## Name:

Period:

Seat#:

Worksheet #6

Required Sections: (Refer to R-15 for guidelines and requirements. Make note of any specific changes given by your teacher in class.) Prelab: Prelab Questions, Purpose, Materials, Reagent Table, Procedures, and set up Data Tables before you get to class. **During Lab:** Data section – Fill out your data table that is already set up from the prelab.

Post-lab: Calculation section, Post-Lab Questions, Post-Lab Two Pager done on separate Worksheet.

# NOTE:

This lab consists of two parts. Depending on time available you will be doing one, or both parts of the lab. Check the box below that matches what your teacher says the plan will be for this year:

Performing only ONE part of the lab, prelab for ONE part, post-lab for ONE part.

Check the box below for the one you are going to be doing:

- Part A Melting Point Lab
- Part B Evaporation of Alcohol Lab
- Performing only ONE part of the lab, prelab for BOTH parts, collect data from another group for the part you did not do, post lab for BOTH parts of the lab.
  - Even lab bench numbers will be doing Part A, collect Part B data from and odd lab bench number.
  - Odd lab bench numbers will be doing Part B, collect Part A data from an even lab bench number.
- Performing BOTH parts of the lab, prelab for BOTH parts, post-lab for BOTH parts.

# Part A – Determining Melting Temperature

The melting temperature of a compound is the temperature at which it changes from a solid to a liquid. This is a physical property often used to help identify compounds or to check the purity of a compound. The melting temperature is related to the amount of kinetic energy that one adds to a solid substance to overcome the intermolecular attractions that maintain its solid state under given conditions.

It is not possible, however, to find an exact melting *point*. Being a thermodynamic process, when a substance begins to melt, a dynamic equilibrium is established within which the substance exists in both solid and liquid form. Because the energy transferred to this system is not used entirely to convert the solid to a liquid, a single temperature value cannot be given for this process, but rather a temperature range.

Thus, melting temperatures are usually reported as values with a range of 2-3°C. Melting temperature is not a unique physical property of a substance, but it does help you understand more about the substance. It can also help determine the purity of a substance that you have synthesized.

You will use a Vernier Melt Station to determine the melting temperature of a solid substance. Your sample will be one of several possible pure compounds. Your first trial will help you narrow your possibilities. On subsequent trials you will be able to accurately determine the melting temperature of your sample, thus identifying the compound.

# Objectives

In this experiment, you will

- Prepare a solid substance for measuring melting temperature.
- Measure the temperature of a solid substance as it warms to melting.
- Analyze the temperature vs. time graphs to determine the rate . of heating and the melting temperature of a sample of a solid organic compound.
- Identify the solid from a list of possible pure compounds.
- Rank the solids from weakest to strongest IMF

# Materials

- Chemicals
- Palmitic acid
- Oxalic acid
- Benzoic acid
- Maleic acid
- Dextrose

## Salicylic acid

- Tartaric acid
- Succinic acid

## Equipment

- Computer with USB port, or a USB adaptor
- LabQuest Mini
- Logger Pro
- Vernier Melt Station
- Glass capillary tubes x 3 - one closed end,
- Kim-wipes
- Compound Melting Temperature (°C) Palmitic acid 61 - 63Oxalic acid 100 - 103 Benzoic acid 122 - 124 138 – 141 Maleic acid 146 - 152 Dextrose Salicylic acid 158 - 160 Tartaric acid 168 – 172 185 - 187 Succinic acid

