

5. (a) Discuss the construction and working principle of a Cyclotron. Obtain suitable expressions for the
(i) cyclotron frequency, (ii) maximum kinetic energy acquired by the particles. (10)
- (b) Show that density of nucleus does not depend on mass number. (5)

Useful physical constants :

$$h = 6.62 \times 10^{-34} \text{ Js,}$$

$$\text{Rest mass of electron, } m_e = 9.1 \times 10^{-31} \text{ kg;}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$\text{Rydberg's constant (R)} = 1.097 \times 10^7 \text{ m}^{-1}$$

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1510

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Unique Paper Code : 2222513501

Name of the Paper : Elements of Modern Physics
(DSC paper)

Name of the Course : **B.Sc. Prog. (Physics)_NEP:
UGCF-2022**

Semester : V

Duration : 2 Hours

Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **four** questions in all.
3. **Q1** is compulsory.
4. **All** questions carry equal marks.
5. Use of non-programmable scientific calculator is allowed.
6. You may use the values of physical constants provided in the end.

1. Answer any five of the following :

- (i) What is Ultraviolet catastrophe? What assumptions were made by Planck in resolving the problem of blackbody radiation?
- (ii) What are the conditions for an acceptable wave function?
- (iii) Find the positions of maximum and minimum probability density for the $n = 2$ state of a particle confined to a one-dimensional box of length 'L'.
- (iv) Obtain the minimum and maximum wavelengths corresponding to the Lyman series in Hydrogen.
- (v) An excited atom gives up its excess energy by emitting a photon within an average time interval of 10^{-8} s. Estimate the uncertainty in the frequency of the photon emitted in the process.
- (vi) Write the characteristics of nuclear forces.

(5×3)

2. (a) What is Compton effect? Obtain an expression for Compton - shift in terms of the scattering angle of the photon.

(10)

- (b) The photocurrent of a photocell is cut off by a retarding potential of 2.92V for radiation of wavelength 250 nm. Find the work function in eV for the material. (5)
3. (a) Define the terms probability density and probability current density. Find them for a free particle moving along the positive x-axis, described by the wavefunction : $\psi(x, t) = A \exp[i(kx - \omega t)]$, where symbols have their usual meanings. (9)
- (b) Calculate the expectation value of position $\langle x \rangle$ and momentum $\langle p_x \rangle$ for a particle confined to a one-dimensional region of unit width, having a wavefunction $\psi(x) = \sqrt{3}x$ for $0 \leq x \leq 1$. (6)
4. (a) Briefly describe the construction and working of a Coolidge tube to generate X-rays. Distinguish between continuous and characteristic spectrum using a suitable diagram. (10)
- (b) Write the quantization conditions suggested by Sommerfeld to explain fine structure of hydrogen spectrum. (5)