Sessions will begin on Friday morning and continue until noon on Saturday. The following addresses will be given by invitation of the program committee: "Spectral Theory," by Professor Nelson Dunford, of Yale University, on Friday afternoon; and "Absolutely Convergent Trigonometric Sums," by Professor R. H. Cameron, of the Massachusetts Institute of Technology, on Saturday morning.

DISCUSSION

THE TRIPLE POINT OF WATER

IN a survey of ten current text-books on physical chemistry, it was found that in only one of the eight which gave data on the triple point of water was the correct value for the temperature given. The usual value given is +.0075° C, which is that in the International Critical Tables.[1] This is actually the difference between the triple point temperature and the temperature at which ice and pure water are in equilibrium under one atmosphere total pressure. More recently this difference in temperature has been established experimentally[2,3] as 0.0074° C, and it can be calculated from the Clausius-Clapeyron equation of thermodynamics.[3,4] But the equilibrium temperature of ice and pure water at one atmosphere pressure is not zero degrees Centigrade.

In 1927, at the international Seventh General Conference of Weights and Measures, it was agreed that 0° Centigrade be defined as the temperature at which ice and air-saturated water are in equilibrium at one atmosphere total pressure.[5] Saturation of water with air lowers the equilibrium temperature by 0.0024° C.[2,3,4] The total difference in temperature between this as 0° C (on the International Scale defined at this conference) and the triple point is then .0024 + .0074, and the triple point temperature is + 0.0098° C (International).[6]

The vapor pressure of the liquid is usually defined as the pressure exerted by the pure vapor in equilibrium with pure liquid when the liquid is under no pressure except that of its own vapor; a similar definition is given for the vapor pressure of the solid. At the triple point, the vapor pressures of liquid and of solid are identical, but they decrease at different rates as the temperature is decreased. Therefore they are not identical at a temperature of 0° C, as most tables imply.[7] Usually, in calculating the vapor pressure of the solid, it is equated to that of the liquid at 0° C, instead of at the triple point.[8,9] There are thus inconsistencies in the values given for the vapor pressures of solid and of liquid near 0° C. The differences are small but appreciable.

The pressure exerted by the vapor in equilibrium with the liquid under various conditions not only changes with temperature, but also changes slightly if an excess pressure is exerted on the liquid phase, and if substances are dissolved in the liquid. The pressure exerted by the vapor in equilibrium with the solid behaves similarly. Liquid and solid water may exist in equilibrium, with equal but varying vapor pressures over a range of conditions, if these conditions are properly varied.

In addition to the triple point, two other equilibria are of interest. Pure liquid and solid are in equilibrium under one atmosphere total pressure at +.0024° C, and air-saturated liquid and solid are in equilibrium under one atmosphere total pressure at 0° C. The vapor pressure will be different in each of these three equilibrium states. The triple point pressure is the vapor pressure of liquid water or of ice (under only its own vapor pressure) at the triple point temperature. The difference between this and the vapor pressure in these other two states may be calculated by considering the variation as made up of the sum of three separate effects.

First, as noted above, the vapor pressures of solid and liquid decrease with a decrease in the temperature. Second, the vapor pressure of a liquid or solid (a condensed phase) is increased if a pressure is exerted on the condensed phase alone and not on the vapor. For example, if air pressure is exerted on a condensed phase, the vapor is not itself compressed since it can mingle freely with the air. This gives an excess pressure on the condensed phase. Third, the dissolving of air in the liquid lowers the vapor pressure of the liquid. We may assume air is insoluble in ice, or at worst that its solubility is so small as to have a negligible effect on the vapor pressure. The first and third effects tend to cancel the second, in our particular examples.

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[1] "International Critical Tables," Vol. IV, p. 11. McGraw-Hill, New York, 1928.

[2] H. Moser, *Ann. der Physik,* (5), 1: 341–360, 1929; quoted in references 3 and 4.

[3] J. A. Beattie, T. C. Huang and M. Benedict, *Proc. Amer. Acad. Arts and Sciences,* 72: 137–155, 1938.

[4] N. E. Dorsey, "Properties of Ordinary Water-Substance," p. 604. Reinhold Publishing Corporation, New York, 1940.

[5] G. K. Burgess, *Bur. Standards Jour. Res.,* 1: 635–640, 1928.

[6] See also B. P. Veĭnberg, *Jour. Exptl. Theoret. Phys.* (U.S.S.R.), 9: 106–113, 1939, quoted in *Chemical Abstracts,* 33: 7655, 1939; he selects + 0.0099° C as the best value.

[7] *E.g.,* "International Critical Tables," Vol. III, p. 211.

