# SCIENCE DETECTIVE'S NOTEBOOK #4:

# PHASE CHANGE

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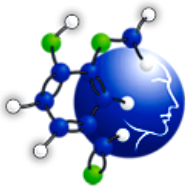

MOLECULES & MINDS

Simulations for Chemistry Learning

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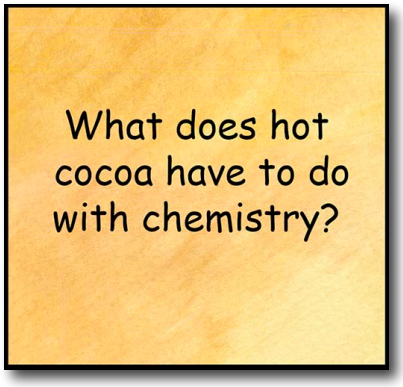
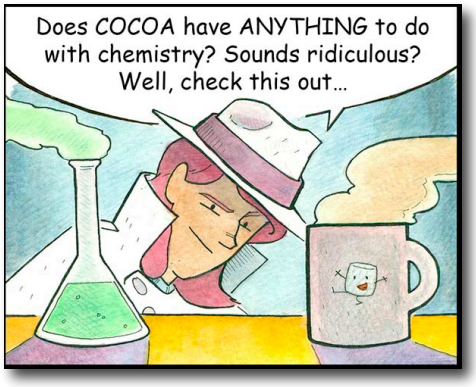
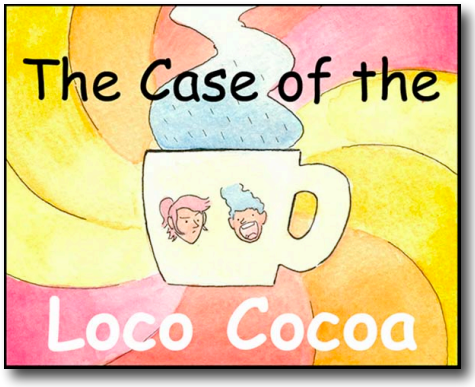
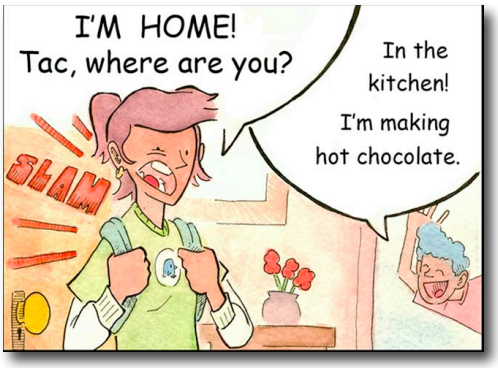
# ENTRY 1: MAKE OBSERVATIONS AND PROPOSE A HYPOTHESIS

"The Case of the Loco Cocoa"
Phase Change in Action



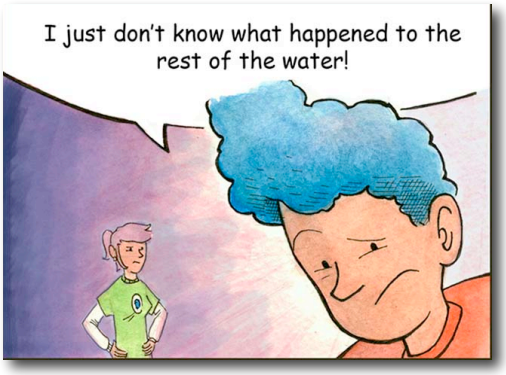



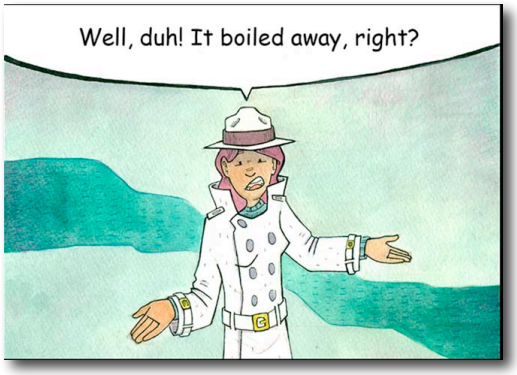




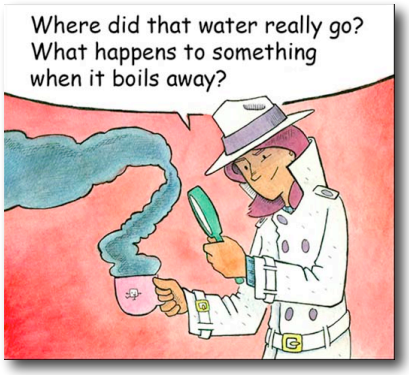

TAC!
You didn't leave me enough water! There's hardly anything in here!

