immediately gave it its true explanation—molecules of residual air, or gas, or vapour projected at great velocities[1] by electric repulsion from the negative electrode. This explanation has been repeatedly and strenuously attacked by many other able investigators, but Crookes has defended[2] it, and thoroughly established it by what I believe is irrefragable evidence of experiment. Skilful investigation perseveringly continued brought out more and more of wonderful and valuable results: the non-importance of the position of the positive electrode; the projection of the torrent *perpendicularly* from the surface of the negative electrode; its convergence to a focus and divergence thenceforward when the surface is slightly convex; the slight but perceptible repulsion betweed two parallel torrents due, according to Crookes, to negative electrifications of their constituent molecules; the change of direction of the molecular torrent by a neighbouring magnet; the tremendous heating effect of the torrent from a concave electrode when glass, metal, or any ponderable substance is placed in the focus; the phosphorescence produced on a plate coated with sensitive paint by a molecular torrent skirting along it; the brilliant colours—turquoise-blue, emerald, orange, ruby-red—with which grey colourless objects and clear colourless crystals glow on their struck faces when lying separately or piled up in a heap in the course of a molecular torrent; "electrical evaporation" of negatively electrified liquids and solids;[3] the seemingly red-hot glow, but with no heat conducted inwards from the surface, of cool, solid silver kept negatively electrified in a vacuum of 1/1,000,000 of an atmosphere, and thereby caused to rapidly evaporate. This last mentioned result is almost more surprising than the phosphorescent glow excited by molecular impacts in bodies not rendered perceptibly phosphorescent by light. Both phenomena will surely be found very telling in respect to the molecular constitution of matter and the origination of thermal radiation, whether visible as light or not. In the whole train of Crookes' investigations on the radiometer, the viscosity of gases at high exhaustions, and the electric phenomena of high vacuums, ether seems to have nothing to do except the humble function of showing to our eyes something of what the atoms and molecules are doing. The same confession of ignorance must be made with reference to the subject dealt with in the important researches of Schuster and J. J. Thomson on the passage of electricity through gases. Even in Thomson's beautiful experiments showing currents produced by circuital electromagnetic induction in complete poleless circuits, the presence of molecules of residual gas or vapour seems to be *the essential*. It seems certainly true that without the molecules there could be no current, and that without the molecules electricity has no meaning. But in obedience to logic I must withdraw one expression I have used. We must not imagine that "presence of molecules is *the* essential." It is certainly *an* essential. Ether also is certainly *an* essential, and certainly has more to do than merely to telegraph to our eyes to tell us of what the molecules and atoms are about. If a first step towards understanding the relations between ether and ponderable matter is to be made, it seems to me that the most hopeful foundation for it is knowledge derived from experiment on electricity in high vacuum; and if, as I believe is true, there is good reason for hoping to see this step made, we owe a debt of gratitude to the able and persevering workers of the last forty years who have given us the knowledge we have: and we may hope for more and more from some of themselves and from others encouraged by the fruitfulness of their labours to persevere in the work.

The President then presented the medals awarded by the Society as follows:—The Copley Medal to Sir George Gabriel Stokes, Bart., F.R.S., for his researches and discoveries in physical science; a Royal Medal to Prof. A. Schuster, F.R.S., for his spectroscopic inquiries, and his researches on disruptive discharge through gases and on terrestrial magnetism; a Royal Medal to Prof. H. Marshall Ward, F.R.S., for his researches into the life-history of fungi and schizomycetes; and the Davy Medal to Prof. J. H. van't Hoff and Dr. J. A. Le Bel, in recognition of their introduction of the theory of asymmetric carbon, and its use in explaining the constitution of optically active carbon compounds.

In the evening the Fellows and their friends dined together at the Whitehall Rooms, Hôtel Métropole.

[1] Probably, I believe, not greater in any case than two or three kilometres per second.
[2] Address to the Institute of Telegraphic Engineers, 189.
[3] Roy. Soc. Proc., June 11, 1891.

THE TEMPERATURE OF IGNITION OF EXPLOSIVE GASEOUS MIXTURES.