[8] E. W. Washburn, *Monthly Weather Review,* 52: 488–490, 1924; these calculations were made for, and are incorporated in, reference 7.

[9] J. E. Goff, *Heating, Piping and Air Conditioning,* 14: 121–124, 1942. Dr. Goff has recently informed me that this correction was allowed for, although not explicitly stated in his paper.

The changes can be calculated quantitatively from thermodynamic equations, and the values found show that the vapor pressure for the equilibrium system at +.0024° C is 0.0012 mm higher than that at the triple point, and at the 0° equilibrium it is 0.0003 mm higher. For most practical purposes these changes are negligible, and the vapor pressure in any of these three states may be taken as 4.579 mm[7] or 4.581 mm.[10] A recent experimental determination has given the triple point pressure as 4.5867 mm;[11] this is not consistent with other values accepted at present for the vapor pressure of liquid water at temperatures near the triple point.

SUMMARY

(1) A common error in text-books on physical chemistry is pointed out. It is hoped that the correct value for the triple point temperature, +.0098° C, will be given in new books and in succeeding editions of the books surveyed above.

(2) Inconsistencies in the vapor pressure values for ice and for liquid water near 0° C are pointed out.

(3) The equilibrium vapor pressures for ice and liquid water under two different sets of equilibrium conditions are compared with the triple point pressure.

WORDEN WARING

TULANE UNIVERSITY

PALEOBOTANY IN INDIA

I HAVE just received from Professor Sahni of the University of Lucknow, India, a Progress Report on Paleobotany in India, at the head of which appears the following statement:

"We mourn the death of Albert Charles Seward (April 11, 1941). Doyen of Paleobotanists, whose noble personality, no less than his vast learning, was a fountainhead of inspiration to the Indian school of paleobotany."

Those of us who knew Sir Albert Seward as Master of Downing College, Cambridge, had long marvelled at his ability to carry on administrative and teaching work, along with research in paleobotany, and had noted his power of inspiring and fostering research among those who were so fortunate as to come under his direction. But at the present time, we are particularly concerned to note what he was able to do for India; mainly, it appears through the influence of his ardent disciple Sahni. With this source of inspiration, a school of Indian paleobotanists, centering in Lucknow, has developed and for many years their writings have brought to us new information concerning the fossil flora of India. Sahni, in recognition of his work, has been elected a Fellow of the Royal Society.

A paper by Sahni, which accompanies the Report, has to do with the beautifully preserved petrified remains of *Azolla,* showing all the minute details of structure. "The first and most striking fact concerning this specimen is the great perfection in which it is preserved. This helps us to see that in this early Tertiary *Azolla,* which is definitely the oldest known species of the genus, some of the most intimate details of the structure, and the way in which the massulae become anchored to the megaspore, are identical with those found in modern species. Considering that this plant lived about 60–70 million years ago it affords an impressive example of the persistence through the ages of a highly specialized type of behavior during the reproductive phase of the life-history of a genus."

The Oriental mind, for ages developing according to what seemed to be its peculiar genius, now shows its ability to take on the qualities of western culture, for good and for evil. It appears that scientific men such as Seward may promote the good influences, and cause the oriental workers to discover and develop their innate abilities. In such ways scientific research may serve the cause of civilization.

T. D. A. COCKERELL

CITRUS EXPERIMENT STATION,
RIVERSIDE, CALIFORNIA,

SCIENTIFIC BOOKS

CYTOPLASM OF THE PLANT CELL

The Cytoplasm of the Plant Cell. By A. GUILLIERMOND. Authorized translation from the unpublished French manuscript by Lenette R. Atkinson. Foreword by Professor William Seifriz. Waltham, Mass.: the Chronica Botanica Company. New York City: G. E. Stechert and Company. 247 pp. 152 figs. 1941. $4.75.

THIS is Volume VI in a new series of plant science books edited by Dr. F. Verdoorn. It is fortunate that the war has not prevented its translation by Mrs. Atkinson and publication in its present form, for it is a critical survey of all that has been done with regard to chondriosomes, vacuoles and various other structures in the cytoplasm of plant cells, by one who has made many of the most important contributions in this field.

One of the difficulties in the study of protoplasm is that it is usually divided into such small compartments, the cells, which are sensitive even to minor

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[10] N. S. Osborne and C. H. Meyers, *Bur. Standards Jour. Res.,* 13: 1–20, 1934.

[11] K. Prytz, *Kgl. Danske Videnskab. Selskab. Math.-fys. Medd.,* 11: 7–46, 1931; quoted in *Chemical Abstracts,* 26: 627, 1932, and in reference 4 pages 563 and 575.