Roll No. ....

Question Booklet Number

O. M. R. Serial No.

M. Sc. (Fourth Semester)

(NEP) EXAMINATION, 2025-26

PHYSICS

(Atomic and Molecular Physics)

Paper Code							
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Questions Booklet Series

C

Time : 1:30 Hours] [*Maximum Marks : 75*

Instructions to the Examinee :

1. Do not open the booklet unless you are asked to do so.
2. The booklet contains 100 questions. Examinee is required to answer 75 questions in the OMR Answer-Sheet provided and not in the question booklet. All questions carry equal marks.
3. Examine the Booklet and the OMR Answer-Sheet very carefully before you proceed. Faulty question booklet due to missing or duplicate pages/questions or having any other discrepancy should be got immediately replaced.

(Remaining instructions on the last page)

परीक्षार्थियों के लिए निर्देश :

1. प्रश्न-पुस्तिका को तब तक न खोलें जब तक आपसे कहा न जाए।
2. प्रश्न-पुस्तिका में 100 प्रश्न हैं। परीक्षार्थी को 75 प्रश्नों को केवल दी गई OMR आन्सर-शीट पर ही हल करना है, प्रश्न-पुस्तिका पर नहीं। सभी प्रश्नों के अंक समान हैं।
3. प्रश्नों के उत्तर अंकित करने से पूर्व प्रश्न-पुस्तिका तथा OMR आन्सर-शीट को सावधानीपूर्वक देख लें। दोषपूर्ण प्रश्न-पुस्तिका जिसमें कुछ भाग छपने से छूट गए हों या प्रश्न एक से अधिक बार छप गए हों या उसमें किसी अन्य प्रकार की कमी हो, तो उसे तुरन्त बदल लें।

(शेष निर्देश अन्तिम पृष्ठ पर)

(Only for Rough Work)

1. Which is not true for a laser source ?
   (A) Monochromatic and highly coherent.
   (B) Long coherence length and highly directional.
   (C) Possess high intensity and brightness.
   (D) Produced either by stimulated or spontenous emission.

2. The incorrect statement for rotational Raman lines is :
   (A) The first Raman line lies at 6B distance with either side of the Rayleigh line.
   (B) Raman lines have twice separation between two successive lines in comparison to far IR lines.
   (C) The intensity of rotational Raman lines is not function of molecule nucleus spin.
   (D) The selection rule of transition for rotational Raman lines is $\Delta J = 0, \pm 2$.

3. Which quantity in vibrational spectra is equal to the twice of anharmonicity constant ?
   (A) ΔG_{v+1}
   (B) $\Delta G_{v+1/2}$
   (C) $\Delta^2 G_{v+1}$
   (D) $\Delta^2 G_{v+1/2}$

4. The isotope effect in molecular spectra is more prominently observed in :
   (A) Electronic transitions
   (B) Vibrational and rotational transitions
   (C) Nuclear spin transitions only
   (D) Conductivity spectra

5. The isotope effect in molecular spectra is primarily due to the change in :
   (A) Electronic energy levels
   (B) Nuclear charge
   (C) Reduced mass of the nuclei
   (D) Spin quantum number

6. The gyromagnetic ratio (γ) of a nucleus determines :
   (A) Its relaxation time
   (B) Its resonance frequency in a given field
   (C) Its chemical environment
   (D) Its molecular weight

7. In NMR spectroscopy, nuclei resonate when :

(A) Their spin aligns with the electric field.

(B) The nucleus vibrates at thermal frequency.

(C) Electrons move to higher orbitals.

(D) Their spin flips in the presence of a radio frequency field.

8. Which nuclei are NMR active ?

(A) Those with both even mass and even atomic number

(B) Those with odd mass number or odd atomic number

(C) Only stable isotopes of hydrogen

(D) Only radioactive isotopes

9. What physical property of the nucleus is essential for observing NMR ?

(A) Unpaired electron

(B) Non-zero nuclear spin

(C) High atomic mass

(D) High atomic number

10. If g_e and μ_B are electron g factor and Bohr magnetron, then energy difference between splitted states under ESR in presence of magnetic field B_0 is :

