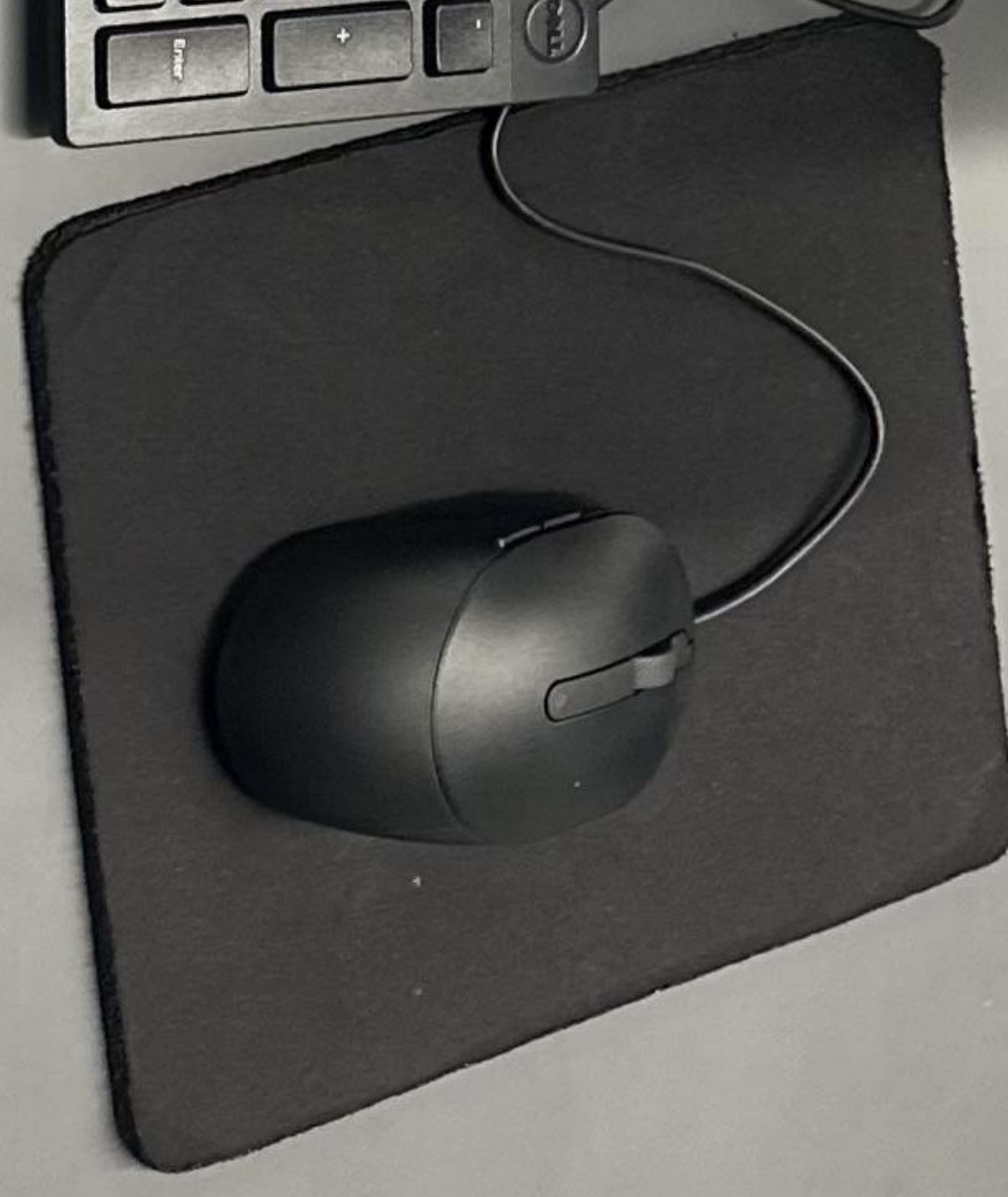
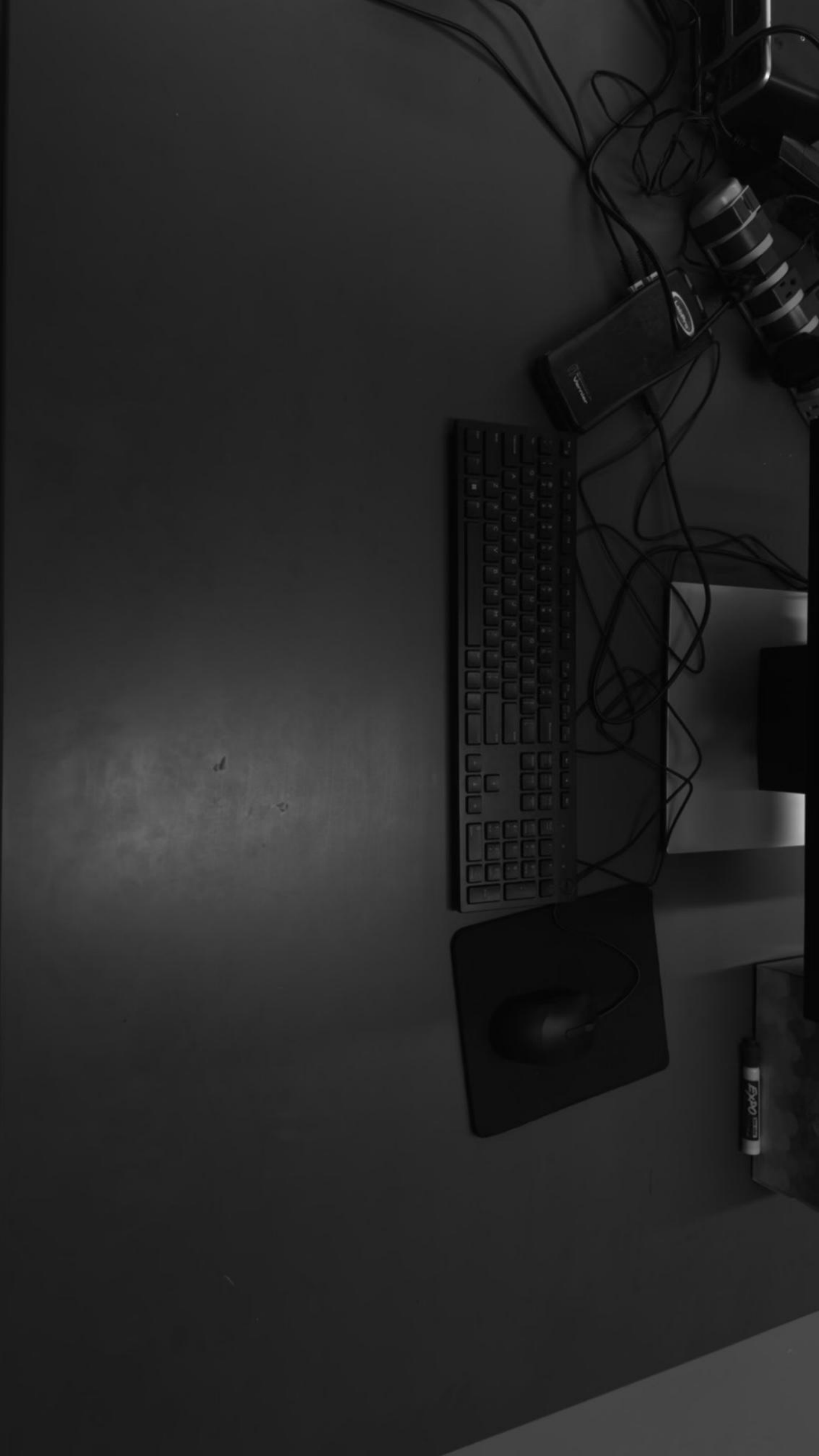






Name: Collin Schaefer

Lab Partner(s): _____

Date: 02/07/25

Lab Room &
Table: USIL 354 2/1

GTA Name: N/A - Stand In

CRN: 19052

Lab 1: Heat and Internal Energy

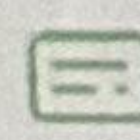
PHYS 2216

1. Calorimetry

1.1 Beginning-of-Lab Tasks

 Survey your lab station.

