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PG CBCS

M.Sc. Semester-I Examination, 2022

PHYSICS

PAPER: PHS 102

(QUANTUM MECHANICS – I & SOLID STATE -I)

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

Write the answer for each unit in separate sheet

UNIT- PHS 102.1
QUANTUM MECHANICS – I

GROUP-A

1. Answer any TWO from the following questions: **2×2=4**

a) A real operator $\vec{A}$ satisfies the equation $A^2-5A+6=0$, what are the eigen vectors of $\vec{A}$?

b) If $\Psi_+(\vec{r})$ and $\Psi_-(\vec{r})$ are the eigen functions of the parity operator belonging to even and odd eigen states, show that they are orthogonal.

c) Show that scalar product is invariant under a unitary transformation.

d) Show that trace of a matrix is invariant under a unitary transformation.

GROUP-B

2. Answer any TWO from the following questions: **2×4=8**

a) Let $|0\rangle$ and $|1\rangle$ denotes normalized eigen state corresponding to the ground and 1st excited state of 1-D harmonic oscillator, find the uncertainty potential in the state $\frac{1}{\sqrt{2}}(|0\rangle+|1\rangle)$.

b) Discuss the condition for the operator $(1+i\hat{A})/(1-i\hat{A})$ to be unitary.

c) Show that the product of two projection operators cannot be a projection operator unless they commute.

d) If $\left[\hat{A},\hat{B}\right]=c$ where c is a number, prove that $e^{\hat{A}}\hat{B}e^{-\hat{A}}=\hat{B}+c$ and $e^{\hat{A}+\hat{B}}=e^{\hat{A}}e^{\hat{B}}e^{-\frac{c}{2}}$.

GROUP-C

3. Answer any ONE from the following questions: **1×8=8**

a) Calculate the position and momentum operators $\hat{X}_H(t)$ and $\hat{P}_H(t)$ in the Heisenberg picture for a one-dimensional harmonic –oscillator.

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b) For a one-dimensional harmonic oscillator in the state $E_n = (n+\frac{1}{2})\hbar\omega$ Prove that

$\langle \Delta x^2 \rangle \langle \Delta p^2 \rangle = \hbar^2 (n+\frac{1}{2})^2$ Given: $\hat{x} = \sqrt{\frac{\hbar}{2m\omega}}(a+a^\dagger)$; $\hat{p} = i\sqrt{\frac{m\omega\hbar}{2}}(a^\dagger - a)$.

UNIT- PHS 102.2
SOLID STATE -I

GROUP-A

1. Answer any TWO of the following questions: **2×2=4**

a) Distinguish between acoustical and optical phonons.

b) Show that fivefold rotational symmetry is absent in Bravis lattice.

c) Write down the significance of using reciprocal lattice vector.

d) What is meant by effective mass of an electron in solid? What does negative effective mass correspond to?

GROUP-B

2. Answer any TWO of the following questions: **2×4=8**

a) Discuss the variation of diamagnetic susceptibility (χ_{dia}) with temperature. Find the molar $\chi_{dia}$of Helium at ground state. Given, average Bohr radius = 0.53 Å, atomic density (n) of He gas = $27x10^{23}$/CC.

b) Clearly explain what is meant by amorphous and crystalline solids. How they can be distinguished experimentally?

c) What is Brillouin Zone? How they are related to the energy levels of an electron in metal?

d) What is phonon? Explain how phonon momentum is transferred to the crystal lattice.

GROUP-C

3. Answer any ONE of the following questions: **1×8=8**

a) Derive Laue equation assuming X-ray falling on a crystal. How does it lead to Bragg's law? 6+2

b) State and prove the Bloch theorem in solids. Discuss the properties of Bloch function. Find the expression of the effective mass of an electron in a solid. 4+2+2

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