The Quantum Equivalent in Photo-electric Conduction.

IF light of frequency ν is sent through a cold gas which does not absorb it, sensitised by admixture of a second gas which can absorb the light; and the pressure is such that the mean time between two collisions is of the same order of magnitude as the mean life of the excited state of the gas; all those spectral lines of the non-absorbing gas appear which have a smaller excitation energy than $h\nu$. On the other hand, those which require more energy than this are not seen. Results with mixtures of mercury and thorium vapours, and of mercury and silver vapours, using the light of the 2536.7 Å Hg line, agree, on the whole, closely with the above statement. The method can also be used in fixing the series relations between the lines of an element, since it allows us to determine which spectral lines can be excited by an amount of energy smaller than a given amount. Results have been obtained at Göttingen for lead and bismuth, which will shortly be published.

In a paper in the *Zeitschrift für Physik*, 17-3, August 23, p. 202, Messrs. G. Carlo and J. Franck consider the theory more closely, and describe experiments which agree with their conclusions. The sensitising gas A has, as the longest wave of its absorption series, a line of frequency ν , while the corresponding line of the fluorescing gas has the frequency ν_1 . Suppose $h\nu : h\nu_1 :: 1 : \frac{1}{2}$; then if light of frequency ν is used, both ν and ν_1 will appear. The elementary act of transmission of energy from an excited atom of A to an atom of B will take place in such a way that $\frac{1}{2} h\nu$ is converted into energy of translation of the colliding atoms. If the temperature is so low that the kinetic energy of temperature movement is small, compared with $h\nu$, the atom receives, besides its excitation energy, the kinetic energy $\frac{1}{2} m_1 v_1^2 = \frac{h\nu}{4} \times \frac{1}{1 + m_1/m}$. This abnormal velocity of the excited atom of B produces a Doppler effect; the effective frequency is $\nu_2 = \nu_1(1 + \cos \phi v_1/c)$, and this is not absorbed by the other practically resting atoms of B .

An experiment with sodium vapour, sensitised with pure argon, has verified the theory. Sodium vapour

can be made to fluoresce by means of the zinc line, 3303 Å, and the sodium can also be excited directly by the D line. Conditions were so adjusted that the tube appeared equally bright with either of these sources, and the light from the fluorescing sodium, in each case, was passed through an absorption tube, containing sodium at a suitable temperature. The light excited by the D line was completely extinguished, while that obtained with the zinc line was much less weakened.

If, in a second experiment, light of frequency ν_1 passes through the mixture of gases A and B , an emission of ν from A can result only if the temperature of the gas is so high that the energy difference $h\nu/4$, which is lacking for the excitation of A , can be obtained on collision from the kinetic energy of the atoms. Experiments have been made with thallium and mercury, and with cadmium and mercury, using the Hg line 2536.7 Å. The quartz vessel containing the vapours was placed in an electric oven, which could be raised to 800° C.; and strong fluorescence was obtained with thallium. In this case it was possible that a thallium line, the excitation energy of which amounts to 5.5 volts, while the energy of 2536.7 Å corresponds to 4.9 volts only, was due to a double or step-by-step process of excitation. At 800° C. part of the atoms are no longer in the normal state; and apparently there is a 1 volt excitation step, from which, up to the 5.5 volts stage, only 4.5 volts would be required, or more than for 2536.7 Å.

With cadmium and mercury this difficulty does not arise, and the confirmation of the theory is direct. It is possible, however, to draw conclusions from the relative intensity of the lines in the fluorescent spectrum of thallium, as compared with the ordinary spectrum of this substance. The differences are ascribed to the differences in absorption, due to the presence or absence of the Doppler effect previously described; and the combined results of the two experiments seem to prove, conclusively, that quantum energy and translation energy can work together, as an elementary act, to produce excitation of the atom.

Early Methods of Oil Painting.¹

By Prof. A. P. LAURIE.