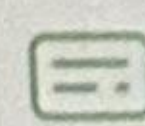
Your lab station should resemble the setup shown in Figure 1. 1. If not, please inform your lab instructor so they can report it to the instructor of the previous lab session. Then, take a moment to rearrange the equipment until your station is properly set up for this lab.

 Open LoggerPro.

From the computer's desktop, open the **Course Resources** folder. Navigate to the following directory:

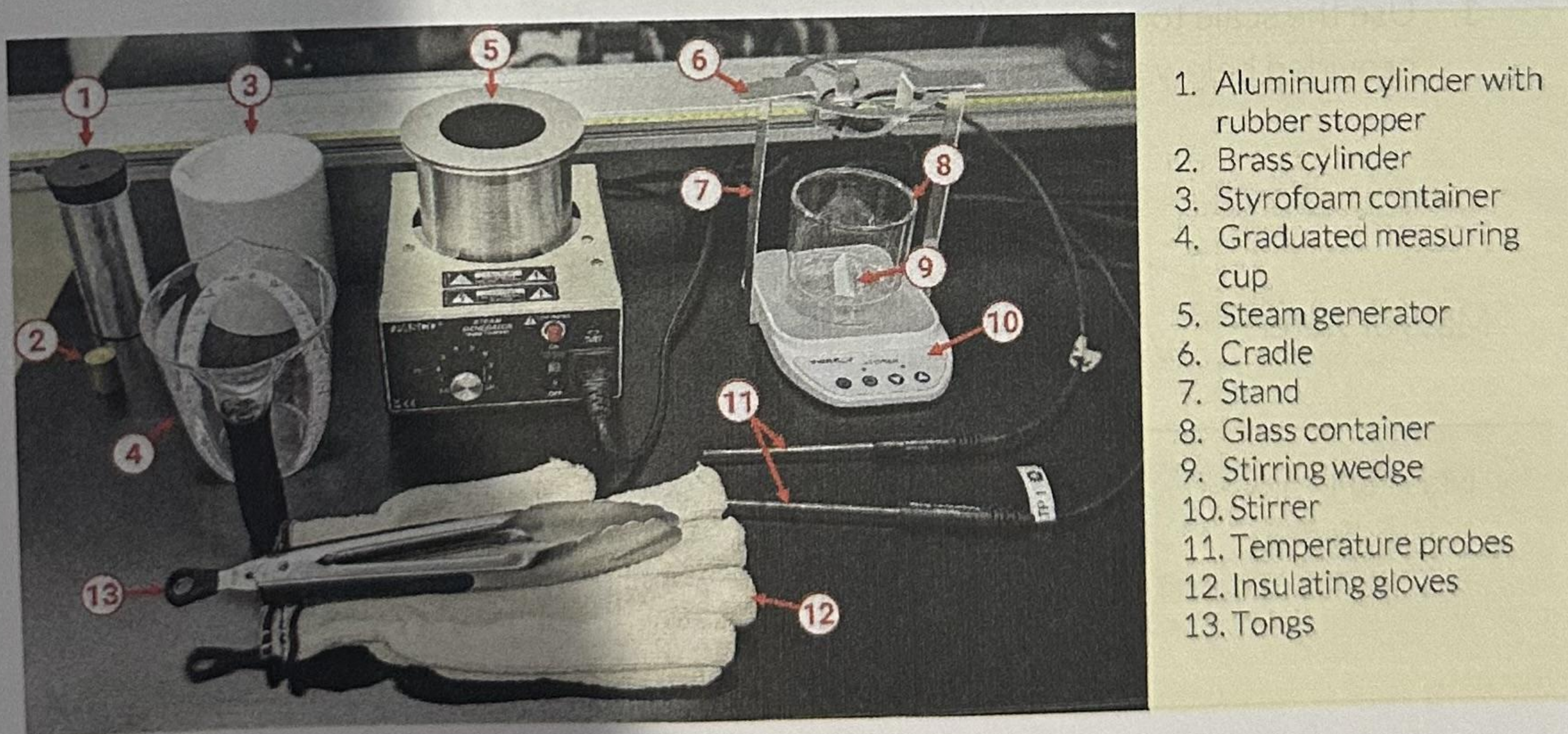
Course Resources > PHYS 2216 > Lab 1 – Heat and Internal Energy

Open the **Lab 1a.cmb1** experiment file.

 Periodically save your data.

You should periodically save your LoggerPro data to avoid losing it if the program crashes. To save your data, select **File** in the top menu bar and then select **Save As**. Save your experiment (i.e., LoggerPro file) to the **Downloads** folder.

FIGURE 1. 1: An annotated list of equipment you will use in this lab.



1. Calorimetry

1.1 Beginning-of-Lab Tasks

Survey your lab station.

Your lab station should resemble the setup shown in Figure 1. 1. If not, please inform your lab instructor so they can report it to the instructor of the previous lab session. Then, take a moment to rearrange the equipment until your station is properly set up for this lab.

Open LoggerPro.

From the computer's desktop, open the **Course Resources** folder. Navigate to the following directory:

Course Resources > PHYS 2216 > Lab 1 – Heat and Internal Energy

Open the **Lab 1a.cmbi** experiment file.

Periodically save your data.

You should periodically save your LoggerPro data to avoid losing it if the program crashes. To save your data, select **File** in the top menu bar and then select **Save As**. Save your experiment (i.e., LoggerPro file) to the **Downloads** folder.

FIGURE 1. 1: An annotated list of equipment you will use in this lab.



1.2. Activity: Measuring the Specific Heat of Brass

In this activity, you will determine the specific heat of brass by placing hot brass into room-temperature water and measuring the temperature changes in both the brass and water.

Procedure 1.2.1.

Assemble equipment.

1. Retrieve DI water.

1. Take both measuring cups to either the back counter (by the windows) or the center table.
2. Fill one measuring cup with approximately 80 ml of DI water from the dispensing container or the sink's white spigot labeled "PW" at the back counter.
3. Fill the other measuring cup with approximately 450 ml of DI water.
4. Return to your station.

2. Add DI water to the styrofoam container.

1. Place the styrofoam container on the scale and tare it.
2. Pick up the container and add ~80 ml of water.
3. Place the container back on the scale. Measure the mass of the water and record it in the space provided below. Remember to include units.

3. Measure the mass of the brass cylinder.

1. Use the scale to measure the mass of the brass cylinder and record it in the space provided below.

Mass of water:

72.88 g

Mass of brass
cylinder :

57.13 g

4. Fill the steam generator and heat the water.

1. Fill the steam generator with some of the ~450 ml of water until it is halfway full. Depending on how much water was initially in the generator, you may need to retrieve more DI water.
2. Turn on the steam generator and set the dial to the "7" setting.
3. Wait for the water in the steam generator to simmer. (While you wait, review the remaining instructions for this lab and start **Prediction 1.1.**)

Collect data.

