

ethics, are well brought out by this author. His book may be heartily recommended to students of the period described.

*A Text-book of Physics, Heat.* By Prof. J. H. Poynting, Sc.D., F.R.S., and Prof. J. J. Thomson, M.A., F.R.S. Pp. xvi+354. (London: C. Griffin and Co., Ltd., 1904.) Price 15s.

THE third volume of this well known text-book more than sustains the standard set by its predecessors. The volumes on sound and properties of matter have already appeared. The volumes on light and on electricity and magnetism we hope may follow at a somewhat shorter interval than has intervened between the first three volumes of the series. It is hardly necessary to say that the work is well up to date, and extremely clear and exact throughout, and that it is as complete as it would be possible to make such a text-book within the limits which the authors have laid down for the scope of their work. Among the more original features which should be valuable to the student as filling gaps which are noticeable in similar text-books, we observe that a useful chapter is included on the subject of circulation and convection, with illustrations from meteorology and ventilation. The treatment of the important subject of radiation, especially in relation to temperature and thermodynamics, is unusually complete and clear, and presents in a simple, connected form a number of most important results which the student would have difficulty in finding elsewhere. The experimental spirit is maintained throughout the work in such a manner that the student will feel that he is learning from a practical master of the subject, and will unconsciously imbibe something of the attitude of mind of the original investigator. H. L. C.

*The Oxford Atlas of the British Colonies.* Part i. British Africa. Seventeen maps. (Oxford Geographical Institute: William Stanford and Co., Ltd., n.d.) Price 2s. 6d. net.

THE first thirteen plates consist of coloured maps, and the remaining four are outlines intended for use as "test" maps or for other class purposes. The first map shows a hemisphere in which Cape Colony occupies the centre, and it is possible from it to see at once the relation of South Africa to the other continents. Map ii. is a political map of the world drawn in accordance with Mollweides's equal area projection, and the student will notice at a glance the apparent distortion in shape, though the relative sizes of land areas in different parts of the map are correctly shown. In addition to meteorological charts, the atlas includes physical and political maps of Africa, and maps of Cape Colony, Natal and Zululand, the Transvaal and Orange River Colony, Rhodesia, and of West, East, and Central Africa.

*High Temperature Measurements.* By H. Le Châtelier and O. Boudouard. Authorised translation and additions by Dr. G. K. Burgess. Second edition. Pp. xv+341. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd. 1904.) Price 12s. 6d. net.

In preparing the present edition it was found necessary to make a large number of additions, and the book now gives a useful summary of what is known about pyrometry. The advances in optical pyrometry during the last few years are recognised by the authors, and a useful chapter on the laws of radiation has been inserted. A number of pyrometers are described, but the discussion of the principles involved is in general more adequate than the description of instruments. No mention is made of some of the best of these in use in this country.

NO. 1865, VOL. 72]

## LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. No notice is taken of anonymous communications.]

### A Comparison between Two Theories of Radiation.

ON two occasions (NATURE, May 18 and July 13) Lord Rayleigh has asked for a critical comparison of two theories of radiation, the one developed by Prof. Planck (*Drude's Annalen*, i. p. 69, and iv. p. 553) and the other by myself, following the dynamical principles laid down by Maxwell and Lord Rayleigh. It is with the greatest hesitation that I venture to express my disagreement with some points in the work of so distinguished a physicist as Prof. Planck, but Lord Rayleigh's second demand for a comparison of the two methods leads me to offer the following remarks, which would not otherwise have been published, on the theory of Prof. Planck.

Early in his second paper, Planck introduces the conception of the "entropy of a single resonator"  $S$ . There are supposed to be  $N$  resonators having a total entropy  $S_N = NS$ , and  $S_N$  is supposed to be given by  $S_N = k \log W + \text{constant}$ , where  $W$  is the "probability" that the  $N$  resonators shall be as they are. Without discussing the legitimacy of assigning entropy to a single resonator, we may at present suppose  $S$  defined by  $S = k/N \log W + \text{const.}$

The function  $W$ , as at present defined, seems to me to have no meaning. Planck (in common, I know, with many other physicists) speaks of the "probability" of an event, without specifying the basis according to which the probability is measured. This conception of probability seems to me an inexact conception, and as such to have no place in mathematical analysis. For instance, a mathematician has no right, *quâ* mathematician, to speak of the probability that a tree shall be between six and seven feet in height unless he at the same time specifies from what trees the tree in question is to be selected, and how. If this is not so, may I ask, "What is the probability that a tree shall be between six and seven feet high?"

When Prof. Planck calculates the probability function  $W$ , he in effect assumes that *a priori* equal small ranges of energy are equally probable. Thus he tacitly introduces as the basis of his probability calculations an ensemble of systems of resonators such that the number of systems in which the energy of any given resonator lies between  $E$  and  $E+dE$  is proportional simply to  $dE$ . This, of course, he has a right to do; only he must continue to measure probability according to this same basis.

The systems of resonators are in motion, their motion being governed by the laws of dynamics. Will they, as the motion progresses, retain the statistical property which has been the cause of their introduction, namely, that the number of systems in which the energy of any given resonator lies between  $E$  and  $E+dE$  is proportional simply to  $dE$ ? It is easily found, by the method explained in my "Dynamical Theory of Gases" (§ 211), that in general they will not; the probability function  $W$  is not simply a function of the coordinates of the system. Prof. Planck's position is as though he had attempted to calculate the probability that a tree should be between six and seven feet high, taking as his basis of calculation an enclosure of growing trees, and assuming the probability to be a function only of the quantities six and seven feet. His ensemble of systems has not yet reached a statistical "steady state."

Prof. Planck supposes his function  $S$  to possess the property of the entropy function, so that  $1/T = dS/dU$ , where  $T$  is the temperature. Combining this with Planck's calculation of  $S$ , we find

$$1/T = k/\epsilon \log(1 + \epsilon/U) \quad \dots \dots (1)$$

Here  $\epsilon$  is a small quantity, a sort of indivisible atom of energy, introduced to simplify the calculations. We may legitimately remove this artificial quantity by passing to the limit in which  $\epsilon = 0$ . In this way we obtain

$$1/T = k/U \quad \dots \dots (2)$$

Thus the mean energy of each resonator, according to this equation, is the same multiple of the temperature; no