irradiation; they both showed, after the first hour, an activity regularly decaying with a half period of about six hours, corresponding to E. Fermi's radiobromine [E. Fermi and co-workers, *Proc. Roy. Soc.* (London), **146,** 483 (1934)]. The other radiobromine, with a period of thirty minutes, as well as the sodium products, had mostly decayed in the first two hours. The activity of the *first* preparation, treated with bromine, *was 2.5 times smaller*, than the *second*, proving that an exchange of bromine atoms had taken place.

It is most probable that the exchange mechanism is described by the reactions

$$\begin{tikzcd} NaBr \arrow[r, leftrightarrows] & Na^+ + Br^- \arrow[d, shift left] \\ Br_2 + H_2O \arrow[r, rightleftarrows] & Br^- + H^+ + HOBr \arrow[u, shift left] \end{tikzcd}$$

If complete exchange has taken place, the ratio of activities should correspond to the mass ratio of free bromine to bromide bromine or equal 3.0:1. The observed deviation is surely due to the fact that part of the bromine has escaped the exchange mechanism, probably because the rate of evaporation was faster than the slow rate of hydrolysis [see W. C. Bray, THIS JOURNAL, **32,** 938 (1910); W. C. Bray and E. L. Connolly, *ibid.*, **33,** 1487 (1911); G. Jones and M. L. Hartmann, *Trans. Am. Electrochem. Soc.*, **30,** 295 (1917)]. This point shows that it also will be possible to measure, besides exchanges, reaction velocities and other phenomena.

The artificial radioelements will be of great value for the investigation of the mechanism of catalytic reactions. Especially radio-isotopes of carbon, nitrogen and oxygen (?) will, like the heavier stable isotopes of these elements, open, if available in sufficient quantity, an unlimited field of investigation in organic and biological chemistry.

Acknowledgments.—It is a pleasure to acknowledge our indebtedness to Dr. M. Cutler, of Michael Reese Hospital, and to Dr. H. Scott and Dr. E. Williams of Hines Veterans Hospital for the radon source, to Dr. W. D. Harkins for the loan of beryllium and to Mr. J. Allen, of the Physics Department, for his advice and help in building the counter. This work was partly supported by a grant from the Chemical Foundation.

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CATALYTIC EXCHANGE OF DEUTERIUM AND METHANE

Sir:

The researches of Hollings and Griffith [*Nature*, **129,** 834 (1932)] and of Turkevich, Howard and Taylor [THIS JOURNAL, **56,** 2254, 2259 (1934)] have shown, by adsorption measurements, that, on a variety of catalysts, activated adsorption of hydrocarbons may occur. The latter work shows that activated adsorption of ethylene occurs generally in a much lower range of temperature than that of the saturated hydrocarbons. Recent studies of Farkas, Farkas and Rideal [*Proc. Roy. Soc.* (London), **A146,** 630 (1934)] and of Horiuti, Ogden and Polanyi [*Trans. Faraday Soc.*, **30,** 663, 1164 (1934)] indicate that exchange between deuterium and unsaturated hydrocarbons can be achieved readily at surfaces of platinum, nickel and copper. These workers also show that the exchange with saturated hydrocarbons does not occur under conditions where the exchange with ethylene occurs rapidly. Using the technique developed in our earlier photochemical studies [THIS JOURNAL, **57,** 383 (1935)] we have examined the exchange, at reduced nickel catalyst surfaces, between deuterium and methane, choosing this latter as probably the most refractory and thermodynamically most stable of the hydrocarbons. By examining the infra-red absorption spectra of the products we have shown that deuterium and methane exchange to yield deutero-methanes in the temperature range 184–305°. At the upper temperature, equilibrium, which is on the heavy methane side, is established within twenty hours. At 218°, in the same time, the equilibrium position is not yet established, but, in fifty hours, equilibrium is obtained. The conversions are slower still at 184°. At 110° even in ninety hours no measurable formation of deutero-methane can be established. Curves of reaction velocity indicate very slow rates of exchange below 170°. We believe that this is evidence that the exchange reaction requires activated adsorption of methane, since other researches [Gould, Bleakney and Taylor, *J. Chem. Phys.*, **2,** 362 (1934)] indicate abundant activation of the deuterium at such surfaces under the given conditions. If our assumption is correct, the activated adsorption of methane is thus demonstrable at temperatures as low as 170°, which is at least 200 degrees lower than this is detectable by adsorption measurements. We assume that activated adsorption is accompanied by a dissociation into fragments, *e. g.*, CH_3 and H from which, by recombination with adsorbed deuterium and subsequent repetition of the several processes, equilibrium concentrations of the deutero-methanes finally result. We are prosecuting this study in a quantitative direction and also catalytically, since we have, in this exchange reaction, an important tool for catalytic research in the important field of saturated hydrocarbon reactions. We are again indebted to Dr. R. B. Barnes of the Palmer Physics Laboratory for the use of his infra-red spectrometer.

