decaying in the same manner as the starting substance, whose decay is shown in curve *c*. This small long-lived tail, which we followed for 24 hours, arises from the bromide liberated in the spontaneous chemical reaction. By repeating the experiment, but with an elapse of 26 hours between the end of the bombardment and the beginning of the chemical reaction, a decay very similar to curve *a* was obtained. These two runs also showed that the upper state (parent substance) was decaying with a half-life of approximately four hours. By comparing curves *b* and *c*, and by taking into account that curve *b* started 27 minutes after the end of the chemical reaction, it can be seen that most of the nuclei in the upper state decay by falling to the lower state from which the observed disintegration electrons are emitted.

DeVault and Libby have applied our method of separation to other bromine compounds and will report their findings shortly.

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E. Segrè
R. S. Halford
G. T. Seaborg

Radiation Laboratory,
Department of Physics,
Department of Chemistry,
University of California,
Berkeley, California,
January 13, 1939.

[1] L. Szilard and J. A. Chalmers, Nature **134**, 462 (1934).
[2] W. Weizsäcker, Naturwiss. **24**, 813 (1936).
[3] B. Pontecorvo, Phys. Rev. **54**, 542 (1938).
[4] E. Segrè and G. T. Seaborg, Phys. Rev. **54**, 772 (1938).

Evidence for Gamma-Radioactivity of 4.5-hour Br^{80} from Radiobromate

In the course of work on the chemistry of the decomposition of bromoform caused by the recoil from the neutron-capture gamma-radiation, it was noticed that the radioactive bromine persisted in coming out of the molecule over a long period of time after the irradiation ceased. This remained unexplained until Dr. E. Segrè (cf. preceding Letter to the Editor) proposed a method of separation of nuclear isomers and that the 4.5-hour Br^{80} isomer was converted to the 18-minute form by emission of a soft highly forbidden gamma-ray. It was found that most of the activity in the later extracts decayed with the 18-minute half-life although no 18-minute bromine not grown from the 4.5-hour isomer could have been present in the bromoform extracted at the time.

Simultaneously with the later experiments on bromoform, work on the chemistry of the neutron-capture gamma-ray recoil for bromate ion gave evidence for the effect which was considerably more definite because it was possible to purify the BrO_3^- solution completely for bromine of lower valence by precipitation of AgBr from BrO_3^- solution 2.5 molal in NH_4OH.

Figure 1A is a typical decay curve for a AgBr precipitate

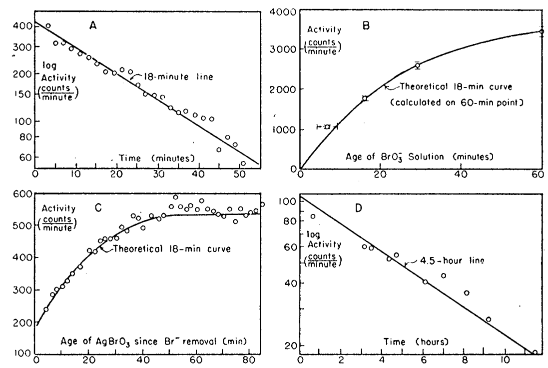

Fig. 1. Growth and decay curves. A, decay of AgBr precipitate; B, growth curve for AgBr precipitates; C, growth curve for $AgBrO_3$ purified for Br^-; and D, decay of AgBr activity with 4.5-hour mother BrO_3^-.

obtained from a mother BrO_3^- solution which had stood several hours so the 18-minute activity originally present when removed from the neutron source (200 mg $RaBr_2$+Be powder) could have been present to less than five percent of the activity found. Apparently very little of the 4.5-hour activity was present in these precipitates. Figure 1B is a plot of the activities of AgBr precipitates obtained from a single mother BrO_3^- solution which had stood various times since its last purification for Br^-. The solid line is the theoretical 18-minute growth curve. Figure 1C is a plot of the activity of a $AgBrO_3$ precipitate (obtained by acidifying the ammoniacal solution) which was purified for Br^- at zero time. The solid line is the 18-minute growth superimposed on an initial activity of 160 counts per minute. This initial activity must have been due to 18-minute Br^{80} still remaining in the BrO_3^- after the activation by the kick from the electron ejected by the converted soft gamma-ray or to beta-radiation from the 4.5-hour body itself, or to both. However, the curve does show that unless the 4.5-hour beta-rays are softer than about 500 kv (this was determined by the thickness of the sample and the wall of the counter) at least 75 percent of the 4.5-hour body must decay by the gamma-emission process. Further, in view of the fact that experiments with BrO_3^- showed the efficiency of the much more powerful neutron gamma-ray recoil in destroying the ion to be only 80 percent approximately, it seems probable that most, if not all, of the initial 25 percent activity is due to retention of 18-minute activity in the BrO_3^- rather than to 4.5-hour beta-emission. Of course this indicates that the 4.5-hour body is practically a pure gamma-ray emitter, unless it has beta-radiation softer than about 500 kv.

Figure 1D shows the activities of AgBr precipitates obtained at various times from a given mother BrO_3^- solution. The solid line is the theoretical 4.5-hour decay curve.

Don C. DeVault
W. F. Libby

Department of Chemistry,
University of California,
Berkeley, California,
January 14, 1939.