The Kinetics of Chemical Change in Gaseous Systems. By C. N. Hinshelwood. 24×16 cm; pp. 204. New York and London: Oxford University Press, 1926. Price: 84.25. The author has "sought to give a continuous account of those phenomena of chemical change which offer some prospect of interpretation in terms of the kinetic theory." The book is therefore confined to the kinetics of gaseous reactions whether homogeneous or occurring at the surfaces of solids or liquids. The treatment is brief but it is wonderfully logical and crystal clear. The author is to be congratulated on the attainment of his objective, a "true perspective of the whole field of inquiry."

The introductory chapter outlines the chief conclusions from the kinetic theory pertinent to gascous reactions, root mean square velocity, mass of gas striking unit area in unit time, distribution of speeds, collision number and free path, size of gas molecules. It discusses types of motion as revealed by heat capacity data, the failure of classical theory and the postulates of quantum theory to account for the failures. The chapter concludes with a general discussion of the nature of chemical union and of the exceptional condition which molecules are capable of assuming under the influence of varying agencies. "It is seen to be probable that, before a molecule can undergo chemical change involving the formation of non-polar linkages, energy must be communicated to it either by collision or by radiation. This is called activation. . . . Where a simple rearrangement of polar linkages occurs, no activation can be needed. . . . A reaction between hydrochloric acid and sodium thiosulphate is not truly ionic . . . because there is formation of free sulphur and this process necessitates the rearrangement of non-polar linkages within the thiosulphate ion itself."

In the second chapter the distinguishing characteristics of homogeneous bimolecular reactions are displayed. The dependence of time of half change on the concentration is chosen as the principal criterion and linear variation of log k with I/T is displayed in both homogeneous and heterogeneous reactions. The molecular statistics of bimolecular processes are set forth and the ratio of effective collisions to total collisions is set equal to $e^{-E/RT}$, whence E is calculable and is shown to be identical with the value obtained from the Arrhenius equation, d log k/dt = E/RT^2 . These several features are illustrated with six homogeneous bimolecular gas reactions. Photochemical kinetics are introduced to show how they lead to the newer work of Bodenstein and his colleagues on the kinetics of collision between bromine atoms, and on the thermal decomposition of phosgene which apparently involves collision of phosgene with chlorine atoms. The formation of hydrogen bromide, thermally and photochemically, apparently both involve the same sequence of changes.

The general theory of energy of activation is discussed in Chapter III. It is concluded that "it is possible to account for the rate of bimolecular reactions quantitatively by assuming that the collision process is the actual activating process and that the kinetic energy of the molecules is transformed at the moment of collision to internal energy of vibration or energy corresponding to a higher quantum state of electrons. . . . It can equally well be assumed that the molecules are activated before collision by radiation or by collisions which have not led to reaction, and it is not possible to tell definitely which methods of activation are actually operative. We require data of greater accuracy and more information about the influence of orientation of the colliding molecules or the effectiveness of the impact. . . The best proof of the real significance of the energy of activation lies in the demonstration of the fact that the higher the activation energy, the higher is the temperature necessary for the attainment of a given rate of change.

Termolecular reactions are few and it is shown (Chap. IV) that their energy of activation must be small. Since the publication of this volume, Hinshelwood and Hutchinson have added one example to the sole example of a unimolecular reaction discussed in Chap. V, namely the decomposition of nitrogen pentoxide. The new reaction is the decomposition of acetone. The authors think that they have measured the rate of its dissociation into $CO + 2(CH^3)$. There is a possibility that they have really measured the rate of thermal

decomposition of ketene. The principal interest of this new example is that it strengthens the argument in Chapter V which attempts to show that activation by collision is about 10⁵ times too slow for the unimolecular process and also that a monochromatic radiation theory is inadequate to explain such unimolecular processes. Hinshelwood concludes that some extended radiation theory is necessary or that reaction chains are possible.