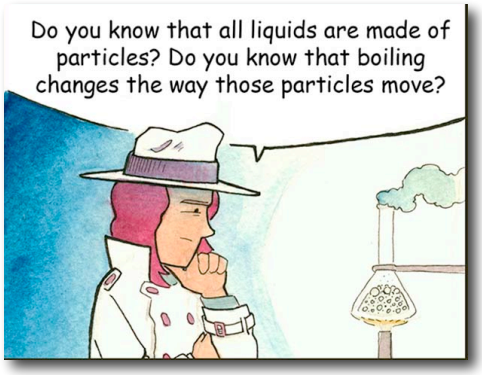

But I did! I'm SURE I measured two cups ... I just ...

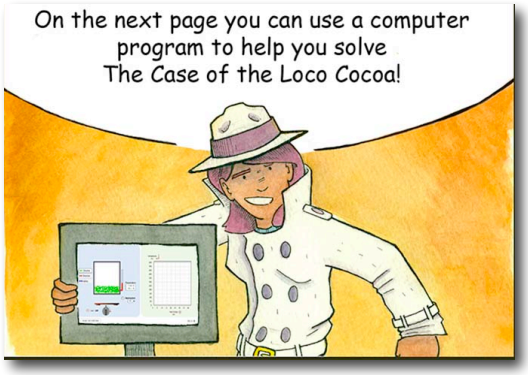

I just don't know what happened to the rest of the water!


Well, duh! It boiled away, right?


Hang on a second!


Where did that water really go? What happens to something when it boils away?


Do you know that all liquids are made of particles? Do you know that boiling changes the way those particles move?


On the next page you can use a computer program to help you solve The Case of the Loco Cocoa!

**Entry 1A:** Describe how Tac put heat into the system of water, saucepan, and stove.

_____

_____

Using what you learned from previous studies of heat, complete the following sentences:

**Entry 1B:** Heat is a process for transferring

_____

**Entry 1C:** Circle one:

Heat always transfers from

(*hot to cold / cold to hot*).

**Entry 1D:** How many cups of water did Tac begin with? _____

**Entry 1E:** How many cups did he end with?

_____

**Entry 1F:** Write a hypothesis about what happened to the water using the words *heat* and *molecules*.

_____

_____

_____

_____

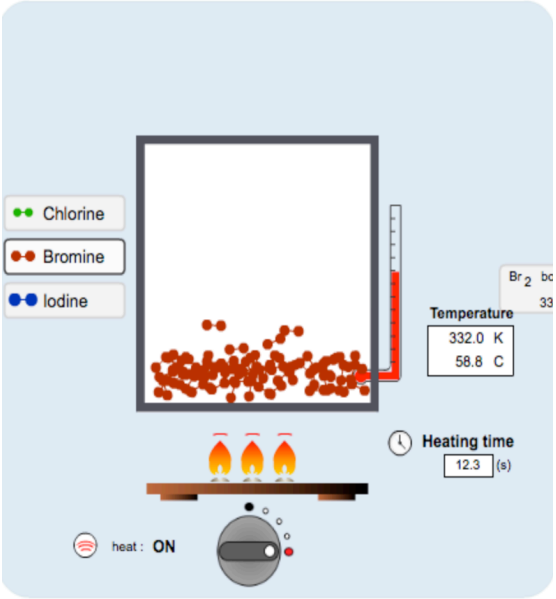
_____

## ENTRY 2: EXPLORE A MODEL TO TEST YOUR HYPOTHESIS

You can test the hypothesis you proposed in Entry 1F by exploring the Phase Change Simulation.

You will see how heat can be used to overcome forces between molecules in a liquid.

First, read the instructions.




The **internal pressure** of the gas is measured in **atmospheres (atm).**

Heat is measured in **kilojoules (kJ)** and can be turned on by using the dial. Adding heat increases the **temperature.** Temperature is measured in **Kelvins (K)** or **degrees Celsius (°C).**

The particles in this program are **molecules** that made up of two atoms chemically bonded together. You can choose to examine the effect of heat on molecules of different mass by exploring chlorine, bromine, and iodine.