## **Procedure**

- **1)** Obtain and wear goggles.
- 2) Check the control dial on the Melt Station to confirm that it is in the Off position. Connect the Melt Station power supply to a powered electrical outlet. \*NOTE\* during the lab do NOT force the knob to turn. If it gives you any resistance STOP and call your teacher over.
- 3) Connect the Melt Station sensor cable to a computer interface.
- 4) Obtain a small amount of a solid organic compound. The solid should be in powder form. If it is not, use a mortar and pestle to carefully grind the solid to a powder.
- 5) Prepare a sample for melting.
  - a. Pack a capillary tube 3 4 mm (~1/8 inch) deep with your sample by inserting the open end into a small pile of the solid. A small amount of the solid will be pushed up into the tube.
  - b. Wipe off any loose solid that is on the outside of the capillary tube.
  - c. Tab the closed end of the capillary tube on the desk top to compress the sample into the closed end.
  - d. To further pack down the sample in the tube, drop the capillary tube (closed end down) down a section of class tubing that has been set up for this purpose.
  - e. Carefully insert the capillary tube of solid into one of the three slots in the heating block of the Melt Station. You may rotate the Melt Station toward you slightly for a better look at the heating block.
  - f. Rotate the Melt Station up or down slightly to get the best view of the solid sample through the viewing lens.
- 6) Start the data-collection program, and then choose New from the File menu. You are now set up to take melting temperature data for up to 20 minutes.
- 7) In the first trial, you will want to observe the melting process and make *rough estimate* of the melting temperature of your sample. Don't worry if the heating rate is a bit too rapid, and the sample melts too quickly. To do this:
  - a. Start data collection.
  - b. One the Melt Station, turn the control knob to a setting of 180°C. The red light will turn on indicating active heating.
  - c. Carefully observe your sample. If the solid begins to melt, click Mark to mark the temperature on your graph. When the entire solid has completely melted, click Mark again. The two values marked on your graph describe the estimated melting temperature range of your substance.
  - d. If the solid does melt by the time the temperature gets to 150°C, turn the control knob to the 220°C setting. Continue observing your sample, and if the sample begins to melt, mark the temperatures on the graph as previously described.
  - e. If the sample has not melted by them time the temperature gets 190°C, turn the knob to the Rapid Heat setting. When the sample finally begins to melt, mark the graph as previously indicated.
  - f. When you have determined the approximate melting temperature range for the sample, stop data collection. Store the run by choosing Store Latest Run from the Experiment menu in Logger Pro. Discard the capillary tube and sample as directed by your instructor.
  - g. On the Melt Station, turn the control knob to the Fan/Cooling setting to get ready for the next trial. The blue light will turn on indicating that the fan is cooling the Melt Station
- **8)** Now that you have a rough idea of the melting temperature, a more accurate determination can be made. Prepare a new sample in a capillary tube, as described in Step 5, to determine the melting temperature:
  - a. Start data collection.
  - b. On the Melt Station, turn the control knob to the Rapid Heat setting.
  - c. Carefully observe the temperature vs. time graph. When the temperature is within approximately 10°C of the lowest possible melting temperature of your sample, turn the control knob to a temperature setting corresponding to your expected melting temperature.
  - d. Carefully observe your sample. When the solid begins to melt, click Mark to mark the temperature on your graph. When the entire solid has completely melted, click Mark again. The two values marked on your graph describe the estimated melting temperature range of your substance. When you are finished with this step, stop data collection.

- e. Store the run.
- f. Discard the capillary tube and sample as directed by your instructor.
- g. On the Melt Station, turn the control knob to the Fan/Cooling setting to get ready for the next trial.
- 9) At the end of the experiment, record the melting temperature range and turn the control knob on the Melt Station to Off.
- **10)** Complete the Data Analysis section before exiting Logger Pro. Save your lab data. Print a copy of your graph.
- **11)** Collect the data for the other samples from the lab, from the other lab groups.

## Data Table

- 1. Make your own data table! Remember, you need to make sure your data table has all required elements!
  - a. Do not forget to collect the starting and ending points for the melting temp ranges
  - b. Do not forget to record the sample code letters for the solid samples in your data table
  - c. Do not forget to collect the data for the other samples from the lab, from the other lab groups
  - d. Indicate which sample was yours, by putting an asterisk (\*) next to the sample cold letter.
- 2. Glue in a copy of your Logger Pro graph below your data table.

