TDC (CBCS) Even Semester Exam., 2022

PHYSICS

(Honours)

(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

SECTION—A

Answer any *ten* of the following questions : 2×10=20

1. State Planck's quantum hypothesis.

2. What is quantum theory of light?

3. What is matter wave? Whose variations give rise to matter wave? 1+1=2

4. State Heisenberg uncertainty principle. Mention its mathematical expression. 1+1=2

5. Does the uncertainty in quantum mechanics arise because of some errors in measurements? Justify your answer.

6. What is the uncertainty in momentum for a single monochromatic wave?

7. What do you mean by stationary state?

8. What is the importance of normalizing a wave function?

9. Can the wave function $\psi(n) = A\sin(kn - \omega t)$ represent a free particle? Justify your answer.

10. What is called zero point energy of a particle in one-dimensional box?

11. What is quantum mechanical tunnel effect?

12. What do you mean by dynamical evolution of a quantum state?

13. Write the full form of LASER. Mention some of its uses. 1+1=2

14. Why can fusion take place only at very high temperature?

15. Define mean life and half life in the context of radioactivity. 1+1=2

SECTION—B

Answer any *five* of the following questions : 6×5=30

16. Define phase velocity and group velocity. Show that if phase velocity is constant, then group velocity is equal to the phase velocity. 2+4=6

17. Explain Davisson and Germer experiment in detail with necessary diagrams.

18. *(a)* How does the concept of Bohr orbit violate the principle of uncertainty? 2

(b) Using uncertainty relation, show that electrons cannot reside within a nucleus. 4

19. *(a)* Obtain the expression of ground state energy of hydrogen atom using uncertainty relation. 4

(b) If the uncertainty in the location of a particle is equal to the de Broglie wavelength, then find its uncertainty in velocity. 2

20. *(a)* What are the fundamental postulates of quantum mechanics? 3

(b) Normalize the wave function

$$\psi(x) = Ae^{-\alpha x^2}$$

where A and α are constants. 3

21. *(a)* Deduce the orthogonality condition of wave functions. 3

(b) Show that the probability current density for the wave function

$$\psi(x, t) = Ae^{i\phi(x,t)} \text{ is } A^2 \frac{\hbar}{m}\frac{\partial \phi}{\partial x}$$

where A is a constant. 3

22. *(a)* Why should wave function be single-valued everywhere? 2

(b) Deduce the one-dimensional Schrödinger equation for a particle of mass m in time-dependent form. 4

23. *(a)* A particle cannot exist in one-dimensional infinitely rigid box if its energy is zero. Justify. 3

(b) For a potential step, write down the two Schrödinger equations corresponding to the regions $x < 0$ and $x > 0$ for the case $E > V_0$. Also write the boundary conditions at the junction between two regions. 1+1+1=3

(Continued)

24. *(a)* What is radioactivity? 1

(b) State the radioactive decay laws. Using these laws, deduce the equation

$$N = N_0 e^{-\lambda t}$$

where symbols have their own meanings. 2+3=5

25. *(a)* Distinguish between nuclear fission and nuclear fusion. 3

(b) Mention three differences between spontaneous emission and stimulated emission. 3

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