(A) $\pm g_e \mu_B B_0/2$

(B) $g_e \mu_B B_0$

(C) $2g_e \mu_B B_0$

(D) $4g_e \mu_B B_0$

11. Applications of NMR is :

(A) Structural determination of organic and inorganic compounds

(B) Identification of functional groups

(C) Medical imaging

(D) All of the above

12. Absorption of radiofrequency radiation in the presence of a magnetic field results in :

(A) Absorption electronic spetra

(B) Absorption vivrational spectra

(C) Nuclear magnetic resonance

(D) Electron spin resonance

13. Absorption of microwave radiation by unpaired electrons in a magnetic field results :

(A) Electron Spin Resonance

(B) Nuclear Magnetic Resonance

(C) Raman effect

(D) Both (A) and (B)

14. The incorrect statement for Ruby Laser is :

(A) It is a solid state laser.

(B) Is a three level laser.

(C) It has high efficieny and low coherence.

(D) It has active ion Cr^{+3} and has 694.3 nm wavelength.

15. Correct statement for He-Ne Laser is :

(A) It is a gas laser.

(B) It is a four level laser.

(C) Wavelength of laser is 632.8 nm.

(D) All of the above

16. Let ρ is square root of ratio of reduced masses of pure and isotopic molecule. If molecule is considered as rigid rorator and harmonic oscillator, then expression for shift in spectral band for isotope is :

(A) $2B(J + 1) (\rho^2 - 1) + \omega(\rho - 1)$

(B) $2B(J + 1) (\rho^2 + 1) + \omega(\rho + 1)$

(C) $2B (\rho^2 - 1) + \omega(\rho - 1)$

(D) $2B(\rho^2 + 1) + \omega(\rho + 1)$

17. If ω_e and $\omega_e x_e$ are vibrational and anharmonicity constant, then expression for dissociation energy of molecule is :

(A) $\omega_e^2/(2\omega_e x_e)$

(B) $\omega_e^2/(4\omega_e x_e)$

(C) $(4\omega_e x_e)/\omega_e^2$

(D) $(2\omega_e x_e)/\omega_e^2$

18. If ω and B are vibrational and rotational constant, then energy of vibrating-rotator in terms of wave number corresponding to vibrational quantum number ν and rotational quantum J is :

(A) $\bar{\varepsilon}(\nu, J) = \omega\left(\nu + \frac{1}{2}\right) + BJ(J+1)$

(B) $\bar{\varepsilon}(\nu, J) = \hbar\omega\left(\nu + \frac{1}{2}\right) + 2B(J+1)$

(C) $\bar{\varepsilon}(\nu, J) = \omega\left(\nu + \frac{3}{2}\right) + BJ(J+1)$

(D) $\bar{\varepsilon}(\nu, J) = \hbar\omega\left(\nu + \frac{1}{2}\right) + 2B(J+1)$

19. What is the term value $G(\nu)$ corresponding to vibrational energy in terms of the vibrational quantum number ν and vibrational constant ω ?

(A) $G(\nu) = \omega(\nu + 1/2)$

(B) $G(\nu) = \omega(\nu - 1/2)$

(C) $G(\nu) = h\omega(\nu + 1/2)$

(D) $G(\nu) = h\omega(\nu - 1/2)$

20. The correct statement for Emission Electronic spectra is :

(A) It consists of large number of bands. The bands are result of vibrational transition defined by progression and sequence.

(B) Band for which $V' =$ fixed, $V'' =$ varies, V'' progression; for which $V' =$ varies, $V'' =$ fixed, V' progression; for which $\Delta V = 0, \pm1, \pm2,...$ called sequence.

(C) It is explained on the basis of Deslandre Table. The diagonal defines sequence while column and row define progression.

(D) All of the above

21. The correct under Franck-Condon Principle is :

(A) There will be one or two intensity maxima corresponding to v'' of v'-progression.

(B) If $r_e' = r_e''$, condon parabola becomes line across diagonal $(\Delta v = 0)$.

(C) If $r_e' > r_e''$, condon parabola widens and if $r_e' >> r_e''$, condon parabola have only low v' or v'' progression.

(D) All of the above

22. Which one is correct for Electronic spectra of molecule ?

(A) It is obtained in Ultraviolet-Visible (UV-Vis) range of spectrum.

(B) It consists of Electronic, vibrational, and rotational transitions.

(C) The absorption intensity of electronic transitions is governed by Beer-Lambert law.