#### Post Lab Discussion Questions

- 1. What is the sample code letter of your solid sample?
- 2. What was melting temperature range of your sample?
- 3. Use the list of possible compounds, at the top of the lab handout, to identify your sample.
- 4. Identify each sample that was used in the lab.
- 5. A heating rate of 1-2 °C/min is considered ideal for the most accurate determination of the melting temperature of a solid substance. Use the Tangent tool in Logger pro to determine the approximate heating rate during the time that your sample was melting.
- 6. Using the class set of data with melting points for each sample number, explain in detail how the IMF for each sample differs to explain the difference in melting points.

## Part B – Evaporation of Alcohols

In this experiment, you will study temperature changes caused by the evaporation of several liquids and relate the temperature changes to the strength of intermolecular forces of attraction. Temperature Probes will be placed in various liquids. Evaporation occurs when the probe is removed from the liquid's container. This evaporation is an endothermic process that results in a temperature decrease. For the molecule to break free from the attractive forces of a liquid state (and evaporate) a molecule must absorb a certain amount of energy from its surroundings.

The magnitude of a temperature decrease is, like viscosity and boiling temperature, related to the strength of intermolecular forces of attraction. You will use the results to predict, and then measure, the temperature changes for several other liquids. The greater the temperature decrease, the more energy was required to allow the molecule to break free from the liquid state.

You will encounter two types of organic compounds in this experiment—alkanes and alcohols. The two alkanes are pentane,  $C_5H_{12}$ , and hexane,  $C_6H_{14}$ . In addition to carbon and hydrogen atoms, alcohols also contain the -OH functional group. Methanol,  $CH_3OH$ , and ethanol,  $C_2H_5OH$ , are two of the alcohols that we will use in this experiment. You will examine the molecular structure of alkanes and alcohols for the presence and relative strength of two intermolecular forces—hydrogen bonding and dispersion forces.

## **Objectives**

In this experiment, you will

- Study the temperature changes caused by the evaporation of several liquids.
- Relate the temperature changes to the strength of intermolecular forces of attraction.
- Rank the various compounds based on the strength of their intermolecular forces of attraction.

# Prelab Questions

Create a table like the one you see below, and fill in the missing information.

Substance	Formula	Lewis Structure	Types of IMFs Present	<b>Predicted Ranking</b> 1 = lowest IMFs, smallest $\Delta T$ 6 = highest IMFs, largest $\Delta T$
ethanol	$C_2H_5OH$			
1-propanol	C <sub>3</sub> H <sub>7</sub> OH		1	0
1-butanol	C <sub>4</sub> H <sub>9</sub> OH		0	0
n-pentane	$C_5H_{12}$		- Sun	
methanol	CH₃OH	(	20	
n-hexane	C <sub>6</sub> H <sub>14</sub>			

## **Materials**

Chemicals

- Methanol
- Ethanol
- 1-propanol
- 1-butanol
- n-pentane
- Equipment

# SAFETY PRECAUTIONS

- Computer with USB port, or a USB adaptor
- LabQuest Mini
- Logger Pro
- Vernier Temperature Probe x2
- Test tubes x6
- Test tube rack

- 6 pieces of filter paper (2.5cm x 2.5cm)
- 2 small rubber bands
- Masking tape
- **DANGER:** The compounds used in this experiment are flammable and poisonous. Avoid inhaling their vapors. Avoid contacting them with your skin or clothing. Be sure there are no open flames in the lab during this experiment. Notify your teacher immediately if an accident occurs.

## Procedure

- 1) Obtain and wear goggles.
- 2) Connect the Temperature Probes to the LabQuest Mini and Logger Pro. Set the data collection for 8 minutes.
  \*NOTE\* you can stop data collection sooner if you have reached the minimum temperature. It may not take a full 8 minutes to reach the minimum temperature.
- **3)** Prepare two pieces of masking tape, each about 10 cm long, to be used to tape the probes in position during Step 6.
- 4) Wrap the tips of the probes with square pieces of filter paper secured by small rubber bands as shown in Figure 1. Roll the filter paper around the probe tip in the shape of a cylinder. Hint: First slip the rubber band on the probe, wrap the paper around the probe, and then finally slip the rubber band over the paper. The paper should be even with the probe end.



