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EDITORIAL

Latin—or Russian—or neither

Over recent years we have heard a great deal about the increasing volume of scientific literature in Russian and of the need for translations of current Russian publications. Some have even carried this a stage further and courses in scientific Russian at present in operation in at least two centres are drawing large attendances including many Institute members.

Points of view regarding foreign publications vary and range from the narrow "if it is worth reading it will be written in English or will be translated into English" attitude to that of the gregarious reader who attempts to study all publications in his field irrespective of language or place of origin. Few will, however, deny the need to cover at least some foreign literature and, if much of this is to be in Russian, two questions raise themselves—does the chemist really need a working knowledge of Russian, and if so, how is this best acquired bearing in mind the many subjects other than his own science with which the modern chemist is expected to be acquainted?

Taking the second question first, a series of recent articles on this subject suggest that it is unreasonable to expect a busy scientist, in the middle of his career, to find time to study a new language from first principles. Instead it would seem that a knowledge of Russian, if it is required by the scientist, would best be acquired at school where the normal school discipline helps to overcome the real drudgery of learning the language, and a case has been advanced in Great Britain for dropping Latin in schools and replacing it with Russian. This is a radical change but the way for it is, in fact, already being paved by the recent deletion of Latin as a compulsory subject in the Cambridge entrance examination.

From the point of view of the scientist this idea would seem to have considerable merit since it suggests the replace-

ment of a subject which in itself, as distinct from the type of training in the exact use of words which it may, if well taught, supply, is of little or no future value, with one which provides the same type of training and which may be of considerable value later in life particularly as a basis for further study. Unfortunately school syllabuses are not so considerate of the possible future needs of scientists and a more general case for the advantages of the teaching of Russian would need to be established before this language could replace Latin. Indeed to stress the value of Russian to the scientist in his future work could prove to be the surest way of defeating our case with educational authorities on the grounds of undue specialization for science pupils!

But if we can find room for another subject in the school curriculum, is Russian the best one to introduce? Few of us are satisfied with the breadth of our knowledge in a great many fields and would all have welcomed the opportunity to broaden these with the help of the school discipline had the curriculum permitted it. Would we not all, to take the most obvious example, have benefited from more time devoted to basic training in written expression leading for the scientist, if we can avoid that bogey of undue specialization, to courses in scientific English?

Which all brings us back to the first question—does the modern chemist really need a first-hand knowledge of foreign languages such as Russian? Certainly it would be very nice to have. But are we not just as conscious of our lack of knowledge in a host of other spheres—laboratory arts and skills such as glassblowing, electronics, photography, mechanical drawing, to take one class of example only? Because our working time is better spent in the purely chemical pursuits for which we have been trained, we have come to accept and expect the services of skilled technicians to perform these ancillary duties for us. Why should our attitude be different with regard to languages? Is not the real need for efficient translation services rather than for the chemist himself to be expected to act as his own technician in this respect? Just as we send our broken apparatus to a glassblower who is much more skilled than we are ourselves in its repair, why not our Russian paper to a skilled translator?

REPERCUSSIONS IN CHEMISTRY OF ADVANCES IN PHYSICS

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The statement attributed to the French philosopher, Auguste Comte: "if mathematical analyses should ever hold a prominent place in chemistry—an aberration which is happily almost impossible—it would occasion a rapid and widespread degeneration of that science", is a text for a chemical sermon. It was just about one hundred years later (in 1932) that the University of Cambridge established a chair of theoretical chemistry and appointed the mathematical physicist, Lennard-Jones as the first incumbent. "Degeneration" has been reasonably rapid, at least during this century. Chemists have largely overcome their traditional dislike of theories, and in his 1955 Tilden lecture to the Chemical Society, Longuet-Higgins, who succeeded Lennard-Jones at Cambridge, was able to discuss "The Role of the π-Electron in Aromatic Chemistry" before what was no doubt an appreciative audience; even if we can imagine that his remark that "the (molecular orbital) method . . . has provided methods of reckoning which, to quote the advertisements, 'Even a child can use'", may have been greeted with some wry smiles. Chemistry, through the labours of chemists who have taken seriously Robert Bunsen's opinion that a chemist who is no physicist is no chemist, has gone a long way towards becoming a theoretical generalizing science fit to rank with physics, without in any way lessening the role of skilful chemical experimentation which has always attracted the great majority of its devotees. It was that king among experimenters, Michael Faraday, who was trained as a chemist and did his greatest work, electromagnetic induction, in physics, who settled all attempts to distinguish between physics and chemistry in the remark, "Such a difference is a mere play upon words, and shows ignorance rather than understanding".

This point is made first because, in talking about the repercussions in chemistry of advances in physics, it is not intended to imply that the answers to chemical questions are either being made more and more by physicists or that they must await, for their solution, the answers to prior physical questions. On the

contrary, examples can be quoted, such as the development of the Third Law of Thermodynamics from Nernst's Heat Theorem, in which physics has been advanced by investigators such as Nernst, Lewis and Richards whose interests were primarily chemical.

In deciding what to consider, the writer finds himself suffering from a surfeit of material. It would be possible to treat the subject under the title given, in terms of instruments alone; for example, from the spectroscope, with which Lockyer detected a new chemical element in the sun, to the latest high resolution nuclear magnetic; and electron paramagnetic, resonance spectroscopy, which promises finer details of molecular structure, including the structure of free radicals. These matters are not, however, the writer's particular interest, nor do they illustrate what seems to be the most important and fundamental chemical consequences of the progress of physics. Chemists are concerned with substances—their structure, their properties and their transformations into other substances. In its descriptive aspect, chemistry is concerned with the discovery, tabulation and correlation of chemical facts: in its theoretical aspect, with the formulation of explanatory theories which unify the facts into a satisfying and well-tested pattern. It is the latter phase of chemistry in which the influence of physics is deepest, and this paper is confined to that, with due recognition of the fact that a major part of the science of chemistry—the explanation of the particular properties of individual substances—is not well incorporated into the theory, and that the few chemical reactions which can be explained reasonably well, such as the gaseous hydrogen-iodine reaction, are not commonly observable phenomena at all.

Let us look briefly at the transformation of the chemical atom—Dalton's atom. The term 'chemical atom' is used deliberately, because until the end of last century, the best evidence for the atomic constitution of matter was Dalton's deduction, from the hypothesis of atoms, of the laws of chemical combination. In fact the majority of physicists, under the influence of Mach, had rejected the atomic theory towards the end of last century, as having no real value as knowledge. Dalton came to his atomic theory through his interest in meteorology, and the composition of the atmosphere; indeed his ideas were based on physical rather than on chemical properties, and in considering compounds he made the simplest possible assumptions, *e.g.*, that a binary "compound-atom" would normally contain one atom of each element. He stated part of his atomic theory as follows,

"atoms are indivisible and indestructible, the atoms of a given element have the same weight, and atoms of different elements have different weights". These statements are all untrue. His assumption about the constitution of binary compounds has, of course, many exceptions, and as he did not accept Avogadro's interpretation of Gay Lussac's law of combining volumes, he failed to solve satisfactorily his major problem, the setting up of an atomic weight scale. Nevertheless, his theory gave a precise quantitative basis to the old vague idea of atoms; it made the concept of element more specific; it explained the discontinuity in the weight proportions of elements in compounds; and it suggested that the arrangement of the atoms in a compound could be represented in such a way as to indicate the actual structure of the compound. Although Berzelius was more successful in establishing an atomic weight scale, most chemists at the time believed it was safer to use numbers which could be determined by direct analysis—Wollaston's "equivalent weights", which remain with us to trouble students today.

Lying alongside this doctrine of atoms was the idea of affinity, the driving force which causes atoms to combine or rearrange their partnerships. It will be the main objective of this paper to consider how far this problem was carried by theorizing related to chemical facts, and then to see how it was revolutionized by advances in physics.

