

# DRAFT

## Georgia Performance Standards

### Physics

#### **The task**

Students were asked to conduct a simple experiment in which they recorded temperature changes that accompany the melting and boiling of a pure substance.

#### **Circumstances of performance**

Students were expected to work in a group/pair, write the laboratory report on their own, activity was timed and in class, report written outside of class with teacher feedback.

#### **What the work shows**

#### **Characteristics of Science**

##### **Habits of Mind**

**SCSh1. Students will be aware of the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.**

- a. Understand how curiosity, honesty, openness, and skepticism affect the progress of scientific inquiry, and exhibit those traits in their own scientific activities.

**SCSh2. Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.**

- a. Find answers to scientific problems by substituting numerical values in simple algebraic formulas, and judge whether the answer is reasonable by reviewing the process and checking against typical values.
- b. Decide what degree of precision is adequate, and round off the result of calculator operations to enough significant figures to reasonably reflect those of the inputs.
- c. Address the relationship between accuracy and precision and the importance of each.
- d. Express and compare very small and very large numbers in scientific problems using powers-of-ten notation. Recall immediately the relations among 10, 100, 1000, 1 million, and 1 billion (knowing, for example, that 1 million is a thousand thousands).
- e. Trace the source of any large disparity between an estimate and the calculated answer for a scientific problem. Consider the possible effects of measurement errors on calculations.

**SCSh3. Students will be able to use tools and instruments for observing, measuring, and manipulating objects in scientific activities.**

- c. Develop and use systematic procedures for recording and organizing information.

**SCSh4. Students will be able to use the ideas of system, model, change, and scale in exploring scientific and technological matters.**

- a. Apply the concept of a system to the analysis of how things work and the design of solutions to problems. Specify the system's boundaries and subsystems, its relation to other systems, and its input and output.

**SCSh5. Students will be able to communicate scientific ideas and activities clearly.**

- a. Write clear, coherent accounts of scientific activities, including possible analyses and alternative interpretations of the results.
- b. Choose appropriate summary statistics to describe group differences, always indicating the spread of the data as well as the data's central tendencies.
- c. Make and use tables, charts, graphs, and scale drawings to make scientific arguments and claims in oral and written presentations.
- d. Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.

**SCSh7. Students will be able to question scientific claims and arguments effectively.**

- a. Identify the flaws of arguments based on the faulty, incomplete, or misleading use of numbers, such as instances in which (1) average results are reported, but not the amount of variation around the average, and (2) a percentage or fraction is given, but not the total sample size (as in "9 out of 10 dentists recommend...").
- c. Suggest alternative ways of explaining data and criticize arguments in which data, explanations, or conclusions are represented as the only ones worth consideration, with no mention of other possibilities. Determine whether both supporting and contrary data relevant to a claim have been set out.

#### **Nature of Science**

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#### SCSh8. Students will be familiar with the character of scientific knowledge and how it is achieved.

- a. Scientists assume that the universe is a vast single system in which the basic principles are the same everywhere. The principles may range from very simple to extremely complex, but scientists operate on the belief that the principles can be discovered.
- c. Hypotheses often guide scientists' choices of what data to pay attention to, what additional data to seek, and how to interpret both new and previously available data.

### Content

#### SP1. Students will be familiar with the forms and transformations of energy and with the significance of energy in understanding the structure of matter and the universe.

- a. Students will analyze, evaluate, and apply the principal of conservation of energy and measure the work-energy theorem by:
  - Describing total energy in a closed system.
- e. Students will analyze the relationship among temperature, internal energy, and the random motion of atoms, molecules, and ions (First and Second Laws of Thermodynamics).

Sample 1

Experiment: Temperature and Change State (Phase Change)

**L**

1. Place a thermometer into a 250mL beaker containing ice and water. Start timing and observing temperature change each minute while stirring continuously. Be sure to record the temperature of the ICE only. Develop a chart, and then record the time and temperature on a data table.

Time (minutes)	Temperature (Celsius)
0 min.	-7□ Celsius
1 min.	-5□ Celsius
2 min.	-3□ Celsius
3 min.	-2□ Celsius
4 min.	-1□ Celsius
5 min.	0□ Celsius

**F**

- a. Why is it important to maintain a fairly constant rate of stirring?  
It is important to keep a constant rate of stirring because this causes the Kinetic energy of the system to increase. Inevitably, this causes the temperature of the system to rise. Since the temperature of the ice is very low it needs a lot of heat and a rise in temperature to change in state. The temperature of a completely solid ice is always below zero degrees. Since the molecules of the ice are so tight

**C**

**I**

together more energy is needed to melt the ice. More kinetic energy is needed and that is why the temperature changes. The transfer of energy and constant zero temperature means that the block of ice is undergoing a phase change. After the entire ice has melted completely, its temperature begins to rise.