- 5) Stand Probe 1 in the ethanol container and Probe 2 in the 1-propanol container. Make sure the containers do not tip over.
- 6) After the probes have been in the liquids for at least 30 seconds, click or tap Collect to start data collection.
- 7) Monitor the temperatures for 15 seconds to establish the initial temperature of each liquid. Then simultaneously remove the probes from the liquids and tape them so the probe tips extend 5 cm over the edge of the table top as shown in Figure 1. \*NOTE\* if there is a drip of liquid hanging from the paper when you remove, touch the drop to the side of the test tube to get rid of it.
- **8)** Examine the graph of temperature vs. time. Based on your data, determine the maximum temperature, T<sub>1</sub>, and minimum temperature, T<sub>2</sub>, for both probes. Record T<sub>1</sub> and T<sub>2</sub> for each probe.

- **9)** For each liquid, subtract the minimum temperature from the maximum temperature to determine ΔT, the temperature change during evaporation.
- 10) Based on the ΔT values you obtained for these two substances, plus information in the Pre-Lab exercise, predict the size of the ΔT value for 1-butanol. Compare its hydrogen-bonding capability and its polarizability and surface area to those of ethanol and 1-propanol. Record your predicted ΔT, then explain how you arrived at this answer in the space provided. Do the same for n-pentane. It is not important that you predict the exact ΔT value; simply estimate a logical value that is higher, lower, or between the previous ΔT values.
- **11)** Test your prediction in Step 10 by repeating Steps 4–9 using 1-butanol with Probe 1 and n-pentane with Probe 2.
- 12) Based on the ΔT values you obtained for all four substances, plus information in the Pre-Lab exercise, predict the ΔT values for methanol and n-hexane. Compare the hydrogen-bonding capability and the polarizability and surface area of methanol and n-hexane to those of the previous four liquids. Record your predicted ΔT, then explain how you arrived at this answer in the space provided.
- **13)** Test your prediction in Step 12 by repeating Steps 4–9, using methanol with Probe 1 and n-hexane with Probe 2.

#### **Data Tables** Remember, you need to make sure your data tables have all required elements!

- 1. Record all relevant data. Do not forget to make your required predictions as you are doing the lab!
- 2. Glue in a copy of your graph under your data tables. Make sure your graph has a key indicating the name of each substance.

Substance	<b>T</b> <sub>1</sub> (°C)	T2 (°C)	∆T (T1 – T2) (°C)
ethanol			
1-propanol			1C
1-butanol		20	
n-pentane		ollin	
methanol	C	S.O.	
n-hexane	Ų	Í	

Substance	Predicted ∆T (°C)	Explanation
1-butanol		
n-pentane	0	010
methanol	C Sh	
n-hexane	S	

## Post Lab Discussion Questions

- 1. Based on the data collected, rank the compounds in terms of rate of evaporation from fastest to slowest.
- 2. Which compound has the strongest IMFs according to this data? Which has the weakest?
- 3. Explain your results on the basis of IMFs.
- 4. Does your prediction from the pre-lab match your results? Explain.
- 5. Two of the liquids, n-pentane and 1-butanol, had nearly the same molecular weights, but significantly different ΔT values. Explain the difference in ΔT values of these substances, based on their intermolecular forces.
- 6. Which of the alkanes studied has the stronger intermolecular forces of attraction? The weaker intermolecular forces? Explain using the results of this experiment and the basis of IMFs.
- 7. Which of the alcohols studied has the strongest intermolecular forces of attraction? The weakest intermolecular forces? Explain using the results of this experiment and on the basis of IMFs.
- 8. Consider the following scenario: A student plots a graph of ΔT values of the four alcohols versus their respective molecular weights, with molecular weight on the horizontal axis and ΔT on the vertical axis. They find a direct relationship between the molecular weight and the ΔT. The student wants to use this graph to claim that the magnitude of London Forces increases with increasing molecular weight. Do you agree or disagree with the student claiming London Force is based on molecular weight? Why or why not? If not, what does the magnitude of London Forces actually depend on?