ENGY 3310 Fundamentals of Nuclear Science and Engineering

Spring 2016

HW #5: Various Mass-Energy-Momentum Relationships

Problem 1 Mass-Energy Equivalency (10 points)

An electron starting from rest is accelerated across a potential difference of 5 million volts.

a. What is its final kinetic energy (MeV)?

b. What is its total energy?

c. What is its final mass?

Problem 2 Speed and Momentum of Various Particles (10 points)

Compute the speed (v/c) and momentum (N-s) of the following particles:

a. 1 MeV neutron

b. 1 MeV electron

c. 1 MeV gamma ray

Problem 3 Wave-Particle Duality (5 points)

We often refer to gamma radiation as a "gamma ray particle" (as in the previous problem).

Compute the de Broglie wavelength for a 1 MeV gamma ray and discuss whether it behaves more like a particle or as an electromagnetic wave. Explain/justify your choice...

Problem 4 F-18 Production for PET Applications (5 points)

F-18 is a β^+ emitter and it is one of the primary isotopes used for generating positron emission tomography (PET) images for medical diagnostics. F-18 is usually produced in a cyclotron by bombarding O-18 with high energy protons. For production of F-18 via the ${}^{18}_{8}\mathrm{O}(\mathrm{p},\mathrm{n}){}^{18}_{9}\mathrm{F}$ reaction, determine the minimum allowable energy of the incident protons.

Problem 5 Neutron Reactions in Al27 (10 points)

Neutron bombardment of Al27 can lead to several different neutron reactions. In particular, for the following specific reactions of the form a(b,c)d, determine the reaction product d and the Q-value for the reaction:

a. ${}^{27}_{13}\mathrm{Al}(\mathrm{n},\gamma)$? ($\gamma \rightarrow$ gamma ray)

b. ${}^{27}_{13}\mathrm{Al}(\mathrm{n},\mathrm{p})$? ($\mathrm{p} \rightarrow$ proton)

c. ${}^{27}_{13}\mathrm{Al}(\mathrm{n},\mathrm{d})$? ($\mathrm{d} \rightarrow$ deuteron = deuterium nucleus)

d. ${}^{27}_{13}\mathrm{Al}(\mathrm{n},\mathrm{t})$? ($\mathrm{t} \rightarrow$ triton = tritium nucleus)

e. ${}^{27}_{13}\mathrm{Al}(\mathrm{n},\alpha)$? ($\alpha \rightarrow$ alpha particle = He-4 nucleus)

Problem 6 Binding and Separation Energies for O-16 vs. O-17 (10 points)

a. Determine the binding energy per nucleon for O-16 and O-17.

b. Determine the neutron separation energy for O-16 and O-17.

From the above computations, what can you say about the stability of O-16 vs. O-17?