Experiment 22. Ice Inquiry Lab

Applying the Scientific Method to Study the Rate of Melting Ice

In this experiment you will:

- Practice active, legible data entry and critical analysis while recording thorough and pertinent observations.
- Explain the scientific method, including the importance of control variables, falsifiable hypotheses and theories grounded in, and perpetually refined through empirical results.
- Explain how differences in temperature and concentrations of solutes affect density.

INTRODUCTION

The scientific method is an investigation process designed to acquire new knowledge and construct theories for explaining and predicting phenomena. Systematic observations are used to formulate hypotheses—proposed ideas meant to tentatively explain phenomena. A sound hypothesis need not be correct, but it must be testable by experiment. Hypotheses are tested by controlled experiments and revised when necessary to be consistent with new observations from experiments. An experiment typically contains at least two variables, quantities that can have more than one value. A well-designed experiment is controlled in that it measures the effect of one variable on another while keeping all other variables constant. If reproducible data support a hypothesis, a model or theory can be developed to explain the observed phenomenon. A good model predicts related phenomena, but must be refined whenever conflicting data appears.

BACKGROUND & BRAINSTORMING: Formulating a Hypothesis and Designing an Experiment

The basis of this lab starts with a proposed question: "Will ice cubes melt faster when placed in deionized water or in salt water?" To answer this question, you and your partner should think about factors that influence the melting of an ice cube. Use your background information and brainstorm some ideas, as you have all seen ice melt before.

In order to facilitate this lab, it will be helpful to think of a few things before you begin. Asking questions is critical to the scientific enterprise. The questions below only represent a starting place for inquiry. Don’t let your investigation be limited by the questions supplied here.

- What do you know about the physical properties of salt water, ice and pure water? Use the pre-lab questions as a conceptual guide to better understand the differences present in each.
- How would these physical properties influence the melting of ice?
- How would you slow down the melting of ice? How would you speed up the melting of ice?
- What factors influence melting (pressure, environment, containers, etc.)?

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1 As adopted from Gonzaga Universities Chem 105 Lab Manual (Fall 2002)
After completing the pre-lab questions, you should work with your lab partner to formulate a hypothesis to address the proposed question above; write your hypothesis in your lab notebook under your pre-lab assignment (title this Hypothesis 1). Then establish a basic experiment to test your hypothesis (title this Experiment 1). Be sure to list variables that you will control in each experiment. Begin to consider alternative explanations and possible experiments that could be implemented to test those alternatives.

**INQUIRY LAB PROCEDURE:**

The lab period will focus on properly designing and carrying your experiments to explain the observed phenomena while testing and refining your hypothesis. Remember, it is just as valuable to reject an incorrect hypothesis as it is to confirm a correct hypothesis. Pay careful attention to the variables involved in your experiments, and practice active data entry.

**After your first experiment:** Once you have a working hypothesis, design additional experiments to test its validity. Perform additional experiments to support or refute your hypothesis. Each additional experiment should be briefly summarized and clearly labeled (Experiment 2, Experiment 3, etc.) with space for observations, records of data collected, and important control variables. Repeat this process until you have a model supported by observations that accurately predicts and explains the results of experiments. Use the questions below to guide further inquiry and refine your understanding. You make need to update and refine your hypothesis several times; title each version sequentially (Hypothesis 2, Hypothesis 3, etc.).

- Is your hypothesis consistent with the observations and outcome of the experiment? If not, how might you revise your hypothesis? Are there any elements of your hypothesis that are not supported by observations? What assumptions does your hypothesis make?

- Hypotheses may often be used to predict related phenomena. For example:
  - What does your hypothesis predict will happen when ice melts if the deionized water or salt water is stirred?
  - What outcome would your hypothesis suggest if you used a dye (food coloring) in the original experiment?

- What other variables might you measure in your experiments to test the validity of your hypothesis? For example: **how might the temperature of the water vary throughout the container?** Do you think the temperature would be the same in the upper portion as the lower portion? What does your hypothesis have to say in this regard?

You may use any materials available in your lab tray or in the fume hood. There is no strict or established procedure, but you or your group should take careful notes and observations regarding what you do in the lab, so you can write a comprehensive summary for your lab report.
Ice Inquiry Lab • Pre-lab Assignment

READING  Experiment – Lab Manual Pages
Introduction to the Scientific Method (Silberberg, 6th ed. pp. 11-13 or Olmsted and Williams, 5th ed. Chapter 1)

PRE-LAB  ALL elements of the pre-lab MUST be completed before an experiment is started.

Heading
• Title of experiment and number, your name, the dates of the experiment.