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RECEIVED FEBRUARY 21, 1935

THE BETA-PARTICLE FROM ACTINIUM

Sir:

Through the use of a screen-wall tube counter [Libby, *Phys. Rev.*, **46**, 196 (1934)] the upper limit of the energy spectrum of the previously undetected actinium electron has been determined. The actinium was shown to be free from members of the radium and thorium series by precipitating lead sulfide from the sample and measuring the decay curve of the gamma activity. This curve was exponential with a half-life of thirty-seven minutes, in excellent agreement with the known half-life of actinium B. A sample sufficient to give a count of approximately 100 electrons per minute was mounted in a very thin layer. The magnetic field strength necessary to bend out the most energetic electrons corresponds to an $H\rho$ of about 1750 gauss.-cm., or an energy of about 220,000 electron-volts. The fact that 60% of the particles are absorbed by an aluminum screen with a thickness of 0.0023 g./cm.^{2} is in agreement with this value. This energy limit would place actinium on the lower Sargent curve [Sargent, *Proc. Roy. Soc.* (London), **A139**, 659 (1933)].

The actinium sample was prepared by extraction from Colorado uranium residues and is chiefly cerium and other rare earth chlorides. The sample was treated as follows. Small amounts of salts of barium, lead, and thorium were added, as bodies for the precipitation of the decay products of actinium. The precipitation of barium chromate removed actinium X, the actinium B and C was carried down with lead sulfide, and finally the radioactinium was coprecipitated with thorium peroxyhydroxide. The thorium was previously purified to remove mesothorium I and II, to prevent contamination of the sample with the latter, which is isotopic with actinium. The other decay products are so short-lived that their effect disappears before the activity can be observed.

It is planned to measure the energy spectrum of the disintegration electrons by means of an apparatus to deflect beams of definite energy into a counter.

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RECEIVED FEBRUARY 4, 1935

NEW BOOKS

A Textbook of Inorganic Chemistry. By FRITZ EPHRAIM. Second edition, revised and enlarged, translated from the fourth German edition by P. C. L. Thorne. Gurney and Jackson, 33 Paternoster Row, London, E. C. 4, England, 1934. 873 pp. Price, 28s./- net.

This second English edition, based on the fourth German edition, is larger than the first edition by nearly one hundred pages. This is due, not to any major change, since the titles and arrangement of the thirty individual chapters remain unaltered, but rather to the insertion throughout of many items representing the progress in inorganic chemistry achieved in the interim. The new edition, therefore, retains the characteristics and outstanding virtues of the earlier edition and of the German original, namely, a simplified and eminently readable presentation of a great amount of information in a relatively brief compass.

ARTHUR B. LAMB

Anwendungen der Röntgen- und Elektronenstrahlen, mit besonderer Berücksichtigung organisch-chemischer Probleme. (Application of Röntgen and Electron Rays, with Particular Consideration of Organo-chemical Problems.) By Professor Dr. J. EGGERT, Berlin, and Professor Dr. E. SCHIEBOLD, Leipzig. Akademische Verlagsgesellschaft m. b. H., Markgrafenstrasse 6, Leipzig C 1, Germany, 1934. vii + 190 pp. 101 figs. 16 × 23.5 cm. Price, RM. 18.00; bound, RM. 19.50.

Some lectures delivered at the meeting of the "Deutsche Bunsengesellschaft" in Bonn on May 19, 1934, are here