An extended discussion of the adsorption theory of gas kinetics at surfaces is given in Chapter V1. The form in which it is developed is essentially that of Langmuir, the concept of a saturation adsorption, with the extension to the cases in which the adsorbing surface is not homogeneous and in which different types of adsorption may be involved. He demonstrates, with a convincing list of examples, how the apparent order depends on the extent of adsorption of the reactants and on the desorption of the products and shows how the true order can be learned. As an example of $2A \longrightarrow A_2$, for which (p. 147) he says a particular case has not been discovered, it may be pointed out that Langmuir found that the combination of hydrogen atoms in contact with a heated wire was bimolecular.

The final chapter is devoted to activation in heterogeneous reactions. The temperature coefficient here gives only the apparent energy of activation. Hinshelwood shows that the true energy of activation is related to this apparent value by the expression

$$E_{app} = E_{true} + \lambda' - \lambda$$

where λ' is the energy of desorption of the products and λ is the energy of adsorption. He concludes, erronerously, from the early data of Taylor and Burns that λ will generally be small compared with E. The newer data of actual measurements of Taylor and Burns are showing that, in catalysed processes, these are frequently of the same order of magnitude as E and such data are giving quantitative bases for the explanation of catalytic mechanism. Hinshelwood's concept of a particular unstable phase for decomposing formic acid moeecules (pp. 182-183) is unnecessary if we assume that all oxide catalysts are dual in nature having positive ions as dehydrogenation catalysts and negative ions as the loci of dehydration change. The book concludes with a consideration of the nature of the action of surfaces, firstly in respect to non-uniformity, next as to spatial configuration and as to orientation of adsorbed molecules and finally as to the nature of the change induced in the reactant by its association with the catalyst. The author thus brings us to the point where "the stream of inquiry divides into several parallel channels which have not yet been explored to their confluence." To all those who would embark on such a voyage of exploration this volume is an indispensable portion of the kit. It could very profitably be read by all students of physical chemistry.

Hugh S. Taylor

Concerning the Nature of Things. By Sir William Bragg. 21 + 15 cm; pp. xrii+249. New York and London: Harper and Brothers, 1925. Price: \$3.00. This is an American edition of the Christmas Lectures given at the Royal Institution in 1923-24. These popular lectures for the young are done very well in England. We have nothing corresponding to them and consequently very few people who could do them because such lectures are not easy to give. The individual lectures are entitled: the atoms of which things are made; the nature of gases: the nature of liquids; the nature of crystals (3)-diamond, ice and snow, metals.

"I have said that all atoms are in motion, and that there is a constant struggle between some form of attractive force which would draw all the atoms together and this motion which would keep them independent. The existence of an attractive force which we here take into account as something very important does not at first seem to be reconcilable with the atomic structure we have just considered, because in this we supposed that the outer shells of electrons would prevent the atoms from coming too close to one another. It is a difficult point, because both views are certainly correct. It is, no doubt, our present ignorance of the nature of these forces that prevents us from arriving at a clear understanding. We have seen how it can happen that when two atoms approach each other at great speeds they go through each other, while at moderate speeds they bound off each other like two billiard balls. We have to go a step further, and see how, at very slow speeds of approach, they may actually stick together. We have all seen those swinging gates which, when their swing is considerable, go to and fro without locking. When the swing has declined, however, the latch suddenly drops into its place, the gate is held, and after a short rattle the motion is all over. We have to explain an effect something like that. When the two atoms meet, the repulsions of their electron shells usually cause them to recall; but if the motion is small and the atoms spend a longer time in each other's neighborhood, there is time for something to happen in the internal arrangements of both atoms, like the drop of the gate-latch into its socket, and the atoms are held. It all depends on some structure of the atom which causes a want of uniformity over its surface, so that there is usually a repulsion; but the repulsion will be turned into attraction if the two atoms are allowed time to make the necessary arrangements, or even if at the outset they are presented to each other in the right way. We shall see later several very interesting examples of this effect," p. 48.

