QP Code: D134297	Total Pages:2	Name:
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THIRD SEMESTER UG DEGREE EXAMINATION, NOVEMBER 2025

(CUFYUGP)

PHY3MN202-SOLID STATE PHYSICS AND SPECTROSCOPY

2024 Admission onwards

Maximum Time :2 Hours | **Maximum Marks :70**

Section A

All Questions can be answered. Each Question carries 3 marks (Ceiling : 24 Marks)

1	Write down the time-dependent Schrödinger equation. Explain the physical significance of the wavefunction ψ(x,t).
2	Briefly explain the mechanism of collision broadening of spectral lines.
3	What is the physical significance of the expectation value of an operator?
4	Explain the nature of Van der Waals bonding. Why is it weaker compared to ionic and covalent bonds?
5	What are the different types of energies possessed by a molecule? Why is the translational energy of a molecule not quantised?
6	Distinguish between spontaneous and stimulated emission.
7	State the normalization condition for a wavefunction.
8	What is Raman scattering. Why are Stokes lines more intense than anti Stokes lines?
9	Define the zero-point energy of a vibrating molecule. What is the selection rule for vibrational transitions in infrared spectroscopy?
10	Briefly explain the main components of a laser.

Section B

All Questions can be answered. Each Question carries 6 marks (Ceiling : 36 Marks)

11	The force constant of the bond in CO molecule is $1870\,Nm^{-1}$. Calculate the frequency of vibration of the molecule and the spacing between its vibrational energy levels in eV. Given that reduced mass of C0 $= 1.14 \times 10^{-26} kg$.
12	A particle confined to the x axis has the wave function $\psi(x) = B(1 - x^2), \quad -1 \leq x \leq +1$

	$\psi(x) = 0,$ elsewhere a)Find the normalization constant B b)Calculate the expectation value < x >
13	Consider a gas of atoms at T=300K. The mass of each atom is $4.2 \times 10^{-27} kg$. Some of the atoms in the excited state emit radiation of frequency ν. Estimate the amount of Doppler broadening.
14	Show that ψ(x)=cos(4x) is an eigenfunction of the operator $\frac{d^2}{dx^2}$. Find the corresponding eigenvalue. Also verify whether ψ(x)= x^2 is an eigenfunction of the same operator.
15	The CO molecule has a bond length of 0.113 nm and the masses of C^{12} and O^{16} atoms are respectively $1.99 \times 10^{-26} kg$ and $2.66 \times 10^{-26} kg$. Find the energy and the angular velocity of the CO molecule when it is in its lowest rotational state.
16	Light from a 2.5 mW laser source of aperture diameter 1.8 cm and $\lambda = 5000\, A^o$ is focused by a lens of focal length 20 cm. Calculate the area and intensity of the image.
17	Define Einstein's coefficients and establish the relations between them.
18	If the bond length of H_2 is 0.07417 nm, what would be the positions of the first three Raman lines in the spectrum? $H^1 = 1.673 \times 10^{-27} kg$.
Section C	
Answer any ONE .Each Question carries 10 marks (1x10=10 Marks)	
19	Explain the quantum theory of Raman scattering. Discuss the rotational Raman spectra of linear molecules and the selection rules for rotational Raman transitions.
20	Explain the concept of operators in quantum mechanics. Illustrate with examples of momentum and Hamiltonian operators, and explain how expectation values are calculated.