(D) All of the above

23. The intensity distribution of absorption or emission band in electronic spectra is explained on the basis of :

(A) Deslendre Table

(B) Selection Rule

(C) Franck-Condon Principle

(D) All of the above

24. Which statement is incorrect for rotational lines corresponding to a vibrational band of electronic spectra ?

(A) Both red and violet degraded bands are obtained in electronic band system.

(B) If $Bv' - Bv'' = -$ ve, then Line spacing increases in P branch while decreases in R branch and a head (red degraded) is formed in R Branch.

(C) If $Bv' - Bv'' = +$ ve, then Line spacing decreases in P branch and a head (violet degraded) is formed in P Branch.

(D) If $Bv' - Bv'' = 0$, yellow degraded head is found in Q Branch.

25. Which one provides a correct difference between vibrational-rotational spectra and electronic rotational spectra ?

(A) First one has red degraded bands while other has both red and violet degraded bands.

(B) Separation in spectral lines for 1st is much less than the second.

(C) The difference of rotational constant for higher to lower vibrational states ($Bv' - Bv''$) is much small for the 1st than the second.

(D) All of the above

26. The correct statement for absorption electronic spectra is :

(A) It consists of series of bands. Bands are of v' progression corresponding to $v'' = 0$.

(B) The bands come closer along higher wave number side as first separation in wave number increases with increase in v'.

(C) The second separation in wave number of energy bands is constant and is equal to anharmonicity

(D) All of the above

27. Which statement is true for intensity of rotational Raman lines ?

(A) Odd J lines are three times intense than even lines for molecule having fermions like nuclei.

(B) Even J lines are two times intense than odd line for molecule having Boson like nuclei.

(C) For zero spin nuclei molecule, even lines are absent.

(D) All of the above

28. The shift in wave number of vibrational and rotational Raman lines under quantum approach are :

(A) 2ω, $4B\,(J - 3/2)$

(B) 2ω, $4B\,(J + 3/2)$

(C) ω, $4B\,(J + 3/2)$

(D) ω, $4B\,(J - 3/2)$

29. Which is not true for Raman spectra ?

(A) It is scattered light spectrum of Visible or UV light from gas, liquid or solid.

(B) Classically it is explained on the basis of polarization. The shift in frequency of both lines from incident is equal to ν_0 or $2\nu_r$.

(C) It has two branch spectra named as Stokes and anti-Stokes line.

(D) Anti-Stokes lines have high wavelength and intensity while other has lower wavelength and intensity.

30. For heavier isotopic mass, which one is correct in case of rotational spectra ?

(A) Rotational constant is small and spectral line comes at lower wave number.

(B) Rotational constant is large and spectral line comes at higher wave number.

(C) Rotational constant is small and spectral line comes at higher wave number.

(D) Rotational constant is large and spectral line comes at lower wave number.

31. Which statement is not true for P, Q and R branch of vibrational rotational spectrum ?

(A) Selection rule for R branch, $\Delta v = +1$, $\Delta J = +1$, $J = 0, 1, 2, 3, ...$

(B) Selection rule for P branch, $\Delta v = +1$, $\Delta J = -1$, $J = 1, 2, 3, ...$

(C) Selection rule for Q branch, $\Delta v = +1$, $\Delta J = 0$, $J = 1, 2, 3, ...$

(D) It is obtained for linear diatomic molecule.

32. What is the value of m for spectral lines in P and R branch spectra of diatomic hetero-nuclear linear molecule ? If wave number expression for PR branch given by :

$$\bar{\nu}_{PR} = \bar{\nu}_0 + (B_1 + B_0)m + (B_1 - B_0)m^2$$

(A) $m = J + 1$, $J = 1, 2, 3, ...$ and $m = -J$; $J = 0, 1, 2, ...$

(B) $m = J + 1$, $J = 1, 2, 3, ...$ and $m = -J$; $J = 1, 2, 3, ...$

(C) $m = J + 1$, $J = 0, 1, 2, ...$ and $m = -J$; $J = 1, 2, 3, ...$

(D) $m = J + 1$, $J = 0, 1, 2, ...$ and $m = -J$; $J = 0, 1, 2, ...$

33. On increasing the temperature of diatomic hetronuclear gas which one is observed :

(A) The P and R branch extends on both sides and more lines are observed.

(B) The intensity maxima in both branches move farther away at high J values.

(C) The height of intensity maxima decreases.