"There are three stages in the arrangements of matter: the single atom as we find it in helium gas; the molecule as it is studied by the chemist; and the crystal unit which we now examine by X-ray analysis. To take an example, there are the *atoms* of silicon or of oxygen. The *molecule* of silicon dioxide contains one unit of silicon and two units of oxygen, arranged, no doubt, in some special way. Lastly, there is the substance quartz, of which the *crystal unit* consists of three molecules of silicon dioxide, arranged, again, in a special fashion which we now know has a certain screw-like character. The quartz crystal contains an innumerable multiplication of these units. Each of the units has all the properties of quartz, and, in fact, is quartz; but a separate molecule of silicon dioxide is not quartz. For example, one of the best known properties of quartz is its power of rotating the place of polarization of light, and this preperty is associated with the screw which is to be found in the crystal unit. It takes three molecules to make the screw," p. 134.

"Ice when it forms quietly on a water surface exposed to the sky crystallizes in a form analogous to that of the snow crystal, all the six-sided figures being horizontal. That it does so is not generally very obvious, though in books on Arctic exploration pictures are to be found of table ice breaking up into six-sided vertical columns, like the basalt columns of the Giant's Causeway. It is also said that when the ice on a lake breaks up, it first divides into vertical columns, which for a time hold one another up; when, however, the ice begins to move, the collapse is rapid and the lake clears quickly.

"In the accounts given by Antarctic explorers, it is especially mentioned that the ice on fresh-water lakes was found to be divided into six-sided prisms, all standing upright on the surface. The planes of separation were marked by lines of air bubbles. On the sea ice the formation of the crystals led to an expulsion of the salt which was deposited in the spaces between the crystals, and sometimes squeezed out above the top surface. The prisms were free from salt inside, and fairly fresh water could be obtained if the outside layers were first melted off. They were clear crystals, through which an observer might look at the rocks underneath as through tubes," p. 182.

"In the case of the cube there are four ways of thinking of the arrangement of the layers; there is a layer perpendicular to each diagonal of the cube, and, as a cube has four diangonals, there are four sets of layers. This does not mean that the atoms in any one layer are specially tied together in that layer; merely that one can sort out the atoms of the crystal into this kind of layer in four different ways.

"Now it turns out that these layers are of very great importance in respect to the properties of the metal crystals built on the close-packed cubic plan. Gold, silver, copper, aluminium, and other metals like them can be drawn into wires, rolled into sheets, and beaten into various shapes. They are, as we say, ductile, and their ductility is one of the characteristics that make them so useful. They can be bent and pulled into all sorts of convenient forms. It seems possible to make a metal flow like treacle. Gold can be hammered into leaves so thin that the metal in a sovereign will cover a large field: the others can be beaten nearly as thin. Cups and vessels of all sorts, chains and ornaments, and innumerable useful things are made by taking advantage of this singular property of ductility. The first thing that we should like the X-ray to explain for us more clearly, if we can make them do

so, is that feature in their structure which accounts for this most valuable property. We should also like to understand the inner meaning of the hardening and other changes that are due to 'cold-working,' as it is called—that is to say, to hammering or straining the metal when it is cold. And what is annealing, the softening and relief from strain that heat brings about? Why are all these things so obvious in the case of a metal, while they do not appear in, for instance, diamond or rock salt or quartz?''

"Gold leaf is very thin, as we have seen. It is even transparent, but it absorbs part of the spectrum of light that passes through it, allowing a greenish light to filter through. It is vellow when viewed by reflected light, as we know. It is very curious that when it has been heated to a dull red it becomes permanently transparent, and white by reflected light. Faraday was very interested in this fact; he suggested as a partial explanation that the thin layer of gold broke up, the metal gathering itself together in little heaps, and that the light went through the holes that were left. Sir George Beilby has made many experiments, and added considerably to the information we have in regard to the behavior of this and other substances when heated in the same way. If there are holes in the heated leaf, they are exceedingly small, he says, beyond the power of the microscope to see. Now the X-rays have something to say on this point. When gold leaf is examined by their aid, it is found that it consists of masses of cubic crystals of gold all lving with faces parallel to the leaf. They are not necessarily cubes, of course. They consist, like ordinary salt, which is cubic, of rectangular blocks of all sizes. They must be exceedingly thin blocks, and no doubt their thickness is far less than their width or length. When the leaf has been heated, the blocks are piled up anyhow, perhaps gathered together to some extent in heaps, as Faraday supposed, even if they are too small to be seen by the microscope; and perhaps this is the reason why gold and silver leaf become transparent when heated. Why gold should be green when looked through is a mystery. But we do see that the heating of the gold has spread out the crystal blocks so that they all lie with one face in the leaf surface, and that heat has destroyed this amount of regularity of arrangement," p. 231.

