

Dr Kuldeep Kumar Singh

30/11/2022

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Roll No.....

Department of Physics & Photonics Science, NIT Hamirpur (HP)

End Semester Examination, Nov., 2022

Subject: Nuclear Science & Engineering (PH-331)

Class: B. Tech. 3rd Year

Time: 3 hrs

Semester: 5th

Max. Marks: 50

Note: All questions are compulsory.

Q.1 (i) By probing nucleus with high energy electron beam, how we can estimate the size of the nucleus? (2)

(ii) In a uranium mineral, lead is found predominantly in the form of isotope 206. The mineral contains 0.093g of lead in 1g of uranium. Calculate the age of the mineral. (half-life of $U^{238} = 4.5 \times 10^9$ years). (2)

(iii) Differentiate between internal conversion and internal pair conversion. (2)

Q.2 (i) Discuss Geiger-Nuttal law. (3)

(ii) Explain the terms: dead time, recovery time and resolving time of GM counter. (3)

(iii) What is the need of quenching mechanism in GM counter? Draw and explain the plateau curve of GM counter. (3)

(iv) Explain Lawson criterion. Why the first fusion reactors are most likely to employ deuterium-tritium mixture as a fuel? (3)

(v) Why we need to develop fusion reactor technology in near future? (3)

(vi) What is a fast breeder reactor? Give fuel breeding reactions from the fertile materials ^{232}Th and ^{238}U . How fast breeder reactor technology differ from other fission reactors' technology? (3)

(vii) Use shell model to predict the ground state spin and parity of the nuclei $^{33}_{16}\text{S}$, $^{10}_5\text{B}$, and $^{67}_{30}\text{Zn}$. (3)

(viii) What is binding energy? Draw binding energy per nucleon curve and explain its characteristics. (3)

Q.3 (i) Explain nuclear cross-section. (2)

(ii) The cross-section of cadmium Cd^{113} used in the control rods in nuclear reactors for capturing thermal neutrons is 20×10^3 barn, the mean atomic mass of natural Cd is 112u and its density is $8.64 \times 10^3 \text{ kg/m}^3$, (Cd^{113} contains 12% of natural Cd, $1\text{u} = 1.66 \times 10^{-27}\text{kg}$).

(a) What fraction of an incident beam of thermal neutrons is absorbed by a Cd sheet of 0.1mm thickness?

(b) What thickness of Cd sheet is needed to absorb 99% of an incident beam of thermal neutrons? (3)

Q.4 Discuss the principle, construction and working of cyclotron. Why cyclotron cannot be used to accelerate electrons? (5)

Q.5 Discuss the construction and working of ionisation chamber. (5)

Q.6 Explain the term radioactive equilibrium. Considering the decay chain, $A \rightarrow B \rightarrow D \rightarrow \dots X$ (stable end product), obtain the expression for number of atoms of B at any time t. Plot how the relative number of nuclides A & B changes with time and then discuss (i) transient equilibrium (ii) secular equilibrium. (5)