caves and shelters and dividing trenches becomes largely a matter of artistic planning and moderate expenditure.

In this handsome park the Society proposes to instal the larger and more hardy of its animals, its breeding and recuperating animals, and the majority of its duplicates. But apart from foreign imported creatures, Ashridge should become a great British sanctuary, tenanted by native birds, and exhibiting, congregated as they cannot be seen in any other part of the country, the few mammals which still exist, and those which formerly existed, in Britain. The stock in the London Zoo will benefit by reduction, and Regent's Park will become the home of a typical synopsis of the animal kingdom, and of the more delicate creatures which demand special conditions of temperature, feeding, and the like.

The proposed extension of the Scottish Zoological Park is less of an adventure in more ways than one, for since its inception in 1912 the Park has all along been developed on modern lines, and the inclusion of the remainder of its 74 acres, nearly twice the extent of the Regent's Park Zoo, is but the fulfilment of a project which the Council has had in view from the beginning. Nevertheless, it is an impressive scheme. The addition will carry the Park to the ridge of Corstorphine Hill at an altitude of 500 ft. above sea-level, and, while still retaining the southern exposure which has meant so much for the welfare of the animals, will throw open a fine northern prospect across the Firth of Forth and its islands to the hills of Fife and the Highlands of Perthshire. The ground is less amenable to artificial treatment than the chalky subsoil of Ashridge, for the rock is hard and costly to excavate; but the gain is greater than the loss, since Nature has already carved the summit into rocky ridges and hillocks, affording sites which will exhibit at their best such mountain creatures as wild sheep, goats, chamois, and the like. On the lower ridges it is proposed to excavate dens and shelters for carnivores, and to give over a portion to native British mammals, while the pasture land will become ranges for native and foreign deer, bison, etc.

The sole obstacle to the development of this ground is a financial one. Last year the takings showed a modest surplus of £2000, and since the opening of the Park, all its surplus income, amounting to more than £10,000, has been spent in improvements which have added to the comfort of the animals and the attractiveness of the exhibits. To lay out and utilise the new ground, and to provide further improvements in some of the existing enclosures for animals, it is estimated that £25,000 will be required. Since such a sum cannot be obtained from the present income of the Park, the Council has issued an appeal for that amount, so that the Park may become a "National Institution, unrivalled for beauty of site and natural amenity." In furtherance of the scheme, it is announced that a mid-summer carnival and fête will be held in the Park in June. The conspicuous success already attained in the development of a modern zoological park in Edinburgh indicates that the new effort of the Zoological Society of Scotland is worthy of all support.

The Theory of Strong Electrolytes.

THE general discussion on "The Theory of Strong Electrolytes," organised by the Faraday Society at Oxford on April 22 and 23, was rendered noteworthy by the foreign guests who were able to attend and to take part in the proceedings: Bjerrum, Brönsted, and Christianssen from Copenhagen, Fajans from Munich, Hevesy from Freiburg, Hückel (a former colleague of Debye) from Göttingen, Onsager (a present colleague of Debye) from Zurich, Remy from Hamburg, and Ulich (a colleague of Walden) from Rostock, represented the European universities, whilst America was represented by Harned from the University of Pennsylvania and Scatchard from the Massachusetts Institute of Technology. The delegates enjoyed the hospitality of Exeter, Jesus, and Lincoln Colleges, and the informal discussions carried on there were not the least valuable features of the meeting.

It is now forty years since Arrhenius effected a far-reaching change in the theory of aqueous solutions by introducing the conception of electrolytic dissociation, and there can be little doubt that similar importance attaches to the recent development, by Milner, and more recently by Debye and Hückel, of theories based upon the conception of 'complete ionisation' of electrolytes. This conception, although devised in the first instance to explain the behaviour of electrolytes in solution, has received important support from the study of crystalline salts, which has shown that most of them can be pictured as aggregates of oppositely charged ions, in which individual molecules cannot be detected, as well as from the electronic theory of valency, which has provided an explanation of the inability of these ions to effect the transfer of electrons which would convert them into neutral molecules.

The chief weakness of Arrhenius's theory lay in the fact that, although the dissociation of weak electrolytes on dilution with water was in accord with the law of mass action, this law broke down completely in the case of strong electrolytes, *i.e.* of all the common salts, as well as the stronger acids and bases. Many formulæ have been devised in the hope of discovering a law of dilution which should be applied to these perfectly normal, but obstinately intractable, electrolytes; but modern theory has turned back to an old expression of Kohlrausch, $\Lambda_c = \Lambda_0 - a\sqrt{c}$, according to which the equivalent conductivity Λ_c, at concentration c, is less than that at concentration 0, by an amount $a\sqrt{c}$ which is proportional to the square root of the concentration. This law, which can be tested by plotting Λ against $\sqrt{c}$, has been verified for a large number of salts both in aqueous and in non-aqueous solutions, and appears to have a wide range of validity; but the constancy of the index was challenged in a paper by Ferguson and Vogel, who assert that the index varies from 0·38 in barium bromide to 0·635 in lithium perchlorate, although the average for thirty-three salts is only just below 0·5. The theory of Debye and Hückel has the merit of deducing Kohlrausch's law from the fundamental laws of electrostatics, so that the index $\frac{1}{2}$ appears as an echo of the index -2 of Coulomb's law.