"It very often happens that the addition to a metal of quite a small quantity of a second metal, or even of a non-metal, causes a notable increase in hardness, p. 240. "Let us take one of the simpler cases—for example, that in which the addition of a small quantity of aluminium to copper produces an increase in hardness. The X-rays show that the structure of the copper crystals remains the same, except that here and there an aluminium atom takes the place of a copper atom. Now the weakness of the crystal lies, as we have seen, in the fact that one part slides on another part along a certain plane. This plane is now no longer even: there is a scattering of aluminium atoms in it, and we can readily suppose that the slipping has become more difficult, and that we have here the cause of hardering. There is a remarkable effect which makes us think we are right in supposing so. The atoms of aluminium must strain the structure of the copper crystal, because the copper will not take up more than a certain number. If an alloy is made containing more than about 10 percent of aluminium, the X-rays tell us that the copper crystals are broken up altogether, and a new structure is formed. The alumnium atoms must be distorting the copper crystal, and this fits in very well with the fact that it hardens the copper. On the other hand, when nickel is added to copper the atoms of the former replace the atoms of the latter to any extent; evidently they can slip into the places of the copper atoms without straining the copper crystals at all. And in this case there is no hardening effect, which is just what we should expect. It is only when we push in atoms which really strain the copper crystal and make its planes uneven that the hardening is brought about. We have jummed the sliding planes.

"In the case of steel the action is the same kind, but here the carbon atoms that are the cause of the hardening do not replace the iron atoms, but are forced into the empty spaces between them. We can easily see that this may distort the iron crystal, and is before prevent the movement along a plane of slip. Once again there is a limit to the mount of the alloying substance: only a small percentage of carbon can be introduced into the iron without breaking up its ordinary simple structure.

"The problems of iron and steel contain, however, many more complications than this. We have only to ask what happens when more carbon is put in than the iron structure can carry, and we find we have a new problem. Among other things, a new crystal appears, formed of molecules, each containing three atoms of iron and one of carbon; it is known as cementite. The new crystals are very hard and unyielding, and in form are like needles. Their presence hardens the iron very greatly and makes it difficult to work. A beautiful example of its effect on steel is to be found in the old swords that once made their way from India through Damascus into Europe. Damascus steel was greatly valued for the excellence of its qualities. Fine specimens are to be seen in the Wallace Collection; they show the characteristic wavy pattern which has always been looked on as evidence of genuiness. When examined under the microscope the lines of the pattern are seen to consist of multitudes of dots, forming a sort of Milky Way in the steel. These dots are the tiny crystals of cementite. As Colonel Belaiew tells us, the steel when it was first made was most difficult to work. The smith, with his little furnace, would heat the steel red hot, but after he had struck but a few blows and made a slight impression on the steel, the momentary softening had gone. The hardness due to the cementite crystals had only been removed for an instant. More heating, a few more blows, and slowly the steel became less rigid. In fact, the cementite crystals were changing their form. They were becoming less like needles, gathering themselves together into more rounded shapes, and as they did so the steel became more pliable. At last the fine Damascus steel was reached, so strong and yet so elastic. It is very likely that much of the keen edge that these swords would take was due to the presence of the very hard particles embodied and held in the softer iron. The edge would be like a saw with extremely fine teeth. In the trial of skill between Saladin and King Richard which Walter Scott describes in *The Talisman*, the former three a gossamer veil into the air and severed it by drawing his scimitar across it, a fine test of keenness and of skill. Richard, on the other hand, used his sword like an ax, and clove in two an iron bar, the mace of one of his knights. This also was a test requiring great qualities in the steel, but on the part of the man the skill lay more in the power to strike a terrific blow than in delicacy of touch," p. 241.

