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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  $0.52\text{\AA}$ . 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  $0.1 \text{ \AA}$ .
- (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 :

$$5 \times 4 = 20$$

- (a) Explain fine structure of  $H_\alpha$  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.

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