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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 : 1×8=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 0.52Å. 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.
- (h) What is Stark effect ?
- (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.

(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 :

$$10 \times 2 = 20$$

(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.

$$2 + 3 + 2 + 3 = 10$$