2. Continue to observe and record the temperature at one-minute intervals for five minutes.

Time (min.)	Temperature (Celsius)
0 min.	0□ Celsius
1 min.	0□ Celsius
2 min.	1□ Celsius
3 min.	3□ Celsius
4 min.	5□ Celsius
5 min.	6□ Celsius

- a. Describe the changes of state (phase change) that occurs.  
During the constant temperature of 0 degrees Celsius the solid underwent a phase change. The substance changed from a solid to a liquid. After it had completely changed from liquid to gas, the temperature began to rise 1 degree Celsius. The kinetic energy increases the temperature making the ice go through changes of phases.

**C** The student describes changes in temperature in terms of molecular interactions. The student demonstrates understanding of cause and effect relationships between change of temperature and change in state of matter.

**F** The student describes how a transfer of energy causes a phase change.

**I** The student uses the concept of phase change to explain constant temperature during the observation.

**L** The student uses various pieces of laboratory equipment to observe and measure the effects of heat.

**F** These items and others indicate the student's ability to convey information through technical writing. It should be noted that errors in Sample 1 should be corrected in a revision. In item 2a, for example "liquid to gas" should be corrected to "solid to liquid." In item 4a, the water molecules are most definitely in motion at 100 degrees Celsius. The student's logic is correct in 4a, but the statement regarding molecular motion indicates a misconception that needs to be corrected.

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#### Sample 1

M

3. Stop and continue to observe and record at one-minute intervals.

Time (min.)	Temperature (Celsius)
0 min.	8□ Celsius
1 min.	14□ Celsius
2 min.	31□ Celsius
3 min.	52□ Celsius
4 min.	71□ Celsius
5 min.	82□ Celsius
6 min.	90□ Celsius
7 min.	94□ Celsius
8 min.	96□ Celsius

4. Continue to measure the temperature each minute until vigorous boiling occurs.

Time (min.)	Temperature (Celsius)
0 min.	100□ Celsius
1 min.	100□ Celsius
2 min.	100□ Celsius
3 min.	100□ Celsius
4 min.	102□ Celsius
5 min.	103□ Celsius
6 min.	104□ Celsius

a. Describe the changes of state (phase change) that occurs.

During the constant temperature of 100 degrees Celsius the liquid underwent a phase change. This is evidence of potential energy because the molecules are not in movement. After it had completely changed from liquid to gas, the temperature began to rise to 101 degrees Celsius. During the increase the energy is kinetic.

5. Graph the heating curve of water from the data table.

a. According to the heating curve you plotted, what is the melting point of the ice?

According to the heating curve I've plotted, the melting point of the ice is 0 degrees Celsius.

b. What patterns do you observe with your heating curve graph?

The pattern that I observe in my heating curve graph is that when the ice is changing into liquid the temperature of the liquid increased. During the phase change the temperature remains constant. After the liquid has converted to a gas the temperature begins to rise again.

c. How do you account for the shape of the heating curve?

The shape of the heating curve is accounted by the fact there is a change in temperature and phase.

d. How has time affected each section on your graph?

Time has affected each section of my heating curve graph because in some sections of the heating curve it took longer time to change phase. In the heating curve graph it took a longer time for the graph to change from liquid to gas than it took to change from solid to liquid. It took longer because it takes a greater amount of heat energy to change from liquid to gas.

G

G The student demonstrates understanding of cause and effect relationships between change of temperature and change in state of matter. These items and others indicate the student's ability to convey information through technical writing. It should be noted that errors in Sample 1 should be corrected in a revision. In item 2a, for example "liquid to gas" should be corrected to "solid to liquid." In item 4a, the water molecules are most definitely in motion at 100 degrees Celsius. The student's logic is correct in 4a, but the statement regarding molecular motion indicates a misconception that needs to be corrected.

M The student uses various pieces of laboratory equipment to observe and measure the effects of heat. The student records data in tables.

G These items and others indicate the student's ability to convey information through technical writing. It should be noted that errors in Sample 1 should be corrected in a revision. In item 2a, for example "liquid to gas" should be corrected to "solid to liquid." In item 4a, the water molecules are most definitely in motion at 100 degrees Celsius. The student's logic is correct in 4a, but the statement regarding molecular motion indicates a misconception that needs to be corrected.

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#### CONCLUSIONS:

1. If you were to replicate this experiment with alcohol in place of water, what changes you happen?

#### HYPOTHESIS:

If this experiment were to be replicated but instead of water the experiment was done with alcohol the melting point and freezing point the experiment would be different. Also

