Lesson Plans: Air Density and Temperature

Objective

The objective of this activity is to investigate the effect of temperature on the density of air.

Materials

Each group of students will need the following:

- Balloon
- Empty 375- or 750-milliliter glass soft drink bottle
- Bucket of ice water
- Bucket of hot water
- Safety goggles for each student

Important Points to Understand

- Density is defined as follows and expressed in kg m-3 generally: Density = Mass/Volume
  As the temperature of a given mass of air increases, its volume increases (i.e., thermal expansion) and its density decreases. As the temperature of a given mass of air decreases, its volume decreases and its density increases.
- Less dense air rises relative to surrounding air. More dense air sinks relative to surrounding air.

Preparation

Aside from securing sources of hot and cold water, no special preparations are required for this activity. However, to be safe, everyone involved should wear safety goggles during this activity. It is not essential that the bottle be of the volume specified in the Materials List. Smaller and larger bottles will also work. What is important is the size of the opening. It must be small enough for the balloon to be placed over it. Plastic bottles should not be used, however, as t hey can deform under sudden temperature changes, perhaps confusing students and reducing the response of the balloon.

Procedure

Trial 1

1. Place the uncovered bottle in the bucket of hot water for three minutes. Do not submerge the bottle or allow water to get into the bottle. You will probably have to hold it in place to keep it upright.
2. Place the balloon over the mouth of the bottle. You have now isolated a mass of air. It is important to remember throughout this trial that the amount, or mass of air will remain constant. In the table marked "Trial I Predictions," suggest what will happen to the balloon when the bottle is placed in a bucket of ice water. Explain your prediction.
3. Before you continue, note that there is a small chance the bottle may break when placed in the ice water. Everyone should be wearing safety goggles. Place the bottle in the bucket of ice water. In the table marked "Trial I Explanation," describe what happens. Remembering that the mass of the air has remained constant, explain what has changed.

Trial 2

1. Take the balloon off the bottle and place the bottle back in the bucket of ice water for three minutes. Do not submerge the bottle or allow water to enter it.
2. Place the balloon over the mouth of the bottle. As in Trial 1, you have isolated a mass of air. Again, it is important to remember throughout this trial that the amount, or mass, of air will remain constant. In the table marked "Trial 2 Prediction," suggest what will happen to the balloon when the bottle is placed in a bucket of hot water. Explain your prediction.
3. As with Trial 1, there is a small chance that the bottle may break when placed in the hot water. Everyone should be wearing safety goggles. In the table marked "Trial 2 Explanation," describe what happens when the bottle is placed in the hot water. Remembering that the mass of the air has remained constant, explain what has changed.

Trial	Prediction	Explanation
1		
2		

Questions

1. What are the two characteristics (or variables) of air that are being changed in this activity? State the relationship between these two characteristics.
2. As air is heated, what happens to its density? In other words, did the molecules of air move closer together or farther apart?
3. As air is cooled, what happens to its density? In other words, did the molecules of air move closer together or farther apart?
4. In the atmosphere, what would you expect to happen to air that is warmed? Or cooled?
5. Based on your observations and your answers to these questions, do you think it would be best to place a warm-air vent near the floor or the ceiling of a room? Where would you place an air conditioning vent (not reverse cycle)? Explain your answers.