

University of Ottawa
Department of Mechanical and Engineering

GNG 4128 Introduction to Nuclear Engineering
Quiz #2
Date: February 13 / 2018

Instructor: Nabel Sadek
Time Allowed: 45 minutes

Name :

Student ID:

1. Find the activity of a sample of cobalt-60 (half-life = 5.27 years) weighing 1 μg . Given that $M_{\text{Co-60}} = 59.93$, $N_a = 6.023 \times 10^{23}$. Also, determine the mean life of cobalt-60. 60%
2. Briefly (no more than three lines) explain each of the following:
 - a) A typical qualitative behavior of the radiative capture cross section (σ_r) with respect to the energy of the incident neutron. 20%
 - b) The conservation laws that govern the nuclear reactions. 20%

Solutions

① Find the number of atoms in the sample

$$\text{Number of atoms} = \frac{m \times N_a}{M_{\text{Co-60}}} = \frac{1 \mu\text{g} \times 10^{-6} \text{ g}/\mu\text{g} \times 6.023 \times 10^{23} \frac{\text{atoms}}{\text{mol}}}{59.93 \text{ g/mol}}$$

$$= 1.005 \times 10^{16} \text{ atoms in the sample} \quad \boxed{2 \text{ points}}$$

$$\lambda = \frac{\ln 2}{T_{1/2}} = \frac{0.693}{5.27 \text{ yrs} \times 365 \frac{\text{days}}{\text{yr}} \times 24 \frac{\text{hrs}}{\text{day}} \times 3600 \frac{\text{sec}}{\text{hr}}}$$

$$= 4.17 \times 10^{-9} \text{ sec}^{-1} \quad \boxed{1 \text{ point}}$$

$$\alpha = \lambda N = 4.17 \times 10^{-9} \times 1.005 \times 10^{16} = 4.19 \times 10^7 \text{ Bq} \quad \boxed{1 \text{ point}}$$

$$\text{Mean life } (\bar{t}) = \frac{1}{\lambda} = \frac{1}{4.17 \times 10^{-9}} = 2.4 \times 10^8 \text{ sec} \approx 7.6 \text{ yrs} \quad \boxed{1 \text{ point}}$$

2 Points

② A typical answer would be

- (a)
- 1- At low energy, σ_r is proportional to $\frac{1}{\sqrt{E}}$
 - 2- At higher energy, there will be region of resonances
 - 3- At very high energy of incident neutron, σ_r is a smoothly decreasing function of energy

(b) **2 Points**

- 1- Conservation of energy
- 2- Conservation of electric charge
- 3- Conservation of momentum
- 4- Conservation of number of nucleons (protons and neutrons) **2 points**