Student's Name: ______________________________ Student's Name: ______________________________

Lab day & time: __________________ Date: __________________

Temperature and Heat (M11) - Data Sheets

(Show all calculations and write all results on the data sheets in ink)

Activity 1: The Air Temperature in the Room *(0.5 p.)*

Room temperature:

T_{room} = _______________ (˚C) = _______________ (˚F) = _______________ (K)

Activity 2: Cooling with Ice - Heat of Fusion Measurement *(2.5 p.)*

. Fill this container with approximately ~150 grams of water and measure the mass of container with water. Mass of empty metal container #1 = _______________ (   )

Mass of water and container #1 = _______________ (   )

Mass of water $m_{water\ 1}$ = _______________ (   )

Turn on the hot plate and set it to "4" by rotating the knob on the right-hand side. Start recording the temperature of water inside the container #1 (i.e., click the "**Start**" button). For your own safety do not use any higher setting of the hot plate than "4"! The hot plate is relatively large, so it takes some time to worm-up. For a while, you will not see any temperature changes. Please, be patient. This part of the lab is going to take ~15-20 min.

Do not touch the white top of the hot plate! It could become extremely hot when turned on!

Once the temperature of the water approaches **70 ˚C, turn off the hotplate**. **Do not put the calorimeter on the hot plate.**

Measure the mass of the empty calorimeter.

Mass of the empty calorimeter = _______________ (   )

Remove the temperature sensor and carefully pour the **hot** water into the Styrofoam cup, which is located inside the metal can. Wait ~3 minutes and measure water temperature.

Initial temperature of water T_i = _______________ (   )

Mass of the calorimeter with hot water = _______________ (   )

Mass of water inside the calorimeter before adding ice $m_{water\ 1}$ = ____________ (   )

Measure the mass of the aluminum cup not marked with a '#1'. Add about 30-40 grams of ice to the water inside the calorimeter. Usually, you will need three pieces of ice. While quickly removing the lid, do not splash the water when you add the ice to the liquid in the calorimeter (do **not** place the double-wall cup onto the hot plate). Put the lid back on the calorimeter and observe the temperature of the mixture plunge rapidly.

Initial temperature of ice: $T_{ice} = 0$ ˚C

Mass of the added ice: m_{ice} = _______________ (   )

Final temperature after ice is completely melted T_f = _______________ (   )

$\Delta T_1 = T_i - T_f =$ _______________ (   )

Mass of the water inside the calorimeter after the ice has melted

$m_{water\ 2}$ = _______________ (   )

Determine the amount of heat Q_L that the hot water lost.

Heat Q_L lost by hot water during cooling from the initial temperature T_i to the final temperature (when the added ice is completely melted) T_f is given by the following expression.

$$Q_L = m_{water\ 1} c_w \left(T_i - T_f\right) = m_{water\ 1} c_w \Delta T_1 \qquad , T_f < T_i$$

The specific heat of water is c_w = 1.00 cal/(g·˚C).

Heat lost $|Q_L|$ = _______________ (   )

Heat Q_G gained by the added ice is used for two processes:

1. Melting ice that has been just added (Q_F),
2. Warming up the water from the melted ice (Q_W) to the final equilibrium temperature T_f.

$$Q_G = Q_F + Q_W$$

The heat needed to melt the ice without changing its temperature is given by the following formula:

$Q_F = m_{ice}\, L_{fusion}$ where L_{fusion} is the latent heat of fusion for the ice ↔ water phase transition

Determine the amount of heat gained by the water created from the melted ice as its temperature was raised from 0˚C to T_f. This water has the same mass as the ice before melting, i.e., m_{ice}.

$$Q_W = m_{ice}\, c_w(T_f - 0^\circ\text{C}) = m_{ice}\, c_w T_f$$

Since energy is conserved in the calorimeter, we can equate the heat lost to the heat gained:

$$Q_L = Q_G = Q_F + Q_W \quad \Rightarrow \quad m_{water\ 1} c_w \left(T_i - T_f\right) = m_{ice} L_{fusion} + m_{ice} c_w T_f$$

The last equation has only one unknown – L_{fusion}. Calculate the experimental value of the heat of fusion. Show your work.

L_{fusion} = ______________ (   )

The precisely measured value of the heat of fusion is equal to:

$$L_{fusion\ prec} = 79.7 \pm 0.1 \text{ cal/gram} \quad \text{or} \quad \left(333.7 \pm 0.4 \text{ J/gram}\right)$$

Calculate the percent difference between your data and the above, precise value.

Percent difference = $\left| \dfrac{L_{fusion} - L_{fusion\ prec}}{L_{fusion\ prec}} \right| \times 100\%$ = ____________ (%)

Note: Do not be surprised by approx. 20% or 30% difference between your results and the precise value. We have neglected the heat capacity of the calorimeter and the thermometer!

Activity 3: Specific Heat of Aluminum *(2 p.)*

Continue recording the temperature of water.

Mass of water at the initial temperature T_i (mass of water + mass of ice)

$m_{water\,2}$ = ________________ (   ) (*from Activity 2*)

Mass of the aluminum ring m_{Al} = _____________ (   )

Initial temperature (before adding the ring) T_i = ________________ (   )

Final temperature (after adding the ring) T_f = ________________ (   )

Calculate the specific heat of aluminum: $c_{Al.}$ See the "M11- Theory and Procedure" file for explanations.

Specific heat of aluminum: c_{Al} = ________________ (   )

The precisely measured value of the specific heat of aluminum is equal to:

$$c_{Al\,prec} = 0.215 \pm 0.002 \;\; \text{cal}/(\text{g} \cdot {}^{\circ}\text{C})$$

Calculate the percent difference between your data and the above, precise value.

Percent difference = $\left| \dfrac{c_{Al} - c_{Al\,prec}}{c_{Al\,prec}} \right| \times 100\%$ = _____________ (%)

Note: Do not be surprised by approx. 20% or 30% difference between your results and the precise value. We have neglected the heat capacity of the calorimeter and the thermometer!

Stop data recording. **Print your graph**.

Do not forget to circle, on the printout of the temperature vs. time graph, the section during which ice was added to the calorimeter (label it as '**ice**'), and the section in which aluminum ring was added (label it as '**Al**').

Remove the aluminum ring from the calorimeter and dump the water from the calorimeter. Thank you! Complete the lab report and return it to the lab TA.