**Entry 2A:** Name the three chemical elements in the model.

1. _____

2. _____

3. _____

**Entry 2B:** These elements belong to a Periodic Group called the Halogens (Group 17) and all elements in the halogens are *diatomic*. What does that mean?

_____

_____

**Entry 2C:** The two variables that you can explore

in this simulation are _____ and

_____ .

**Entry 2D:** Which variable do you need to use to test your hypothesis?

_____

**Entry 2E:** What unit is used for measuring heat? Provide the full word and the symbol.

_____

_____

# ENTRY 3: EXAMINE CHLORINE, THE "GREEN" MOLECULE

Select chlorine and observe carefully.

**Entry 3A:** What is the temperature of chlorine before you turn on the flame?

_____ K = _____ °C

(In New York state, found on Tables A and T of the Regent's Chemistry Reference Tables)

**Entry 3B:**
What phase is the chlorine in before you turn on the flame?

_____
*(solid/liquid/gas)*

Now turn on the heat and observe what happens.

**Entry 3C:** How many seconds does it take for the molecule to reach its boiling point?

_____ seconds. *(You may need to reset the simulation and monitor the time to answer this question)*

**Entry 3D:** What is the temperature when the molecule reaches its boiling point?

_____ K = _____ °C

(In New York state, found on Tables A and T of the Regent's Chemistry Reference Tables)

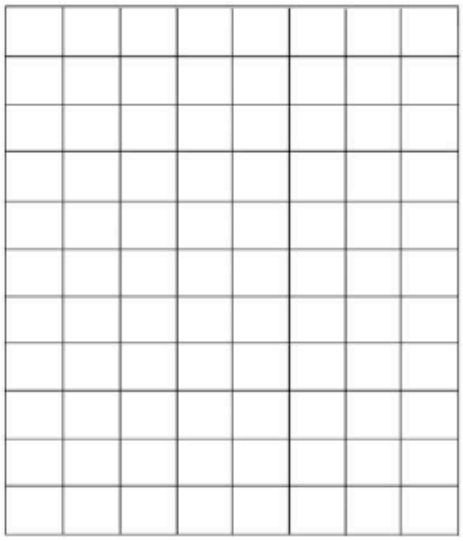
**Entry 3E:** According to the graph, how much heat was put into the container to make the liquid boil?

_____ kJ

**Entry 3F:** How much heat was added to the container after the phase change was completed?

_____ kJ

**Entry 3G:** Copy the graph, including the scale and labels, for both the X and Y-axis. Add a title!



# ENTRY 4: EXAMINE BROMINE THE "RED" MOLECULE

**Entry 4A:** What is the temperature of bromine before you turn on the flame?

_____ K = _____ °C

(In New York state, found on Tables A and T of the Regent's Chemistry Reference Tables)

**Entry 4B:**
What phase is the bromine in before you turn on the flame?

_____
*(solid/ liquid/ gas)*

Now turn on the heat and observe what happens.

**Entry 4C:** How many seconds does it take for the molecule to reach its boiling point?

_____ seconds. *(You may need to reset the simulation and monitor the time to answer this question)*

**Entry 4D:** What is the temperature when the molecule reaches its boiling point?

_____ K = _____ °C

(In New York state, found on Tables A and T of the Regent's Chemistry Reference Tables)

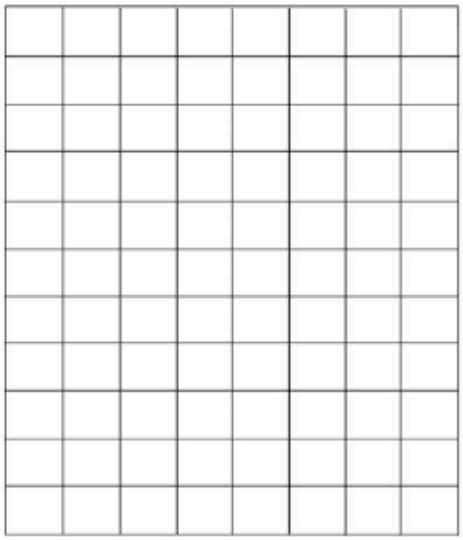
**Entry 4E:** According to the graph, how much heat was put into the container to make the liquid boil?

