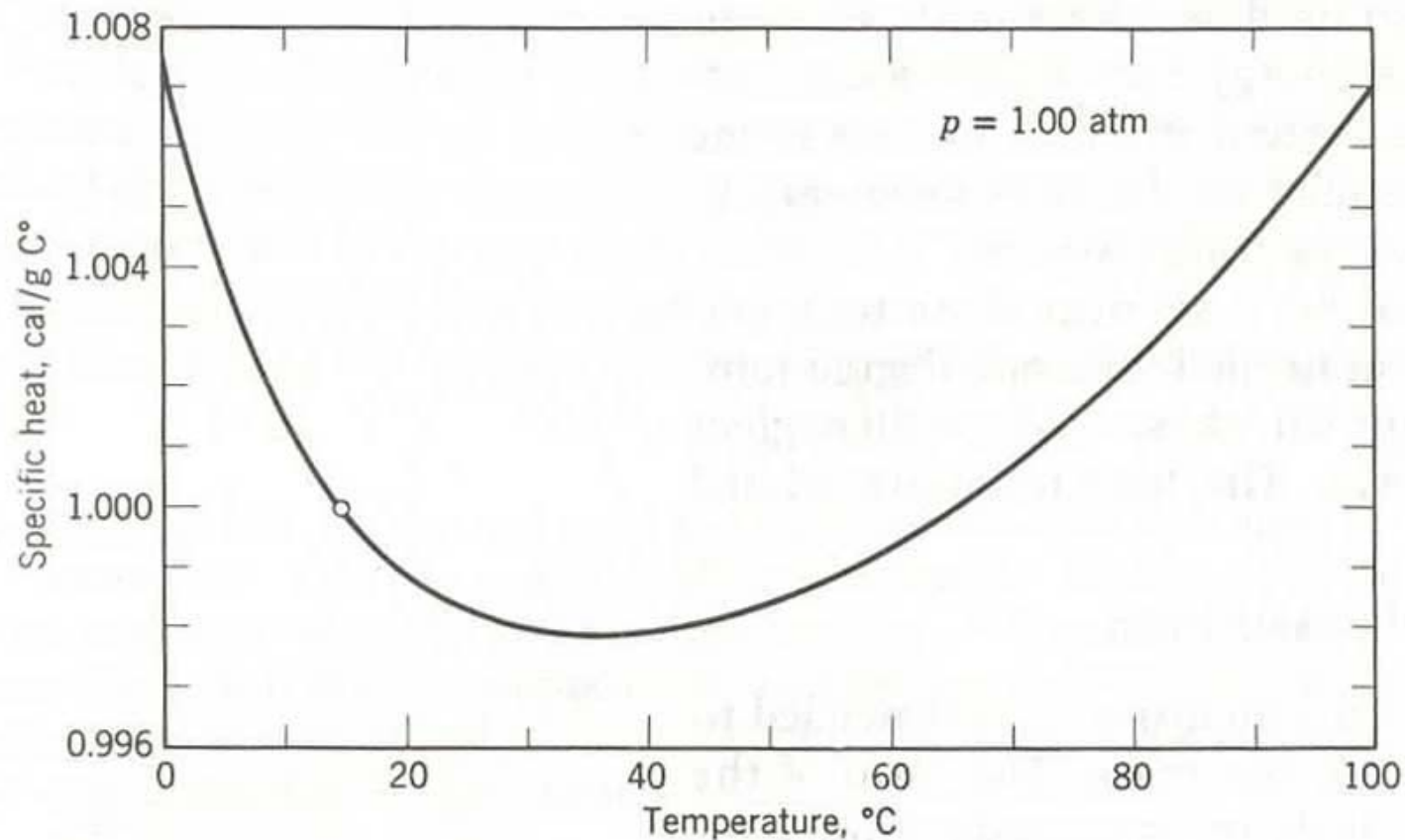


Mechanical Equivalent of Heat

Calorie

- thermal unit for heat is the calorie defined to be the amount of heat required to raise one gram of water from 14.5 °C to 15.5 °C



Calibration of Thermistor

- thermometric property: electrical resistance in wire varies as wire becomes hotter or colder.
- *thermistor* : semi-conductor device with a temperature dependent electrical resistance given by

$$R(T) = R_0 e^{-\alpha T}$$

- where R_0 is the value of the resistance at $T=0$ °C, and α is a constant

Thermistor: Data Analysis

- Take a natural logarithm and make a best fit straight line to find coefficients R_0 and α

$$\ln(R) - \ln(R_0) = -\alpha T$$

- Finding Temperature from resistance measurements. Use linear relation

$$T = (\ln(R_0) - \ln(R))/\alpha$$

Mechanical Equivalent of Heat

Experiment 1: Power Input

- The power P delivered to the reservoir due to the frictional torque τ between the plastic pot scrubber rotating at an angular frequency ω against a thin metal disk that forms the bottom of the plastic reservoir is

$$P_f = \left(\frac{dW}{dt} \right)_{\text{reservoir}} = \tau_f \omega$$

Mechanical Equivalent of Heat

Experiment 1: Summary

- Assumption: all the heat generated by the frictional torque flows into the reservoir .So power in equals rate of heat flow

$$\tau_f \omega \propto \left(\frac{dQ}{dt} \right)_{\text{reservoir}}$$

Mechanical Equivalent of Heat: Experiment 2

- System: calorimeter, resistor, and thermistor.
- Surroundings: power supply and electrical circuit.
- The power delivered from the electrical power supply to resistor