Navigate to the window for the **Lab 1a.cmb1** LoggerPro experiment file. The workspace displays a temperature vs. time graph.

- Click the **Data Collection Button**  and set the **Duration** field to 600 seconds. Ensure the "Continuous Data Collection" box is checked.

1. Place the brass cylinder in the steam generator.

1. When the steam generator's water simmers, use the tongs to gently place the brass cylinder in the simmering water.
2. The brass cylinder has a cavity along the central axis. This cavity should face upwards.
3. Wait 1 minute for the brass and the simmering water to reach thermal equilibrium.

2. Transfer the brass to the styrofoam container and measure temperatures.

1. In quick succession, do the following:
 - i. In LoggerPro, **begin collecting data** from the temperature probes by clicking the **Collect Button** .
 - ii. Use the tongs to transfer the brass cylinder from the steam generator to the water in the styrofoam container.
 - iii. Ensure the cavity in the brass is facing upwards, and do not let the tongs touch the water in the styrofoam container.
 - iv. Place **Temperature Probe 1 (TP1)** in the water of the styrofoam container.
 - v. Place **Temperature Probe 2 (TP2)** in the cavity of the brass cylinder.
 - vi. Turn off the steam generator.
2. Using **TP1**, stir the water in the styrofoam container continuously until the brass and the water reach thermal equilibrium.
3. When the brass and water reach thermal equilibrium, stop the data collection process by clicking the **Stop Button** .

 Reset the equipment.

Clean up your station by

- removing the brass cylinder from the styrofoam container and placing it on a dry paper towel at your station, and
- emptying the water from the styrofoam container into the sink at the back counter.
- (Leave the water in the steam generator.)

 Document your work.

Modify, annotate, and save the plot by doing the following:

1. Scale your plot to showcase relevant data.

When you finish recording data, scale your graph by clicking the **Auto Scale Button**  in the graph menu, or follow these steps to scale it manually:

1. Double-click on any part of the graph. The **Graph Options Window** will appear.
2. Navigate to the **Axes Options tab**.
 - a. Under the **Y-Axis** section,
3. Enter values in the **Top** and **Bottom** fields to specify the data range for the graph's vertical axis.
 - a. Under the **X-Axis** section,
4. Enter values in the **Left** and **Right** fields to specify the data range for the graph's horizontal axis.

2. Label your plot

You can add a title to your plot by doing either of the following:

1. Open the **Graph Options Window**. Under the **Graph Options tab**, enter your label in the **Title** field.
2. Navigate to **Insert** in the top menu bar and select **Text**. A textbox will appear on the graph. Enter your label in the textbox and move the box to an appropriate location in the plot.

3. Annotate your plot.

Use the **Text Annotation** feature to indicate on your graphs

- a. Which curve represents the temperature response of the brass, and
- b. Which curve represents the temperature response of the water in the styrofoam container.

Reset the equipment.

Clean up your station by

- removing the brass cylinder from the styrofoam container and placing it on a dry paper towel at your station, and
- emptying the water from the styrofoam container into the sink at the back counter.
- (Leave the water in the steam generator.)

Document your work.

Modify, annotate, and save the plot by doing the following:

1. Scale your plot to showcase relevant data.

When you finish recording data, scale your graph by clicking the Auto Scale Button  in the graph menu, or follow these steps to scale it manually:

1. Double-click on any part of the graph. The Graph Options Window will appear.
2. Navigate to the Axes Options tab.
 - a. Under the Y-Axis section,
3. Enter values in the Top and Bottom fields to specify the data range for the graph's vertical axis.
 - a. Under the X-Axis section,
4. Enter values in the Left and Right fields to specify the data range for the graph's horizontal axis.

2. Label your plot

You can add a title to your plot by doing either of the following:

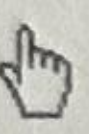
1. Open the Graph Options Window. Under the Graph Options tab, enter your label in the Title field.
2. Navigate to Insert in the top menu bar and select Text. A textbox will appear on the graph. Enter your label in the textbox and move the box to an appropriate location in the plot.

3. Annotate your plot.

Use the Text Annotation feature to indicate on your graphs

- a. Which curve represents the temperature response of the brass, and
- b. Which curve represents the temperature response of the water in the styrofoam container.

To add an annotation to your graph, follow these steps:

1. Click on the plot you want to annotate.
2. Then, click **Insert** in the top menu bar and choose **Text Annotation**. An annotation box will appear on the graph.
3. If you need to move the annotation box or its line, hover the mouse over it until the  cursor appears. Then, click and drag the box to the desired location.

4. Screenshot and save your plot.

1. Take a screenshot of your plot using the **Snipping Tool** in Windows (Win+Shift+S).
2. Save your screenshot as a JPG or PDF, and name the file with its procedure number and a brief description of its contents. *(Alternatively, you can paste your screenshot into a Word document and save it as a PDF.)*
3. Include the screenshot in your submission for this assignment.

Question 1.1: Use either the Statistics $\frac{1}{2}$ or Examine Tool $\times$ to measure the following quantities from your temperature vs. time plot.

(To apply the Statistics Tool to a specific region of a plot, first click and drag the cursor across that region, which will highlight it in grey. Then click the Statistics Tool.)

Initial temperature of the
water in the styrofoam
container:

19.8°C

Final temperature of the
water in the styrofoam
container:

23.0°C

Initial temperature of the
brass:

48.9°C

Final temperature of the
brass:

23.1°C

Question 1.2: Calculate the specific heat of brass using your temperature and mass measurements. Show your work.

(The specific heat of water is $c_{\text{water}} = 4186 \text{ J/kg}^\circ\text{C}$)

$$Q = mc\Delta T$$

$$Q = 0.07288(4186)(23.6 - 19.8^\circ\text{C})$$

$$Q = 934$$

$$934 = 0.05713c(23.9 - 18.9^\circ\text{C}),$$

$$c = 633.669 \text{ J/kg}^\circ\text{C}$$

Question 1.3: Compare the value you calculated in Question 1.2 with the known specific heat of brass: $c_{\text{brass}} = 385 \text{ J/kg}^\circ\text{C}$. If there are discrepancies, discuss them and their sources. (For instance, were the discrepancies caused by experimental factors? If so, which factors were responsible for the discrepancies, why did they cause them, and how do you know they caused them? Alternatively, were the discrepancies caused by flaws in your assumption or reasoning? If so, how were they flawed, and what helped you realize this?)

The time constraint of 1 minute was not sufficient time for the H₂O to truly impart all of its energy to the Brass

Question 1.4: When you transferred the brass from the steam generator to the styrofoam container, we instructed you not to let the tongs contact the water in the styrofoam container. Explain the rationale behind these instructions, particularly in the context of your calculations in Question 1.2. For instance, if the tongs contacted the water, how would that affect your calculations?

(Hint: Consider the underlying assumptions of the mathematical model you used in your calculations.)

