2024/TDC (CBCS)/EVEN/SEM/
PHSHCC–402T/091

TDC (CBCS) Even Semester Exam., 2024

PHYSICS

(4th Semester)

Course No. : PHSHCC–402T

(Elements of Modern Physics)

Full Marks : 50
Pass Marks : 20

Time : 3 hours

The figures in the margin indicate full marks for the questions

UNIT—I

1. Answer any *two* questions : 2×2=4

(a) What is Planck's quantum hypothesis?

(b) Show that de Broglie waves are produced due to motion of the particle.

(c) Show that the wavelength of electron of mass m, accelerated through a potential difference (V) is given by

$$\lambda = \frac{h}{\sqrt{2meV}}$$

2. Answer *either (a) or (b)* : 6

(a) Describe Davisson and Germer experiment in detail with necessary diagram. 6

(b) An electron and a photon each has a wavelength of 2 Å. Calculate their momenta and total energies. 2+4=6

UNIT—II

3. Answer any *two* questions : 2×2=4

(a) Write the physical significance of Heisenberg's uncertainty principle.

(b) Why are uncertainties inescapable in quantum mechanics?

(c) Justify that the concept of Bohr orbit violates uncertainty relation.

4. Answer *either (a) or (b)* : 6

(a) Find the expression of radius of Bohr orbit and ground-state energy of hydrogen atom using uncertainty relation. 3+3=6

(b) *(i)* Show that electron cannot reside within a nucleus. 3½

(ii) The uncertainty in the velocity of a particle is equal to its velocity. If $\Delta P \Delta x = \hbar$, then show that the uncertainty in its location is its de Broglie wavelength. 2½

UNIT—III

5. Answer any *two* questions : 2×2=4

(a) Write any four properties of wave function.

(b) What is probability current density? Write its symbol.

(c) Write down the one-dimensional time-independent Schrödinger equation for a particle of mass *m*. Also write the same equation for a free particle.

6. Answer *either (a) or (b)* : 6

(a) Deduce orthogonality condition of wave functions. 6

(b) *(i)* For the wave function $\psi(x) = Ae^{-ikx}$, find the probability current density. 2

(ii) Show that if a particle is in a stationary state at a given time, it will always remain in a stationary state. 4

UNIT—IV

7. Answer any *two* questions : 2×2=4

(a) Write down the symbol and expression of Hamiltonian operator.

(b) Write down the time-dependent Schrödinger equation for a particle of mass m in one-dimension and in three-dimension.

(c) What will be the value of potential function on the wall of the box and inside the box for a particle residing within an infinitely rigid box of length L?

8. Answer *either (a) or (b)* : 6

(a) For a particle placed in an infinitely rigid box of length L, find the expression of normalized wave function. Also show that energy of the particle is quantized. 4+2=6

(b) Show that for a particle whose energy is more than the height of the potential step (V_0) $R+T=1$, where symbols have their own meaning. 6

UNIT—V

9. Answer any *two* questions : 2×2=4

(a) What is half life? How is it related to disintegration constant?

(b) Define mass defect and binding energy.

(c) Mention the differences between spontaneous and stimulated emission.

10. Answer *either (a) or (b)* : 6

(a) Discuss construction and working of ruby laser. 6

(b) Explain the process of nuclear fission and fusion with necessary reactions. 3+3=6

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