AN INVESTIGATION INTO FREEZING POINT DEPRESSION

Prep Time: 30 minutes
Teaching Time: 2 hours

Science Concept:

Energy can be transferred and transformed.

Objectives:

The student will:

- explain the flow of energy in a system;
- collect and organize data; and
- write a conclusion for an experiment.

GLEs Addressed:

Science

[10] SB2.1 The student demonstrates an understanding of how energy can be transformed, transferred, and conserved by examining energy (i.e., nuclear, electromagnetic, chemical, mechanical, thermal) transfers, transformations, and efficiencies by comparing useful energy to total energy.

[10] SA1.2 The student demonstrates an understanding of the processes of science by reviewing pertinent literature, hypothesizing, making qualitative and quantitative observations, controlling experimental variables, analyzing data statistically, (i.e., mean, median, and mode), and using this information to draw conclusions, compare results to others, suggest further experimentation, and apply student's conclusions to other problems.

Math

[10] S&P-1 The student demonstrates an ability to classify and organize data by designing, collecting, organizing, displaying, or explaining the classification of data in real-world problems (e.g., science or humanities, peers, community, or careers), using information from tables or graphs that display two or more sets of data or with technology.

Materials:

- Ice
- Magnesium sulfate ($MgSO_4$)
- Magnesium chloride ($MgCl_2$)
- Sodium chloride (NaCl) (approximately 6 grams per group)
- Sugar
- Potassium cloride (KCl)
- Other salts, such as Epsom salt
- 500 milliliter beakers (two per group)
- Water
- Materials for student experiment, including, but not limited to, a scoop, sand, and balances
- Stirring rods (two per group)
- Graduated cylinders, 200 milliliters or larger (one per group)
- Safety goggles (one per student)
- Stopwatches (one per group)
- Thermometers (two per group)

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Activity Procedure:

Please refer to the assessment task and scoring rubric located at the end of these instructions. Discuss the assessment descriptors with the class before teaching this lesson.

Gear Up

Process Skills: observing, predicting, measuring, collecting data

1. Divide students into small groups and distribute NaCl, two stirring rods, two 500-milliliter beakers, and a 200 milliliter graduated cylinder to each group. Provide a central location for water and ice.
2. Instruct students to completely dissolve 5.85 grams of NaCl in 100 milliliters of distilled water. This will give groups a 1 molal solution. Instruct students to add as much ice to the solution as they can and still be able to freely stir it.
3. Instruct students to set up a control beaker with distilled water only.
4. Ask groups to predict how the temperature will change for each solution.
5. Instruct groups to stir the contents of both beakers for five minutes (using a stirring rod, not a thermometer), and record the starting temperature and the temperature of each beaker every 30 seconds. Students should record their results in an appropriate data table.
6. Instruct groups to describe any other observations in addition to the temperature changes.
7. After groups have performed the investigation, discuss the following questions as a class:
   a. What happened to the temperature of each beaker?
   b. What happened to the volume of ice?
   c. What do you think is happening?

Generalize

Process Skills: observing, communicating

8. Distribute samples of the sugar and the salts to each group. Groups may rinse out and reuse their beaker from the Gear Up activity. Allow students to explore the different substances in the same manner as the Gear Up. Ask groups to write down qualitative and quantitative observations for the substances they observe.

Explore

Process Skills: communicating, predicting

9. Ask the class the following questions and discuss:
   a. Which of the materials produced a temperature change?
   b. Which materials were more efficient at changing the temperature of the solution than others?
   c. If there was a temperature change, was energy brought into the solution or was energy released? Where did the energy come from or go to?
   d. For those materials that had temperature changes, did they change temperature at the same rate as each other?
   e. What factors seem to contribute to the temperature changes?
   f. Describe the flow of energy in this system. (Where did it come from? Where is it going?)
10. Ask students to write two testable questions based on their observations and the class discussion.

Experiment

Process Skill: observing, measuring, controlling variables, making graphs, experimenting, and collecting data

11. Ask groups to create two hypotheses to explain the phenomenon they observed during the Gear Up and Explore. Explain groups will design an experiment to test each hypothesis. Remind students that proper experimental design requires that they test only one variable at a time. Students may have discovered that the amount of solute affects freezing point temperature. It is equally probable that students noticed that the type of solute matters as well. Instruct groups to write an experiment procedure and make a list of required materials. Review each group's experimental design before

they begin. (NOTE: Students wishing to test the effects of solute concentration should prepare their desired solutions before adding ice. It is highly recommended that students use molal concentrations [concentrations of 0 molal, 0.5 molal , 1 molal, 1.5 molal, etc. should produce measurable results]. Students who decide to test the effect of solute type should prepare a 1 molal solution of each solvent.)

12. If possible, guide the class so that roughly half of the groups are working on concentrations and half on solutes.
13. Remind students to collect data in a chart.

Interpret

Process Skills: communicating, interpreting data

14. Invite a student volunteer to organize group data on the board. One table should be created for each of the tested hypotheses.
15. As a class, discuss the following questions. A student volunteer may be designated to record responses.
    a. To what errors, other than carelessness, is this experiment subject?
    b. How does solute concentration affect freezing point depression? (NOTE: If students have not come up with a mathematical solution, ask them to create a line graph to help them see the relationship.)
    c. How does the type of solute affect the freezing point temperature? Depending on students' chemical knowledge, it may be useful to write chemical formulas on the board and compare them as a class.
    d. Was energy transferred?
    e. Was energy transformed?
    f. Where did the energy originate? Why do you think so? Where did the energy go?

Apply

Process Skills: communicating

16. Ask students to reflect on how this phenomenon affects their lives. Can salt water ice (commonly called sea ice) freeze fresh water? Explain.
17. Explain sea ice comes in contact with much of Alaska's coast for several months a year. As the climate gets warmer, the sea ice spends much less time in contact with the land. Ask students what they think might happen to the coastline as a result of this. Explain it is okay to speculate and use imagination. If students need help getting started, suggest they imagine a specific area of coast, such as a swampy area, a river delta, an area of permafrost, etc.

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RUBRIC

Assessment Task

Organize your group's data into properly labeled tables. Write a conclusion for your investigation that includes your original hypothesis, reference to your data, and any revision that you thought was necessary. Your conclusion may reflect other groups' data and must include a discussion of possible sources of error. Your conclusion should contain a discussion about the flow of energy in this system.

Rubric

Objective	GLE	Below Proficient	Proficient	Above Proficient
The student explains the flow of energy in a system.	[10] SB2.1	The student does not write about the transference of energy in the system.	The student writes an explanation of the flow of energy in the system. The student specifically describes the observed energy transference.	The student writes an explanation of the flow of energy in the system. The student specifically describes the observed energy transference and uses the law of conservation of energy to explain where the thermal energy went.
The student writes a conclusion to her or his experiment.	[10] SA1.2	The student does not refer to the data, or draws unreasonable conclusions from it. The student does not refer to the original hypothesis. The student does not identify possible sources of data.	The student writes a reasonable conclusion that is based on the data. The student refers to the original hypothesis and identifies possible sources of error.	The student writes a reasonable conclusion that is based on the data. The student refers to the original hypothesis and identifies possible sources of error. The student uses data from other groups in the analysis.
The student collects and organizes data.	[10] S&P-1	The student does not produce an appropriate table or does not interpret the data correctly.	The student organizes data in an appropriate table that is labeled correctly. The student interprets the data correctly.	The student organizes data in an appropriate table that is labeled correctly. The student interprets the data correctly and produces a graph of the data. The student incorporates data from other groups in his or her analysis.