Modern Physics

Nuclear reactions

Problem 1.- Complete the nuclear reactions equations that follow, making sure that charge, mass and angular momentum are conserved:

$$^{63}_{29}Cu + ^{2}_{1}H \rightarrow ^{62}_{29}Cu +$$

$$^{1}_{0}n \rightarrow ^{1}_{1}H +$$

Solution:

$$^{63}_{29}Cu + ^{2}_{1}H \rightarrow ^{62}_{29}Cu + ^{3}_{1}H$$

$$^{1}_{0}n \rightarrow ^{1}_{1}H + ^{0}_{-1}\beta + ^{0}_{0}\nu$$

Problem 2.- A sample of radioactive nuclei of a certain element can decay by γ-mission and β-emission. If the half-life for γ-emission is 24 minutes and that for β-emission is 36 minutes, calculate the half-life for the sample.

Solution: Notice that in a differential of time dt the probability of decaying by either of the two possible ways is:

P = 1-2^(-dt/24) + 1-2^(-dt/36) = ln(2)(dt/24+dt/36) = ln(2)(dt)(36+24)/(36×24)

$$P = 1 - 2^{-dt/24} + 1 - 2^{-dt/36}$$

This can be expressed as

$$P = 1 - e^{-\ln(2)dt/24} + 1 - e^{-\ln(2)dt/36} \approx \ln(2)dt/24 + \ln(2)dt/36$$

Then

$$P \approx \ln(2)\left[\frac{1}{24} + \frac{1}{36}\right]dt$$

Where we can identify the equivalent half-life of the sample

$$t_{1/2} = \frac{1}{\frac{1}{24} + \frac{1}{36}} = \textbf{14.4 minutes}$$

Problem 3.- What is a possible way for ${}_4Be^7$ to transform into ${}_3Li^7$?

(A) Emitting an alpha particle only
(B) Emitting an electron only
(C) Emitting a neutron only
(D) Emitting a positron only
(E) Electron capture and emitting a neutrino

Solution: The atomic mass number of the nucleus doesn't change, so alpha emission is not a possible way. The charge changes from 4 to 3 in the nucleus which can happen if an electron is captured or a positron emitted, however either of these two possibilities requires emitting a neutrino to conserve spin, so the correct answer is **(E)**.

Problem 4.- The main source of the Sun's energy is the result of nuclear fusion Δmc^2, where the change in mass is between:

(A) Two hydrogen atoms and one helium atom
(B) Four hydrogen atoms and one helium atom
(C) Six hydrogen atoms and two helium atoms
(D) Three helium atoms and one carbon atom
(E) Two hydrogen atoms plus two helium atoms and one carbon atom

Solution: The correct answer is **(B)**.