Since no one is omniscient, it is not surprising to find Sir William nodding at times. "A very curious feature of the soap bubble is its reluctance to join up with another bubble. If we blow a bubble on a ring, we may take a second bubble and knock it against the first with force, one would think, enough to break them. But the bubbles bounce from one another like india-rubber balloons. Perhaps the explanation lies in the fact that in both cases the outer layer consists of those ends of the molecules which, as we saw before, have very little tendency to associate with other molecules or parts of molecules. There is no tendency for the one bubble to coalesce with the other when the two are pressed together, because the parts that come first into contact do not attract each other." The adsorbed air flm has been overlooked completely.

It is a little misleading to say, p. 242, that the copper crystals are broken up altogether and that a new structure is formed when more than ten percent of aluminium is added to copper. What actually happens is that some new crystals are formed in addition to those containing about ten percent of aluminium.

This is a delightful book.

Wilder D. Bancroft

Hexosamines and Mucoproteins. By P. A. Lerene, $24 \times 15 \text{ cm}$; pp. x + 163. London and New York: Longmans Green and Co., 1925. Price: 83.75. For the present most physical chemists will be interested only in portions of this book.

"The problem of mucoproteins and of the so-called glucoproteins, more than that of any other tssue component, is intimately connected with that of hexosamines. The original interest in mucoproteins, as well as in hexosamines, may be attributed to theories connecting the glucosidic structure of proteins with the capacity of proteins to take up the place of carbohydrates in the economy of the animal organism. As the result of more modern work the mechanism of sugar formation from proteins has been explained more accurately. It was shown that even without preformed sugar the protein molecule contains components which in the organism may be transformed into sugar. On the other hand, it was found that the function of the nitrogenous sugars is different from that of simple sugars. As yet it is not possible to define accurately the rôle which hexosamines play in the animal organism. Only an approximate estimate can be formed, and that on the basis of the distribution of the tissue elements containing hexosamine. The most striking example is chitin. The rôle of chitin as an architectonic element is so evident that it scarcely needs to be pointed out. The similarity of its function to that of cellulose is striking. It is peculiar that whereas cellulose, the architectonic element of the plant, is nitrogenfree, chitin, which, in the lower forms of animal life, takes the place of celloluse is a product of the condensation of a nitrogenous sugar. In the higher animal forms, amino sugars are constituent parts of the skin, the skeleton, the connective tissue, the serous and mucous membranes, in a word all of those tissues which preform either an architectonic or a protecting function. It is then not surprising that nitrogenous sugars do not possess the same tendency to burn in the organism as do the ordinary sugars. Thus the direction of interest of the biologist in regard to nitrogenous sugars has changed but the interest has remained, or perhaps has even increased, since it was discovered that their distribution in the animal tissue is wide," p. 1.

"Theoretically hexosamines permit of a greater number of isomers than the correspondding hexoses, for the reason that to every hexose five hexosamines are possible according to the position of the amino group. Fortunately the nitrogenous sugars thus far discovered in nature have the structure of 2-aminohexoses. Synthetically were prepared hexoses with an amino group also in positions 3 and 6, as well as one 1-amino-2-ketohexose (aminofructose," p. 11.

Many of the properties of the sugars can be studied with advantage on hexonic acids for the reason that in these acids the symmetry of the carbon atom (1) has dissapeared and thus their molecules represent structurally simpler systems......Amino hexonic acids, as sugar acids generally, represent a very convenient material for the study of relationships which exist between configuration and optical behavior.

