八十四學年度 核工與工物 所 組碩士班研究生入學考試

科目 核工原理 科號 3302 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

1. (10%)

Compute the number of elastic scattering collisions that is required for a $_1H^2$ atom to slow down a fission neutron from 2 MeV to a thermal energy of 1 eV.

2. (10%)

The radioactive nuclide $_{11}Na^{24}$ ($t_{1/2}$ =14.8 hours) can be produced by the neutron bombardment of $_{11}Na^{23}$. Assume the production rate of $_{11}Na^{24}$ is a constant and equals to 10^8 nuclei/sec, and the bombardment is started with a sample of $_{11}Na^{23}$ which originally has an activity of 0.1 μCi of $_{11}Na^{24}$ before the bombardment. One starts to bombard the sample of $_{11}Na^{23}$ for a period of 14.8 hours and then stops the bombardment. Assume that the absorption of $_{11}Na^{24}$ atoms to incident neutrons is negligible. Determine the activity of the sample at the time 29.6 hours after the bombardment was stopped.

3. (15%)

The most important fission product poison in nuclear fuels is $_{54}Xe^{135}$ (fission yield is γ_X, decay constant is λ_X) and whose thermal absorption cross section is denoted as σ_X. This isotope can also be formed as a result of the β^- decay of $_{53}I^{135}$ (decay constant is λ_I) which is produced directly from fission (fission yield is γ_I). Assume that the absorption of iodine atoms to thermal neutrons can be neglected. The thermal flux and the macroscopic fission cross section to thermal neutrons in the nuclear reactor are denoted as ϕ and Σ_f respectively.

a) Find the expressions of equilibrium xenon and iodine concentrations

b) If the nuclear reactor is shut down after both xenon and iodine have reached their equilibrium concentrations. Find the time at which the xenon concentration reaches its maximum.

4. (20%)

A bare sphere of moderator of radius R contains uniformly distributed source emitting S_0 neutrons/sec-cm^3. The diffusion length is L, the diffusion coefficient is D, and the extrapolated distance is d.

a) Write down the diffusion equation and the boundary conditions.

b) Solve for the flux distribution in the sphere.

c) Solve for the neutron leakage rate from the surface of the sphere.

5. (12%)

A PWR is operating at a thermal power of 2800 MW. It is made up of 160 fuel assemblies of 264 rods each. Fuel rod height is 360 cm, rod diameter is 1.05 cm, and pellet diameter is 0.92 cm. Determine

a) q', the average linear power density (W/m).

b) q", the average rod surface heat flux (W/cm^2).

c) q_p''', the volumetric pellet power density (W/cm^3).

6. (10%)

For a bare homogeneous cylindrical core of a given composition, calculate the ratio of height to diameter of the core which has the smallest critical mass.

Hint: $B_g^2 = (\frac{2.405}{R})^2 + (\frac{\pi}{H})^2$ for a bare homogeneous cylindrical core.

7. (18%)

Briefly explain the following terms:

a) nuclear Doppler effect

b) self-shielding

c) thermal disadvantage factor

d) risk

e) buildup factor for gamma ray

f) DNB

8. (5%)

Explain why a single shielding material is unsatisfactory for high energy shielding?