CHARGED PARTICLE ACTIVATION ANALYSIS WITH CYCLOTRONS

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Abstract

Sensitivity curves for detecting any element with Z = 20 to Z = 92, through 1,2 and 3 particle emission reactions, activated by protons, deuterons and alphas of up to 35 MeV energy have been estimated and presented in graphical form. From these activity curves the detection sensitivity of any eliment in the aforementioned range, can be directly obtained for an infinitely thick, a moderately thick or even a thin target can be directly obtained at any bombarding conditions. Furthermore, these curves would also help select the most suitable reaction for the measurement of a particular element or isotope in a given matrix, and also give a measure of the unwanted and interfering activities being produced simultaneously.

1 INTRODUCTION

Activation analysis with charged particles is another important and useful application of cyclotrons. With this technique good detection sensitivity is achieved for many elements. Furthermore, it can also help detect and measure those elements which cannot conveniently, or at all, be determined by the most commonly used thermal neutron activation analysis using a reactor. Examples of such elements are the light elements as well as Al, Si, Ti, Cd, Tl. Pb, Bi, etc.

In charged particle activation analysis it is often helpful to know in advance that, out of many possible nuclear reactions that could activate a particular element or isotope, which is the most suitable from sensitivity and interference aspects, and which is the optimum incident energy.

In order to obtain this sort of information we have calculated the sensitivity curves for all the elements with Z = 20 to Z = 92 located in different matrices, activated by protons, deuterons and alphas of up to 35, MeV.

2 METHOD AND EVALUATION

The excitation functions used to evaluate various sensitivity curves had been taken from Lange and Muenzel [1] and the stopping power data from Williamson et al [2]. Then using the simple method described by Chaudhri et al [3] the detection sensitivity curves were obtained for different groups of elements, identified by their atomic numbers, and assumed to be located in different matrices.

3 RESULTS AND DISCUSSION

The activation sensitivity curves for 1, 2 and 3 particle emission reactions for most of the elements between Z = 20 and Z = 92, activated by protons, deuterons and alphas of up to 35 MeV are shown in sets of graphs in fig. [1]. Due to the way in which the excitation functions are presented in ref. [1], we have also presented the activation curves in similar fashion, that is grouping a number of elements in different sets, such as Z = 20-40; 41-60; 61-83 and Z>90.The average of Q-values of the sets of elements for a particular reaction type, used to convert the excitation functions of Lange et al to a useful form, are also given. As matrices the means Z's of the elements in various groups are chosen. For example the matrix for the group Z=20-40 is the element or compound with Z=30. However, this data would also be applicable for matrices of the neighbouring elements or compounds.

The left hand ordinate gives the activation sensitivity in dps / sec/ppm/ uA at irradiation time which is much longer than the half-life of the induced activity. The right hand ordinate gives the same information for an irradiation time which is one-tenth of the half life of the induced activity. The activation sensitivity of different elements can directly be obtained for different reactions at given bombarding conditions.

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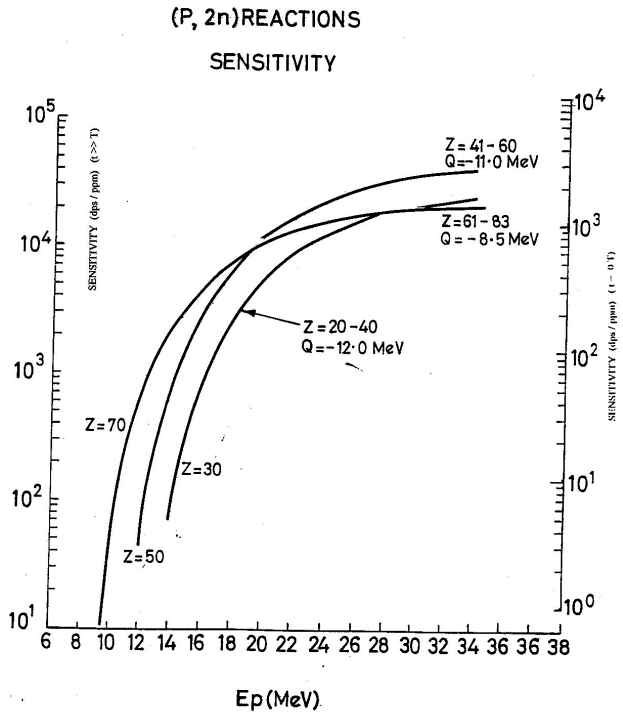