In the early experiments on electricity it was found that different substances, if brought together and then separated, remained charged with what Franklin called positive and negative electricity. In the brilliant experiments of Davy on the effects of the electric current on various chemical substances, he was led to the idea that the particles of substances become electrified when they meet dissimilar particles, and that the attraction between the opposite charges so produced is the cause of chemical union. This idea was developed by Berzelius (1819) into the electro-chemical theory: zinc becomes positive to oxygen and zinc oxide results; sulphur would be negative to zinc and positive to oxygen, and sulphur trioxide negative to zinc oxide, leading to zinc sulphate. As long as chemistry dealt mainly with acids, bases and salts, the theory served well enough, and it still influences the manner in which some analytical results are expressed. But it prevented the acceptance of Avogadro's theory in which two similarly charged atoms, say of hydrogen or nitrogen, were united to form a molecule, and hence the solution of the problem of the atomic weight scale. This difficulty became

evident with the rise of the chemistry of carbon compounds, and when the theory was abandoned the main work of chemistry was the marvellous development of structural organic chemistry, deriving from the work of Kekule on the chemical bond and the arrangement of atoms in space, and the development of the latter by Van't Hoff and Le Bel. No generalization in science, even those capable of exact mathematical statement, has achieved greater success in assembling in simple form a multitude of observations than the group of ideas we call structural theory. The graphical formula of the organic chemist is far more than a theory of atomic arrangements; it is a remarkable shorthand method of representing a great variety of chemical knowledge. Chemistry in the nineteenth century made tremendous advances on the basis of few and simple theories.

At the same time as the organic chemists, with their great tool the idea of valence, were synthesizing and classifying an immense number of compounds, the principles of thermodynamics, the theory of energy, were laid bare by the physicists Joule, Kelvin and Clausius and crowned by the work of Gibbs. The conservation law led to studies by the chemists, Thomsen in Copenhagen and Berthelot in Paris which seemed to bear on the affinity problem. They believed that the heat evolved in a chemical reaction is a measure of the affinity and that reactions go spontaneously in the direction of heat evolution. It is an attractive idea and it is often roughly correct, but the true thermodynamic measure of affinity is the work which can be obtained from a reaction, as Van't Hoff showed. Thermodynamics is a branch of science which develops logically from a few fundamental axioms, the so-called laws, each of which can be stated in terms of our failure to devise a method of doing something—of making a perpetual motion machine (First Law) —of completely reversing any natural process (Second Law)—and of obtaining the absolute zero of temperature (Third Law). Other fundamental principles of physics, such as the uncertainty principle (Heisenberg), the exclusion principle (Pauli) and the Einstein principle—that no signal can be sent at a speed exceeding that of light—are capable of similar formulation as "frustration principles". But thermodynamics is independent of any theory that matter has a grained structure, and tells us nothing of the mechanism by which reactions proceed. We want to delve deeper into affinity than Van't Hoff's principle will take us. The thermodynamic concept led chemists away from thinking about affinity between atoms, to the idea of the affinity of chemical processes, which is essentially a statistical concept. There was

little relation between the affinity of the student of thermodynamics and that of the organic chemists who followed Kekule. Interest in explaining the nature of affinity between atoms was revived only when interest in the atoms themselves was renewed by work on the structure of the atoms.

This can be briefly summarized. At the end of last century, it was widely believed that the major discoveries in physical science had been made. Newtonian physics seemed adequate, and the chemist's indivisible atoms and fixed elements had left him happily immersed in the preparation of new compounds and in studying their properties and reactions. Ostwald, who had never made a new compound, and had indeed shown that two allegedly different organic acids were the same, called himself a "negative chemist". Electricity was a puzzle and new discoveries about spectra were unexplained, but that did not shake faith in traditional ways of thought. Then came the deluge. The repetition of properties among the families of elements—Mendeleev's periodic law—had suggested to some bold spirits that there was something repeating in the atoms, thus hinting at structure. Stoney (1874) and Helmholtz (1877) pointed out that Faraday's quantitative results on electrolysis implied that each ion passing through an electrolytic bath carries just so much charge and the former gave the name electron to the unit charge (1891). By the end of the century, the electron was found as an isolated particle by Thomson. Becquerel's radioactive elements gave off several types of rays, and one type was identical with Thomson's electrons. By 1900 it was realized that uranium is changing into something else, and Rutherford and Soddy's hypothesis of atomic disintegration brought order among a complex of observations. The nature of the positive part of atoms, which all contain (negative) electrons, was explained by Rutherford's nuclear model, and Moseley counted the number of positive charges on the nucleus, and established the importance of the atomic number. Aston's mass spectrograph completed the abolition of the Daltonian atom, and its inventor joined Rutherford as a recipient of the Nobel prize for chemistry. The indivisible was divided; the indestructible was found to be destroying itself, and as someone added, Rutherford had unscrewed the inscrutable.

Niels Bohr, applying in a highly arbitrary way, Planck's quantum theory to the atom, gave a picture of Rutherford's nuclear atom in which the nucleus is surrounded by shells of electrons moving in orbits of which the outermost are held respon-

sible for the chemical properties. In addition to his explanation of the atomic spectrum of hydrogen, he asked what sort of orbits and energy levels a series of electrons would occupy if they were fed one by one into the field of the nucleus (whose atomic number increased as required). He thus set up a preliminary theory of chemistry's broadest generalization, the periodic law. He lacked some of the fundamental ideas now known to be necessary—Pauli's exclusion principles and the concept of electron spin. But the theory, which correlated the facts of X-ray spectroscopy (Moseley), atomic spectra (summarized by Sommerfeld) and chemistry (Mendeleev) is correctly assessed by J. C. Slater as, "one of the very important syntheses in the history of scientific thought". It could only be seen subsequently to Bohr's work that his explanation of the periodic system involves several assumptions (Slater):

(1) The assumption of the self consistent field (Hartree); the energy levels and orbits of an electron in an atom can be closely approximated by those of a single electron moving in a spherically symmetrical field: the field in turn being produced by the nucleus and all the other electrons in their orbits so as to give a spherically symmetric charge distribution.

(2) The number of electrons in a given shell is limited in number, a postulate which became Pauli's exclusion principle.

(3) Subject to condition (2), the available electrons in an atom in its ground state, fill the lowest energy levels.

Since periodicity is, in considerable measure, a repetition of valence states, the way was open for a physical theory of valency. The initial work had been done by chemists. Kossel, Lewis and Langmuir had constructed atomic models to explain the chemical properties, which had no resemblance to the Rutherford-Bohr model. They noticed, as Abegg had, the importance of the shell of eight electrons. Langmuir called it the octet, and located the electrons at the corners of a cube. Rutherford, writing to Arthur Smithells (26 January, 1922) said: "I am glad to hear that you feel you are making progress with your explanation of chemical facts on the electronic theory. I have no doubt that even at this present stage the model systems will help a good deal in explaining many chemical facts. As you know I lay no very great stress on Langmuir's particular contribution which is largely a hotch-potch of half a dozen different theories. From a physical point of view, his theory is merely a transition stage until we know the average position and movement of the elec-

trons and the forces that constrain them. J.J.T. is, I believe, hard at work on this side of the problem and he tells me he has got some interesting results".

Rutherford was looking forward to the development of the appropriate dynamics for electrons. They came soon afterwards, and turned out to be non-Newtonian. We must step back again some twenty years to look at this development. Planck introduced the quantum hypothesis to get a law of black-body radiation which agreed with experiment. It was a brilliant insight, since there is nothing in classical mechanics which suggests that some values of the energy of an oscillator should be allowed and others not. It virtually "exhausted Planck's powers" (Slater). Einstein took the next step, seeing clearly that the new theory had implications far beyond black-body radiation. He cleared up the problem of specific heat and went beyond Planck to postulate that radiation consists of quanta of energy (now called photons), each of amount $h\nu$, and is not to be regarded as being continuously distributed in the field, as the classical electrodynamics of Maxwell assumed. This idea seemed to contradict the wave nature of light, so well established as the explanation of such phenomena as diffraction and interference. We have now become accustomed to a compromise, with the energy carried by photons, with a wave field to guide them, this being the field of electromagnetic theory. There could be some kind of statistical relation between the wave field and the photons, in the sense that we should be likely to find photons where the wave theory tells us that we should have high intensity in the diffraction pattern, and not find them where the wave theory predicts darkness.

