Physics Lab
ETH zürich

D PHYS

Specific Heat Capacity

Abstract & goal of the experiment:

Measure the specific heat capacity C_V of beryllium over the temperature interval -196 °C to +100 °C

$$C_V = \left(\frac{\partial U_\mathrm{M}}{\partial T}\right)_V$$

Idea:

Measure the temperature dependent specific heat capacity, C_V, of beryllium with a calorimeter

Experimental background:

Debye function:

The temperature dependent specific heat capacity of a body can be described with the Debye function, knowing the Debye temperature θ of the body:

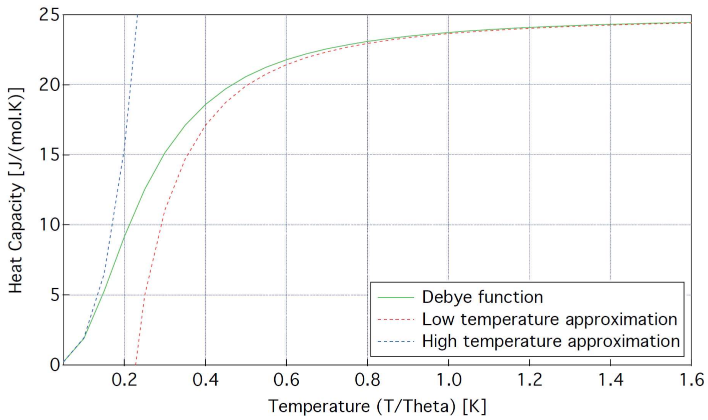
$$C_V\left(\frac{\theta}{T}\right) = 3\,R \cdot 3\left(\frac{T}{\theta}\right)^3 \int_0^{\frac{\theta}{T}} \frac{x^4 \mathrm{e}^x}{(\mathrm{e}^x - 1)^2}\,\mathrm{d}x$$

Where $x = \frac{\hbar\omega}{k_\mathrm{B}T}$. This function can be approximated for low temperatures with:

$$C_V = \frac{12\,\pi^4}{5} R \cdot \left(\frac{T}{\theta}\right)^3$$

And for high temperatures with:

$$C_V = 3\,R\left[1 - \frac{1}{20}\left(\frac{\theta}{T}\right)^2 + \cdots\right]$$



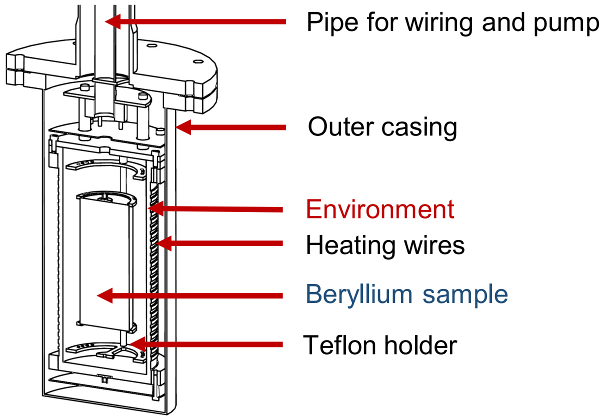
Experimental approach:

The specific heat capacity of the beryllium body can be measured using a calorimeter. In this calorimeter the body and its environment can be heated up almost independently with two heating wires.

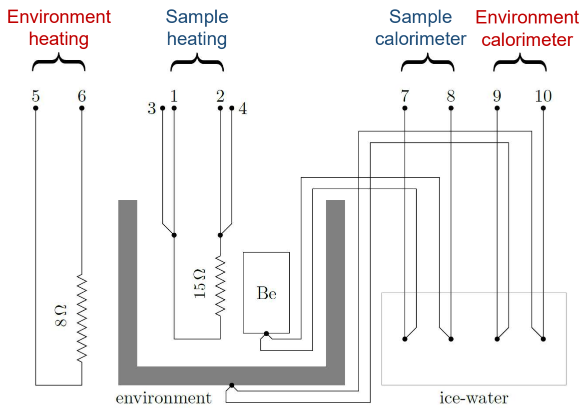
During the measurement and the analysis, the student has to take into the following:

- Heat exchange/loss with the environment
- Increased heat capacities (e.g. teflon holder)
- Heat capacity of free electrons
- $C_p - C_V$ correction (*cte.* pressure vs. *cte.* volume)
- Temperature dependency of the measurement equipment
- Measurement errors

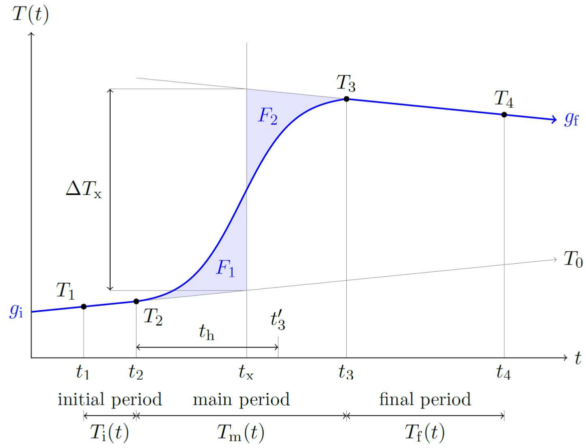
Experimental setup:



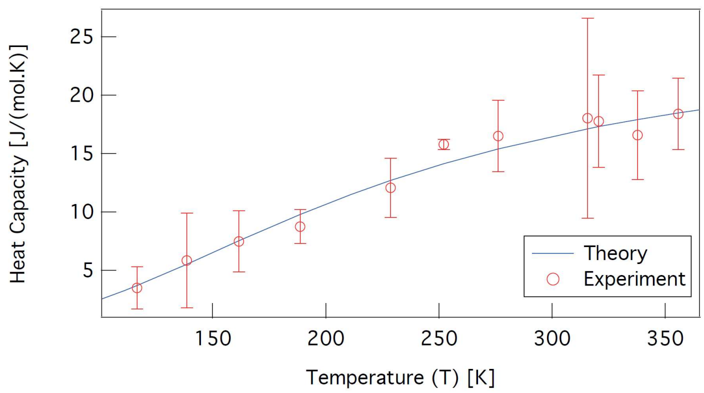
Schematic of the calorimeter and experimental setup:



Characteristic temperature evolution when heating the sample:



Series of measurements points at different temperatures (including error estimations and theoretical prediction):



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