AN important contribution to our knowledge of this subject is communicated to the *Berichte* by Prof. Victor Meyer of Heidelberg, in conjunction with his assistant, Herr A. Münch. The interesting experiments which were carried out some eighteen months ago in the Heidelberg laboratory, concerning the conditions under which the explosion or silent combination of gaseous mixtures occurs, left the question of the precise temperatures of explosive combination undetermined, inasmuch as the necessary high temperatures were attained by the use of boiling salts whose temperatures of ebullition lay a considerable number of degrees apart. The researches have since been continued under conditions in which it has been found possible to determine the actual temperatures with precision. In these experiments any possibility of the occurrence of appreciable amounts of silent combination has been avoided, in order that the determinations of the temperature of explosive combination might be unaffected by errors due to that cause. The conspicuous novelty of the method adopted consists in placing the small bulb containing the mixture to be exploded inside the larger bulb of the air thermometer employed to determine the temperature, thus at once ensuring that the explosion bulb and the thermometer bulb shall be heated to precisely the same temperature. The objection which at first suggests itself, that the heat suddenly developed at the moment of explosion might exert a disturbing influence upon the indications of the air thermometer, was proved by direct and repeated experiment to be without validity, such disturbance being found to be too small to be measured. The bulb in which the explosion is brought about is not closed, for the explosion of such detonating mixtures of gases at rest, that is to say, confined to a closed space, is so violent that if the glass escapes pulverisation it is much distorted, owing to the temperature to which it requires to be heated being about its softening point. The distortion usually takes the form of a shrinking from two opposite points, where the glass is drawn in and distended to such an extent as to produce two internal spheres. Such deformation would of course alter considerably the volume of the air thermometer. This is avoided by attaching a long stem to the bulb, open at the free extremity, and of passing a slow current of the gaseous mixture through the apparatus. The bulb of the thermometer was heated by means of a bath of a fused alloy consisting of equal parts of tin and lead, and it was found immaterial whether the thermometer was directly immersed in the molten metal or protected by means of a closely-fitting refractory metal sheath. The estimation of the temperature was effected by displacing the air of the thermometer, whose volume was known, by means of a current of hydrochloric acid gas, and measuring its volume over distilled water which had recently been freed from air by boiling.

The first series of experiments were made with the detonating electrolytic mixture of hydrogen and oxygen. The gases were freed from ozone by passage through a solution of potassium iodide. They were then washed through water, with which a Woulfe's bottle was almost filled, after which they traversed a tube packed with numerous discs of brass gauze, which were found effectual in preventing the explosion from travelling back to the Woulfe's bottle. The mixed gases were then allowed to enter the explosion bulb by means of a capillary tube passing down the stem to the bottom of the bulb. The rapidity of the gaseous stream was found to exert no influence upon the temperature of explosion, within the limits imposed by the mode of experimenting. The bath was then gradually raised to the neighbourhood of the combining temperature, and the instant the explosion ensued the air contained in the thermometer was displaced by hydrogen chloride, collected over water in the measuring vessel, and its volume ascertained on the attainment of atmospheric temperature and pressure. By displacing the air the instant the detonation was heard, any appreciable augmentation of the temperature during the moment of explosion was prevented.

As the result of several series of experiments carried out with four distinct sets of apparatus, the temperature of explosion of electrolytic hydrogen and oxygen is found to vary from 612° to 686°. It would thus appear, conformable with the supposition of Prof. Van t'Hoff from theoretical considerations, that this mixture is incapable of exhibiting a sharply fixed temperature of explosion. Moreover, it makes no difference whether the mixture is dry or moist; for if dried a small amount of silent

combination invariably renders it again moist before explosion occurs.

It has been currently supposed that the presence of sharp solid fragments, such as those of glass, exerts a lowering effect upon the temperature of explosion of hydrogen and oxygen. This supposition has been practically tested and found wanting in accuracy. Neither glass fragments nor sea-sand were found to reduce the temperature below the limits above stated. A remarkable result, however, was obtained when pieces of platinum foil and wire were introduced into the explosion bulb. It was found impossible in their presence to bring about an explosion, even when the temperature of the bath was raised to 715°. Quiet combination invariably ensued.

The size of the explosion vessel appears to be immaterial, except when reduced to very small dimensions, such as 4·5 mm. diameter, as in the case of the smallest bulb tested, when the range of molecular forces is approached. In six experiments with this small bulb no explosion occurred; in others the explosion did not occur in the vessel, but the quiet combustion there initiated was transmitted along the leading tube, through the tube containing the brass gauze discs, and eventually occasioned an explosion in the wash-bottle, disastrous to the latter.

In the cases of other explosive mixtures the admixture was effected, in the proper proportion, in a three litre flask, from which the gases were driven first through a wash-bottle, and subsequently through a test-tube, arranged likewise as a small safety wash-bottle, to prevent the explosion reaching the larger one.

Carbon monoxide and oxygen, in the proportion to form carbon dioxide, were found to suffer, for the most part, silent combination in the apparatus, and the wide limits of the observed temperatures of explosion, 636° to 814°, in those cases when explosion did ensue, were found to be due to more or less of such silent combination.

Gaseous mixtures of hydrocarbons and oxygen were found, however, with the exception perhaps of marsh gas and oxygen, to exhibit practically no quiet combination; and these mixtures have afforded most trustworthy and constant temperatures of explosion.

Marsh gas was found to explode, as a rule, with oxygen at temperatures varying from 656° to 678°, but occasionally quiet and complete combustion occurred. Other hydrocarbons never failed to yield an explosion.

