Title
MEETING XIV -- BEVATRON RESEARCH CONFERENCE -- CHEMISTRY EXPERIMENTS

Author
Hyde, Earl K.

Publication Date
2010-12-01

UCRL - 2548
B - 23

MEETING XIV BEVATRON RESEARCH CONFERENCE
March 29, 1954
4 PM Auditorium, Bldg. 50

UNCLASSIFIED

Earl K. Hyde: Chemistry Experiments

I General

The main purpose of Chemistry Division personnel in using the Bevatron will be to learn as much as possible about nuclear reactions in the Bev energy range using the radiochemical approach. The type and extent of these experiments will depend greatly on the beam intensity. Significant results can be obtained at 10^6 or 10^7 protons per pulse, but it is highly desirable that this figure ultimately be raised to 10^{10} or greater.

II General Spallation Studies

1. Brief review of 184-inch cyclotron results: Chemists have carried out detailed spallation studies using the proton, deuteron and helium ion beams of the 184-inch cyclotron. In such studies targets selected from all regions of the periodic chart were bombarded and analyzed by quantitative radiochemical methods for the yields of the numerous isotopes produced. In a typical study Batzel, Miller and Seaborg (Phys. Rev. 84, 671 (1951)) bombarded copper and obtained cross sections for 30-40 isotopes representing 16-18 elements below copper.

The results indicate the inapplicability of compound nucleus mechanism for such high energy reactions. Serber's description of high energy reaction gives a good general description of the results. The incoming particle leaves only a small part of its total energy with target nucleus in most cases and this energy is disposed of by evaporation of protons and neutrons. For higher Z targets the products tend to lie more and more on neutron deficient side of stability indicating increasing difficulty of evaporation of protons.

In the copper study cited above, evidence for a "fission" reaction was found by determining the yield of such light products as Na^{24} and Cl^{38} as a function of proton energy and finding an appreciable yield well above the threshold for any reasonable spallation reaction. With bismuth and uranium targets, the fission reaction is very prominent. The fission product distribution indicates symmetric fission of a nucleus formed from the target nucleus by evaporation of a large number of neutrons. In intermediate Z targets such as silver and tantalum, a well defined region of fission products well separated from the main spallation products is observed but fission is not as prominent as in the heaviest elements.

2. Bevatron and Cosmotron spallation studies: In general one would expect greater energy on average to be transferred to target nucleus and hence decreased cross sections in neighborhood of target and increased cross sections in products far removed in mass. Production of neutron deficient isotopes will be more probable. The distinction between the fission products and the spallation products should become blurred because of this general rise in cross section of lower mass spallation products. Preliminary Cosmotron studies indicate these predictions to be true. Yields in the bombardment of copper were constant over entire mass range. With bismuth, tantalum and gold targets cross sections remained high 60 mass numbers below target.

III Secondary Particles

1. Direct studies: Barkas and Tyren (UCRL-1914) and Deutsch (UCRL-2258) have

made direct studies by photographic emulsion methods of the light element nuclei such as H^3, He^3, He^4, Li^6, Be^7.

Chemists such as Marquez and Perlman (Phys. Rev. 81, 953 (1951)) and Marquez (Phys. Rev. 86, 405 (1952)) have studied same general problem by measuring yield of Be^7, Li^8, F^{18}, C^{11} and Na^{24} as a function of energy and of atomic number of target. In most cases these yields are quite low but appreciable.

The yields of these products will be studied in the Bev range when they may be expected to be somewhat higher. Cosmotron results, for example, indicate 11 fold increase in Be^7 cross section in the bombardment of copper with 2.2 Bev protons rather than 340 Mev protons.

2. Indirect evidence from abnormal charge increase: In cyclotron bombardments of copper ($Z = 29$) with protons, small but definite amounts of gallium ($Z = 31$) and germanium ($Z = 32$) were identified. These products could arise only by secondary reactions with energetic helium ions and lithium nuclei formed in the primary reactions. Other examples of such secondary reactions are known but the maximum abnormal charge increase so far observed has been 2.

With Bev protons one might expect to find increased yields in such secondary reactions and to observe abnormal charge increases of 3 or more. At the Cosmotron chemists have found arsenic isotopes in copper targets, indicating reaction of secondary beryllium nuclei with the target.

The questions raised in such studies are (a) what is the formation cross section of the secondaries? (b) What is their energy distribution? (c) What are the cross sections for the reaction of the energetic secondaries with the target? Data on question (c) will be obtained directly by studies of reactions of the heavy ions now being accelerated in the 60-inch cyclotron and those to be obtained a few years hence in a new heavy ion accelerator.

IV Recoil Studies

Fung and Perlman (Phys. Rev. 87, 623 (1952)) studied the recoil loss of Na^{24} produced in 1/4 mil foils of aluminum when bombarded with protons of varying energy up to a maximum of 340 Mev. The recoil losses in the forward direction went through a definite maximum and the slight losses in the backward direction increased at the higher energies. These studies provide further evidence for rejection of compound nucleus formation and suggest that Na^{24} is formed primarily by those encounters in which about 70 Mev of excitation is transferred to the target nucleus. Extending studies to the Bev range with selected reactions may give interesting information on high energy reactions.

V Isotope Studies

Certain isotopes will probably turn out to be more easily prepared in Bevatron reactions than in any other way, or be freer of interfering activities than by more typical preparative methods. One example from the Cosmotron studies is the production in good yield of the rare earth alpha emitting isotopes when tantalum, gold or bismuth targets are bombarded.