"There was another reason which attracted the interest of the author of this monograph to the synthesis of 2-becosaminic acids, namely, their relationships to simple amino acids. Since all simple beconic acids are readily converted into caproic acid, it seemed that 2-aminobeconic acids could also be transformed into the corresponding simple amino acids, and this reaction seemed to hold out the promise of correlating the configurations of amino acids with those of sugars. Indeed, Neuberg recorded a successful reduction of chitosaminic acid to 2-aminocaproic acid (normal leucin). Unfortunately, Wildman and the writer did not meet with the same good fortune and the product they obtained was always amino hydroxycaproic acid which, besides, was optically inactive. The same result was obtained with several other 2-aminohexonic acids. Some day the experimental difficulties of the problem will perhaps be overcome," p. 26.

"Biologists and often even chemists referred to aminohexoses as substances occupying an intermediate position between carbohydrates and proteins. This assumption inferred that the nitrogenous sugars were capable of functioning in the organism either as carbohydrates or as proteins. It was a disappointment, particularly to the physiologist that this expectation was not borne out by experiments. Chitosamine was found to act differently from ordinary carbohydrates. The animal organism possesses a certain mechanism which brings about a condesation of the unconsumed simple sugars into glycogen. Only when the quantity of ingested sugar is exceedingly large, is part of it eliminated in the urine. The sugar which is neither climinated nor burned is stored up in the form of glycogen. On the basis of this fact it was reasoned that every substance which leads to an increase in the stored glycogen is being transformed in the organism into glucose. Applying this test to chitosamine, it was found that it did not function glycogenetically," p. 61.

"A curious incident should be recorded in connection with the preparation of the *a*- and β -isomers of this sugar. When chondrosamine hydrochloride was isolated the first time on hydrolysis of chondroitin sulphuric acid, it had a specific rotation of + 129.5°, reaching an equilibrium at + 95°. A few years later the specific rotation of the same sample was

measured and found + 125°. A sample chondrosamine obtained from another source 15 minutes after the substance was brought into solution, had a specific rotation of + 115°, and an equilibrium rotation of + 96.4°. Thus these two samples were evidently the α -forms. Subsequently when the natural sugar was prepared on the larger scale the hydrochloride invariably crystallized in the β -form. The synthetic chondrosamine also crystallized in the β -form. This is a very peculiar occurrence, particularly as the β -isomer is the common form for only a few of the simpler sugars. However, this occurrence in not unique. It is well known that α -mannose could not be prepared in spite of many efforts, but after it was once obtained by the present author it became impossible in his laboratory to recrystallize the β -isomer without changing it into the α -form. On the other hand, in the case of other sugars, such as glucose and galactose, one can obtain at will either one or the other isomer.

"Eventually a method was found to prepare the α - and the β -isomers of chondrosamine hydrochloride. The rate of mutarotation of each of the isomers was measured and the initial rotation of each form was obtained by extrapolation," p. 20.

Wilder D. Bancroft

The New Physics. By Arthur Haas. Translated by Robert W. Lawson. 19 + 14 cm: pp., 1x + 165. New York: E. P. Dutton and Company. Price: \$2.50. The chapters are entitled: the electromagnetic theory of light: molecular statistics; the electron theory; the quantum theory; the theory of the chemical elements; the theory of relativity and gravitation.

"In consequence of the magnificent advances made in theoretical physics since the beginning of the twentieth century, our views on natural phenomena have undergone a complete transformation. . . Our conception of nature has been beautifully extended, and at the same time simplified and unified.

"This most recent development of physics, so revolutionary and yet so successful, was aided by two theories which originated in the latter half of the nineteenth century, each of which represented a great advance in an endeavour to obtain uniformity in physics. The first of these theories, due to Maxwell, identified the phenomena of light with those of electricity, and thus converted optics into a branch of the science of electricity. The other theory explained the phenomena of heat by assuming a continuous motion of the smallest particles composing bodies, and thus the science of heat became a branch of mechanics. At the same time, this latter theory clearly showed the extraordinary fruitfulness of the atomistic principle. At the end of the nineteenth century the extension of Maxwell's theory led to the electron theory. This theory enabled us to regard electricity as the primordial constituent of all things, and to recognize in the small electrical charges the building stones of matter. The quantum theory, which constitutes an extension and a development of the atomistic principle, has been pre-eminently successful, especially in the interpretation of spectra, and it has supplied us with valuable information on the internal structure of the atoms of the chemical elements. The theory of relativity brought about an entirely new conception of the nature of space and time, of motion and of matter, and from a generalization of the theory of relativity we have been led to the modern theory of gravitation, which also yields important information on cosmological questions," p. 1.

