



MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

P.O. Box 972-60200 – Meru-Kenya.
Tel: +254(0) 799 529 958, +254(0) 799 529 959, +254 (0)712 524 293
Website: www.must.ac.ke Email: info@mucst.ac.ke

UNIVERSITY EXAMINATIONS 2023/2024

FOURTH YEAR, FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN PHYSICS AND BACHELOR OF EDUCATION SCIENCE

SPH 3400: NUCLEAR AND RADIATION PHYSICS

DATE: DECEMBER 2023

TIME: 2 HOURS

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

- Define isotopy (2 Marks)
 - Describe a radionuclide giving an example (3 Marks)
 - For the nuclide find the binding energy per nucleon given that the mass of neutron is 1.0086649U, Proton is 1.0072765U and that X is 5.005487U (5 Marks)
 - State any two reasons why a beta particle is less ionizing than an alpha particle (2 Marks)
 - The half-life of Carbon-14 is 5600 years. Find the activity of a sample of dead matter of mass 2.4 Kg containing 0.002% of carbon-14 (6 Marks)
 - Differentiate between photoelectric effect and Compton scattering (3 Marks)
 - For a cyclotron of maximum orbiting radius of 1.4m and frequency of 8.4 MHz Find:
 - The applied magnetic flux density (3 Marks)
 - Velocity of emergency of the electrons (3 Marks)
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- h) Using a suitable example and nuclear equations explain how a nucleus can decay producing a beta particle (4 Marks)

QUESTION TWO (20 MARKS)

- a) A radioactive emitter of alpha particles of 12 MeV with an activity 120 Bq is placed in an ionization chamber. If the energy required to produce an ion-pair is 42 eV. Find the current produced (6 Marks)
- b) A proportional counter has coaxial wire radius of .1mm and a tube of radius of 0.4m. if the is applied voltage is. Find the applied radial field (5 Marks)
- c) A nuclear reactor is used to supply electricity to the mains grid of a city. The city daily consumption rate is, if the nuclear plant uses the following reaction to generate electricity and given the efficiency of the energy transmission is 100%. Find the amount of U-238 required to supply the power per day (9 Marks)

Given that the following

U-238 mass =238.0507826U

Th-234 mass = 234.0435954U

He-4 mass = 4.0026032U

QUESTION THREE (20 MARKS)

- a) A sealed capsule containing the radiopharmaceutical phosphorus-32 (^{32}P), an emitter of beta particles is implanted into a patient's tumor. The average kinetic energy of the beta particles is 700 Kev. The initial activity is 5.22 MBq. Determine the energy absorbed during a 10.0-day period given that the half-life is 14.26 Days. Assume that the beta particles are completely absorbed within the tumor (10 Marks)



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- b) To destroy a cancerous tumor, a dose of gamma radiation totaling an energy of 2.12 J is to be delivered in 30.0 days from implanted sealed capsules containing palladium-103. Assume that this isotope has half-life 17.0 d and emits gamma rays of energy 21.0 keV, which are entirely absorbed within the tumor.
- Find the initial activity of the set of capsules (7 Marks)
 - Find the total mass of radioactive palladium that these "seeds" should contain (3 Marks)

QUESTION FOUR (20 MARKS)

- A beam of X-rays of wavelength 0.2 nm is incident on a free electron and gets scattered in a direction with respect to the direction of the incident radiation resulting in maximum wavelength shift. Find the percentage energy loss of the incident radiation (7 Marks)
- The energy required to remove an electron from sodium is 2.3 eV. Does sodium show a photoelectric effect for orange light with $\lambda = 6800 \text{ \AA}$? (7 Marks)
- The nuclear reaction has a Q-value of 6.2 MeV. Find the kinetic energy of the alpha particles produced (6 Marks)

