# Molality and Specific Heat Capacity

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# Experimental Objectives

- Examine how various salt molalities affect specific heat capacity
- Use the resistance of a thermistor to determine change in temperature
- Use LabView to take continuous temperature measurements over a period of time

# Hypothesis

Our team hypothesized that due to the ionic interactions between the polar NaCl molecules and the water molecules, which would affect the hydrogen bonds between water molecules, which would mean less energy is required to break the existing bonds and raise the temperature of the water molecules. So we predict as the salt molality of the solution increases, the specific heat capacity of the solution will decrease.

# Relevant Formulas

Chemistry-Based

- $Q=mc\Delta T$

Circuits-Based

- $P = V^2/R$

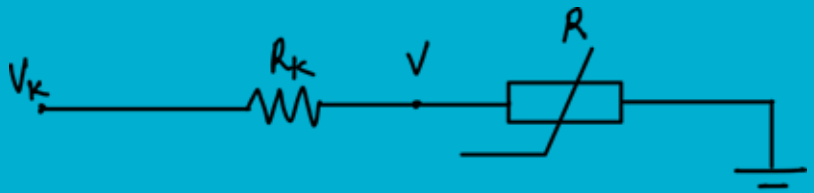
In a closed system (Thermodynamics)

- $Q = W$
- $W = P\Delta t$

Final Equation

$C(p) = (V^2\Delta t)/(mR\Delta T)$

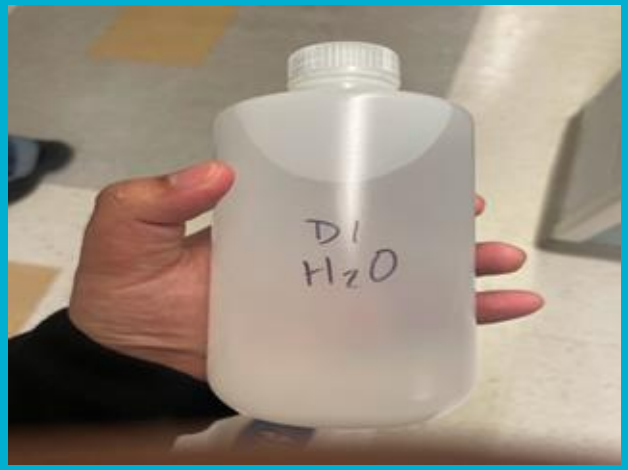
Determining the resistance of the thermistor using the DAQ board:

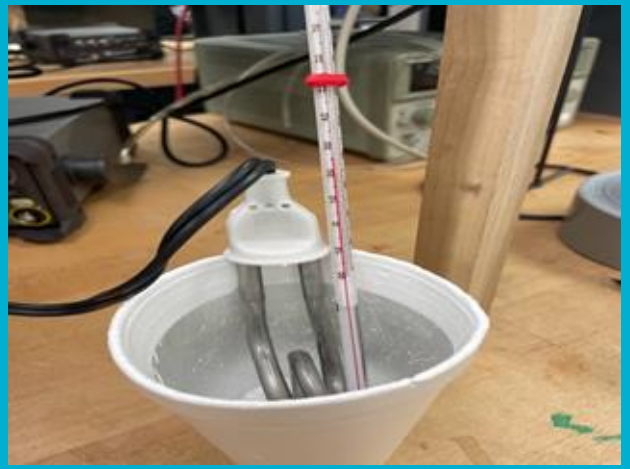



$$\frac{V}{R} = \frac{V_K - V}{R_K} \Rightarrow R = \frac{V}{V_K - V} R_K$$

# Equipment

- Protek DC Power Supply
- NI USB-6341 DAQ Board
- DigiKey 317-1378-ND Thermistor
- Immersive Water Heater
- DI (Deionized) Water
- Table Salt
- Styrofoam Cups
- Kitchen Scale
- BNC Cables
- Banana Clippers
- LabView Program



