

Your Name _____

Partners _____

HEAT OF FUSION

Object: To measure the heat of fusion of ice.

Theory: When a substance changes phase, say from the solid form to the liquid form, a characteristic amount of heat is required to bring about the change of phase. Since the change occurs at a constant temperature (for most crystalline substances) the additional heat is used to further separate the molecules and so the melted substance has a greater internal energy than when it was in the solid state.

The amount of heat necessary to melt one unit of mass of a substance is called the heat of fusion of the substance. It used to be called latent (hidden) heat of fusion, by the ancients, since as heat was added in the melting process the customary rise in temperature, as observed in heating cold water, was not observed. The added heat was "hidden" as the substance changed state. In symbols, the heat of fusion may be expressed as:

$$L_f = Q/m \quad (1)$$

Where Q is the amount of heat required to melt m mass units of the substance. Some typical units for the heat of fusion are cal/gram and BTU/lb. NOTE : There is no reference to temperature units as in the units for specific heat since there is **NO CHANGE IN TEMPERATURE**. Note also that the units in the English System refer to the weight of the substance rather than the mass. This might appear as a flagrant violation of our definition of heat of fusion, but it was done for the sake of convenience.

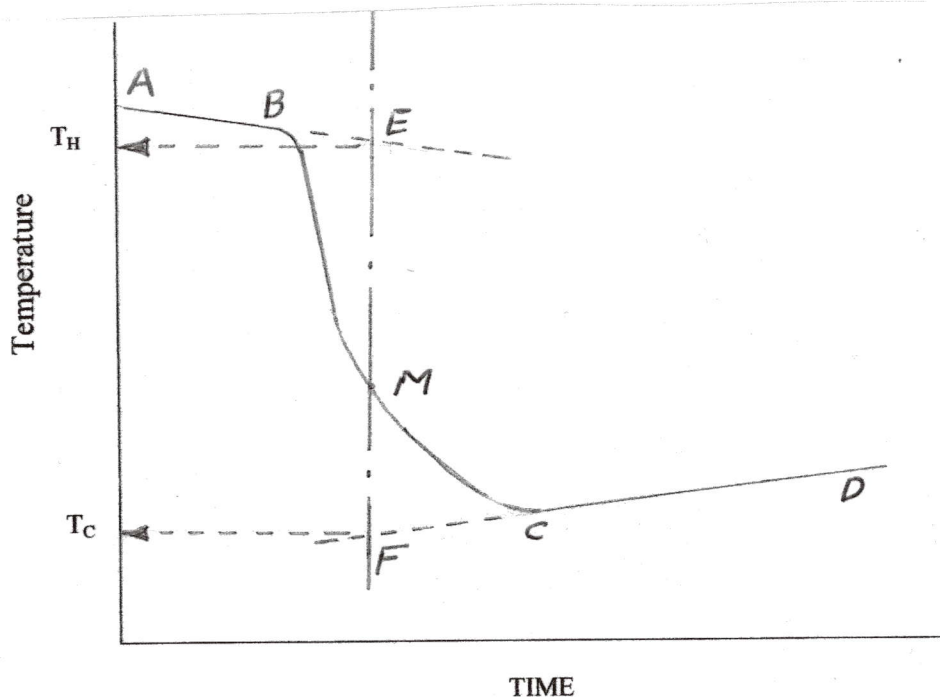
When a crystalline substance freezes, the same amount of heat is liberated in the solidification process as is absorbed in the melting process for the same amount of the substance.

Method: To measure the heat of fusion of H_2O , we will melt a known amount of ice (i.e., solid H_2O) and measure (indirectly) the amount of heat required for the process. The heat of fusion can then be found by using a loss-gain equation of the method of mixtures which incorporates the definition shown in equation 1.

Procedure: The Pasco Science experiment should be set up so as to measure temperatures as a function of time with a sensitive probe. The results will display data both in a table as well as a graph. The time sample of recording needs to be set at 15 seconds per reading. The x axis (abscissa) should be set with a range of 20 minutes. The y axis (ordinate) should be set for a temperature range from 0° to 40° Celsius.

