

fusion of gold, silver, and platinum in lead. The rate of diffusion in these cases, and notably in the case of gold, seems to be enormously high compared with the rate of diffusion in liquids.

Mr. W. J. Millar read a paper on iron and other metals in a liquid and solid state, which started a lively and entertaining discussion of the question of the expansion of iron on solidification. Mr. Millar contended that iron did not expand on solidification; while Sir William Thomson, and other members of the section, protested that Mr. Millar's own experiments proved conclusively that it did.

The matter of the velocity of light of different colors was considered by Professor Michelson, and also by Professor George Forbes. Mr. Michelson explained, somewhat in detail, his method of determining the velocity of light, and gave the results of an investigation of the velocity of red and blue through a column of carbon bisulphide about ten feet long. The velocity of the mean ray through this medium had been found to be about 1.75 times its value in air, which was somewhat higher than theory would indicate; but the difference was doubtless attributable to errors in experiment. A measurable difference between the velocity of the red and that of the blue ray had been observed, agreeing very closely with that indicated by theory. Professor Forbes's paper was a discussion of the observations by means of which he, in junction with Mr. Young, had shown, apparently, that there was a measurable difference between the velocities of red and blue light in air. The paper was discussed by Sir William Thomson, Lord Rayleigh, Professor Newcomb, Professor Michelson, and several others; and the general opinion was quite decidedly against the view that such difference really existed.

On the last day of the session, the section was divided; and a number of papers on pure mathematics occupied the attention of a sub-section. No report of these papers can be made, as the *Science* reporter found it impossible to organize a sub-section to follow the mathematicians.

#### PROCEEDINGS OF THE SECTION OF CHEMICAL SCIENCE.

THE session opened at noon, Aug. 28, with the president, Sir Henry E. Roscoe, in the chair. Dr. Perkins, the retiring president, sat on his right hand; and Drs. Wolcott Gibbs, Gladstone, and Frankland, on his left. The room was filled to overflowing; and the address was listened to with marked attention and interest, and the comments upon it were uniform in their commendation. This is rather surprising when we recall the present state of feeling in England which the efforts to found a superior institution for technical instruction have aroused, but his views on chemical education are in conformity with those generally entertained in the United States. It will be seen by the papers presented at this session, that the particular phases of the recent advances in chemistry of which the president treated occupy

at present the attention of many of the English chemists.

The first paper read was by Dr. Wolcott Gibbs, at the request of the section, and was upon the complex inorganic acids. It consisted of a *résumé* of the magnificent work which he has done in the field which he has discovered and explored.

It is impossible in the brief space at our command to do justice to this superb research; which is destined to revolutionize many of our chemical conceptions, and in which has been shown the cumulative power of the molybdenum and tungsten oxides, the existence of dominant and subdominant groups, and of different kinds of basicity prevailing within the same molecule, and of the production of isomerism by the orientation of the atoms.

Mr. H. B. Dixon exhibited tables in which Bunsen's, Horstmann's, and his own results on the effect of mass on the incomplete combustion of mixtures of carbon monoxide, hydrogen, and oxygen were compared; and the discrepancies were found to be due to differences in the temperature and pressure under which the experiments were conducted. Above four hundred millimetres, the pressure did not affect the results; and at temperatures between 60° and 140° constant results were also obtained. It is believed, that when the mixtures were exploded below 60°, the reaction was interfered with by the condensation of water on the sides of the tube. Further, it was found that mixtures of carbon monoxide and oxygen, in equivalent proportions, could not be exploded unless there were aqueous vapor, or some body containing hydrogen, present. With traces of hydrogen, hydrochloric acid, hydrogen sulphide, or a hydrocarbon present, the mixture could be exploded. It is supposed that the steam is reduced by the carbon monoxide, and that the liberated hydrogen burns, and re-forms steam, which again acts on more carbon monoxide. By a series of alternate reductions, a few molecules of steam serve to carry oxygen to the carbon monoxide just as the oxide of nitrogen acts in the sulphuric-acid chamber. By putting a dry mixture of carbon disulphide and oxygen into a dry mixture of carbon monoxide and oxygen, the first could be inflamed, then by introducing a little water the carbon monoxide and oxygen could be exploded.