IT is evident both from the manuscript of Theophilus and the manuscript of Eraclius that the properties of such drying oils as linseed oil and walnut oil were thoroughly understood as early as the 12th century, if not earlier.

The methods used in their preparation differ very little from the best practice of to-day. The refining and bleaching of the oil and the use of driers was well understood, nor is there any indication, in passing from those earlier recipes to those of the 15th century, that any new discovery of importance was made at the time of the brothers Van Eyck. Passing to later times, Vasari directs that pigments are to be ground in walnut oil or linseed oil, and this is all that is necessary; he recommends the use of walnut oil as less liable to darken with time.

Many recipes for varnishes are given, and, as neither spirit of turpentine nor alcohol was available in commercial quantities until the end of the 15th century, these varnishes are what we should now describe as oil varnishes, consisting of resins dissolved in hot oil. The natural balsams of the pine, resin, mastic, and sandarac, often all mixed together, were

used in the preparation of these varnishes. The proportion of resinous material to oil being very high, the varnishes were consequently very sticky and had to be heated and rubbed on with the hand. Spirit varnishes corresponding to the mastic varnishes of to-day are found in 16th century and later recipes.

The evidence of the accounts preserved at Ely and Westminster show that both oil and varnish were used in painting on walls during the 13th and 14th centuries, this being the northern tradition, while the Italian tradition was the use of egg as a medium. There is no indication in these recipes of any special secret differing from what we know to-day.

These early pictures were painted on a wood panel sometimes covered with strips of linen and coated with a gesso made of parchment size and whitening or plaster of Paris which had been soaked in water until it lost its binding properties. Recent experiments carried out by Mr. Thompson at the Heriot-Watt College, Edinburgh, on an old 16th century panel have revealed the fact that this panel was coated with a non-absorbent gesso upon which a very thin layer of absorbent gesso was laid so as to ensure the binding of the oil to the surface of the gesso and, at the same time, to preserve from staining the pure white surface

¹ Synopsis of lecture delivered at the Royal Academy of Arts, London, on Wednesday, November 14.

of the gesso below. On this pure white gesso panel the picture was drawn in detail and laid out either in monochrome or partly in colour with pigments probably mixed with size. Upon this were laid the pigments ground in oil, or it may be an emulsion of varnish and egg, care being taken to paint the high lights very thinly as compared with the rest of the picture. In course of time the oil yellows and the pigments, more especially the white lead, get more translucent. By painting the picture in this way the artist ensures that the increased translucency of his white lead will correct the yellowing of the oil owing to the white light being reflected from the gesso, and that his contrast of light and shade will be maintained.

There is much more yet to be discovered as to these early methods, and the question as to whether varnish, emulsion, or oil was used, has still to be finally cleared up, but our knowledge of the general methods of procedure is growing.

The Geological Society of China.

THE Geological Society of China is one of the scientific institutions founded since the establishment of the Chinese Republic in 1911. The first two Bulletins of the Society promise well for its future. One of the first papers deals with the history of geology in China, which it carries back to early times; but it shows that independent Chinese work on the subject on scientific lines dates from 1911, when V. K. Ting and H. T. Chang returned to China from their western studies. Mr. Chang, the first president of the Society, organised a department and school of geology under the Ministry of Commerce at Nanking in 1912. The Geological Survey of China was established in 1916 with Mr. Ting as its director, and he also secured in 1918 the reopening of Mr. Chang's geological school, which had been discontinued in 1916. To Messrs. Ting and Chang is due the establishment of the promising school of Chinese geology. They have been aided by Mr. Lee, a Chinese student who was trained at Birmingham, Prof. Grabau, the well-known American palæontologist, now professor at Pekin, and Dr. Gunnar Andersson, formerly head of the Geological Survey of Sweden, and now mining advisor to the Chinese Government and director of the Geological Survey Museum.

