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CRYSTAL STRUCTURE OF POLONIUM AND ITS DECAY PRODUCTS

(Information Meeting Paper No. 14)

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INTRODUCTION

X-ray diffraction patterns have been obtained from a sample of elemental polonium over a period of more than four half-lives. This time study was made for the purpose of determining the effect of decay upon the lattice constants and crystal structure of the element.

EXPERIMENTAL DATA

All of the X-ray patterns used in this study of the decay of polonium were obtained from a single sample. This sample was prepared by vaporizing the element in an evacuated tube and condensing the vapor in a thin walled Pyrex capillary. The freshly prepared sample was first submitted for X-ray analysis on January 17, 1947.¹ Patterns were obtained at intervals of a few days for the first month. After the first month patterns have been obtained at intervals of one to two months until the present time. The elapsed time is over four half-lives of the element.

X-ray patterns of the original sample and several later samples have been analyzed to determine the crystal structure of pure polonium. The crystal structure and lattice constants of these freshly prepared samples of both the high temperature, β Po, and low temperature, α Po, ² forms were in good agreement with those reported by Maxwell and Beamer.² The β Po structure is rhombohedral with $A_0 = 3.36 \text{ \AA}$, $\beta = 98^\circ 13'$. The α Po structure is unquestionably simple cubic with $a_0 = 3.348 \pm 0.002 \text{ \AA}$.

During the early stage of the decay of polonium into lead the simple cubic, α Po, crystal structure was retained with only a slight increase in the lattice constant due to the substitution of lead atoms for polonium. On a pattern obtained after twenty-six days, at which time 12 per cent of the atoms had decayed, an additional set of lines was detected.

These additional lines increased in intensity and the lines due to the original α Po structure decreased through the series of patterns obtained during the first four months. This second pattern was found to be due to a lead polonide compound with a sodium chloride type crystal structure. The crystal structure of this compound is of the same type as PbS, PbSe, and PbTe. The lattice constant of 6.60 is also about the

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value that would be expected for the PbPo compound. Although the decay of polonium atoms must occur at randomly selected points within the crystal, it is thought that the recoil of the heavy nucleus when an α particle is emitted is sufficiently large to cause the nucleus to move into the strictly ordered arrangement that would be required by a sodium chloride type crystal.

On a pattern obtained at 150 days, when 53 per cent of the atoms had decayed, the original α Po structure could no longer be detected and only the PbPo compound was present. At 213 days with 66 per cent of the atoms decayed a series of lines identified as metallic lead first appeared. On succeeding patterns the intensity of the lines due to lead increased and the intensity of the lines due to the PbPo compound decreased. At 573 days with 5.7 per cent of the polonium remaining the PbPo compound was barely detectable.

CONCLUSIONS

The results obtained from the analysis of the X-ray patterns obtained from a single sample of polonium are summarized on Chart I. The change in lattice constants of the three distinct crystal structures due to either lead or polonium being in solution within the crystal is very small in all cases. Very careful measurements are now being made on another sample to determine the exact magnitude of the changes in these lattice constants.

REFERENCES

1. L. G. Fauble, Fundamental Research Progress Report, January 15-31, 1947.
2. Maxwell and Beamer, Los Alamos Report #624.

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DIAGRAM OF THE CRYSTALLINE PRODUCTS
RESULTING FROM THE DECAY OF Po.