BC the tongs are metallic and are highly thermally conductive and this will become part of the system by imparting themselves or their energy into the system

1.3. Activity: Measuring the Latent Heat of Ice

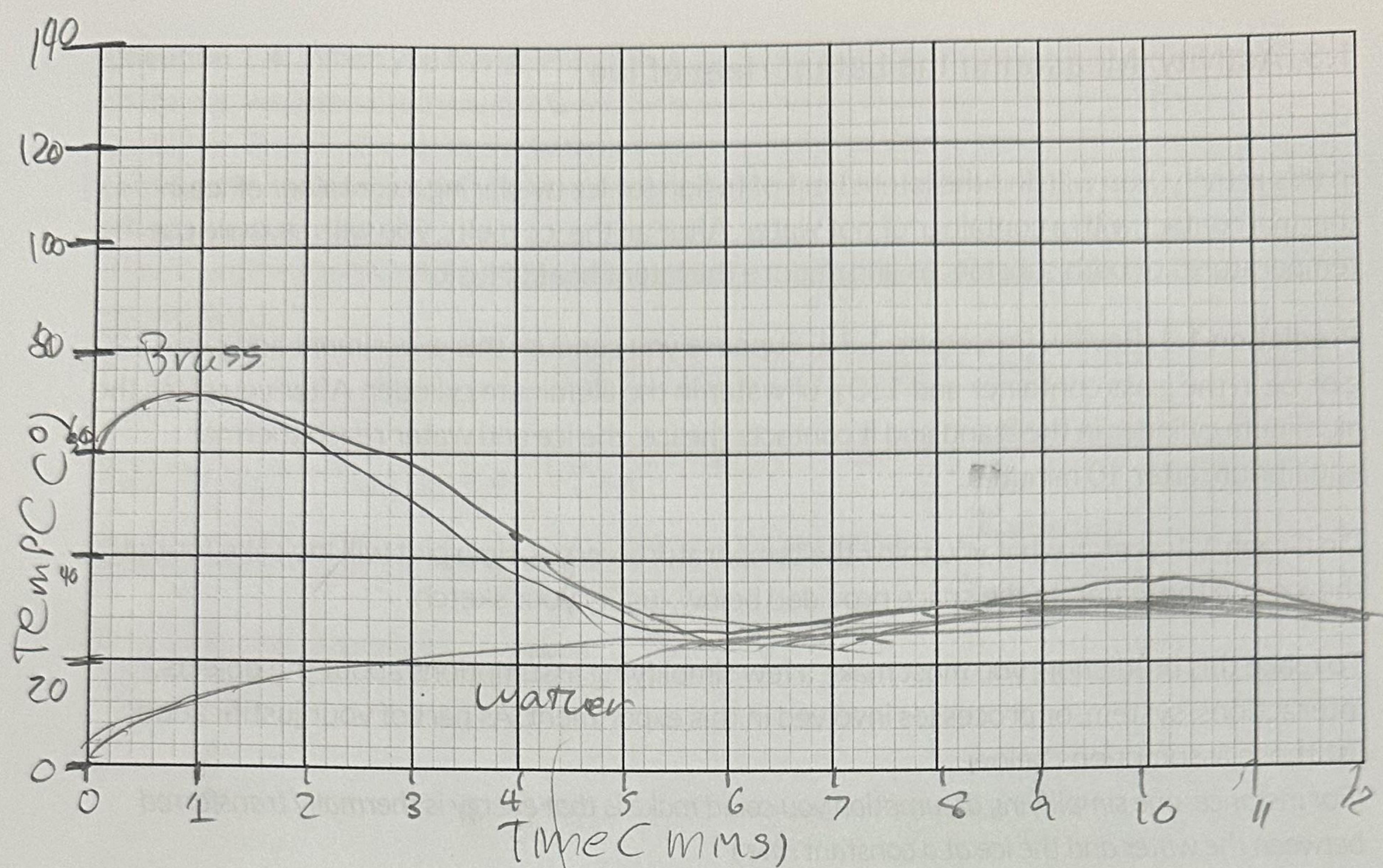
In this activity, you will find the latent heat of fusion for ice by placing a container of ice in thermal contact with a container of hot water. After all the ice melts, you will measure the temperatures of both substances and deduce the latent heat of fusion.

Prediction 1.1: Review **Procedure 1.3.1**. Suppose you conduct this experiment and place 130 g of ice in the glass container and 150 g of water in the aluminum cylinder. After you place the aluminum cylinder in the stand and it contacts the ice, the ice and water reach thermal equilibrium after 10 minutes.

On Graph 1.1, sketch what you think the temperature-versus-time plot will look like for both the ice and the water. In the space provided below, justify your sketch.

To make this prediction, you must make a few simplifying assumptions about the objects, interactions, system, or processes involved in this experiment. As part of your justification, list those assumptions below.

(For instance, one simplifying assumption you could make is that energy is thermally transferred between the water and the ice at a constant rate.)



GRAPH 1.1

Procedure 1.3.1.

(Before starting this experiment, refer to Figure 1.2 and Figure 1.3 and briefly review the experimental setup and equipment you will use for this activity.)

Assemble equipment.

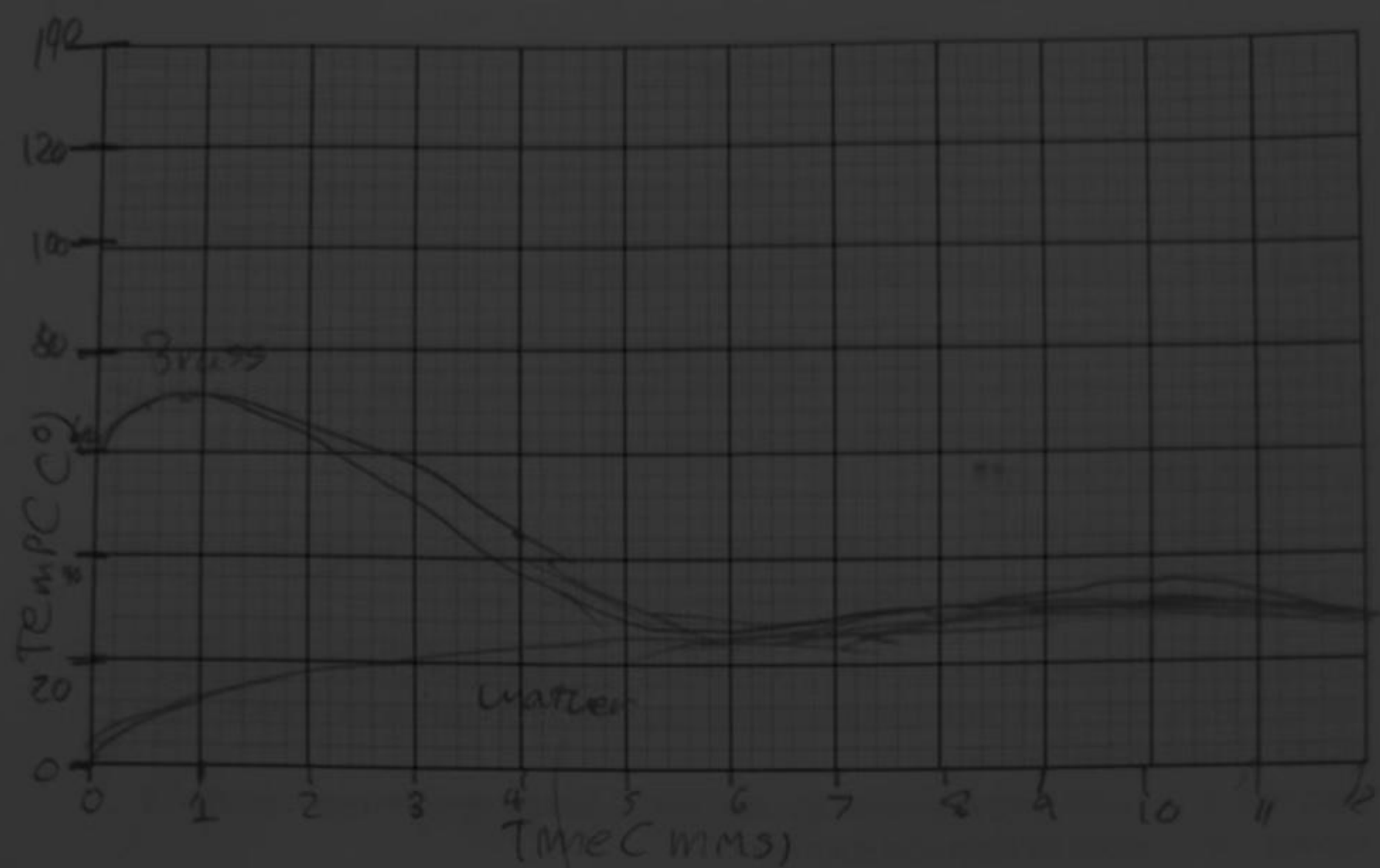
Gently place the pill-shaped stirring bar in the glass container.