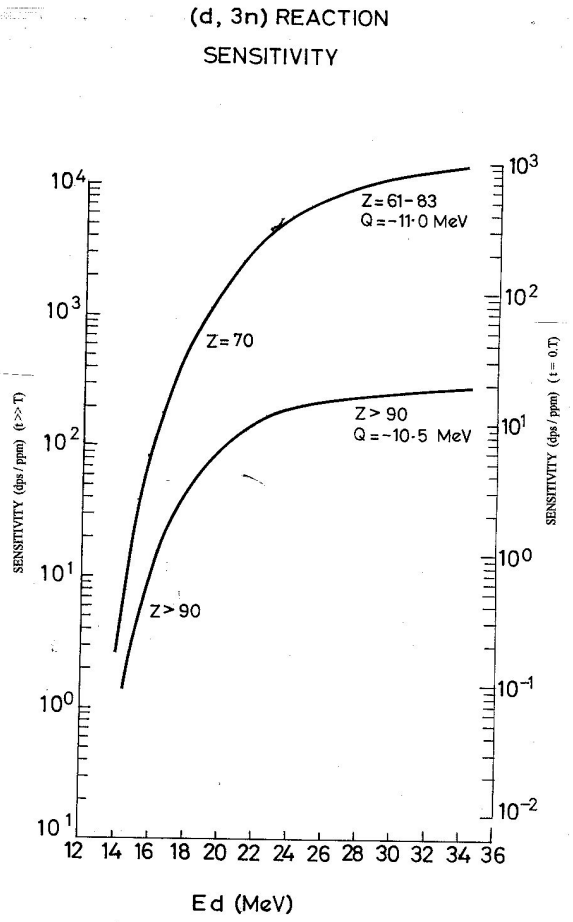

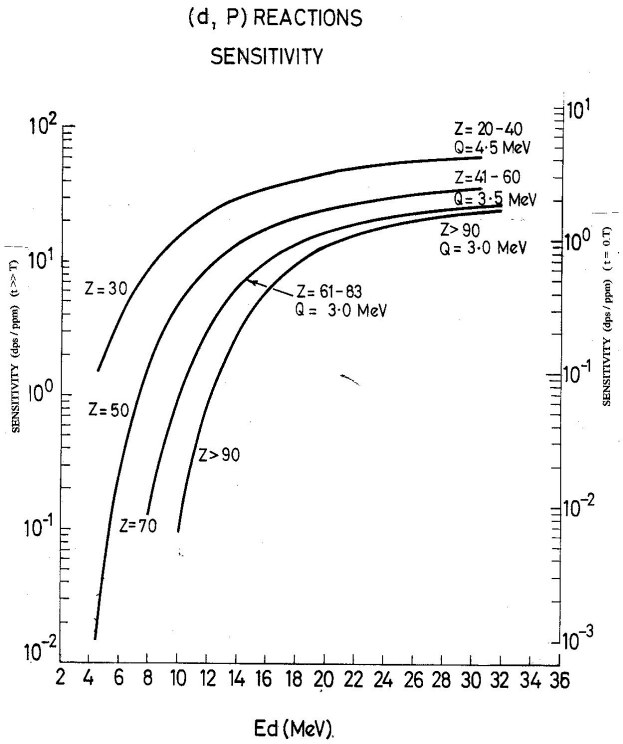

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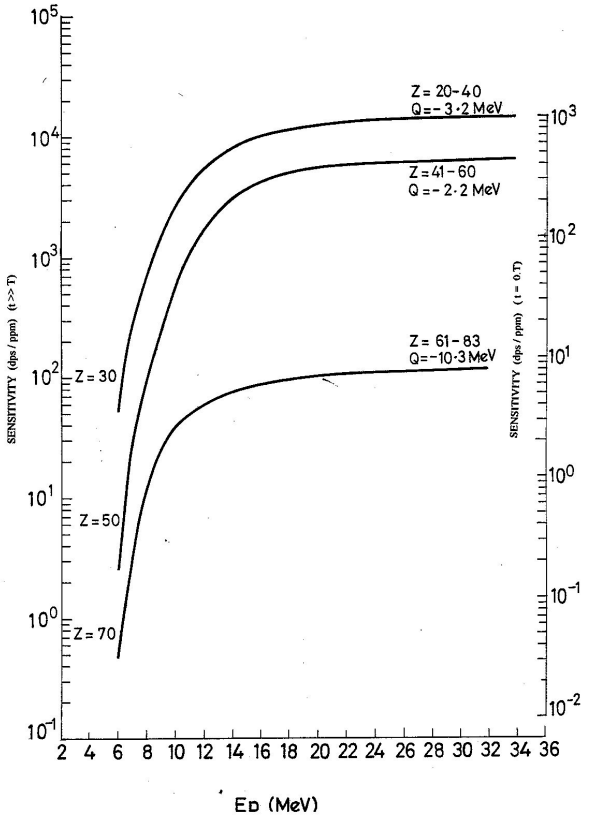
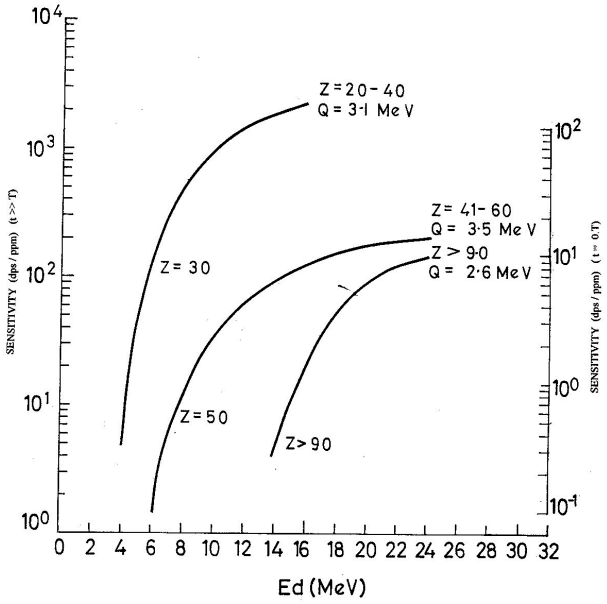
[3] M.A. Chaudhri,G.Burns E. Reen,J.Rouseand B.M.Spicer, A method of charged particle activation and its application to F detremination by the F(p,αγ)O reraction.J. Radioanal. Chem.37 (1977) 243

