statements should be revised as in case of the gas constant on p. 79, where the reader would be puzzled if he did not understand that a gram-molecule of gas is the amount dealt with. Also we find quantity of heat defined as "the total kinetic energy of the molecule or ultimate particles of a body," without explaining that this excludes what is ordinarily called latent heat. In describing the Nicols' prism the spar is said to be cut along a "parallel plane" without indicating to what the plane is parallel. In the statement about vector potential the phrase "all lines of magnetic induction" is used where the meaning is, the total flux, or total number of lines of induction. Also the interior of a hollow enclosure at uniform temperature is spoken of as at "black body temperature" instead of as giving off the radiation characteristic of a black body at that temperature.

It is perhaps unfortunate that the author has chosen Rankine as his source for various thermodynamic statements, for with all his undoubted genius Rankine is not an easy guide to follow, and the two statements of the second law of thermodynamics which are quoted from him are practically useless unless interpreted by the fuller discussion in the original to which reference is given. We should have expected a more modern statement of so important a matter as the second law, to supplement the statement by Clausius which is given.

But it is easy to be too critical; the author has successfully carried out his proposal and has done an important service in bringing together in this convenient form so large a collection of the laws and principles of physical science, clearly and accurately stated, and in the care with which the specific references under each topic have been selected, making it easy for the student to turn to sources where the subject is more fully developed.

The volume is well gotten up, with flexible covers in handy form for reference, and has a full index. A few misprints are noted, as in formulas on pages 37 and 42, where the figure 1 is used instead of the letter l, also in the general equation for the flow of heat the coefficient of conductivity K is omitted, and in the formula for the frequency of vibration of a stretched cord the factor $2l$ does not appear.

A. L. KIMBALL

THE PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES

THE ninth number of Volume 3 of the *Proceedings of the National Academy of Sciences* contains the following articles:

Heliotropic Animals as Photometers on the Basis of the Validity of the Bunsen-Roscoe Law for Heliotropic Reactions: Jacques Leob and John H. Northrop, Rockefeller Institute for Medical Research, New York City. New quantitative experiments proving that the "instinctive" motions of animals to light are phenomena of automatic orientation and a function of the light intensity, the function being the Bunsen-Roscoe Law of photochemical action.

The Appearance of Reverse Mutations in the Bar-Eyed Race of Drosophila under Experimental Control: H. G. May, Department of Zoology, University of Illinois. Such a phenomenon is not difficult of explanation on the theory that it is produced by a chemical change in the constitution of some substance.

The Part Played by Alcyonaria in the Formation of Some Pacific Coral Reefs: Lewis R. Cary, Department of Biology, Princeton University. On certain of the Pacific reefs the alcyonaria are important coral-forming agents; their relative importance can be determined only after borings have been made through some reefs to determine the history of the reefs.

Observations upon the Alkalinity of the Surface Water of the Tropical Pacific: Alfred Goldsborough Mayer, Department of Marine Biology, Carnegie Institution of Washington.

The Effect of Temperature on Linkage in the Second Chromosome of Drosophila: Harold H. Plough, Zoological Laboratory, Columbia University. Both high and low temperatures produce an increase in the percentage of crossing over. 'The crossing over appears to take place in the stage when the chromo-

somes are known to be finely drawn out threads, not in the early oogonial divisions nor in the late thick thread stage.

Genetic Factors affecting the Strength of Linkage in Drosophila: A. H. Sturtevant, Zoological Laboratory, Columbia University.

Further Evidence on the Concentration of the Stars toward the Galaxy: Frederick H. Seares, Mount Wilson Solar Observatory, Carnegie Institution of Washington.

Theoretical Relations in the Interferometry of Small Angles: Carl Barus, Department of Physics, Brown University.

Inter-Periodic Correlation in the Egg Production of the Domestic Fowl: J. Arthur Harris, A. F. Blakeslee, and Wm. F. Kirkpatrick, Station for Experimental Evolution, Cold Spring Harbor, N. Y., and Connecticut Agricultural College, Storrs, Conn. The results make possible the selection of groups of birds of high annual egg production from the trap nest records of individual months.

Two Laws governing the Ionization of Strong Electrolytes in Dilute Solutions and a New Rule for Determining Equivalent Conductance at Infinite Dilution Derived from Conductivity Measurements with Extremely diluted Solutions of Potassium Chloride: Edward W. Washburn, Department of Chemistry, University of Illinois. In sufficiently dilute solution all uni-univalent salts of strong acids and bases obey the Mass-Action Law and all have the same ionization constant; the values of the mass-action expression for all such salts are identical, the identity persisting up to higher concentrations the more nearly the salts resemble each other.

On the Growth and Fecundity of Alcoholized Rats: E. C. MacDowell and E. M. Vicari, Station for Experimental Evolution, Cold Spring Harbor, N. Y. Both growth and the fecundity of the alcoholized is subnormal as compared with non-alcoholics.