_____ kJ

**Entry 4F:** How much heat was added to the container after the phase change was completed?

_____ kJ

**Entry 4G:** Copy the graph, including the scale and labels, for both the X and Y-axis. Add a title!



# ENTRY 5: EXAMINE IODINE THE "BLUE" MOLECULE

**Entry 5A:** What is the temperature of iodine before you turn on the flame?

_____ K = _____ °C

(In New York state, found on Tables A and T of the Regent's Chemistry Reference Tables)

**Entry 5B:**
What phase is the iodine in before you turn on the flame?

_____
*(solid/ liquid/ gas)*

**Entry 5C:** How many seconds does it take for the molecule to reach its boiling point?

_____ seconds. *(You may need to reset the simulation and monitor the time to answer this question)*

**Entry 5D:** What is the temperature when the molecule reaches its boiling point?

_____ K = _____ °C

(In New York state, found on Tables A and T of the Regent's Chemistry Reference Tables)

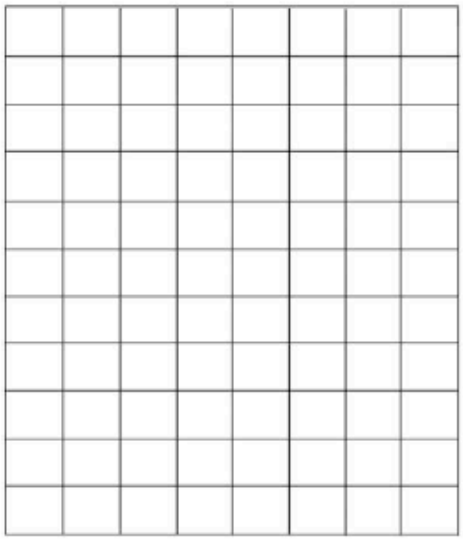
**Entry 5E:** According to the graph, how much heat was put into the container to make the liquid boil?

_____ kJ

**Entry 5F:** How much heat was added to the container after the phase change was completed?

_____ kJ

**Entry 5G:** Copy the graph, including the scale and labels, for both the X and Y-axis. Add a title!



# ENTRY 6: EXAMINE YOUR DATA

Look at the the three graphs.

**Entry 6A:** Describe what is happening to the three liquids when their boiling points are reached.

**Entry 6B:** When the three liquids reach their boiling points, what happens to the temperature?

**Entry 6C:** What evidence from the graphs support your answer to Entry 6B?

**Entry 6D:** At boiling point, heat is still being transferred into the container, but the temperature stays the same. Where is the energy going?

**Entry 6E:**
Which element has the highest boiling point? Explain why.

# ENTRY 7: SYNTHESIZE WHAT YOU LEARNED

Apply your understanding to
"The Case of the Loco Cocoa"

**Entry 7A:** Explain why there wasn't enough water in the saucepan for Gabriella to make hot cocoa.

_____

_____

_____

**Entry 7B:** How is the water Tac was heating like the liquids you used in the simulation?

_____

_____

_____

**Entry 7C:** How is the water Tac was heating different from the liquids you used in the simulation?

_____

_____

_____

**Entry 7D:** What phase change were you observing in this simulation?

_____

_____

_____

**Entry 7E:** In the simulation, bromine molecules were shown as red, chlorine molecules as green, and iodine molecules as blue. Are the molecules really those colors? Explain.

_____

_____

_____

**Entry 7F:** What is the connection between heat and temperature? (Use your graph for support)

_____

_____

_____

_____

**Entry 7G:**
You should have observed that as you heated the molecules of chlorine, bromine, and iodine, they moved faster. As heat was added, the molecules gained kinetic energy (energy of motion) because temperature was increased. BUT, as the phase change took place the temperature of the element did not change, even though we continued to heat the element. *What was happening?*
(H*int: think about the different types of energy!*)

_____

_____

_____

_____

# PHASE CHANGE LAB NOTEBOOK

# ENTRY 1: DO IT NOW!

Today you will be looking at phase change a little differently using lauric acid, which is a solid at room temperature.

**Entry 1A:** Go online or look up a table in your textbook to find out the published melting point for lauric acid. Write what you find.

_____°C and _____K

**Entry 1B:** Today you will be investigating the melting point of lauric acid. What can you learn by comparing your experimental result to the published value?

_____

_____

_____

# ENTRY 2: LAB/DEMO

**Introduction to the Lab:**

You know that matter can exist in one of three physical states or phases—solid, liquid, or gas. For a pure substance, changes in state occur at a definite temperature. Water, for example, changes from a solid to a liquid at 0°C and at standard pressure from a liquid to a gas at 100°C.

