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Preliminary study of the characteristics of a new design of a tub type moderator for neutron counting reveals some definite advantages over the laboratory Hanson setup.

Two determinations of the purity of postum were made with the vacuum balance apparatus. The first result was 94.81 per cent postum and the second 100.5 per cent.

A redesigned effusion apparatus is described in detail, and results of nine exposures are presented. The data lie fairly close to a straight line on a log p vs. 1/T plot, but the line lies much lower and differs in slope from that representing earlier data.

A quartz sickle gauge apparatus with a small internal volume is being constructed to be used to measure the vapor pressure of postum.

The coefficient of expansion of the low temperature form of postum has been measured in the temperature range of -76°C. to 24°C. and a preliminary value of 22.0 ± 1.5 x 10^-6 per °C. has been obtained.

**DETAILED REPORT**

**Neutronics – T. Davenport and E. Harvill**

The study of the tub type moderator for neutron counting has been continued. We are not yet ready to make a complete report; however, from the work accomplished to date, these advantages can be claimed for the tub:

1. Increased counting efficiency.
2. Low background.
3. Easy calibration for routing work.
4. Slight errors in positioning of source do not noticeably affect the counting rate.
5. Better operator protection.
6. Self contained system.

Two disadvantages, present but probably to be overcome by changes in the present design, are:

1. Inconvenience in source handling.
2. Increased coincidence effects for fast sources.

The work will be continued and reported later.
Nine sources were counted for the Neutron Source Group and five for the Marlite Group during the period of this report.

Purity of Postum by the Vacuum Balance Method – R. Davis and H. Morgan

Two purity determinations were made following the procedure outlined in the Physics Progress Report of February 16-28, 1947. A brief outline is the following:

(1) Place sample of Q to be assayed in a quartz tube of the following size and shape.

![Figure 1](image)

(2) Calorimeter the tube for the quantity of Q, accurate to 0.1 per cent.

(3) Scratch the tube at point A and weigh on a Micro balance (Ainsworth) in an evacuated case.

(4) Break tube at point A (in dry N₂ atmosphere) and place the two pieces of the tube inside a quartz tube that can be placed on a vacuum line.

(5) Distill the Q out of the weighing tube onto the walls of the containing tube.

(6) Remove the two pieces of the weighing tube and reweigh.

The purity obtained by the first determination was 94.81 per cent. Since there were some chips formed during step 4 and some of them lost, the purity is lower than it should be. The same postum was placed in a normal quartz tube and the procedure repeated. A purity of 100.5 per cent was obtained. There were no chips lost during this run, so the reasons for this extra 1/2 per cent will have to be determined.

Resistivity of Postum – H. Morgan

The work on the apparatus to measure the resistivity of postum is being postponed while the purity problem is being worked on.

Vapor Pressure of Postum by the Effusion Method – R. Davis

The apparatus was completely redesigned in order to correct the difficulties experienced with the first apparatus. The new apparatus is shown in Figure 2. The sample is held in a platinum
lined block which is about 1 1/2 inches in diameter and 2 inches long, having an effusion orifice about 0.2 mm. diameter. The sample itself is held in a quartz tube held near the top of sample space by a platinum wire stirrup. The temperature of the block is determined by a copper-constantan thermocouple near the top of the sample space. The details of the block are shown in Figure 2. The block was heated by an induction heater arranged so that the orifice end of the block was heated hotter than the main bulk of the block. The crucible block was supported in a glass envelope that was constricted to form the collimator, and flattened at the bottom for positioning the cassettes. A steel ball bearing served as a shutter. The ball bearing could be moved with a magnet and placed in a recess in the sloping portion of the tube during the exposure. The entire tube below the crucible was immersed in liquid air. This design insured that the walls of the tube, and the collimating orifice were cooled to liquid air temperature, thus effecting complete condensation. The region above the shutter was pumped out directly to the vacuum line, and the region below the shutter was pumped through a trap. This arrangement kept the part of the apparatus below the shutter free from activity. A second trap was placed between the effusion assembly and the cassette storage and seal-off tubes. The cassettes were exposed, and then moved to the seal-off tube. After a number were exposed they were removed from the apparatus and counted. While the cassettes were inside the apparatus they were kept at liquid air temperatures.

