CHAPTER I

NEUTRON SOURCES

1.1 ALPHA-NEUTRON SOURCES

One useful type of neutron source is based on the (α, n) reaction. Alpha particles incident on a target nucleus result in the ejection of neutrons. Consider the reaction $Li^7(\alpha, n)B^{10}$:

$$Li^7 + He^4 \longrightarrow B^{11} \longrightarrow B^{10} + n^1 + Q \qquad (1\text{-}1)$$

In this equation B^{11} is the intermediate state or compound nucleus. Q is the reaction energy and can be calculated from the mass-spectrographically measured masses of the atoms as follows:

Li^7:	7.01804 m.u.	B^{10}:	10.01605 m.u.
He^4:	4.00388	n^1:	1.00893
	11.02192 m.u.		11.02498 m.u.

$$Q = \text{(Mass on left)} - \text{(Mass on right)} = -\ .00306 \text{ m.u.}$$

The masses given are those of the neutral atoms, i.e., the "mass of an atom" is equal to the mass of the nucleus plus the mass of the associated electrons, and the units are defined by the relation

$$1 \text{ m.u.} = 1 \text{ mass unit}$$
$$= \left\{ \begin{array}{l} \text{Mass of a neutral atom of the most} \\ \text{abundant isotope of oxygen} \end{array} \right\} \div 16$$

Now, in equation (1-1) there is an excess of mass on the right side which means that the reaction is endothermic. That is, energy equivalent to the increased mass must be supplied to make the reaction energetically possible. This energy, denoted by Q, can be computed by conversion of the mass-difference $-.00306$ m.u., to energy units using the relation $E = mc^2$. Since 1 m.u. is equivalent to 931 Mev (see problem 2 at the end of this chapter) the value of the reaction energy for (1-1) is $Q = -.00306 \cdot 931$ Mev or -2.85 Mev. The *negative* sign indicates that the reaction is *endothermic*, i.e., Q is taken *positive* for *exothermic* reactions.

The "threshold energy" for this reaction is that *minimum value of the kinetic energy which the alpha must have in order to make the reaction energetically possible.* The threshold is not the same as the Q value, since the end-products, as a consequence of momentum conservation, will retain some kinetic energy. In the Li^7 (α, n) reaction the incident alphas will need *more* than 2.85 Mev of kinetic energy.

* A revision of class notes taken by I. Halpern on a series of lectures by Professor Enrico Fermi of the University of Chicago as explained in the preface to this document.

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