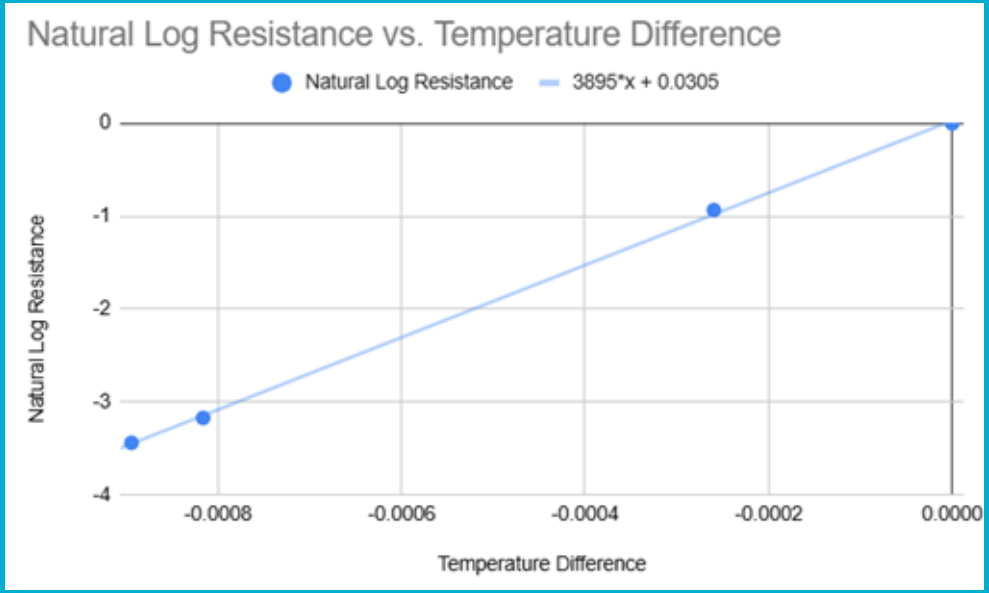



# Experimental Set-Up

- Immersive water heater powered via DC Power Supply
- Thermistor powered and measured using DAQ board
- Thermistor and water heater both placed in solution

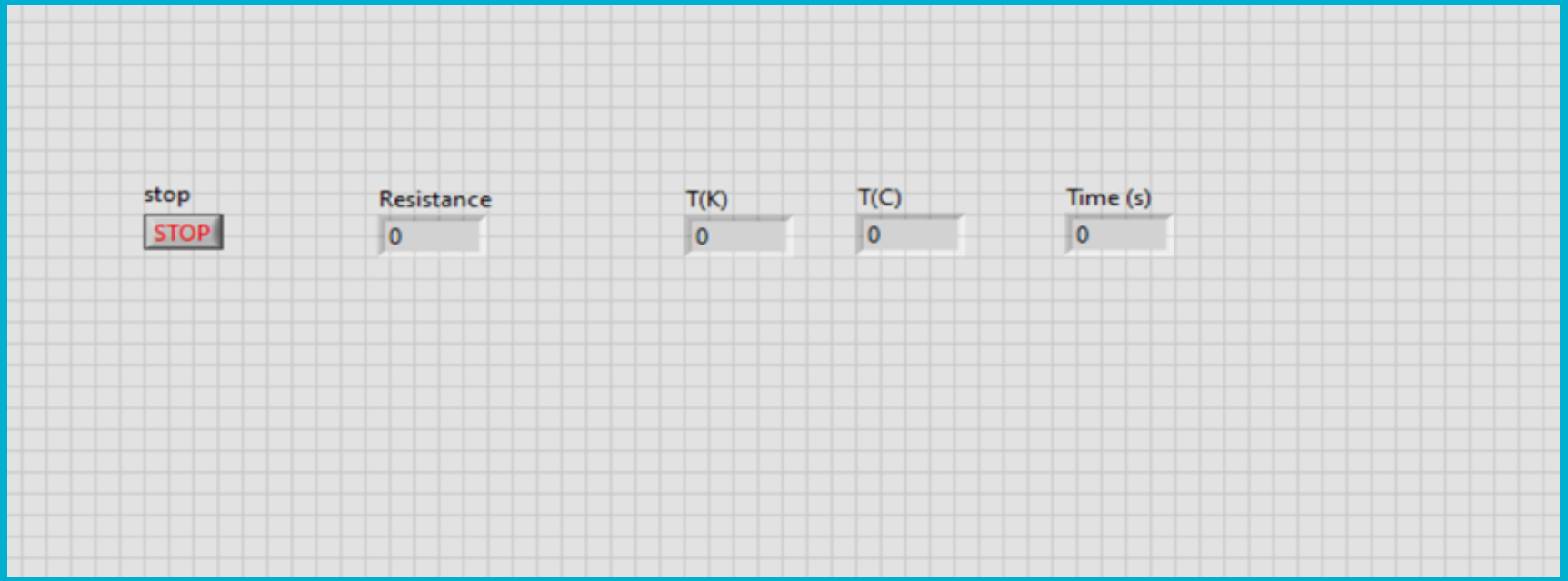
# Thermistor Calibration

- Took temperatures at four different spots (ice bath, room, 90 degrees celsius water, and 80 degrees celsius water)