"As to whether or not a physicist detects fluctuations in density will thus depend solely on the smallness of the volume chosen for his molecular statistical considerations. From an objective point of view, molecular fluctuations of density will be unimportant for all processes in which distances of about a hundred thousandth of a millimetre are too small to be of moment for the process. On the other hand, for those processes in which such small (or not appreciably greater) distances have to be taken into account, the effect of the molecular fluctuations must make themselves manifest. The passage of a ray of light through a gas belongs to this class of phenomena. The value of the quantity that characterizes the optical behavior of a gas, i.e. the so-called refractive index, depends on the density of the gas. Fluctuations in the density must therefore result in fluctuations in the value of the refractive index.

"The great progress made in theoretical atomistics since the beginning of the twentieth century is due largely to Smoluchowski. He recognized that such fluctuations of the rerefractive index in the atmosphere are responsible for the blue colour of the sky. The correctness of this interpretation has been established without doubt by different interesting experiments. In fact it was possible, on the basis of Smoluchowski's theory to calculate the size of the molecules from optical measurements on the colour of the sky, and the results are in good agreement with those obtained by quite different methods. The phenomenon of the blue of the sky has been known since the beginning of mankind, and yet we are indebted to modern physics for recognizing in it a brilliant empirical confirmation of the atomistic hypothesis, devised long ago on purely philosophical grounds by the genius of a Grecian thinker," p. 35.

"In 1907, two years after he founded the idea of light quanta. Einstein discovered an additional very important field of application of the quantum hypothesis, in the theory of the specific heat of solid bodies. By the specific heat of a substance we understand the amount of heat that must be supplied to 1 grm. of the substance to raise its temperature by 1° C. In 1819 Dulong and Petit discovered an interesting relation between the specific heat of a solid element and its atomic weight. According to the so-called law of Dulong and Petit, the product of these two quantities, the atomic heat, should have the same value for all solid elements. This relation, a theoretical basis for which was given later, in is general well confirmed by experience. But even at the time of the formulation of the law, very large deviations from the law were noted in the case of several elements of low atomic weight, e.g. beryllium, boron, and particularly diamond. Later, the fact was established that, especially in the case of diamond, the specific heat decreases very much when the crystals are strongly cooled.

The deviations from Dulong and Petit's law could not be explained by classical physics. But they certainly found a simple interpretation when Einstein applied the quantum principle to the theory of heat of solid bodies. In accordance with the classical ideas, Einstein assumed that the heat of solid bodies is based on the vibrations of their atoms, but he further assumed that the energy of these vibrations is made up of elements of energy in the sense of Planck's hypothesis, according to which these elements are proportional to the frequency. As a result of this assumption of Einstein, not only did the increase of the specific he, t at low temperatures become intelligible, but also the fact that even at room temperature appreciable deviations from Dulong and Petit's law occurs with elements, the atoms of which, being particularly light, vibrate very rapidly in consequence. Einstein's idea was subsequently developed by different scientists, in particular by Debye, who improved the theory of Einstein and thus brought into still better agreement with experience. In 1912, Debye's work led him to an important law, according to which the specific heat of a solid body is proportional to the third power of the absolute temperature at very low temperatures,'' p. 85.

"Positive and negative electrical charges now appear as the bricks of the universe. They are arranged in numerous ways into systems that we call atoms. The kind of arrangement determines the chemical nature of the atoms, the internal structure of which is regulated by quantum relations. The appearance of a mechanical mass follows from electrical properties. In consequence of their charge and motion, the electrons call forth an electromagnetic field, which is periodic in space and time. Space is therefore filled with electromagnetic waves of all possible frequencies. Only a very small part of the spectrum is revealed to the most perfect of the human dense organs, i.e. to the eye, as light. Totality phenomena, in which a large number of material individuals take part, are responsible for the phenomena of heat. Space and time, however, in which all processes appear to operate, are linked together to form a four-dimensional manifold, the geometry of which is manifested in the phenomena of gravitation.

