

Activity 7.5

Changing the density of a liquid—Heating and cooling

Is there a difference in density between hot and cold water?

In *Activities 7.3* and *7.4*, students saw that different liquids have different densities. In this activity, students will investigate whether the temperature of water affects its density. Students will place colored hot and cold water in a cup of room-temperature water to see that cold water sinks while hot water floats. Then they will use this experience to suggest how colored hot and cold water should be stacked to prevent mixing.

Materials needed for each group

| | |
|----------------------------|----------------------|
| Room-temperature water | 2 Droppers |
| Hot water (colored yellow) | 2 Clear plastic cups |
| Cold water (colored blue) | 2 Small cups |

Materials needed for the demonstration

| | |
|------------------------|---------------------------------|
| Room-temperature water | Water-resistant card |
| Hot water | 2 Small jars |
| Cold water | Coffee stirrer, straw, or spoon |
| Yellow food coloring | Paper towels |
| Blue food coloring | |

Notes about the materials

- Be sure you and the students wear properly fitting goggles.
- Either use a single playing card from a deck of cards or laminate an index card. The water-resistant card should completely fit over the opening of the jars.
- Be sure that the two jars have exactly the same-sized openings so that one jar can be inverted on top of the other with no gaps.



Preparing materials

- Label one small cup **hot water** and another **cold water**.
- Place one drop of yellow food coloring in the cup labeled “hot water”.
- Place one drop of blue food coloring in the cup labeled “cold water”.
- Immediately before distributing to students, place 2 tablespoons of hot and very cold water into the labeled cups.
- You may wish to practice the demonstration a couple of times before demonstrating for students.

Activity sheet



Copy *Activity sheet 7.5—Changing the density of a liquid—Heating and cooling*, pp. 424–426, and distribute one per student when specified in the activity.

Assessment

An assessment rubric for evaluating student progress during this activity is on pp. 437–439. For this formative assessment, check a box beside each aspect of the activity to indicate the level of student progress. Evaluate overall progress for the activity by circling either “Good”, “Satisfactory”, or “Needs Improvement”.

Activity 7.5

Changing the density of a liquid—Heating and cooling

Question to investigate

Is there a difference in density between hot and cold water?

1. Discuss with students their ideas about whether heating and cooling can affect the density of a substance.

Ask students if anyone has ever noticed that water at the bottom of a lake feels colder than water at the surface. Ask students if this temperature difference—warm water near the surface and cooler water down below—might have something to do with density. Since student experiences suggest that warm water floats on cooler water, maybe different temperatures of water have different densities and can form layers.

2. Have students place colored hot and cold water in colorless room-temperature water.



Distribute *Activity sheet 7.5—Changing the density of a liquid—Heating and cooling.*

Procedure

1. Fill 2 clear plastic cups about $\frac{2}{3}$ of the way with room-temperature water.
2. Fill one dropper with cold water colored blue. Poke the end of the dropper a little beneath the surface of the colorless room-temperature water. While observing from the side, gently squeeze the dropper so that the cold water slowly flows into the room-temperature water.
3. Fill another dropper with hot water colored yellow. Poke the end of the dropper a little beneath the surface of the room-temperature water. While observing from the side, gently squeeze the dropper so that the hot water slowly flows into the room-temperature water.
4. In a separate cup of room-temperature water, push a dropper filled with hot yellow water to the bottom of the cup. While observing from the side, gently squeeze so that the hot water slowly flows into the room-temperature water.
5. Push a dropper filled with cold blue water to the bottom of the cup. While observing from the side, gently squeeze so that the cold water slowly flows into the room-temperature water.
6. Record your observations on the activity sheet.



Expected results:

Liquids placed just beneath the surface:

- The cold blue water will flow down and collect at the bottom of the room-temperature water.
- The hot yellow water will collect at the surface.

Liquids placed at the bottom:

- The hot yellow water will flow up and collect at the surface.
- The cold blue water will collect at the bottom of the cup.

3. Discuss student observations.

Ask students questions such as the following:

- What does your experiment say about the relative densities of hot, room-temperature, and cold water?
- Based on your observations, would you expect equal volumes of hot, room-temperature, and cold water to weigh the same?
- Which temperature of water would you expect to weigh the most?
- Which would you expect to weigh the least?
- Which would you expect to weigh somewhere in between?

Cold water is the most dense, hot water is the least dense, and room-temperature water is somewhere in-between. The weight of equal volumes of hot, room-temperature, and cold water is slightly different. Although these measurements are very difficult to make in a classroom setting, hot water weighs less than room-temperature water, and cold water weighs more than room-temperature water.

Demonstration

4. Do a demonstration to highlight the difference in density between hot and cold water.

Tell students that you are going to try to place one jar filled with colored water upside down over another one and that you want the colors to stay separate. Ask students if you should use hot and cold water to do this, or if the temperature of the water doesn't matter. Then ask students which temperature of water should be on the top and which should be on the bottom to improve the chances of the colors staying separate.

Procedure

1. Completely fill a baby food jar with hot tap water and 2 drops of yellow food coloring.
2. Completely fill another baby food jar with very cold water and add 2 drops of blue food coloring. Stir the water in both jars so that the coloring is well-mixed in both. Place the cold water jar on a paper towel.
3. Hold a water-resistant card, like a playing card or a laminated index card, over the top of the hot water jar.
4. While holding the card against the jar opening, carefully turn the jar upside down.
5. With the card still in place, position the jar of hot water directly over the jar of cold water so that the tops line up exactly.
6. Slowly and carefully remove the card so that the hot water jar sits directly on top of the cold water jar.



Expected results: Although removing the card may result in some mixing, for the most part, the hot yellow water will remain in the top jar and the cold blue water will remain in the bottom jar.

Ask students to predict what would happen if you placed the cold blue water on top of the hot yellow water and then removed the card. Use the same procedure as above, but place the jar of cold water upside down over the jar of hot water. The colors will immediately mix, resulting in green water throughout.