Proceedings of the Iowa Academy of Science

Volume 37 | Annual Issue Article 46

1930

The Selection of Thermometers for General Organic Chemistry

Thomas H. Liggett

THE SELECTION OF THERMOMETERS FOR GENERAL ORGANIC CHEMISTRY

THOMAS H. LIGGETT

In selecting suitable thermometers for the use of students in General Organic Chemistry, it is often found that the ordinary chemical thermometers on the market at moderate prices have a number of defects. Some of these are as follows:

1. Graduation lines too close together, making reading difficult.
2. Lack of sufficient accuracy.
3. Stems too large, causing difficulty when more than one hole must be bored through a small cork.

In order to secure better thermometers the dealer may be asked to select those that appear as free as possible from the above defects. After the thermometers are issued to the students, each student may test his own for accuracy, using as reference points, the melting and boiling points of pure substances, such as water, ethyl alcohol, acetanilide, aniline, etc. This is good training for the student but such testing, made at the beginning of the course, is not likely to be very reliable.

Better results may be obtained by testing each lot of thermometers, as they are received from the dealer, by a uniform method. The following procedure has been found reasonably satisfactory: the thermometers, in groups of two to six were compared directly with a thermometer certified by the U. S. Bureau of Standards, at five points: o°, 20° 100° 200° 250°. The comparison at zero was made in a double icebath such as is used for determining freezing points in physical chemistry work. At 20° the same bath filled with distilled water was used. For higher temperatures, a heated bath of engine oil, glycerine, or Crisco was used. For some special tests above 300° C. a mixture of equal parts of sodium nitrate and potassium nitrate was found better, since it did not fume.

A satisfactory testing bath (Fig. 1) that was reasonably constant in temperature, and convenient to operate, was made from two cylindrical vessels of enameled iron. The smaller vessel held about one gallon, and was filled with engine oil of high flash point. This was placed inside the larger vessel and the space between,

about two and one-half inches on the sides, was packed with asbestos wool. The bottoms were allowed to be in direct contact in order to permit heating more quickly. The outer vessel was covered on the sides with asbestos paper. The top cover was made from three layers of transite, with one hole for the shaft of the

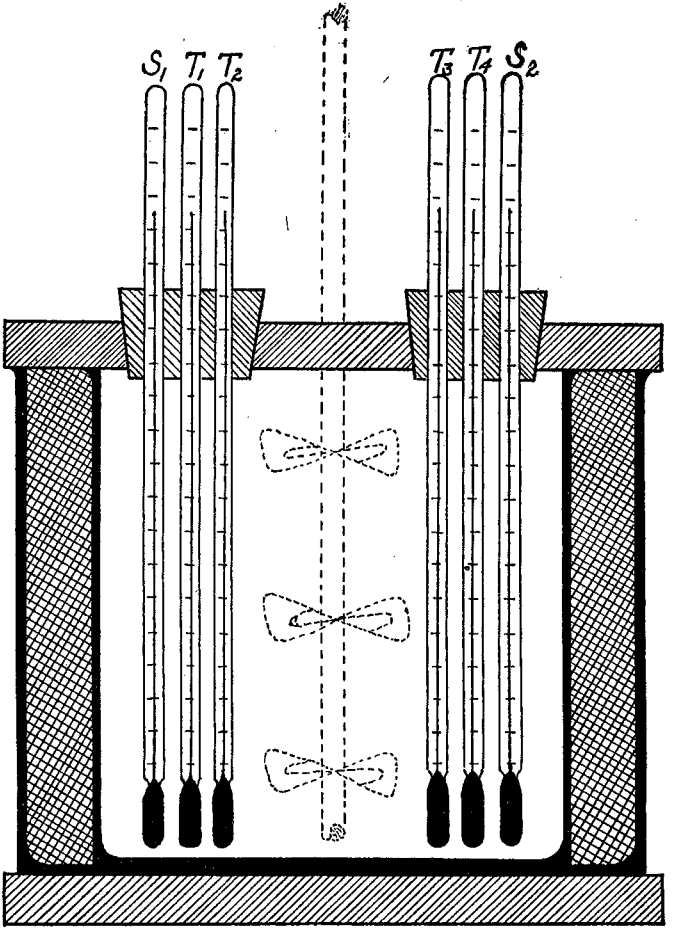

Fig. 1: Testing Bath for Thermometers.

mechanical stirrer, and two other holes for large corks, each of which held one standard thermometer (S_1, S_2) and two of the thermometers to be tested, (T_1, T_2, T_3, T_4).

This bath was heated on a gas hot-plate to about 20 degrees above the temperature desired, after which the flame was turned low and two layers of transite were inserted between the hot-plate

and the outer vessel. The stirrer, which was an unusually efficient one with three sets of two-inch blades, was then started and after a few minutes the temperature would become constant enough for testing to begin. While testing, the temperature of the bath did not change faster than one degree in ten to fifteen minutes. The bulbs of the thermometers to be tested were almost in contact with those of the standard thermometers so that there was little difficulty in determining the corrections with accuracy. The difference between the corrected readings of the two standard thermometers was seldom more than 0.2 degrees, or only slightly more than the error in reading. No trouble was experienced with fire as the bath was kept covered and the oil did not fume much.

