Heat of Fusion

Science Objectives

- Students will collect, analyze, and interpret data to develop a mathematical model that explains their experimental results.
- Students will determine the heat of fusion for ice and their percent error.

Vocabulary

- heat energy
- specific heat
- molar mass
- heat of fusion

About the Lesson

- This lesson involves observing the effect of adding ice to warm water.
- As a result, students will:
  - Analyze data to determine a mathematical model to explain their experimental results.
  - Calculate heat of fusion for ice and percent error.
  - Speculate on possible sources of error.

TI-Nspire™ Navigator™ System

- Send and collect the Heat_of_Fusion.tns file.
- Screen Capture to monitor student progress.
- Live Presenter allows students to show their heat calculations to the class
- Discuss results using Slideshow.

Activity Materials

- TI-Nspire™ CX CAS handheld
- 600-mL Beakers
- 100 mL Graduated Cylinder
- Styrofoam cups
- Ice
- warm water
- Tongs
- Paper Towels

TI-Nspire™ Technology Skills:

- Download a TI-Nspire™ document
- Move between pages
- Use DataQuest™ App
- Use math boxes

Tech Tips:

- Make sure the font size on your TI-Nspire™ handhelds is set to Medium.

Lesson Files:

Student Activity

- Heat_of_Fusion_Student.pdf
- Heat_of_Fusion_Student.doc

TI-Nspire document

- Heat_of_Fusion.tns

Discussion Points and Possible Answers

Tech Tip: Students need to be familiar with how to set up a time graph and how to navigate the DataQuest app for this inquiry.

Q1. What actually happens when ice melts in a glass of room-temperature soda?

Answer: The heat from the soda is transferred to the ice.

TI-Nspire™ Navigator™ Opportunity: *Quick Poll*
See Note 1 at the end of this lesson.

Teacher Tip: Laminate Appendix B: Using DataQuest™ on Handheld and have available for students to refer to when changing the time settings for their investigations.

Teacher Tip: Have hot water at approximately 60°C available on a hot plate. Such a temperature can be maintained at a low setting. By the time students get the water measured and ready for data collection, its temperature will have dropped to 50–55°C. Large ice cubes work best. Encourage students to use around 100 mL of water so that the tip of the temperature probe is submerged. Remind them to tare the balance to remove the mass of any containers used to hold the ice or water.

Data Quest App with Sample student data:

- Mass of water: 100.0 grams
- Mass of ice: 64.5 grams
- Initial temp: 53.0°C
- Final temp: 1.8°C

Teacher Tip: Students might need prompting to deduce the starting temperature of ice (it will equal the temperature of the freezer).

TI-Nspire™ Navigator™ Opportunity: *Quick Poll*
See Note 2 at the end of this lesson.

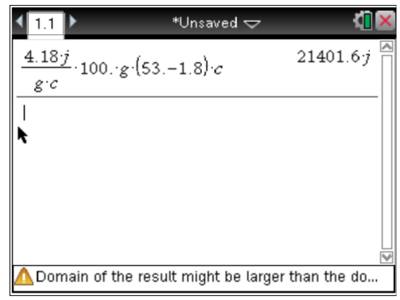
Note: Procedure steps from the student worksheet have been deleted from this document; however, the numbering of questions has been preserved.

> **Teacher Tip:** If you want the students to research possible explanations or explore vocabulary, you could delete Pages 3.1 and 3.2.

> **Teacher Tip:** Encourage students to use unit cancellation if they have a TI-Nspire CAS handheld.

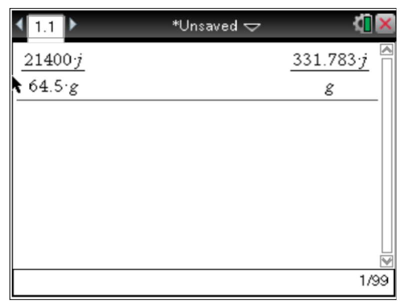
25. Use the equation *Q* = *m*•*s*•Δ*t* to calculate the energy (in joules) released by the 100 g of liquid water as it cooled through Δ*t* .

    <u>Sample Answers:</u> Students answers will vary but should use experimental data collected in Problem 2.
    *Q= 4.18 J/g*C * 100.0 g * (53.0- 1.8)C*
    Q= 21401.6 J Round the answer to 21,400 J.



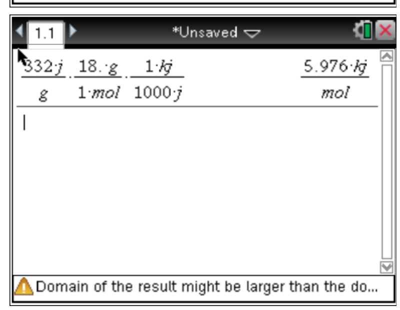
26. Now use the results obtained above to determine the heat of fusion, the energy required to melt one gram of ice (in J/g H_2O).

    <u>Sample Answers:</u> Student answers will vary but should use calculated Q from previous calculation.
    21400J/64.5 g = 331.783 J/g Round the answer to 332 J/g.



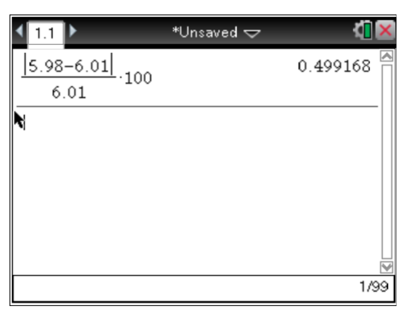
27. Use your answer to Step 26 and the molar mass of water to calculate the molar heat of fusion for ice (in kJ/mol H_2O).

    <u>Sample Answers:</u> Student answers will vary but should include calculated heat of fusion from previous calculation.
    (332 J/g)(18.0 g/mol)/1000J/kJ= 5.976 kJ/mol
    Round the answer to 5.98 kJ/mol.



28. Find the percent error for the molar heat of fusion value in Step 27. The accepted value for molar heat of fusion is 6.01 kJ/mol.

    <u>Sample Answers:</u> Student answers will vary but should include the calculated molar heat of fusion from previous calculation.
    |5.98-6.01| / 6.01 x 100% = 0.5 %



29. Using your previous knowledge of the boiling point of water and melting point of ice,

explain your results in the space below.

Sample Answers: Since the temperature of water stays the same during boiling, it should also stay the same when it is melting, regardless of the starting temperatures (if the amounts are the same). The heat is being transferred to the ice from the warm water. During this phase change (ice to water), the temperature of the water will go down until almost all the ice is melted because the heat is need to undergo the phase change.

30. Explain your percent error value. Give possible sources of error.

    Sample Answers: Student answers will vary.

Wrap Up

Discuss with students possible sources of error in the experiment.

Assessment

Formative assessment will consist of questions embedded in the .tns file.

TI-Nspire™ Navigator™

Note 1

Question 2, Feature: Quick Poll

Use TI-Nspire Navigator to send a Quick Poll with Question number 2. Engage students in discussion around why different answers might make sense. Don’t mark correct answer at this point if using the Slide Show to review responses with class.

Note 2

Feature: Quick Poll

Use TI-Nspire Navigator to send a quick poll with Question number 4. Engage students in discussion around whether or not the differences between their predicted and actual results are significant. Encourage them to share why they think the data supports or refutes their claims.