Two cassettes were exposed at 150°C. and 200°C. respectively for a period of time necessary to obtain about 100 and 1000 counts per minute per seconds exposure based on the vapor pressure extrapolated from the measured values in the high temperature region. These cassettes had a very low count, of the same order of magnitude as the background, so it was necessary to expose additional cassettes for much longer times. Two were exposed at 341°C. and 257°C., for a long enough period of time to obtain high counting rates. Based upon these results a series were exposed in the temperature range 190°C. to 366°C. The vapor pressures were computed from the following expressions:

\[
\text{mass (gms.) effusing per second} = 1.195 \frac{r^2}{\sqrt{T}} \quad \text{(1)}
\]

\[
\text{mass (gms.)} = (\text{c.}/\text{min.})/(\text{sec. exposure}) \times 1.927 \times 10^{-16} \quad \text{(2)}
\]

Combining:

\[
p (\text{mm. of Hg}) = 1.613 \times 10^{-16} \frac{\sqrt{T}}{a} \frac{r^2}{\beta^2} ((\text{c.}/\text{min.})/(\text{sec. exposure}). \quad \text{(3)}
\]

Where \(a\) is the area of the orifice in \(\text{cm}^2\), \(\beta\) the radius of the collimator, \(r\) the distance from the orifice to the collimator, and \(T\) the absolute temperature. In the present apparatus the dimensions have the following values: \(a = 3.365 \times 10^{-4} \text{ cm}^2\), \(\beta = 0.129 \text{ cm}\), and \(r = 13.13 \text{ cm}\). Using these values in equation (3) one obtains,

\[
p (\text{mm. of Hg}) = (\text{c.}/\text{min.})/(\text{sec. exposure}) \times 0.4965 \times 10^{-8} \sqrt{T} \quad \text{(4)}
\]

The results of these measurements are listed in Table I.
<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Type of Sample</th>
<th>Time of Exposure (Seconds)</th>
<th>Count per min.</th>
<th>Counts per min. per sec. exposure</th>
<th>p mm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>341.5</td>
<td>Blank</td>
<td>600</td>
<td>217</td>
<td>-</td>
<td>- -4</td>
</tr>
<tr>
<td>341.8</td>
<td>Exposed</td>
<td>597</td>
<td>1.985 x 10⁶</td>
<td>3,324</td>
<td>- -4</td>
</tr>
<tr>
<td>255.0</td>
<td>Blank</td>
<td>600</td>
<td>261</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>257.0</td>
<td>Blank</td>
<td>60</td>
<td>293</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>256.6</td>
<td>Exposed</td>
<td>606</td>
<td>5,866</td>
<td>9.23</td>
<td>1.06 x 10⁻⁶</td>
</tr>
<tr>
<td>190</td>
<td>Exposed</td>
<td>17,083</td>
<td>3,218</td>
<td>0.188</td>
<td>2.01 x 10⁻⁸</td>
</tr>
<tr>
<td>229.7</td>
<td>Exposed</td>
<td>3,797</td>
<td>7,71</td>
<td>2.03</td>
<td>2.66 x 10⁻⁷</td>
</tr>
<tr>
<td>251</td>
<td>Blank</td>
<td>1,000</td>
<td>34</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>250.8</td>
<td>Exposed</td>
<td>1,010</td>
<td>9,628</td>
<td>9.55</td>
<td>1.08 x 10⁻⁶</td>
</tr>
<tr>
<td>275.8</td>
<td>Exposed</td>
<td>213</td>
<td>9,621</td>
<td>45.3</td>
<td>5.26 x 10⁻⁶</td>
</tr>
<tr>
<td>303</td>
<td>Blank</td>
<td>100</td>
<td>35</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>302.8</td>
<td>Exposed</td>
<td>105.6</td>
<td>15,132</td>
<td>143</td>
<td>1.70 x 10⁻⁵</td>
</tr>
<tr>
<td>334.9</td>
<td>Exposed</td>
<td>151</td>
<td>139,490</td>
<td>927</td>
<td>1.14 x 10⁻⁴</td>
</tr>
<tr>
<td>366.3</td>
<td>Blank</td>
<td>100</td>
<td>42</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>366.3</td>
<td>Exposed</td>
<td>98.3</td>
<td>915,000</td>
<td>9,310</td>
<td>1.17 x 10⁻³</td>
</tr>
</tbody>
</table>