Mind the Glass

Dropping the stirring bar into the container can break the glass. Always handle the glass containers with care.





GRAPH 1.1

Procedure 1.3.1.

(Before starting this experiment, refer to Figure 1.2 and Figure 1.3 and briefly review the experimental setup and equipment you will use for this activity.)

Assemble equipment.

Gently place the pill-shaped stirring bar in the glass container.



Mind the Glass

Dropping the stirring bar into the container can break the glass. Always handle the glass containers with care.

1. Retrieve DI water and ice.

1. Take both measuring cups to either the back counter or the center table.
2. Fill one measuring cup with approximately 150 ml of DI water.
3. Fill the other measuring cup with crushed ice from the ice-crushing machine.
 - i. The ice machine dispenses ice very quickly, so be prepared to turn it off. If the machine gets stuck, toggle the switch to "Reverse."
4. Return to your lab station.

2. Add DI water to the aluminum cylinder.

1. Attach the rubber stopper to the empty aluminum cylinder, place them on the scale, and tare it.
2. Pick up the aluminum cylinder, remove the stopper, and pour in enough water to fill the cylinder but leave enough space for the rubber stopper. Reattach the rubber stopper.
3. Place the aluminum cylinder with the rubber stopper back on the scale. Measure the mass of the water and record it in the space provided below.

3. Add ice to the glass container.

1. Place the glass container with the stirring bar on the scale and tare it.
2. Pick up the glass container and add a small amount of the ice to the glass container to barely cover the stirring bar and ensure the bar is centered in the container.
3. Fill the rest of the glass container with ice.
4. Place the glass container with the ice back on the scale. Measure the mass of the ice and record it in the space provided below.

Mass of water (kg): 0.013993 kg

Mass of ice (kg): 0.00225 kg

4. Heat the water in the aluminum cylinder with the steam generator.

1. Place the aluminum cylinder in the cradle.
2. Put on the insulating gloves at your lab station.
3. Using your glove-protected hands, pick up the aluminum cylinder by the cradle and lower it into the water of the steam generator, as shown in Figure 1.3.
4. Turn on the steam generator and set the dial to the "7" setting.

5. Place the glass container on the stirrer so the stirring bar is centered on the stirrer.
6. Turn on the stirrer, set the stirring speed, and activate Reversion mode.
 1. When turned on, the stirrer will reload its last setting. Therefore, you must first reset it. Turn on the stirrer and adjust it to its lowest stirring setting by holding the down arrow button until the green LED stops blinking.
 2. Gradually increase the stirring speed by pressing the up arrow. For this experiment, we recommend pressing the up arrow 7-10 times.
 3. The stirring bar will initially not rotate because the ice impedes its motion. However, it should start rotating when enough ice melts and water surrounds the bar.
 4. Turn on Reversion Mode by pressing the  button. Reversion mode reverses the direction of the stirring bar every 30 seconds, which helps the bar stir in ice/water solution.
7. Insert the thermal probes into the aluminum cylinder and glass container.
 1. Thread TP1 through the stand's probe holder and into the ice. (The probe holder is the 90° bracket attached to the stand with a hole in it, as shown in Figure 1. 2.)
 2. Thread TP2 through the hole in the rubber stopper of the aluminum cylinder.

Collect data.

Close LoggerPro. Then, navigate to the window for the **Lab 1b.cmb1** LoggerPro experiment file. The workspace displays a temperature vs. time graph.

1. Click the **Data Collection Button**  and set the **Duration** field to 600 seconds. Ensure the "Continuous Data Collection" box is checked.

When the temperature reading of TP2 exceeds 95 °C and when the temperature reading of TP1 stabilizes, transfer the aluminum cylinder + cradle from the steam generator to the stand by following the steps below:

1. Transfer the aluminum cylinder to the stand and measure temperatures.
 1. In quick succession, do the following:
 - i. In LoggerPro, begin collecting data from the temperature probes by clicking the **Collect Button** .
 - ii. Put on the insulating gloves at your lab station.
 - iii. Using your glove-protected hands, lift the aluminum cylinder by the cradle and it to the stand. The aluminum cylinder should rest on top of the ice.
 - iv. Turn off the steam generator.
 2. You will collect temperature data until all the ice in the glass container melts.

5. Place the glass container on the stirrer so the stirring bar is centered on the stirrer.
6. Turn on the stirrer, set the stirring speed, and activate Reversion mode.
 1. When turned on, the stirrer will reload its last setting. Therefore, you must first reset it. Turn on the stirrer and adjust it to its lowest stirring setting by holding the down arrow button until the green LED stops blinking.
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 1. Thread TP1 through the stand's probe holder and into the ice. (The probe holder is the 90° bracket attached to the stand with a hole in it, as shown in Figure 1.2.)
 2. Thread TP2 through the hole in the rubber stopper of the aluminum cylinder.

Collect data

Close LoggerPro. Then, navigate to the window for the Lab 1b.cmbl LoggerPro experiment file. The workspace displays a temperature vs. time graph.

1. Click the Data Collection Button  and set the Duration field to 600 seconds. Ensure the "Continuous Data Collection" box is checked.

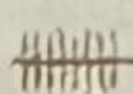
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1. Transfer the aluminum cylinder to the stand and measure temperatures.
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 - i. In LoggerPro, begin collecting data from the temperature probes by clicking the Collect Button .
 - ii. Put on the insulating gloves at your lab station.
 - iii. Using your glove-protected hands, lift the aluminum cylinder by the cradle and it to the stand. The aluminum cylinder should rest on top of the ice.
 - iv. Turn off the steam generator.
 2. You will collect temperature data until all the ice in the glass container melts.

- i. During this process, you may need to jostle the glass container to redistribute the ice or re-center the stirring bar.
 - ii. Throughout the process, ensure TP1 remains in contact with the ice and does not touch the aluminum cylinder.
3. In **Observations 1.1**, record any relevant observations, particularly any anomalous or interesting behavior in the data (e.g., when the ice fully melts). Include a timestamp. If you take any actions that affect the data, such as jostling the glass container, record these actions as well. (After collecting the data, you will annotate your plot indicating when these observations and actions occurred.)
4. When all the ice melts, stop the data collection process by clicking the **Stop Button** .



Troubleshooting the Magnetic Stirrer



bar

If the stirring bar fails to rotate, try the following:

1. Turn off Reversion Mode and reduce the stirring speed to its lowest setting.
2. Ensure the bar is centered on the stirrer (i.e., over the crosshair printed on the stirrer.) If not, reposition the glass container until the bar is centered.
3. Slowly ramp up the speed of the stirrer.
4. If the bar starts rotating, you may want to reactivate the Reversion Mode to prevent the bar from getting stuck.

