THE CHEMISTRY OF THE RADIO-ELEMENTS

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649436750

The Chemistry of the Radio-Elements by Frederick Soddy

Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

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FREDERICK SODDY

THE CHEMISTRY OF THE RADIO-ELEMENTS

Trieste

Monographs on Inorganic and Physical Chemistry

EDITED BY

ALEXANDER FINDLAY, M.A., PH.D., D.Sc.

Professor of Chemistry University College of Wales, Aberystwyth

To those engaged in guiding the reading of advanced students of Chemistry, the difficulty of obtaining adequately summarised accounts of the progress made in recent years, more especially along certain of the more actively pursued lines of advance, becomes ever more acutely felt. So great has now become the volume of chemical investigation, and so numerous the channels of its publication, that not only the Honours Student but also the worker desirous of undertaking Research in one or other department of his subject, feels it a growing difficulty to become *au fait* with the present state of the more important and more strenuously cultivated regions of his Science. To assist these two classes of students—those reading for an Honours Degree, and those undertaking Research—is the main aim of the present Series of Monographs.

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Arrangements have already been made to publish the following monographs, and should these prove themselves to be of value, others will be issued from time to time.

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MONOGRAPHS ON INORGANIC AND PHYSICAL CHEMISTRY

EDITED BY ALEXANDER FINDLAY, D.Sc.

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BY

FREDERICK SODDY, F.R.S.
LECTURER IN PHYSICAL CHEMISTRY AND RADIOACTIVITY IN THE UNIVERSITY OF GLASGOW

LONGMANS, GREEN AND CO.
39 PATERNOSTER ROW, LONDON
NEW YORK, BOMBAY, AND CALCUTTA
1911

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to the present day, in spite of numerous attempts, it has neither been found possible to destroy or diminish the radioactivity of a radio-element by any artificial process nor to cause an element which is not radioactive to become so. The radioactive process goes on at a definite rate and in a definite way which it is at present quite impossible to influence. This, of course, applies to the whole process. In many chemical and physical operations the radioactivity appears to be diminished or removed just as a candle burning in air appears to be destroyed. This is often simply accounted for by the escape during the process of radioactive gases or "emanations," as such have come to be styled. The sum total of radioactivity is not affected by any operation yet tried. In spite of the existence at one time of a vague belief (a belief which has no foundation), that all matter may be to a certain extent radioactive, just as all matter is believed to be to a certain extent magnetic, it is recognised to-day that radioactivity is an exceedingly rare property of matter. Of the eighty or more elements known in 1896, the year of the first discovery of the property, two only, uranium and thorium, are certainly radioactive in the now accepted full sense of that term. These two elements are at the end of the Periodic Table with the heaviest atoms known (238.5 and 232.4), and before them in the Table is a great gap, the next heaviest atoms being those of bismuth (208.0) and lead (207.1) (O = 16). Radioactivity has peopled this gap with thirty new elements. Two other elements, potassium and rubidium, possess a feeble indication of a radioactivity of a peculiar kind, but it is far from proved that this radioactivity is of the same nature as in the case of uranium and thorium, and for the present it need not be further considered. To-day, however, some thirty distinct types of radioactive matter are known with certainty, each with a definite and characteristic kind of radioactivity. Radioactivity is an atomic phenomenon, and each of these new types is fully entitled to be considered a new atom, and therefore a new chemical element. These are all derived from natural minerals containing uranium or thorium, and their isolation and identification as separate individuals is due entirely to the delicacy of radioactive methods,

which far surpass in this respect the utmost that the spectroscope can accomplish.

The first discovered of these new radio-elements were radium, polonium,[2] and actinium.[3] They were derived from the working up of large quantities of pitch-blende (impure uranoso-uranic oxide, U_3O_8) from the Joachimsthal mine in Bohemia. Latterly a similar study of the thorium minerals has resulted in the isolation of similar new radio-elements of technical value, mesothorium and radiothorium. In all of these the radioactivity of the material is relatively enormous compared with that of uranium, and is more or less permanent. Of these new types of chemical elements only radium and its first product, the radium emanation, have been thoroughly examined in the same way as the ordinary elements. For these the atomic weight has been directly determined and the spectrum mapped. All the others either exist in too small quantity for this yet to have been possible, or are incapable of being separated from the inactive elements with which they are always associated in the mineral. In radium and actinium no diminution of the radioactivity with time after separation has yet been observed, and the same is true of the common radio-elements, uranium and thorium, while in the others a slow decay over a period of years takes place. Besides these, numerous other types of radioactive matter are known which are more transitory, lasting in the various cases only months, days, hours, minutes, or even seconds.

Some of the earliest of these types of transitorily radioactive matter to be studied were the emanations.[4] The radio-elements, thorium, radium, and actinium, but not uranium or polonium, produce, in addition to radiations, what are known as radioactive emanations, and the two phenomena must on no account be confused. A current of air passed through the first-named substances, preferably in solution, carries away radioactive gases or "emanations" which give out rays of similar kind to those from the other radioactive elements. The radioactivity of the emanations is, however, transient, lasting a few days in the case of radium, a few minutes in the case of thorium, and a few seconds in the case of actinium. The emanations can all be condensed out from the air at the temperature of liquid