UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2023

Course: Atomic, molecular and laser physics   **Semester: II**
Program: MSc (Physics)   **Time: 03 hrs.**
Course Code: PHYS7022   **Max. Marks: 100**

Instructions: • All the questions of section-A are compulsory
                 • Q9 in Section-B and Q11 in Section-C have internal choice

SECTION-A (5Qx4M=20Marks)

S. No.		Marks	CO
Q1	What are the characteristics of an ideal laser beam?	4	CO1
Q2	What are the differences between E.S.R and N.M.R	4	CO1
Q3	Draw 3-level laser system and discuss briefly the population inversion. Give reason why output is pulsed	4	CO2
Q4	A He-Ne laser (633.5 nm) has beam diameter of 1.5 mm, calculate angular spread	4	CO2
Q5	Difference between first rotational energy levels of a diatomic molecule is 50 cm^{-1}. Compute the moment of inertia of the molecule	4	CO3

SECTION-B (4Qx10M= 40 Marks)

Q6	Discuss construction and working of 4 level He-Ne laser	10	CO1
Q7	Write down m_j values for $3^2P_{3/2}$ state. Calculate Lande 'g' factor and hence, gm_j	10	CO2
Q8	Compute vibrational force constant k when HCl, a polar diatomic molecule vibrates at 280000 m^{-1}. Atomic mass unit = 1.66×10^{-27} Kg	10	CO2
Q9	Analyze, P, R and Q branches of vibrational-rotational spectra of diatomic molecule	10	CO3

	OR		
	Analyze rotational spectra when a diatomic molecule shows 1st microwave absorption at, $\bar{\nu} = 10 \; cm^{-1}$ to obtain rotational constant (B) and moment of inertia (I)		

SECTION-C (2Qx20M=40 Marks)

Q10	a) Discuss normal Zeeman effect with neat diagram (level splitting: $2p \rightarrow 1s$). What external magnetic field can produce 35 GHz frequency shift when atoms are placed in that magnetic field?	**10**	**CO1**
	b) State Franck-Condon principle for electronic-vibrational transition. Depict Morse curve for three different cases when upper state equilibrium position is shifted with respect to ground state	**10**	**CO2**
Q11	a) Write short note on N.M.R. Estimate the MHz frequency required for N.M.R. to perform when applied magnetic field is 1.35 Tesla	**10**	**CO3**
	b) An experiment is performed using green laser ($\lambda = 540$ nm) to estimate separation (D) between earth and moon. If the laser beam has initial diameter of 1 mm (on earth) and areal spread (at moon) of 43×10^3 km^2, calculate D	**10**	**CO3**
	OR		
	a) Discuss 4-level laser system with energy levels. Analyse why threshold energy is required less than that of 3-level laser system.	**10**	**CO3**
	b) Force constant (k) of HBr is 380 N/m. What is the estimated vibrational level spacing for HBr?	**10**	**CO3**