Professors Liveing and Dewar read a paper on the spectral lines of the metals developed by exploding gases. Berthelot has recently investigated, by means of the chronograph, the rate of propagation of the explosion of mixtures of oxygen with hydrogen and other gases; and has found, that, with a mixture of hydrogen and oxygen in the proportion to form water, the explosion progresses along a tube at the rate of 2,841 metres per second, a number which is not far from the velocity of mean square for hydrogen particles, on the dynamic theory of gases, at a temperature of 2,000°.

This velocity, though far short of the velocity of light, bears a ratio to it which cannot be called insensible. It is, in fact, about  $\frac{1}{100,000}$  part of it. Hence, if the explosion were advancing towards the eye, the waves of light would proceed from a series of

particles lit up in succession at this rate. This would be equivalent to a shortening of the wave-length of light by about  $\frac{1}{100000}$  part; and, in the case of the yellow sodium lines, would produce a shift of a distance of about  $\frac{1}{167}$  of the space between the two lines. It would require an instrument of very high diffusive power and sharply defined lines to make such a displacement appreciable. With lines of longer wave-length, the displacement would be proportionately greater; while, if a receding explosion could be observed simultaneously with an advancing one, the relative shift would be doubled. In this way the two images of the red lithium line would be separated by about  $\frac{1}{2}$  of a unit of Angström's scale, a distance about equal to that between the components of the less refrangible of the pair of E lines.

The experiments were made first in a straight glass tube, and then in a U tube, which enabled them to observe the advancing and retreating wave. In these cases it was found that the calcium spectrum was produced, owing to particles of the glass detached by the explosive reaction. The reversals showed too, that, in the wave of explosion, the gases do not reach their maximum temperatures all at once, but the front of the wave is cooler than the part which follows and absorbs some of its radiations, while the rear of the wave does not produce the same effect.

Experiments were now made in iron tubes, and here the spectrum of iron was obtained from the particles detached from the tube. Altogether, sixty-eight lines of iron were identified, of which about forty lie in the ultra-violet between hydrogen and oxygen. Only one iron line above oxygen was definitely seen, and that in only a few photographs. Since iron gave so many lines, linings of copper, lead, cadmium, zinc, aluminium, and tin were inserted in the tube. Cadmium, aluminium, and tin gave no lines whatever; zinc gave only a doubtful impression; lead gave one visible line, and two in the ultra-violet; copper gave one visible line in the green, two in the ultra-violet, and occasionally a shaded band in the blue; cobalt and nickel gave a great many lines. Berthelot and Vielle having put the temperature produced by the explosion of hydrogen and oxygen under a pressure of 9.8 atmospheres at 3,240°, the authors believe that they cannot be far wrong in assuming the temperature at about 3,000°, and that at this temperature such metals as iron, nickel, and cobalt are vaporous, and emit many characteristic rays, and that by far the greatest part of these rays lie between G and P.

The discussion on the constitution of the elements was opened by Dr. Dewar; and after referring to the doctrine of continuity found in the essays of Grove, taught by Black, and held by Newton, and the views of Clerk Maxwell who said that the process by which atoms are formed cannot be known, since they are neither born nor do they die, he stated that our recent knowledge on the constitution of molecules was largely due to the studies of Deville upon dissociation, and that he was led to make these studies from the observation of Grove that a platinum bead heated in an oxyhydrogen flame would decompose

water when immersed in it. Experiments made by Dr. Dewar in this direction were described; and it was stated that chemical bodies are not fixed or unstable at certain fixed temperatures, but that there exists a relation between the pressure, temperature, and character of the body, which determined its stability. Deville held the change to be similar to a change in state of bodies; and, this relation being true, thermodynamics enable us to determine the amount of change for given conditions. The change of state in elementary substances is not unlike a chemical change.