The theory of Debye and Hückel is based on the postulate that each negative ion in a solution is surrounded by a region containing an excess of positive ions, and conversely. Such a distribution is quite practicable, since it is realised in the lattice of the crystalline salts; thus, in the case of sodium chloride, the closest neighbours of a sodium ion are 6 chloride ions, followed by 12 sodium ions at a rather greater distance, and then by 8 more chlorine ions at a slightly greater distance still. In electrolysis, this surrounding atmosphere of ions is drawn through the solution, and creates an increased frictional resistance by dragging the solvent with it, as in the phenomenon of electrophoresis. Moreover, since the atmosphere of oppositely charged ions lags behind the ion under consideration, as soon as it begins to move, a retarding electrostatic potential will be set up, the strength of which will depend on the rapidity with which the excess of oppositely charged ions is dissipated in the rear of the moving ion and collected in the new region into which it is advancing. The calculation of the magnitude of these effects presents a very difficult problem in statistical mechanics, but it can be shown in both cases that the resultant decrease of equivalent conductivity is proportional to the square root of the concentration. Kohlrausch's law can therefore be explained as due to variations of ionic mobility, resulting from the phenomenon of interionic attraction, without requiring any variation in the number of ions involved in carrying the current.

The formulæ of Debye and Hückel give results which are not yet in precise numerical agreement with experiment, although a closer agreement is obtained by making use of a modification due to Onsager, in which (by allowing for the Brownian movement of the ions) the numerical factor is reduced in the ratio 1 : 0·586. It is, however, a fact of fundamental importance that the theory of interionic attraction has at last provided a physical basis for Kohlrausch's law, since the earlier theory of electrolytic dissociation led to an entirely different, and incompatible, relationship between conductivity and concentration. On the other hand, it is a disappointment to find the old warning repeated, and in a still more emphatic form, that the formulæ now used are only valid in 'dilute solutions,' and that a close concordance between theory and experiment is not to be looked for in solutions of greater concentration than $N/100$ or $N/1000$, since it was at least reasonable to hope that the new theory of strong electrolytes would be applicable to strong solutions also.

An important question was raised at the discussion as to whether the theory of strong electrolytes requires that *all* the ions must be free, even in solutions of high concentration. The momentary existence of pairs of ions which have insufficient kinetic energy to separate from one another appears to present no difficulty, and may perhaps be covered by the existing equations. Numerical calculations suggest that the number of these neutral doublets is small; but as the new formulæ are only valid for solutions of extreme dilution, no experimental verification of these calculations is possible. On the other hand, Walden's observations of the small conductivity of salts such as $[NEt_4]^+I^-$, when dissolved in solvents of low dielectric capacity, indicate that the proportion of electrically neutral doublets may under some conditions be quite as high as that of the undissociated molecules of Arrhenius's theory. The same conclusion can be deduced in a still more emphatic form from the fact that potassium bromide behaves as an insulator when dissolved in liquid bromine, although phosphorus pentabromide acts as an electrolyte in this solvent.

During the discussion the position was generally adopted of classifying as 'weak electrolytes' all those compounds in which real molecules can be formed from the ions. This classification can scarcely be valid, since hydrochloric acid has all the properties of a 'strong electrolyte,' in spite of the fact that anhydrous hydrogen chloride has just as much claim as hydrogen cyanide to be regarded as a covalent compound. These neutral molecules are, however, so readily ionised by contact with water that it is only in concentrated solutions that they become sufficiently numerous to produce a marked vapour pressure. Since the theory of Debye and Hückel only applies to dilute solutions, it may be taken for granted that no difference would be detected by means of it between a strong electrolyte which is wholly ionised even in the solid state, and one in which the real molecules of the crystal are resolved almost completely into ions by the influence of an ionising solvent; in a hydrocarbon solvent, on the other hand, both types of solute would behave as weak electrolytes.

The problem of solvation was also discussed. Mr. R. H. Fowler expressed the view that, since water behaves as a dipole, it must be attracted towards the ions, and expecially to those of small radius. A pressure gradient would thus be set up which would check the approach of all other ions, whether of similar or of opposite sign. The orientation of the water molecules would be reversed with the sign of the ions, as suggested by Ciamician in 1891, and formulæ expressing this view were included in a paper by Ulich.

