PROBLEMS IN THE DETERMINATION OF PHYSICAL PROPERTIES

IN preparing for publication the data on physical properties of chemical substances, the editorial staff of *International Critical Tables* will find from time to time that important physical properties of substances of technical and scientific importance are missing from the literature. As fast as we become aware of missing data of this character, it is our policy to formulate research problems covering such missing data and to endeavor to interest chemists and physicists in undertaking the necessary investigations to supply the required data.

Most of the research problems formulated in this way will be suitable for bachelors' or masters' theses and in a few instances topics sufficiently broad to be suitable for doctors' theses will also be available. Many of them will be suitable for experimental problems in the ordinary laboratory courses in physical chemistry and physics. Thus, for example, the laboratory experiment covering the determination of solubility might to advantage deal with substances whose solubility is needed but is unknown. The average of the determinations made by a class of students, while not as accurate and reliable as the determinations made by a skilled investigator, will nevertheless be very valuable when they constitute the only data available on the subject. Moreover the average student will be more interested in a laboratory experiment the results of which are of actual value and worthy of publication than he would be in repeating for the *n*th time the measurement of a property of some system which has been measured many times before.

International Critical Tables will be glad to submit to interested instructors in universities and colleges lists of problems of this character and to advise as far as it can concerning suitable apparatus and methods of measurement. It may be possible also in some instances to secure moderate financial assistance to aid in the purchase of materials and apparatus for investigators interested in carrying out work of this character. The results of such work may be published by the investigator in any appropriate publication medium and they should also be reported in duplicate to the office of *International Critical Tables* on completion of the work.

A number of problems on the following subjects are available at the present date: Heats of combination: solid oxides; Fe compounds. Specific heats: brass; solid oxides; steels; oils and fats; petroleum products; metals; salts; Fe compounds; asphalts. Latent heats of fusion: brass; metals. Heat conductivity: steels. Latent heats of vaporization: petroleum products. Viscosities: industrial materials; solutions. Kinetics: rates of drying; hydrolysis of industrial materials; catalysis; transpiration of moisture; biochemical. Strength: industrial materials. Thermal expansion: steels; Fe compounds. Freezing-point-solubility diagrams: salts; acids; metals in water; soaps. Boiling points: solutions. Solubility of gases: in molten metals; in water. Chemical equilibrium; dissociation pressures at 1600° C. Electrical conductivity: metals; refractories. Properties of colloidal systems; industrial materials. Vapor pressures: metals; solutions. Specific rotatory power: gliadin. Index of refraction: solids. Density: certain organic compounds; solutions. Flash points. Surface tensions: solutions.

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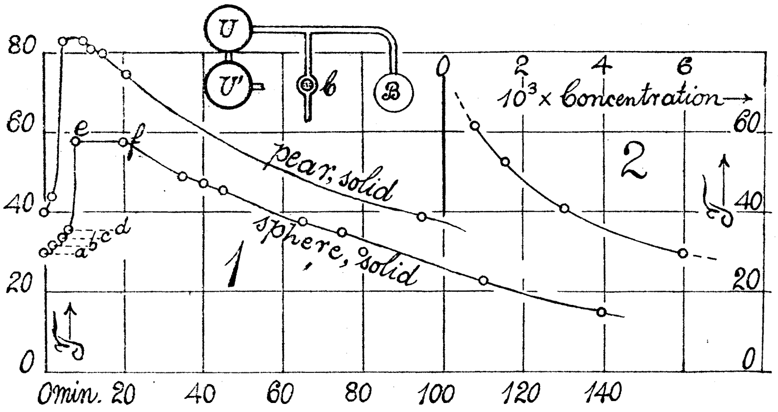
SPECIAL ARTICLES

GLUE BUBBLES

1. *Introductory.* The improvements which I have recently given to the interferometer U-gauge adapt it for measurements throughout larger intervals. The apparatus requires some experience on the part of the operator, but it gives absolute pressure values directly, and is quite robust, if not abused. Adding the pin hole valve as heretofore, I detected a hysteresis-like phenomenon in the telephone, according as an intermediate intensity of sound was reached from increasing or from decreasing intensity.

But the chief promise which the interferometer U-gauge seems to hold out is the measurement of such small but persistent pressure increments as arise in certain chemical and bacteriological processes. Here, how-



ever, one is liable to be misled by the inseparable temperature effect. For when one shank of the U-gauge is closed, it becomes an air or vapor thermometer, responding to much less than .001° C. per fringes. Hence though I ventured at some length upon experiments on gas absorption, vapor diffusion and solutional effects, it became increasingly obvious that the pressure increments and decrements obtained in a heated room were not trustworthy. I shall resume the work in the summer.