(D) All of the above

34. If ω is vibrational constant and rotational constants for ν = 0 and ν = 1 are equal ($B_1 = B_0 = B$), then what is wave number corresponding to spectral line of R and P branch lines of diatomic hetero-nuclear linear molecule ?

(A) $\bar{\nu}_R = \omega + 2B(J+1);$ $\bar{\nu}_P = \omega - 2BJ$

(B) $\bar{\nu}_R = \omega + 2B(J-1);$ $\bar{\nu}_P = \omega - 2BJ$

(C) $\bar{\nu}_R = \omega + 2B(J-1);$ $\bar{\nu}_P = \omega + 2BJ$

(D) $\bar{\nu}_R = \omega - 2B(J+1);$ $\bar{\nu}_P = \omega + 2BJ$

35. If the molecule is considered as anharmonic oscillator, then wavenumber corresponding to 1st band and 1st overtone is :

(A) $\omega_e; 2\omega_e$

(B) $\omega_e(1-2x_e); 2\omega_e(1-3x_e)$

(C) $\omega_e(1-3x_e); 2\omega_e(1-2x_e)$

(D) $\omega_e(1-3x_e); 2\omega_e(1-4x_e)$

36. If ω is vibrational constant, then the possible value energy in terms of wave number of vibrational energy states considering molecule as harmonic oscillator in term of rotational constant is :

(A) $\frac{1}{2}\hbar\omega; \frac{3}{2}\hbar\omega; \frac{5}{2}\hbar\omega; ......$

(B) $\frac{1}{2}\omega; \frac{3}{2}\omega; \frac{5}{2}\omega; ......$

(C) $\hbar\omega; 3\hbar\omega; 5\hbar\omega; ......$

(D) $\omega; 3\omega; 5\omega; ......$

37. Considering molecule as non-rigid rotator, the wave number corresponding to spectral line for transition J = 1 to 2 is :

(A) 2B–4D

(B) 2B–24D

(C) 4B–32D

(D) 4B–16D

38. The rotational constant for a linear diatomic molecule is B. If the rotational spectral line corresponding to transition J to J + 1 at temperature T has maximum intensity, then the value of J is :

(A) $\sqrt{\frac{kT}{2Bhc}}-\frac{1}{2}$

(B) $\sqrt{\frac{kT}{2Bhc}-\frac{1}{2}}$

(C) $\sqrt{\frac{2Bhc}{kT}}-\frac{1}{2}$

(D) $\sqrt{\frac{2Bhc}{kT}-\frac{1}{2}}$

39. If B is rotational constant and D is centrifugal distortion, then term value corresponding to energy of non-rigid rotator is :

(A) $2B(J + 1) - 2D(J + 1)^2$

(B) $2BJ(J + 1) - 2DJ^2 (J + 1)^2$

(C) $BJ(J + 1) - DJ^2 (J + 1)^2$

(D) $B(J + 1) - D(J + 1)^2$

40. If B is rotational constant and ω is vibrational constant for linear diatomic molecule, then centrifugal distortion constant D is equal to :

(A) $D = 4\omega^2/B^3$

(B) $D = 4\omega^3/B^2$

(C) $D = 4B^3/\omega^2$

(D) $D = 4B^2/\omega^3$

41. The rotational spectrum of molecule is obtained in region :

(A) $10^{-2}\,\mu \rightarrow 10^{0}\,\mu$

(B) $10^{0}\,\mu \rightarrow 10^{2}\,\mu$

(C) $10^{2}\,\mu \rightarrow 10^{4}\,\mu$

(D) $10^{4}\,\mu \rightarrow 10^{6}\,\mu$

42. If a linear molecule is considered as rigid rotator having moment of Inertia I, then expression for rotational constant, energy of rotational state and wave number corresponding to transition J → J + 1 are respectively :

(A) $B = h/(8\pi^2 Ic);$

$E(J) = hcBJ(J+1);$

$\bar{\nu} = 2B(J+1)$

(B) $B = \hbar/(8\pi^2 Ic);$

$E(J) = hcBJ(J+1);$

$\bar{\nu} = 2B(J+1)$

(C) $B = \hbar/(8\pi^2 Ic);$ $E(J) = BJ(J+1);$

$\bar{\nu} = 2BJ(J+1)$

(D) $B = h/(8\pi^2 Ic);$ $E(J) = BJ(J+1);$

$\bar{\nu} = 2BJ(J+1)$

43. Which statement is not true for the rotational spectrum of a molecule considered as rigid rotator ?

(A) It is obtained for hetero-nuclear molecule having permanent dipole moment.