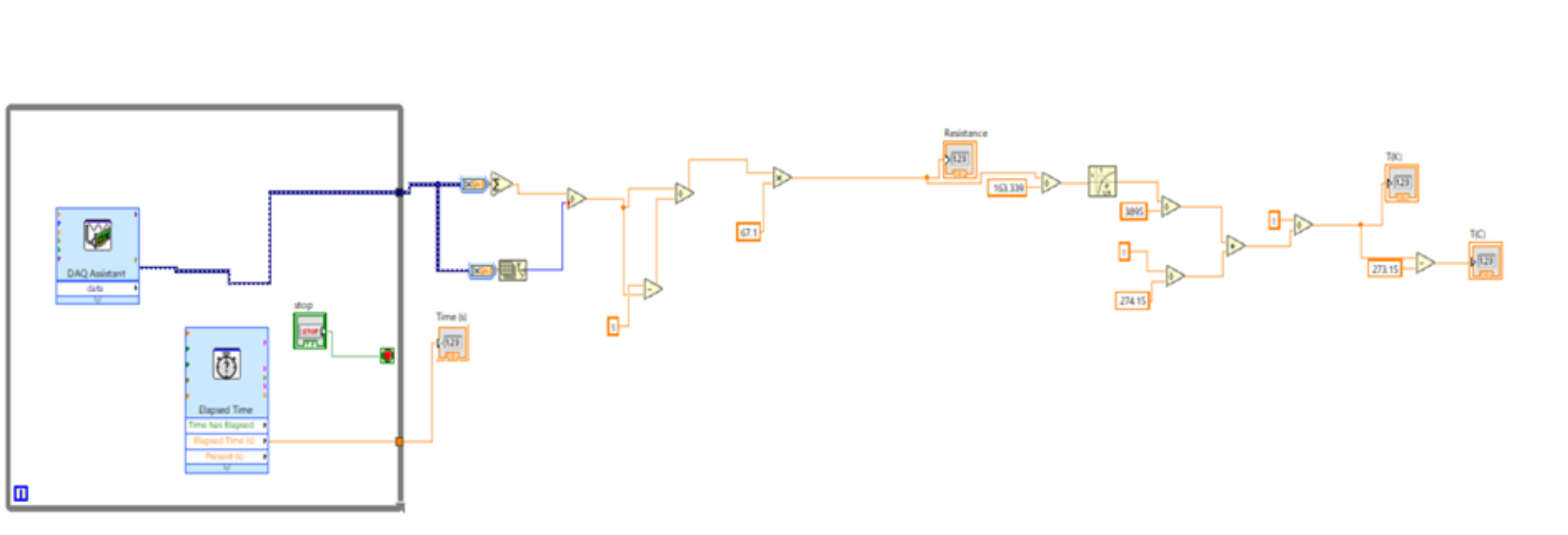



| Setting | Temperature (Degrees Celsuis) | Resistance (Kilo-Ohms) | DAQ Measured Resistance (Kilo-Ohms) | DAQ Measured Temperature (Celsius) | Temperature Difference (Degrees Celsuis) |
|---|---|---|---|---|---|
| Ice Bath | 1 | 159.6 | 163.339 | 0.9768 | 0.0232 |
| Room | 22 | 62.7 | 56.724 | 23.0247 | -1.0247 |
| Reference Temperature | 90 | 5.11 | 5.09704 | 92.1 | -2.1 |
| Second Reference Temperature | 80 | 6.68 | 6.64348 | 79.3156 | 0.6844 |

