

HOUSEHOLD CHEMISTRY

INSULATION

INTRODUCTION:

If you want to enjoy your favorite cold drinks on a hot day at the beach, you need to think about keeping them cold for a long time. You might have a cooler or an icebox. What if you don't? You can insulate or protect your drinks from heat by using insulators. The same principle is used when homes are insulated. Insulation helps keep the house warm during cold seasons and cool during hot seasons and greatly helps to save energy used to warm or cool the house (gas heater, central or portable AC).

QUESTION:

What is the best insulator: cotton, foil, or air?

LEARNING OBJECTIVES:

- Understand what an insulator is and what insulate means.
- Describe how natural materials differ in their insulating ability

PERSONAL PROTECTIVE EQUIPMENT:

- Goggles/eye protection

MATERIALS:

- Three small plastic cups to freeze water (aka ice cups);
- three empty plastic cups of the same size or slightly bigger to insulate the ice cups (aka insulating cups);
- three big plastic cups to hold warm/hot water (aka baths). These can be replaced with Ziplock bags of appropriate size.
- insulators (cotton, aluminum foil, air or vegetable oil);
- toothpicks, scissors, marker
- measuring cup (optional: kitchen scale). If none of these is available, have additional three plastic cups of the same size to measure the volume of melted ice)
- protective wear
- timer (you can use the stopwatch function on a smartphone)

PROCEDURE:

Preparing the ice (overnight for complete freezing and about 30 min for the rest).

Take three small-size transparent cups. Fill one cup approximately to a half level with cold tap water. Draw a line with a marker to indicate the volume. Pour the water into the next cup. Fill the first cup with water up to the marker line, fill the third cup. Fill the first cup with water till the line. By doing so, you will get the same amount of water in each cup. Alternatively, you can use a measuring cup to pour water into each of the cups.

Place the plastic cups in your freezer overnight. Note: it takes 6 hours for the water to freeze completely.

PROCEDURE CONTINUED:

Preparing the baths for the test (5-10 min): Take one of the big plastic cups (which will serve as baths), fill it with a bit of tap water, place one of the cups with ice, put it in the big cup. The water level in the outer cup shall be slightly above the ice in the inner cup. By doing so, you ensure that the ice is in contact with water. You might need to pour out or add some water. Take out the ice cup, wipe it off, and put it back in the freezer. Mark the level of water in the bath with your marker. Pour this water into the next bath cup, draw a marker line to indicate the water level. Repeat for the third cup. Pour the water out. Now you can be sure that each bath will have the same volume of water.

Preparing the insulators (20-35 min; up to 1-2 hours if the ice melted during the preparation): Take additional three plastic cups to prepare your insulators. It is the trickiest part to prepare the cotton and foil insulators. Do it ahead of time. Once the water is frozen in your ice-cups, take one at a time to insulate it and put it back in the freezer immediately.

Cotton: Put a piece of cotton at the bottom of the first empty plastic cup (the insulating cup). Cover the ice cup with small pieces of cotton. Tuck in all sticking cotton pieces with a toothpick. Put it back in the freezer.

Aluminum foil: Put a piece of foil at the bottom of the second insulating cup. Wrap the second ice cup with one layer of aluminum foil and insert it in the insulating cup. Put in freezer.

Note: If the ice melted during these preparatory steps, you might need to refreeze the cups for an hour or two to start the actual experiment.

Air: Insert the third ice cup into the empty plastic cup.

Vegetable Oil (an additional insulator): Fill the remaining empty insulating cup by $\frac{1}{6}$ with vegetable oil, insert the ice cup. Ensure that the level of oil in the outer cup is at the same level or slightly above the ice level in the inner cup. If needed, you can add more oil. Make the fourth bath using the same approach as before.

Testing three insulators (30-45 min): Once you have prepared everything and made sure that no ice melted, you can proceed to the actual experiment. Fill all three baths with hot tap water. Alternatively, you can fill a thermos with the hot tap water and then pour the water from the thermos in the baths up to the marked level. Take out your ice cups along with the insulating cups from the freezer. Place the third ice cup in the remaining empty insulating cup (insulator air). Insert these cups in the baths. Start the stopwatch. Check every 15 min whether the ice melted. Notice in which cup the ice started to melt first. After your final check (20-30 min), pour the water from the first ice cup to your measuring cup and record the volume. Pour the water out, dry the cup. Repeat for the remaining cups. Alternatively, you can pour the water from the ice cups into empty plastic cups of the size and visually estimate which cup has more water.

Which cup has more water? What does it mean?

Which insulator was the most effective? How can you tell?