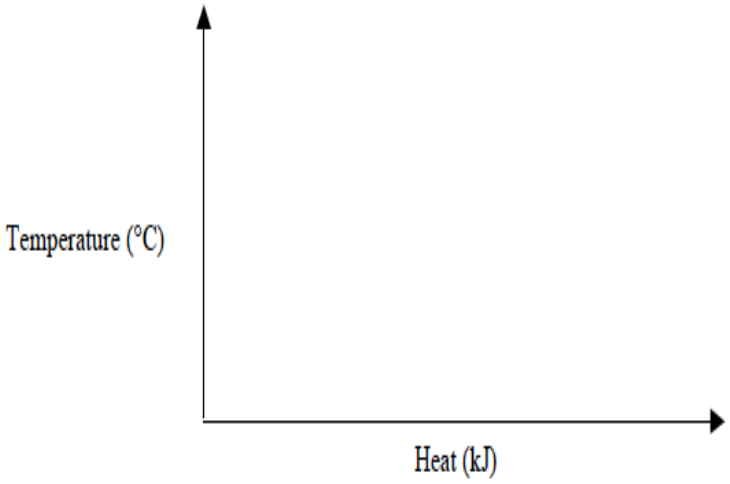
In a solid, the particles are arranged in an orderly, repeating, three-dimensional pattern. As the solid is heated, the energy of the particles increases. Eventually at some temperature, which is called the melting point, the molecules overcome the forces of attraction holding the particles together and the substance changes to a liquid. At another temperature, called the boiling point, molecules in the liquid state overcome the forces of attraction between them and the substance changes from a liquid to a gas.

When a liquid is cooled, the reverse process occurs. The temperature of the gas decreases until the condensation point is reached and the gas becomes a liquid. Only after the gas has completely changed to a liquid will the temperature decrease again. The temperature of the liquid decreases further until the freezing point is reached. Only after the liquid is completely changed to a solid will the temperature begin to decrease further. Any changes of a substance from liquid to gas or solid to liquid are called phase changes.

**Purpose:** In the phase change simulation, you observed a change between liquid and gas. In this activity, you will observe what happens when heat is applied to lauric acid ($C_{12}H_{24}O_2$). You will measure the temperature at timed intervals and determine its melting point experimentally.

**Entry 2A:** *Predict*

Based on the phase change simulations you have completed, predict the shape of its heating curve:




**Entry 2B:** *Confidence*

What did you learn from the simulation that makes you confident about your predictions?