2. *Bubbles in general.* In case of bubbles of any kind (see diagrammatic insert, U-tube *UU'*, cock *C*, bubble *B*), these annoyances fall away and the pressure increment within the bubble is adjusted by the liquid film itself. It is of interest, therefore, to measure from pressures within the surface tension *T* of such films, passing by evaporation continuously from the liquid to the solid states. Of course, when the latter is reached, the bubble is no longer contractile and *T* ceases to be measurable; but one may at least reach a high state of viscosity. I have worked with sugar solutions, molasses and glue. In the former case, persistent bubbles are not producible; but by adding a drop of commercial soap solution to 10 cm.^{3} of sugar solution (1 gram in 10 cm.^{3}), bubbles 2 cm. in diameter or more are obtained. Occasionally one persists and dries out to a smooth, iridescent bubble of solid sugar, which may be detached and preserved. Again the sugar solution (or better plain distilled water) with one drop of liquid soap may be successively diluted, until the surface tension of pure water is closely approached. I passed in this way from *T* below 30 to *T* above 60 and could have gone further. It is interesting to note that when *T* is high, it rapidly falls off to lower values, possibly from the contamination of the surface of the film on exposure, but more probably, as I think, from the marshalling of the remaining colloidal molecules at the surface, with expenditure of potential energy.

3. *Glue bubbles.* These (common liquid glue diluted 5 to 10 times) are obtainable directly, since a diameter of 2 cm. or less is adequate. Nevertheless, if the mixture were expensive, the inevitable waste would be prohibitive. Fortunately it is not, and all that need be expended is patience, which is cheap. As above, bubbles are sometimes obtained which actually last indefinitely and these solid glue bubbles may be ultimately detached. I give the time record for two of them in Figure 1, in which surface tension *T*, is exhibited in the lapse of minutes. In the first of these the drop at the bottom of the bubble dried without further distortion, the bubble remaining spherical. In the second the drop blew itself out further and the bubble became symmetrically pear-shaped. In the case of the sphere, *T* at the beginning increased in *stages* shown at *a, b, c, d, e,* in the figure, the interval of persistence from *a* to *d* being less and less prolonged, while *e* is permanent. One would be inclined to consider these steps as successive phases passed through on the way to solidification; but the mottled color patterns on the bubble show that at most a complex of phases are temporarily in equilibrium. At *f*, after about 20 minutes, *T* apparently begins to decrease regularly.[1] It is obvious, therefore, that at *f* the bubble is practically solid, that most

of the water is gone and the compressed air within is now following, diffusing outward through the meshwork of colloidal molecules. The apparent decrease of T is thus spurious, merely implying that the solid bubble is continuous but leaky. This may be tested by opening the stopcock. After 4 hours no internal pressure is left. In case of the pear shaped bubble, the phenomenon was like the preceding, but much more rapid, so that stages of T could not be recognized. The T reached by the nearly solid bubble is very high, but a part of it must be referred to the change of shape specified.

In figure 2, I have shown the result of the successive dilution of the original liquid glue. The surface tension remains low and nearly constant until a dilution of the order of .005 is reached. Thereafter, with further dilution, T increases very rapidly to above 60 in the figure. Using the last (dilute) solution about a week later, bubbles were no longer obtainable, even after warming. Adding a drop of dilute soda solution, however, restored its bubbling virtue. On successive dilution by halving, this gave (in mean values) $T = 52$, 59, 63, 68, 73. With two observers, one to measure the diameter of the bubbles and the other to manipulate the interference fringes, even closer approach to a water surface would be possible. Though thick and colorless, the bubbles have to withstand an increasing capillary strain and like time and tide they tarry for no man.

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SECTION G—BOTANICAL SCIENCES

Vice-president and chairman, Francis E. Lloyd.

Retiring vice-president, Mel. T. Cook.

Secretary, Robert B. Wylie; State University of Iowa, Iowa City, Iowa.

(*Report by R. B. Wylie*)

From the viewpoint of the botanists the Boston meeting was one of the best in recent years. While the number of members in attendance from the interior and from the west was somewhat smaller than at the Chicago meeting, there were proportionately more of the eastern workers in attendance. The botanical programs presented an imposing array of titles. Something over two hundred papers and addresses were scheduled in the various meetings for plant workers.

The extent of the program as well as diversity of interest compelled two or more series of botanical papers at each session. The efficient messenger system, however, readily enabled all to know the progress of all programs so that papers of special interest, though in different rooms, could readily be heard unless they actually conflicted in time.

An examination of the content of the botanical programs offered by the different sections of the affiliated societies shows a tendency towards greater variety than formerly. The strict categories are breaking down, along certain lines at least, and it often happens that a given paper may very properly be classified or presented in two or more sections. This may be due to broader interest or better training of the present workers, but primarily to the growing appreciation of the interdependence of the several fields of plant science.

In a still larger sense the boundaries between zoology and botany as a whole are becoming rather shadowy in many places, and the physiologists, geneticists and ecologists properly pass from one class of material to another and follow both sides with keener interest. These facts bespeak the need for large scientific meetings where members of the several sciences may hold programs in parallel series with greater profit to all concerned. Though emphasized elsewhere, it may be repeated here that modern buildings such as those at the Massachusetts Institute of Technology afford ideal conditions for holding such meetings as those recently held in Boston.

The invitation program of Section G was held on Wednesday afternoon as a joint session with the Botanical Society of America and the American Phytopathological Society. The program, which was attended by a large number of botanists, included the address of the re-

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[1] Even at *e* the evidence of increasing T may be masked by the incipient solidification.