will not separate again, except under special circumstances; but so far the fact that different gases behave differently in this respect remains unexplained. If two spherical bodies collide, they will remain in contact only if perfectly inelastic, otherwise they will fly off in opposite directions.

In the latter case the elastic forces are due to the displacement of the molecules of the spheres from their positions of equilibrium. If the colliding bodies are two of Thomson's atoms, similar elastic forces will be called into play by a displacement of their outer shells. If the mass m_1 of each of the outer shells is very large compared with that of the inner ones, the outer shells will remain nearly at rest after the collision, while the inner ones will be thrown into violent vibration; indeed it follows from (24) that x_1 will be very small. The atoms will therefore behave very nearly as if they were inelastic, and may remain long enough in contact to assume a new condition of equilibrium by uniting to form a single molecule. Exactly the reverse will happen if m_1 is small compared with the mass of the inner shells.

We must therefore assume that in diatomic chemical molecules the masses of the outer shells are very large compared to the sums of the masses of the interior shells, while in the monatomic molecules the masses of the outer shells are comparatively small.

We might now inquire why it is that in general more than two atoms do not unite in this manner. To which the answer is that the more complicated the structure of a molecule, the more easily will it be broken up by the impacts of other molecules. We must therefore assume that in the case of diatomic molecules the violence and frequency of the impacts, even under ordinary circumstances, are sufficient to break up any molecules which may be formed containing more than two atoms; while in the case of other elements, such as arsenic and phosphorus, the impacts are unable to break up the tetratomic molecules, even at the high temperature of vaporization.

In virtue of these considerations it appears that the formation of a chemical compound, such as hydric chloride, is not such a simple process as it was supposed to be in § 7. The impacts will frequently produce diatomic molecules of hydrogen and of chlorine respectively. The final condition of equilibrium will, however, be arrived at on the same principle as before—namely, that the molecules of hydric chloride are the least sensitive to the action of light. Tetratomic molecules of hydric chloride, will not be permanently formed, as the impacts, increased in violence and frequency by the heat developed, will break them up. Similar considerations apply to the formation of water.

The formation of these simple compounds is, therefore, accompanied by, and due to the simultaneous breaking up of the original diatomic molecules of the elements present.

Double decompositions will take place in an exactly similar manner, and considerations of the same kind apply to solid and liquid bodies, in which, however, the impacts will be very much less frequent.

We also see that the broadening of the bands in the spectrum of a gas, especially when due to a lowering of temperature, does not necessarily show that the gas is a compound, as it may be due to the union of previously dissociated similar atoms into molecules.

§ 10. *Dissociative Action of Light and Heat.*

The fact that the same compounds which are formed by the action of heat are again broken up when the temperature is further increased, and, indeed, the dissociation of every chemical compound at a sufficiently high temperature, is in apparent contradiction to the conclusions of § 8. In the case of compounds formed by the action of light it is quite possible that the internal energy due to the action of heat may be greater than that of the atoms at the same temperature. In general, it may be that when the two constants c_i (§ 1) combine to form one, the corresponding critical vibrations are only produced at a much higher temperature, and may then give rise to dissociation. Since, however, all compounds are dissociated at sufficiently high temperatures, there must be some other causes at work. We may suppose that in gases at very high temperatures the molecules are broken up simply by the violence of the impacts, and this process would be facilitated by the molecules not being spherical in form.

The dissociative action of light observed in certain cases cannot of course have a similar general explanation, and must not be attributed to special chemical properties of light of certain wave-lengths, but to the values of the internal constants of the molecules being of a kind specially favourable to such action. Thus, as the author points out, we are led to the point of view expressed by Lockyer,[1] as follows:—

"The causes which are given in the text-books, showing us the maxima of heat, light, and chemical action, are, I fancy, merely causes showing us, as it were, the absorption spectra of those substances by which the maxima have been determined—whether they be lamp-black, the coating of the retina, or salts of silver, and are really altogether independent of the nature of light."

§ 11. *Fluorescence.*

It has been pointed out in § 4 how critical vibrations may be excited in a molecule by external disturbances, causing the molecule to emit light of a certain wave-length. The disturbance was supposed to be due to the action of heat, but from what has gone before it is clear that they may be produced by ether vibrations if only the molecule or atom is very sensitive to light vibrations. For as soon as the impact of light waves of a certain (critical) vibration period has raised the internal energy of the molecule to its maximum value, the molecule itself—that is to say, its centre of gravity—will begin to execute vibrations; the different molecules will strike against one another, and the result of these encounters will be to produce vibrations of the other critical periods of the molecule, which will be different from the vibration period of the impinging light.

The substance will therefore emit rays different from those which have fallen upon it. As a matter of fact some substances having such special sensitiveness have been observed,[2] and are known as fluorescent substances. The phenomena of fluorescence must therefore be attributed to the absorption of light, as was pointed out by Stokes.

