

Roll No.

Exam Code : J-22

Subject Code—55615

B.Sc. EXAMINATION

(Main/Reappear) (Batch 2018 Onwards)

(Fifth Semester)

PHYSICS

CPL-501 Paper I

Elements of Modern Physics

Time : 3 Hours

Maximum Marks : 80

Note : Attempt *Five* questions in all, selecting *one* question from each Unit. Q. No. 1 is compulsory.

1. (a) Define Kirchhoff's Law. 2
- (b) What is a Photon ? Give its properties. 2
- (c) What is wave-particle duality ? 2
- (d) Draw spectrum of hydrogen atom as observed. 2

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- (e) What are the limitations of wavefunction ? 2
- (f) Write down time dependent and time independent Schrödinger wave equations in three dimensions. 2
- (g) Why is a two-level system not suitable for lasing system ? 2
- (h) What is the importance of Einstein co-efficients ? 2

Unit I

- 2. (a) What is Planck quantum hypothesis to explain spectrum of black body radiation ? 6
- (b) What is pair production and annihilation ? 6
- (c) Calculate the least and maximum values of wavelength obtained when gamma rays of energy 0.5 MeV are scattered by matter. 4

3. (a) What is Photoelectric Effect ? Give the laws of photoelectric emission. 8
- (b) Define ultraviolet Catastrophe. 4
- (c) If the speed of photoelectron is 10^4 m/s, what would be the frequency of radiation incident on a metal surface of work function 2.3 eV ? 4

Unit II

4. (a) State Bohr's correspondence principle. 5
- (b) Derive relation between group velocity and phase velocity. Also show that the phase velocity of associated wave is always greater than the velocity of light in vacuum. 6
- (c) An electron and proton have same de-Broglie wavelength. Prove that kinetic energy of electron is greater than that of proton. 5

5. (a) State postulates of Bohr's atomic model and Bohr's quantization rule. 6
- (b) What are de-Broglie waves ? Find an expression for de-Broglie wavelength. 6
- (c) Calculate the de-Broglie wavelength of a 2 eV photon. 4

Unit III

6. (a) State Heisenberg's uncertainty principle and derive it from de-Broglie wave-particle Quality. 6
- (b) What is normalization of a wavefunction ? Normalize the wave function $\psi(x) = N \sin(Kx)$ for a particle in a box. 6
- (c) Define operator and observable in quantum mechanics with examples. 4
7. (a) Solve Schrödinger's wave equation for a particle in one-dimension infinite potential well. 10

- (b) Which of the following wavefunctions are acceptable in quantum mechanics, discuss : 4
- (i) $\sin(x)$
 - (ii) $\tan(x)$
 - (iii) $\operatorname{cosec}(x)$
 - (iv) $\cos(x) + \sin(x)$.
- (c) Prove that electrons cannot exist inside the nucleus. 2

Unit IV

8. (a) Define three level and four level laser systems. What is the importance of metastable state ? 6
- (b) What is pumping process ? Discuss different types of pumping process in laser systems. 6
- (c) A He-Ne laser is operated at 632.8 nm. Calculate the ratio of stimulated emission to spontaneous emission coefficient. 4

9. (a) Derive Threshold condition for laser oscillations. 8

(b) What is a laser ? What are its important features ? Discuss the essential requirements for producing a laser action. 6

(c) A He-Ne laser has a coherence time of 10^{-8} s. Determine the coherence length. 2