thorium-I were non-separable by chemical processes, and had a chemical character not merely like, but identical. It followed that some of the common elements might similarly be mixtures of chemically identical elements. In the cases cited the non-separable pairs differ in atomic weight from two to four units. Hence the lack of any regular numerical relationships between the atomic weights would, on this view, follow naturally (Trans. Chem. Soc., 1911, vol. xcix., p. 72). This idea was elaborated in the Chemical Society's Annual Report on Radio-activity for 1910, in the concluding section summing up the position at that time. This was, I think, the beginning of the conception of different elements, identical chemically, which later came to be termed "isotopes," though it is sometimes attributed to K. Fajans, whose valuable contributions to radio-activity had not at that date commenced, and whose first contribution to this subject did not appear until 1913.

In the six or seven years that have elapsed the view has received complete vindication. Really three distinct lines of advance converged to a common conclusion, and, so far as is possible, these may be disentangled. First there has been the exact chemical characterisation from the new point of view of every one of the members of the three disintegration series with lives over one minute. Secondly came the sweeping generalisations in the interpretation of the periodic law. Lastly there has been the first beginnings of our experimental knowledge of atomic structure, which got beyond the electronic constituents and at the material atom itself.

In pursuance of the first, Alexander Fleck, at my request, commenced a careful systematic study of the chemical character of all the radio-elements known, of which our knowledge was lacking or imperfect, to see which were, and which were not, separable from known chemical elements. Seldom can the results of so much long and laborious chemical work be expressed in so few words. Every one that it was possible to examine was found to be chemically identical either with some common element or with another of the new radio-elements. Of the more important characterisations, mesothorium-II was found to be non-separable from actinium, radium-A from polonium, the three B-members and radium-D from lead, the three C-members and radium-E from bismuth, actinium-D and thorium-D from thallium. These results naturally took some time to complete, and became known fairly widely to others working in the subject before they were published, through A. S. Russell, an old student, who was then carrying on his investigations in radio-activity in Manchester. Their interpretation constitutes the second line of advance.

Before that is considered, it may first be said that every case of chemical non-separability put forward has stood the test of time, and all the many skilled workers who have pitted their chemical skill against Nature in this quest have merely confirmed it. The evidence at the present day is too numerous and detailed to recount. It comes from sources, such as in the technical extraction of mesothorium from monazite, where one process is repeated a nearly endless number of times; from trials of a very great variety of methods, as, for example, in the investigations on radium-D and lead by Paneth and von Hevesy; it is drawn from totally new methods, as in the beautiful proof by the same authors of the electrochemical identity of these two isotopes; it is at the basis of the use of radio-active elements as indicators for studying the properties of a common element isotopic with them, at concentrations too feeble to be otherwise dealt with; and from large numbers of isolated observations, as well as prolonged systematic researches. One of the finest examples of the latter kind of work, the Austrian researches on ionium, will be dealt with later. The most recent, which appeared last April, is by T. W. Richards and N. F. Hall, who subjected lead from Australian carnotite, containing therefore radium-D, to more than a thousand fractional crystallisations in the form of chloride without appreciably altering the atomic weight or the β activity. So that it may be safely stated that no one who has ever really tested this conclusion now doubts it, and, after all, they alone have a right to an opinion.

This statement of the non-separability by chemical methods of pairs or groups of elements suffers perhaps from being in a negative form. It looks too much like a mere negative result, a failure, but in reality it is one of the most sweeping positive generalisations that could be made. Ionium, we say, is non-separable from thorium, but every chemist knows thorium is readily separated from every other known element. Hence one now knows every detail of the chemistry of the vast majority of these new radio-elements by proxy, even when their life is to be measured in minutes or seconds, as completely as if they were obtainable, like thorium is, by the ton. The difference it makes can only be appreciated by those who have lived through earlier days, when, in some cases, dealing with the separation of radio-constituents from complex minerals, after every chemical separation one took the separated parts to the electroscope to find out where the desired constituent was.

