



**WEST BENGAL STATE UNIVERSITY**  
B.Sc. Honours 5th Semester Examination, 2021-22

**PHSADSE03T-PHYSICS (DSE1/2)**

**NUCLEAR AND PARTICLE PHYSICS**

Time Allotted: 2 Hours

Full Marks: 50

*The figures in the margin indicate full marks.  
Candidates should answer in their own words and adhere to the word limit as practicable.  
All symbols are of usual significance.*

**Question No. 1 is compulsory and answer any two from the rest**

1. Answer any *fifteen* questions from the following: 2×15 = 30
- (a) What is mirror nuclei? Give example.
  - (b)  ${}^2\text{He}^4$  nucleus has no magnetic moment. Explain.
  - (c) Determine the radii of a  ${}^{16}\text{O}$  nucleus, given  $r_0 = 1.2$  fm
  - (d) State Geiger-Nuttall law.
  - (e) Find the Q-value of the reaction  ${}^{14}_7\text{N}(\alpha, p){}^{17}_8\text{O}$ . Take mass of  ${}^4\text{He} = 4.0026$  u,  ${}^{14}\text{N} = 14.0031$  u,  ${}^1\text{H} = 1.0078$  u,  ${}^{17}\text{O} = 16.9994$  and  $1\text{u} = 931$  Mev.
  - (f) A muon is not a meson. Explain.
  - (g) Calculate the minimum speed of a charged particle for emission of Cerenkov radiation in a medium of refractive index 1.5.
  - (h) What are the differences between Compound nuclear reaction and direct reaction?
  - (i) What is strangeness of an elementary particle?
  - (j) How does interaction of  $\gamma$ -ray in matter differ from interaction of charged particles?
  - (k) What are packing fraction and binding energy fraction?
  - (l) What are the quark contents of proton and neutron?
  - (m) What is straggling of range of  $\alpha$ -particle?
  - (n) An ultra-relativistic proton moves in a magnetic field. Can it radiate  $\pi^+$ ,  $\pi^-$  and  $\pi^0$  mesons, electrons and positrons?
  - (o) Why the following reactions are not found in nature?
    - (i)  $e^- \rightarrow e^- + \gamma$  in vacuum
    - (ii)  $K^+ \rightarrow \pi^+ + \gamma$  in vacuum
  - (p) Can photoelectric emission take place with free electron? Explain.
  - (q) Give example of two hyperons. What is hyper nucleus?
  - (r) Define parity of a nucleus.
  - (s) What is resonant reaction?
  - (t) Why neutron show magnetic moment though it lacks charge?

2. (a) 1 g of  $^{226}\text{Ra}$  has an activity of 1 curie. Calculate the mean life and half life of Radium. 3
- (b) What are the problems to explain continuous  $\beta$ -decay spectrum? How they were solved? 3
- (c) Why  $\text{U}^{235}$  is fissile with slow neutrons but  $\text{U}^{238}$  requires fast neutrons for fission process? 4
3. (a) Why spin-orbit coupling is necessary in Shell model to reproduce magic numbers? 3
- (b) What are the spin-parity ( $J^\pi$ ) of  ${}_4\text{Be}^{11}$  in its ground state? 1
- (c) What are the basic assumptions behind Fermi gas model of the nucleus? 2
- (d) Calculate the threshold energy for the nuclear reaction  ${}^{14}\text{N}(n,\alpha){}^{11}\text{B}$  in MeV. Use the following data: 4  
 Mass of  ${}^{14}\text{N}$ (14.007550 u), mass of n (1.008987 u), mass of  $\alpha$  (4.003879 u), mass of  ${}^{11}\text{B}$ (11.012811 u).
4. (a) Explain how the Wave theory failed to explain photoelectric effect and Compton effect. 2
- (b) What are the major interaction processes by which energized electron loses energy within matter? Explain them. 4
- (c) How fast neutrons interact with matter? 2
- (d) Why  $e^- - e^+$  pair production cannot occur in vacuum? 2
5. (a) What is meant by SU(3) symmetry of strong interaction? How is this broken? 4
- (b) Write CPT conservation law. 2
- (c) The isospin, baryon number and strangeness of a particle are given by  $I = 0$ ,  $B = +1$  and  $S = -3$ , respectively. Find the electric charge of the particle. 2
- (d) Identify the type of the reaction 2
- (i)  $\mu^- \rightarrow e^- + \nu + \bar{\nu}$
- (ii)  $\Sigma^0 \rightarrow \Lambda^0 + \Lambda$

**N.B. :** Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within 1 hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.

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