The next step took place in mechanics, when de Broglie suggested that wave-particle duality exists generally; that is, waves somehow accompany electrons and other particles. Einstein pointed out that electrons should then show diffraction effects, and these were soon found by Davisson and Germer, and G. P. Thomson. Schrodinger took the suggestion of a wave accompanying a particle seriously and showed how the form of the wave equation could be guessed. He thus arrived at a differential equation, the importance of which in theoretical physics, and consequently in theoretical chemistry, can hardly be over estimated. The Schrodinger equation contains, in addition to the total and potential energies of the system under consideration, a function ψ, the wave function, which measures the amplitude of the wave, and whose intensity, ψ^2 gives the probability

of finding the particle at a given point in space. (This is the interpretation given by Born, Schrodinger himself first believing that the intensity of ψ (*i.e.*, ψ^2) gives the actual density of charge.) Schrodinger found that when he substituted the potential energy, e^2/r, of the electron-proton pair which make up a hydrogen atom in his equation, he could solve it in terms of known functions, and the solution represented standing waves only for discrete values of the total energy, which were just those given by Bohr's theory which had successfully explained the spectra. In principle he also showed how the equation could be set up for a many electron problem, though the mathematics become very complex. However, Hylleras calculated the ground state of the helium atom, and James and Coolidge that of the hydrogen molecule. In each case the energies agreed with experiment within experimental error. The extension to molecules was actually made first on the H_2^+, which can be solved exactly, and gave hints for more complex problems.

It is not proposed to discuss any of the approximation methods which are necessary for tackling even simple chemical problems. There are, however, certain terms in common use which will bear a brief comment. One useful principle in seeking an approximate solution of Schrodinger's equation is the variation principle. Suppose we do not have the correct wave function, but have a function containing some parameters, which there is reason to think may approximate the true function reasonably, with suitable values of the parameters. We want a criterion for choosing the parameters which will give the best approximation. The energy is given by an integral which contains the wave function. This is computed and the values of the parameter which make the energy a minimum give, according to the variation principle, the best approximation to the true wave function. Moreover, the energy of the true solution of the Schrodinger equation will be lower than that found for the best approximation. For the H_2^+ and H_2 cases, the best approximations give energies very close indeed to the experimental energy. Very often a wave function is approximated by a linear combination of a number of different functions, each of which might be considered to give a reasonable approximation. This method is called "resonance". It is the quantal aspect of an idea developed by Pauling, Sidgwick and others. Where more than one reasonable electronic formula can be written for the same molecule, it is assumed that the true state of the molecule can be represented by an intermediate wave function, to which an approximation can be made by a suitable

combination of the wave functions for the different electronic formulae. An analogy has been given of a mediaeval explorer who has discovered a rhinoceros, which is a real animal, and who describes it on his return home as a cross between a dragon and a unicorn, both believed to be real in those far off times. The quantum mechanical theory of covalency emphasizes the requirement that two electrons which pair to form a covalent bond must have opposite spins. It also provides a reason why the atoms of the inert gases, and ions with closed shells, repel instead of attracting at close distances, and thus have finite size. In the case of the ions, those of opposite sign will attract each other at larger distance by the long range force discovered by Coulomb, and now regarded as being transmitted by the photon field. The Bohr concept of orbits has disappeared and the wave functions replacing them are called orbitals, atomic or molecular, depending on the type of system being treated. The theory of chemical binding illustrates one way in which the dynamics of electrons has led to new concepts of the structure of matter. The chemical bond takes on a physical meaning.

It was remarked earlier that the affinity of chemical processes is a statistical concept. Another major development in chemistry, deriving from advances in physics, is the linking of kinetic theory with thermodynamics. Following Hammett, let us consider the interconversion of two isomers, *e.g.*, normal and *iso*-butane. As the structural formulae indicate, these isomers differ in the geometric arrangement of the atoms, and in the way they are linked together. The formulae, however, imply a lifelessness which is far from that of the physical picture. The molecules are in active motion, the atoms in a molecule vibrating with respect to each other, rotating around the bonds, and the whole molecule rotating. At high temperatures electrons may be in excited states. All the motions, including translational, are quantized, and the equilibrium is not just one between two kinds of molecules, as we formulate it in a mass-action equation, but between a very large number of quantum states. These states can be classified into two main groups, one we can recognize as *n*-butane, and the other as *iso*-butane. Within each group transitions are so rapid that we cannot isolate molecules in one state from those in another. The transition, normal to *iso*-butane, is slow enough for us to separate these as distinct chemical species. From the standpoint of equilibrium, however, the rate of attainment of the equilibrium state is irrelevant, and the law which determines the number of molecules in any state in either group also determines the distribution of

the molecules between the groups. This law was provided by Boltzmann, prior to the development of the quantum theory, but is most usefully considered in terms of quantum-mechanical ideas. These may be stated as follows:

(1) all atomic and molecular motions are quantized, *i.e.*, only certain discrete levels of energy are possible;

(2) the spacing of the energy levels is determined mainly by two factors—the masses of the moving bodies, and the restraints under which they move; a decrease in mass or an increase in the restraints widens the spacing;

(3) the energy levels may be multiple, *i.e.*, what are essentially different kinds of motion may give the same energy;

(4) in a gaseous system at equilibrium, the number of molecules N_i with energy ε_i is given to a useful approximation by Boltzmann's equation:

$$N_i = \text{const. } g_i \exp\ (-\varepsilon_i/kT)$$

where g_i is the multiplicity, and k is the gas constant per molecule (Boltzmann constant).

A system of gas molecules is continually interchanging energy through collisions, and no one molecule remains long in a single energy state. But one of the most important facts we know about nature is that there is a normal distribution of the molecules among the possible energy levels, and for a sufficiently large number of molecules the actual number in each level will not spontaneously deviate widely from the normal (or average) number. If we produce an abnormal distribution, the system will revert to its normal distribution when the constraint is removed. This normal distribution is the condition of equilibrium. If there are N_a molecules in level a, and N_b in level b, in the equilibrium state, Boltzmann's law gives:

$$\frac{N_a}{N_b} = \frac{g_a \exp\,(-\varepsilon_a/kT)}{g_b \exp\,(-\varepsilon_b/kT)} = \frac{g_a}{g_b}\exp\ \left(\frac{\varepsilon_b - \varepsilon_a}{kT}\right)$$

Because this relation is so fundamental, a wide variety of chemically interesting relations derive from it. For N (Avogadro number) molecules in level i, having energy

$$E_i = N\varepsilon_i,$$
$$N_i = \text{const. } g_i \exp\ (E_i/RT)$$
$$\log\ N_i = \log \text{const.} + \log g_i - (E_i/2.3\ R.T)$$

Such properties as the equilibrium and rate constants of chemical reactions, the vapour-pressure of a liquid and a solid, and the viscosity of a liquid, all show a linear relation between the

logarithm of the property and the reciprocal of the Kelvin (absolute) temperature. They can all be derived from a single property, the partition function or sum-over-states, involving Boltzmann's distribution law.

One of the earliest insights into the importance of the distribution of molecules among what we now call quantum states was that of Arrhenius (1889), again prior to the quantum theory. The dependence of the rate constant of chemical reactions of measurable rate on the temperature is given empirically to a considerable precision, by $k_r = C \exp(-A/RT)$. Arrhenius interpreted this in terms of the idea that only "activated" molecules (somewhat vaguely defined) could undergo reaction, and about 1917 W. C. M. Lewis showed that for the hydrogen-iodine gaseous reaction, C can be replaced by the collision frequency Z, which is given by the kinetic theory of gases. The exponential factor, which is obviously of the Boltzmann type, was interpreted as giving the fraction of the colliding molecules which had enough energy to react. "Enough energy to react" could mean that the colliding pair have a high relative speed, or that one or both contain a large amount of internal energy. Considerations of structural chemistry, however, show that for complicated molecules, a very small fraction of the collisions will bring the molecules together so that their reactive portions come close enough and in the right orientation to allow the breaking and formation of bonds, and it is not surprising that some reactions are slower by factors up to 10^5 than the collision theory predicts. In addition the energy factor A, the "energy of activation", remained empirical till the development of quantum mechanics. This allowed the question to be considered of how the potential energy of the system of nuclei and electrons, which make up the reacting molecules, will vary as the molecules come close together. The first reasonably successful application of quantum mechanics was made in 1931 by Eyring and Polanyi. They considered such simple chemical reactions as

$$H + \textit{para}\ H_2 = \textit{ortho}\ H_2 + H \text{ and } D + H_2 = HD + H.$$

For the latter, experimental work by A. and L. Farkas gave 8.5 kcal for the activation energy. The theoretical calculation indicates that the minimum energy of the three atom system which will allow the necessary interchange of partners is 7.8 kcal, occurring at a configuration of

$$D \overset{r_1}{\text{——}} H \overset{r_2}{\text{——}} H, \text{ where } r_1 = r_2 = 0.95°K.$$

This is greater than the normal internuclear separation in H_2, which is 0.74° K. The configuration given is called the activated complex, and it may either go forward to HD + H, or return to D + H_2. The assumptions required for the calculation to be made are drastic, even for so simple a reaction. Nevertheless, the theory gives a clear physical picture instead of the vague concept of "collision".

