XXXVII.—*A New Form of Pyrometer.*

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SINCE the pressure exerted by a given volume of gas varies as the absolute temperature, if the pressures at two temperatures are measured and one temperature is known, the other can be calculated. For short ranges of temperature, an air thermometer of constant volume, connected with a mercury gauge, may be used to measure the pressures produced at the known and unknown temperatures; but such an instrument cannot be employed if there is much difference between the temperatures, owing to the great expansibility of air.

This difficulty may be overcome and any temperature found by using a modification of the apparatus described in the preceding paper. The annexed drawing shows a tube of convenient length and about one centimetre in diameter, ending in a bulb with a capacity of 100—200 c.c.

The top of the tube has a branch for inserting a support for a capsule containing a substance which is to be vaporised, and a narrow tube leads to a manometer.

When the substance is dropped into the bulb, the vapour produced compresses the air above it, but the bulb being many times larger than the volume of the vapour, there is not much displacement of heated air, and the pressure developed can be measured before the vapour diffuses to a place where condensation could take place.

With such an instrument, containing air at the atmospheric pressure, when equal weights of a substance are dropped into the bulb at different temperatures, the pressures produced are proportional to the absolute temperatures. This is the same law as for the air thermometer, but the principle is readily seen to be different.

There is no limit to the range of the instrument so long as the capacity remains unaltered, and it thus forms a simple pyrometer by which temperatures may be ascertained with an accuracy of a few degrees.

To use the apparatus, the pressure produced by a weighed quantity of substance at a known temperature is first determined. This is done by heating the instrument in the vapour of a constant-boiling liquid or by other means, and measuring the pressure produced when a weighed quantity of substance is vaporised in the bulb.

This determination has only to be made once, and it might be done by the maker of the instrument, who would supply the information with respect to temperature and pressure. The bulb is now placed where the unknown temperature has to be found, and the pressure produced from a weighed quantity of substance is measured. The pressures produced at the two temperatures from equal weights of substance are then calculated, and these are proportional to the absolute temperatures. An example will explain the process :

The bulb was heated in the vapour of boiling quinoline at 230° and 0.0439 gram of sodium hydrogen carbonate dropped in. The pressure developed was 14.5 centimetres, or one gram would produce a pressure of 330.3 centimetres.

The bulb was then placed in melted lead, and 0.0509 gram of sodium hydrogen carbonate caused a pressure of 24.2 centimetres. The pressure for one gram was, therefore, 475.4 centimetres.

$p/p_1 = T/T_1$, $T_1 = \frac{330.3 \times 503}{475.4} = 724.1$, or the lead had a temperature of 451° .

If the internal volume of the instrument is known, the temperature of the bulb may be found without performing a comparison experiment at a known temperature if a substance of definite molecular weight is used to produce the vapour. Let a weight w of a substance having a molecular weight M be vaporised in an instrument of volume V and produce a pressure p , the temperature of the vapour is found from the following considerations :

The pressure in the instrument increases from the barometric pressure P to $P+p$, the volume at pressure P would therefore increase from V to $\frac{V(P+p)}{P}$, and the vapour would have a volume of

$\frac{V(P+p)}{P} - V = \frac{Vp}{P}$. This volume at P and t° becomes at 760 mm. and t° , $\frac{Vp}{760}$.

The volume of gas produced from a weight w of a substance having a molecular weight M is $\frac{22.24w}{M}$ at 760 mm. and 0° .

We have now the two volumes occupied by a gas at 0° and t° , under the same pressure, and these volumes being proportional to the absolute temperatures, $(t^\circ + 273) = \frac{VM}{22.24 \times 760} \cdot \frac{p}{w}$, or for the same instrument and using the same substance to produce the vapour, $t^\circ = K \frac{p}{w} - 273$.

Example: Experiment to find the boiling point of quinoline. 0.0364 gram of naphthalene, molecular weight 127.1, vaporised in a bulb of 113 c.c. capacity, heated by the vapour from boiling quinoline, caused a pressure of 7.9 centimetres of mercury. Using the above formula, $t^\circ = 503.4 - 273 = 230.4^\circ$. The quinoline boiled at 230° .

Sodium hydrogen carbonate, contained in a little capsule of lead foil, is a good substance to use for the production of vapour. The lead melts and the powder is instantly decomposed. Any other substance giving a vapour may be used, but the best material would be one from which a permanent gas was evolved.

The bulb of the apparatus may be made of glass, porcelain, or metal, and may have any convenient shape. The error due to expansion of the bulb is small, as an increase of 1 c.c. on a bulb of 100 c.c. would only alter the result about 2° , and this would be proportionately less the larger the bulb.

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