Experiment 4: Latent Heat of Fusion

EQUIPMENT NEEDED:

— Calorimeter
— Ice in water (at melting point)
— Thermometer
— Warm water

Just as steam has a higher internal energy content than water, so water has a higher internal energy content than ice. It takes a certain amount of energy for the water molecules to break free of the forces that hold them together in the crystalline formation of ice. This same amount of energy is released when the water molecules come together and bond to form the ice crystal.

In this experiment, you will measure the difference in internal energy between one gram of ice at 0°C and one gram of water at 0°C. This difference in energy is called the Latent Heat of Fusion of water.

Procedure

① Measure T_{rm}, the room temperature.

② Weigh a calorimeter to determine M_{cal}, the mass of the empty, dry calorimeter.

③ Fill the calorimeter approximately 1/2 full of warm water (about 15°C above room temperature.)

④ Measure $M_{cal + H_2O}$, the mass of the calorimeter and water.

⑤ Measure $T_{initial}$, the initial temperature of the warm water.

⑥ Add small chunks of ice to the warm water, wiping the excess water from each piece of ice immediately before adding. Add the ice slowly, stirring continuously with the thermometer until each chunk melts.

⑦ When the temperature of the mixture is as much below room temperature as the warm water was initially above room temperature (i.e., $T_{rm} – T = T_{initial} - T_{rm}$), and all the ice is melted, measure the final temperature of the water (T_{final}).

⑧ Immediately after measuring T_{final}, weigh the calorimeter and water to determine M_{final}.

Suggested Additional Experiment

Repeat the above experiment, but, instead of ordinary ice, use the material which is packaged in metal or plastic containers to be frozen and used in picnic coolers.

Data

T_{rm} = ____________________

M_{cal} = ____________________

$M_{cal + H_2O}$ = ____________________

$T_{initial}$ = ____________________

T_{final} = ____________________

M_{final} = ____________________

Calculations

According to the principle of the conservation of energy, the quantity of heat absorbed by the ice as it melts and then heats up to the final equilibrium temperature must equal the quantity of heat released by the warm water as it cools down to the final equilibrium temperature. Mathematically:

$$(\mathbf{M}_{ice})\,(\mathbf{H}_f) + (\mathbf{M}_{ice})\,(\mathbf{1\ cal/g^\circ C})\,(\mathbf{T}_{final} - \mathbf{0^\circ C}) = (\mathbf{M}_{H_2O})\,(\mathbf{1\ cal/g^\circ C})\,(\mathbf{T}_{initial} - \mathbf{T}_{final});$$

where,

$M_{ice} = M_{final} - M_{cal + H_2O}$ = ________________________

$M_{H_2O} = M_{cal + H_2O} - M_{cal}$ = ________________________

H_f = the Latent Heat of Fusion for one gram of water

Use your data and the above information to determine H_f, the latent heat of fusion per gram of water.

H_f = ____________________

Questions

① What advantage might the commercially packaged coolant material have over ice other than that it produces less mess? (If you didn't perform the optional part of the experiment, what properties would a material need in order to be a better coolant than ice?)

② Design an experiment to determine which of two substances (e.g. ice and packaged coolant) will keep a cooler:

a. cool for the longest time, and

b. at a lower temperature.