Heat in Motion

Read, calculate, and graph how heating changes molecular motion.

HS-PSII-2.1 "Develop graphical and mathematical representations that describe the relationship among the temperature, thermal energy, and thermal energy transfer (i.e...."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline where the passage describes heat transfer, circle the equation, and number two statements that connect temperature to molecular motion.

Warming a Water Sample

1. A covered beaker holds 100 g of liquid water while an electric heater warms it slowly. Energy crosses from the hotter heater into the cooler water as heat. The water's temperature tracks the average kinetic energy of its molecules, not the total energy in the beaker. A thermometer reports temperature, but it cannot directly count every molecule's motion.

2. For this sample, about 4.2 joules of heat raise each gram of liquid water by 1°C. The relationship is $Q = mc\Delta T$, where Q is heat transferred, m is mass, c is specific heat capacity, and ΔT is the temperature change. The table records heat added since heating began, assuming all the heater's energy enters the water and it remains liquid.

HEATING 100 G OF LIQUID WATER

Temperature (°C)	Heat added (J)
20	0
25	2,100
30	4,200
35	6,300
40	8,400

3. A temperature versus heat-added graph rises steadily for this fixed mass of liquid water. Heat increases thermal energy, which includes molecular motion and interactions. With no phase change, the water's temperature rises as heat enters. Molecules move faster on average as temperature rises, although they do not all move at one speed.

2 ANSWER WITH EVIDENCE

Use the passage

1. If heat added is the horizontal axis, what two points would you plot for 25°C and 35°C? Describe the graph between them.

2. How much heat enters the water as its temperature rises from 25°C to 35°C? Show your calculation.

3. Use $Q = mc\Delta T$ to calculate the heat needed for a 2°C rise in this same water sample.

4. At 40°C, how does the water's average molecular motion compare with its motion at 20°C? Does the table's 8,400 J represent total thermal energy or heat added since heating began?

3 YOUR TURN

Your own words

A 50 g sample of liquid water starts at 18°C. Use $c = 4.2$ J/(g·°C) to graph its temperature at 0, 1,050, and 2,100 J of heat added, then write one sentence connecting your graph to molecular motion.



ANSWER KEY

Heat in Motion

HIGH SCHOOL · HS-PSII-2.1

PART 1 · READ AND MARK

Underline where the passage describes heat transfer, circle the equation, and number two statements that connect temperature to molecular motion. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	If heat added is the horizontal axis, what two points would you plot for 25°C and 35°C? Describe the graph between them.	**Plot (2,100 J, 25°C) and (6,300 J, 35°C). The graph rises in a straight line.**
2	How much heat enters the water as its temperature rises from 25°C to 35°C? Show your calculation.	**6,300 J − 2,100 J = 4,200 J.**
3	Use Q = mcΔT to calculate the heat needed for a 2°C rise in this same water sample.	**Q = (100 g)(4.2 J/(g·°C))(2°C) = 840 J.**
4	At 40°C, how does the water's average molecular motion compare with its motion at 20°C? Does the table's 8,400 J represent total thermal energy or heat added since heating began?	**The molecules move faster on average at 40°C. The 8,400 J is heat added since heating began, not the water's total thermal energy.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Plot heat added on the horizontal axis and temperature on the vertical axis. Plot (0 J, 18°C), (1,050 J, 23°C), and (2,100 J, 28°C), then connect them with a rising straight line. As heat enters, the water's temperature rises and its molecules move faster on average.

Accept equivalent axis scales and calculations. The graph should show a 5°C rise for each 1,050 J added.