八十五學年度核子工程與工程物理系（所）＿＿＿＿組碩士班研究生入學考試

科目 核工原理 科號 3802 共 3 頁第 1 頁 *請在試卷【答案卷】內作答

1. Briefly explain each of the following terminologies:
   a) thermal disadvantage factor; (4%)
   b) lethargy; (3%)
   c) reactor deadtime; (5%)
   d) multiple barriers of reactor safety design. (4%)

2. a) Please write down the one-group diffusion equation and the criticality condition. Use the terms "infinite multiplication factor" and "non-leakage probability" to express the criticality condition. Please define your notations carefully and completely. (8%)

   b) For a university research reactor core, the following conditions apply:
   - 8.5% of the fast neutrons leak out of the core while slowing down;
   - Of the neutrons that do not leak out, 12% of the fast neutrons are absorbed in the U-238 resonances;
   - 3% leak out of the core while they are diffusing as thermal neutrons;
   - Of the neutrons that do not leak out, 84% are absorbed in fuel material;
   - Of the neutrons absorbed in fuel material, 78% are absorbed in U-235;
   - Of the neutrons absorbed in U-235, 85% induce fission;
   - Of the fission neutrons produced, 10% are due to fast fission;
   - ν is equal to 2.42;
   - Neglect the absorption of neutrons due to oxygen.

   Determine the effective multiplication factor, and the conversion ratio. (10%)

3. Neutron sources are distributed in a bare infinite slab of diffusing moderating medium of extrapolated thickness "a" according to the relation:

$$S(x) = (x + \frac{a}{2}) S_o,$$

   where S_o is a constant and x is measured from the center of the slab.

   What is the probability that a source neutron will leak from the slab? (20%)

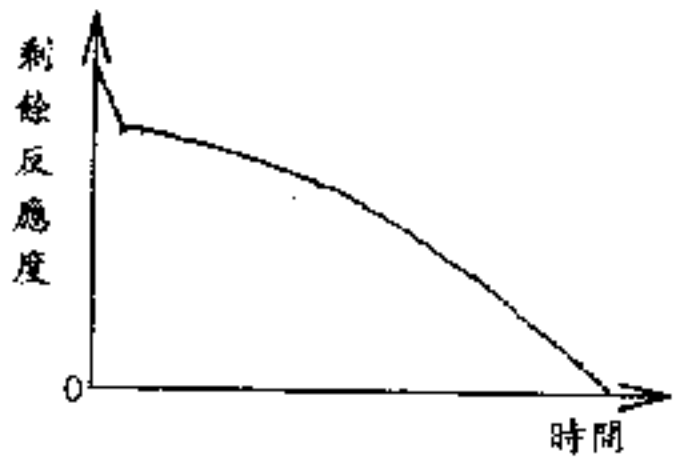
4. a) What are the stochastic and non-stochastic biological effects of radiation? (2%)
   b) What is the average value of natural background radiation dose per year? (2%)
   c) What are the dose limits per year, per week, and per hour, respectively for radiation workers? and what is the dose limit for general population? (3%)
   d) What is the definition of dose commitment? (3%)

5. A mono-directional beam of 2 MeV gamma rays of intensity 10^6 gamma-rays/cm^2-sec is incident upon a lead shield 10 cm thick. Calculate at the rear side of the shield: (5%)
   a) the uncollided flux;
   b) the buildup flux;
   c) the exposure rate in terms of Roentgen/sec.

   Given: 1 esu $= 3.33 \times 10^{-10}$ Coulomb, 1 e$^-$ $= 1.6021 \times 10^{-19}$ Coulomb.
   It requires 34 eV to produce an ion-pair.
   For 2 MeV gamma rays:
   lead: $\mu/\rho = 0.0457$ cm^2/g, $B_m(4) = 2.41$, $B_m(7) = 3.36$, $\rho = 11.34$ g/cm^3;
   air: $\mu_a/\rho = 0.0238$ cm^2/g.

6. A spherical shell of inner radius R_1 and outer radius R_2 contains a radioactive water solution emitting S_o gamma-rays/cm^3-sec. Derive an expression for the uncollided gamma-ray flux at the center of the shell. (5%)

7. 在無控制棒插入情況下，壓水式反應器爐心剩餘反應度隨時間之變化曲線，如圖所示：
   a) 解釋造成該曲線變化之原因為何？ (5%)
   b) 可用那些方法來抑制剩餘反應度，以使反應器維持臨界？ (5%)



8. In a pressurized water reactor, power density of fuel rod at the center of the core can be represented by following equation:

$$q''' = q'''_{max} \cos(\frac{\pi z}{H}),$$

where z is in the direction of coolant flow and H is height of the core.

(a) Please derive an equation to calculate the coolant temperature along the coolant channel. Use following notations in your derivation: (5%)

A_f : the cross sectional area of the fueled portion of a fuel rod;

W : coolant flow rate through the coolant channel;

C_p : specific heat of coolant;

T_o : coolant temperature at core entrance.

(b) Please derive an equation to calculate the cladding surface temperature along the direction of coolant flow. (5%)
Use following notation on your derivation:

C_c : the circumference of the fuel rod;

h : heat transfer coefficient at cladding surface.

(c) Sketch qualitatively the temperature distribution of coolant and cladding surface along the direction of coolant flow. (3%)

(d) Sketch qualitatively the temperature distribution of coolant and cladding surface along the direction of coolant flow in a boiling water reactor for the same power distribution. (3%).