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B.Sc. Course (CBCS) Ordinance (Sem-VI)
EXAMINATION MAY 2023
PHYSICS - NUCLEAR PHYSICS

[Time:2 Hours]

[Max. Marks:80]

- Instructions:**
- 1) All questions are compulsory, however internal choice is available.
 - 2) Figures to the right indicate marks.
 - 3) Symbols have the usual meaning unless otherwise stated.
 - 4) Draw neat diagrams where necessary.
 - 5) Use of non-programmable calculator is allowed.

Q1 Answer any four of the following

(4x4=16)

- a) Explain saturation property and spin dependence property of nuclear forces.
- b) If the number of nucleons in a copper nucleus is 64 and number of nucleons in oxygen nucleus is 16. How much larger is the copper nucleus than an oxygen nucleus?
- c) Give the energetics of β^+ decay. why is β^+ decay less probable than β^- decay?
- d) What is meant by Packing Fraction? Draw the graph of packing fraction versus mass number. How does its value explain the stability of the nucleus?
- e) What do you mean by 1) dead time and 2) quenching of G.M counter?
- f) Give the three stages of the nuclear programme for India. What was the main goal in adopting this programme?

Q2 Answer any four of the following:

(4x4=16)

- a) What is meant by electric quadrupole moment of a nucleus? What is its physical significance?
- b) Explain What you mean by Fissile and Fertile nuclei. Give two examples of each.
- c) Estimate the mass of meson using Heisenberg Uncertainty Principle.
- d) What is a Breeder reactor? Explain its working. Explain material
- e) Show that the nucleus is made of extremely dense material and its density is a constant for all nuclei.
- f) Calculate the amount of energy produced by the fission of 1.00kg of U^{235} given the average fission reaction of U^{235} produces 200MeV of energy per fission.

- Q3 A) p) 1 gm of ^{90}Sr remains as 0.953gm after 2 years. Calculate the half-life of ^{90}Sr . 3
How many grams of ^{90}Sr will be left after a period of 5yrs?

- q) What is secular equilibrium? Show graphically the decay of parent and growth of daughter with time. 3

OR

- A) x) What is radio Carbon dating? How is Carbon - 14 formed in the atmosphere? 3
How does it decay?

- y) Explain how natural radioactive elements are classified to form the radioactive series. 3

- B) In successive radioactive disintegration of $A \rightarrow B \rightarrow C$ type, where C represents the stable end product, derive the expression for number of atoms of A and B at any instant of time t. 6

- Q4 A) p) The mass of $^{20}_{10}\text{Ne}$ is 19.992442 a.m.u., $^{21}_{10}\text{Ne}$ is 20.993849 a.m.u and $^{22}_{10}\text{Ne}$ is 21.991385a.m.u respectively. What is the binding energy of the last neutron in $^{22}_{10}\text{Ne}$? (Mass of neutron=1.000865a.m.u) 3

- q) Give any three conservation laws that are obeyed during a nuclear reaction. 3

OR

- A) x) Explain briefly: 1) Elastic scattering 2) Radiative capture and 3) spallation nuclear reactions. 3

- y) A piece of ancient wood shows an activity of C^{14} of disintegration per minute per gram of C^{14} . Estimate the age of wood piece, if the half-life of C^{14} is 5568 yrs. Assume the activity of fresh Carbon-14 is 15.6 disintegrations per minute per gram. 3

- B. Explain how the mass of the neutron was determined in the laboratory. 6

- Q5 A) p) Derive the expression for alpha disintegration energy. 3

- q) State Geiger-Nutall Law. Give its graphical representation. What was observed in the range of long lived nuclei? 3

OR

- A) x) Explain how gamma rays get attenuated when passing through matter by pair production and Compton scattering. 3

- y) Define multiplication factor k, in the neutron cycle. What happens to the nuclear chain reaction when value of $k > 1$ and $k=1$? 3

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- B) Give the beta decay spectrum. Which two laws of physics were violated in this decay? Give the Pauli's hypothesis of neutrino for beta decay. 6
- Q6 A p) Explain three similarities between a liquid drop and a nucleus. 3
- q) Give the spins and parities using the Jensen Mayer scheme in the shell model for ^{17}O and ^{16}N ? 3

OR

- A) x) Give three experimental evidences for Magic numbers that led to shell model. 3
- y) Draw the potential energy of fission fragments versus the distance between them. How does it explain stability of nuclei? 3
- B) The Semi-Empirical mass formula is simplified as, $zM^A = \alpha A + \beta Z + \gamma Z^2 \pm \delta$, where A is mass number and Z is atomic number. What is the nature of M(Z,A) versus Z graph for even A isobaric family? Draw the M(Z,A) versus Z curves. Find the expression for charge of the most stable isobar. Hence explain the beta activity of the isobaric family. 6