Purpose
• Briefly, but specifically explain the purpose of the experiment.

General Strategy
• Write your hypothesis to address the proposed question: "Will ice cubes melt faster when placed in deionized water or in salt water?" Remember that your hypothesis is not just an expected outcome, but also an explanation for the observational result. Complete Hypothesis 1.
• Working with your lab partner: summarize and explain the experiment you will employ to test the validity of your hypothesis. Complete Experiment 1.
• List important control variables for Experiment 1 on the table.

<table>
<thead>
<tr>
<th>Hypothesis 1</th>
<th>Complete in your LAB NOTEBOOK PRELAB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 1</td>
<td></td>
</tr>
<tr>
<td>Variables 1</td>
<td></td>
</tr>
</tbody>
</table>
Data Table

- **On a NEW page**, prepare a table for Experiment 1 that has space for all the necessary records and data to be collected. (Do not turn this page in with the pre-lab assignment)

<table>
<thead>
<tr>
<th>Results 1</th>
<th>Complete in your LAB NOTEBOOK PRELAB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesis 2</td>
<td></td>
</tr>
<tr>
<td>Experiment 2</td>
<td></td>
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<tr>
<td>Variable 2</td>
<td></td>
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<tr>
<td>Results 2</td>
<td></td>
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<tr>
<td>Hypothesis 3</td>
<td>Complete in your LAB NOTEBOOK PRELAB</td>
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<tr>
<td>Experiment 3</td>
<td></td>
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<tr>
<td>Variable 3</td>
<td></td>
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<tr>
<td>Results 3</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesis 4</th>
<th>Complete in your LAB NOTEBOOK PRELAB</th>
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</thead>
<tbody>
<tr>
<td>Experiment 4</td>
<td></td>
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<tr>
<td>Variable 4</td>
<td></td>
</tr>
<tr>
<td>Results 4</td>
<td></td>
</tr>
</tbody>
</table>
Answers to Pre-Lab Questions: Written in the lab notebook

- Submit these questions with the components above. The answers will serve as a conceptual foundation for investigating the physical phenomena found in the Ice Inquiry Lab. Be sure to draw from these concepts when formulating your hypothesis and designing your experiments.

PRE-LAB QUESTIONS

Please answer the following questions in your lab manual to submit with your pre-lab assignment. The answers will serve as a conceptual foundation for investigating the physical phenomena found in the Ice Inquiry Lab. Be sure to draw from these concepts when formulating your hypothesis and designing your experiments with your lab partner.

1. Briefly explain why ice floats on water.

2. What is the density of liquid water at 25 °C? What about H₂O(l) at 0 °C? You may consult reference tables of physical properties.

3. Is the density of saturated salt water (with the maximum amount of NaCl dissolved per liter) higher or lower than the density of pure water? Explain your reasoning by emphasizing the differences between a pure liquid and a solution.
4. List at least 3 factors that would affect the rate at which solid H₂O melts.

**MINI LAB REPORT GUIDELINES**

*Begin the lab report on a new page of the lab notebook.*

**Heading**

- Title of experiment and number, your name and lab partner, the dates of the experiment.

**Data / Observations / Results**

- ORIGINAL QUALITATIVE & QUANTITATIVE DATA (signed data pages from your lab notebook). Each element below should be clearly labeled and distinguishable:
  - Hypothesis 1 and subsequent revisions (Hypothesis 2, Hypothesis 3, etc.)
  - Below each hypothesis to be tested, experiments should be titled (Experiment 1, Experiment 2, etc.) and summarized. Include important observations, control variables, and any data that was collected. Draw pictures when necessary to adequately describe the experimental setup or observations.

**Discussion – Theory / Results / Error Analysis**

*In this section, you will explain the experiment, as well as evaluate and discuss your results.*

- Briefly explain *why* it is important to have control variables in an experiment.
- What was your initial hypothesis?
- Describe your first experiment designed to test the above hypothesis. What were the control variables?
- Were the experimental results consistent with your hypothesis? If not, how did you revise your hypothesis to fit the observations?
- What additional experiments did you perform to test your hypothesis?
- Describe your final conclusions with regard to the proposed question: "Will ice cubes melt faster in distilled water or in salt water?" Explain the experimental results with a simple model. Use this model to answer the questions below:
  - How would the temperature of the water vary throughout the container? Explain your reasoning using concepts integrated into your model and from the pre-lab questions.
  - What outcome would your model suggest if you used a dye (food coloring) in the original experiment? How would the dye spread out over the course of the melting? Explain your reasoning.
  - If the water is stirred, how will the results change? Why?