$$P_{resistor} = \left(\frac{dW}{dt} \right)_{resistor} = \Delta VI$$

- flow of heat from resistor into reservoir,

$$\Delta VI \propto \left(\frac{dQ}{dt} \right)_{reservoir}$$

Heat Capacity of Water

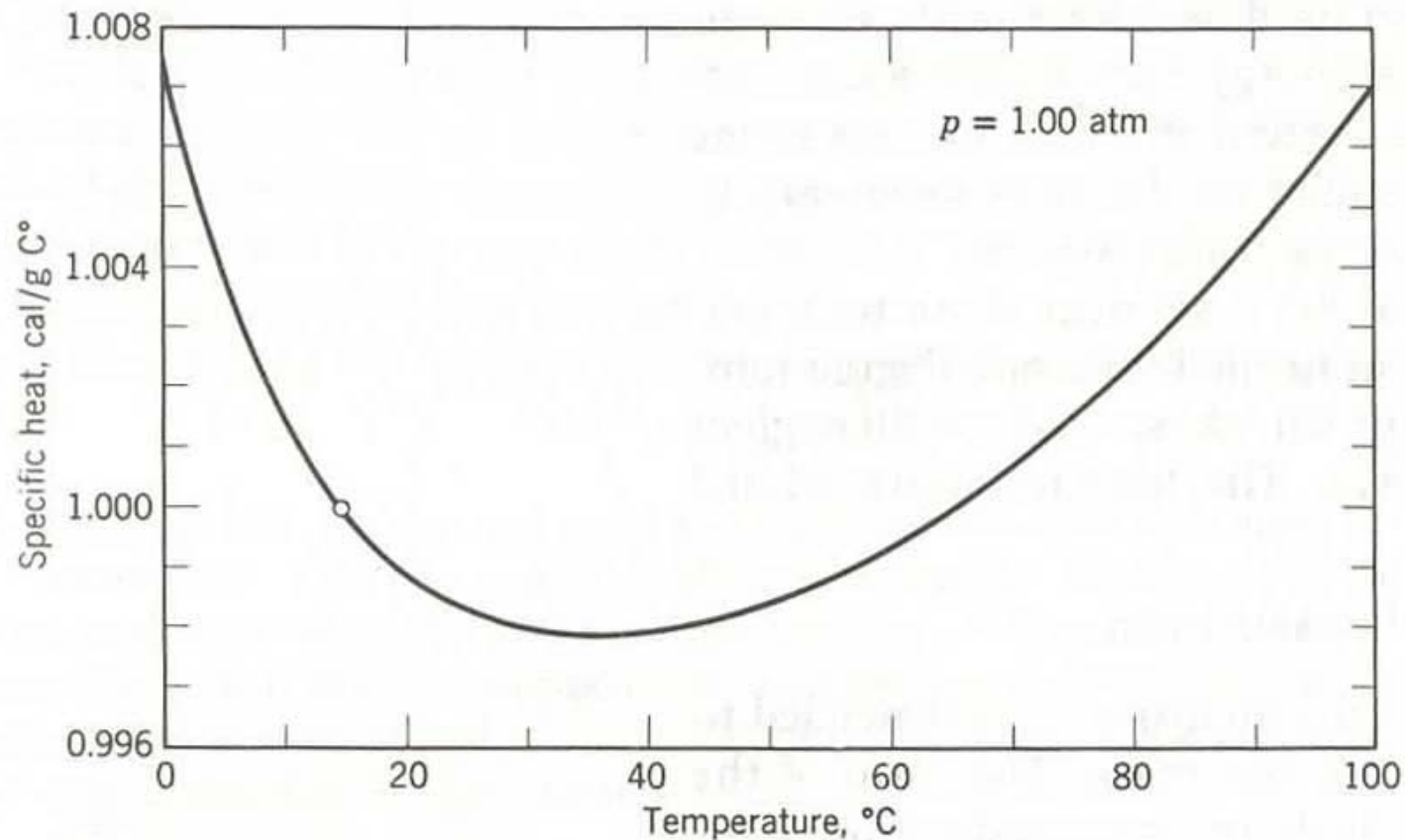
- Assumption: all the heat ΔQ goes into raising the temperature of the water, then the rate of heat flow $\Delta Q/\Delta t$ is proportional to the rate of change of temperature $\Delta T/\Delta t$

$$\left(\frac{dQ}{dt} \right)_{\text{reservoir}} = cm \frac{dT}{dt}$$

- where c is the specific heat of water and m is the mass of the water

Calorie

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Specific Heat of Water

- For water, the specific heat varies as a function of temperature. For the range 14.5 °C to 15.5 °C, the value is

$$c_{H_2O} = 1 \text{ cal} \cdot \text{g}^{-1} \cdot ^\circ\text{C}^{-1}$$

- Note that this defines the calorie

Specific Heat of Water

- Experiment 1:

$$c = \frac{\tau_f \omega}{m \left(dT / dt \right)}$$

- Experiment 2:

$$c = \frac{\Delta VI}{m \left(dT / dt \right)}$$

Mechanical Equivalent of Heat

The rate of loss of mechanical energy, measured in joules, is proportional to the rate of increase in heat, measured in calories

$$\frac{dE_{mech}}{dt} = -k \frac{dQ}{dt}$$

where k is the constant of proportionality

The result at 15°C is $4.186 \text{ J} = 1 \text{ cal}$