“The Fireproof Balloon Demonstration”
Teacher’s Guide
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Chemical Concepts Addressed

The “Fireproof Balloon Demonstration” emphasizes the relatively high heat capacity and specific heat of water as compared to those of air. Water placed inside a balloon will absorb the heat from a candle flame preventing the balloon from popping.

How Demonstration Addresses Chemical Concepts

The “Fireproof Balloon” is a simple and safe inquiry-based demonstration that challenges the students to explain why the instructor-filled balloon does not pop over a lit candle while student-filled balloons do. The 25 mL of water placed in the instructor’s balloon prior to the demonstration will absorb sufficient heat from the candle flame such that it will not allow the latex to melt and the balloon to pop. The heat capacity of a 25 gram sample of water (in the bottom of a 1 liter air-filled balloon) is approximately 100 times greater than the heat capacity of a 1 liter air-filled only balloon. (See calculations in last section of Teacher’s Guide.)

Guide to Preparing and Performing Demonstration

Advance Preparation

Obtain the following prior to the demonstration:

1) pack of black latex (party) balloons (9 inches or larger)
2) small candle (recommend votive candle which is not easily knocked over)
3) small ring stand and ring (approximately 6 inches in diameter)
4) plastic cup filled with water
5) graduated cylinder
6) platter or flame proof board
7) igniter

Safety Equipment:

1) fire extinguisher
2) safety glasses or goggles (optional)

Open the pack of balloons and place 25 mL of water in one of the balloons. Place the balloon back in the pack such that the water does not spill out and the instructor can easily remove the balloon by its neck. Place the platter or flame proof board on the demonstration table or bench. Place the ring stand on the platter, and set the candle on the ring stand platform. The ring is placed above the candle such that the flame is approximately 1 inch from the bottom of the balloon when it is set on the ring.

Performing the Demonstration

The demonstration requires audience participation and interaction.

1. Challenge the audience by saying there will be a competition to see whose filled balloon will last the longest (without popping) over a lit candle.
2. Choose two "cool" students to challenge you, the "coolest" teacher.
3. Ask the two participants from the audience to come up front.
4. Open the pack of balloons, the instructor picking the first balloon, which has the 25 mL of water previously placed in it.
5. Hold the balloon by the neck so that the main body of the balloon and mass of the water is concealed in the palm of your hand.
6. Then have each student select a balloon.
7. Teacher and students blow their balloon up to equal size (8-10 inches in diameter) and tie the end of their balloon with a knot.
8. Light the candle that is on the ring stand platform.
9. Place each student's balloon on the ring. They will pop very quickly. The audience can be the judge of the competition and count how long it takes for the balloons to pop.
10. Place your balloon on the ring. It should not pop for about 2-5 minutes.
11. Ask the students to explain the results. Why is the teacher the "coolest"? Results can be related to properties of water in the balloon, especially its high heat capacity.

Disposal:

There are no disposal hazards in this demonstration.

<u>How Demonstration Fosters Learning and Understanding of Concept</u>

The demonstration is normally done after we have discussed heat exchange, specific heat, and heat capacity in lecture. After the demonstration, the students are asked to explain why the teacher's balloon didn't pop. If there are no responses, the teacher can ask what he/she may have done to the balloon in advance of the demonstration. Students may suggest a variety of possibilities and someone usually comes up with the idea of adding water. The presence of the water (with a high heat capacity) allows the heat from the flame to be absorbed by the water and not cause the rapid breaking of the latex balloon.

It is of interest to note that the specific heat of water (4.18 J/g ^{o}C) is only about 4 times that of air (1.00 J/g ^{o}C). This relatively small difference could not explain the results of the teacher's balloon remaining intact versus the students' balloons rapidly popping. The difference in the heat capacities of the water and of the air in the balloons is the relevant factor and some approximate comparisons can be made. Let's first consider that the total volume of each balloon is 1.0 liter. For the teacher's balloon, if we assume the heat could be absorbed by the 25 mL of water, than what is its heat capacity? It would be:

$$(25\ \text{ml}\ H_2O)(1.0\ \text{g}\ H_2O/\text{mL}\ H_2O)(4.18\ \text{J/g}\ ^oC) = 104\ \text{J}/^oC.$$

For the student balloons, if we assume the heat could be absorbed by the 1.0 liter of air (due to its kinetic energy and movement within the balloon), than what is its heat capacity? It would be:

$$(1.0\ \text{L air})(1.2\ \text{g air/L})(1.00\ \text{J/g}\ ^oC) = 1.2\ \text{J}/^oC.$$

The calculations show that, in fact, the balloon with the 25 mL of water in it has an approximately 100 fold greater heat capacity. Therefore, the water absorbs the heat energy from the flame with a smaller increase in temperature than the air would. The lower temperature change of the water keeps the temperature below the melting point of the balloon preventing it from popping. This approach demonstrates the difference between specific heat of a material and its heat capacity, which is dependent upon the mass of material present.

Variations:

1. The balloon containing the water may be heated on the side to note what happens. This could be done by placing the demonstration over a trash can or bucket to collect the water.
2. For added fun, ask the participants to choose (from a selection of weird hats) and wear the "coolest" hat before blowing up the balloons. The teacher will inevitably end up wearing the "corniest" hat.
3. An additional demonstration can be done to show how water can be boiled in a paper cup.

* Constants (specific heat and densities were found in the ***CRC Handbook of Chemistry and Physics***.

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