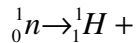
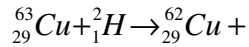


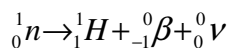
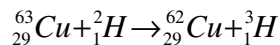
Modern Physics

Nuclear reactions

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



Solution:



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:

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

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

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

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

Problem 3.- What is a possible way for ${}^7_4\text{Be}$ to transform into ${}^7_3\text{Li}$?

- (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)**.