Heat of Fusion

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**Objective**: The purpose of this lab is to find the latent heat of fusion, or in layman’s terms, the heat required to melt ice into water without changing its temperature. This will be done by combining known masses of liquid water and water ice in a container that will be assumed to be a near perfect insulator. Ice will be added to the liquid water so that it can be melted as the water is cooled. Once a predetermined temperature loss for the liquid water is reached, knowing the amount of ice added to the mixture (and consequently melted) to achieve this temperature decrease, the latent heat of fusion can be found.

**Theory**

Heat is the kinetic energy of the random vibration of particles, and temperature is the average heat (kinetic energy) of the particles in a given body of material. Generally, the more heat energy a body acquires, the higher its temperature becomes. The exception to this rule is when matter undergoes a change of phase, for example from solid to liquid, or from liquid to gas. This also works in reverse: as heat energy is lost, temperature falls, except during a phase change. This is because as matter changes phase, its particles need energy to gain the freedom from the forces that hold them in their current state/position; this energy does not increase the speed at which the particles vibrate, but rather breaks bonds or overcomes the forces holding the particles in place. This energy that seems “lost” in terms of temperature change is known as latent heat. When discussing matter transitioning between solid and liquid states, this is known as the latent heat of fusion.

By knowing that different substances require different amounts of heat energy to achieve temperature change, known as a specific heat, and knowing the amount of the substance, we can observe a change in temperature and calculate the heat energy required to achieve such a temperature. The specific heat of a material is defined as follows:

[1]

where C is the specific heat of the material in Joules times Kelvin per kilogram, Q is the total heat energy in Joules, ΔT is the change in temperature in Kelvin, and m is the mass of the body of material in kilograms.

Heat, like any other form of energy can be neither created nor destroyed; only transferred. It is this principle that will aid us in this experiment via the following equation:

[2]

which accounts for the heat transfer between all of the materials involved in the experiment as the ice melts, assuming that the heat that escapes the calorimeter to the surrounding environment is negligible, where Lf is the latent heat of freezing water. It should be noted that the specific heat of water is 1 cal / (˚C \* g).

This experiment is based on the assumption that a negligible amount of heat will be lost/gained to/from the surroundings, meaning that the decrease in temperature of the mixture (once all of the ice is melted) will have come solely from the apparent heat “loss” of the warm water melting the ice while the, now, ice-water maintains its temperature (Note: this heat is not actually lost, just used in the phase change from the ice to water, rather than temperature change). Once the ice has melted into water, this water with a lesser temperature than the original water will mix in with the original water, thus being included in the average heat energy measurement, the temperature, of the mixture. This change in temperature will allow us to calculate the latent heat energy of the phase transition by assuming that the mass, composition, and total heat energy of the system did not change.

**Procedure**

The materials for the experiment include: a calorimeter to contain a mixture of water and ice, a scale to find the mass of the water and ice, a stirring rod to stir the mixture, a thermometer to measure the temperature of the mixture, warm water and ice to be the subject of our experiment for which we will find the latent heat, and paper towels to dry the ice before adding it to the mixture.

The experiment will be conducted by placing the warm water in the calorimeter and carefully adding the ice to the mixture. The ice and water will be weighed so the amounts of each added to the mixture can be tracked; the temperature of each material, separately and mixed, will also be measured and tracked. The ice will be dried to before adding it to the mixture to ensure no already melted water is added to the mixture, thus introducing error into our results. The mixture will be stirred until the ice is melted and the temperature will be tracked. From this data, the latent heat of fusion can be calculated using equation [2]. The experiment will be repeated until a number of calculated values for the latent heat of water fusion that are in sufficient agreement are found.