As the evidence accumulated that we had to deal here with something new and fundamental, the question naturally arose whether the spectrum of isotopes would be the same. The spectrum is known, like the chemical character, to be an electronic rather than mass phenomenon, and it was to be expected that the identity should extend to the spectrum. The question has been tested very thoroughly, by A. S. Russell and R. Rossi in this country, and by the Austrian workers at the Radium Institut of Vienna, for ionium and thorium, and by numerous workers for the different isotopes of lead. No certain difference has been found, and it may be concluded that the spectra of isotopes are identical. This identity probably extends to the X-ray spectra, Rutherford and Andrade having shown that the spectrum of the γ-rays of radium-B is identical with the X-ray spectrum of its isotope lead.

(To be continued.)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE Merthyr Education Committee has accepted with thanks an offer from Mr. H. Seymour Berry to equip a technical mining and engineering institute at a cost of 10,000*l.*, in commemoration of the part his late father, ex-Alderman J. M. Berry, had taken in the public life of the town.

THE trustees of the Beit Fellowships for Scientific Research, which were founded and endowed four years ago by Mr. Otto Beit in order to promote the advancement of science by means of research, have recently elected Mr. Leslie Hartshorn to a fellowship. Mr. Hartshorn will carry out his research in the Imperial College at South Kensington.

A CONFERENCE on new ideals in education is to be held at Bedford College, Regent's Park, London, on August 14-21. The inaugural address will be delivered by the President of the Board of Education, Mr. H. A. L. Fisher, on August 15 at 10 a.m. Among the subjects and speakers we notice the following: On August 15, Mr Frank Roscoe, on the mind of youth; on August 16, Prof. Bompas Smith, on problems of the urban continuation school; on

August 17, Mr. R. G. Hatton, on the problem of the rural continuation school; and on August 18, Mr. W. G. W. Mitchell, on some new ideals in geometry teaching, and Miss Dewdney, on self-instruction in elementary arithmetic. The committee invites teachers conducting experiments in education to communicate with the secretary, 24 Royal Avenue, Chelsea, S.W.3.

AT the meeting of the London County Council Education Committee on July 11 the applications of the governing bodies of the London polytechnics for grants from the Council were considered. The committee decided to recommend that grants for the year 1917-18 only be made, as it was felt that in the circumstances of the present times it is impossible to forecast the position three years ahead. Eventually the following block grants for 1917-18 were decided upon: Battersea Polytechnic, 11,133*l.*; Birkbeck College, 7100*l.*; Borough Polytechnic, 9100*l.*; City of London College, 4040*l.*; Northampton Polytechnic, 4400*l.*; Northern Polytechnic, 9650*l.*; Regent Street Polytechnic, 14,300*l.*; Sir John Cass Technical Institute, 4000*l.*; South-Western Polytechnic, 7300*l.*; Woolwich Polytechnic, 9700*l.* A special grant of 1567*l.* was made to the governing body of Battersea Polytechnic for the establishment of a superannuation fund for the teachers in the secondary school.