1. Since the equipment has been on the laboratory table for some time, the recording button of the experiment can be activated and the temperature will show in the accompanying table. Record this as the room temperature T_r . Stop and delete this run.
2. Weigh the dry, inner calorimeter can AND the stirrer. Record this mass as m_c .
3. Insert the inner calorimeter into the outer calorimeter. Place the cover on the outer calorimeter with the temperature probe inserted through the rubber stopper. Adjust the distance by which the thermometer is inside the inner calorimeter so as to be just above the bottom of the inner calorimeter. This will insure that the temperature of the solution will be what the thermometer is sensing.
3. Fill the inner calorimeter about $\frac{1}{4}$ full with water whose temperature has been adjusted to be about $10^\circ C$ above T_r .
4. Weigh the inner calorimeter can AND the stirrer and record the gross mass as m_{cw} . Now you can determine m_w , the amount of water initially in the calorimeter. If the stirrer and the can are of two different materials you need to weigh them separately and adjust your heat balancing equations accordingly.
5. Place the inner calorimeter can inside the outer can and replace the top with the thermometer inserted in it.
6. After waiting two minutes, activate the record button on the Pasco experiment. The computer will now be displaying the temperature of the solution in both table and graphic form.
7. As the time reaches 4 minutes, take TWO ice cubes from the ice tray and with a paper towel dab off any excess water that may have formed. As the five minute time approaches, lift the top and QUICKLEY but yet GENTELY place the two ice cubes into the inner calorimeter and replace the top.

8. Begin a very gentle movement of the stirrer up and down so as to be mixing the solution. Continue to stir until a consistent low temperature has been reached.
9. Allow the Pasco experiment to continue to record the temperature until the remainder of the 20 minute time period. Stop the recording.
10. Using the graph resize button on the Pasco screen, Enlarge your graph so that it shows the full range of your data collection and send this to the printer. Each partner needs a copy. Also each partner needs to print out on a separate sheet the table of the temperatures recorded.
11. Carefully remove the inner calorimeter can AND the stirrer and find the new weight. Record this as m_{cwi} . You now have the ability of determining the mass of ice that was used.



12. Take the graph from the printer and using a straight edge draw all of the following lines. Take the downward slope AB and extend it to the right. Extend the upward slope CD and extend this to the left. Construct a vertical EF so as to make the areas BME and MFC to appear equal. This is done so as to balance out the heat lost and gained from the environment. Where this vertical line EF intersects the extension of AB, draw a horizontal line $T_H E$. The intersection of the ordinate by this line will give the equivalent initial temperature of the warm water. By a similar process, construct $T_C F$ and determine the equivalent final temperature of the cold mixture. Finally Find the room temperature on the ordinate and construct a horizontal line across the entire graph.

Data : $m_c =$ _____ $T_r =$ _____

$m_{cw} =$ _____

$m_w = m_{cw} - m_c =$ _____ $-$ _____ $=$ _____

$m_{cwi} =$ _____

$m_i = m_{cwi} - m_{cw} =$ _____ $-$ _____ $=$ _____

$T_H =$ _____ $T_C =$ _____

Analysis : Write a balanced heat gained-heat loss equation and in an ORDERLY MANNER, determine the heat of fusion of ice. You may assume that the original temperature of the ice was 0°C . Determine the percent of error that you determined as compared to accepted value.

- Questions :
- 1) Is the absolute value of the slope of lines AB and CD the same? If not, give a possible explanation.
 - 2) A 70 gm bullet traveling at 250 m/s penetrates a block of ice at 0°C and comes to rest within the ice. Assuming that the temperature of the bullet doesn't change appreciably, how much ice is melted as a result of the collision?
 3. If you mixed 200 gm of ice that is at -5°C with 20 gm of water that is at 15°C , what will be the temperature and condition of the final state once equilibrium is achieved?

Conclusion : Discuss errors that you believe occurred in this experiment. Make suggestions as to how this experiment can be improved so as to get improved results closer to the expected value of the heat of fusion of ice. Be sure to attach your graph and computer data sheet to this laboratory report.