



**WEST BENGAL STATE UNIVERSITY**  
B.Sc. Honours 5th Semester Examination, 2022-23

**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 the significance of non-zero electric quadrupole moment of a nucleus?
- (b) What is the minimum kinetic energy required to probe a nucleus of diameter 10 fm?
- (c) What is straggling of range of an  $\alpha$ -particle?
- (d) Mention two differences between direct nuclear reaction and compound nuclear reaction.
- (e) Explain why an isolated photon cannot produce an electron-positron pair.
- (f) Discuss the working principle of a scintillation detector.
- (g) How close can a proton with kinetic energy 2 MeV get to a gold nucleus ( $Z = 79$ ) at rest?
- (h) Why is nuclear fusion not possible beyond the iron group of elements?
- (i) Consider the reaction among nuclei:  

$$A + B \rightarrow C + D^*,$$
 where the nucleus  $D$  is created in an excited state with excitation energy  $E_D$ . If the masses of the nuclei are given, write down an expression for  $Q$ -value of this reaction.
- (j) What are fertile and fissile nuclei?
- (k) Can you accelerate an electron by a cyclotron? Discuss.
- (l) Give names and symbols for the antiparticles of  $e$ ,  $p$ ,  $\nu_e$  and  $k^+$ .
- (m) Calculate the mass of U-238 with 1 Curie activity.
- (n) What are baryons and mesons? Give one example for each of them.
- (o) What are anomalous about the magnetic dipole moment of a neutron?
- (p) What is the difference between beta decay and internal conversion process?
- (q) Give an example each for a LINAC and a cyclotron situated in India.
- (r) What are the quark contents of a proton and an electron?
- (s) Give the spin and parity of two stable isotopes of Li.
- (t) Give an example of a hyperon. What is a hyper nucleus?

2. (a) Define range of an  $\alpha$ -particle in a medium. Why is it expressed in  $\text{kg/m}^2$  unit? 1+1  
 (b) Mention two inadequacies in the nuclear liquid drop model. 1+1  
 (c) What is mass parabola? What is its utility? 1+2  
 (d) A nucleus of mass number 240 decays by  $\alpha$ -emission to the ground state of the daughter nucleus. The Q-value of this process is 5.26 MeV. Find out the energy of the  $\alpha$ -particle. 3
3. (a) What is a Geiger-Müller counter? How does it work? 1+3  
 (b) In Compton scattering between a photon and a stationary electron, what is the maximum wavelength of the scattered photon if the incident photon has wavelength  $\lambda$ ? 1  
 (c) Explain three processes by which  $\gamma$ -rays lose energy by interaction with matter. Give your answer in brief. 3  
 (d) Write down and complete the nuclear reaction  $^{15}\text{N}_7(p, d)$ , indicating the compound nucleus. 2
4. (a) An experimentalist found a radioactive source that emits both  $\alpha$  and  $\beta$  particles with half-lives 1600 years and 400 years respectively. After what time would one-fourth of the material remain undecayed? 3  
 (b) Write down the CPT conservation law. 2  
 (c) What is the definition of binding energy of a nucleus? How much is it for a valence neutron of a nucleus lying on the neutron drip line? 1+1  
 (d) What is bremsstrahlung radiation? Why is it important in the context of electrons interacting with matter? 1+2
5. (a) Show, using weight diagram, the octet symmetry of mesons and baryons. 2+2  
 (b) Check whether the following reactions are allowed or forbidden:  $1\frac{1}{2}+1\frac{1}{2}$   
 (i)  $p + \bar{p} \rightarrow 2\pi^+ + 2\pi^- + 2\pi^0$   
 (ii)  $\pi^+ + p^- \rightarrow \bar{\Sigma}^- + k^-$   
 (c) Show that an electron is a clean probe for probing a nucleus at high beam energies. 3

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