B. Sc. Semester VI (Honours) Examination, 2021 (CBCS)

Subject: Physics

Paper: DSE-3 (Nuclear and Particle Physics)

Time: 3 Hours Full Marks: 60

1. Answer **any six** of the following questions: **5 × 6 = 30**

(a) (i) What is meant by 'packing fraction'? How is it related to the binding energy of a nucleus? Why is the binding energy per nucleon relatively constant?

(ii) Calculate the binding energy and average binding energy per nucleon of ${}^{12}_{6}C$.

(b) (i) All odd-A nuclides have a nuclear spin, $I = \frac{1}{2}(2n+1)\,\hbar$, where $n = 0, 1, 2$ .... and the electron, proton, neutron all have a spin angular momentum $\frac{1}{2}\,\hbar$. Prove that electron cannot exist inside the nucleus.

(ii) A neutron has no electric charge, but has a magnetic moment. How is this possible?

(c) (i) State the main assumptions of the nuclear shell model.

(ii) What are the experimental evidences that suggest the shell model?

(d) (i) Why are there no magic numbers that are odd?

(ii) Write down the shell configuration and predict, on the basis of single particle shell model, the spin and parity of the following nuclei: ${}^{17}_{8}O$, ${}^{27}_{13}Al$ and ${}^{45}_{21}Sc$.

(e) (i) When electron is not an integral part of a nucleus, how do we justify the emission of electrons from nuclei in β-decay?

(ii) How do neutrinos differ from photon, which also has no charge or rest mass?

(iii) A nucleus emits an α-particle followed by two β-particles. Show that the final nucleus is an isotope of the original one.

(f) (i) What are the quantities that are conserved in a nuclear reaction? Discuss the significance of Q-factor in this context.

(ii) Deuterons of energy 10 MeV are incident on a ^{63}Cu target and neutrons are observed with 15 MeV of kinetic energy. Evaluate (a) the Q-value for the reaction, (b) the kinetic energy of the residual nucleus ^{64}Zn. (The atomic masses are ^{2}H = 2.014102 u, n = 1.008665 u, ^{63}Cu = 62.929599 u and ^{64}Zn = 63.929144 u.)

(g) (i) What is meant by the 'dead time' of a GM-counter? How does it differ from a proportional counter?

(ii) A GM-counter has a 'dead time' 400 μs. What are the true counting rates when the observer rates are (a) 100 per minute, (b) 1000 per minute?

(h) (i) Explain the conservation law for the lepton number with an example.

Distinguish between mesons and baryons.

(ii) Name the conservation law violated in $\nu_e + p \rightarrow n + e^+$.

2. Answer **any three** of the following questions: **10 × 3 = 30**

(a) (i) Assuming that 1 $amu = 1.66 \times 10^{-27} kg$ and the radius of a nucleus to be given by $R_0 = r_0 A^{\frac{1}{3}}$ where $r_0 = 1.2 \times 10^{-15}\ m$, calculate the density of nuclear matter.

(ii) On what factor does the stability of a nucleus depend?

(iii) Why are the fission and fusion observed for only heavy and light nuclei respectively having less binding energy per nucleon?

(iv) Why do the stable medium nuclei contain excess neutrons?

(b) (i) How does the range of α-particles in matter depend on the energy? What is the Geiger-Nuttall rule? Explain the 'straggling' of the range of α-particles.

(ii) Explain how the emission of a particle with the properties postulated by Pauli removes the anomalies with angular momentum in β-decay.

(iii) Explain the role of neutrino hypothesis in understanding the β-decay.

(iv) Explain what is inverse β-decay?

(c) (i) Explain the proton-proton cycle. Why it is a very slow process?

(ii) Why does carbon cycle require higher temperature than the proton-proton cycle?

(iii) $^{235}_{92}U$ captures a thermal neutron and fissions to release energy of 180 MeV. If the mass numbers of the fission fragments be 140 and 93, calculate the kinetic energy of the lighter fragment.

(iv) What is thermonuclear fusion?

(d) (i) Junction detectors are usually operated with large reverse bias. Why?

(ii) Outline the working of a scintillation counter.

(iii) Explain Einstein's explanation for photoelectric effect.

(iv) If the detector measures a wavelength for the scattered x-rays of 0.2412 nm, what is the x-ray scattering angle?

(e) (i) Where are accelerator facilities available in India?

(ii) Explain the concept of isospin.

(iii) Find the value of the third component of isotopic spin of Ξ^- in the following strong interaction: $\pi^+ + n \rightarrow \Xi^- + K^+ + K^+$

(iv) Check if the following reaction are allowed or forbidden.

a. $p + \bar{p} \rightarrow 2\pi^+ + 2\pi^- + 2\pi^0$

b. $\pi^- + p \rightarrow \Lambda^0 + \pi^0$

(v) The quark contents of Λ^0 and Σ^+ are as: $\Lambda^0 = u + d + s$ and $\Sigma^+ = u + u + s$. What are their charges?

OR

B. Sc. Semester VI (Honours) Examination, 2021 (CBCS)

Subject: Physics

Paper: DSE-3 (Biophysics)

Time: 3 Hours Full Marks: 60

1. Answer any (6) questions **6×5=30**

(a) What are the structure and function of cytoplasm in living cells?

(b) Discuss quaternary structure of protein.

(c) Compare Time-scale and Spatial-scale of biological systems.

(d) What do you know about secondary structure of proteins?

(e) Write briefly about the loss of Multicellularity.

(f) Write a short note on integral membrane protein.

(g) Write a short note on human metabolites.

(h) Write a short note on nucleus of an animal cell.

2. **Answer any (3) questions:** **3×10=30**

(a) (i) Write a short note on self-realization in cells.

(ii) Draw the basic primary protein structure.

(b) Discuss briefly about four major nutritional types of prokaryotes.

(c) (i) What do you mean by random walk?.

(ii) Define simple random walk, lazy random walk and with resistance.

(d) (i) Write a short note on molecular evolution.

(ii) What do you know about convergent and divergent evolution?

(e) (i) What is genotype-phenotype mapping? Discuss it's applications.

(ii) What is self-sustaining ecosystem?