

(6 pages)

Reg. No. :

Code No. : 6383

Sub. Code : HPHM 31

M.Sc. (CBCS) DEGREE EXAMINATION,
NOVEMBER 2014.

Third Semester

Physics

QUANTUM MECHANICS – I

(For those who joined in July 2012 onwards)

Time : Three hours

Maximum : 75 marks

SECTION A — (10 × 1 = 10 marks)

Answer ALL questions.

Choose the correct answer :

1. Quantum mechanical operator for K.E. is

- (a) $\hbar/i\nabla$ (b) $-\hbar/2m\nabla^2$
(c) 0 (d) -1

2. For a free particle the potential energy is

- (a) Positive real (b) Negative real
(c) Complex (d) Zero

3. Degeneracy is a consequence of

- (a) Quantum ideas
(b) Boundary condition
(c) Symmetry of the Hamiltonian
(d) Uncertainty principle

4. The angular part of the solution of a spherically symmetric problem leads to

- (a) Legendre polynomials
(b) Associated legendre polynomials
(c) Spherical harmonics
(d) Associated laguerre polynomials

5. From the definition of scattering cross section $\sigma(\theta, \phi)$ is equal to

- (a) $|f(\theta)|^2$ (b) $|f(\phi)|^2$
(c) $|f(\theta, \phi)|^2$ (d) $|f(\theta, \phi)|$

6. Total scattering cross section in the case of scattering by a perfect rigid sphere is

- (a) $4 a^2$ (b) $4 \pi a$
(c) 4π (d) $4 \pi a^2$

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7. The operator e^{iA} is unitary if A is
 (a) Unitary (b) Hermitian
 (c) Any matrix (d) Square
8. If the Hamiltonian is invariant under the time, then the conserved quantity is
 (a) Energy (b) Linear momentum
 (c) Angular momentum (d) Parity
9. The commutator of x and L_z is
 (a) $-i\hbar y$ (b) $i\hbar x$
 (c) $-i\hbar L_y$ (d) $i\hbar L_x$
10. Clebsh – Gordon coefficients relate
 (a) Schrodinger picture and Heisenberg picture
 (b) Heisenberg picture and interaction picture
 (c) Coupled representation and uncoupled representation
 (d) Coordinate representation and momentum representation.

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SECTION B — (5 × 5 = 25 marks)

Answer ALL the questions, choosing either (a) or (b), each answer should not exceed 250 words.

11. (a) What are discrete energy levels? Explain their briefly.

Or

- (b) Explain the normalization of ψ .

12. (a) Give the asymptotic behavior of the eigen function of harmonic oscillator.

Or

- (b) Explain the parity of eigen function.

13. (a) Obtain the relations between angles in the laboratory and center-of-mass systems.

Or

- (b) State and prove optical theorem.

14. (a) Show that the unitary matrix transforms the non-diagonal matrix into diagonal form.

Or

- (b) Explain the representation of a state in Hilbert space.

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15. (a) Explain the proper rotation group.

Or

- (b) Discuss briefly the spin of vector particle.

SECTION C — ($5 \times 8 = 40$ marks)

Answer ALL the questions, choosing either (a) or (b),
each answer should not exceed 600 words.

16. (a) A particle constrained to move along x-axis in the domain $0 \leq x \leq L$ has a wave function

$$\psi(x) = \sin\left(\frac{n\pi x}{L}\right) \text{ where } n \text{ is an integer.}$$

Normalize the wave function and evaluate the expectation value of its momentum.

Or

- (b) State and prove Ehrenfest's theorem.

17. (a) Discuss the orthonormality of energy eigen functions which are normalized in box of finite volume.

Or

- (b) Using the minimum uncertainty product obtain the eigen function and position probability of the motion of a free wave packet in one dimension.

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18. (a) Describe the method of particle wave analysis.

Or

- (b) Discuss the scattering by a perfectly rigid sphere.

19. (a) Explain the usefulness of Dirac's Bra and ket notation with suitable examples.

Or

- (b) Obtain the equation of motion using schrodinger picture.

20. (a) For a spin 1/2 system, state the matrices for S_x , S_y and S_z . List their eigen values with the corresponding eigen vectors.

Or

- (b) Obtain the matrix of Clebsh-Gordan coefficients for $j_1 = 1$ and $j_2 = 1$.

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