1 Ice calorimetry lab questions

This question is about the ice calorimetry lab from class.

(a) **Procedure** Give a brief description of the procedure you used to gather data. You should include a picture or diagram of the apparatus you used, any measurements you made, and any steps you took to hold something constant. Your description should also highlight any challenges or difficulties you encountered, how they might have impacted your data, how if at all you overcame them, and any changes you made to your procedure over the course of the lab.

(b) **Plot your data** Plot the temperature of the system at time t, with respect to the total energy that had been thermally added to the system at time t. This thermally-added energy is called "heat". In this experiment, heat Q is increasing as a function of time. To find the net heat transferred from 0 to t, you will need to integrate the power from 0 to t. Discuss your $T(Q)$ curve and any interesting features you notice on it.

(c) **Specific heat capacity** From your data, find C_p, the heat capacity of the liquid water in your cup at a particular temperature, and c_p, the specific heat capacity of liquid water at a particular temperature. You can find the heat capacity by examing the slope of your T vs. Q graph. i.e.

$$C_p = \frac{\text{Heat that entered the system during the temperature change}}{\Delta T} \tag{1}$$

where ΔT is the temperature change. The S.I. units of heat capacity are joule/kelvin. The p subscript means that your measurement was made at constant pressure.How does your answer compare with the prediction of the Dulong-Petit law?

(d) **Latent heat of fusion** Looking at data from a group that vigorously stirred the ice bath, what did the temperature do while the ice was melting? How much energy was required to melt the ice in the calorimeter? How much energy was required per unit mass? per molecule?

(e) **Experimental uncertainty** Compare your experimental values for c_p and latent heat to published values for water. If your values are larger or smaller, discuss systematic errors in the experiment that might be responsible. What would you do differently in a follow-up experiment?

(f) **Entropy of fusion** The change in *entropy* is easy to measure for a reversible isothermal process (such as the slow melting of ice). It is

$$\Delta S = \frac{Q}{T} \tag{2}$$

where Q is the energy thermally added to complete the melting, and T is the temperature in kelvin. What is was change in the entropy of the ice you melted? What was the change in entropy *per molecule*? What was the change in entropy per molecule divided by Boltzmann's constant?

(g) **Entropy for a temperature change** Choose two temperatures that your water reached after the ice melted. Choose a reasonably large change in temperature (for example, from 2 C to 5 C). Use your experimental data to calculate the change in entropy of the water between these two

temperatures.
Hint: this change is given by

$$\Delta S = \int \frac{đQ}{T} \tag{3}$$

$$= \int \frac{P(t)}{T(t)} dt \tag{4}$$

where $P(t)$ is the heater power as a function of time and $T(t)$ is the temperature as a function of time, and the limits of integration are the final and inital times. Do this integral numerically, using your raw data (discrete time points).

(h) **Reflection** Write a short (1-2 paragraph) reflection on how the lab went, including both data collection and data analysis. Is there anything you would do differently? Is there any advice you would give to someone else attempting this experiment?