If the stirring bar still does not rotate, you can manually stir the ice water by jostling either the glass container or Temperature Probe 1.

- i. During this process, you may need to jostle the glass container to redistribute the ice or re-center the stirring bar.
 - ii. Throughout the process, ensure **TP1** remains in contact with the ice and does not touch the aluminum cylinder.
3. In **Observations 1.1**, record any relevant observations, particularly any anomalous or interesting behavior in the data (e.g., when the ice fully melts). Include a timestamp. If you take any actions that affect the data, such as jostling the glass container, record these actions as well. (After collecting the data, you will annotate your plot indicating when these observations and actions occurred.)
4. When all the ice melts, stop the data collection process by clicking the **Stop Button** .



Troubleshooting the Magnetic Stirrer

If the stirring bar fails to rotate, try the following:

1. Turn off Reversion Mode and reduce the stirring speed to its lowest setting.
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3. Slowly ramp up the speed of the stirrer.
4. If the bar starts rotating, you may want to reactivate the Reversion Mode to prevent the bar from getting stuck.

If the stirring bar still does not rotate, you can manually stir the ice water by jostling either the glass container or Temperature Probe 1.

Observations 1.1:

Initially, a high water temp
Ice starts at 0
As heat is transferred water cools while ice
melts maintaining a constant temp

Reset the equipment.

Clean up your station by

- emptying the water from the aluminum cylinder and glass container into the sink at the back counter, and
- placing the aluminum cylinder, rubber stopper, glass container, stirring bar, and thermal probes on a dry paper towel at your station.

Document your work.

Modify and save the plot by doing the following:

1. **Scale your plot** automatically by clicking on the Auto Scale Button  or manually by using the Graph Options window.
2. **Label your plot** using either the Graph Options window or Insert>Text.
3. **Annotate your plot** using Insert>Text Annotation. Indicate
 - a. Which curve represents the temperature response of the ice,
 - b. Which curve represents the temperature response of the water, and
 - c. When observations or actions listed in Observations 1.1 occurred.
4. **Take a screenshot of your plot** using the **Snipping Tool**. In the filename, include the procedure number and a brief description of the screenshot's content. Include this screenshot in your assignment submission.

Observations 1.1:

Initially, a high water temp
Ice starts at 0

As heat is transferred water cools while ice
melts maintaining a constant temp

Reset the equipment.

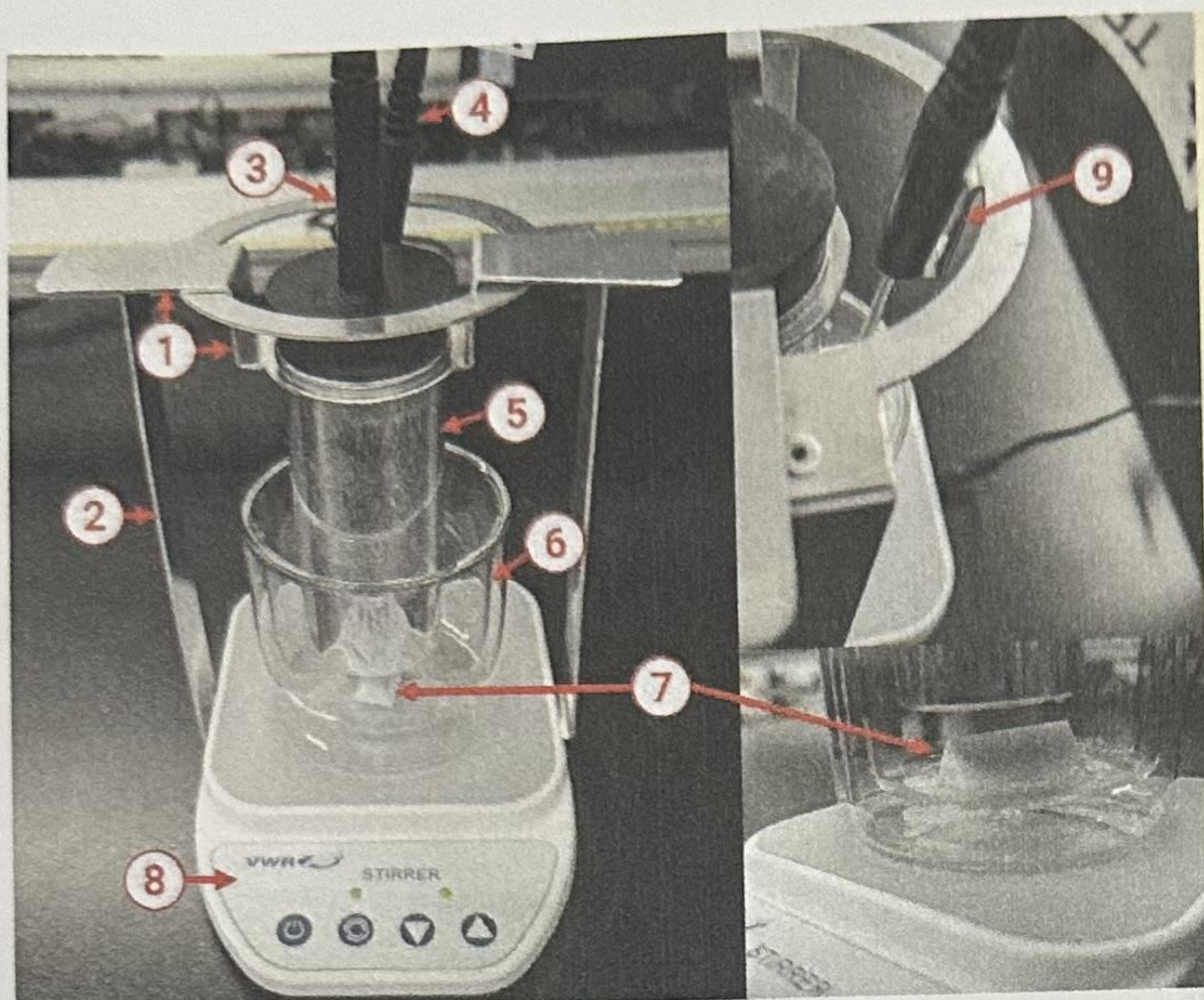
Clean up your station by

- emptying the water from the aluminum cylinder and glass container into the sink at the back counter, and
- placing the aluminum cylinder, rubber stopper, glass container, stirring bar, and thermal probes on a dry paper towel at your station.

Document your work.

Modify and save the plot by doing the following:

1. Scale your plot automatically by clicking on the Auto Scale Button **A** or manually by using the Graph Options window.
2. Label your plot using either the Graph Options window or Insert>Text.
3. Annotate your plot using Insert>Text Annotation. Indicate
 - a. Which curve represents the temperature response of the ice,
 - b. Which curve represents the temperature response of the water, and
 - c. When observations or actions listed in Observations 1.1 occurred.
4. Take a screenshot of your plot using the Snipping Tool. In the filename, include the procedure number and a brief description of the screenshot's content. Include this screenshot in your assignment submission.



1. Cradle
2. Stand
3. Thermal Probe 2
4. Thermal Probe 1
5. Aluminum cylinder
6. Glass container
7. Stirring wedge
8. Stirrer
9. Probe holder

FIGURE 1. 2: Annotated experimental setup for Procedure 1.3.1



FIGURE 1. 3: The aluminum cylinder + cradle is placed in the steam generator to heat the water inside the cylinder. Temperature Probe 2 is threaded through the rubber stopper to measure the water's temperature.

