Another reaction using protons on lithium gives monoenergetic neutrons down to rather low energies. The reaction is $Li^7(H^1,n)Be^7$ with a Q-value of −1.62 Mev. Similar to the example discussed in Section 1.1 the threshold is greater than Q, being in this case 8/7 of 1.62 Mev or 1.85 Mev. If the lithium target is bombarded with protons of threshold energy the neutrons come off with finite energy, about 30 kev, for then they move with the speed of the center of gravity. If the proton energy is increased then there will be sufficient energy to give the neutrons a velocity *with respect to the center of gravity*. The net velocity is calculated by vector addition of the velocity of the center of gravity and the neutron velocity relative to the center of gravity, so that for high enough energies, neutrons can have resultant velocities of zero or even backward velocities. For a given proton energy, the energy of the neutrons will vary with the angle between the incident proton beam and the resultant neutron direction, that is for each angle of emergence of neutrons there will be a corresponding neutron energy. This will be discussed in greater detail in a later chapter.

Perhaps the most common neutron source is the "cyclotron source" in which deuterons bombard a beryllium target. In the reaction, $Be^9(H^2,n)B^{10}$, the target is stable and can be made to dissipate the heat generated in the "non-successful" collisions. For a thick target 1 Mev deuterons give about 10^8 neutrons/sec/microamp; 8 Mev deuterons give 10^{10} neutrons/sec/microamp.

PROBLEMS

1. In the calculation of Q for the reaction of equation (1-1) explain why you can use atomic masses for such calculations, when it is true that nuclear masses alone are involved in the reaction.

2. Prove that one mass unit equals 931 Mev. Convert from mass units to grams; then, using $E = mc^2$, convert grams to ergs to Mev.

3. Given a hollow sphere of beryllium, inside radius 1 cm, outside radius 3 cm. A one gram capsule of radium is placed at the center of the sphere. Neglecting the absorption of the gamma radiation what is the approximate strength of this (γ,n) source? If one curie of Na^{24} were used in place of the radium, what would be the source strength?

4. How many neutrons per second would one expect from a heavy hydrogen target bombarded by one milliampere of 500-kilovolt deuterons?

a-93-10