The rate of any chemical reaction can be formulated in terms of the activated complex, and the concentration of such complexes, which is the key to the rate of reaction, can be calculated on the assumption that they are in equilibrium with the reacting molecules, so that statistical mechanics according to Boltzmann can be applied. This "transition-state theory" developed notably by Eyring is another important application of quantum mechanics to chemistry, and with all its limitations in the quantitative sense, is another landmark in modern chemical theory.

It was implied earlier that explanatory theories are regarded as the keystone of a developed science. They are both genuine conjectures about the nature of the world we live in—the best we can achieve at a given time, tested as critically as we can test them—and also valuable instruments by which we can predict new phenomena, and decide which among the myriad of chemical facts available to us, are really significant. An interesting remark was made by Ingold in the Chemical Society's symposium (February, 1954) on the kinetics and mechanism of inorganic reaction in solution. Describing the work of his school on octahedral substitution, he said "on surveying the literature . . . , we thought we found various indications of a duality of mechanism . . . but we could achieve no certainty: nothing approximating to a demonstration could be found. As in the organic case, studied 20 years earlier, an enormous literature existed, but the right experiments for revealing mechanism had not been done". This is a familiar situation. It is very seldom that the right experiments are done by accident, but even a primitive theory is often sufficient to indicate what the significant experiments are. Broadly, one of the major lessons learned by chemists in this century is the importance of adequate theory, and the lesson has come mainly from physics. The explanation of known facts, however, is only one function of theories. We gain confidence in them as they succeed in predicting new unknown phenomena. Physics has an impressive list of such achievements—electron diffraction from de Broglie's work; the

positron predicted by Dirac and found four years later by Anderson; the mesons, predicted by Yukawa and found by Anderson and by Blackett and Occhialini; the neutrino, predicted by Pauli to explain the apparent failure of the law of the conservation in β decay phenomena, and recently reported as found, despite the difficulties arising from its slight interaction with other particles. Debye's theory of electrolytic conductance predicted the breakdown of Ohm's law at high frequencies, as well as explaining the similar already known breakdown at high field strengths. Similar predictions in chemistry, apart from simple ones such as Mendeleev's of the properties of unknown elements, will require a more developed theory than we have today.

In his presidential address to the Chemical Society in 1944, W. H. Mills remarked: "Chemistry is more interesting now than it ever was. There is more logical connection between the facts. But the amount the student has to learn is greater and the temptation to over-specialize much increased. Our deeper knowledge enables us now to see things in truer perspective and the teacher needs more than ever to seek out the essentials and to find the simplest methods of presentation and so to help the student on the long road he has to travel to the stage where he can undertake independent research".

This entirely reasonable view leaves many questions to be solved. The repercussions in the *teaching* of chemistry of advances in physics is another aspect of the broad topic of which only one part has been discussed. It is not expected that even the chemistry staffs in our universities would agree about what constitutes "over-specialization". For example, the "deeper knowledge" which enables us to "see things in truer perspective", is, to the writer, the better understanding of the underlying physical principles, some of which have been outlined here. It it not clear, however, that Dr Mills meant that at all, or that he would regard the study of these matters as "the essentials". What are the "simplest methods of presentation" which will help the student on his long road to independent research? Simplicity is often the end point of a very deep and subtle analysis.

Sir Henry Tizard in his Rutherford Memorial Lecture to the Chemical Society (1939) suggested that one advantage Rutherford had over Faraday was that he had had a good education, but not too good an education. "He had been taught science at Canterbury College by a man who was completely unorthodox, who, it would not be unfair to say, did not know

very much, but who was convinced that there was a great deal yet to be known and discovered". Tizard went on to quote the remark of one of the most famous of contemporary men of science, "If you ever think of investigating anything, don't start by looking up the literature on the subject. If you do, you will probably come to the conclusion that everything is known about it". There is much truth in this. Certainly the emergence of an entirely new way of looking at chemical phenomena, such as bonding, both in stable molecules and in the "transition states" which play so important a role in rate processes, demands a re-orientation both of our thinking and our teaching. "Men who have had established doctrines dinned into them in youth", said Tizard, "violently resist a complete change in their habits of mind forced on them by a younger generation. Let us resolve to be on our guard as we ourselves grow old".

Erratum

"Line Drawings for Lantern Slides" by H. R. Penhale. Page 44, Table 2. The second column should be read *cm* not *mm*.

SALARY SURVEY—NOVEMBER, 1958

G. S. LAMBERT AND A. G. FRIEBERG

The results of previous salary surveys conducted by the Institute have been published in the following issues of this *Journal*: 1944—*J. N.Z. Inst. Chem.*, *8* : No. 3; 1948—*J. N.Z. Inst. Chem.*, *12* : 32, 132; 1952—*J. N.Z. Inst. Chem.*, *16* : 144; 1955—*J. N.Z. Inst. Chem.*, *19* : 128. The present survey has been conducted on similar lines so that comparisons can readily be made. The questionnaire was sent out, with stamped addressed envelopes for return, to 470 members resident in New Zealand and a total of 357 replies were received. The percentage of replies was thus 76% compared with 78% in 1955 and 66% in the 1948 and 1952 surveys.

Table 1 summarizes the replies and shows a similar distribution of members in the various groups of employment. Significant increases in the number of returns occur in the industrial and teaching groups.

Table 2 shows the distribution of salaries in the different age groups and shows the distributions in the three largest employment groups, industry, Government and university respectively.

Table 3 shows the average salaries for the age groups in the principal occupational classes. Average salaries have been computed as previously by using the figure in the middle of each salary range (see top of Table 2) as the actual salary for each member in that range. In most cases errors introduced by this procedure would be small, except in the "over £2,500" group

TABLE 1: RETURNS

Group	*Male*	*Female*	*Total*
Industry	139	4	143
Government	97	11	108
University	38	3	41
Research associations	18	1	19
School teaching	21	4	25
Local body	4	1	5
Private practice	7	0	7
Retired	8	0	8
Unclassified	1		1*
Total	333	24	357

*Return from an associate not practising.

where this figure has been taken as the average. In the industrial group it is likely that the average salary for some age groups has been appreciably lowered from this cause.

Figure 1 shows the data from Table 3 in graphical form for industry, Government, university and teaching. The graphs are very similar to those produced from the 1955 survey. Salaries