The two Bulletins contain a valuable series of contributions to the geology of China. They include a lecture given to the Society by Prof. Berkey, of Columbia University, New York, on "the New Petrography," which attaches most importance to the mode of origin of rocks; Prof. Berkey proposes a plethora of new names such as reactionite, saturite, evaporite, disintegrationite, and recrystallisationite. The new petrology must be vigorous to sustain such a nomenclature. The section of this paper of most interest is its expression of the reaction in America against the ingenious quantitative arrangement of rocks which is often known as "the American classification." Prof. Berkey represents that classification as mechanical and misleading, and sets it aside as only a side issue in real petrology.

Prof. Grabau contributes three papers, of which the longest is on the Sinian system; he protests against the modified use of that term proposed by Prof. Bailey Willis, who, with the temporary agreement of von Richthofen, interpreted Sinian as Lower Palæozoic. Von Richthofen, however, appears soon to have gone back from that modification of his term. Prof. Grabau justly holds that the term is in that sense useless, and he applies it to the sedimentary formations in China of pre-Cambrian age.

In that sense it is equivalent to the Toridonian, which, as well as the Sinian, Prof. Grabau includes in the Palæozoic.

Mr. Wong contributes a short note upon Chinese earthquakes and on the distribution of the chief seismic centres. The red beds in China are discussed in three papers. Mr. Wong shows that those in Shansi belong to two horizons, one pre-Jurassic and the other later than the Jurassic Coal Measures. Mr. Hsieh shows that in Kansu these deposits range from the Jurassic to the Kainozoic. Mr. Tan describes a marine red series of Eocene age as widely developed in Shantung, and its discovery is one of the most interesting recent additions to Chinese geology.

Three papers by students of the University of Pekin on observations during an excursion to the Nankou district add materially to the knowledge of that now classical section. Prof. Grabau describes from their collections three new species of *Collenia*, which he explains are based only on the external characters; in the absence of microscopic evidence it must be quite doubtful whether these supposed calcareous algæ are of organic origin. Prof. G. B. Barbour, of the Pei-yang University, Tientsin, describes an intrusive sill in Shantung which, according to his interpretation, shows the effect of gravitational differentiation. The intrusion is pre-Cretaceous, and the later folding and faulting in this region are now definitely identified as Oligocene or Miocene, as the movements are later than the newly discovered Eocene deposits and earlier than the Pliocene.

The two volumes are in English, with a title-page and contents and a summary of one paper in Chinese. Chinese characters are given of the personal names. The titles of some papers which are to be published in future bulletins suggest that the interest of this serial will be well maintained.

J. W. GREGORY.

University and Educational Intelligence.

ABERDEEN.—The Senatus Academicus has awarded the following research scholarships: Fullerton scholarship in science to Mr. Charles Bisset; Robbie scholarship in chemistry to Miss Margaret F. Aitken.

A mural tablet in memory of the late Prof. James W. H. Trail, F.R.S., professor of botany in the University from 1877 until his death in 1919, has been placed in the classroom of the new Department of Botany, and was unveiled and presented to the University, on behalf of the subscribers, by Sir David Prain, on Friday, December 7. The tablet is mounted on a slab of slate. A portrait plaque in dull green bronze is surrounded by a wreath of oak leaves, acorns, and galls. It is flanked by two Brazilian palms, and a decorative panel shows other natural objects representing the varied interests of Prof. Trail. The tablet is the work of Miss Alice B. Woodward. The subscribers have also issued a memorial volume which, besides biographical and bibliographical matter, includes the "Flora of the City Parish of Aberdeen," a comparative and historical work of great detail which had occupied Prof. Trail for many years, and had been completed shortly before his death.

CAMBRIDGE.—A fellowship has been founded at Christ's College by Mr. J. Pierpont Morgan, a member of the College. This is the first addition to the number of fellowships in the College since 1682, and represents a valuable endowment all too rare in these modern times.

The Empire Cotton Growing Corporation has offered to the University a sum of 1000*l.* a year for five years to be devoted to the Plant Genetics Depart-