

Subject Code—52602

B. Sc. EXAMINATION

(Batch 2018) (Main)

(Fifth Semester)

PHYSICS

CPL-501 (Paper-I)

Elements of Modern Physics

Time : 3 Hours

Maximum Marks : 80

Note : Attempt *Five* questions in all. Q. No. 1 is compulsory. All questions carry equal marks.

1. (a) Define Stephan-Boltzman Law. 2
- (b) Why visible light cannot be used to demonstrate Compton effect ? 2
- (c) What is the origin of line spectrum ? 2
- (d) Define group velocity, phase velocity and particle velocity. 2

- (e) What is orthogonality condition for a wave function ? 2
- (f) Draw first three normalized wave functions of a particles in a box. 2
- (g) Define resonance cavity in a laser system. 2
- (h) Write some applications of laser in industry. 2

Unit I

- 2. (a) Define Compton effect and find an expression for Compton shift. 8
- (b) Discuss production of X-rays. 4
- (c) A photon of energy 1.02 MeV is scattered through an angle of 90° by a free electron. Calculate energy of photon and electron after scattering. 4
- 3. (a) Define Bremsstrahlung effect and Cherenkov radiations. 6
- (b) State Plank's law of black body radiation and derive Wien's law and Rayleigh Jean's law from it. 6

- (c) Find the maximum energy in eV required when light of frequency 1.2×10^{15} Hz is directed on metal surface to eject electron. Threshold frequency of metal is 1.1×10^{15} Hz.

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Unit II

4. (a) What is the effect of nuclear mass on atomic spectra ? Compare the wavelength of spectral lines of positronium with those of ordinary hydrogen. 6
- (b) Define phase velocity and group velocity and obtain expression for both. 6
- (c) An electron collides with a hydrogen atom in its ground state and excites it to a state of $n = 3$. How much energy was given to hydrogen atom in this inelastic collision. 4
5. (a) What is a wavepacket ? Describe its construction and develop a wave function representing a wave packet. 8

- (b) Discuss drawbacks of Rutherford model. 4
- (c) Find the longest wavelength present in Balmer series of hydrogen corresponding to $H(\alpha)$ line. Given $R = 1.097 \times 10^7 \text{ m}^{-1}$. 4

Unit III

6. (a) State Heisenberg's uncertainty principle and show that neutrons and protons exist inside the nucleus. 6
- (b) What is a wavefunction ? Write important properties of wave function. 4
- (c) Explain and derive probability current density. What do you understand by stationary states ? 6
7. (a) Illustrate Heisenberg's uncertainty principle by diffraction of beam of electron by a narrow slit. 6
- (b) Define energy and momentum operator in quantum mechanics. 4

- (c) Derive one dimensional time independent Schrödinger wave equation. 6

Unit IV

8. (a) Discuss with suitable diagram, the principle, construction and working of He-Ne laser. 12
- (b) A He-Ne laser emits light of wavelength 632.8 nm and has a power output of 4 mW. How many photons are emitted per second by the laser ? 4
9. (a) What are Einstein Co-efficient ? How are they related with each other. 8
- (b) Distinguish between temporal and spatial coherence. 5
- (c) Determine what emission frequency width would be required to have a temporal coherence length of 10 m at a source wavelength of 488 nm. 3

$$L = \tau_c \times c$$

$$\tau_c = \frac{L}{c} = \frac{10}{3 \times 10^8} \text{ m s}^{-1}$$