(6 pages) **Reg. No. :** .....

Code No. : 8383 **Sub. Code : HPHM 31**

M.Sc. (CBCS) DEGREE EXAMINATION, NOVEMBER 2016.

Third Semester

Physics

QUANTUM MECHANICS – I

(For those who joined in July 2012 – 2015)

Time : Three hours Maximum : 75 marks

PART A — (10 × 1 = 10 marks)

Answer ALL questions.

Choose the correct answer :

1. The group velocity (v_g) with which a wave packet moves is

   (a) $v_g = d\omega/dk$ (b) $v_g = c$

   (c) $v_g = c/2$ (d) $v_g = c/8$

2. Which of the following functions are acceptable wave functions?

   (a) $\psi = x$ (b) $\psi = x^2$

   (c) $\psi = e^x$ (d) $\psi = \sin x$

3. In a harmonic – oscillator, the particle varies in position from $-A$ to $+A$ and in momentum $A/\sqrt{2}$ and $\Delta p = p_{o/\sqrt{2}}$. The minimum energy of this harmonic oscillator is

   (a) 7/2 $h\upsilon$ (b) 5/2 $h\upsilon$

   (c) 3/2 $h\upsilon$ (d) ½ $h\upsilon$

4. The period of a linear harmonic oscillator is 1 s. Its zero point energy is

   (a) $3.3 \times 10^{-27}\ J$ (b) $3.3 \times 10^{-34}\ J$

   (c) $3.3 \times 10^{-41}\ J$ (d) $3.3 \times 10^{-13}\ J$

5. A Particle in a force free region moving in a definite direction with a definite energy has a definite

   (a) Power (b) Momentum

   (c) Wave function (d) Mass

6. The method of partial waves is suited only for

   (a) Low energy scattering

   (b) Medium energy scattering

   (c) High energy scattering

   (d) Very high energy scattering

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7. An orthonormal basis can be represented by a

(a) unitary matrix (b) space matrix

(c) orthogonal matrix (d) base matrix

8. The Columns and rows of a unitary matrix represent

(a) normal vectors (b) orthonormal vectors

(c) basic vectors (d) independent vectors

9. When $J = 0, 1/2$ and 1

(a) $\left[J_x^2, J_y^2\right] \neq \left[J_y^2, J_z^2\right]$

(b) $\left[J_x^2, J_y^2\right] = \left[J_y^2, J_z^2\right] = \left[J_z^2, J_x^2\right] \neq 0$

(c) $\left[J_x^2, J_y^2\right] = \left[J_y^2, J_z^2\right] = \left[J_z^2, J_x^2\right] = 0$

(d) $\left[J_x^2, J_y^2\right] = \left[J_y^2, J_z^2\right] \neq \left[J_z^2, J_x^2\right]$

10. The number of independent vectors for $|Jm>$ for given J_1 and J_2 is

(a) $J_1 J_2$ (b) $(J_1 + 1)(J_2 + 1)$

(c) $(2J_1 + 1)(2J_2 + 1)$ (d) $(J_1 - 1)(J_2 - 1)$

PART B — (5 × 5 = 25 marks)

Answer ALL questions, choosing either (a) or (b).

Each answer should not exceed 250 words.

11. (a) Discuss about travelling harmonic waves and need for a wave function.

Or

(b) Derive one dimensional wave function and extend it to 3D.

12. (a) Explain the motion of free wave packets in one dimension.

Or

(b) Find the most probable radial distance for the electron of a hydrogen atom in its ground state.

13. (a) Discuss and get the differential scattering cross section in asymptotic form.

Or

(b) Discuss the scattering by spherically symmetric potentials.

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14. (a) Determine the eigen values of energy of a harmonic oscillator with Hamiltonian $H = p^2/2m + 1/2kx^2$ using matrix method.

Or

(b) Prove the identity $[Jx^2, Jy^2] = [Jy^2, Jz^2] = [Jz^2, Jx^2]$. And show that these commutators are zero in states for which $J = 0$, 1/2 or 1.

15. (a) What are Clebsch – Gordan Co-efficient? Derive their properties.

Or

(b) Prove that rotation in space leads to conservation of angular momentum.

PART C — (5 × 8 = 40 marks)

Answer ALL questions, choosing either (a) or (b).

Each answer should not exceed 600 words.

16. (a) State and explain Ehrenfest's theorem.

Or

(b) Derive energy eigen values and normalized wave functions for a particle in a one dimensional square well potential of width L.

17. (a) Obtain the energy states and eigen function of linear harmonic oscillator.

Or

(b) Discuss about the spherically symmetric potential in three dimensional.

18. (a) Discuss one Dimensional Oscillator collision of particle with the square Potential barrier and arrive the scattering co-efficient.

Or

(b) Explain collision of particles in 3D and arrive scattering cross section.

19. (a) Derive about Transformation of Hamiltonian with 'W' and 'V'.

Or

(b) Describe the equation of motion using Dirac's bra and ket notation.

20. (a) Explain time reversal symmetry in quantum mechanics. Show that the corresponding time independent operator T which affects time reversal is not a linear operator.

Or

(b) Outline the method of addition of two angular momenta. Evaluate the Clebsch — Gordan coefficients for $J_1 = 1$ and $J_2 = ½$.

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