"Thus the new physics reveals to us a picture of nature of great simplicity. In point of fact, it is not nature that is complicated, but only the path that led to the true knowledge of it. This path was complicated because it started off from the narrow limitations of the human senses, and because theoretical physics only gradually succeeded in liberating it from human points of view," p. 154. Wilder D. Bancroft

Relativity. By G. B. Jeffery. 19 + 13 cm. pp. vii + 150. New York: E. P. Dutton Company, 1924. Price: \$2.40. This book is written "to introduce the theory of relativity to students of science who are able to make some use of mathematics as an instrument of thought; but who may be not quite ready to face the mathematical analysis which is essential for the thorough exploration of the subject in all its ramifications." The chapters are entitled: introduction—Einstein's theory of relativity; the origin of the theory; the Michelson-Morley experiment and the Lorentz transformation; the laws of motion and of magnetism; the restricted principle of relatively and some consequences; the equivalence hypothesis; the four-dimensional continum: the general theory.

"As I conceive the office of a professor, it is that he should stand before his students as the living representative of those great men who in the past have laboured in that branch of human knowledge which he has made his own: that by means of a reverent yet unflinching criticism he should strive to reveal the workings of these master minds, to the end that he may impart, not merely knowledge, but that more precious gift—the art of acquiring knowledge, the art of discovery. If we approach our task with this spirit, we shall find the key to the solution of much that is difficult and perplexing in our present knowledge, and the inspiration which will lead us on to further discoveries," p. 31.

"The young scientist can suffer from no greater fault than a misunderstanding of scientific genius. We are to apt to think that advance in scientific knowledge is reserved for those who, by reason of some special gift, are able for the first time in human history to see something which others have been blind to see. Now there is a measure of truth in this view, but it is important that we should see what that measure is, more particularly when we come to the conclusion, as most of us must quite young in life, that we are very ordinary people with no very special gifts. When that moment comes, it will depend upon our conception of the way in which science advances whether we go forward and play our part, such as it may be, in the progress of knowledge, or whether in despair we leave the matter to those more fortunate ones who have been predestinated for the work," p. 33.

"Relativity is commonly supposed to be a revolutionary theory. The theory has its roots in the very beginning of modern science, but it is nevertheless a revolutionary theory in that its acceptance commits us to a radical reconstruction of our most fundamental physical concepts. In attempting this task of reconstruction it is essential that we should understand the reasons which led to the formation of the older concepts, in order that, if these are eventually discarded, we may ensure that nothing of value is lost.

"Perhaps the most important lesson of the history of science is the abiding value of the result of a physical experiment carefully and accurately carried out under definite conditions. The chapter of scientific history with which we shall be most concerned is very largely the story of an always-changing theory based upon a growing body of unchanging experimental facts," p. 36.

Wilder D. Bancroft

An Introduction to the Literature of Chemistry. By F. A. Mason. 18×12 cm; pp. 42. New York: Oxford University Press, American Branch, 1925. Price: 70 cents. In the foreword W. H. Perkin says that "those employed in supervising research are only too well aware of the difficulty in familiarizing students with the way chemical facts are catalogued and with the method which must be adopted in order to find out whether a substance is known or not, if known, where an account of its preparation and properties is to be found. It will be a relief to those in charge of the everincreasing number of research students to be able to direct them to the clear introduction to the literature contained in the following pages, and Dr. Mason is to be congratulated on producing so valuable and convincing and at the same time so simple a work on this important aspect of the subject."

The reviewer hopes that the student will find this book as valuable as this introduction implies. Personally, he does not quite see why a student interested in looking up any special problem should read a biographical sketch of Sir Henry Roscoe, for instance, or Cohen's life of van't Hoff, to take another case. One does not see why Clibbens and Rivett should be cited under the phase rule and not Findlay.