TABLE 2: DISTRIBUTION OF SALARIES IN AGE GROUPS

Age	Below £800	£800 to £899	£900 to £999	£1000 to £1099	£1100 to £1199	£1200 to £1299	£1300 to £1399	£1400 to £1499	£1500 to £1599	£1600 to £1699	£1700 to £1799	£1800 to £1899	£1900 to £1999	£2000 to £2199	£2200 to £2399	£2400 to £2499	Above £2500	Total
ALL GROUPS																		
21-25	1	4		2		1												
26-30	1	3	6	12	4	6	4	1		1		2						40
31-35			6	10	10	21	12	8	7	1	2	1		1			1	80
36-40			2	4	1	11	10	7	4	7	6	2	3	3			1	61
41-45	1			3	3	10	9	5	4	5	2	4	2	4	2		4	58
46-50						10	4	7	5	5	3		1		2	1	3	41
51-55					1	1	5	3	3	2	7	5		4	3		1	35
56-60				1		1	1		1	1	2	1		5	2		3	18
61-65			1	1			1	1	1			1					1	7
65+	6				1			1										8
Totals	9	7	15	33	20	61	46	33	25	22	22	16	6	17	9	1	14	356
INDUSTRY																		
21-25		1		2														3
26-30			2	5	3	4	2	1				1						18
31-35			5		6	10	7	5	4	1	2	1		1			1	43
36-40				1		4	4	4	2	2	2	2	3	2			1	27
41-45				1	2	2	1	2	3	3	1	1		2			4	24
46-50						1		1	3	3	2				2		3	15
51-55								1	1			1			2		1	6
56-60											2			1			2	5
61-65			1														1	2
Totals		1	8	9	11	21	14	14	13	9	10	6	4	6	4		13	143
GOVERNMENT																		
21-25		2																2
26-30		1	4	2	1	2	1											11
31-35			1	7	2	4	3	1	1									19
36-40				3		6	3	2			2							16
41-45				2	1	4	5	3	1	1		3	1					21
46-50						7	3	4	2	1	1		1					19
51-55					1		3	2	1		3	2						12
56-60							1		1			1		1	1			5
61-65								1	1									2
65+					1													1
Totals		3	5	14	6	23	19	13	7	2	6	6	2	1	1			108
UNIVERSITY																		
21-25		1				1												2
26-30		1		3			1											5
31-35				1		5	1		1									8
36-40							1	1	1	4	1			1				9
41-45						1	1			1				1	2			6
46-50																1		1
51-55						1				2	1			2				6
56-60														2			1	3
61-65												1						1
Totals		2		4		8	4	1	2	7	2	1		6	2	1	1	41

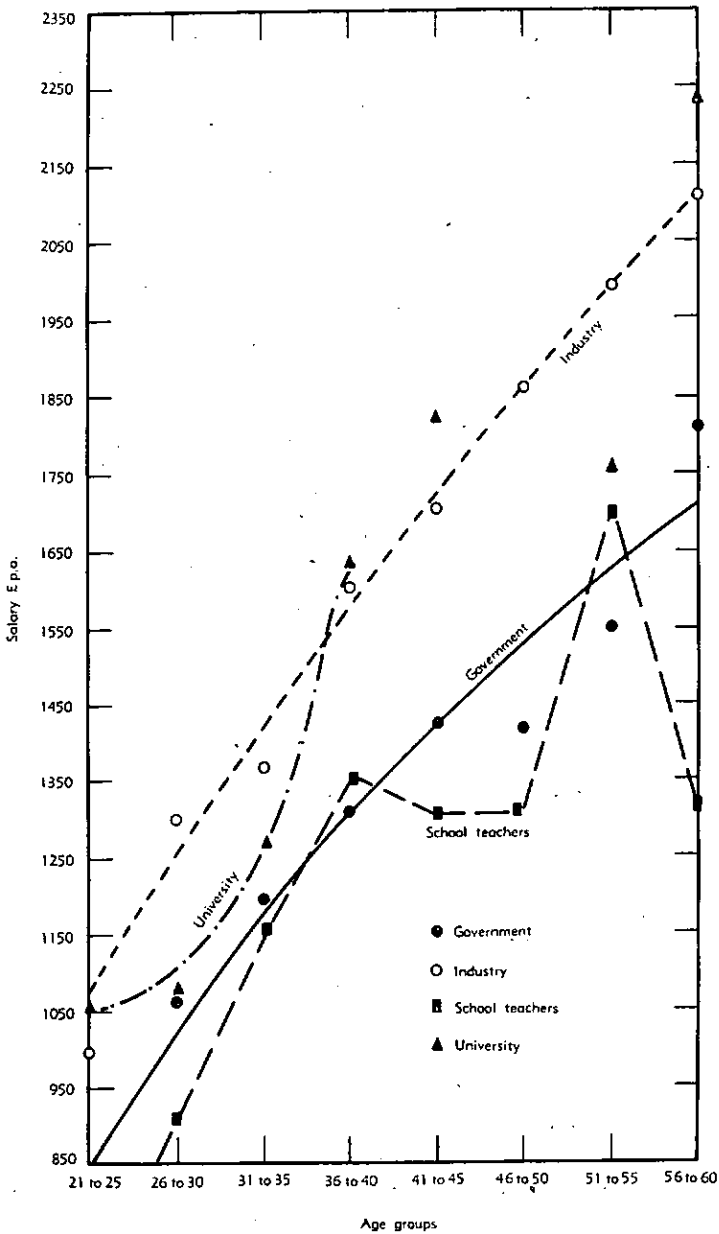

Fig. 1: Average salaries for the age groups in the main occupational classes. (University data above £1,650 insufficient for accuracy.)

TABLE 3: AVERAGE SALARIES FOR AGE GROUPS—COMPARISON OF 1944, 1948, 1952, 1955 AND 1958 SALARIES

Age	*Government*					*Industry*				
	1944	1948	1952	1955	1958	1944	1948	1952	1955	1958
21-25	300	425	589	758	(850)	310	515	700	(1475)	(983)
26-30	378	480	707	888	1068	432	571	828	1028	1291
31-35	470	617	871	1039	1192	545	721	953	1166	1363
36-40	535	672	974	1113	1319	660	850	1086	1321	1604
41-45	625	821	1093	1231	1431	770	1100	1436	1506	1713
46-50		893	1183	1333	1424		844	1171	1432	1860
51-55		(850)	1275	1443	1550		950	965	1715	1992
56-60				1350	1820				(1700)	2120
61-65				1050	(1500)				(1063)	(1725)
65+					(1150)				(1650)	

Parentheses indicate data insufficient for accuracy.

in industry tend to be higher than in Government by about £200 in the lower age groups and about £400 in the older age groups. University Salaries appear to follow those in industry fairly closely. From the limited number of teaching returns it appears that in this section salaries are approximately £100 below the equivalent age groups in Government.

In an effort to relate salaries to degree of responsibility members were again asked to classify their duties as mainly administrative or bench. As pointed out by some members in their replies there are a number of occupations where such a classification is impossible. However, in the industrial and Government groups the classification has some significance. Of the 143 replies received from industry 94 (66%) were classed as administrative and of the 108 Government replies 23 (21%). Average salaries for the various age groups in the two classes are set out in Table 4 which shows much the same picture as in the 1955 survey. Salaries of bench workers in industry and Government are comparable, while those with administrative responsibility in industry receive from £200 to £400 and in Government from about £150 to £300 more than bench workers in the same age group.

Table 5 shows the distribution of academic qualifications in the various classes of employment. In industry academic qualifications showed no relation to salary. There was no significant difference between the salaries paid to bachelors and masters while the average salaries received by chemists with no degrees were higher than those received by doctors. It should, however, be pointed out that the doctors were predominantly much younger than their colleagues with no degrees.

TABLE 3: CONTINUED

Age	*University*				*School Teaching*			*Research Associations*		
	1948	1952	1955	1958	1952	1955	1958	1952	1955	1958
21-25	525	714	—	1050	—	—	800	—	(775)	—
26-30	604	765	963	1070	750	(925)	900	—	(1000)	1350
31-35	779	960	1132	1275	806	958	1150	730	1106	1390
36-40	817	1537	1380	1644	925	1000	1350	1500	(725)	1300
41 45	908	1300	1555	1825	1091	(925)	1300	1075	(1450)	—
46-50	1370	1300	1425	(2450)	1187	1231	1317	—	1350	(1450)
51-55	950	1700	1567	1750	(950)	1225	1700	1550	1575	1838
56-60			1550	2233		1100	1300		(1200)	2017
61-65			—	(1850)						
65+			(1850)							

Parentheses indicate data insufficient for accuracy.

TABLE 4: AVERAGE SALARIES FOR ADMINISTRATIVE AND BENCH DUTIES

INDUSTRY

Age Group	*Admin. (94)*	*Bench (49)*	*Both Classes (143)*
21-25	(1050)	950	983
26-30	1330	1150	1200
31-35	1382	1203	1348
36-40	1680	1290	1608
41-45	1885	1321	1713
46-50	1929	1583	1860
51-55	1992	—	1992
56-60	2120	—	2120
61-65	2500+	(950)	1725

GOVERNMENT

Age Group	*Admin. (23)*	*Bench (85)*	*Both Classes (108)*
21-25	—	850	850
26-30	—	1068	1068
31-35	(1250)	1189	1192
36-40	—	1319	1319
41-45	1550	1383	1431
46-50	1533	1373	1424
51-55	1710	1436	1550
56-60	1900	(1550)	1820
61-65	(1550)	(1450)	1500
65+	—	(1150)	(1150)

Parentheses indicate data insufficient for accuracy.

