5 SEM TDC PHY M 3

2019

(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 answer from the following (any *six*) : 1×6=6

(a) In normal Zeeman effect, a level of given l splits into

(i) l levels

(ii) $2l$ levels

(iii) $(2l+1)$ levels

(iv) $(2l-1)$ levels

(b) The number of fine structure lines of H_α line, according to vector atom model, is

(i) 2

(ii) 3

(iii) 4

(iv) 5

(c) The probability of spontaneous emission increases as

(i) ν

(ii) ν^2

(iii) ν^3

(iv) ν^{-1}

where ν is the frequency of the exciting radiation.

(d) The radius of the first Bohr orbit is a_0. The electron in the n-th orbit has a radius

(i) na_0

(ii) $\frac{a_0}{n}$

(iii) $n^2 a_0$

(iv) $\frac{a_0}{n^2}$

(e) Frequency of Raman lines depends upon

(i) frequency of incident line

(ii) the scattering substance

(iii) intensity of incident light

(iv) strength of the field

(f) He-Ne laser is

(i) two-level laser

(ii) three-level laser

(iii) four-level laser

(iv) no-level laser

2. Answer any *six* of the following : 2×6=12

(a) State the selection rule for pure rotational spectra and Raman spectra.

(b) Calculate Landé splitting factor for *S*-electron.

(c) What is the precessional frequency of an electron orbital when placed in a magnetic field of 6T ?
(Given
$e = 1 \cdot 6 \times 10^{-19}$ C
and $m = 9 \cdot 1 \times 10^{-31}$ kg)

(d) State and explain the population inversion for laser.

(e) Mention the drawbacks of Sommerfeld's atom model.

(f) When benzene is irradiated with mercury line 4358 Å, a Raman line is observed at the same position as the argon line $\lambda = 4201$ Å. Calculate the wave number of the corresponding absorption line of benzene.

(g) Define gyromagnetic ratio and show that spin gyromagnetic ratio is twice the orbital gyromagnetic ratio.

3. *(a)* State and prove Bohr's correspondence principle. Justify the statement, "the greater the quantum number closer the quantum physics approaches classical physics". 1+4+1=6

(b) Describe the main features of the vector atom model. Explain various quantum numbers associated with it. 2+4=6

(c) What is Larmor precession? Derive the expression for Larmor frequency. The angular momentum vector $\vec{L}$ never points in the Z direction. Why? 2+2+1=5

Or

Hydrogen atom in its ground state is excited by means of a monochromatic radiation of wavelength 970·6 Å. How many different wavelengths are possible in the resulting emission spectrum? Find the longest wavelength amongst these. 5

4. What is meant by fine structure of hydrogen spectra? How is it explained on the basis of spin-orbit interaction? 1+5=6

Or

What is Zeeman effect? How can you find e/m of an electron from Zeeman effect? The Zeeman components of a 500 nm spectral line are 0·0116 nm apart, when magnetic field is 0·00 T. Find the ratio of e/m for the electron. 1+2½+2½=6

5. *(a)* Define Einstein's co-efficients A_{12} and B_{12}. In what situation may A_{12}/B_{12} be small enough for laser action? 2+2=4

(b) Explain the origin of the vibrational spectrum of a diatomic molecule. In which region of the electromagnetic spectra do the vibrational spectra of molecules lie? Show that vibrational energy is not zero even at the lowest vibrational level. 3+1+2=6

Or

Why do molecules show band spectra rather than line spectra? In an experiment in the Raman effect using mercury green radiation of $\lambda = 546 \cdot 1$ nm of Stokes lines of wavelength 554·3 nm was observed. Find the Raman shift and the wavelength corresponding to the anti-Stokes lines. 2+4=6

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

(a) Landé's g-factor

(b) Spatial and temporal coherence

(c) Space quantization

(d) Stark effect

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