(B) It is obtained in far IR and microwave region.

(C) The energy states are equidistant but spectral lines are not equidistant.

(D) The selection rule for transition in rotational energy states is $\Delta J = \pm 1$.

44. If I_a, I_b and I_c are principal axis moment of inertia, then which condition satisfies for the oblate type symmetric top molecule ?

(A) $I_a = I_b = I_c$

(B) $I_a < I_b = I_c$

(C) $I_a = I_b < I_c$

(D) $I_a = I_b > I_c$

45. Which type of effect will be prominent for transition $^3D_3 \rightarrow {}^3P_2$ in weak magnetic field ?

(A) Normal Zeeman effect

(B) Anomalous Zeeman effect

(C) Paschen back effect

(D) Hyperfine structure splitting

46. Which statement is correct regarding shift in spectral line ?

(A) Isotope effect shifts spectral lines between different isotopes.

(B) Hyperfine structure splits spectral lines within the same isotope due to nuclear spin interaction.

(C) Fine structure is splitting of lines due to spin-orbit coupling of electrons.

(D) All of the above

47. Which statement is true regarding isotope shift in atomic spectra ?

(A) It arises due to difference in nuclear mass and nuclear size.

(B) Isotope effect is strongest for transitions involving *s*-states.

(C) Isotopic shift is significant for low nuclear mass and heavy elements with large nuclear charge.

(D) All of the above

48. If hyperfine structure of resonance lines of sodium has intensity ratio 5 : 3, then what will be the nuclear spin ?

(A) 1/2

(B) 3/2

(C) 5/2

(D) 3/5

49. If I, J and F are nuclear spin, inner and hyperfine quantum numbers, then incorrect statement for Hyperfine structure splitting in atomic spectra is :

(A) Energy of hyperfine level is proportional to $[F(F + 1) – I(I + 1) – J(J + 1)]$.

(B) F can have values from J – I to J + I in increment of one.

(C) The energy difference between two consecutive hyperfine levels is proportional to F + 1.

(D) Selection rule for hyperfine is $\Delta F = \pm 2$.

50. The hyperfine structure in atomic spectra primarily arises due to interaction between :

(A) Electron spin and orbital angular momentum

(B) Electron orbital motion and external magnetic field

(C) Nuclear spin and total electronic angular momentum

(D) Electron-electron repulsion

51. Which statement said to be true with respect to Stark effect ?

(A) Spectral lines H_α and H_β suffer first order Stark effect while H_γ and H_δ suffer second order Stark effect.

(B) Selection rule for weak field Stark effect is same as for Zeeman effect.

(C) Spectral line corresponding to $3\ {}^2D_{5/2} \rightarrow 2\ {}^2P_{3/2}$ transition does not show Stark splitting.

(D) All of the above

52. First line of principal series for sodium in strong magnetic field splits into :

(A) Three spectral lines

(B) Four spectral lines

(C) Six spectral lines

(D) Ten spectral lines

53. The spectral line for transition ${}^2D_{3/2} \rightarrow {}^2P_{1/2}$ in weak magnetic field provides :

(A) Normal Zeeman pattern with three lines

(B) Anomalous Zeeman pattern with four lines

(C) Anomalous Zeeman pattern with six lines.

(D) Paschen back pattern with three lines

54. The shift of splitted energy levels in presence of magnetic field is measured in terms of Lorentz unit, which is equal to :

(A) $\frac{eh}{4\pi mc}$

(B) $\frac{e\mathrm{B}}{4\pi mc}$

(C) $\frac{e\mathrm{B}}{4\pi m}$

(D) $\frac{eh}{4\pi m}$

55. Splitting of D_2 line of Na in weak magnetic field provides :

(A) one π and two σ component spectral lines

(B) two π and one σ component spectral lines

(C) two π and four σ component spectral lines

(D) two π and two σ component spectral lines

56. Which statement is said to be correct with respect to atomic energy levels ?

(A) Lower multiplicity and lower L gets higher states.

(B) For less than half-filled shells, higher J lies higher in energy, but for more than half-filled shells, ordering reverses.