# LabView Front Diagram



# LabView Block Diagram



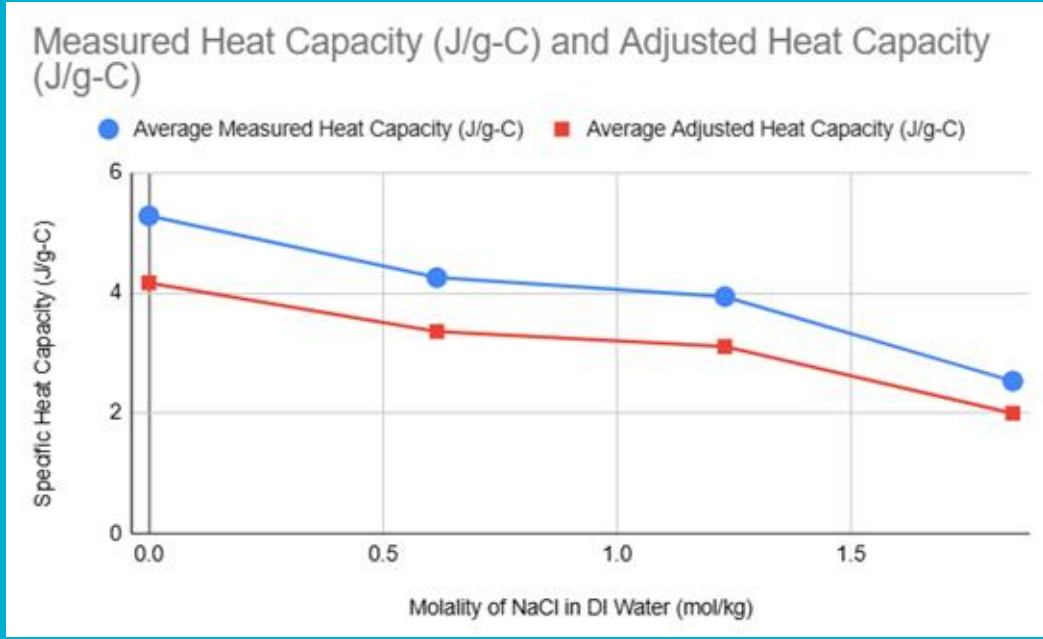
# Efficiency Calibration

- DI Water Heat Capacity is known to be 4.184 J/g-C.
- We adjusted the heat capacity to account for the non perfect efficiency of the heater using the known value of the heat capacity of DI water.

| | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Trial 6 |
|---|---|---|---|---|---|---|
| Inital Temperature (C) | 22.1617 | 24.0679 | 25.7485 | 27.6023 | 29.1325 | 21.198 |
| Final Tempature (C) | 24.2166 | 25.2064 | 27.9919 | 29.5049 | 31.2886 | 22.1997 |
| Change in Temperature (C) | 2.0549 | 1.1385 | 2.2434 | 1.9026 | 2.1561 | 1.0017 |
| Time Passed (s) | 145.518 | 86.1665 | 167.442 | 142.605 | 153.377 | 71.374 |
| Measured Heat Capacity (J/g-C) | 5.115665034 | 5.467408108 | 5.391799846 | 5.414562054 | 5.138867429 | 5.147287633 |
| Efficiency | 81.7879977 | 76.52620615 | 77.5993197 | 77.27310092 | 81.41871838 | 81.28552936 |
| Average Efficiency | 78.92106857 | | | | | |
| Adjusted Heat Capacity | 4.037282845 | 4.314878479 | 4.255208439 | 4.273172373 | 4.055594175 | 4.0622394 |
| Percent Error | 3.506624173 | 3.12807072 | 1.701922527 | 2.131270859 | 3.068972868 | 2.910148186 |

# Results

- An increase in salt molality led to a linear decrease in specific heat capacity
  - Implies a zero-specific heat capacity at a point
  - Likely levels off as molality approaches maximum amount
- More data points could reveal exact nature of relationship




| | Concentration 1 | Concentration 2 | Concentration 3 | Concentration 4 |
|---|---|---|---|---|
| Molality of NaCl in DI Water (mol/kg) | 0 | 0.6155240079 | 1.231048016 | 1.846572024 |
| Average Measured Heat Capacity (J/g-C) | 5.279265017 | 4.253687775 | 3.937131915 | 2.532610554 |
| Average Adjusted Heat Capacity (J/g-C) | 4.166395952 | 3.357055845 | 3.107226579 | 1.998763312 |

# Challenges

- Calibrating for Heat Loss
  - Finding the specific heat capacity of DI Water
  - Calculating efficiency of immersion water heater
- Safety
  - Controlling output of heater via voltage
  - Properly grounding water heater
- Inconsistent temperature readings
  - Minimizing time needed for heater to reach max output
  - Keeping consistent water levels in styrofoam cups
  - Keeping consistent water heater and thermistor placement

# Conclusions

- Maintaining a proper set-up throughout the duration of the experiment is vital for accurate calculations.
- Equipment issues can lead to issues with data collection.
- The table and graph indicated that the specific heat of a saltwater solution decreases with an increase in salt molality.