

C 4757

(Pages : 2)

Name.....

Reg. No.....

**SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY)  
EXAMINATION, APRIL 2021**

(CBCSS)

Physics

PHY 2C 05—QUANTUM MECHANICS—I

(2019 Admissions)

Time : Three Hours

Maximum : 30 Weightage

**General Instructions**

1. *In cases where choices are provided, students can attend **all** questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

**Section A***8 short questions answerable within 7.5 minutes.**Answer **all** questions.**Each question carries weightage 1.*

1. Prove that an operator in a linear vector space can be represented by a square matrix.
2. What is the quantum mechanical operator representing energy ?
3. What are Hermitian operators ? Give their important properties.
4. Briefly explain the features of interaction picture.
5. Are the rigid rotator energy levels degenerate ? Explain.
6. What are the admissibility conditions on a wavefunction ?
7. Explain the principle of indistinguishability in quantum mechanics.
8. Discuss the conservation law associated with space inversion symmetry.

(8 × 1 = 8 weightage)

**Section B***4 essay questions answerable within 30 minutes.**Answer any **two** questions.**Each question carries weightage 5.*

9. Describe the Sequential Stern-Gerlach experiment and the conclusions which lead to the basics of quantum mechanics.

**Turn over**

10. Establish the Schrodinger equation for one dimensional harmonic oscillator and solve it to obtain the energy eigen values and eigen functions. Also discuss the significances of zero-point energy.
11. Establish the addition of orbital angular momentum and spin angular momentum. Arrive at Clebsch-Gordan coefficients.
12. Discuss the importance of symmetry of the wavefunctions, taking the example of the ground state of Helium atom.

(2 × 5 = 10 weightage)

### Section C

7 problems answerable within 15 minutes.

Answer any **four** questions.

Each question carries weightage 3.

13. Show that  $(\sigma \cdot A)(\sigma \cdot B) = A \cdot B + i\sigma \cdot (A \times B)$  where A and B are arbitrary vectors.
14. An electron has a speed of 500 m/s with an accuracy of 0.004%. Calculate the certainty with which we can locate the position of the electron.
15. For an electron in a one-dimensional infinite potential well of width  $1\text{\AA}$ , calculate (i) the separation between two energy levels (ii) the frequency and wavelength of the photon corresponding to a transition between these two levels (iii) in what region of the electromagnetic spectrum is this frequency wavelength?
16. Evaluate the commutator (i)  $[x, p_x^2]$ ; and (ii)  $[xyz, p_x^2]$ .
17. A beam of electrons is incident from left, normally, on a semi-infinite step potential 5.0 eV height. The incident electrons have kinetic energy E (when to the left of the step potential). What is the relative probability that any given electron will be reflected back by the step potential When E = 10.0 eV.
18. For the operators A, B and C show that  $[[A, B], C] + [[B, C], A] + [[C, A], B] = 0$ .
19. Prove that the spin matrices  $S_x$  matrix and  $S_y$  have  $\pm \frac{\hbar}{2}$ .

(4 × 3 = 12 weightage)