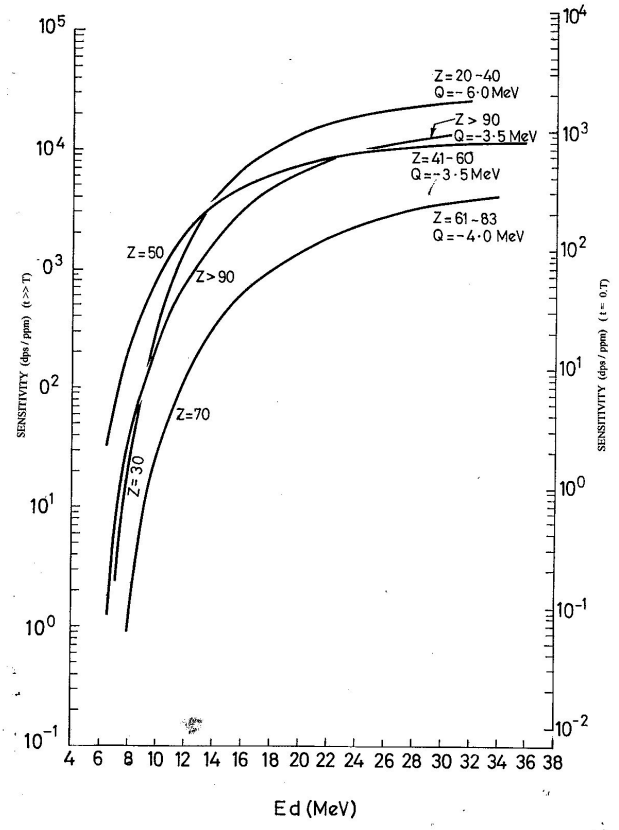
(P, n) REACTION
SENSITIVITY



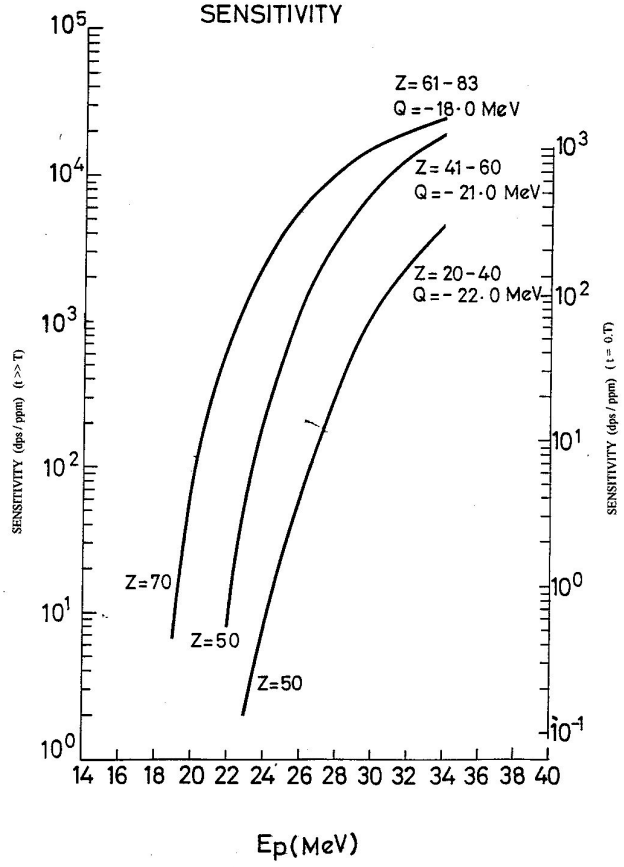
(d, n) REACTIONS
SENSITIVITY



(d, 2n) REACTIONS
SENSITIVITY



(P, 3n) REACTIONS
SENSITIVITY



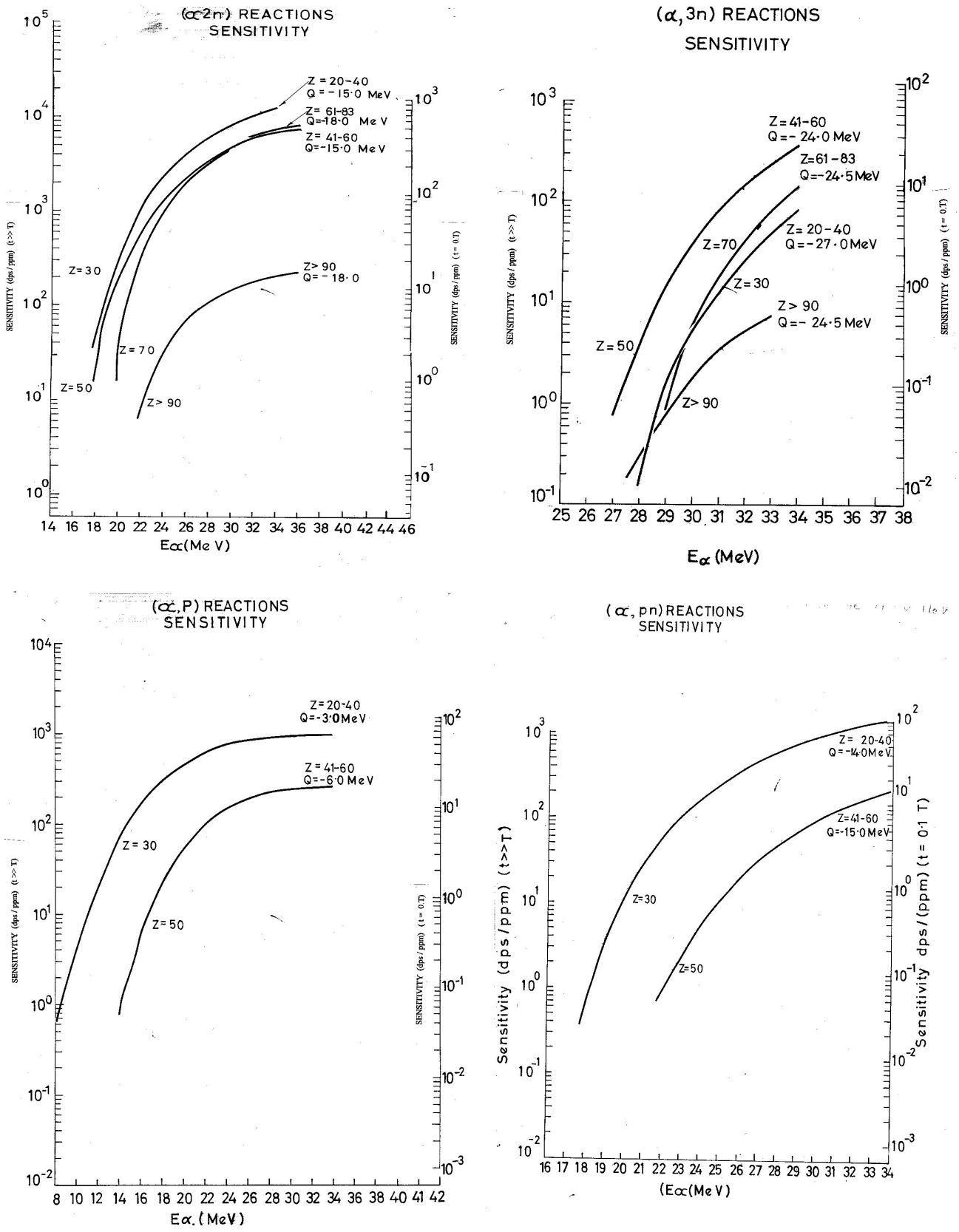


Fig. 1. Activation sensitivity curves of elements with Z=20-92 in different matrices activated with protons, deuterons and alphas of up to 35 MeV. The left hand ordinate gives the sensitivity of activation (dps/ppm/.uA) for irradiation time>>than the half life of the induced activity while the right hand ordinate gives the same value of activation for irradiation time= 0.1 half-life of the activity being induced.