

Team Exercises #1

*Problems 1 & 2 borrowed from Nuclear Engineering 101 homework problem sets, Fall 2016

Problem 1

The radioactive isotope ^{233}Pa can be produced following neutron capture by ^{232}Th when the resulting ^{233}Th decays to ^{233}Pa . In the neutron flux of a typical reactor, neutron capture in 1 g of ^{232}Th produces ^{233}Th at a rate of $2.0 \times 10^{11} \text{ s}^{-1}$.

- What are the activities (in Ci) of ^{233}Th and ^{233}Pa after this sample is irradiated for 1.5 hours?
- The sample is then placed in storage with no further irradiation so that the ^{233}Th can decay away. What are the activities (in Ci) of ^{233}Th and ^{233}Pa after 48 hours of storage?
- The decay of ^{233}Pa results in ^{233}U , which is also radioactive. After the above sample has been stored for 1 year what is the ^{233}U activity in Ci? (Hint: it should not be necessary to set up an additional differential equation to find the ^{233}U activity.)

| Nucleus | Half-life |
|-------------------|--------------------------------|
| ^{233}Th | 22.3 min |
| ^{233}Pa | 27.0 days |
| ^{233}U | $1.592 \times 10^5 \text{ yr}$ |

$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ s}^{-1}$$

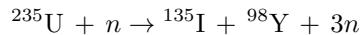
Problem 2

Use the following masses for parts (a) and (b):

| Nucleus | Atomic Mass |
|------------------|--------------|
| n | 1.008665 u |
| ^1H | 1.007825 u |
| ^2H | 2.014102 u |
| ^{56}Fe | 55.934939 u |
| ^{98}Y | 97.922203 u |
| ^{135}I | 134.910048 u |
| ^{235}U | 235.043924 u |

$$1\text{u} \cdot c^2 = 931.502 \text{ MeV}$$

a) Calculate the Q -value of the reaction:



b) Calculate the average binding energy per nucleon (in MeV) of ^2H , ^{56}Fe , and ^{235}U .

Problem 3

a) Solve the first order differential equation

$$\frac{dy}{dx} + 3y = 0$$

b) Solve the second order differential equation (A and B are constants)

$$\frac{d^2y}{dx^2} - A^2y = B$$

The boundary condition is $y(\pm\frac{1}{A}) = 0$.

Problem 4

Classify the following cross section plots. They are, in no particular order:

- (1) ^{155}Gd absorption
- (2) ^{235}U fission
- (3) ^{238}U absorption
- (4) ^{238}U fission
- (5) ^{239}Pu fission