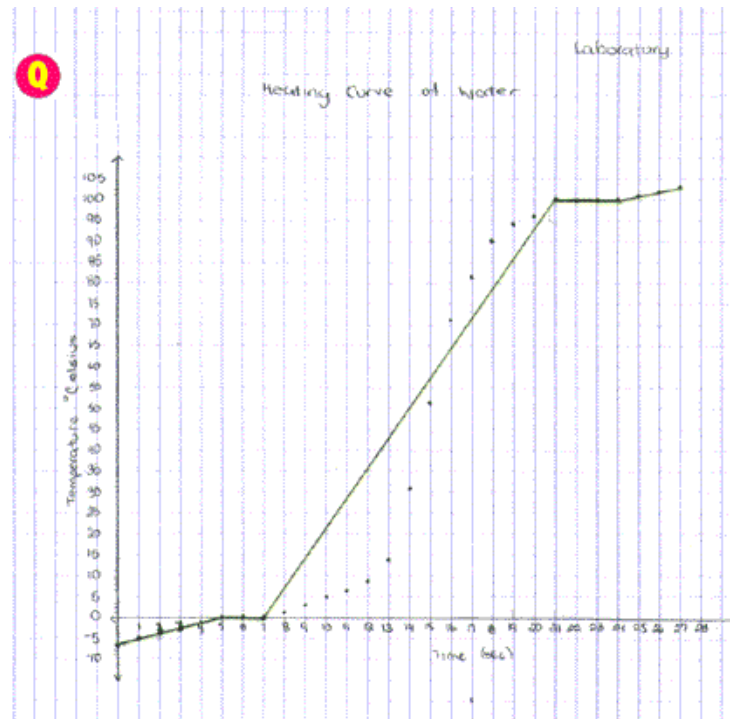
**D** alcohol requires less heat energy to melt and evaporate than water..

2. Based on your data and results from Heating Curve of Water, design an experiment that will justify your hypothesis.

Place a thermometer into a 250ml beaker containing a solid block of alcohol. Start timing and observing temperature and speed up the phase changes. Be sure to record the temperature of the block of alcohol only. Develop a chart, and then record the temperature on a data table for the alcohol until the alcohol reaches its melting point of  $-117$  degrees Celsius. Continue to observe and record the temperature at one-minute intervals for five minutes. Place the beaker on a hot plate and continue to observe and record at one-minute intervals until the alcohol reaches its boiling point of  $79$  degrees Celsius. Then continue to measure the temperature each minute until vigorous boiling occurs. After the experiment is completed graph the heating curve for alcohol.

**D** The student's hypothesis clearly relates phase change and energy. The student describes the effects of heat in relative terms. These items and others indicate the student's ability to convey information through technical writing. It should be noted that errors in Sample 1 should be corrected in a revision. In item 2a, for example "liquid to gas" should be corrected to "solid to liquid." In item 4a, the water molecules are most definitely in motion at  $100$  degrees Celsius. The student's logic is correct in 4a, but the statement regarding molecular motion indicates a misconception that needs to be corrected.

**Q** The student uses a graph to represent the data recorded in the tables.





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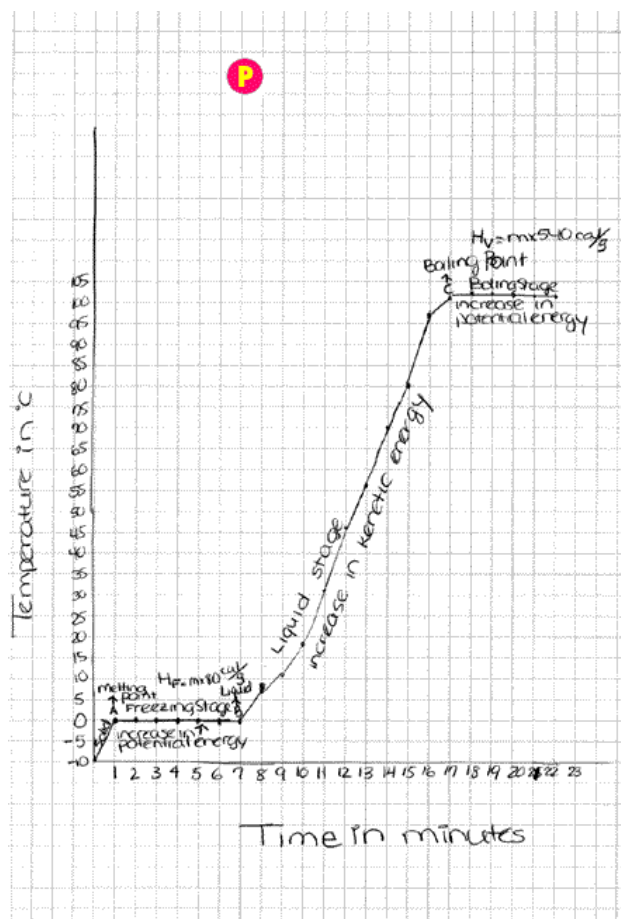
### Physics

**J** A: Compared to liquid water, gaseous water molecules are the least tightly packed and ~~travel~~ move in different direction.

**N** Explanation for error -

The reason that my boiling point is  $102^{\circ}\text{C}$  and my freezing point is  $1^{\circ}\text{C}$  is because the thermometer was off.

**K** The way I found this out is by placing my thermometer into my partner's beaker. While his thermometer read  $100^{\circ}\text{C}$  (boiling point) my thermometer still read  $102^{\circ}\text{C}$ !



- J** The student compares the liquid and gaseous phases of water in terms of relative molecular organization and motion.
- K** The student uses various pieces of laboratory equipment to observe and measure the effects of heat.
- N** The student indicates that calibration of the thermometer is needed in order to get an accurate temperature reading.
- P** The student uses a graph to represent the data recorded in the tables.