A fluorescent body is to be regarded as one in which the molecular constants c_i have such values that the corresponding light vibrations can be easily excited by external impulses. Fluorescent substances must, in agreement with Stokes's conclusions, be regarded as being exceptionally sensitive.

The theory does not lead to the law which has usually been asserted, that the emitted light must necessarily be of longer wave-length than the impinging light, and therefore the theory is not inconsistent with Lömmel's observations on naphthalin red.

Fluor-spar exhibits the phenomena of fluorescence to an exceptional degree. It may be that fluorine itself is exceptionally sensitive to the action of light, and that the formation of the mineral has not altogether destroyed this sensitiveness. If this be so, it would explain the impossibility of preventing fluorine from entering into combination with any substance with which it is in contact.

G. W. DE TUNZELMANN.

(*To be continued.*)

THE FORESTRY SCHOOL IN SPAIN.

IN a Report to the Foreign Office which has just been published the British Ambassador at Madrid states that Mr. Gosling, First Secretary to the Embassy, has had the opportunity of studying the excellent School of Forestry established at the Escurial, and as great interest is now taken in forestal science in England, and as efforts are being made to establish a British National School of Forestry, he sends the information collected by Mr. Gosling at an institution which, he thinks, is well adapted as a type for a similar institution in England.

Forestal legislation in Spain dates as far back as the close of the fifteenth century—that is, in the reign of Ferdinand and Isabella—and there is reason to believe that reckless destruction of the rich forests was checked from time to time by Royal ordinances. At the close of the sixteenth century Madrid was surrounded by dense forests; in fact, the city arms—a bear climbing up a green tree—bear out the old chroniclers when they speak of the forests which lay around the city, which must have existed in the time of Charles V. So far is this from being the case at present that for the most part the districts around Madrid are treeless and unproductive, and as a consequence exposed to the furious mountain storms, and unsheltered in the scorching summer, whence comes the extreme unhealthi-

[1] "Studies in Spectrum Analysis," p. 110.

[2] Thomson mentioned, "Lectures on Molecular Dynamics," p. 280, that his theory of absorption would account for the phenomena of fluorescence, but he did not follow up the subject.

ness for any person with a delicate constitution. While Spanish rule in South America carefully protected the forests from destruction, it permitted this to go on almost unchecked at home. Towards the end of the last century the great agrarian lawyer and reformer, Jovellanos, who was the first to call the attention of Spain to the disastrous effects which were being produced by the want of supervision of the forests, wrote a pamphlet entitled "Informe de la Sociedad economica de Madrid, al real y supremo Consejo de Castilla, en el expediente de ley agraria extendido por su individuo de numero Don Melchor Gaspar de Jovellanos à nombre de la Santa encargada de su formacion, y con arreglo à sus opiniones." This pamphlet paved the way for the present excellent system of forestry. Special ordinances were passed in the year 1835 for the foundation of a school of forest engineers, but at the time no practical steps were taken; but ten years later, when domestic troubles had to some extent passed away, the "Escuela especial de Ingenieros de Montes" (School of Forestry) was firmly established and was followed by the formation of a corps of forest engineers. The first School of Forestry was situated at Villaviciosa, not far from Madrid, and was under the control of Señor Bernardo de la Torre Rojas, who is still styled "el padre de la Escuela Española de Montes." In 1869 the school was transferred from Villaviciosa to the Escurial, part of which had been granted by the Government in the preceding year for that purpose. This institution is now under the direction of Señor Bragat y Viñals, and there are nine professors and three assistants under him, all of whom must have served five years on the staff of forest engineers. The annual salaries of these officers amount to £1400, and appear in the annual Budget of the Minister of "Fomento," which Department includes public works, industry and commerce, agriculture, public instruction. The total yearly cost of the school is £1700. The following are the subjects taught by the professors, each group having a professor: (1) forestal legislation; (2) political economy, forestal meteorology; (3) applied mechanics and forestal construction; (4) topography and geodesy; (5) chemistry, mineralogy, and geology (applied); (6) botany; (7) sylviculture, (8) zoology and forestal industries; (9) classification of forests and their valuation. The instruction is free, but the books and instruments are charged for. The vacation depends on circumstances. If the practical work is completed, the months of August and September are given; four days in December and three during the Carnival are given—that is, in all about nine weeks. The number of students is practically unlimited. The school is open to all who pass the preliminary examination—that is, to all who show proficiency in Spanish and Latin grammar, geography, and Spanish history, elements of natural history, of theoretical mechanics, geometry, and its relations to projections and perspective, physics, chemistry, lineal, topographical, and landscape drawing, and an elementary knowledge of French and German. Immediately on entrance to the school, particular attention is paid to topography, chemistry (practical), and mathematics (applied). The topography course includes the object of topography, and the difference between it and geodesy; the rules of triangulation and methods of demonstrating the physical characteristics of the ground under survey; chart and plan drawing; and an intimate knowledge of the use of the instruments used in forestal topography. The course in chemistry is very wide, including every detail of the applied science appertaining to botany, mineralogy, and sylviculture. In the school is a very fine collection of chemical apparatus and instruments, including those of Bunsen, Dupasquier, Gay-Lussac, Donovan, &c. Every kind of instrument required in applied mechanics is also here. There is a very good library of books attached to the school, comprising about 3000 volumes on mathematics and the physical sciences, natural history, language, literature, and history, arts and manufactures, &c. During the first year the studies are topography, differential and integral calculus, descriptive geometry, applied mathematics, and chemistry. In the second year the subjects are mechanics, geodesy, meteorology, climatology, construction, and drawing; in the third year, mineralogy and applied zoology, applied geology, botany, and sylviculture; in the fourth year, kilometry, scientific classification of forests, forest industries, law, and political economy. On the completion of this four years' course, the successful candidates are appointed to the staff of forest engineers. This corps consists of 3 general inspectors, 15 district inspectors, 40 chief engineers of the first class, 50 chief engineers of the second class, 60 second engineers of the first class, and 70 of the second class. There are also 25 assistants of the first class, 350 of the second class, and 420 foremen planters. The salaries of the six grades of engineers are respectively £500, £400, £300, £260, £200, £160, besides an active service allowance of £1 a day to inspectors, 16*s.* a day to chief engineers, and 12*s.* a day to the others. The country is divided into 46 forestal departments, the forest in each case being under the care of a chief engineer, but the inspecting officers reside in Madrid.

