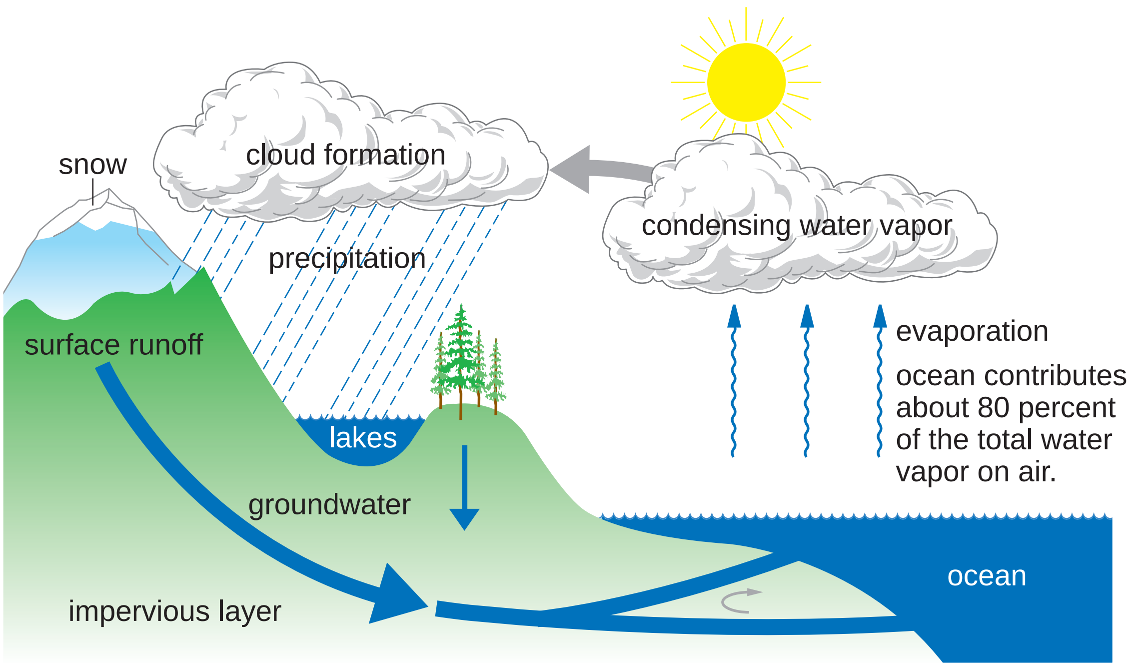


Figure 2

The water cycle

Want to Know More?

See Our Findings.

OUR FINDINGS

THE SHAPE OF AN ICE CUBE AFFECTS RATE OF MELTING

Idea for class discussion: Ask two or three students to sketch the shape of “ice cubes” on the board. Shapes might include true cubes, cylinders, and crushed particles. Discuss the reasons for making cubes in different shapes.

Analysis

1. Answers will vary. Students should describe the six different shapes that were chosen for their ice molds.
2. Answers will vary. Students should choose the ice cube shape they believe will melt the fastest and the one that will melt the slowest. Students should justify their answers.
3. Answers will vary based on shapes chosen and experimental results.
4. Graphs will vary. Student graphs should be labeled and include a bar that represents each shape of ice cube and the time that it took for that shape to melt completely.
5. Answers will vary. Possible factors include a thin shape, several projections or intricate patterns, or an increased surface area.
6. The same volume should be used for each sample so that the shape will be the only experimental factor. All other variables should be kept constant.
7. A spherical shaped ice cube would have the lowest surface-area-to-volume ratio and would therefore melt the slowest.
8. Answers will vary. Possible sources of error include spilling water, not being able to determine when the ice had melted completely, and touching the ice cubes as they were melting.

SAFETY PRECAUTIONS

Review Before Starting Any Experiment

Each experiment includes special safety precautions that are relevant to that particular project. These do not include all the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read and remain mindful of the General Safety Precautions that follow. Experimental science can be dangerous, and good laboratory procedure always includes following basic safety rules. Things can happen very quickly while you are performing an experiment. Materials can spill, break, or even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following the basic safety guidelines during the entire experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. For one reason, we want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical.

Read the safety precautions here and at the beginning of each experiment before performing each lab activity. It is difficult to remember a long set of general rules. By rereading these general precautions every time you set up an experiment, you will be reminding yourself that lab safety is critically important. In addition, use your good judgment and pay close attention when performing potentially dangerous procedures. Just because the book does not say "Be careful with hot liquids" or "Don't cut yourself with a knife" does not mean that you can be careless when boiling water or using a knife to punch holes in plastic bottles. Notes in the text are special precautions to which you must pay special attention.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking an unnecessary risk can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the individual experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone. When you are working off-site, keep in groups with a minimum of three students per groups, and follow school rules and state legal requirements for the number of supervisors required. Ask an adult supervisor with basic training in first aid to carry a small first-aid kit. Make sure everyone knows where this person will be during the experiment.

PREPARING

- Clear all surfaces before beginning experiments.
- Read the instructions before you start.
- Know the hazards of the experiments and anticipate dangers.

PROTECTING YOURSELF

- Follow the directions step by step.
- Do only one experiment at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure there is adequate ventilation.
- Do not horseplay.
- Keep floor and workspace neat, clean, and dry.
- Clean up spills immediately.
- If glassware breaks, do not clean it up; ask for teacher assistance.
- Tie back long hair.
- Never eat, drink, or smoke in the laboratory or workspace.
- Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult.

USING EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives or other sharp-pointed instruments with care.

- Pull plugs, not cords, when removing electrical plugs.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.
- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use alcohol-filled thermometers, not mercury-filled thermometers.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read labels carefully.
- Avoid chemical contact with skin and eyes (wear safety glasses, lab apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING SUBSTANCES

- Wear safety glasses, apron, and gloves when boiling water.
- Keep your face away from test tubes and beakers.
- Use test tubes, beakers, and other glassware made of Pyrex™ glass.
- Never leave apparatus unattended.
- Use safety tongs and heat-resistant gloves.
- If your laboratory does not have heat-proof workbenches, put your Bunsen burner on a heat-proof mat before lighting it.
- Take care when lighting your Bunsen burner; light it with the airhole closed, and use a Bunsen burner lighter in preference to wooden matches.

- Turn off hot plates, Bunsen burners, and gas when you are done.
- Keep flammable substances away from flames and other sources of heat.
- Have a fire extinguisher on hand.

FINISHING UP

- Thoroughly clean your work area and any glassware used.
- Wash your hands.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Do not dispose of materials in the sink unless instructed to do so.
- Clean up all residues and put them in proper containers for disposal.
- Dispose of all chemicals according to all local, state, and federal laws.

BE SAFETY CONSCIOUS AT ALL TIMES!