# B.Sc. 4th Semester (Honours) Examination, 2023 (CBCS)

## Subject : Physics

## Course : CC-IX

## (Elements of Modern Physics)

**Time: 2 Hours** **Full Marks: 40**

*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

**1.** Answer *any five* questions: 2×5=10

(a) What is meant by a wave packet? Why do we need it? 1+1

(b) The life-time of an excited state of an atom is $10^{-8}$ s. Calculate the minimum uncertainty in the determination of the energy of that excited state. (Given $h = 6{\cdot}6 \times 10^{-34}$ J.s)

(c) In one dimension the wave function of a particle is represented by $\psi(x) = \sqrt{a}e^{-ax}$. What is the probability of finding the particle in the region between $x = \frac{1}{a}$ and $x = \frac{2}{a}$ ?

(d) What do you understand by quantum tunnelling? Mention one of its application. 1+1

(e) State the basic assumptions related to the single particle shell model of nucleus.

(f) Mention the different types of nuclear reactors. Why do we use a moderator in a nuclear reactor? 1+1

(g) What do you mean by 'induced or artificial radioactivity'?

(h) What does the acronym 'LASER' stand for? What are the 'metastable states'? 1+1

Group-B

**2.** Answer *any two* questions: 5×2=10

(a) (i) Find the probability current density associated with a plane wave $Ae^{ikx}$ in one dimension and verify that it satisfies the equation of continuity in one dimension.

(ii) Find the probability current density for a real wave function. (2+2)+1

(b) (i) Define the terms 'stopping potential $(V_0)$' and 'threshold frequency $(v_0)$' in the case of photo-electric effect.

(ii) Show that Planck's constant $(h)$ has the dimension of angular momentum. 3+2

(c) (i) Give the definition of 'binding energy $(E_b)$' of a nucleus.

(ii) ${}_2He^4$ nucleus has no magnetic moment. Explain.

(iii) A reactor is producing energy at the rate of $32 \times 10^6$ watts. How many atoms of U-235 do undergo fission per second?

(Assume that on an average 200 MeV is released per fission.) 2+1+2

(d) What are Einstein coefficients? Derive the relation between them.

Group-C

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

(a) (i) Deduce Planck's law of radiation.

(ii) A proton is confined to a nucleus of radius $5\times10^{-5}$ m. Calculate the minimum uncertainty in its momentum and also calculate the minimum kinetic energy the proton should have. The proton mass is $1{\cdot}67 \times 10^{-27}$ Kg. 6+4

(b) (i) Establish the Geiger law $R \propto v^3$ for mono-energetic α-particles (the symbols have their usual meanings).

(ii) What is Geiger-Nuttal law? State the importance of this law.

(iii) Using semi-empirical binding energy formula, calculate the binding energy of ${}_{20}Ca^{40}$. 4+(1+1)+4

(c) (i) A betatron working on an operating frequency of 60 Hz has a stable orbit of diameter 1·6 m. Find the energy gained per turn and also the final energy if the magnetic field at the orbit is 0·5 Tasla.

(ii) What is a nuclear reactor? What are the essential elements of a nuclear reactor?

(iii) Write down all possible conservation laws of nuclear reactions. 2+(1+3)+4

(d) (i) Discuss the significance of the results of Davisson-Germer experiment.

(ii) What are the different natural radioactive series?

(iii) Explain, in brief, the construction and working principle of (Pulsed) Ruby laser. 2+2+(3+3)