Experiment 4-Heat of Fusion and Melting Ice Experiment

In this lab, the heat of fusion for water will be determined by monitoring the temperature changes while a known mass of ice melts in a cup of water. The experimentally determined value for heat of fusion will be compared with the accepted standard value. We will also explore the following question regarding the rates of melting for ice cubes is posed: Will ice cubes melt faster in distilled water or in salt water?

Part A-Heat of Fusion

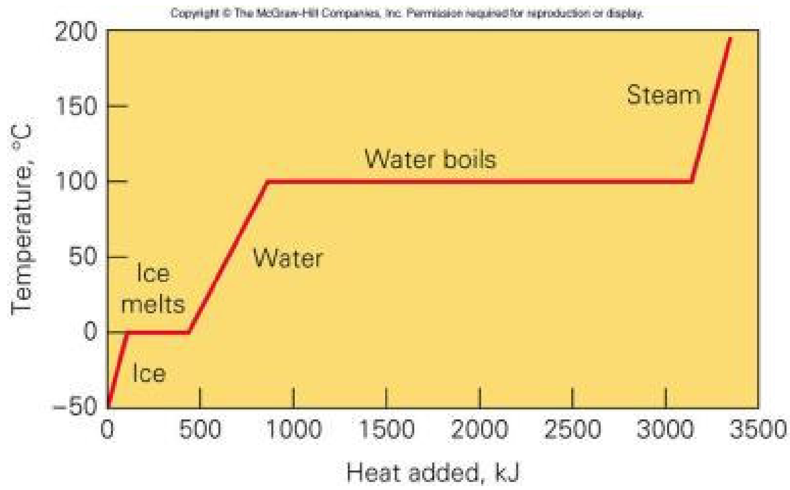
A **phase change** is a term physicists use for the conversion of matter from one of its forms (solid, liquid, gas) to another. Examples would be the melting of solid wax to a liquid, the evaporation of liquid water to water vapor, or condensation of a gas to a liquid. The melting of a solid to a liquid is called **fusion**.

As a phase change occurs, say the evaporation of boiling water, the temperature of the material remains constant. Thus, a pot of boiling water on your stove remains at 100 °C until all of the water is gone. Even if the pot is over a big flame that is 900 °C, the water in the pot will only be 100 °C. A tray of water in your freezer will approach 0 °C and remain at that temperature until the water is frozen, no matter how cold the freezer is. In a phase change, heat energy is being absorbed or emitted without changing the temperature of the material.

The amount of energy that is absorbed or emitted during a phase change obviously depends on the mass of the material undergoing the change. It takes more energy to melt a bag of ice than it takes to melt a single ice cube. The amount of energy also depends on the substance, because of the particular composition of each substance. It takes 80 calories of heat energy to melt 1 g of ice. This is the **heat of fusion** (H_{fusion}) for ice (heat required per gram of substance).

In order to determine the heat of fusion for ice, we need to melt some ice and measure how much heat energy is absorbed. The ice needs to be isolated from its surroundings, so we place it in an insulating Styrofoam cup, which is a simple device called a **calorimeter** (*heat measurer*). Measuring changes in heat energy is simply measuring changes in temperatures. Warm water will be used in the Styrofoam cup to melt the ice. Recall that the mass of the ice is important. It is hard to weigh ice without melting some of it, so the mass of the ice will be determined after it has melted. As ice melts (at a constant temperature of 0 °C), it forms water at 0 °C, absorbing heat energy form the warm water. This cold water then needs to be warmed, which absorbs more heat energy form the warm water, until a final temperature is reached. The heat lost by the warm water must be equal to the heat gained by the ice and cold water.

The property of **specific heat** (H_{sp}) is the amount of heat energy needed to change the temperature of one gram of a material by one degree Celsius. Like H_{fusion}, the value of H_{sp} depends on the substance. For example, it takes much more energy to heat up a pot full of water than it does to heat up the metal of the pot itself. H_{sp} for water is 1 calorie/ g °C.



Hypothesis: What is the heat of fusion for water?

Experiment:

Materials: ice, 400 ml beaker, hot plate, thermometer, Styrofoam cup and lid, distilled water

SAFETY:
Use caution when working near the hot plate to avoid burns. Ice is slippery.

Procedure:
Remember, you are trying to replicate numbers obtained by professional scientists! Be careful to make accurate measurements!

1. Fill the 400 mL beaker about half full of distilled water and heat on the hot plate to about 40-45 °C.
2. Insert the thermometer into a bucket of ice and allow the temperature to stabilize. Record the temperature, which is T_{ice}, in row 6
3. Assemble the Styrofoam cup calorimeter and put on the cover, and record the mass in row 1.
4. Fill the inner cup about half full with warm, distilled water. Replace the cover and record the mass of the calorimeter + warm water in row 2.
5. Insert the thermometer into the calorimeter, stir for 1 min, and record the temperature, T_w, in row 7.
6. Get two ice cubes, pat dry with a paper towel, and carefully place into calorimeter. Be careful not to touch the ice with your bare fingers, since this will melt the ice. Don't let it splash!!
7. Quickly cover the calorimeter and stir with the thermometer until all of the ice has melted. The temperature should drop down to 8-12 °C. If it doesn't, add more ice.
8. Observe the thermometer, and record the minimum temperature that it displays as T_{final} in row 8.
9. Remove the thermometer and record the mass of the calorimeter, cover and cool water,

in row 4.