The spectroscope has been used to study the constitution of molecules, and Roscoe has found that the allotropic forms of bodies give different spectra. Lockyer has attempted to show the evolution of the elementary bodies from hydrogen. His results have been criticised as having been due to the presence of impurities, but Lockyer disproved this. It has been said, too, that he did not use a spectroscope of sufficiently dispersive power.

Prout's hypothesis was next considered; and it was shown that the most careful determinations of the atomic weights of nitrogen, potassium, magnesium, zinc, and bismuth, by Stas and Marignac, yielded results that were not simple multiples of hydrogen.

In continuing the discussion, Dr. Gibbs said he was not sure that the accepted views of the molecular constitution of chemical compounds was the correct one. Taking common salt, for instance, it might in the solid state be composed of one hundred molecules of sodium and one hundred molecules of chlorine; when in solution it might be simpler; when in the gaseous form, simpler still; and when exposed to a vacuum, such as Mr. Crookes has produced, it might have the accepted constitution. He referred to the fact, that Professors Liveing and Dewar had found that cadmium, mercury, and zinc gave no spectra at high temperatures. As these are all monatomic molecules, it might be that in this process we possessed a means for studying the constitution of the elementary molecules. Professor Liveing thought Dr. Gibbs's suggestion concerning the action of the monatomic elements an improbable one, since aluminium and tin gave no lines under the same conditions. He said that many lines of iron suggested either a very complex constitution, or else that the substance we term iron is really formed of a number of elements which yet defy separation, and which have nearly similar atomic weights. We have an instance of such a case in the cerium group. The  $D_3$  line, for instance, may belong to an element more volatile than hydrogen. Sir Lyon Playfair pointed out, that when solid iodine was immersed in liquid sulphurous acid no action resulted; but if the iodine was in solution, and the sulphurous acid gaseous, they combined readily. He suggested the study of the temperature at which iodine or sulphur would combine with sulphurous acid. Dr. Tilden said we needed more extensive and accurate observations on the temperature at which chemical action—such, for instance, as the point of ignition—begins. Dr. Dewar stated that we have, in the result of the researches of Dr. Perkins in the magnetic rotation of

compounds in relation to their chemical composition, a means for determining molecular weights by optical methods.

The reports of the committees on spectrum analysis and on chemical nomenclature will be published in full, in the annual report of the association.

A paper was next read on some phenomena of solution illustrated by the cases of sodium sulphate by William A. Tilden. In a recent paper in the *Philosophical transactions*, the author has favored the theory which ascribes solution, not to any combination, chemical or otherwise, of the solid with the solvent, but to liquefaction arising from the mechanical or kinetic action of the molecules of the liquid in which the solid is immersed. This theory is now being tested through a study of the thermal phenomena attending the solution of sodium sulphate.

Crystallized sodium sulphate containing ten molecules of water melts at 33°-34°. At 34° or thereabouts it begins to show signs of dissociation. The maximum point of solubility likewise is at this temperature. In consideration of these facts, Professor Tilden propounds the query: In what condition is the dissolved salt at temperatures above 33°? Is it in the form of the usual hydrate, or is it wholly or in part in the anhydrous state? The diminished solubility is believed to indicate progressive dissociation; but, this view being questioned, the heat of solutions at temperatures above and below the critical temperature is being determined. The data given, although subject to some slight revision, show that at temperatures as high as 55° the thermal change is still positive, although a diminishing quantity; and hence, that the act of solution is still attended at these temperatures by a chemical combination between the salt and a portion of the water. In this connection, Professor Tilden presented a modified form of calorimeter used in his experiments.