SCIENTIFIC SERIALS.

American Journal of Science, August.—History of the changes in the Mount Loa craters; Part 2, on Mokuaweoweo, or the summit crater (continued), by James D. Dana. The subjects here considered are (1) the times and time-intervals of eruptions and of summit illuminations or activity, with reference to periodicity, relations to seasons, variations in activity since 1843, and lastly the changes in the depth of the crater; (2) the ordinary activity within the summit crater; (3) causes of the ordinary movements within the crater. Among the general conclusions are the rejection of any law of periodicity, and the apparently established fact that the inland waters supplied by precipitation are the chief source of the vapours concerned in Hawaiian volcanic action. Then follows Part 3, dealing with the characteristics and causes of eruptions; metamorphism under volcanic action; the form of Mount Loa as a result of its eruptions; the relations of Kilauea to Mount Loa; lastly, general volcanic phenomena.—The Fayette County (Texas) meteorite, by J. E. Whitfield and G. P. Merrill. The specimen was found about ten years ago on the Colorado River near La Grange, Fayette County. It weighs about 146 kilogrammes, and analysis shows that the rocky portion consists essentially of olivine and enstatite with some pyrrhotite. It belongs to the class to which G. Rose has given the name of "chondrites," and its most striking feature is its fine and compact texture, exceeding that of any similar meteorite known to the authors.—Evidence of the fossil plants as to the age of the Potomac formation, by Lester F. Ward. From these researches it appears that no Jurassic species, but many strongly Jurassic types, occur. The Wealden furnishes the largest number of identical species, after which follow the Cenomanian and Urgonian. All these formations also yield many allied species, which, however, are most abundant in the Oolitic. Altogether the flora would appear to be decidedly Cretaceous, but probably not higher than the Wealden and Neocomian.—E. H. Hall describes some experiments carried on for over three years at Harvard College on the effect of magnetic force on the equipotential lines of an electric current; and Thomas M. Chathard gives the analyses of the waters of some Californian and other North American alkali lakes.

Mémoires de la Société d'Anthropologie, tome troisième (Paris, 1888).—This volume contains an exhaustive treatise by Dr. Nicolas on automatism in voluntary acts and movements. The author, who is an ardent opponent of the materialistic and atheistic views common to many of his scientific brethren, is especially anxious to call attention to questions such as those of which he here treats, and which have hitherto been little considered in France. The main conclusion that he draws from the accumulated mass of facts, which he has borrowed principally from the labours of British and German biologists, is that the superiority of an animal in the scale of being is determined by the degree of liberty which it enjoys in controlling reflex actions, and directing automatic reactions.—Contribution to the study of anomalies of the muscles, by M. Ledouble. The principal subjects here treated of are the variations in the iliac, costal, and spinal processes of the latissimus dorsi muscle.—Philosophy, considered from an anthropological point of view, by Dr. Fauvelle. Although the writer passes in review the various schools of philosophy which have sprung up in various periods of time, his purpose is rather to follow the gradual evolution of philosophic thought from the first appearance of man, than to recount its history. Pointing out that comparative anatomy and physiology teach us that intelligence depends directly on the number and degree of differentiation of the cerebral cellules, he asks whether we must assume that these have reached their utmost limits of development, or whether new manifestations of cerebral perfection may not be reserved for man? According to his views, religions of all forms, and speculative philosophy, have equally had the effect of impeding every kind of independent intellectual labour, and have thus in different parts of the universe