2026

6th Semester Examination (CCFUP : NEP)

PHYSICS

Paper : MJ 11-T

(Single Core Major)

[Nuclear and Particle Physics]

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Full Marks : 60 Time : Three Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Group - A

Answer any ***ten*** questions : 2×10=20

1. What do you mean by nuclear spin?
2. Define nuclear magnetic moment.
3. Show the plot of number of neutrons N against the number of protons Z for the stable nuclei of different elements. What is stability line? 1+1
4. What are the characteristics of nuclear force?
5. Why are the β- and α-particles, rather than protons and neutrons emitted by radioactive nuclei?

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6. Calculate the density of nuclear matter, the radius of a nucleus is given by $R = r_0 A^{1/3}$, where $r_0 = 1.2 \times 10^{-15}$m, and A, the mass number of the nucleus.
7. Radioactive decay is a statistical process — Explain.
8. State and explain Geiger-Nuttal law.
9. Using the shell model energy level diagram, predict the ground state spin-parity of $^{17}_{8}O$ nucleus.
10. What is electron capture process?
11. Define nuclear reaction cross section.
12. What is spontaneous and induced fission?
13. What are the main compositions of primary and secondary cosmic rays?
14. Write down the Gell-Mann-Nishijima formula and explain each of the terms.
15. What do you mean by mesons and baryons?

Group - B

Answer any ***four*** questions : 5×4=20

16. (a) Define nuclear binding energy.

    (b) Obtain its expression in terms of atomic masses.

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    (c) Calculate the binding energy of deuteron $\left(^{2}_{1}H\right)$. Given $M_H = 1.007825$ amu, $M_n = 1.008665$ amu, $M_d = 2.014102$ amu. 2+2+1

17. Show that if N_{10} be the number of parent atoms initially and λ_1, λ_2 the decay constants of the parent and daughter respectively, the time at which the number of daughter atoms is a maximum is given by

$$t_{max} = \frac{1}{\lambda_1 - \lambda_2} \ln\left(\frac{\lambda_1}{\lambda_2}\right).$$ 5

18. (a) Determine an expression of a α-disintegration energy.

    (b) Explain with the help of energy level diagram, the fine structure of α-spectrum. 3+2

19. (a) Derive Q-value of a nuclear reaction.

    (b) What is threshold energy? Derive an expression of threshold energy for an endoergic reaction. 2+(1+2)

20. (a) Give two examples of typical nuclear fission reactions.

    (b) Explain qualitatively nuclear fission on the basis of liquid-drop model of the nucleus. 2+3

21. (a) What is a particle accelerator?

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(b) What are its essential parts?

(c) A cyclotron having segments of radius 0.4 m is adjusted for accelerating hydrogen nuclei. The polarity is reversed 3×10^7 times a second. Find the energy of the particles in the issuing beam. 1+2+2

Group - C

Answer any ***two*** questions : 10×2=20

22. (a) Write down Bethe-Weizsäcker semi-empirical mass formula mentioning the terms.

(b) What is mass parabola?

(c) Explain β^+ and β^- decay with the help of mass parabola.

(d) Masses of isobars $^{64}_{28}Ni$ and $^{64}_{29}Cu$ have been measured as 63.9280 amu and 63.9298 amu respectively. Which of the two will be less stable? Given $M_H = 1.007825$ amu, $M_n = 1.008665$ amu. 2+2+3+3

23. (a) Show graphically the observed distribution of the kinetic energies of the β-particles with the number of particles (β-spectrum).

(b) What are the difficulties in interpreting the β-spectrum?

(c) Explain qualitatively how the Pauli's neutrino hypothesis solves the apparent breakdown of the conservation of momentum and energy in β-decay.

(d) What is the origin of γ-rays?

(e) Explain internal conversion. 1+2+3+2+2

24. (a) State Bohr's compound nucleus hypothesis.

(b) Discuss how the Ghoshal's experiment provides direct confirmation of the Bohr's independent hypothesis.

(c) Discuss the theory and construction of a Geiger-Müller counter. 2+4+4

25. (a) What are cosmic ray showers?

(b) How they are observed?

(c) Discuss qualitatively the mechanism of their origin.

(d) What are the different types of fundamental interactions?

(e) Write down the relative strengths, range, characteristic time and intermediate particles (mediators) for these interactions.

(f) Write down the quark structure of proton and neutron. 1+1+2+1+3+1+1