_____

_____

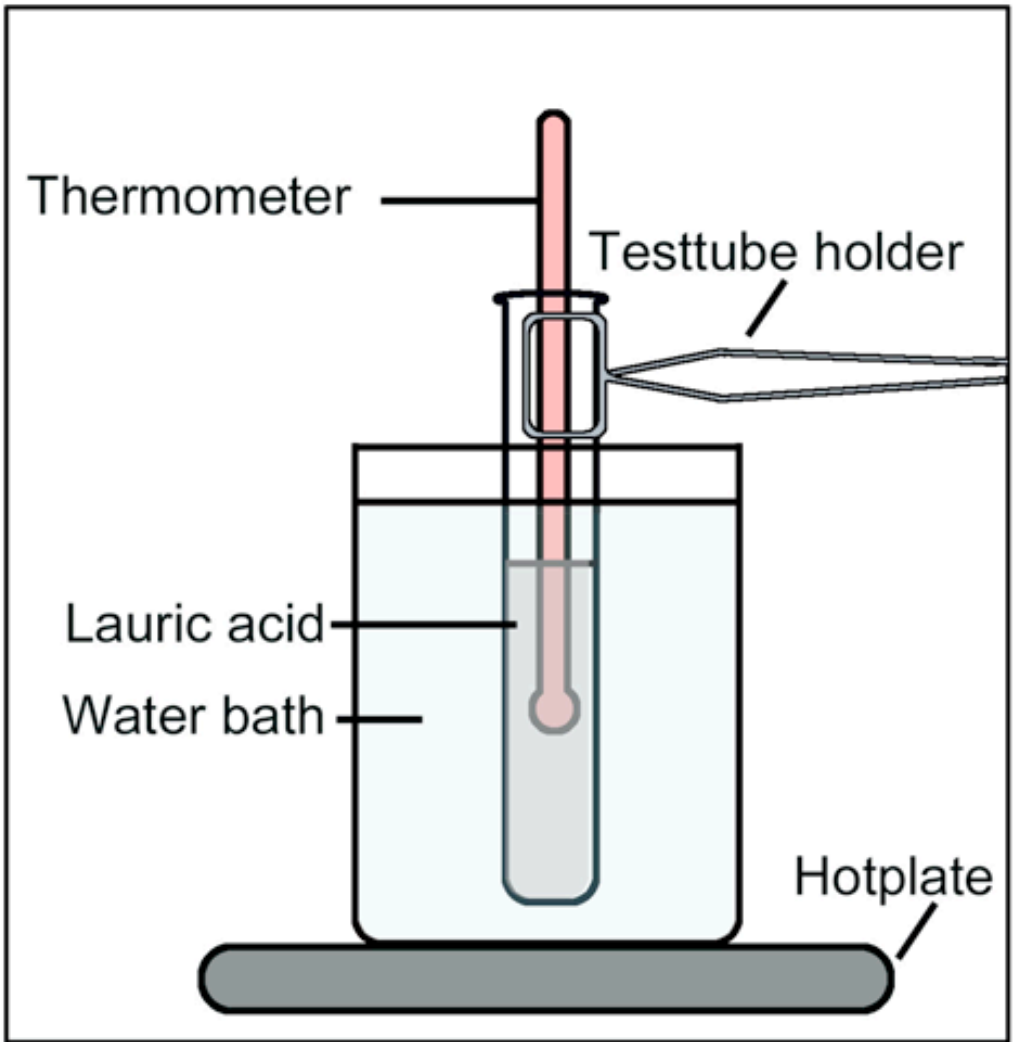
_____

_____

**Entry 2C:** *Collect* your equipment:

- Goggles
- Lauric acid test tube
- Two beakers, 400 mL
- Thermometers
- Hot plate
- Tap water
- Ice for ice bath

## Demonstration: Lauric acid & phase change



**Entry 2D:** *Perform* your experiment

1. Put on goggles and other safety attire.

2. Fill one 400 mL beaker full of tap water and heat it on the hot plate. Turn the hot plate all the way to 10. Once you see tiny bubbles, turn it down to 6. CAUTION: Do not touch the hot plate or beaker.

3. At the same time make an ice bath using a 400 mL beaker and ice from the front desk.

4. Get a large test tube of lauric acid and hold it with a test tube holder. Place it in the hot water bath. (You need to melt the lauric acid so you can insert the thermometer into the acid)

5. As the solid begins to melt, place a thermometer into the test tube, once you are able to insert the thermometer (see diagram on previous page), use the test tube holder to place the test tube in an ice water bath. Stop once the temperature reaches about 30°C.

6. Carefully place the test tube containing the lauric acid back into the hot water bath (it should NOT be boiling).

7. Immediately begin to take temperature readings every 30 seconds. Record your temperatures and time in the data table provided (Entry 2H).

8. Begin stirring gently as soon as you are able to move the thermometer easily. Continue to measure and record the temperature until the lauric acid is at approximately 55°C.

