Chemistry. — The Exact Measurement of the Specific Heats of Metals at Higher Temperatures. XII. The Specific Heat of metallic Rhenium. By F. M. JAEGER and E. ROSENBOHM.

(Communicated at the meeting of September 30, 1933.)

§ 1. Metallic rhenium (mpt: ca. 3160° C.), obtained from the Chemische Fabriken in Leopoldshall was enclosed in an evacuated platinum crucible of the usual form and thus used for the determination of the specific heats by means of the metal calorimeter formerly described. Rhenium crystallizes in the hexagonal system: it has a closest hexagonal packing with two atoms within its parallelopipedic elementary cell; 

\[ a_0 = 2.752 \text{ Å.U.}; \quad c_0 = 4.448 \text{ Å.U.}; \quad a:c = 1:1.616. \]

The specific weight of the metal at 0° C. is: 21.04; its atomic weight: 186.31.

Although the measurements of the specific heats do not betray any allotropie change within the interval of temperatures considered, i.e. between 0° and 1200° C., some particulars observed are worth mentioning. The maximum temperature of the calorimeter was between 0° and 1000° C. reached within 1.5 minutes; but on heating above 1000° C. an appreciable dilatation of the crucible was observed, perhaps as a setting free of occluded gases. Analysis proved the specimen to contain 99.19 % Re and 0.81 % oxygen, — which corresponds to about 3.5 % of the volatile Re₂O₇; potassium was not present in any appreciable amount. The gas developed may, therefore, be the oxide. The maximum temperature of the calorimeter then proved to be reached no sooner than within 2.5—3 minutes. Above 1200° C. the deformation of the crucible became so appreciable, that it appeared advisable to stop the measurements at higher temperatures. A meating at 1300° C. for one hour proved to have no influence upon the specific heats found at lower temperatures.

The increase of the temperature \( \Delta t \) of the calorimeter above 20° C. in function of the E.M.F. \( E \) of the thermoelements is expressed by:

\[ \Delta t = 4.15999 \cdot 10^{-5} \cdot E - 6.3085 \cdot 10^{-11} \cdot E^2 - 6.1399 \cdot 10^{-15} \cdot E^3. \]

As the crucibles did not contain more than 7.4520 grammes of rhenium and its specific heats are only small, — being about the same as those of platinum, — the results obtained are less accurate than in other cases hitherto studied: the numbers for \( Q_0 \) are exact only within about 0.5 % of their values. However, they are sufficiently exact to state the linear

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dependance of \( c_p \) on the temperature, as can be seen from the data collected in the following Table:

<table>
<thead>
<tr>
<th>Temperature ( t ) in °C</th>
<th>Final temperature ( t' ) of the Calorimeter</th>
<th>( \Delta t ) of the Calorimeter in M.V.</th>
<th>Heat developed ( Q_0^t ) between ( t ) and ( t' ) by 1 Gr. of rhenium</th>
<th>Heat ( Q_0 ) developed between ( t^o ) and ( 0^o ) by 1 Gr. of the metal</th>
<th>( Q_0 ) calculated from the formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>393.58</td>
<td>20.53</td>
<td>81.559</td>
<td>12.659</td>
<td>13.328</td>
<td>—</td>
</tr>
<tr>
<td>393.72</td>
<td>20.77</td>
<td>85.500</td>
<td>12.662</td>
<td>13.332</td>
<td>—</td>
</tr>
<tr>
<td>631.80</td>
<td>20.82</td>
<td>136.564</td>
<td>21.188</td>
<td>21.867</td>
<td>21.891</td>
</tr>
<tr>
<td>801.58</td>
<td>21.12</td>
<td>176.990</td>
<td>27.461</td>
<td>28.149</td>
<td>28.225</td>
</tr>
<tr>
<td>801.68</td>
<td>21.01</td>
<td>177.348</td>
<td>27.541</td>
<td>28.226</td>
<td>28.227</td>
</tr>
<tr>
<td>1062.2</td>
<td>21.55</td>
<td>242.215</td>
<td>37.662</td>
<td>38.364</td>
<td>38.319</td>
</tr>
<tr>
<td>1063.2</td>
<td>21.27</td>
<td>242.211</td>
<td>37.625</td>
<td>38.319</td>
<td>38.357</td>
</tr>
<tr>
<td>1064.9</td>
<td>21.26</td>
<td>242.518</td>
<td>37.618</td>
<td>38.311</td>
<td>—</td>
</tr>
<tr>
<td>1200.4</td>
<td>22.26</td>
<td>277.530</td>
<td>43.128</td>
<td>43.854</td>
<td>43.864</td>
</tr>
<tr>
<td>1200.8</td>
<td>21.46</td>
<td>277.272</td>
<td>43.174</td>
<td>43.874</td>
<td>—</td>
</tr>
</tbody>
</table>

The mean specific heat between \( 0^o \) and \( 20^o \) C. was: 0.03262.

From these measurements, the quantities of heat \( Q_0 \) developed by 1 gr. of rhenium between \( t^o \) and \( 0^o \) C. can be calculated by means of the formula:

\[
Q_0 = 0.03256 \cdot t + 0.000003312 \cdot t^2.
\]

Therefore, the mean specific heats can be expressed by:

\[
\bar{c}_p = 0.03256 + 0.3312 \cdot 10^{-5} \cdot t
\]

and the true specific heats \( c_p \) by:

\[
c_p = 0.03256 + 0.6625 \cdot 10^{-5} \cdot t
\]

The atomic heats \( C_p \) are, therefore, given by:

\[
C_p = 6.0661 + 0.12342 \cdot 10^{-2} \cdot t
\]

Some of the values of \( \bar{c}_p, c_p \) and \( C_p \) are thus calculated:
The value of $3R$ calories is, for $C_p$, already surpassed at about $-66^\circ$ C.

From the measurements of the linear coefficient of the thermal dilatation by Becker (loc. cit.), the value of the mean cubic coefficient of dilation $a$ can be deduced; between $15^\circ$ and $1917^\circ$ C. $\nu_t$ can thus be calculated from the formula: $\nu_t = \nu (1 + 21.79 \times 10^{-6} \times t)$.

As, however, no data for $k$ are available in the literature, $c_p^0$ and $C_p^0$ cannot be determined with any appreciable degree of certainty.

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**Geology. — Structure of the Sierra de Baza and adjacent regions in southern Spain.** By H. A. Brouwer and H. Jansen.

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To the east of the basin of Guadix the older rocks of the Sierra Nevada extend northward in the Sierra de Baza, where the overthrust sheets of the Alpujarrides — which are covered by young deposits in the basin of Guadix and only locally appear along its southern margin — have a great extension.