TABLE 5: ACADEMIC QUALIFICATIONS (PERCENTAGES IN PARENTHESES)

Qualifications	*Government*	*Industry*	*University*	*School Teachers*	*Research Associations*
No Degree	3 (3)	5 (4)	—	—	—
Bachelor	22 (20)	54 (38)	2 (5)	10 (40)	3 (16)
Master	58 (54)	75 (52)	11 (27)	14 (56)	5 (26)
Doctor	25 (23)	9 (6)	28 (68)	1 (4)	11 (58)

In Government, research association, university, and school teaching higher academic qualifications in general commanded slightly higher salaries particularly in the younger age groups.

Table 6 shows the numbers of fellows and associates in the various employment groups.

TABLE 6: FELLOWS AND ASSOCIATES

	Fellows	*Associates*
Government	11 (10)	97 (90)
Industry	11 (8)	132 (92)
University	14 (34)	27 (66)
Research associations	4 (21)	15 (79)
School teachers	1 (4)	24 (96)

FEMALES

In industry, Government and school teaching, female members appear in general to receive salaries similar to the lowest paid males in their respective age groups. In the university no distinction was apparent between males and females.

HIGHER SALARIES

In the 1948 survey "higher salaries" were considered to be those over £1,000 and in subsequent surveys comparable figures have been selected taking into account the increase in cost of living as shown by the Government Statistician's "Consumers' Price Index". For 1958 the figure suggested is £1,750 and Table 7 shows the number of salaries above this figure compared with those of previous surveys. It will be seen that the percentages have increased in each group. It is also interesting to note that in all employment groups, average salaries have more than kept pace with the increase in cost of living since 1955. This is in contrast with the Government Statistician's index for "Weekly Wage Rate for Adult Male Workers" which has lagged behind the "Consumers' Price Index" over the same period.

TABLE 7: NUMBER RECEIVING HIGHER SALARIES

Group	Number in Group				*Number receiving higher salaries*							
					1948		1952		1955		1958	
	1948	1952	1955	1958	£1000+	%	£1400+	%	£1550+	%	£1750+	%
Industry	74	99	126	143	14	19	14	14	26	21	38	27
Government	68	89	109	108	2	3	1	1	4	4	13	12
University	29	33	42	41	5	17	6	18	9	22	12	29
Research associations	—	12	18	19	—	—	3	25	3	17	6	32
Teaching	38	20	19	25	6	16	1	5	—	—	2	8
Others	—	20	11	20	—	—	1	5	2	18	4	20

Superannuation

Employees in Government, university, research associations and local bodies have the opportunity of joining the Government Superannuation Scheme. If contributors join before the age of 30 their contribution rate is 5% with a rise of 1% for each five years over thirty for those joining later with a maximum rate of 10%. Contributions are subsidized £ for £ by the Government up to a limit. Most members in these employment groups contribute to the scheme.

Table 8 shows the number of members in industry contributing to subsidized schemes and the employers' contributions. Rates vary considerably but by far the biggest proportion receive a subsidy equal to 5% of their salary. The number unattached to a scheme has dropped from 34 out of 129 in 1955 (26%) to 27 out of 143 in 1958 (19%).

Table 8: Superannuation (Industry Only) Estimate of Employer's Contribution to Superannuation or Insurance as a Percentage of Salary

Percentage Contribution	*Number in Group*
0	27
½ — 2½	11
3 — 4½	12
5	48
5½ — 7	17
7½ — 9	14
10 and over	9
Not known	5

BRANCH NEWS AND NOTES

Conference News

The Conference committee is making good progress. Dr J. F. Duncan of Melbourne and Dr R. L. M. Synge have accepted invitations to give major addresses. Symposia on biochemistry, agricultural chemistry, geochemistry, and natural products will be held. Good accommodation, either at Carrington Hall or the Grand Hotel, is assured for all visitors. The Committee is confident that the dinner and weekend excursions to Roxburgh and/or Southland will provide a fitting climax to a successful Conference.

Auckland Branch

¶ Members of the Auckland Branch combined with the Auckland Branch of the New Zealand Institute of Engineers for the April meeting to hear an address by Sir Leonard Owen entitled "Recent Developments in Nuclear Power Plants". Sir Leonard is Managing Director of the Industrial Group of the United Kingdom Atomic Energy Authority and has been concerned in the development of Britain's atomic energy programme since 1946.

¶ Many members of the Branch were invited by the University to hear an address by Professor L. I. Sedov, a mathematician, who with Dr K. I. Ivanov, pro-rector of Moscow University, recently spent a ten-day goodwill visit to New Zealand. Professor Sedov's address was concerned with a review of the sputnik achievements of the U.S.S.R.

¶ Dr B. R. Davis, at present on leave at Harvard University where he is working under Professor L. Fieser, has been awarded an I.C.I. Research Fellowship at Oxford University. The fellowship, which is for three years is for research in organic chemistry.

Waikato Branch

¶ The Waikato Branch has recently lost two active members and will soon lose three more. J. C. B. White, who has been on the staff of the Rukuhia Soil Research Station, leaves in May for the Postgraduate School at Canberra where he will work on structural spectra. Mrs. White (*nee* Gwenda Sheat), also formerly of the Rukuhia staff is remaining in New Zealand for a short while to complete a metabolic synthesis before joining her husband. R. R. White, once of Ruakura Animal Research Station but more recently chemist to Waikato Breweries, and energetic chairman of the 1958 Hamilton Conference Committee, left in March for the University of New England (Armidale, New South Wales). There he will be again engaged on biochemical studies in relation to animal husbandry and nutrition.

¶ Early in May Dr R. P. Newbold also departed for Australia to take up an appointment with the C.S.I.R.O. in the Division of Food Preservation and Transport at Sydney. Dr Newbold will continue research in muscle biochemistry, a field in which he has worked for the last three years at Ruakura and earlier in Canada.

¶ R. N. Woodward (noted for his rock 'n roll version of "The Happy Farmer" at last year's Conference) has transferred from Rukuhia to the Division of Nuclear Sciences, Lower Hutt.

¶ To offset the previously mentioned desertion of the Branch by three Whites, we record especially welcome news regarding the White residue, this year's Chairman, E. P. White. The University of New Zealand has approved the award of the degree of Doctor of Science to Mr White for his work, including that on legume alkaloids and the extraction of the facial eczema poison. To Institute members familiar with this work this award is particularly pleasing.

¶ At the first meeting of the year the Chairman welcomed Dr R. L. M. Synge of the Rowett Research Institute, who is at present working with the facial eczema team at Ruakura. Dr Synge addressed the meeting on the subject of "Molecular Sieves". Others welcomed as newcomers to the Branch at recent meetings were G. Russell and P. Carnegie, both from Great Britain, who have joined the Ruakura staff; and F. R. Leighton of the N.Z. Co-op. Dairy Company Laboratory.

¶ The Institute President, Professor L. H. Briggs, visited the Branch in April and gave an enlightening talk on impressions drawn from his overseas travel last year.

Manawatu Branch

¶ It was fitting that the April meeting of this Branch, at which opportunity was taken to farewell Dr C. R. Barnicoat, who has now left Palmerston North to take up his new position as Director of the Cawthron Institute, should have been held in a private home. Dr Barnicoat was the organizer of regular meetings of local chemists long before the Branch was formed. These early meetings were held in private homes until increasing membership and the large number of visitors usually wishing to attend meetings eventually necessitated a move to a larger meeting place at Massey College. An informal address by Dr A. T. Johns on the facial eczema problem followed by discussion and supper round the fire revived, for the older members at least, very pleasant memories of Dr Barnicoat's earlier meetings. In making a presentation on behalf of the Branch, the Chairman, Dr J. W. Lyttleton, spoke of Dr Barnicoat's work for the Branch and the Institute in general and of his very great influence on the development of chemistry in this area over the past 26 years.