9. Turn off the hot plate. Remove the thermometer from the lauric acid and return test tube to your teacher.

10. Clean up your workstation and wash your hands.

**Entry 2E:** Record your *observations*
Approximate melting point of lauric acid:

_____°C and _____K

**Entry 2F:** Describe the changes you witnessed.

_____

_____

_____

**Entry 2G:** Could you see the actual molecules? Why or why not?

_____

_____

## **Entry 2H:** Your data table

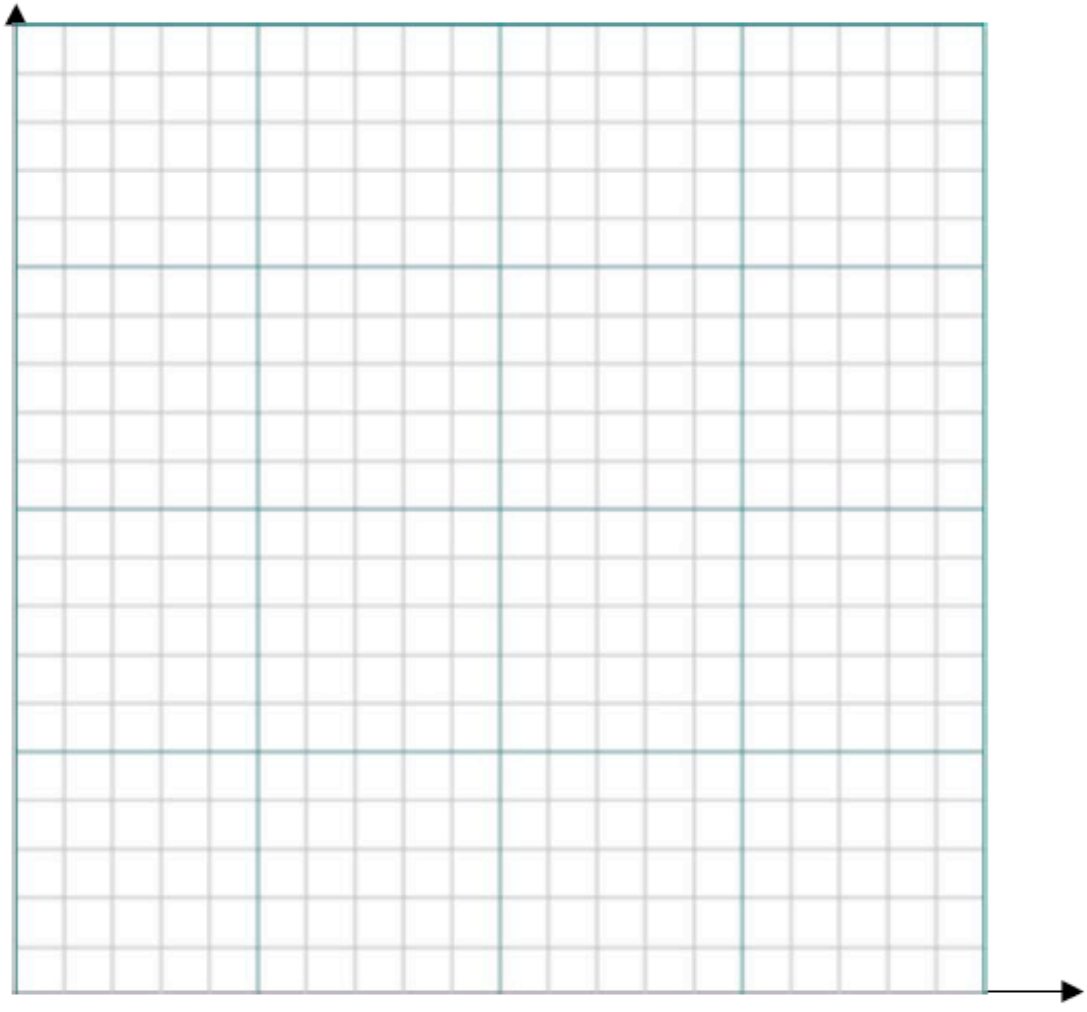
Data Table:

Title: _____

| Time (min) | Temperature (°C) |
|---|---|
| 0 (right when you put the test tube in hot water) | |
| 0.5 (30 seconds) | |
| 1.0 | |
| 1.5 | |
| 2.0 | |
| 2.5 | |
| 3.0 | |
| 3.5 | |
| 4.0 | |
| 4.5 | |
| 5.0 | |
| 5.5 | |
| 6.0 | |
| 6.5 | |
| 7.0 | |
| 7.5 | |
| 8.0 | |
| 8.5 | |
| 9.0 | |
| 9.5 | |
| 10.0 | |
| 10.5 | |
| 11.0 | |
| 11.5 | |
| 12.0 | |

**Entry 21:** Draw a graph representing the table on the previous page. You MUST label all axes, put in the scale, and write a title.

Title: _____



**Entry 2J:** *Explain your observations*
Did your prediction (from Entry 2A) match your actual data?

_____

Why do you think it was the same or different?

_____

_____

_____

**Entry 2K:** Explain why you need to record so many points.

_____

_____

_____

**Entry 2L:** Think back to the simulation and explain why the temperature of lauric acid's melting point did not change even though you were still adding heat.

_____

_____

_____

**Entry 2M:** What is happening to the forces of attraction between the lauric acid molecules when it is changing from a solid to a liquid?

