國 立 清 華 大 學 命 題 紙

98 學年度 核子工程與科學研究所工程組 碩士班入學考試

科目 核工原理 科目代碼 2902 共 3 頁第 1 頁 *請在【答案卷卡】內作答

解釋名詞： (12%; each 3%)

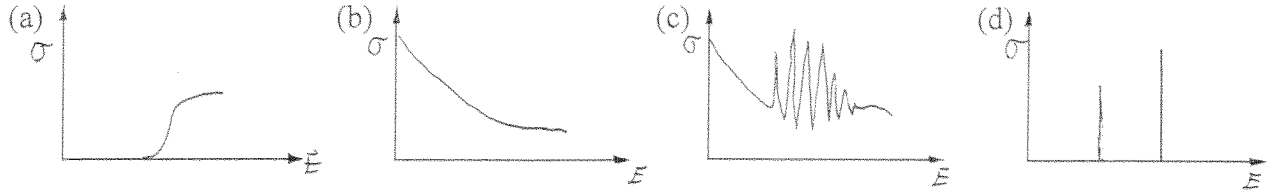
(1) internal conversion
(2) Bragg curve
(3) delayed critical
(4) inhour

單選題： (27%; each 3%)

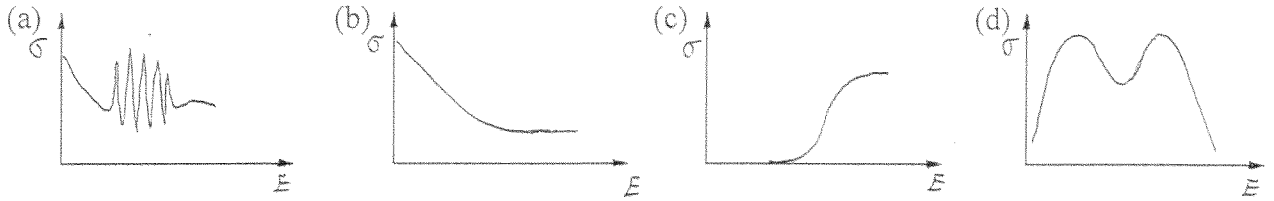
1. Regarding to the nuclei C^{14}, N^{15}, O^{16}, which statement is correct?
   (a) C^{14} and O^{16} are isotopes, (b) N^{15} and O^{16} are isomers, (c) C^{14} and O^{16} are isotones, (d) C^{14} and N^{15} are isobars, (e) none of above.

2. For the (effective) multiplication factor k of a typical thermal reactor, which statement is correct?
   (a) $f > 1$, (b) $\eta < 1$, (c) $P_{FNL} > 1$, (d) $p < 1$.

3. Regarding to the microscopic (n, α) cross section of ${}_5B^{10}$ versus neutron energy E, which figure is correct?



4. Regarding to the microscopic fission cross section of ${}_{92}U^{238}$ versus neutron energy E, which figure is correct?



5. Regarding specific ionization I_s, which statement is correct?
   (a) same E, mass ↑ => I_s ↑, (b) same E, mass ↑ => I_s ↓, (c) same M, charge ↑ => I_s ↓, (d) none of above.

6. Regarding to the most probable velocity (v_p), average velocity (v_{ave}), and root-mean-square velocity (v_{rms}) of thermal neutrons with a Maxwellian velocity spectrum as follows, which statement is correct?

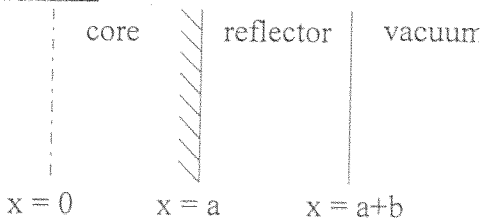
$$N(v) = 4\pi N_0 \left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{-\frac{mv^2}{2kT}}$$

   (a) $v_p = (3kT/m)^{1/2}$, (b) $v_{ave} = (2kT/m)^{1/2}$, (c) $E_{ave} = m v_{rms}^2 / 2$, (d) none of above.