(C) The energy difference between J and J + 1 states under LS coupling is proportional to J + 1.

(D) All of the above

57. Natural broadening of a spectral line arises due to :

(A) thermal motion of atoms

(B) collisions between atoms

(C) external electric fields

(D) finite lifetime of excited states

58. If $J_1 = 3/2$ and $J_2 = 5/2$, then the values of J under JJ coupling scheme are :

(A) 1, 4

(B) 2, 3

(C) 0, 1, 2, 3

(D) 1, 2, 3, 4

59. The number of splitted energy states corresponding to $n = 2$ and $n = 3$ in presence of strong electric field are :

(A) 2, 3

(B) 3, 5

(C) 2, 5

(D) 5, 7

60. The true statement for Stark effect is :

(A) The splitting of spectral line in electric field is called as Stark effect.

(B) The energy shift in first order Stark effect is proportional to applied field.

(C) The energy shift in second order Stark effect is proportional to square of applied field.

(D) All of the above

61. If B is external magnetic field, then frequency shift of sigma lines in normal Zeeman effect is :

(A) $\frac{eB}{4\pi m}$

(B) $\frac{4\pi m}{eB}$

(C) $\frac{eB}{2m}$

(D) $\frac{eB}{m}$

62. Which effect shall occur in presence of low magnetic field corresponding to transition $^1P_1 \rightarrow {^1S_0}$?

(A) Normal Zeeman Effect

(B) Anomalous Zeeman effect

(C) Paschen back effect

(D) All of the above

63. The value of g_l and g_s are :

(A) 1, 2

(B) 2, 1

(C) 1, 3

(D) 3, 1

64. Magnitude of orbital magnetic moment is :

(A) $\frac{e}{2m} L$

(B) $g_l \frac{e}{2m} L$

(C) $g_l \sqrt{l(l+1)}\mu_B$

(D) All of the above

65. The shift of energy in anomalous Zeeman effect is :

(A) $g_1 m_1 \mu_B B$

(B) $g_s m_s \mu_B B$

(C) $g_j m_j \mu_B B$

(D) $(g_1 m_1 + g_s m_s)\, \mu_B B$

66. Lande *g* factor for $^2S_{1/2}$ is :

(A) 2

(B) 3

(C) 3/2

(D) 2/3

67. Expression for Bohr magnetron and angular Larmour frequency are equal to :

(A) $\frac{e\hbar}{2m}, \frac{eB}{2m}$

(B) $\frac{eB}{2m}, \frac{e\hbar}{2m}$

(C) $\frac{eB}{4\pi m}, \frac{e\hbar}{4\pi m}$

(D) $\frac{e\hbar}{4\pi m}, \frac{eB}{4\pi m}$

68. Space quantization is reason behind the :

(A) Normal Zeeman Effect

(B) Anomalous Zeeman Effect

(C) Paschen Back Effect

(D) All of the above

69. Which statement is true for the Normal Zeeman effect ?

(A) Occurs due to transition in singlet states at low magnetic fields.

(B) It causes splitting in 2 circularly polarized spectral lines along view to magnetic fields.

(C) It causes splitting in 3 plane polarized spectral lines at perpendicular view to magnetic fields.

(D) All of the above

70. The number of lines in Paschen Back effect is equal to spectral lines in :

(A) Normal Zeeman Effect

(B) Anomalous Zeeman Eeffct

(C) Stark effect

(D) All of the above

71. Which is correct statement for alkaline earth spectra ?

(A) The selection rule for transition is $\Delta S = 0$, $\Delta L = \pm 1$ and $\Delta J = 0, +1$ (but not $J = 0 \rightarrow 0$).

(B) Fine structure of each Principal/Sharp series lines due to transition in triplet state has three components.

(C) Fine structure of each Diffuse/Fundamental series lines due to transition in triplet state has six components.

