國立清華大學 104 學年度碩士班考試入學試題

系所班組別：生醫工程與環境科學系(0524) 丙組 (放射組)

考試科目（代碼）：放射物理學(2402)

1. (10%). (1) 2%. Define the potential difference (V) by the work done in an electrical circuit (W) and the charge passing through the circuit (Q). (2) 8%. A potential of 24 volts placed across a heating coil produces a current of 2 amperes. Find the resistance of the coil, the charge which passes through the coil in 2 minutes, the energy dissipated, and power developed. Present your answers with SI units.

2. (10%). (1) 2%. Define the unit of roentgen (R). (2) 2%. Define the absorbed dose and provide its SI unit. (3) 2%. What quantity does the unit of becquerel stand for? Define this quantity. (4) 4%. A patient is given an x ray exposure of 400 R. Calculate this exposure in unit of Ckg^{-1}. Given that 1 R = 2.58 x 10^{-4} Ckg^{-1}.

3. (10%). (1) 2%. Define the mass number of a nucleus. (2) 2%. What is an isotope of a nucleus? (3) 3%. Can you separate isotopes of a nucleus chemically? Why or why not? (4) 3%. Provide a method or an instrument which can separate isotopes.

4. (10%). (1) 3%. What is characteristic radiation? (2) 3% What is the anode heel effect in an x ray machine? (3) 4%. According to the anode heel effect, shall we place the thicker part of the body on anode side or cathode side? Why?

5. (10%). Calculate the rise in temperature of a rotating anode after an exposure of 120 mA for 1 s at constant potential of 150 kV. Assume the target to have a mass of 400 g and the surface area of the bombarded region to be 30 cm^2; take the density of tungsten to be 19.3 g/cm^3 and specific heat 0.03 cal g^{-1} $^{o}C^{-1}$. (1) 5%. Assume the heat instantly distributes itself over the whole of the anode and none is lost by heat transfer. (2) 5%. Assume no heat escapes from the immediate area of the bombarded region but is concentrated to a depth of 1.5 mm under the bombarded area. Hint: 4.18 J = 1 calorie.

6. (10%). (1) 5%. Use a diagram to illustrate the geometrical factors that lead to beam penumbra in a linac. (2) 5%. Given the diameter of the source S, the distance from the source to the end of the collimator, fc, and the distance from the source to the detector's

position, f. Derive the penumbra P by S, f, and fc.

7. (10%). A scintillation detector in nuclear medicine is usually composed of a scintillation crystal and a photomultiplier. (1) 4%. Describe the basic principle of a scintillation crystal. (2) 4%. Describe the working principle of a photomultiplier tube. Use a diagram, including the parts of photocathode, dynode, and anode, to illustrate your answer. (3) 2%. Describe the difference between the scintillation detector and Geiger counter.

8. (10%). (1) 3%. Define the transformation constant λ. Derive λ by the initial number of atoms of a radioactive source, N_0, and the number at time t, N. (2) 3%. Let λ_b be the fraction of the isotope eliminated biologically per unit time, λ_p the fraction which decays physically per unit time, and λ_{eff} the fraction that disappears per unit time by both processes. The three transformation constants are related to the corresponding half-lives of T_b, T_p, and T_{eff}, respectively. Derive T_{eff} by T_b and T_p. (3) 4%. In a thyroid study, the activity of the thyroid was found to decay with a half-life of 4 days as measured against a source of constant activity. Given the physical half-life for iodine is 8.05 days. Find the biological half-life.

9. (10%). Plot a diagram to illustrate the production of a KLM Auger electron. Explain your answer shortly.

10. (10%). (1) 5%. We want to determine the dose to the medium at point P when the medium is placed in a radiation field. At P we place the Bragg-Gray cavity, of outside radius c and inner radius a. What is the minimum requirement for the value of (c-a)? Why? (2) 5%. A cavity with 1 cm^3 volume, filled with air at STP, is exposed to a radiation field that liberates 3.336×10^{-10} C in a given time. Determine the dose to the air. Hint: the density of air = 1.293 kg m^{-3}; the average energy required to cause one ionization in the air: 33.85 J/C; the ratio of averaged stopping power of carbon to air: 1.009.