WE have recently noticed with satisfaction the signs of an improved temper on the part of professed "humanists" with respect to the position to be accorded to natural and experimental science as an element in general education. The attention of our readers has been directed within the last few months to articles by writers so important as Mr. A. C. Benson and Lord Bryce. Now we have another even more sympathetic utterance from the Master of Balliol College, Oxford, who contributes to the *English Review* an expression of his views on "Natural Science in Education," beginning with the following words: "If there is one lesson more than another which the war is going to teach us, it will be the lesson as to the future place of natural science in our education." This is fairly obvious, and from one point of view almost a commonplace, for the majority of the public look to science merely for the sake of its practical application. It is not so much the invention of new flying machines or the discovery of new explosives that the world requires, but more exact knowledge in every direction. Science purifies common observation and teaches the nature and use of evidence. By science we learn something of the rules of the universe, and their control of the conditions under which human life exists. These rules cannot be ignored, and, as the writer remarks, "how powerless against them is even the best Parliamentary debating." Then there is the further and deeper influence which can only be justly expressed by the term "spiritual"—that effect of mingled awe and exultation which is produced when science opens out some profound vista of the universe. All the methods to be used in education require good teachers, and therein lies one of the difficulties of the time immediately ahead of us. The author touches on many of the questions concerning which debate is still going on, such as, for example, the already generally overloaded curriculum. While it is comforting to reflect that the best classical teachers admit that there has been a great deal of wasted drill in grammar and composition, it is the ignorance and apathy of the public which are to blame in having so long accepted without stronger remonstrance the purely bookish character of the system under which our boys and girls have been brought up.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 28.—Sir J. J. Thomson, president, in the chair.—Sir Robert **Hadfield,** Ch. **Chéneveau,** and Ch. **Géneau**: A contribution to the study of the magnetic properties of manganese and of some special manganese steels. (1) The research has had for its object the investigation of the mass-susceptibility of manganese metal, and of certain of its alloys with iron and other metals. The work was carried out on a Curie-Chéneveau magnetic balance. (2) Manganese itself, when free from occluded gases, is para-magnetic, its value of χ being $+11{\cdot}0\times10^{-6}\pm2$ per cent. This corresponds on Weiss's theory to a number of magnetons equal to 6. The removal of occluded gases is essential, as the ferro-magnetic properties of certain specimens of manganese are shown to be due to the presence of hydrogen. (3) The manganese alloys investigated, with one exception, are all para-magnetic, χ varying from $17{\cdot}0\times10^{-6}$ to $259{\cdot}0\times10^{-6}$. The exception mentioned is a silico-manganese steel containing 6 per cent. of silicon, which is distinctly ferro-magnetic. (4) An endeavour is also made to correlate the values of the mass-susceptibility with the composition of the alloys. In this connection it has been shown that the quantity of manganese within the limits investigated has very little influence upon the susceptibility, whilst increase of carbon tends to decrease it. In general it is concluded that in these special steels the susceptibility decreases as the carbon-manganese ratio increases. (5) The carbon-manganese ratio being constant, addition of chromium, nickel, or tungsten raises the susceptibility. (6) The addition of copper to a manganese-nickel steel also raises the susceptibility—this notwithstanding the diamagnetism of copper.—W. R. **Bousfield**: Note on the specific heat of water. Replying to criticisms by Callendar (Bakerian Lecture, Phil. Trans., A, 212, p. 1, 1912) on the methods for investigating the specific heat of water described in a former paper (W. R. Bousfield and W. Eric Bousfield, Phil. Trans., A, 211, p. 199, 1911), it is pointed out that the observations of Callendar do not substantially affect the question as to which figures are more correct in the lower range of temperature from 0° to 40° or 50° C. Callendar and Barnes differ from other observers in placing the minimum value for the specific heat of water in the neighbourhood of 40° C., whilst other observers put it at about 25° C.—W. R. **Bousfield** and C. Elspeth **Bousfield**: The specific heat of aqueous solutions with special reference to sodium and potassium chlorides. The specific heats of solutions of NaCl and KCl ranging from saturated solutions to quarter-normal solutions at mean temperatures of 7°, 20°, and 33° C. have been determined by the method and apparatus used for the determination of the specific heat of water and described in a former paper (Phil. Trans., A, 211, p. 199, 1911). The corresponding densities have also been determined. The relation of the specific heat of the solution to the specific contraction of the water is studied, and it is shown that the specific heat of a series of solutions of different concentrations may be reckoned on the hypothesis that the specific heat of the solute is constant, whilst the mean specific heat lowering of the water is proportional to the specific contraction of the water. The temperature variations of the specific heats of the solutions are also compared with the temperature variations of the specific heat of water. The minimum value on the temperature-specific heat curve, which occurs at about 25° C. in the case of water, disappears altogether in solutions of half-normal to normal strength. This curve for the most concentrated solutions becomes a straight line.—