

PHYSICS

 α -Radioactivity of Cerium-142

JOHNSON AND NIER¹ have measured the atomic masses of some of the rare-earth isotopes and have shown that the mass difference cerium-142—(barium-138 + helium-4) is equivalent to 1.68 ± 0.10 MeV. Similar results for the naturally occurring samarium and neodymium isotopes show that the α -active isotope of each element is the one having the largest possible decay energy. Rasmussen and others² suggest that the two or three neutrons just beyond the closed shell of 82 neutrons have decreased binding energies and hence the α -energy has a maximum about 84 neutrons. Johnson and Nier suggest that the α -decay of cerium-142 may take place with enough energy to be experimentally observable. Porschen and Riezler³ examined a sample of unenriched cerium ammonium citrate using nuclear track plates sensitive to α -particles. No α -activity was observed after a 30-day exposure of 1.2 mgm. of the cerium salt. In 1957 Riezler and Kauw⁴ reported an alpha activity for an enriched sample of cerium-142. From their results they calculated a half-life of 5.1×10^{15} years with an uncertainty factor of 2.

A sample of cerium oxide enriched in cerium-142 was made available by the Oak Ridge National Laboratory to check the α -radioactivity by an emulsion technique. Mass spectrographic and semi-quantitative spectrochemical analyses showed the heavy-element contaminant reported was neodymium whose abundance was < 0.3 per cent. This amount of neodymium would not significantly affect the results.

In this experiment we were primarily interested in showing that the α -activity, if detectable, could be ascribed directly to the cerium salt. To eliminate contamination in process chemicals, the oxide powder (300 μ gm.) was loaded directly on a type C-2 Ilford nuclear track plate. The cerium oxide containing 90.2 per cent cerium-142 was exposed for 125 days. After a thorough examination of the nuclear plate at the end of the exposure period no alpha tracks were visible emanating from the particles of cerium oxide, contrary to the observation of Riezler and Kauw.

A similar plate containing unenriched impure cerium oxide was also exposed for the same period as a control. Several tracks were found emanating from the surface of the particles. In each case the α -track was shorter than those we have observed for the thorium or uranium series when radioactive mineral grains are embedded in an emulsion in a similar manner. The few short α -tracks observed on the control plate are believed to be from a samarium contaminant in the impure cerium oxide.

Although this experiment is considered as only qualitative, it is of interest to make a rough estimate of the half-life. After considering self-absorption, non-uniform loading of the crystals and correcting for geometry we can assume that about ten per cent of the cerium salt is actually exposed to the emulsion. Although no activity was observed one should consider that statistically a count of 1 ± 1 is possible⁵. Thus, if a maximum of two alpha tracks were observed, this would correspond to a minimum half-life of about 10^{16} years. This qualitative half-life, although based on negative results, agrees with Riezler and Kauw within the uncertainty factor they

have quoted. For an α -decay energy of 1.68 MeV. one can calculate a half-life of 9×10^{18} years for cerium-142 assuming a one-body model as outlined by Biswas⁶. If the half-life is this long, one could just detect the activity with 10 mgm. of the enriched material and probably the order of several hundred milligrams would be required to make a good half-life determination.

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² J. O. Rasmussen, S. G. Thompson, and A. Ghiorso, *Phys. Rev.*, **89**, 33 (1953).

³ W. Porschen and W. Riezler, *Z. Naturforsch.*, **9**, A, 701 (1954).

⁴ W. Riezler and G. Kauw, *Z. Naturforsch.*, **12**, A, 665 (1957).

⁵ G. Friedlander and J. W. Kennedy, "Introduction to Radiochemistry", 1212 (John Wiley and Sons, Inc., New York, 1949).

⁶ S. Biswas, *Indian J. Phys.*, **23**, 51 (1949).

Colour Centres produced by Radiation in Silica Gel

COLORATION of inorganic solids by ionizing radiations has been well known and studied for many years. The possibility that defects associated with such colour might bear a relation to the processes of adsorption and catalysis has been suggested¹, but never directly observed. We have recently observed that the procedure which produces radiation enhancement of catalytic activity in silicas², that is, irradiating a gel degassed at 500° C. or above with comparatively small ($\sim 10^{19}$ eV./gm.) doses of cobalt-60 γ -rays or 50 keV. X-rays also produces a marked magenta coloration of the gel. The comparative rarity of such observations^{3,4}, and their possible connexion with the radiation enhancement of catalytic activity² have prompted this communication.

The colour produced probably corresponds to the broad absorption band at 500–600 $m\mu$ observed in irradiated quartz and vitreous silica⁵, and is stable to light and to temperatures less than 250°. We now find that contact with excess hydrogen or ethylene at room temperature bleaches it instantaneously. The colour is less rapidly discharged by water vapour or ammonia; the action of mercury vapour is somewhat sluggish. Oxygen is without effect. Activation energy is required for the hydrogen bleaching, for the colour is not removed by contact with excess hydrogen at –196° C. for 1 hr. At –78° C. the gel is decolorized in 15 min. The action of water vapour proceeds by diffusion of the water into the solid, rather than by migration of electrons or holes, for if the coloured grains are exposed to moist air they bleach first around the edges, lastly in the centre. Reheating gradually to 300° C. after hydrogen bleaching does not regenerate the colour or desorb more than a few per cent of the adsorbed hydrogen.

Adsorption of hydrogen at room temperature by freshly degassed silica gel is either extremely slow or vanishingly small; hence, by measuring the amount of hydrogen adsorbed after irradiation, one can determine the number of colour centres. The simultaneous