# 國立清華大學
# ESS 201000 核工原理
# (Principle of Nuclear Engineering)

**Homework #3**

1. The $\beta^-$-emitter $^{28}$Al (half-life 2.30 min) can be produced by the radiative capture of neutrons by $^{27}$Al. The 0.0253-eV cross-section for this reaction is 0.23 b. Suppose that a small, 0.01-g aluminum target is placed in a beam of 0.0253-eV neutrons, $\phi = 3 \times 10^8$ neutrons/cm$^2$-sec, which strikes the entire target. Calculate
(a) the neutron density in the beam;
(b) the rate at which $^{28}$Al is produced;
(c) the maximum activity (in curies) that can be produced in this experiment.

2. *Boral* is a commercial shielding material consisting of approximately equal parts by weight of boron carbide ($B_4C$) and aluminum compressed to about 95% theoretical density (2.608 g/cm$^3$) and clad with thin sheets of aluminum 0.25cm thick. The manufacture specifies that there are 0.333 g of boron per cm$^2$ of a boral sheet 0.457 cm in overall thickness. What is the probability that a 0.0253-eV neutron incident normally on such a sheet will succeed in penetrating it?

3. What is the probability that a neutron can move one mean free path without interacting in a medium?

4. Calculate at 0.0253 eV the macroscopic absorption cross-section of uranium dioxide ($UO_2$), in which the uranium has been enriched to 3 *w/o* in $^{235}$U. The density of $UO_2$ is approximately 10.5 g/cm$^3$.

5. The first resonance in the scattering cross-section of the nuclide $^{A}Z$ occurs at 1.24 Me V. The separation energies of nuclides $^{A-1}Z$, $^{A}Z$, and $^{A+1}Z$ are 7.00, 7.50, and 8.00 Me V, respectively. Which nucleus and at what energy above the ground state is the level that gives rise to this resonance?

6. There is a prominent resonance in the total cross-section of $^{56}$Fe at 646.4 keV. At what energy, measured from the ground state, is the energy level in $^{57}$Fe that corresponds to this resonance?[*Hint*: Use the masses of neutral $^{56}$Fe and $^{57}$Fe to compute the binding energy of the last neutron in $^{57}$Fe.]

7. Suppose that a fission neutron, emitted with an energy of 2 Me V, slows down to an energy of 1 eV as the result of successive collisions in a moderator. If, on the average, the neutron gains in lethargy the amount $\xi$ in each collision, how many collisions are required if the moderator is

(a) hydrogen,

(b) graphite?