nEDM Dual Temperature Operation

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Cooling the Measurement Cells

- 10 liters LHe4, 145*g/liter, 4g/mole =>362*moles
- Cv LHe4 @ .5K:10mJ/mole-K (Pobell)
- Cv LHe4 @.2K: 2mJ/mole-K - T^3 dependence*
- Integration of T^3 dependent heat capacity from .3K to .5K: 1.1mJ/mole*
- Change the temperature from .5K to .3K: 362 mole x 1.1mJ/mole = .4Joules

* From George Seidel

Measurement Cell Heat Leak

- Assume .5K for main bath and .3K for measurement cell
- Cell inside dimensions: 7.6cm x 10.1cm x 50cm=> .2m^2
- Cell wall thickness: 1.3cm
- Acrylic (PMMA) thermal conductivity: .01W/m-K (Pobell)
- $Q=KA\delta T/L$= (.01W/m-K)(.2m^2)(.2K)/.013m= .03W/cell
- Connecting tube: 3cm ID x 120cm long=>.16m^2/cell
- No way to safely insulate this tube – Kapitza resistance is negligible, thermal gradient is small
- Heat leak = ~4 x .03W = .12W or .12J/sec
- Conclusion: need a thermal capacitor and a thermal break

Thermal Break

- Assume 3cm ID acrylic tube with 2.98cm OD plug x 2.5cm long – also acrylic
- Assume .3K at one end of the plug and .5K at the other
- What is the heat leak?
- Answer: .3mW - George Seidel

Thermal Capacitor Candidate

gas and the temperatures[11] were changed to the T_{58} scale. The magnetic thermometer was calibrated against the vapor pressure of He^3.

The heat capacity of the empty calorimeter, measured in a separate experiment, was always less than 1% of the heat capacity of the holmium sample.

III. RESULTS AND DISCUSSION

Our holmium metal was purchased from Research Chemicals, Inc. (Division of Nuclear Corporation of America). It was vacuum distilled, then remelted in a vacuum and cast into a tantalum crucible. Next, the tantalum was machined off and the sample turned down to a cylinder 0.8 cm long and 2.8 cm in diam; its weight was 41.390 g (=0.25094 mole). The following impurities were detected in our laboratory: other metals not found in spectrochemical analysis, hydrogen 0.005%, carbon 0.07%, nitrogen 0.07%, oxygen 0.21% (by weight).

Two completely independent runs were made on our sample. The experimental results are listed in Table I and the points are also plotted in Fig. 1. All calculations were done on an IBM 704 digital computer.[12] The results have been corrected for curvature.

TABLE I. Specific heat (in mJ/mole °K) of holmium metal. Experimental results.

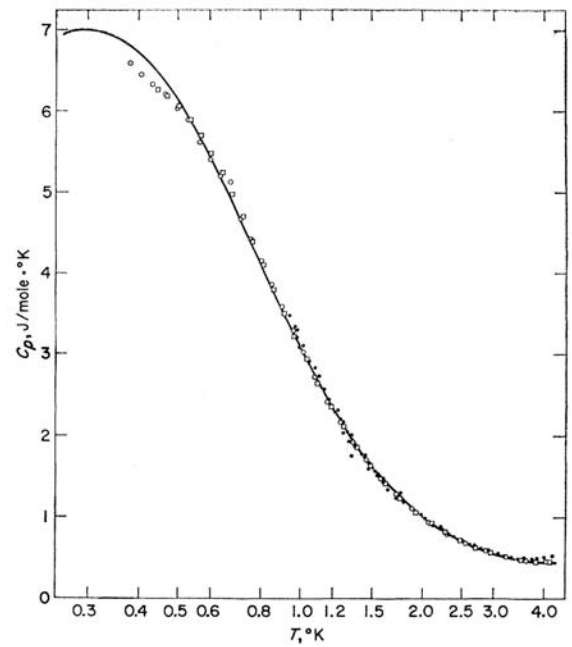

FIG. 1. The specific heat of holmium metal: ○, run I; □, run II; solid curve, $C_p=2.26T^3+10T+C_N$ (C_N given in Table II); ●, Gordon, Dempesy, and Soller.[1]

After a heating period the sample usually came to equilibrium in less than ten seconds. Only at the lowest temperatures were equilibrium times as long as

Proposed Thermal Budget

- 12mW for 1000 seconds => 12Joules
- Temperature rise of .7K (.25K to .32K) takes .5J/mole => 24moles Holmium or ~4Kg
- 12J/(.12J/sec) = 100 seconds to remove 3He and refill

What Next?

- Oh, by the way, Holmium is magnetic …
- Simulations?
- Implications for 3He services?