2018

PHYSICS

PHY 302

ATOMIC & MOLECULAR PHYSICS

Full Marks: 80
Time: 3 Hours

(Figures in the margin indicate full marks for the questions)

1 Answer all the following questions 1x6=6

(a) What are the purposes of using slits in grating spectrometer? 1

(b) Write the spectral terms for $1s^2 2s^2$ configuration. 1

(c) Due to spin-spin interaction, an unperturbed energy level splits into _____ levels. 1

(d) Why is semiconductor laser less monochromatic than other lasers? 1

(e) What are the differences between atomic spectra and molecular spectra? 1

(f) Explain the differences between Stokes and anti-Stokes lines in Raman spectroscopy. 1

2 Answer all the following questions 2x7=14

(a) Explain what would happened if electrons were spin 0 particles. 2

(b) Show that the $^4D_{1/2}$ term does not split in magnetic field. 2

(c) Evaluate the Lande g-factor and hence calculate the shift in wavenumber for the $^3P_1$ level of ^6C atom in 2p3s configuration when external magnetic field of 0.1 tesla is applied. (Symbols have their usual meaning) 2

(d)Discuss the differences between emission band spectrum and the corresponding absorption band spectrum. 2

(e) Explain why spiking occurs in Ruby laser. 2

(f) What effects will the presence of isotopic species such as H^1, H^2, Cl^{35} and Cl^{36} have on rotational spectrum of HCl. Explain with suitable energy level diagram. 2

(g) What are P, Q and R branches in vibration-rotation spectra? Explain their origin. 2

3 Answer the following questions (any four) 5x4=20

(a) What is anomalous Zeeman effect? Show that the Zeeman splitting in anomalous Zeeman effect depends on Lande g-factor. 1+4

(b) Determine the spectral terms for neutral oxygen atom. 5

(c) What is Paschen-Back effect? Deduce an expression for the strong- field magnetic interaction energy. 1+4

(d) Describe the different types of couplings in atoms with illustrative examples to each type. 5

(e) Discuss the Zeeman effect in the following transitions

(i) $^1F_3 - ^1D_2$ $2\frac{1}{2}+2\frac{1}{2}$

(ii) $^2F_{3/2} - ^2D_{1/2}$

4 Answer the following questions (any four) 5x4=20

(a) Explain the rotational spectrum of a diatomic molecule treating the molecule as a non-rigid rotator. In a microwave spectrum, the transition J = 4 to J = 5 in H^1Cl^{35} molecule occurs at 8303 m^{-1}. Regarding the molecule as rigid rotator, calculate the moment of inertia and internuclear distance. (Given, h = 6.63 x 10^{-34}Js, C = 3.8 x 10^8 ms^{-1}, 1 amu = 1.66 x 10^{-27} kg). 2+3

(b) A space probe was designed to see $C^{12}O^{16}$ in the atmosphere of Saturn by looking for lines in its rotational spectrum. If the bond length of $C^{12}O^{16}$ is 112.8 pm, at what wavenumber do the first three rotational transitions appear? 5

(c) The force constant of the bond in $C^{12}O^{16}$ molecule is 1870 Nm^{-1}. Calculate the frequency of vibration of the molecule, energy level of lowest vibrational level and energy difference between the lowest and the first vibrational energy level of $C^{12}O^{16}$. (Given, 1 amu = 1.66 x 10^{-27} kg, 1 eV = 1.60 x 10^{-19} J) 5

(d) A diatomic molecule HX (X is an unknown atom) has a vibrational force constant k = 9.6800 x 10^5 gs^{-2}. The vibrational frequency in wavenumber is 4143.3 cm^{-1}. Calculate the reduced mass of the molecule and also find the mass number of unknown atom. What atom is X?(Given, 1 amu = 1.66 x 10^{-27} kg). 5

(e) Discuss why Stokes radiation is more intense than anti-Stokes radiation?. For exciting line of 4358 Å, a molecule shows a Raman line at 4567 Å. Find the positions of Stokes and anti-Stokes lines of this molecule when exciting line 4047 Å is used. 2+3

5 Answer the following questions (any four) 5x4=20

(a) Describe the working of He-Ne Laser with the help of energy level scheme. 5

(b) What is meant by population inversion? Show that population inversion is necessary condition for Laser action. 1+4

(c) Discuss the various interaction of an atom with electromagnetic radiation. 5

(d) Write a short note on main components of a Laser. 5

(e) Show that the probabilities of stimulated absorption and stimulated emission are equal. 5

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