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1 (Sem-5/FYUGP) PHY01MJ

2025

PHYSICS

(Major)

Paper : PHY0500104

(Atomic and Molecular Physics)

Full Marks : 60

Time : 2½ hours

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

1. Answer the following questions : $1 \times 8 = 8$
- (a) Write one limitation of Bohr's atomic model.
- (b) The radius of 1st orbit of hydrogen atom according to Bohr's model is 0.52 \AA . What is the radius of the 2nd orbit?
- (c) The spectral lines of which series of hydrogen spectrum are in the visible region?
- (d) In spectroscopic term ${}^2S_{\frac{1}{2}}$, what does $\frac{1}{2}$ represent?

(e) Draw the figure of transition of sodium D_1 line indicating the energy states.

(f) Why X-ray beam cannot be deflected by electric or magnetic field?

(g) For Ne atom the atomic number is 10. Write the electronic configuration according to AUFBAU principle.

(h) Write one difference between Infrared spectroscopy and Raman spectroscopy.

2. Answer **any six** of the following :

$2 \times 6 = 12$

(a) What are the *two* assumptions of Sommerfeld's atomic model?

(b) The orbital quantum number (l) of an electron is 2. Find the possible magnetic orbital quantum number (m_l).

(c) The spectroscopic notation of the ground state of Na atom is ${}^2S_{\frac{1}{2}}$. Find the value of S , L and J .

(d) State Moseley's law and write it mathematically.

(e) Calculate the minimum voltage that must be applied to an X-ray tube to produce X-ray photon of wavelength 0.1 \AA .

(f) Explain Hund's rule.

- (g) Define Gyromagnetic ratio. $\frac{m_s}{\mu_B}$
- (h) What is Stark effect? electric field
- (i) The total energy of a molecule depends on three factors. Write the name of *any two* factors.
- (j) Under what condition, the Bragg's equation will have no solution?

3. Answer **any four** of the following :

5×4=20

- (a) Explain fine structure of H_α line using Sommerfeld atom model.
- (b) Write the postulates of vector atom model. State different quantum number associated with this model.
- (c) Explain $L-S$ coupling and $J-J$ coupling.
- (d) State Pauli's exclusion principle. Using this principle, calculate the maximum number of electron that M shell may have. 2+3=5
- (e) Explain the spectra of alkali metal atom Na .
- (f) Calculate Lande 'g' factor for $^2S_{\frac{1}{2}}$ and $^2P_{\frac{3}{2}}$ energy states. 2+3=5
- (g) In Compton effect, derive an expression for the change in wavelength of a photon when it is scattered by an electron.

$$\lambda' - \lambda = \frac{h}{m_0 c} (1 - \cos \theta)$$

$$m_0 c \lambda' = \dots$$

I =

(h) The moment of inertia of the CO molecule is $1.4 \times 10^{-46} \text{kgm}^2$. Calculate the energy and the angular velocity in the lowest rotational energy level of CO molecule.

4. Answer **any two** of the following : 10×2=20

(a) Draw a neat diagram of the experimental arrangement of Stern and Gerlach. Show how *two* traces are produced by the atomic beam. 4+6=10

(b) What is Zeeman effect? Explain the quantum theory of anomalous Zeeman effect. 2+8=10

(c) What are X-rays? Write *any two* properties of X-rays? What is X-ray spectra? Explain the mechanism of continuous X-ray spectrum. 2+2+3+3=10

(d) What is molecular spectra? Discuss vibrational-rotational spectra of diatomic molecules. 2+8=10

(e) What is Raman effect? Explain the quantum theory of Raman effect. Why are the stokes lines brighter than the anti-stokes lines? Compare Raman spectra with infrared spectra. 2+3+2+3=10

B.T.(5-11)

$E = \frac{1}{2} I \omega^2$

B14FO 0009

(2+1)

4

3500

$E = \frac{1}{2} I \omega^2$

0.512