Ethane detonated with oxygen in three experiments at 622°, 605°, and 622° respectively. A mixture of ethylene and oxygen exploded at 577°, 590°, and 577° in three consecutive experiments. Acetylene prepared by Gattermann's method, which in Prof. Meyer's experience yields it in a purer state than the more recent convenient method discovered by Maquenne, explodes with oxygen with exceptional violence, the wash-bottle being destroyed in every experiment. The temperature of this explosion was very constant, 510°, 515°, and 509° being successively observed. Propane mixed with five times its volume of oxygen likewise exhibits a very constant temperature of ignition, 548°, 545°, and 548° being indicated in three determinations. Propylene exploded with four and a half times its volume of oxygen at 497°, 511°, and 499°. Isobutane mixed with six and a half times its volume of oxygen detonated at 549°, 550°, and 545°; and isobutylene at 546°, 548°, and 537°. Finally, coal gas mixed with thrice its volume of oxygen was found to explode in three experiments at the remarkably constant temperatures of 649°, 647°, and 647°. It was found impossible, however, to induce a mixture of coal gas and air to explode under these experimental conditions.

It will be clearly seen from the above experiments with gaseous mixtures of hydrocarbon and oxygen, that the temperature of explosion falls as the content of carbon increases. Thus the mean temperatures for methane, ethane and propane are 667°, 616°, and 547° respectively. Further, the temperature also falls with the degree of saturation, or in other words, the less saturated the hydrocarbons become the more readily do they ignite in contact with oxygen. Thus ethane, ethylene and acetylene explode with oxygen at 616°, 580° and 511°; propane and propylene at 547° and 504°; and isobutane and isobutylene at 548° and 543°. It will also be observed, however, as would be expected, that these differences due to difference of saturation diminish as the series are ascended.

A. E. TUTTON.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Mr. Austen Leigh, Provost of King's, the Vice-Chancellor, has been appointed a member of the Geographical Committee, in the place of Dr. Ferrers, resigned. The award of the Geographical Studentship of £100 will be made towards the end of the Lent Term.

The first award of the Walsingham Medal, founded by the Lord High Steward for the encouragement of biological research, has been made to Mr. E. W. MacBride, Fellow of St. John's, for his monographs in zoology.

MR. ARTHUR WILLEY, at present giving a course of lectures in Columbia College, New York, has been elected to the vacant Balfour Studentship by the Special Board of Biological and Geological Studies of the University of Cambridge. It is understood that the investigation prescribed for him will be that of the embryology of *Nautilus pompilius*, for which purpose he will proceed to the South Seas.

SCIENTIFIC SERIALS.

The Quarterly Journal of Microscopical Science for September, 1893, contains studies on the comparative anatomy of sponges: V. Observations on the structure and classification of the *Calcarea Heterocœla*, by Dr. Arthur Dendy (plates 10–14). In this paper the author gives a general account of the anatomy, histology, and classification of the *Calcarea Heterocœla*, from the point of view of one who has for a long time past been engaged in an independent study of the group, and he brings together all that is known on the subject. While on the classification of the group he departs somewhat widely from the lines laid down by previous writers, yet the necessity of doing so was forced upon him by a study of nearly fifty Australian species. The author finds neither the canal system nor the skeleton affords a reliable guide for classification, and a compromise is the only satisfactory way out of the difficulty. The families adopted are: (1) Leucasidæ, (2) Sycettidæ, (3) Grantidæ, (4) Heteropidæ, (5) Amphoriscidæ. —On some points in the origin of the reproductive elements in Apus and Branchipus, by J. E. S. Moore (plates 15 and 16). Calls attention to some important details in the spermatogenesis of Branchipus and in the ovigenesis in Apus. In the former, the observations bear out the general law as to the similarity of the male and female cells, their specific peculiarities being physiological in origin, without morphological import. The divisional phenomena of these cells are intimately related to a protoplasmic structure, which might be fitly described as "Schaumplasma," and one of the initial impulses towards metamorphosis is a fusion of some of the intra-nuclear globules; while a considerable portion of the complicated karyokinetic figures, with their centrosomes, pseudosomes, and dictyosomes, appear to be the logical as well as the actual consequence of the continuance of this process. Some time before and always during the course of the chromatic changes bodies answering to the centrosomes in all details except in their numbers, which is much greater, make their appearance; these the author provisionally names "pseudosomes." The term "dictyosomes" is given to bodies which make their appearance connected one to another and to the inner group of chromosomes by fine strands, and which remain uncoloured by reagents, and are more or less related to the cell periphery. (In connection with these, Farmer's notes and figures of like bodies in the Pollen mother-cells is of interest. (See *Ann. of Bot.* September, 1893).—Notes on the Peripatus of Dominica, by E. C. Pollard (plate 17). Miss Pollard's species is apparently very nearly related to *P. edwardsii*, but differs in the number of ambulatory appendages, there being 29 to 34 pairs in *P. edwardsii*, while in *P. dominicæ*, sp. nov., there are from 25 to 30.—Studies on the Protochordata, by Arthur Wiley, B.Sc. (plates 18–20). II. The development of the neuro-hypophysial system in *Ciona intestinalis* and *Clavelina lepadiformis*, with an account of the origin of the sense-organs in *Ascidia mentula*. III. On the position of the mouth in the larvæ of the Ascidians and Amphioxus, and its relations to the Neuroporus.

Symons's Monthly Meteorological Magazine, November. Mr. Symons gives a summary of all the rainfall observations known to have been taken in Persia; the only places at which such appear to have been made are Ooromiah, in the north-