

**University of Ottawa**  
**Department of Mechanical and Engineering**

**GNG 4128 Introduction to Nuclear Engineering**

**Mid-Term exam**

**Date: February 14 / 2017**

**Calculators (non-programmable) allowed**

**Instructor: Nabel Sadek**

**Time Allowed : 90 minutes**

**Closed book Exam**

1. Let us consider a representative atom, its nucleus made up of the fundamental particles (protons and neutrons), when combined they constitute an aluminum nucleus ( $A=27$ ,  $Z=13$ , atomic mass = 26.98153844 u) Assume that the nucleus is in the ground state and its kinetic energy is zero. Using rest mass values in u available for all the nucleons that make up this atom, calculate the nuclear binding energy. **8 points**
2. List the factors (parameters) affecting the binding energy in a nucleus! **3 points**
3. Name and define the SI units of radioactivity! **2 points**
4. Define nuclear cross-section. Specify the factors affecting its value. **3 points**
5. A uranium-aluminum alloy contains 10 % U and 90 % Al, by weight and has a density of 3.4 g/cm<sup>3</sup>. Compute the atomic density of the aluminum atoms present in the alloy. **4 points**
6. Name the following neutron reactions a) C-13 (n,  $\gamma$ )? b) O-17 (n, p)? c) O-17 (n,  $\alpha$ )? d) N-14 (n, p)? **2 points**
7. How long after a sample is placed in a reactor is it before the sample activity reaches 75% of the maximum activity? Assume the production of a single reactive species at a constant rate of R second<sup>-1</sup>, the decay rate is  $\lambda$ , and that there initially are no activity in the sample material ( $\alpha_0=0$ ). **8 points**

Given

Atomic mass of Al = 26.98153844 u

1 Atomic mass unit (u) = 1.660565 x 10<sup>-27</sup> kg

Electron Rest Mass = 5.48579911 x 10<sup>-4</sup> u

Proton Rest Mass = 1.0072764669 u

Neutron Rest Mass = 1.0086649158 u

Speed of light = 3.0 x 10<sup>8</sup> m/s

Avogadro's number  $N_A = 0.6023 \times 10^{24}$

Mass Defect =  $BE/c^2 = Z m_p + (A - Z)m_n - \text{rest mass of nucleus}$

$$\alpha = \alpha_0 \exp(-\lambda t) + R[1 - \exp(-\lambda t)]$$

$\text{Atomic Density} = \frac{\rho N_A}{M}$ , Atomic density is the number of atoms per unit volume.