THE ATOMIC HEATS OF GOLD, PLATINUM AND 
ANTIMONY AT LIQUID HELIUM 
TEMPERATURES

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INTRODUCTION

The specific heat of platinum was measured in the liquid helium range of 
temperature by Kok and Keesom as early as 1936 while that of gold was 
measured only very recently by Corak et al. (1955). Apart from these two 
measurements no other calorimetric data appear to be available for these 
two metals in the liquid helium range. Therefore, it was decided to obtain 
fresh measurements with a view to provide an independent check on the 
elier data using the new vacuum calorimeter (Ramanathan and Srinivasan, 
1955) developed in this laboratory.

Travis Anderson (1930) investigated the temperature variation of the 
specific heat of antimony in the range 60° to 300° K. Below this range, how-
ever, no data appear to be available. So, the investigation of the tempera-
ture variation of atomic heat of antimony in the liquid helium range was 
also carried out with the purest available metal, using our calorimeter.

EXPERIMENTAL DETAILS

The new vacuum calorimeter which is capable of an accuracy of over 
3 per cent. in the temperature range 1.2 to 4.2° K. has been fully described 
in an earlier communication (Ramanathan and Srinivasan, 1955).

The specimens of gold and platinum were supplied by Messrs. Johnson 
Matthey & Co., Ltd., London, in cylindrical forms with diametrical holes 
for embedding carbon resistance thermometers. The purity of the gold 
specimen is 99.97 per cent. and it weighs 67.99 gm. The platinum specimen 
is 99.99 per cent. pure and weighs 74.88 gm. The antimony specimen of 
mass 33.92 gm. was cast out of a Johnson Matthey sample of 99.6 per cent. 
purity.

The resistance thermometer (a 1/4 watt, 100 ohms resistor manufactured 
by Speer Resistor Corporation, U.S.A.) was calibrated against the 1948 
vapour pressure-temperature scale (Van Dijk and Shoenberg, 1949) and 
corrected to the 1955 scale (Van Dijk and Durieux, 1955).
RESULTS

Gold and Platinum.—Figures 1 (a) and (b) show the variation of the atomic heats of gold and platinum respectively in the liquid helium range of temperature.

The atomic heats of these elements can be represented by the equation \( C_v = aT + bT^3 \), where 'a' and 'b' are the constants corresponding to

![Graph showing the variation of atomic heats of gold and platinum.](image-url)
Atomic Heats of Gold, Platinum and Antimony

Electronic and lattice contributions and 'T' is the absolute temperature.

It is noticed from the graphs that the specific heat of the monovalent metal gold falls off more rapidly than the specific heat of the transition metal, platinum. This indicates a much larger linear term in the specific equation for platinum and is consistent with the supposition of Mott Jones (1936) that the unfilled 'd' band contributes appreciably to the ionic specific heats of transition metals.

The atomic heat constants of gold have been calculated by the method of least squares from the results in the range 1.3 to 4.2\degree K. and are found to be

\[
a = (1.825 \pm 0.069) \times 10^{-4} \\
b = (1.049 \pm 0.010) \times 10^{-4}
\]

The Debye temperature calculated from the 'b' value \((b = 464.4/\theta^3)\) is 164.2\degree K.

Similarly the constants of platinum are found to be

\[
a = (15.956 \pm 0.100) \times 10^{-4} \\
b = (0.337 \pm 0.014) \times 10^{-4}
\]

and \(\theta = 239.7\degree K\).

The results of earlier workers together with ours are given in Table I for comparison.

<table>
<thead>
<tr>
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<th>Gold</th>
<th>Platinum</th>
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<tbody>
<tr>
<td><strong>Purity %</strong></td>
<td><strong>a \times 10^4</strong></td>
<td><strong>\theta^o K.</strong></td>
</tr>
<tr>
<td>This work</td>
<td>99.97</td>
<td>1.825</td>
</tr>
<tr>
<td>Corak et al.</td>
<td>99.99</td>
<td>1.777</td>
</tr>
<tr>
<td>Schultz (1954)</td>
<td>..</td>
<td>1.48</td>
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<tr>
<td>Kok and Keesom (1936)</td>
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<td>Burton (1940)</td>
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<td></td>
<td>(Res.) 175</td>
<td></td>
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</tbody>
</table>

S.H.—Value derived from specific heat data.
Res.—Value derived from electrical resistivity by Gruneisen's formula.
The electronic specific heat constants and the Debye $\theta$ values of gold and platinum of earlier workers show general agreement with our values.

*Antimony.*—Figure 2 (a) shows the variation of the atomic heat of antimony with temperature in the range 1.3 to 4.2° K. Figure 2 (b) is a plot
of $C_v/T^3$ against $T$. The region where the electronic contribution becomes predominant appears below $2^\circ$ K. Figure 2 (c) is a plot of $C_v/T$ versus $T^2$ in this region.

The constants have been calculated by the method of least squares from all the measurements below $2^\circ$ K. and are found to be

$$a = (0.575 \pm 0.041) \times 10^{-4}$$

$$b = (0.525 \pm 0.013) \times 10^{-4}$$

and

$$\theta = 206.8^\circ \text{ K.}$$

Burton (1940) has calculated $\theta$ as $201^\circ$ K. from the specific heat data of Travis Anderson (1930). This is also in good agreement with our result.

**Summary**

The variation of atomic heats of gold, platinum and antimony have been investigated in the liquid helium range of temperature ($4.2$ to $1.3^\circ$ K.). The atomic heats of these elements can be represented by the formula

$$C_v (\text{Gold}) = 10^{-4} [(1.825 \pm 0.069) T + (1.049 \pm 0.010) T^3] \text{ Cal./}^o \text{ K.}$$

$$C_v (\text{Platinum}) = 10^{-4} [(15.956 \pm 0.100) T + (0.337 \pm 0.014) T^3] \text{ Cal./}^o \text{ K.}$$

$$C_v (\text{Antimony}) = 10^{-4} [(0.575 \pm 0.041) T + (0.525 \pm 0.013) T^3] \text{ Cal./}^o \text{ K.}$$

**Acknowledgment**

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**References**


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Travis Anderson, C.  
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