5 SEM TDC PHY M 3

2017

(November)

PHYSICS

(Major)

Course : 503

(Atomic and Molecular Physics)

Full Marks : 60
Pass Marks : 24/18

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option (any *five*) : 1×5=5

(a) In terms of Rydberg's constant R, the wave number of the first Balmer line is

(i) R

(ii) $\frac{3}{4}R$

(iii) $\frac{5}{36}R$

(iv) $\frac{8}{9}R$

(b) H_α line results from the transition of electron from the energy level corresponding to

(i) $n = 1$ to $n = 3$

(ii) $n = 3$ to $n = 2$

(iii) $n = 2$ to $n = 1$

(iv) $n = 2$ to $n = 3$

(c) The phenomenon of splitting of a spectral line into components by an electric field is called

(i) Raman effect

(ii) Paschen-Back effect

(iii) Stark effect

(iv) Zeeman effect

(d) He-Ne laser is

(i) two-level laser

(ii) three-level laser

(iii) four-level laser

(iv) no-level laser

(e) The value of Lande's splitting factor g_j for S-state is

(i) 0

(ii) 1

(iii) 2

(iv) $\frac{1}{2}$

(f) The relation between Einstein's A_{21} and B_{21} coefficients is

(i) $\frac{A_{21}}{B_{21}} = 1:2$

(ii) $\frac{A_{21}}{B_{21}} = \frac{8\pi h\nu^3}{c^3}$

(iii) $\frac{A_{21}}{B_{21}} = 1:1$

(iv) $\frac{A_{21}}{B_{21}} = \frac{\nu}{c}$

(g) Rotational spectra lie on the

(i) microwave region

(ii) visible region

(iii) infrared region

(iv) ultraviolet region

2. Answer any *five* of the following : 2×5=10

(a) "Homonuclear molecules do not exhibit rotational spectra." Explain.

(b) Define temporal and spatial coherence.

(c) Explain multiplicity of states and the notation.

(d) The first member of Balmer's series of hydrogen has wavelength of 6563 Å. Calculate the wavelength of the first member of the Lyman series.

(e) State two basic differences between Zeeman and Stark effects.

(f) Mention the method of pumping for creating population inversion. What is population inversion?

(g) Calculate the normal Zeeman shift observed when a spectral line of wavelength 4000 Å is subjected to a magnetic field of 5000 oersted ($e/m = 1 \cdot 76 \times 10^7$ e.m.u./gm).

3. *(a)* Describe vector model of atom and explain various quantum number associated with it. Explain what the notation $^2P_{3/2}$ implies. 5+2=7

(b) State and prove Bohr's correspondence principle. Show that for electron transitions in large adjacent quantum energy levels, Bohr's atom model corresponds to the classical theory. 1+4+1=6

Or

How does the normal Zeeman effect differ from the anomalous Zeeman effect? What is the importance of Zeeman experiment? The calcium line of wavelength $\lambda = 4226{\cdot}73$ Å $(P \rightarrow S)$ exhibits normal Zeeman splitting when placed in a uniform magnetic field of 4 webers/m^2. Calculate the wavelength of three components of normal Zeeman pattern and the separation between them. 2+1+3=6

(c) Calculate the velocity, radius and energy of the first Bohr orbit and also, Rydberg constant for H-atom. What is called Bohr radius?
($h = 6{\cdot}6 \times 10^{-34}$ J-s, $m_e = 9{\cdot}1 \times 10^{-31}$ kg, $\varepsilon_0 = 8{\cdot}85 \times 10^{-12}$ C^2/Nm^2) 1+1+1+1+1=5

4. What is Lande g-factor? Calculate Lande g-factor for *(a)* $^2D_{3/2}$ states and *(b)* $^2P_{3/2}$ states. 1+2½+2½=6

5. *(a)* Obtain an expression for the rotational energy levels of a diatomic molecule taking it as a rigid rotator. Discuss its spectrum and hence relevant selection rules. 7

Or

What is Raman effect? Why are Stokes lines more intense than anti-Stokes lines? Indicate the importance of Raman effect. In observing the Raman spectrum of a sample, using 2537 Å as the exciting line, one gets Stokes line at 2683 Å. Deduce the Raman shift in cm^{-1} units. Compute the wavelength in Å for corresponding Stokes line if the exciting line is 5461 Å. 1+1+1+4=7

(b) Distinguish between spontaneous and stimulated emission processes in laser. Explain the action of He-Ne laser. 2+3=5

6. Write short notes on any *three* of the following : 3×3=9

   (a) Gyromagnetic ratio

   (b) Ammonia-beam maser

   (c) Population inversion

   (d) Normal Zeeman effect.

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