The applicability of Stokes's law to ions was repeatedly challenged, as also was Walden's relation between mobility and viscosity; but it seems likely that these relations will continue to be used in future arguments in reference to the mechanism of conductivity, if only as providing a standard from which deviations can be measured. On the other hand, it is equally clear that all such arguments will henceforth be dominated by the theory of interionic attraction, in one form or another. The Faraday Society is therefore to be congratulated on having secured so lively a discussion of the subject. This discussion, with the twenty-seven papers circulated before the meeting, will provide the basis for a most valuable report.

T. M. L.

Obituary.

DR. ABRAHAM LEVIN.

THE tragic death of Dr. Abraham Levin on April 20, within a few minutes of leaving his laboratory at Plymouth, deprives physiology of a young and brilliant worker. A man of versatile talents, he showed from an early age a remarkable mechanical ingenuity and an extraordinary aptitude for engineering. This subject he studied in Rome, but long-continued ill-health, exaggerated in later years by privation during the Russian revolution, prevented him pursuing this study further. He therefore turned to other less exacting activities and studied music at Kieff with great success.

At the outbreak of War, Levin took up the study of medicine at the Crimean University at Simferopol, where he took his M.D. Prof. Gurvitch recognised his ability and made him his assistant. His mechanical bent resulted in the invention of a highly ingenious sphygmometer. Being able to come to England in 1924, his tireless mental energy found an ideal outlet in research with Prof. A. V. Hill at University College, London, and at the Marine Biological Laboratory, Plymouth. Levin's mechanical ability here stood him in the greatest service and enabled him to perform many beautiful experiments on the viscosity and elasticity of muscle and on the action current in nerves, as his published work shows.

Unfortunately, much of Levin's work is not yet finished; he died in the middle of a series of experiments on the action current in Crustacean nerve, which promised to yield results of the highest importance to the theory of nervous conduction and excitation. He was a man of the highest promise in his field of research, and his early death is a very great loss.

C. F. A. P.

THE issue of the *Physikalische Zeitschrift* for Feb. 15 devotes twelve pages to the obituary address delivered in the hall of the Physikalisch-Technische Reichsanstalt at Charlottenburg on Dec. 18 by Dr. F. Henning, following on the death on Sept. 19 of his friend and colleague Dr. C. F. L. Holborn, head of the Heat Section of the Reichsanstalt. Dr. Holborn was born at Göttingen on Sept. 29, 1860, and after attending the local Realschule entered the University in 1879, and passed the government examination for teachers in 1884. He elected not to teach, but entered the Observatory as assistant to Schering in the terrestrial magnetism department, and in 1887 took his doctor's degree with a dissertation on the daily variation of the magnetic elements. In 1890 he joined the Reichsanstalt as assistant and rose gradually to be head of the Heat Section. For a time in 1924 he acted as director of the establishment, and the date of his retirement from office was put three years later than the usual age of sixty-five years. His work on the temperature scale and on the thermal properties of gases has proved of great value for both science and industry.

WE regret to record the death of Sir Philip James Hamilton-Grierson, who died suddenly on Monday, April 25, at Kemnay, Aberdeenshire, at the age of sixty-six years. He was educated at Cheltenham College and Merton College, Oxford, taking his degree in 1876. A member of the Scottish Bar, he held a number of legal appointments in Scotland, was knighted in 1910 and received the honorary degree of LL.D. from the University of Edinburgh in 1920. In addition to editing a number of legal works, he was the author of several articles which appeared in Hastings' "Encyclopædia of Religion and Ethics," but his most important contribution to scientific literature was "The Silent Trade: A Contribution to the Early History of Human Intercourse," a valuable book in which he brought his legal training to bear upon the facts and underlying principles involved in primitive systems of economics and exchange.

WE regret to announce the following deaths:

Dr. A. W. Brightmore, engineering inspector at the Ministry of Health and formerly professor of structural engineering at the Royal Indian Engineering College, Cooper's Hill, on April 20, aged sixty-two years.

Dr. W. Collingridge, formerly Medical Officer to the Port of London and the City of London, on April 29, aged seventy-three years.

Prof. W. H. Dall, palæontologist of the U.S. Geological Survey since 1885 and honorary curator of the Division of Mollusks of the U.S. National Museum since 1869, on Mar. 27, aged eighty-one years.

Mr. E. T. Dumble, consulting geologist in Texas and formerly State geologist, who contributed notably to our knowledge of the economic geology of the Pacific slope, on Jan. 27, aged seventy-four years.

Dr. Charles E. Marshall, director of the graduate school and professor of microbiology at the Massachusetts Agricultural College, on Mar. 20, aged sixty years.

Prof. C. C. Nutting, professor of zoology in the State University of Iowa, and vice-president in 1902 of Section F of the American Association for the Advancement of Science, who was known for his work in marine systematic zoology, and particularly on the Cœlenterata, on Jan. 23, aged sixty-eight years.

Prof. E. H. Starling, F.R.S., Foulerton research professor of the Royal Society and formerly Jodrell professor of physiology in the University of London, on May 2.