   Given: $\Gamma(n) = \int_0^\infty dt\, e^{-t} t^{n-1}$; $\Gamma(n+1) = n\Gamma(n)$; $\Gamma(1/2) = \sqrt{\pi}$; $\Gamma(1) = 1$; $\Gamma(0) = \infty$.

7. Regarding to thermal flux (ϕ_T) and 2200 meters-per-second flux (ϕ_0), which statement is correct?
(a) $\phi_T = N_0 v_{ave}$, (b) ϕ_T denotes a flux assuming all the thermal neutrons at 20°C, (c) ϕ_0 denotes a flux assuming all the thermal neutrons possess energies ranging from 0 to $5kT_n$, (d) none of above.

8. Regarding to two-group fluxes (fast flux ϕ_1 and thermal flux ϕ_2) in a reflected reactor shown below, which statement is incorrect?



(a) ϕ_1 vanishes at $x = a + b + d$, where d denotes the extrapolated distance, (b) ϕ_1 rises near the core-reflector interface and exhibits a peak in the reflector, (c) the reflector tends to flatten the ϕ_2 in the core, (d) the reflector acts as to reduce the critical size and mass of the reactor.

9. Compare the four-factor formula in a heterogeneous reactor to that in a homogeneous reactor, which statement is correct?
(a) $\eta_{hetero} > \eta_{homo}$, (b) $\varepsilon_{hetero} < \varepsilon_{homo}$, (c) $p_{hetero} = p_{homo}$, (d) $f_{hetero} < f_{homo}$, (e) none of above.

計算題： (61%)

1. It has been proposed to use uranium carbide (UC) for the initial fuel in certain types of breeder reactors, with the uranium enriched to 25 w/o in $_{92}U^{235}$. What is the atomic percent (a/o) $_{92}U^{235}$. The density of UC is 13.6 g/cm^3. (6%)

2. Polonium-210 decays to the ground state of $_{82}Pb^{206}$ by emitting a 5.305-MeV α-particle with a half-life of 138 days. What mass of polonium-210 is required in order to produce 10 MW of thermal energy from its radioactive decay? (8%)

3. A reactor operates at 300 MW (thermal) for 100 days and is then shut down for refueling. What is the power (rate of energy, in terms of watts) release due to fission-product decay after a cooling period of 30 days? (12%)
Hint: Rate of emission of β-rays $\cong 3.8\times10^{-6} t^{-1.2}$ $\beta-$rays/sec$-$fission.
Rate of emission of γ-rays $\cong 1.9\times10^{-6} t^{-1.2}$ $\gamma-$rays/sec$-$fission.
The averages energies of β- and γ-rays are 0.4 MeV and 0.7 MeV, respectively.

4. The photoelectric cross section (σ_{pe}) of $_{82}Pb^{208}$ at 0.6 MeV is approximately 18 b. Estimate σ_{pe} at 0.3 MeV for $_{92}U^{235}$. (6%)

5. Determine the critical radius of a bare, 120 cm high, multiplying cylindrical reactor containing the following data: (12%)
$\Sigma_a = 0.082$ cm^{-1}, $\Sigma_{tr} = 0.342$ cm^{-1}, $\nu\Sigma_f = 0.0843$ cm^{-1}, $\Sigma_f = 0.03413$ cm^{-1}, $\rho = 19$ g/cm^3.

6. An isotropic point source emitting $S(r) = S_0\delta(r)$ neutrons/sec is placed at the center of a non-multiplying spherical moderator of radius R. The medium surrounding the spherical moderator is an infinite vacuum. The diffusion length of the moderator is L, the diffusion coefficient is D, and the extrapolated distance is d. Find the probability that a neutron emitted by the source will escape from the surface of the sphere. (10%)

7. Write down the detailed form of the steady-state five-group diffusion equations that contain all the following features: (7%)

   There is only fission neutrons source existed in the source term;
   the fission source only exists in the upper-most three energy groups;
   the lower-most two energy groups contain thermal neutrons;
   up-scattering collisions only apply for thermal neutrons;

   direct coupling scheme applies for all the five energy groups.