Wellington Branch

¶ Branch members were amongst those invited to a lecture held under the auspices of Victoria University and given by Professor L. I. Sedov of Moscow University. The lecture dealt with sputniks and their ways.

¶ H. R. Penhale, Soil Bureau, is Acting-Secretary in place of P. P. Williams who will shortly be proceeding overseas.

¶ Miss L. E. Greig has transferred from Standard-Vacuum Oil Co. Ltd. to International Paints of N.Z. Ltd.

Canterbury Branch

¶ W. R. McKeegan has left Woolston Taneries Ltd., to become chemist for Aulsebrook & Co. Ltd., Christchurch.

¶ E. R. Hounsell, Senior Science Master at Christ's College, Christchurch, has been appointed Liaison Officer at the University of Canterbury. Mr

Hounsell, who has been on the College staff for 21 years, is a member of the Canterbury Branch committee.

¶ The Canterbury Branch has just completed another series of lectures to senior post-primary school pupils. Like their previous series, these lectures again proved very popular and it is hoped to publish the lectures in the October issue of this *Journal*.

¶ Following a suggestion by M. S. Carrie the Canterbury Branch circulated its members with a view to organizing a course in scientific Russian. There was a good response and the course has now been organized by the Adult Education Department, University of Canterbury, and is proving most successful.

OVERSEAS BRANCH

¶ Dr V. Armstrong, Senior Scientific Liaison Officer for the D.S.I.R. in London arrived in New Zealand recently on a brief refresher visit. Dr Armstrong will be contacting D.S.I.R. branches and other research units before returning to London in June.

Obituary

¶ It is with regret that we record the sudden death of H. V. Rowe, a member of the Canterbury Branch. Mr Rowe was first assistant at Christchurch Boys' High School and had since 1921 been senior science master at that school—a school noted for its strength in science. Educated at Christ's College and Canterbury University College, Mr Rowe was a foundation member of the Institute and was Chairman of the Canterbury Branch in 1945.

COUNCIL NOTES

ABRIDGED MINUTES OF A MEETING OF THE COUNCIL OF THE NEW ZEALAND INSTITUTE OF CHEMISTRY (INC.) HELD IN THE CONFERENCE ROOM, D.S.I.R., WELLINGTON, ON FRIDAY, 20 FEBRUARY, 1959.

PRESENT

Professor L. H. Briggs (President, in the chair), Dr A. L. Odell (Auckland), E. P. White (Waikato), Dr W. A. McGillivray (Manawatu), P. P. Williams (Wellington, proxy), D. J. Hogan (Canterbury), Dr A. D. Campbell (Otago), Dr W. E. Harvey (Gen. Secretary) and L. J. Rollo (Registrar). Apologies were received from Messrs E. W. Hullett (Vice-President) and J. R. Beck (Wellington Delegate).

HONOURS

The chairman drew attention to the fact that several members of the Institute had been honoured in the New Year's Honours List and it was agreed that letters of congratulation should be sent to the people concerned, as follows:

Dr M. M. Burns, C.B.E., (recently appointed Chairman of the Council of D.S.I.R.).

Dr Muriel Bell, C.B.E.

Dr F. B. Shorland, O.B.E.

CONFERENCE, 1958

The report of the 1958 Combined Conference Committee was received, and Council extended warm thanks to the Committee for the excellent way in which they had organized and run the Conference. The statement of accounts showed a credit balance of 12s. 5d. and this will be divided between the N.Z.I.C. and the R.I.C. on the usual *pro rata* basis. It was resolved that the N.Z.I.C. share be paid into the Overseas Visitors Fund.

CONFERENCE, 1959

Dr A. D. Campbell reported on progress made with the arrangements for the 1959 Conference in Dunedin. The dates suggested are Wednesday, 26 August to Friday, 28 August. It is hoped that three invited guests, Drs Duncan, de la Mare and Synge will be present and will deliver special addresses. Arrangements are being made to obtain accommodation for members at Carrington Hall and, if numbers warrant, two excursions to Roxburgh and to Otago and Southland will be organized for the weekend after the Conference.

L.A.C.

RESOLVED (Otago/Waikato) 'That the following be awarded the Laboratory Assistant's Certificate':

COXHEAD, Miss E. J., Biochemistry Dept., Massey College.
LEENEN, F. C. J., Tasman Pulp & Paper Co., Kawerau.
MONNIE, Miss J. M., D.S.I.R., Wellington.
LOACH, Miss C. A., Dominion Laboratory, Christchurch.
COULSON, S. D., Wallaceville Animal Research Station.
BALDWIN, Miss P. M., Dominion Laboratory, Auckland.
O'HARA, Miss S. G.

In addition C. B. PLUYMERS was accredited with the L.A.C.

REGISTRAR

As stated in the agenda D. J. Hogan has received approval from the Public Service Commission to allow him to take up the position of Registrar. Mr Hogan's appointment will date from 1 May, 1959.

RECORDS

The Institute has a considerable pile of records, mainly old applications for membership which are at present housed in the D.S.I.R. in Wellington. This arrangement will have to terminate in the near future and it is desirable that a decision be made as to what records should be kept. Members of Council were asked to give thought to this matter so that a final decision can be made at a later meeting. The Institute has no permanent filing facilities to hold current correspondence and working papers and it was RESOLVED (Secretary/Auckland) 'That the Institute purchase a filing cabinet at a cost of approximately £20'.

BANK ACCOUNT

RESOLVED (Manawatu/Otago) 'That the Institute account with the Bank of New Zealand be transferred to Christchurch as from 1 May, 1959'.

P.O. BOX

RESOLVED (Auckland/Wellington) 'That the Institute hire a post office box in Christchurch in addition to Box 250 in Wellington'.
[P.O. Box 1926 has now been taken in Christchurch]

AUDITOR

It may be desirable to appoint an auditor in Christchurch in place of the present auditors. This question should be discussed at the Annual General Meeting.

CHANGE-OVER OF REGISTRAR

RESOLVED (Secretary/Auckland) 'That the Institute meet the cost of a trip to Christchurch by Mr Rollo, should such seem desirable to facilitate the change-over of the Registrarship.

REGISTRAR AS DELEGATE

RESOLVED (Auckland/Manawatu) 'That in the opinion of Council the appointment of D. J. Hogan as Registrar does not prevent his acting as delegate for the Canterbury Branch'.

INVESTMENTS

Council considered the views of the Trustees as to the investment of certain monies and it was RESOLVED (Chair) 'That the Institute-invest the sum of £500 of the Trust Fund in Lyttelton Harbour Board stock maturing in 1964, this investment being subject to the approval of the Trustees'.

RESOLVED (Chair) 'That the sum of £200 from the compounded subscription account be invested in Lyttelton Harbour Board Stock maturing in 1964 and that the Trustees be advised accordingly'.

RESOLVED (Manawatu/Auckland) 'That the Bank of New Zealand be empowered to hold the debenture documents'.

TECHNICIAN TRAINING

Dr A. L. Odell tabled a draft of a letter to the Superintendent of Technical Education which answered point by point the comments made by the Superintendent on the Institute's proposals for a suitable course for technicians. It was agreed that the Institute should stand by these proposals and the draft, with only slight modification, was approved for transmission to the Department of Education.

L.A.C. REGULATIONS

RESOLVED (Otago/Secretary) 'That Regulation 2.2.2. be amended by the addition of the words "or passed such examination either in the year immediately prior to that in which he registered, or two years prior if a further year was spent in the study of Chemistry".

This alteration is made with the consent of the Public Service Commission.

PRIZE REGULATIONS

Modified regulations for the Chemical Essay Prize and the I.C.I. Prize were approved. These new regulations will be printed in the *Journal* and will be circulated to Branches.

ANNUAL REPORT FOR 1958

The 28th Annual Report of the Institute was received.

JOURNAL SUBSCRIPTIONS

RESOLVED (Chair) 'That the cost of the *Journal* to local members be 10s.'

MEMBERSHIP

Election of Fellow

VAUGHAN, JOHN, Senior Lecturer, Chemistry Department, University of Canterbury.

Election of Associates

BAILEY, MAURICE ROSS, James Hargest High School, Invercargill.
CARR, ROBERT MELVILLE, Chemistry Department., University of Otago, Teaching Fellow.
MCANNELLY, FRANCIS PATRICK, Shell Co. of N.Z. Ltd., Wellington.
MITCHELL, COLIN DONALD, 36 Jedburgh Street, Tokoroa, Chemist.
O'CONNOR, KEVIN AUGUSTINE, Senior Chemistry Master, St. Bede's College, Christchurch.
PAGE, RONALD BURNAND, 23 Eltham Road, Kohimarama, Chemist.
PAGE, SALLY GRACE, Chemistry Department, University of Canterbury, Assistant Lecturer.

Resignations

Bailey, R. W., Newbold, R. P., Harpham, M. M. F., Stephens, O. C.

FELLOWS

The Canterbury Branch has pointed out that the proportion of Fellows in the N.Z.I.C. is not nearly as great as is the case in the R.I.C. Over the past few years there has been considerable discussion from time to time on the best method to adopt in an effort to get more Associates to apply for the Fellowship. In general discussion it was pointed out that the higher subscription payable by Fellows may be a contributing factor as Fellows do not obtain any correspondingly increased benefits.

The Manawatu Branch gave NOTICE OF MOTION that it is intended to move that the subscription payable by Fellows be reduced to £2. 2s. 0d.

INCOME TAX

The Wellington Branch Committee was asked to investigate the possibility of obtaining some form of tax exemption on subscriptions. It would appear that most of the learned societies in New Zealand would have to co-operate in presenting a case to the Inland Revenue Department to have any hope of success.

DISTINGUISHED VISITORS TO AUSTRALASIA

After a general discussion on the problems of financing visits by overseas chemists it was agreed to write to the R.A.C.I. reminding them of their offer to keep the N.Z.I.C. informed of any overseas chemists visiting Australia, to make enquiries about possible visitors during 1960, and to ask for details of the methods they use to finance such visits.

HONORARY MEMBERSHIP

RESOLVED (Chair) 'That Dr R. M. L. Synge, F.R.S., be made an Honorary Member of the Institute with all the privileges of a Fellow, such membership to last for the duration of Dr Synge's stay in New Zealand'.

CAREERS IN CHEMISTRY BOOKLET

The Canterbury Branch Delegate submitted a memorandum dealing with the above. This was referred to Branches for consideration.

UNIONS

It was agreed to write to the Registrar of Industrial Unions asking that the N.Z.I.C. be informed of possible changes in union rules if these changes are likely to affect members of the Institute.

The Wellington delegate reported that a member of the Wellington Branch was proposing to call a meeting to discuss the formation of a union of chemists. It was agreed to ask this member (J. K. Johannesson) and the Wellington Branch Committee to present in person to Council at its next meeting a report on the proposals to form a union, so that there may be adequate co-ordination between any union which may be formed and the N.Z.I.C. It was suggested that details of the N.Z.I.E.-P.E.A. relationship be included in any such report.

W. E. HARVEY,

Hon. General Secretary.

BOOK REVIEWS

AUTOMATIC PROCESS CONTROL by D. P. Eckman. Published by John Wiley & Sons, Inc., New York 1958. 368 pp. *Price*, 9 dollars.

This book is intended for engineers and advanced students of engineering who are concerned with instrumentation. It gives a very complete coverage of the theory of process control with special emphasis on the analysis of control system characteristics.

Consideration is given first to process characteristics and then to the various components of the control system. Separate chapters are devoted to process instrumentation, sinusoidal analysis and stability analysis.

Extensive use has been made of block diagrams. Liquid flow analogies have been freely employed to illustrate processes.

The book includes references to such special topics as the use of analogue computers or differential analysers for analysis of automatic control systems.

R.M.D.

HANDBOOK OF CHEMICAL MICROSCOPY (Third Edition) by the late Emile Morrin Chamot and Clyde Walter Mason. Published by John Wiley & Sons, Inc., New York, 1958. 502 pp. *Price*, 14 dollars. Volume I: Principles and uses of Microscopes and Accessories; Physical Methods for the Study of Chemical Problems. Volume II: Chemical Methods and Inorganic Qualitative Analysis (to be published later).

This standard work has been completely rewritten by C. W. Mason (Professor of Chemical Microscopy and Metallography at Cornell University). It is a good example of the best type of American textbook, presenting the various aspects of the subject lucidly and informatively and with sufficient introductory material to make them comprehensible to the general chemical practitioner. There are over 1,100 references (to 1957), 132 illustrations and figures and 16 chapters: Microscopes, Illuminations and Preparation of Materials (5); Special Methods for Physical Properties

(1); Photomicrography and Projection (1); Electron Microscopy, Ultramicroscopy, Polarized Light, Refractive Index (4), Crystallography (2); Microscopical Measurements, Particle Size Determination and Quantitative Methods (3).

This authoritative book, covering a somewhat neglected branch of analytical chemistry, can be recommended as a thoroughly interesting and practical treatise.

C.R.B.

PROCESS DYNAMICS, by D. P. Campbell. John Wiley & Sons, Inc., New York, 1958. 316 pp. *Price,* 10.50 dollars.

To the initiated, "Process Dynamics" has a meaning; to the uninitiated the sub-title explains further—The Dynamic Behaviour of the Production Process; to the wary chemical engineer the sub-sub-title expands the title and shows that the book Translates Process Dynamic Performance into Mathematical Form, Showing its Influence upon Control System Design. And the author does just that—in fact, the present reviewer was led to a sense of satisfaction with the form and presentation of the subject matter.

The author comments that designers of industrial control systems tend to rely on the more complex corrective mechanisms of control devices to achieve control stability, but better engineering would result from a better understanding of process lags and process characteristics—in other words, process dynamics. The comment is laudable, the attempt to provide constructive assistance is effective.

Processes are almost infinite in variety, thus the main objective of the author was to systemize, generalize and summarize the many facets of process dynamics. The presentation requires six chapters. First the kinematics of materials handling with an approach that is partly in the sign language of electrical engineering and servo theory. The treatment is extended in the next chapter on fluids in motion. A collective family group, namely forming, propulsion, and guidance is discussed in the third chapter which is a well written example of the use of mathematical synthesis in compacting relevant information in apparently different fields. The fourth chapter deals with thermal process dynamics, and although there is little factual information that is new, the cybernetic approach would be new to many readers and of value to them. Similarly, the next chapter on mass transfer dynamics, and the last chapter on chemical process dynamics, uses the words that typify a chemical engineering text but a method of handling that typifies a text on control engineering.

The mathematics are restrained, sufficiently diluted with descriptive matter, and necessary for the development of the subject. The book is readable and of value to persons who have technical problems associated with the changing characteristics in processing industries.

The book is an example of the effect of cybernetic infiltration into our technical thought-ways. To assist persons with inadequate background for the methods used, appendices on signal flow diagrams, Fourier and Laplace transforms have been added. There is a chapter of grouped problems; the book is well printed and is typical of a modern, attractive technical textbook.

J.K.S.

GROWTH AND PERFECTION OF CRYSTALS, edited by R. H. Doremus, B. W. Roberts and David Turnbull. Published by John Wiley & Sons, Inc., New York, 1958. 609 pp. *Price,* 12.50 dollars.

This volume consists of the papers and discussion presented at the International Conference on Crystal Growth, held at Cooperstown, New York, in August, 1958. Following an introduction by F. C. Frank on the general subject of crystal morphology, symposia were held on the following topics: the growth of whiskers (filamentary single crystals) and their properties, growth of crystals from the melt and from solution, and the crystallization of polymers. Each section is introduced by a comprehensive review presented by a leading worker in the field, the various papers follow, and the lively discussions which resulted are reported *verbatim*. No scientist directly concerned with crystal growth phenomena could consider being without the record of this major conference, but in addition the above-mentioned reviews should make it a most valuable book for all who are interested in the solid state.

D.H.

BOOKS RECEIVED

A copy has been received of a new British journal, 'Lapis industrial opportunities'. Published by Kenneth Mason Publications, 1 Old Burlington Street, London, W.1., this journal is devoted to details of products and new inventions available for manufacture throughout the world under licence. The subscription rate for New Zealand is £10 10s. 0d. STG. per year. The publishers will supply further information and a free copy of the journal on request.

Registered at the G.P.O. as a magazine.