10. Repeat steps 3-9 two more times. There are two extra columns in case a set of data reveals a gross error.

Part B-Melting Ice

The basis of this lab starts with the question that is proposed in the Purpose: "Will ice cubes melt faster in distilled water or in salt water?" To answer this question, think about factors that influence the melting of an ice cube. Or, think about what you would do in order to slow down (or speed up) the melting rate of an ice cube. Use your background information and brainstorm some ideas, as you have all seen ice melt before. In order to facilitate this lab, it will be helpful to think of a few things before the lab period.

What do you know about the physical properties of salt water?
How would these influence the melting of ice?
How would you slow down the melting of ice?
How would you speed up the melting of ice?
What factors influence melting (environment, containers, etc.)?

Now that you have thought of all of these things, here is the answer: ice cubes melt faster in distilled water than in salt water. The lab period will focus on developing hypotheses and experiments to figure out why this occurs. Remember, it is just as valuable to confirm a correct hypothesis as it is to reject an incorrect hypothesis.

Hypotheses: Will ice cubes melt faster in distilled water or in salt water?

Experiment:

Materials: ice, 400 ml beakers, salt water, thermometers, Styrofoam cup, distilled water, extra salt, stop watches

Procedure: There is no established procedure, but you or your group should take careful notes regarding what you do in the lab, so you can write a procedure for your lab report.

Experiment 4-Heat of Fusion and Melting Ice Experiment Lab Report

Name: ______________________________ **Section:** __________________

Part A: Heat of Fusion

	trial 1	trial 2
1. Mass of Calorimeter + Cover (g)		
2. Mass of Calorimeter + Cover + Warm Water (g)		
3. Mass warm water m_w (g)		
4. Mass of Calorimeter + Cover + Cool Water (g)		
5. Mass of ice m_{ice} (g)		
6. T_{ice} (°C)		
7. T_w (°C)		
8. T_f (°C)		
9. Heat lost, warm water		
10. Heat gained, cold water		
11. Heat gained, ice		
12. H_{fusion}		
13. Average H_{fusion}	XXXXXXXXX	
14. % error	XXXXXXXXX	

Conclusion:

CALCULATIONS:
Make sure that you keep track of your units

1. Subtract the mass of the calorimeter (row 1) from the mass of the calorimeter + warm water (row 2), enter this difference as the mass of warm water (m_w in row 3).
2. Subtract the mass of the calorimeter and warm water (row 2) from the mass of the calorimeter + cool water (row 4), enter this difference as the mass of the ice (row 5).

3. The warm water in the cup loses heat to melt the ice and then to warm up the new cold water formed when the ice cube melts. The heat lost by the warm water can be calculated using the equation below: (H_{sp} = 1 cal/g ° C)

   Heat lost (warm water) = m_w x H_{sp} x (T_w -T_{final}) (enter in row 9)
4. In our experiment, the ice cube melts and turns into cold water (which has the same mass as the ice cubes). This cold water gains heat from the warm water, and the heat gained can be calculated from the equation below: (H_{sp} = 1 cal/g ° C)

   Heat gained (cold water) = m_{ice} x H_{sp} x (T_{final} -T_{ice}) (enter in row 10)

5. Obviously, the ice cubes must gain heat from the warm water in order to melt. The law of conservation of energy says that the heat gained by the ice and the cold water must be equal to the heat lost by the cold water.

   Heat gained (ice) + Heat gained (cold water) = Heat lost (warm water)

We need to know the heat gained (ice), so the above equation can be rearranged and solved:

   Heat gained (ice) = Heat lost (warm water) - Heat gained (cold water) (enter in row 11)

6. We are trying to determine the heat of fusion for ice and compare it to the accepted value. The heat gained by the ice depends on the mass of ice multiplied by H_{fusion}. To find H_{fusion}, the equation can be rearranged and solved:

   Heat gained (ice) = m_{ice} x H_{fusion}

   $$H_{fusion} = \frac{\text{Heat gained (ice)}}{m_{ice}} = \frac{\text{row 11}}{\text{row 5}}$$

   (enter in row 12)

7. Compute the average H_{fusion} for your three trials.

8. Compare your average H_{fusion} with the accepted value of 80.0 calories/gram. The most convenient way to express their relationship is by calculating the % difference.
   % difference = 100 x (80.0 - H_{fusion})/80.0

Part B-Melting Ice

Write what you did (your procedure):

Write what you observed and your conclusions: