

國立清華大學 104 學年度碩士班考試入學試題

系所班組別：核子工程與科學研究所 甲組(工程組)

考試科目 (代碼)：核工原理(2702)

共__2__頁，第__1__頁 *請在【答案卷】作答

1. Briefly explain the following terms: (20%, each 4%)
 - A. Binding energy
 - B. Cross sections and mean free path
 - C. Buckling
 - D. Specific burnup
 - E. Ionization, bremsstrahlung, and stopping power
2. Natural uranium nowadays is mostly U-238, with U-235 only constituting about 0.72% of its abundance. Estimate the U-235 enrichment at the birth of Earth? The life time of Earth up to now is 4.5 billion years. The half-life of U-235 is 7.04×10^8 years and that of U-238 is 4.47×10^9 years. (20%)
3. In a infinite critical reactor fueled with natural uranium, it is observed that, for every neutron absorbed in U-235, 0.254 neutrons are absorbed in resonances of U-238 and 0.640 neutrons are absorbed by U-238 at thermal energies. (1) What is the conversion ratio for the reactor? (2) How much Pu-239 in kilograms is produced when 1 kg of U-235 is consumed? (20%)
4. The three-group fluxes for a bare spherical fast reactor of radius $R = 50$ cm are given as follows:

$$\phi_1(r) = \frac{3 \times 10^{15}}{r} \sin\left(\frac{\pi r}{R}\right); \quad \phi_2(r) = \frac{2 \times 10^{16}}{r} \sin\left(\frac{\pi r}{R}\right); \quad \phi_3(r) = \frac{1 \times 10^{15}}{r} \sin\left(\frac{\pi r}{R}\right)$$

The group-diffusion coefficients are $D_1 = 3$ cm, $D_2 = 2$ cm, and $D_3 = 1$ cm. Calculate the total leakage of neutrons from the reactor in all three groups by ignoring the extrapolation distance at the reactor surface. (20%)

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5. Calculate the concentrations in grams per liter of (1) U-235, (2) U-233, and (3) Pu-239 required for criticality of infinite homogeneous mixtures of these fuels in water. Assume the presence of these fissile nuclides does not change the molecular concentration of the water. The macroscopic absorption cross section of water $\Sigma_a = 0.0222 \text{ cm}^{-1}$. (20%)

TABLE 3.4 THERMAL (0.0253 eV) DATA FOR THE FISSILE NUCLIDES*

	σ_a^\dagger	σ_f	α	η	ν
^{233}U	578.8	531.1	0.0899	2.287	2.492
^{235}U	680.8	582.2	0.169	2.068	2.418
^{239}Pu	1011.3	742.5	0.362	2.108	2.871
^{241}Pu	1377	1009	0.365	2.145	2.917

TABLE 3.2 NON-1/V FACTORS*

$T, ^\circ\text{C}$	Cd	In	^{135}Xe	^{149}Sm	^{233}U		^{235}U		^{238}U	^{239}Pu	
	β_a	β_a	β_a^\dagger	β_a	β_a	β_f	β_a	β_f	β_a	β_a	β_f
20	1.3203	1.0192	1.1581	1.6170	0.9983	1.0003	0.9780	0.9759	1.0017	1.0723	1.0487
100	1.5990	1.0350	1.2103	1.8874	0.9972	1.0011	0.9610	0.9581	1.0031	1.1611	1.1150
200	1.9631	1.0558	1.2360	2.0903	0.9973	1.0025	0.9457	0.9411	1.0049	1.3388	1.2528
400	2.5589	1.1011	1.1864	2.1854	1.0010	1.0068	0.9294	0.9208	1.0085	1.8905	1.6904
600	2.9031	1.1522	1.0914	2.0852	1.0072	1.0128	0.9229	0.9108	1.0122	2.5321	2.2037
800	3.0455	1.2123	0.9887	1.9246	1.0146	1.0201	0.9182	0.9036	1.0159	3.1006	2.6595
1000	3.0599	1.2915	0.8858	1.7568	1.0226	1.0284	0.9118	0.8956	1.0198	3.5353	3.0079