Nuclear Physics

1. In a neutron diffraction experiment, a beam of neutrons of energy 85 MeV are directed towards a lead foil where they diffract. The first diffraction minimum is observed at an angle of 13o relative to the central maximum. Estimate the radius of the Lead Nucleus *(The size of each Lead Nucleus will represent the distance between openings of the diffraction grating).*
2. How would the results of Rutherford’s Scattering Experiment change if the gold foil was replaced by Aluminum Foil of the same thickness?
3. Solar Neutrinos constitute the majority of the Neutrinos reaching Earth. The majority of these Neutrinos are produced through proton-proton fusion in the Sun through the reaction below:

$$$$

 Every second roughly 1011 Solar Neutrinos pass through your finger nail.

 Use the masses below to answer the next 3 questions.

$$ = 1.007825*u*

$$ = 2.014102*u*

$$ = 3.016029*u*

$$ = 3.016029*u*

$$ = 4.002603*u*

1. Identify the isotope X.
2. Determine the mass defect of the reaction.
3. Determine the maximum kinetic energy that the neutrino could have.

Uranium-235 is a fissile isotope of Uranium. It makes up about 0.73% of naturally occurring Uranium and will undergo a nuclear chain reaction through the process of Neutron Capture. In Neutron Capture, a low speed neutron is fired at a U-235 atom. The atom absorbs the neutron, becoming the unstable isotope U-236 which then fissions into two daughter nuclei.

Part of the nuclear reaction is shown below:

$+\rightarrow \rightarrow ++A$

1. The neutron that strikes Uranium-235 has a speed of 2.20 km/s. The neutron is absorbed by the Uranium atom; determine the recoil speed of the Uranium-236 atom.
2. Complete the above reaction by identifying the values of X, Y, Z and A.
3. Explain why the above reaction is called a Chain Reaction.
4. Using the information below determine the energy released by the reaction.

$$ = 1.008701*u*

U-235 = 235.0439299*u*

U-236 = 236.0455682*u*

U-238 = 238.0507883*u*

Pu-239 = 239.052163*u*

Ba-143 = 142.920627*u*

Ba-144= 143.922953*u*

Kr-92 = 91.926156*u*

Kr-89 = 88.91764*u*

Br-82 = 81.916804*u*

La-144 = 143.91960*u*

β = 5.49 x 10-4 *u*

1. The answer above represents the energy released when one atom of Uranium fissions. Determine the energy (in Joules) released by 1.0 kg of Uranium. *Hint: there are 6.023 x 1023 atoms in 1 mol. 1 mol of U-235 has a mass of 235g/mol.*

Compare this to the amount of energy released by 1.0 kg of coal (24 MJ).

After being produced, Barium-144 undergoes Beta minus decay. The half-life of Barium-144 is 11.5 s.

1. If 15.5 kg of Barium-144 are produced in a fission reaction, how long does it take for the amount of Barium to be less than 121 g?
2. Write the decay equation for Barium-144.
3. Determine the maximum kinetic energy of the Beta particle.
4. Is the Beta particle ionizing?

BONUS: The electron in question 8 is considered to be relativistic; it has so much kinetic energy that it does not obey normal mechanics. To find the actual speed you must use Einstein’s theory of special relativity. The equation below gives the (corrected) relativistic velocity:

$$E\_{k}=mc^{2}\frac{1}{\sqrt{1-\frac{v^{2}}{c^{2}}}}-1$$

Using this equation, determine the percent of the speed of light the electron in question 8 will be travelling at.