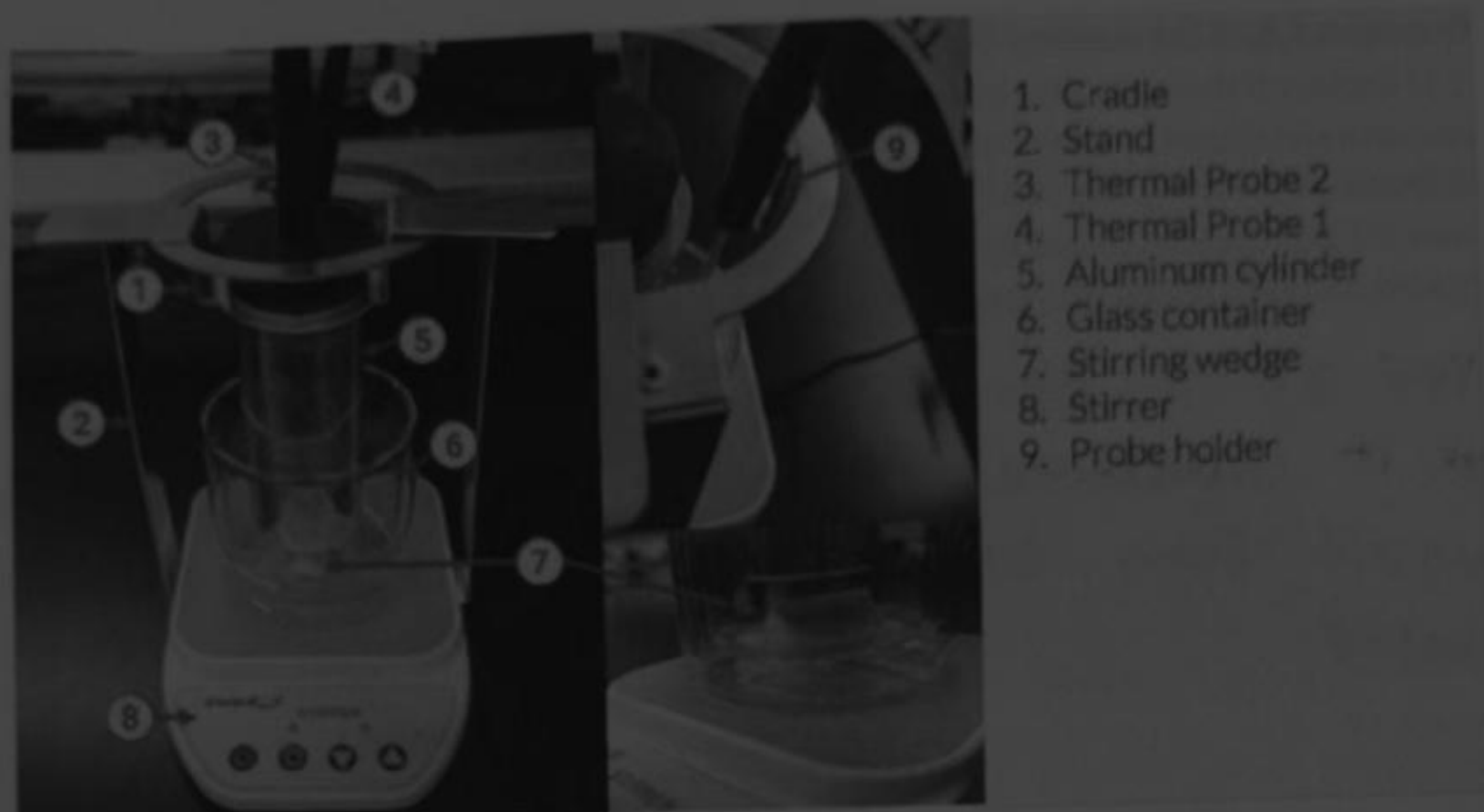


FIGURE 1. 2: Annotated experimental setup for Procedure 1.3.1



FIGURE 1. 3: The aluminum cylinder + cradle is placed in the steam generator to heat the water inside the cylinder. Temperature Probe 2 is threaded through the rubber stopper to measure the water's temperature.

Question 1.5: Is the outcome of Procedure 1.3.1 consistent with your response to Prediction 1.1? Explain. If there are discrepancies, discuss them and their sources. (For instance, were the discrepancies caused by experimental factors? If so, which factors were responsible for the discrepancies, why did they cause them, and how do you know they caused them? Alternatively, were the discrepancies caused by flaws in your assumption or reasoning? If so, how were they flawed, and what helped you realize this?)

Yes it is bc the temp of water decreased
as it transferred heat to the ice and the ice
would stay at 0°C until the ice is fully
melted

Question 1.5: Is the outcome of Procedure 1.3.1 consistent with your response to Prediction 1.1? Explain. If there are discrepancies, discuss them and their sources. (For instance, were the discrepancies caused by experimental factors? If so, which factors were responsible for the discrepancies, why did they cause them, and how do you know they caused them? Alternatively, were the discrepancies caused by flaws in your assumption or reasoning? If so, how were they flawed, and what helped you realize this?)

Yes It is BC the Temp of water decreased as it transferred heat to the ice and the ice would stay at 0°C until the ice is fully melted

Question 1.6: Use either the Statistics $\frac{1}{2}$ or Examine Tool $\times$ to measure the following quantities from your temperature vs. time plot.

(To apply the Statistics Tool to a specific region of a plot, first click and drag the cursor across that region, which will highlight it in grey. Then click the Statistics Tool.)

Initial temperature of the water in the aluminum cylinder:

95.5°C

Final temperature of the water in the aluminum cylinder:

39.3

Initial temperature of the ice in the glass container:

4.1°C

Final temperature of the ice in the glass container:

18.7

Question 1.7: Calculate the latent heat of fusion for ice using your data. Show your work. (The specific heat of water is $c_{\text{water}} = 4186 \text{ J/kg}^\circ\text{C}$.)

$$Q = mc\Delta T$$

$$Q = 0.00225 \text{ kg} (4186 \text{ J/kg}^\circ\text{C}) (4.1 - 18.7)$$

$$Q = 529.3197$$

$$Q = m \cdot \Delta H$$

$$529.3197 = 0.00225 \text{ kg} (\Delta H)$$

$$\Delta H = 235253.8 \text{ J/kg}^\circ\text{C}$$

Question 1.8: Explain how your mathematical procedure is consistent (or inconsistent) with the temperature-versus-time plot from Procedure 1.3.1 for the ice and water.

(For instance, are there any differences between the temperature responses of the ice and the water? If so, how are these differences reflected in your calculations and the equations you used?)

The math used follows principles of heat transfer and latent heat of fusion. In theory, the water cools down as it loses heat to the ice. Water gradually decreases its temp.

Question 1.8: Explain how your mathematical procedure is consistent (or inconsistent) with the temperature-versus-time plot from Procedure 1.3.1 for the ice and water.

(For instance, are there any differences between the temperature responses of the ice and the water? If so, how are these differences reflected in your calculations and the equations you used?)

The math used follows principles of heat transfer and latent heat of fusion. In theory, the water cools down as it loses heat to the ice. Water gradually decreases its temp.