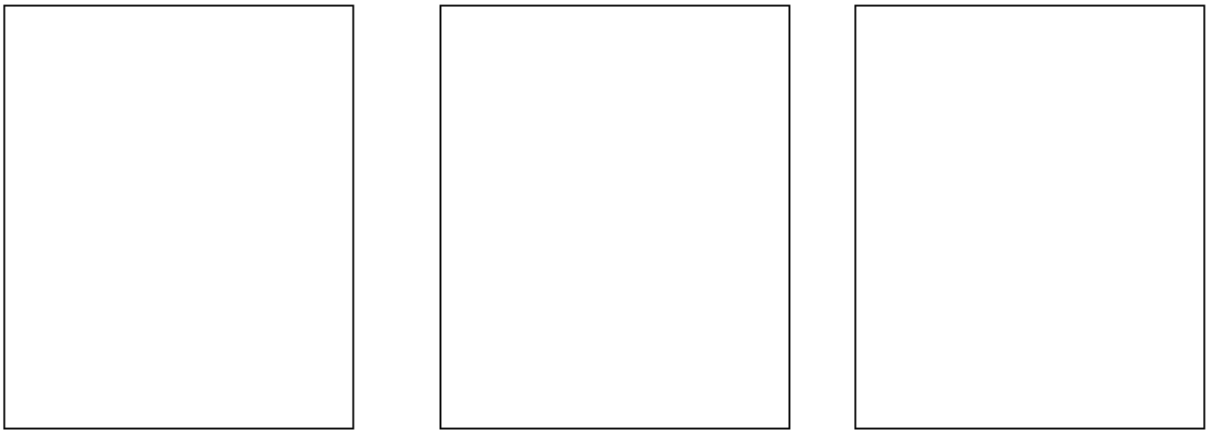
_____

_____

_____

_____

**Entry 2N:** Draw particle diagrams of what you think the molecules will look like as a solid, while changing phase, and as a liquid.



Solid | During Melting | Liquid

**Entry 2O:** *Discussion Question*

You are attending a summer science fair, and one of the instructors gives you a sample of what he claims is pure lauric acid. When you measure the melting point of the sample he gave you, you get a value of 50°C. Using the results of your experiment, what can you deduce about the purity of this sample?

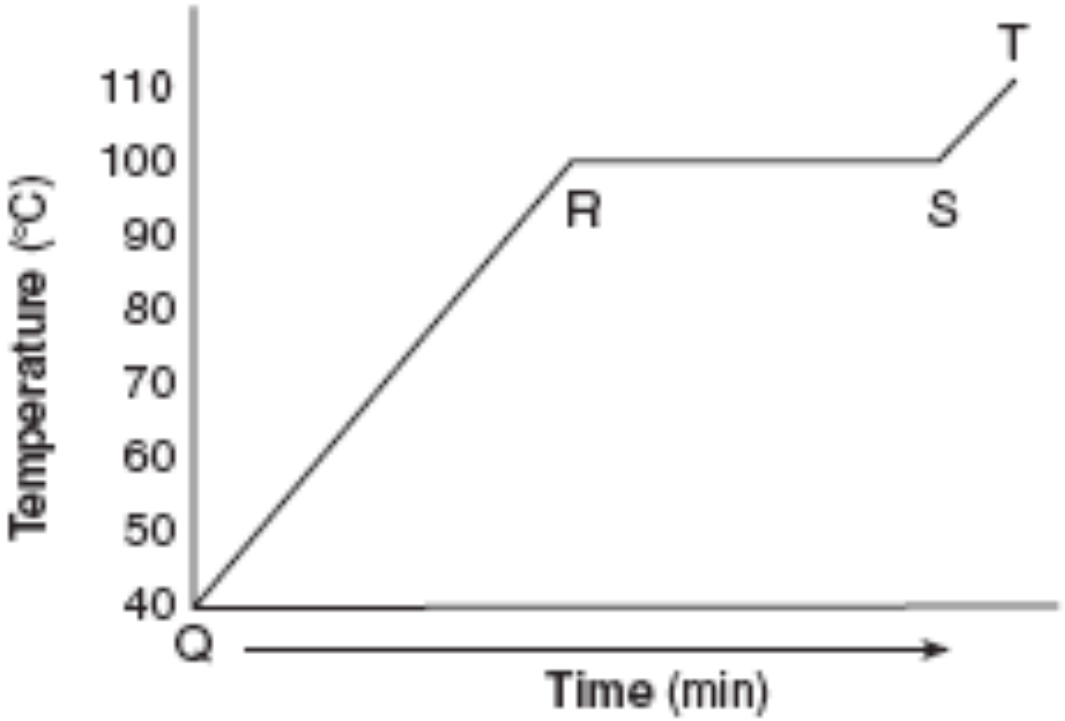
_____

_____

_____

# ENTRY 3: EXTENSION ACTIVITIES

**Entry 3A:** The sample of water that Tac heated from a liquid at 40°C to a gas at 110°C is shown in the heating curve below. Label the regions on the graph below with the correct state of matter.




Your choices are:

- Phase change
- Liquid only
- Gas only
- Solid only

**Entry 3B:**

Here is some information about ethanoic (acetic) acid.

| *Substance* | *Melting Point/°C* | *Boiling Point/°C* |
|---|---|---|
| Ethanoic Acid | 17 | 118 |

Describe what you would expect to observe as ethanoic acid was heated steadily from room temperature (25°C) to 120°C.