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**5 SEM TDC PHY M 3**

**2016**

( November )

PHYSICS

( Major )

Course : 503

**( Atomic and Molecular Physics )**

*Full Marks* : 60

*Pass Marks* : 24 (Backlog) / 18 (2014 onwards)

*Time* : 3 hours

*The figures in the margin indicate full marks for the questions*

1. Fill in the blanks (any *five*) : 1×5=5

   (a) The value of spin quantum number of an electron in hydrogen atom is _____.

   (b) The *D*-lines of sodium originate from _____ transition.

   (c) Normal Zeeman effect occurs only in atoms which have a total spin *S* equal to _____.

   (d) For heavier atoms _____ coupling holds.

   (e) The procedure to achieve population inversion is called _____.

   (f) If $\Delta\nu = \frac{eB}{4\pi m}$ is the frequency shift in the Zeeman splitting of a spectrum, then the corresponding wavelength shift $\Delta\lambda$ = _____.



( Turn Over )

**2.** Answer any *five* of the following : $2\times5=10$

(a) Find the possible values of $j$ and $m_j$ for states $l=3$ and $s=\frac{1}{2}$.

(b) State Bohr's postulates regarding the atomic model.

(c) Calculate the radius of the first Bohr orbit of hydrogen atom. Given $e=1\cdot6\times10^{-19}$ C, $h=6\cdot63\times10^{-34}$ joule-sec, $k=9\times10^{9}\,N\,m^2/c^2$ and $m=9\cdot1\times10^{-31}$ kg.

(d) Discuss the essential requirements for producing laser action.

(e) Distinguish between Raman scattering and Rayleigh scattering.

(f) Calculate Lande's $g$-factor for $s$-electron.

**3.** (a) Describe the different types of coupling in atom. 5

*Or*

The first member of Balmer series of hydrogen has a wavelength of 6563 Å. Calculate the wavelength of its (i) second order and (ii) third order. In which region of the e.m. spectrum does this series lie? $2+2+1=5$

(b) Describe the principle, construction and working of Ruby laser with necessary diagram. 5



( Continued )



**4.** Discuss the Sommerfeld theory of elliptical orbit of hydrogen atom and compare its results with those of Bohr's theory of circular orbits. 7

*Or*

What is Raman effect? Prove that to be Raman active, a molecular vibration or rotation must cause some change in molecular polarizability. Explain Raman lines intensity or polarization states from classical theory. $1+5+1=7$

**5.** What are Stokes and anti-Stokes lines? In an experiment, the exciting line is at $\lambda=5460$ Å and the Stokes line is at $\lambda=5520$ Å. Find Raman shift and wavelength corresponding to anti-Stokes line. $2+5=7$

*Or*

Discuss vibrational-rotational spectra of diatomic molecules with energy-level diagram. What are $P$ and $R$ branches in vibrational-rotational spectra? $5+2=7$

**6.** What is anomalous Zeeman effect? In a normal Zeeman experiment, the Ca 4226 Å line splits into three lines separated by 0·25 Å in a magnetic field of 3 T. Determine $e/m$ for the electron from these data. $2+4=6$



( Turn Over )

*Or*

What are the drawbacks of Rutherford's atomic model? Discuss briefly the success and failure of Bohr's atomic model. 2+2+2=

7. Derive an expression for magnetic moment of orbiting electron. Why is orbital magnetic momentum ($\mu_l$) oppositely directed to orbital angular momentum ($P_l$)? 5+1=

*Or*

What is Larmor precession? An atomic dipole is subjected to very strong magnetic field $B$ so that it begins to precess about the field. Calculate the frequency of Larmor precession. 1+5=

8. Write short notes on (any *three*) : 3×3=

*(a)* Stark effect

*(b)* Population inversion

*(c)* Space quantization

*(d)* Bohr's correspondence principle

*(e)* Einstein's coefficients

*(f)* Vector atom model

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