A plot of these results is given in Figure 3 along with a straight line showing the results of the Bourdon sickle gauge measurement. It is readily seen that the effusion measurements are much too low and the measurements themselves are not very consistent. These low results could be caused by any one of the following factors: (1) The postum has reacted with impurities present in the crucible or with the platinum metal in the crucible, or it has become oxidized, (2) the orifice has become clogged, (3) the beam has not been condensed on the cassettes, (4) the postum is re-evaporating from the cassette, and (5) the orifice is colder than the rest of the crucible. To check some of these points several tests were made. The crucible was removed from the apparatus and examined, and it was found that the orifice was clear, and that most of the activity was in unoxidized form (judging from its appearance). The open end of the quartz sample tube was resting on the orifice plate, and a small deposit of postum was on the platinum at that point. This latter fact suggests that the orifice plate was cooler than the rest of the crucible. One of the platinum foils (1.985 x 10⁶ c./min.) was placed face down on a photographic plate for a period of 30 minutes.
FIGURE 3

RESULTS OF EFFUSION VAPOR PRESSURE MEASUREMENTS OF POSTUM

Extrapolated line based on vapor pressures measured with the Bourdon sickle gauge.
and then developed. The activity on the foil blackened the film in a uniform circular patch with no noticeable scattering or background around the edge. This experiment was repeated using the foil exposed at 190°C. for around 4.7 hours, and it also showed that the beam had been condensed properly. Although this experiment will not tell whether or not the condensed deposit re-evaporated, it does show that the beam is condensed and there is no scattering inside of the apparatus. This technique was also applied to a foil exposed in the first effusion apparatus (reported in the Progress Report for the period January 16-31, 1948) and it was found that the beam was condensed, but there were a large number of tiny specks of activity distributed over the foil. This observation suggests that the postum deposit inside the sample holder was torn loose by disintegration in tiny chips which fell through the orifice onto the cassette.

A new crucible is being prepared for this apparatus with a built-in heater for the orifice, and a thermocouple on the orifice foil so that its temperature can be observed. In addition a valve mechanism will be placed on the apparatus so that individual cassettes may be removed or introduced at any time, and also making it possible to check for re-evaporation of the deposit from the cassette. However, it might be remarked that the main difficulty is in obtaining a condensate. Once crystallization has started on the foil and the deposit begins to build up, the number of atoms re-evaporating is small. If the temperature of the cassette is below the critical condensation temperature a deposit will be formed and loss by re-evaporation is governed by the vapor pressure of the metal. The vapor pressure of postum is very low at liquid air temperatures.

The Vapor Pressure of Postum by the Quartz Sickle Gauge Method -
L. Brooks

A quartz sickle gauge apparatus is being constructed to measure the vapor pressure of postum. It is advantageous to use the minimum amount of postum for the experiment not only to conserve the metal, but also to minimize the heating of the sample bulb by the postum to facilitate accurate temperature measurements, and to minimize the amount of destructive action of the alpha particles on the quartz tubing. It was, therefore, necessary to make the volume available to the sample smaller than it was in previous experiments with other metals. The volume of the connecting tube between the sample bulb and the sickle bulb was reduced by using 1 mm. I.D. quartz tubing instead of the 3 to 6 mm. I.D. tubing that was used before. After many trials several sickle gauge bulbs were blown with an internal volume of less than 2 cc. which is about one-half the volume of the sickle gauge bulbs used in previous experiments. However, these sickle gauge bulbs with the smaller volume were not so sensitive as the larger gauge bulbs and the best one had a sensitivity of 0.08 mm.
pressure per scale division when used with the same telescope that was used in the previous experiments. The telescope was modified so that the movement of gauge pointer could be magnified from about two to ten times. With the increased magnification of the telescope the field of view was decreased, so that there is a limit in our system on the amount we can increase the magnification of the movement of the gauge pointer. The optical system has been arranged so that the apparent sensitivity of the sickle gauge bulb will be 0.02 mm. of pressure per scale division.

X-ray Studies - R. Brocklehurst and L. Vassamillet

The coefficient of thermal expansion of the alpha form of Q metal has been measured for the temperature range of -76°C to 24°C. The value of the coefficient, alpha, is 22.0 ± 1.5 x 10^-6. The complete details of the technique used and a discussion of the accuracy of the method are given in an interim report on "The Technique of Measuring the Coefficient of Expansion of Metals by X-ray Diffraction". Due to the fact that a failure in the equipment resulted in considerable contamination of the equipment and surroundings, it has been decided to abandon temporarily any further efforts to measure the coefficient of expansion at any other temperature.

FUTURE PLANS

A study will be made of the sources of errors in the determination of the purity of postum by the vacuum balance method.

Considerable time will be spent in obtaining exact calibration data on the recently acquired Debye-Scherrer powder cameras. At the same time work will be started in growing single crystals of metals inside quartz capillaries. The ultimate purpose of this work will be to establish the space groupings of the various forms of postum metal.