2016

PHYSICS

PAPER : PHY 201

ATOMIC & MOLECULAR PHYSICS

(Old Course)

Full Mark : 80

Time : 3 Hrs

Figures in the right hand margin indicate full marks for the question

1. Choose the correct answer $\qquad$ $1 \times 6 = 6$

    (a) Which of the following is not true for LASER?

       (i) extremely intense light

       (ii) highly monochromatic

       (iii) coherent

       (iv) divergent.

    (b) The population inversion necessary for laser action used in ruby laser is:

       (i) electric discharge (ii) optical pumping

       (iii) direct conversion (iv) Inelastic atomatom collision.

    (c) What effect would you expect, the rapid motion of the atoms of an excited gas, to have on the spectral lines they produce ?

P.T.O.

(i) the intensities of the lines increases

(ii) the intensities of the lines decrease

(iii) the Doppler broadening of the lines occurs

(iv) no effect at all occurs

(d) Which of the following molecules does not exhibit a rotational spectrum?

(i) H_2 (ii) CO   (iii) HCl   (iv) HBr

(e) The carbon monoxide molecule has a bond length R of 0.113 nm and the masses of the ^{12}C and ^{16}O atoms are respectively 1.99×10^{-28} kg and 2.66×10^{-26} kg. The moment of inertia I of the molecule is

(i) 1.16×10^{-28} kg m² 　　　(ii) 1.46×10^{-46} kg m²

(iii) 2.14×10^{-46} kg m² 　　　(iv) 2.66×10^{-46} kg m²

(f) The force constant of $C^{12}O^{16}$ is 1840 Nm⁻¹. The oscillation frequency will be

(i) 4.02×10^{14} s⁻¹   (ii) 6.402×10^{14} s⁻¹

(iii) 6.402×10^{13} s⁻¹   (iv) 4.02×10^{15} s⁻¹

2. Answer any seven questions　　　　$2 \times 7 = 14$

(a) Why are the nitrogen and helium added to CO_2 in the discharge tube of the CO_2 laser?

(b) Mention the advantages of a gas laser over a solid state laser.

(c) Explain with diagram and hence find the allowed vibrational energy levels of adiatomic molecule undergoing simple harmonic oscillations.

(d) Obtain the spectral terms arising from an atom having two optical electrons with outer configuration 4p 4d using L-S coupling

(e) Why Diatomic molecules having a permanent electric dipole moment exhibit rotational spectrum.

(f) Transitions corresponding to vibrational quantum number change $v = 1 \rightarrow v = 2$ of a diatomic molecule are called hot bands. Explain.

(g) Give reasons why an ordinary flash lamp is used to pump the active medium in the ruby laser?

(h) The force constant of H^1F^{19} is 966 Nm⁻¹. Calculate the wave number $\bar{\omega}$ osc.

3. Answer any four questions　　　　$4 \times 5 = 20$

(a) Discuss the factors governing the breadth of spectral lines. Estimate the fractional width of a spectral line of 6000 A wavelength emitted from a level of a life-time of 10^{-8} second.　　　　$3+2=5$

(b) Illustrate with the help of diagrams the splitting of ^2D levels of sodium when (i) a weak magnetic field (ii) a strong magnetic field is applied.　　　　5

(c) We know that the $^2S_{1/2}$ level of an atom is single and does not have any fine structure. If the nucleus of the atom has spin not equal to zero, what is the multiplicity of the $^2S_{1/2}$ term? In a transition from a single hyperfine component of $^2P_{1/2}$, what is the relative intensity of transitions to the various hyperfine components of $^2S_{1/2}$?　　　　5

(d) Evaluate the Lande g-factor for the $^3P_1$ level in the 2p3s configuration of the ^6C atom, and use the result to predict the splitting of the level when the atom is in an external field of 0.1 tesla.   5

(e) Obtain the spectral terms arising from the two equivalent p electrons in L-S coupling.   5

4. Answer any four questions $4 \times 5 = 20$

(a) Draw the Morse-curve showing the energy of a diatomic molecule undergoing anharmonic extensions and compressions. Write an expression for the pattern of the allowed vibrational energy levels.   2+3=5

(b) The force constant of the bond in $C^{12} O^{16}$ molecule is 1870 Nm^{-1}. Find the energy of the lowest vibrational level. (h = 6.63 x 10^{-34} Js, 1 eV = 1.60 x 10^{-19} J).   5

(c) What is Raman effect? Give its quantum theory. What are Stokes and anti-Stokes lines?   1+2+2=5

(d) Write short notes on NMR of H-atom.   5

(e) In what way the absorption spectra of diatomic molecules differ from the emission spectra? What is the importance of the study of absorption spectra over that of emission spectra?   3+2=5

(f) Write short notes on Frank-Condon principle.   5

5. Answer any four questions $4 \times 5 = 20$

(a) Write short note on the applications of lasers.   5

(b) Draw the schematic diagram of a ruby laser, and explain its excitation mechanism with the help of an energy level diagram.   2+3

(c) How could the problem of having a large number of modes within an atomic line width be overcome? A laser cavity is formed by two mirrors placed at a distance of 1m apart. If the refractive index of the active medium is 1.5, calculate the spacing between longitudinal modes   5

(d) What are the basic properties of laser light. Show that population inversion is necessary for light amplification and hence for laser action.   2+3=5

(e) Derive Einstein's relations for non-degenerate energy levels. Show that at the temperature 300K, the probability of spontaneous transition far exceeds the probability of stimulated transition at optical frequencies while it is other way round at microwave frequencies.   3+2 = 5

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