W. W. J. Nicol next presented a theory of solution. The theory proposed is, that the solution of a salt in water is a consequence of the attraction of the molecules of water for a molecule of salt, exceeding the attraction of the molecules of salt for one another. It follows, then, that, as the number of dissolved salt molecules increases, the attraction of the dissimilar molecules is more and more balanced by the attraction of the similar molecules: when these two forces are in equilibrium, saturation takes place. At the saturation point the force tending to keep in solution any single molecule of salt (attraction of dissimilar molecules) is balanced by the force tending to produce separation of that molecule from the solution (attraction of similar molecules). Further, any external cause tending to alter the intensity of either of these two forces, or to modify both in unequal degrees, disturbs the condition of equilibrium, and further solution or solidification ensues. The above theory is based on the molecular theory of liquids, and has many points in common with that of Dassios proposed in 1866.

In putting this theory to the test of experiment, certain results followed which in such a brief note as this cannot be mentioned.

Mr. Nicol lays stress upon the fact that he expresses the value of a salt solution by  $n$  molecules (equivalents) of salt to one hundred molecules of water; and he holds that the experiments made on the continent are valueless where they have been made by dissolving one, two, or more molecules of salt in a litre of solution, since, as the molecular volumes of the salts in solution vary, the solutions are not similar as supposed.

A paper followed on evaporation and dissociation, by Professor William Ramsay, and Sydney Young. It having been suggested, that the closer proximity of molecules in the liquid and solid state may be due to the coalescing of two or more gaseous molecules, to form a complex molecule, the authors hold that the work done in dissociating these complex molecules into single molecules is analogous to that expended in converting a solid or liquid into gas, and that the same relations between the existing temperature and pressure would exist. The temperature of volatilization of a large number of solids was determined by the 'cage' described by them before the Royal society, April, 1884. With bodies like phthalic and succinic acids, this relation was found to exist; but with acetic acid little or no dissociation was discovered. Also a distinct difference was observed in the behavior of dissociating substances in the liquid and solid states when evaporating from a full surface. So long as a substance is solid, the residue retains its original composition, but a liquid separates into its components: this amounts to a proof that a solid in volatilizing does not pass through the liquid state, and that so long as a substance remains solid it cannot dissociate. The results obtained lead the authors to provisionally doubt the existence of complex molecular groups in liquids.

The object sought in Professor William Ramsay's paper on molecular volumes was to ascertain whether the boiling-points of compounds, under equal pressures, really afford suitable points for a comparison of the molecular volumes. The experiments made decisively show that in methyl, ethyl, propyl, isopropyl, and isobutyl alcohols, and ether, the value of the group  $\text{CH}_2$  is by no means constant: while at the boiling-points of the liquids at low pressures, the value is approximately constant, fluctuating between 17.5 and 22, at high temperatures the difference becomes much more apparent, attaining at pressures of 20,000 mm. (which was the highest measured) the greatest irregularity.

Professors Goodwin and Marshall are studying the solubility of chlorine gas in solutions of metallic chlorides; and finding that other experimenters have been observing the expansion of solutions made by dissolving  $n$  molecules of the salt in  $m$  molecules of water, and that consequently these contain, when diluted, neither the same number of molecules of the salt nor of the water, they have arranged their experiments so that this ratio shall remain constant throughout the observations.

Sir H. E. Roscoe, speaking in regard to the diamantiferous deposits of South Africa and the ash of the diamond, showed that silica and iron oxide form

constant constituents of the diamond. It is a curious fact, that when these yellow diamonds are heated out of contact with the air they lose their color, and remain colorless so long as they are not exposed to the light: then they immediately regain it.

