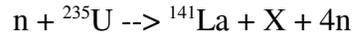


War & Peace Cluster, Summit Program  
Physics Assignment 8 Answers

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### Fission reactions

1. Given the fission reaction



- a. What nucleus is represented by the X? (Hint: both atomic number and mass number has to be conserved.)
    - i. Initially there are 92 charges, and so there must be a total of 92 after the reaction. Of those 57 are in the La nucleus, and so the remaining 35 are in the nucleus X, which makes it bromine (Br).
    - ii. The initial total atomic mass is  $1+235 = 236$ , which must be the final total atomic mass. With 141 accounted for in the La, and 4 in the neutrons, there remaining 81 are in the Br nucleus.
    - iii. The "X" is therefore  ${}^{81}\text{Br}$ .
  - b. What is the (combined) kinetic energy of the neutrons? (Assume that the incident neutron has negligible kinetic energy.)
    - i. The total mass before the reaction is  $1.008665 + 235.0439 = 236.0526$
    - ii. The total mass after the reaction is  $140.9110 + 80.9340 + 4 * 1.008665 = 235.8796$
    - iii. There is a mass loss of  $236.0526 - 235.8796 = 0.173 \text{ u}$
    - iv. There is an energy gain of  $0.173 * 931.4 = 162 \text{ MeV}$
2. Using the answer to the previous question, how many reactions per second are needed to produce a reactor rates at 200 MW?
- a. Each reaction produces 162 MeV of energy =  $162 * 1.6 \times 10^{-13} = 2.59 \times 10^{-11} \text{ J}$
  - b. In each second, to get 200 MJ =  $2 \times 10^8 \text{ J}$  we need  $2 \times 10^8 / 2.59 \times 10^{-11} = 7.7 \times 10^{18}$  reactions.
3. How many  ${}^{235}\text{U}$  atoms are needed to operate the reactor for a year?
- a. Each  ${}^{235}\text{U}$  atom has a mass of  $235 \text{ u} = 235 * 1.66 \times 10^{-27} = 3.9 \times 10^{-25} \text{ kg}$
  - b. Total mass used in one second =  $7.7 \times 10^{18} * 3.9 \times 10^{-25} = 3 \times 10^{-6} \text{ kg}$
  - c. Total mass used in one year =  $3 \times 10^{-6} * 60 * 60 * 24 * 365 = 94.9 \text{ kg}$
4. What is the mass of uranium need to operate the reactor for a year if
- a. Only  ${}^{235}\text{U}$  is used? 94.9 kg
  - b. Natural uranium containing only 0.7 %  ${}^{235}\text{U}$  is used?
    - i. We still need 94.9 kg of  ${}^{235}\text{U}$ , but this is now only 0.7% of the total mass
    - ii.  $0.007 M = 94.9 \text{ kg}$
    - iii.  $M = 13,600 \text{ kg}$
  - c. Enriched uranium containing 4 %  ${}^{235}\text{U}$  is used?
    - i. We still need 94.9 kg of  ${}^{235}\text{U}$ , but this is now 4% of the total mass
    - ii.  $0.04 M = 94.9 \text{ kg}$
    - iii.  $M = 2400 \text{ kg}$