Lab Handout

Lab 5. Design Challenge

Which Design Will Cool a Soda the Best?

Introduction

Many chemical processes are accompanied by a change in temperature of the substances involved. These temperature changes occur because energy is either released or absorbed during the process. When energy is released during a chemical process, the process is exothermic. Think about a hand warmer pack that you might place in a glove on a cold day. A chemical reaction is taking place inside the pack, which releases energy that is absorbed by your hand and warms them up. Other chemical processes need to absorb energy to occur; these processes are endothermic. Cold packs inside a first aid kit are a good example of an endothermic process. The pack is normally at room temperature, but shaking it up activates it, and the chemicals inside are allowed to mix together and they get very cold. The cold pack feels cold because it must absorb energy from its surroundings to help the chemicals dissolve together. The energy the cold pack absorbs is coming from your hand and the air, and because energy is leaving your hand, your hand gets cold.

FIGURE L5.1

Cardboard sleeves on coffee cups act as insulators to slow the transfer of energy from the hot beverage to our hand.

Endothermic and exothermic processes are common, but sometimes it is necessary to control the flow of energy during these processes. Substances called insulators slow down the transfer of heat energy. Insulation in the walls and ceiling of homes is used to keep a home warm for longer on a cold winter day. The same insulation also helps keep the inside of the home cool on a hot summer day. Some materials work very well as insulators, but others do not. Styrofoam is a good insulator and is often used to keep hot drinks warm, such as coffee (see Figure L5.1), but it is also used to keep other drinks cold, such as soda. Engineers often have to investigate how much insulation to use for different products so that they can regulate the amount of thermal energy that transfers into or out of a system, so they can design a quality product.

Your Task

Use what you know about chemical reactions, thermal energy, and how energy flows into and out of a system to design a product that will help to cool a can of soda (or other beverage) by using a chemical reaction. The structure and function of your design should

be related in a way that causes the drink to cool down but also ensures that your hand does not get cold if you are holding the drink.

The guiding question of this investigation is, **Which design will cool a soda the best?**

Materials

You may use any of the following materials during your investigation:

Consumables

- Ammonium chloride, NH_4Cl
- Ammonium nitrate, NH_4NO_3
- Calcium chloride, $CaCl_2$
- Magnesium sulfate, $MgSO_4$
- Sodium bicarbonate, $NaHCO_3$
- Sodium chloride, NaCl
- Sodium thiosulfate, $Na_2S_2O_3$
- Paper cups
- Plastic baggies
- Water or soda

Equipment

- Polystyrene cups
- Beaker (50 ml)
- Graduated cylinder (25 ml)
- Insulators
- Electronic or triple beam balance
- Thermometer or temperature probe
- Chemical spatula
- Scissors
- Tape
- Rubber bands
- Safety glasses or goggles
- Chemical-resistant apron
- Nonlatex gloves

Safety Precautions

Follow all normal lab safety rules. Ammonium chloride, ammonium nitrate, sodium thiosulfate, and magnesium sulfate are all moderately toxic by ingestion and tissue irritants. Your teacher will explain relevant and important information about working with the chemicals associated with this investigation.

1. Follow safety precautions noted on safety data sheets for hazardous chemicals.
2. Wear sanitized indirectly vented chemical-splash goggles and chemical-resistant nonlatex gloves and aprons during lab setup, hands-on activity, and takedown.
3. Never put consumables in your mouth.
4. Clean up any spilled liquid immediately to avoid a slip or fall hazard.
5. Use caution when working with hazardous chemicals in this lab that are corrosive, toxic, and/or irritant.
6. Handle all glassware with care.
7. Handle glass thermometers with care. They are fragile and can break, causing a sharp hazard that can cut or puncture skin.
8. Never return the consumables to stock bottles.

9. Follow proper procedure for disposal of chemicals and solutions.
10. Wash hands with soap and water after completing the lab activity.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

To answer the guiding question, you will need to make systematic observations of the various salts. To accomplish this task, you must determine what type of data you need to collect, how you will collect it, and how you will analyze it.

To determine *what type of data you need to collect,* think about the following questions:

- How will you know if a chemical will help make the drink sample cold?
- What information do you need to determine if your design is successful?

To determine *how you will collect your data,* think about the following questions:

- What equipment will you use to collect the data you need?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of the data you collect?
- How will you organize your data?

To determine *how you will analyze your data,* think about the following questions:

- What type of calculations will you need to make?
- What type of table or graph could you create to help make sense of your data?
- How will you determine if your design is successful or not?

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

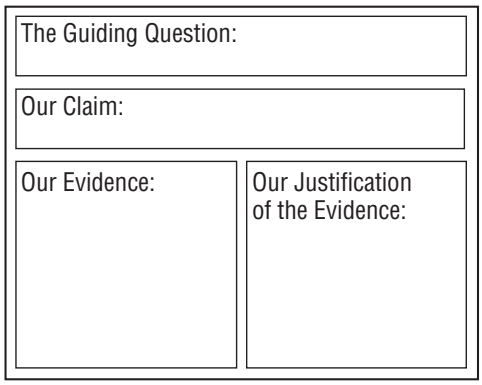
- how scientists often need to track how energy moves into, out of, and within a system;
- the relationship between the structure and function of an object;
- how scientists and engineers use a variety of methods to answer questions and solve problems; and
- the role of imagination and creativity when scientists and engineers attempt to solve problems.

Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a *claim*, *evidence* to support your claim, and a *justification* of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L5.2.

FIGURE L5.2

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- How did you collect your data? Why did you use that method? Why did you collect those data?
- What did you do to make sure the data you collected are reliable? What did you do to decrease measurement error?
- How did your group analyze the data? Why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that way?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?

- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most acceptable and valid answer to the research question!

Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections. Each section should provide an answer to the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable and valid!