A discussion on chemical changes in their relation to micro-organisms was opened by Professor Frankland. He stated that contact action had been held to be of two kinds, — that where both of the bodies underwent a change, and that in which one of the bodies remained unchanged. The last was called catalytic action. The changes taking place in organized bodies had been referred to the last class, but organic chemistry had proved them to belong to the first. In organized bodies, both analytical and synthetic changes take place; but in general the first take place in the bodies of animals, and the last in vegetables. This enables us to determine to which of the two kingdoms a body belongs, and judged by this criterion the microcosms belong to the animal kingdom. Soluble ferments, on the contrary, act by contact without giving of themselves. The changes which these soluble ferments produce were then shown in a series of tables; and it was seen that the resulting analytical reactions were usually quite simple, but were attended by the evolution of heat. Referring to this point, it was suggested, that as allotropic and isomeric changes often convert potential into kinetic energy, it might be possible to maintain life through these changes. The reactions produced by the micro-organisms were next shown in a series of charts, together with illustrations of their forms. The reactions in these cases were far less simple; but in some instances, as with the *Saccharomyces cerevisiae*, it is a question how far the by-products are due to the action of the micro-organism. The power of these organisms to resist chemical substances generally and high temperatures was shown, yet spongy iron quite destroyed them. It is of the utmost importance to discover some simple agent for destroying these bodies, which is harmless to man.

In discussing this topic, Professor Roscoe pointed out the fact that one ferment produces only one reaction, and that this was probably true in those more complicated reactions which attend disease. Dr. Dallinger stated that he was able by slow stages to so change the environment of a micro-organism, that eventually it lived under conditions entirely unlike its natural ones, and that he had cultivated the most highly organized ones in solutions which contained no organic matter whatever. Dr. Dewar called attention to the wonderful preservative power of hydrogen peroxide. One one-hundredth of one per cent will preserve urea indefinitely. It does not, however, preserve milk indefinitely, on account of the physical action of the milk globules, while it has no action whatever on the soluble ferments. He believes the heat evolved by the action of the ferments to be due to the hydration of the alcohol; and he pointed out that we have in bacteria the most delicate agent we now possess for detecting oxygen, and the most accurate for measuring light.

Sir John Lawes and Dr. Gilbert presented a paper

on some points in the composition of soils. This was a continuation of the paper presented to the American association two years ago; and it is sought to show that the view which has been maintained, that a soil is a laboratory and not a mine, is erroneous; for not only the facts adduced by the authors in this and other papers, but the whole history of agriculture so far as we know it, clearly show that a fertile soil is one which has accumulated within it the residue of ages of previous vegetation, and that it becomes less fertile as this residue is exhausted. The results of many analyses and experiments with the soils of Manitoba and other prairie lands were cited in evidence.

#### PROCEEDINGS OF THE SECTION OF GEOLOGY.

It is impossible, in the limited space at our disposal, to do any thing like justice to the large number of interesting papers presented to this section, and to the discussions called out by them. Moreover, coming prominently before the section as there did, such questions as glacial action, causes of the ice age, formation of the basins of the great lakes, the origin of coal, metamorphism, and the many questions connected with the archæan rocks, and when these questions were discussed by men like Dawson, Hall, Geikie, Newberry, Hunt, Bonney, and by many younger though no less earnest workers in geology, it is easier to imagine than to describe in detail the interest attached to such an occasion.

The number of papers presented — fifty-one — was too large to admit of satisfactory discussion; and, even hurried over as they were, it was necessary for the section to meet again upon a fifth day, instead of completing its work in four sittings as was originally anticipated. Many of the topics presented were passed over so lightly as rather to discourage the presentation of papers containing the results of long and patient labor. Even the important questions treated of by Dr. Blanford in his opening address were lost sight of except as he occasionally called them to mind.

While the discussions were sufficiently animated, — some of them perhaps even more so than was seemly, — the animation was due, to a considerable extent, to the tenacity with which each one held to his own theories, rather than to any considerable array of facts brought forward to sustain them.

The section met in the lecture-room of the Redpath museum. A full audience heard the address of Dr. Blanford the chairman, and toward the close of its delivery Lord Lansdowne was one of the listeners.

At the close of the address, in accordance with English usages, a vote of thanks to the speaker was proposed by Sir William Dawson, who commended Dr. Blanford's presenting a subject so full of debatable matter as likely to excite the greatest interest and discussion. Seconding the motion, Dr. Selwyn, director of the Geological survey of Canada, referred to instances similar to those mentioned, which occur in Vancouver's Island and in parts of Australia not re-