

## U.G. 4th Semester Examination - 2022

## PHYSICS

## [HONOURS]

Course Code : PHY-H-CC-T-09

(Elements of Modern Physics)

Full Marks : 40

Time :  $2\frac{1}{2}$  Hours*The figures in the right-hand margin indicate marks.**Candidates are required to give their answers in their own words as far as practicable.*

## GROUP-A

1. Answer any **five** questions from the following:

2×5=10

- What do you mean by threshold frequency and stopping potential?
- What is the rest mass of a photon? Find the mass of a photon having frequency  $\nu$  moving with velocity of light  $c$ .
- Quantum mechanics is probabilistic whereas classical mechanics is deterministic – Explain.*

[Turn over]

- Find the de Broglie wavelength of an electron moving with the velocity  $v = \frac{4}{5}c$ .
- Can pair production takes place in vacuum? – Explain your answer.
- What is neutrino? What are the basic differences of a neutrino and an anti-neutrino?
- What do you mean by degeneracy? Find the degeneracy in case of second excited state of a particle confined in a cubical box.
- Show that  $[\hat{L}_z, \hat{L}_+] = \hbar \hat{L}_+$ .

## GROUP-B

2. Answer any **two** questions from the following:

5×2=10

- What is Compton Effect? Show that energy of the recoil electron in Compton Effect is always less than the energy of the incident X-ray photon. What will be the value of Compton shift if visible light is used?  
1+3+1
- State and explain Heisenberg's uncertainty principle. Starting from de-Broglie wave concept obtain Heisenberg's uncertainty principle  $\Delta x \Delta p_x \geq \hbar$ .  
2+3

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[ 2 ]

- c) i) What do you mean by hermitian operator? Show that momentum operator  $\frac{\hbar}{i} \frac{\partial}{\partial x}$  is hermitian.
- ii) The normalized ground state wave function of a single electron atom is  $\psi(r) = \pi^{-\frac{1}{2}} \left(\frac{Z}{a_0}\right)^{\frac{3}{2}} e^{-\frac{Zr}{a_0}}$ , where the notations have their usual meaning. Find the probability that the electron in this state will be found at a distance greater than  $\frac{2a_0}{Z}$ . 1+2+2
- d) What do you mean by inverse beta decay? How can the continuous nature of beta -ray spectrum be explained theoretically? In case of beta decay is Parity remain conserved? 1+3+1

### GROUP-C

Answer any **two** questions from the following:

$$10 \times 2 = 20$$

3. a) What are the physical significances of a wave function in quantum mechanics? Obtain one dimensional time-dependent Schrodinger equation for a particle moving in a potential V. 2+2

- b) A particle is confined to move in one dimensional box with perfectly rigid walls at  $x = 0$  and  $x = a$ . Find the normalized wave functions and energy eigen values. 4
- c) An electron is confined in a cubical box of width  $1 \text{ \AA}$ . Calculate the values of its energy and momentum in ground state. 2
4. a) Obtain Bethe-Wiezsacker semi empirical mass formula describing clearly the contributions of various energy terms. 4
- b) What are mass parabolas? What is their importance as regards stability of nucleus? 2+2
- c) A nucleus with  $A = 235$  splits into two nuclei of mass numbers in the ratio 2:1. Find the radii of the nuclei. 2
5. a) What are four level lasers? Give a short description of construction and working principle of RUBY Laser. 2+4
- b) Define critical radius of a nuclear reactor. 2
- c) A free neutron decays into a proton, an electron and an anti-neutrino. If  $M(n) = 1.00898u$ ,  $M(p) = 1.00759u$  and  $M(e) = 0.00055u$  and the proton is at rest. Find the kinetic energy shared by the electron and anti-neutrino. 2

6. a) What are the basic assumptions of nuclear shell model? 5
- b) State the reason that makes  $I = l + \frac{1}{2}$  state more tightly bound than the  $I = l - \frac{1}{2}$  state in a nucleus. 3
- c) Find the ground state angular momentum and parity of  ${}_{13}^{27}\text{Al}$ . 2
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