Question 1.9: Compare the value you calculated in Question 1.7 with the known latent heat of fusion for ice: $L_{f,water} = 3.35 \times 10^5 \text{ J/kg}$. If there are discrepancies, discuss them and their sources.

$$\text{Known} = 3.35 \cdot 10^5 \text{ J/kg}$$

$$\text{The calculated was } 2.36 \cdot 10^5 \text{ J/kg}$$

which is different. This could be -
be due to loss of heat to the surrounding environment
or if the stir bar didn't distribute heat
evenly or if maybe we mis measured ice
and water

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2. Synthesis and Reflection

2.1 Applying lab concepts to real-world contexts.

Question 2.1: Phase change materials (PCMs) are substances that absorb or release significant amounts of thermal energy when they transition between solid and liquid states. During melting, they store heat; during solidification, they release it. This ability to store and release thermal energy helps regulate temperatures in their surroundings, making PCMs valuable for regulating temperatures in environments where fluctuations could pose risks or impact performance.

In healthcare, PCMs help maintain safe temperatures when transporting temperature-sensitive materials like blood, vaccines, and organs. They are also used in low-resource medical treatments, such as cooling blankets for neonatal asphyxia, where lowering an infant's body temperature can prevent brain damage. In food safety, PCMs ensure that perishable goods stay within safe temperature ranges during storage and transport. Additionally, sustainable architecture incorporates PCMs into building materials like drywall to reduce reliance on active heating and cooling systems by absorbing heat during the day and releasing it at night. Similarly, greenhouses use PCMs to moderate temperatures, preventing sudden changes that could hinder plant growth.

Consider a PCM made of calcium chloride hexahydrate, commonly used for thermal energy storage. This material melts at $27\text{ }^{\circ}\text{C}$, has a specific heat of $1900\text{ J/kg}^{\circ}\text{C}$, and a latent heat of fusion of $1.7 \times 10^5\text{ J/kg}$.

- (a) Calculate the energy required to raise the temperature of 1.0 kg of this PCM from $20\text{ }^{\circ}\text{C}$ to its liquid state at $27\text{ }^{\circ}\text{C}$.
- (b) If 1.0 kg of water, initially at $20\text{ }^{\circ}\text{C}$, absorbed the same amount of energy, what would its final temperature be?
- (c) In the context of environmental temperature regulation, discuss the advantages of calcium chloride hexahydrate as a thermal energy-storage material compared to water.

A)

$$Q_1 = mc\Delta T = 1 \cdot 1900 \cdot 27 - 20 = 13300 \text{ J}$$

$$Q_2 = mL = 1 \cdot (1.7 \cdot 10^5) = 170000 \text{ J}$$

$$Q_T = 13300 + 170000 = 183300 \text{ J}$$

B) $Q = mc\Delta T$ $T_F = T_{\text{initial}} + \frac{Q}{mc}$

$$T_F = 20 + \frac{183300}{1.4184} = 63.8^\circ\text{C}$$

C)

- 1) higher energy storage density,
- 2) Phase Change Stability.
- 3) efficient heat management in buildings as it's used to release/receive heat at night
- 4) improved temp control in medicine + food

2)

$$Q_1 = mc\Delta T = 1 \cdot 1400 \cdot 27 - 20 = 13300 \text{ J}$$

$$Q_2 = mL = 1 \cdot (1.7 \cdot 10^3) = 170000 \text{ J}$$

$$Q_t = 13300 + 170000 = 183300 \text{ J}$$

3) $Q = mc\Delta T$ $T_p = T_{\text{initial}} + \frac{Q}{mc}$

$$T_p = 20 + \frac{183300}{1.4184} = 63.8^\circ\text{C}$$

C)

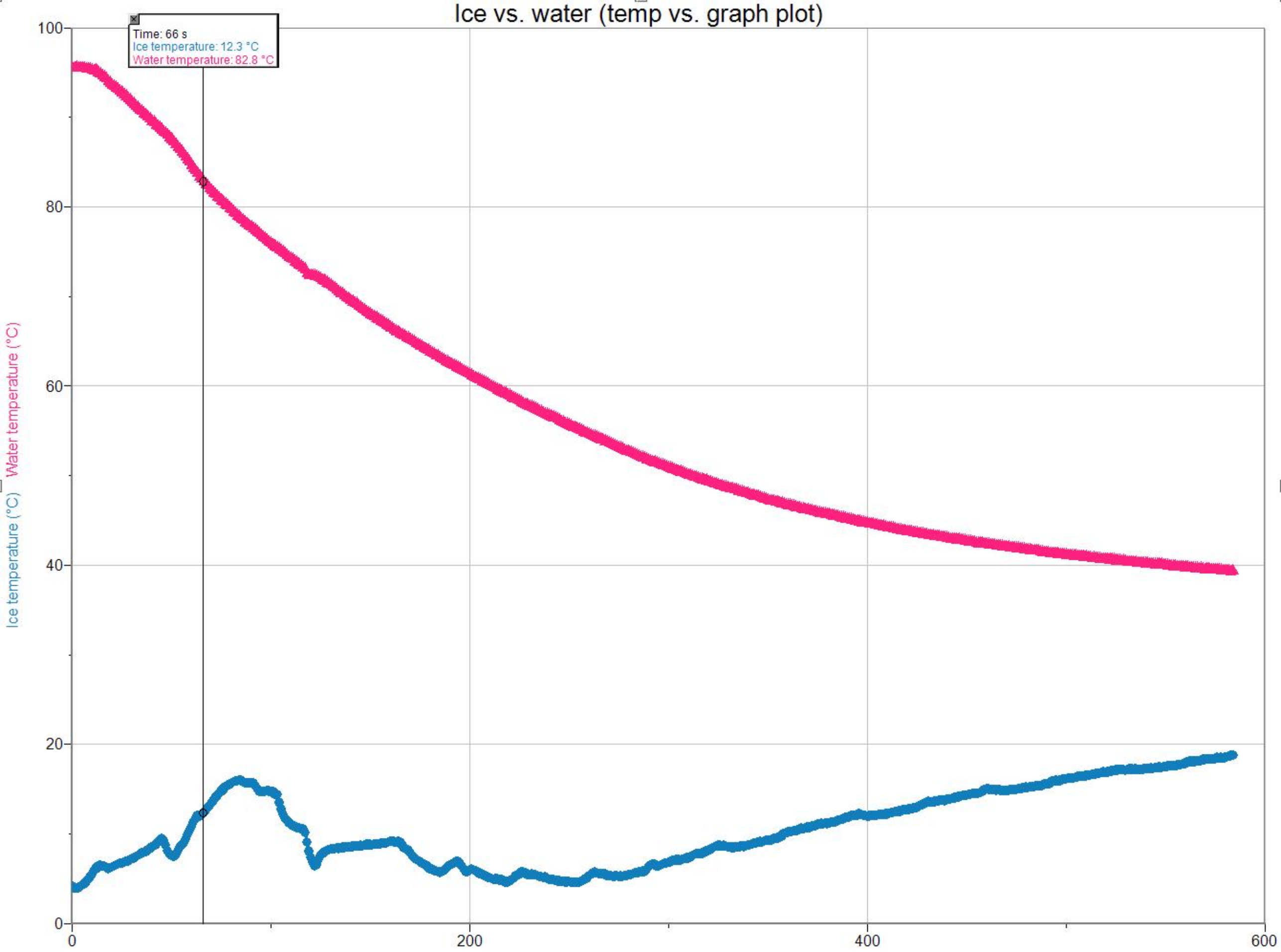
1) higher energy storage density,

2) Phase Change Stability.

3) efficient heat management in buildings as it's used to release energy at night

4) improved temp control in medical food

Ice vs. water (temp vs. graph plot)



Temp vs. time of brass cylinder in water

