Latent Heat of Fusion

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1 Aim

The aim is to determine the Latent Heat of fusion of ice. We will be mixing the two objects in order to determine the heat of fusion of ice.

2 Apparatus

See lab sheet.

3 Procedure

See lab sheet.

4 Data Collection

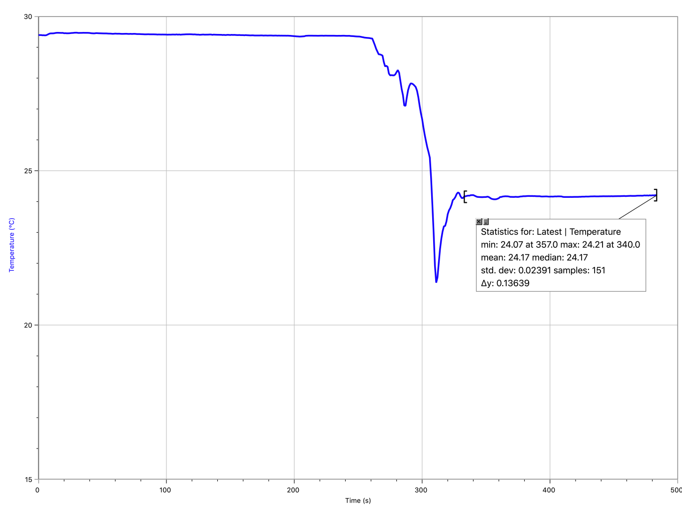

Figure 1: final equilibrium temperature of the mixture

Table 1: Data

Name	Value
m_w	283.37g
m_I	28.77g
c_w	$4.186\,\mathrm{J\,g^{-1}\,°C^{-1}}$
T_0	0°C
T_1	34.50°C
T_2	24.17°C

5 Data Analysis

If adiabatic isolation of the ice-water mixture is assumed in the calorimeter, then we can use

thermal energy lost from the warm water = thermal energy gained by the ice

to write a equation:

$$m_w c_w (T_2 - T_1) + (m_I L_f + m_I c_w (T_2 - T_0)) = 0 \tag{1}$$

where

m_w: mass of warm water initially in calorimeter

m_I: mass of the ice and melted water

c_w: specific heat of liquid water

L_f: specific heat of fusion of water and ice

T_0: temperature of ice ($T_0 = 0°C$)

T_1: initial temperature of the warm water

T_2: final equilibrium temperature of the mixture

x'

Then we can solve the equation by

$$\begin{aligned} 283.37\mathrm{g} \cdot 4.186\,\mathrm{J\,g^{-1}\,°C^{-1}}\,(24.17°C - 34.50°C) + \\ \left(28.77\mathrm{g} \cdot L_f + 28.77\mathrm{g} \cdot 4.186\,\mathrm{J\,g^{-1}\,°C^{-1}}\,(24.17°C - 0°C)\right) = 0 \\ L_f = 324.730\,\mathrm{J\,g^{-1}\,°C^{-1}} \end{aligned}$$

Error Analysis

Percentage Error: $\dfrac{|324.730 - 340|}{340} \times 100 = 4.49\%$

Common Errors

- Failure to thoroughly stirring the water-ice mixture will cause the final temperature to be warmer than its actual value and will cause the Latent Heat of Fusion to be too low, because the temperature will not get the reading of the solution, rather it will get the reading of the warm water part which is higher than the actual value. By interpreting Equation 1 we can see that when T_2 increases, and any other variables (except L_f) remains intact, the calculation result of L_f will be decreasing.

  The right side of equation is $= 0$, indicating the left side of the equation should always be 0 too. Given that $(T_2 - T_1)$ should always < 0, the $m_I L_f + m_I c_w (T_2 - T_0)$ part should always ≥ 0. Since T_0 will always be 0, it then can be simplified to $m_I L_f + m_I c_w T_2$ which leads us to the conclusion that when T_2 increases L_f must be decreasing.

- Failure to avoid letting the thermometer having contact with the calorimeter will also cause the final temperature to be warmer than its actual value and will cause the Latent Heat of Fusion to be too low, because the experiment environment is in normal room temperature which its temperature will be higher than the mixture. By letting such two object having direct contact the thermometer will be effected by the outside environment temperature. The main cause of this error may to blame by using a poor insulation performance calorimeter.

- Failure to clean the water on the ice may lead to have a higher m_I but it will not contribute to a heat loss than equivalent mass of ice. By interpreting Equation 1 we can also see that if m_I goes up but other variables remain intact, the L_f will go down. The reason of T_2 will also remain intact is because such 'more' ice is not contributing to the heat loss but it was counted as the final mass of the experiment.

Strengths and Weaknesses of the Lab

Strengths

- We used a calorimeter made up by styrofoam, allowing us lost much less heat comparing to a plastic or a glass setup, and also by using a cap on the cup we were able to significantly reduce the heat loss during the measurement.

- We stirred the cup constantly during the experiment in order to reduce the possibility of letting a specific area having significantly lower temperature comparing to other areas of the solution. By stirring the solution constantly we reduced such effect.

Weaknesses

- We have only partially sealed the calorimeter by leaving a hole on top of it in order to let our thermometer go through; such setup may increase the amount of heat loss during the experiment.

- During stirring, the thermometer may touched the ice which can lead to sudden temperature drop and also may effect the proper operation on the thermometer.

- When we deploy our ice we have to open the cap of the cup, which will:

  Firstly, causing the heat loss in the system due to we were unable to close the cap very quickly right after the ice is in the water

  Secondly, causing a small proportion of water may enter the cup.

6 Conclusion

The calculation of the Latent Heat of Fusion of water is $324.730 \mathrm{J\,g^{-1}\,^{\circ}C^{-1}}$ with a percentage error of 4.49%. Such high percentage error may caused by the errors stated above. One side is that our lab equipment and experiment environment has restricted us to get a better result, but another side may blame to the poor experiment performance since we realized we can apply some modification on improving the experiment design but we realized it only after the experiment was done. In order to eliminate such downside on designing an experiment we may want to research on other experiment design to have inspirations and clear directions on the weaknesses of our design.