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**PG (NEW) CBCS**
**M.Sc. Semester-I Examination, 2019**
**PHYSICS**
PAPER: PHS-102

**Full Marks: 40** **Time: 2 Hours**

**Write the answer for each unit in separate sheet**

The figures in the right-hand margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

**PHS 102.1: QUANTUM MECHANICS - I**

**Marks: 20**

1. **Attempt any two of the following** **($2\times 2 = 4$)**
   a) Prove that for any normalized wave function of particle of mass m in one dimension $\int_{-\infty}^{\infty} J(x)dx = \frac{<p_x>}{m}$, where the symbol have usual meanings.
   b) Evaluate $[\hat{x}, e^{ip_x a/\hbar}]$.
   c) If $\psi_2(x) = (2x^2-1)\exp(-x^2/2)$ is the wave function of one dimensional Harmonic oscillator, find $\psi_3(x)$ and $\psi_1(x)$.
   d) If $\psi(x)=A\exp[-\frac{x^2}{a^2}]$ calculate $\Phi(p)$ (momentum eigenfunction).

2. **Attempt any two of the following** **($4\times 2 = 8$)**
   a) Write down the time-independent Schrodinger equation for a free particle in the momentum space and obtain the form of the wave function.
   b) An electron is confined in the ground state of a one-dimensional H.O. Such that $\Delta x=1A^0$. Assuming $< T >=< V >$. Find the energy in ev required to excite it to its 1st excited state.
   c) If $\psi_{100}(r) = \frac{1}{\sqrt{\pi a_0^3}} e^{\frac{-r}{a_0}}$ find $<p_r^2>$.
   d) If En and $E_m$ are the energies corresponding to the eigen states $|n>$ and states $|m>$ respectively. Then prove that $\sum_n (Em - En)\,|<m|\hat{x}|n>|^2 = -\hbar^2/2M$, where M is the mass of the particle.

3. **Answer any one of the following** **($1\times 8 = 8$)**
   a) i) What are the basic differences between Schrodinger picture and interaction picture of equation of motion of a particle? **(2)**
   ii) Derive the expression of the time rate of change of an operator represented in interaction picture of the equation of motion. **(4)**
   iii) Find the energy eigen values of a particle in an infinite height potential well using Heisenberg picture. **(2)**

**(Turn Over)**

b) A particle is trapped in a potential well V(x)=0 for $-a/2 \leq x \leq a/2$

$=\infty$ otherwise

Prove that $(\Delta x)(\Delta p)=\sqrt{(\frac{\pi^2}{12}-\frac{1}{2})}\,\hbar$ **(8)**

**PHS 102.2: SOLID STATE – I**

**Marks: 20**

1. **Answer any two of the following:** **(2× 2 = 4)**
   a) Explain the symmetry element associated with point group.
   b) Explain how a single crystal material can be identified by Laue diffraction technique.
   c) What is meant by Van Hove singularity?
   d) Explain what is meant by effective mass of an electron? When negative effective mass of an electron correspond to?

2. **Answer any two of the following:** **(2× 4 = 8)**
   a) Find an expression of interplaner spacing of Hexagonal lattice.
   b) Show that total number of space group in monoclinic system is thirteen.
   c) Derive the dispersion relation for a monoatomic linear chain and hence designate first Brillouin zone.
   d) Show that effective number of free electron is maximum when the outermost band is half filled.

3. **Answer any one of the following:** **(1×8=8)**
   a) Find the expression of intensity corresponding scattering of x-ray from a crystal and hence derive Laue equation. **(8)**
   b) What is physical origin of band gap in a solid and hence find an expression of forbidden energy region. **(3+5)**

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