For quickly testing a small number of thermometers with a moderate degree of accuracy a very simple heating bath was sometimes used. It consisted of a one-liter Pyrex beaker, with a jacket of eight or ten layers of asbestos paper on the sides, a cover of two pieces of asbestos board, and a base of Nichrome gauze and asbestos. The standard thermometer and the one being tested were held together in the hand and used as a stirring rod for the bath. With proper precautions fair results could be secured.

All thermometers in a given lot that were inaccurate by more than 1.5 degrees were either discarded or else put aside for use in work that required only approximate temperature measurements. The good ones were given individual numbers and issued to the students with a statement of the corrections.

Although these tested thermometers were fairly satisfactory, the amount of time required for the testing, and the fact that testing did not remedy other defects, made it seem worth while to have thermometers for this work made to more accurate specifications. Accordingly, tentative specifications were drawn up, based on the results of experience in our laboratory, and on suggestions from the Bureau of Standards, and from several manufacturers. Sample thermometers, made to these specifications, were next secured, tested, and several points for improvement noted. Six more thermometers, made according to the revised specifications, were then secured, and found, by actual class use, to be very satisfactory. One was sent to the Bureau of Standards and found to meet the requirements for certification.

The specifications, as they now stand, are given below. Further tests are being made to find defects that can be remedied. Suggestions on any of these points will be welcome.

Specifications for Thermometers for College Classes in General Organic Chemistry

Range: minus 5 degrees C. to plus 250 degrees C.

Subdivisions: 1 degree, the degree marks to be at least 1.25 mm. apart.

Total Length: 400 to 450 mm.

Stem: solid stem with white background. Scale engraved on stem. Diameter of stem 5.5 mm. to 6.2 mm. (5.8 to 6.0 preferred). Mercury bulb at bottom must be a well-shaped cylinder of reasonable size, slightly smaller in diameter than the stem. Expansion chamber at top of mercury column. Nitrogen filled. Ring at top must be part of stem, strong and well-made.

Graduation marks must be clear and distinct, capable of being read even after the filling material is out. Figures every 10 degrees.

Accuracy: scaled for total immersion.

Correct to within 0.5 degree for the range 0 to 100
Correct to within 1.0 degree for the range 100 to 200
Correct to within 1.5 degree for the range 200 to 250

Test for Permanency of Range: After being subjected to the maximum scale temperature for 24 hours, the accuracy shall be within the limits specified. In order to retain this degree of accuracy a high-grade thermometer glass must be used, and the annealing properly done.

Number: Each instrument shall have an individual identification number etched on the stem.

Notes on the Specifications

Some of the reasons for the most important of the specifications are as follows:

Range: A range of minus 5 to plus 250 includes all of the temperatures that usually need to be measured in the laboratory work of General Organic Chemistry classes. A range of 250 degrees instead of 360 allows the degree marks to be farther apart, as shown below.

Sub-divisions: One degree subdivisions are satisfactory for this work. Fractions of degrees can be easily estimated when necessary.

Length: A total length of 400 mm. to 450 mm. allows the degree marks to be made at least 1.25 mm. apart, instead of about 0.8 mm., as is usual in 360 degree thermometers. This makes reading much easier, especially when the top of the mercury column is within the flask and is more or less obscured by the vapors of the reaction mixture.

Stem: A diameter of 5.8 mm. to 6.0 mm. is very convenient because of the ease of boring holes through corks when more than one hole is necessary in the same cork.

Filling with an inert gas: Filling with nitrogen under pressure helps to prevent separation of the mercury column and minimizes the distillation of mercury from the top of the column when the thermometer is used at temperatures in the upper part of the range.

Length of immersion: Thermometers graduated for "partial immersion," that is, immersion to a small definite length, are useful when the mercury column must be exposed and where the outer temperature is nearly constant. But thermometers intended for use under widely varying conditions, as in the present case, are usually graduated for "total immersion." When used

so that much of the mercury column is exposed, a correction must be applied as described in most organic laboratory manuals.

Graduation marks: Clear, distinct marks are specified because if the lines are too light, it is very difficult to read them after the filling is out. The problem of an entirely satisfactory filling for the marks has not been solved by manufacturers as yet.

Accuracy: The accuracy specified is greater than that of ordinary chemical thermometers because it is believed that the increased satisfaction of using an accurate instrument fully justifies the increased cost. The required accuracy is graduated from 0.5 degrees to 1.5 degrees, because the conditions of manufacture and use make an accuracy of 0.5 degree as easy of attainment in the lower ranges, as 1.5 degrees in the higher ranges.

Test for Permanency of Range: This specification is necessary because if the thermometer is not thoroughly annealed, the bulb will slowly and progressively contract, when exposed to its maximum temperature for a long time, and will not regain its original size. After such a thermometer has been cooled to room temperature, and is again used, it will read high at all points on the scale. Improper annealing is a very common fault of ordinary chemical thermometers. Circular No. 8 of the Bureau of Standards states that these annealing changes sometimes amount to several degrees. Our experiments show changes due to this cause, of one to three degrees.

As knowledge of the properties of glass and their relation to chemical composition increases, manufacturing practice in this field will doubtless improve. Just recently one manufacturer has developed a thermometer tubing containing a band of red glass so placed behind the mercury column that the red color is reflected in the mercury, making the exact height of the column very easy to observe.

SUMMARY

1. An effective laboratory method of testing thermometers has been described.
2. Specifications for a satisfactory type of thermometer for General Organic Chemistry classes have been given.

PELLA, IOWA