National Research Council: Minutes of the Meeting of the National Research Council held on Thursday, April 19, 1917, in Rooms 42 and 43 of the United States National Museum, Washington, D. C.; Meetings of the Executive Committee.

The tenth number of Volume 3 of the *Proceedings of the National Academy of Sciences* contains the following articles:

On the General Theory of Curved Surface and Rectilinear Congruences: Gabriel M. Green, Department of Mathematics, Harvard University. Preliminary announcement of the number of theorems in a field which seems to be promising.

A Contribution to the Petrography of Southern Celebes: J. P. Iddings and E. W. Morley, Brinklow, Maryland and West Hartford, Conn. Twelve analyses of lavas from Celebes.

On the Non-Existence of Nervous Shell-shock in Fishes and Marine Invertebrates: Alfred Goldsborough Mayer, Department of Marine Biology, Carnegie Institution of Washington. Corroboration of the conclusion that war shock is predominantly a psychic phenomenon and being hysteria can be cured by hypnotic suggestion.

Chemical Differentiation of the Central Nervous System in Invertebrates: A. R. Moore, Rutgers College, New Brunswick, New Jersey. In the cephalopod, caffein brings about hyperirritability of the cerebral ganglia, while camphor affects the stellar ganglia in the same sense. Atropin causes spasms in the squid, but inhibits the activity of the chromatophores. Camphor shows a selective action in the shrimp paralyzing the elements controlling backward swimming and exciting those controlling forward motion.

Proof of the Muscle Tension Theory of Heliotropism: Walter E. Garrey, Physiological Laboratory of Tulane University, and Marine Biological Laboratory, Woods Hole. Experiments show that the motion of animals to or from a source of light are due to an influence of the light on the tension of muscles of different sides of the body.

Changeable Coloration in Brachyura: W. H. Longley, Goucher College, Baltimore, and Department of Marine Biology, Carnegie Institution of Washington. The colors of crabs and their capacity to change them vary from species to species according to the same general rule that appears to prevail among fishes.

The Equilibrium of Tortugas Sea Water with Calcite and Aragonite: J. F. McClendon, Department of Physiology, University of Minnesota and Tortugas Laboratory, Carnegie Institution of Washington. The surface water of the sea is the supersaturated solution of $CaCO_3$ and it is only necessary to introduce calcite crystals in order to cause precipitation of this substance.

An Oenothera-Like Case in Drosophila: Herman J. Muller, The Rice Institute, Houston. Report of an extended series of experiments showing that it will not do to accept evidence apparently in favor of factor inconstancy without the support of highly rigorous factorial analysis.

Is Death from High Temperature due to the Accumulation of Acid in the Tissues? Alfred Goldsborough Mayer, Department of Marine Biology, Carnegie Institution of Washington. Death is probably due rather to the formation of acid than to coagulation of proteid substances.

National Research Council: Meetings of the Executive Committee.

EDWIN BIDWELL WILSON

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SPECIAL ARTICLES

THE DETERMINATION OF ATOMIC WEIGHTS BY MEANS OF X-RAYS

IT does not seem to be generally realized that the recent developments in the study of crystal structure by the use of X-rays afford a method of determining atomic weights which may be of considerable value.

From the spectra obtained by exposing crystals of two different substances to X-rays of the same wave-length, the ratio of the distances between adjacent layers of atoms in the two substances can be easily determined, as is well known. If the relative distances are determined in the direction of each crystal axis, these results, together with the inclination of the axes to each other in each crystal, enable one to calculate the ratio of the volumes of the elementary parallelopipeds of each crystal. From this ratio and the ratio of the densities we can easily calculate the ratio of the molecular weights. From the ratios of molecular weights, atomic weights can be calculated in the usual manner.

This method requires the preparation of elements or compounds in a state of purity; the production of crystals of practically perfect internal structure, though not necessarily with perfect faces, or of large size; and the measurement of densities and spectral angles and, except when the crystal axes are mutually perpendicular, the measurement of the angles between axes. All of these measurements can be made with considerable accuracy.

Most of the measurements of the angles of X-ray spectra that have been made hitherto have not been highly accurate, for such measurements have been used principally for the determination of the relative positions of atoms in crystals, and for this purpose great accuracy is not required. It appears, however, that sufficient accuracy might be obtained to permit the determination of atomic weights with greater accuracy than that of most of the chemical determinations, and perhaps such accuracy has been obtained with recent spectrometric apparatus.

We are accustomed to think of the density of a substance as being a rather variable quality, but very few density measurements have been made upon perfectly pure material in the form of crystals of perfect internal structure. Very many materials, including metals, are handled commonly in the form of masses composed of a great number of small crystals, which, even if they consist of pure material, are likely to be very much distorted, and at the surface between two crystals there must be a layer of atoms many atoms deep which are not located exactly according to the space lattice of either crystal. There appears to be no reason why the density of a flawless crystal of pure material should not be quite definite, except that the surface forces might cause a difference in density near the surface, as the result of which the mean density might depend somewhat upon the size of the crystal.

After suitable apparatus had once been set up this method should permit the determina-