Identification of Two Radioactive Xenons from Uranium Fission

The observation of two long-life radioactive xenons growing out of radioactive iodine from uranium fission has been reported by us[1] and confirmed by Dodson and Fowler.[2] Recently some samples of cesium and barium were placed immediately behind a beryllium target bombarded by 16-Mev deuterons. After the bombardment the active cesium or barium was dissolved in water and the radioactive gas was then extracted into an ionization chamber. In the case of cesium only one radioactivity was observed which decayed with a half-life of 5 days, but in the case of barium, both 9.4-hr. and 5-day periods were present. The identity of the periods and of the absorption curves of these 9.4-hr. and 5-day radioactive gases from cesium and barium with those of radioactive xenon from uranium and thorium fission proves that they are the same substances.

Cesium has only one stable isotope with a mass number of 133, and since its bombardment gives only one radioactive xenon, we assume that the 5-day xenon is produced by the following reaction

$$_{55}\mathrm{Cs}^{133}(n,\,p)_{54}\mathrm{Xe}^{133}$$

and assign to it the mass number 133.

Although barium has seven known isotopes (130, 132, 134, 135, 136, 137 and 138), only three of them would be able to produce radioactive xenon (except for isomers of stable nuclei) by $a(n,\,\alpha)$ reaction. These are 130, 136, and 138. We have seen that Ba gives by $a(n,\,\alpha)$ reaction the 5-day xenon and we interpret this as

$$_{56}\mathrm{Ba}^{136}(n,\,\alpha)_{54}\mathrm{Xe}^{133}.$$

Since the abundance of Ba^{130} is only 1/700 of that of Ba^{138}, it is very likely that the barium of mass number 138 is responsible for the formation of the 9.4-hour xenon according to the reaction

$$_{56}\mathrm{Ba}^{138}(n,\,\alpha)_{54}\mathrm{Xe}^{135}.$$

Based on these results, the two chains found in uranium and thorium fission may be identified as

$$_{52}\mathrm{Te}^{133}\ 60\text{ min.}\rightarrow{}_{53}\mathrm{I}^{133}\ 22\text{ hr.}\rightarrow{}_{54}\mathrm{Xe}^{133}\ 5\text{ days}\rightarrow{}_{55}\mathrm{Cs}^{133}$$

and

$$_{52}\mathrm{Te}^{135}\sim 10\text{ min.}\rightarrow{}_{53}\mathrm{I}^{135}\ 6.6\text{ hr.}\rightarrow{}_{54}\mathrm{Xe}^{135}\ 9.4\text{ hr.}\rightarrow{}_{55}\mathrm{Cs}^{135}?.$$

Iodine was also separated from the fast-neutron-activated cesium sample. The separated iodine decayed with a single period of 12.6 hr. This confirms the assignment[3] of 12.6-hr. iodine to $_{53}\mathrm{I}^{130}$ resulting from a reaction

$$_{55}\mathrm{Cs}^{133}(n,\,\alpha)_{53}\mathrm{I}^{130}.$$

The author wishes to thank Professor E. O. Lawrence for his interest in this work and Dr. E. Segrè for his helpful suggestions and criticisms.

C. S. Wu

Radiation Laboratory,
University of California,
Berkeley, California,
October 17, 1940.

---

[1] E. Segrè and C. S. Wu, Phys. Rev. **57**, 552 (1940).
[2] R. W. Dodson and R. D. Fowler, Phys. Rev. **57**, 966 (1940).
[3] J. J. Livingood and G. T. Seaborg, Phys. Rev. **54**, 775 (1938).

Vibration Analysis of the Chlorine Dioxide Absorption Spectrum

The electronic band system appearing in the absorption spectrum of chlorine dioxide between 2600A and 5225A has been measured by several investigators[1–4] and vibration analyses have been attempted. The author offers evidence in support of a new analysis. Urey and Johnston were the first to attempt a detailed analysis of this system. However, none of their frequencies for the ground state agreed with the two infra-red frequencies found later by Bailey and Cassie;[5] namely, 945 cm^{-1} and 1109 cm^{-1}. For the third fundamental frequency of the ground state Bailey and Cassie accepted 528 cm^{-1} which appeared as a constant difference in two pairs of strong progressions in Urey and Johnston's analysis. Later Ku made more accurate and more complete measurements on the bands and attempted an analysis using the above frequencies but did not use the selection rules of Herzberg and Teller.[6]

Using the data of Ku, one finds that the 528 frequency comes out to be either 528 cm^{-1} or 524 cm^{-1} depending on which pair of progressions is used in determining its value. This disagreement is greater than experimental error. The author proposes to replace the fundamental frequency of 528 cm^{-1} by 447 cm^{-1} which appears as a constant difference in three separate pairs of progressions.

Photographs taken by the writer with the absorbing gas at dry ice temperature give clear evidence in support of this change.

From electron diffraction experiments, Brockway[7] finds that the apex angle of $\mathrm{ClO_2}$ is 137°±15°. On this basis one must make the following assignment to the fundamental frequencies of the lower state:

$$\begin{aligned}\nu_1''&=\ 447\ \mathrm{cm}^{-1},\\ \nu_2''&=\ 945\ \mathrm{cm}^{-1},\\ \nu_3''&=1109\ \mathrm{cm}^{-1},\end{aligned}$$

where ν_1'' designates the frequency of the bending vibration, ν_2'' that of the breathing vibration, and ν_3'' that of the antisymmetrical vibration. The apex angle of the lower state of $\mathrm{ClO_2}$ calculated from these frequencies on the basis of the valence force model is approximately 122°.

As for the symmetrical frequencies of the upper state, the author essentially agrees with Urey and Johnston as well as Ku. These are:

$$\left.\begin{matrix}\nu_1'\\ \nu_2'\end{matrix}\right\}\left\{\begin{matrix}290\ \mathrm{cm}^{-1},\\ 708\ \mathrm{cm}^{-1}.\end{matrix}\right.$$

The bands have been photographed by the writer in the second order of the 30-ft. 30,000-line per inch grating at the University of Chicago. Each band is made up of sub-bands, some of which show clearly defined rotational series. This rotational structure is now in process of analysis. The sub-bands, like the bands themselves, degrade to the red. This is sufficient to show that both dimensions of the molecule increase as it passes to the upper state.

Further, the 708 frequency is excited up to 20 quanta or more, while no more than two quanta of the 290 frequency are excited with enough intensity to be observed. If qualitative use is made of the Franck-Condon principle,