SAMPLE QUESTIONS FOR PHYSICS HONOURS FIFTH SEMESTER

UNIT: ATOMIC & MOLECULAR SPECTROSCOPY, LASER & FIBER OPTICS

1. Why is the ground state of an atom always singlet?
2. What is meant by *intrinsic magnetic moment of an atom*?
3. What is *gyromagnetic ratio*?
4. Establish an expression for the magnetic moment associated with an orbital electron. Define '*Bohr Magneton'* in this context. States its value in SI unit.
5. Discuss the effect of finite nuclear mass i.e. the motion of the nucleus on spectra of hydrogen atom.
6. How many different phtons can be emitted by hydrogen atoms that undergo trasitions to the ground state from $n = 5$ state?
7. What is the basis of the origin of *vector atom model*? What are its sailent features?
8. Give an idea about *space quantization* and *spinning electron*.
9. What is meant by multiplicity of an atom?
10. Discuss how the state of an electron and an atom are respresented spectroscopically?
11. If one of the states of the configuration is $6_{H_{5/2}}$, what are the other possible states?
12. Give an idea about *L-S coupling* and *j-j coupling* schemes.
13. Consider $L = 1$ and $S = 3/2$, then find the possible values of J using vector addition theorem. Draw the quantum mechanical vector diagram.
14. Calculate the values of (i) l, s and j (ii) L, S and J for a d electron in one electron atomic system.
15. For the $^2D_{5/2}$ state of the electron, calculate the possible values of m_j and J_z.
16. Calculate the frequency at which an electron's orbital magnetic moment precesses in a magnetic field.
17. What is *spin-orbit coupling*?
18. Find the maximum number of electrons that can occupy an *f* subshell and list the values of m_l and m_s.
19. Find the maximum number of electrons that can occupy a *d* subshell.
20. Give the following states in spectroscopic notation: (i) $L = 0, S = 0, J = 0$, (ii) $L = 2, S = 0, J = 2$, (iii) $L = 3, S = 1/2, J = 5/2$, (iv) $L = 4, S = 1, J = 5$
21. Calculate the possible values of J for $L = 3$ and $S = \frac{1}{2}$.
22. Express $\boldsymbol{L}.\boldsymbol{S}$ in terms of J, L and S.
23. Calculate $\boldsymbol{L}.\boldsymbol{S}$ for $^3F_2$ state.
24. Calculate $\boldsymbol{L}.\boldsymbol{S}$ for a $^2D_{3/2}$ state
25. Calculate the possible values of $\boldsymbol{L}.\boldsymbol{S}$ for $L = 1$ and $S = \frac{1}{2}$.
26. Explain the doublet structure of sodium D-line on the basis of vector atom model.
27. (a) What was the aim of the Stern-Gerlach Experiment?
    (b) In that experiment, why is it necessary to use a beam of neutral atoms and not of ions?
    (c) Give a schematic description of the Stern-Gerlach experiment and indicate its main conclusions.
    (d)Explain the significance of the Stern-Gerlach Experiment.
28. Find out different states of L-S coupling scheme for a two electron atom. Given $l_1 = 3$ and $l_2 = 1$.

29. Find out different states in j-j coupling scheme for a two-electron atom. Given $l_1 = 1$ and $l_2 = 2$.

30. In an atom, two electrons have orbital angular momentum $l_1 = 2$ and $l_2 = 3$. What are the possible values of L, the orbital angular momentum, S, the total intrinsic spin and J, the total angular momentum?

31. (a) What is Zeeman effect?
(b) When do you observe normal Zeeman effect?
(c) Give the quantum theory of normal Zeeman effect and hence derive an expression for the Zeeman shift.
(d) Draw the energy level and spectral lines appear in normal Zeeman effect with proper explanation.
(e) Draw the schematic diagram for various allowed transitions between $^1D_2$ and $^1P_1$ energy levels due to normal Zeeman splitting.
(f) What is anamalous Zeeman effect?
(g) What is Paschen-Back effect?
(h) What is Lande g-factor? Obtain an expression for it in terms of l, s and j.
(i) What is the value of the g-factor for an atom with a single optical electron in $d_{3/2}$ level?
(j) Find the value of g-factor for 3_{S_1} and 3_{P_1} energy levels.
(f) Draw the schematic diagram of various allowed transitions between 3_{S_1} and 3_{P_1} energy levels due to normal Zeeman splitting.

32. What are the various types of energies possesessed by a molecule?

33. Discuss the *pure rotational spectra of a diatomic molecule* using the rigid rotator model.

34. Discuss the *effect of isotope* on pure rotational spectra.

35. Discuss the *vibrational spectra of a diatomic molecule using LHO model.*

36. (a) What is Compton's effect?
(b) Derive an expression for the Compton's shift.
(c) When a beam of monochromatic X-rays is scattered by a light element such as carbon, show that the wavelength shift depends on the angle of scattering but is independent of the wavelength of the incident beam and also the nature of the scatterer.
(d) For the Compton scattering, show that the change in wavelength of the scattered radiation is $\Delta\lambda = \frac{h}{m_0 c}(1 - cos\varphi)$, where symbols used have their usual meanings.
(e) Derive expressions for the recoil energy of the electron and also the energy of the scattered photon.
(f) Calculate the Compton's wavelength of a proton.
(g) If the energy of the incident photon is 1.22 MeV and that of scattered one is 0.511 MeV, what is the scattering angle of the photon?

37. (a) What are the full forms of LASER and MASER?
(b) What is spontaneous absorption?
(c) What is spontaneous emission?
(d) What is stimulated emission?
(e) What are the sailent features of LASER?

(f) What are Einstein's A and B co-efficients? Obtain a relation among these co-efficients?
(g) Define *Population inversion.* How is it achieved?
(h) What is *pumping?*
(i) What is an optical resonator?
(j) Discuss briefly about three level and four level laser systems.
(k) Discuss the working of Ruby Laser.
(l) Discuss the working of a gas Laser (He-Ne laser).
(m) Give a brief idea about the working of a semiconductor laser.
(n) Mention some important applications of Laser.
(o) What is Holography?
(p)Discuss the principle of Holography (recording a holgram and its reconstruction).

38. (a) Mention the advantages of optical fibre communication over wired communication.
(b) What are 'core', 'cladding' and 'jacket' in connection with an optical fibre?
(c) Discuss the working principle of an optical fibre.
(d) What are 'step index' and 'graded index' optical fibres?
(e) Discuss the transmission of a signal through an optical fibre and subsequently define *numerical aperture* and *acceptance angle*.
(f) What are sources of various losses in an optical fibre?
(g) Discuss the terms: 'band width' and 'channel capacity' in connection with a typical optical fibre system.
(h) What are 'splicing' and 'couplers'?
(i) Discuss briefly the working of a fibre sensor.

39. *What is Stark effect?*

40. *(a) State the origin of continuous and characteristics X-ray spectra.*
(b)What is Duane-Hunt law?
(c)State Moseley's law of X-ray spectra and discuss its significance.
(d)Explain Moseley's law from Bohr's theory.
(e)In an X-ray tube containing tungsten as a target metal, a voltage of 50 kV is applied. Calculate the minimum X-ray wavelength that will be emitted. If the target is replaced by molybdenum, will there be any change in the minimum wavelength? Justify your answer.

41. *(a) What is Raman effect?*
(b) How is it different from Compton's effect?
(c)What are Raman lines and Rayleigh lines?
(d) Why are Stokes' lines brighter than anti-Stokes lines?
(e)Give the quantum theory of Raman effect.
(f) "Raman shift depends on the nature of the substance under investigation and not on the wavelength of the original line". Discuss.