(D) All of the above

72. The Lande g factor and magnetic moment in terms of Bohr magnetron (μ_B) for the state $^3P_1$ are respectively :

(A) $\frac{1}{2}$ and $\frac{3}{\sqrt{2}}\mu_B$

(B) $\frac{3}{2}$ and $\frac{3}{\sqrt{2}}\mu_B$

(C) $\frac{3}{\sqrt{2}}$ and $\frac{3}{\sqrt{2}}\mu_B$

(D) $\frac{1}{\sqrt{2}}$ and $\frac{2}{\sqrt{3}}\mu_B$

73. Limiting wave number corresponding to Principal and Diffuse series in Na spectra are :

(A) $\frac{R}{(3+p)^2}; \frac{R}{(3+d)^2}$

(B) $\frac{R}{(3+s)^2}; \frac{R}{(3+p)^2}$

(C) $\frac{R}{(3+s)^2}; \frac{R}{(3+d)^2}$

(D) $\frac{R}{(3+p)^2}; \frac{R}{(3+s)^2}$

74. What causes spin-orbit interaction in atoms ?

(A) External magnetic field.

(B) Magnetic interaction between the nucleus and the electron.

(C) Magnetic interaction between an electron's spin and its orbital motion.

(D) Coulomb attraction between nucleus and electron.

75. Under vector atom model the value of inner quantum number can have values :

(A) $l - s$ and $l + s$

(B) $l - s$ to $l + s$ in increment of 1

(C) $l - s$ to $l + s$ in increment of 2

(D) All of the above

76. In LS coupling, which of the following is conserved during spin-orbit interaction ?

(A) L and S separately

(B) Only S

(C) Only L

(D) Total angular momentum J

77. Why do the alkali metals spectral lines deviate slightly from those of hydrogen ?

(A) Due to presence of isotopes

(B) Due to nuclear reactions

(C) Due to screening effect from core electrons

(D) Due to different numbers of protons

78. If L and S are orbital and spin angular momentum associated with electron motion, then under vector atom model the total angular momentum is :

(A) $\vec{L} \times \vec{S}$

(B) $\vec{L} + \vec{S}$

(C) $\vec{L} - \vec{S}$

(D) $\vec{L} \pm \vec{S}$

79. The fine structure of hydrogen spectral lines arises due to :

(A) Zeeman effect

(B) Spin-orbit interaction

(C) Hyperfine interaction

(D) Doppler broadening

80. Which one is not an equivalent electron system ?

(A) np^1nd^1

(B) ns^2

(C) np^3

(D) nd^4

81. Alkaline earth elements show spectral lines mainly due to transitions of :

(A) $ns \cdot np \rightarrow ns^2$

(B) $ns \cdot nd \rightarrow ns^2$

(C) $np^2 \rightarrow ns^2$

(D) $nd^2 \rightarrow ns^2$

82. Which of the following is said to be correct with respect to alkaline earth atom and its spectra ?

(A) The ground-state configuration ns^2 corresponds to spectroscopic term $^1S_0$.

(B) The first excited configuration *ns*-*np* gives rise to spectroscopic term $^1P_1$ and $^3P_{0, 1, 2}$.

(C) The multiple structure in alkaline earth spectra is singlets and triplets.

(D) All of the above

83. The sepectroscopic term under LS coupling for electron system s^1p^1 :

(A) $^1P_1$, $^3P_{0, 1, 2}$

(B) $^1S_1$, $^3P_{0, 1, 2}$

(C) $^1S_0$, $^3S_0$

(D) $^1S_1$, $^3P_{1, 2, 3}$

84. Which pair of states in hydrogen atom is degenerate in Dirac theory but separated by Lamb shift experimentally ?

(A) $^2S_{1/2}$ and $^2P_{3/2}$

(B) $^2S_{1/2}$ and $^2P_{1/2}$

(C) $^2P_{1/2}$ and $^2P_{3/2}$

(D) $^1S_{1/2}$ and $^2S_{1/2}$

85. The doublet splitting due to LS coupling always happens in :

(A) optical electron system

(B) non-equivalent electron system

(C) equivalent electron system

(D) All of the above

86. The intensity ratio for D_1 and D_2 spectral lines of sodium is :

(A) 1 : 2

(B) 2 : 1

(C) 3 : 2

(D) 2 : 3

87. The transition responsible for 5890 Å wavelength of spectral line of sodium ?

(A) $3\,^2P_{1/2} \rightarrow 3\,^2S_{1/2}$

(B) $3\,^2P_{3/2} \rightarrow 3\,^2S_{1/2}$

(C) $3\,^2P_{1/2} \rightarrow 2\,^2S_{1/2}$

(D) $3\,^2P_{3/2} \rightarrow 2\,^2S_{1/2}$

88. In an atom, three energy levels $E_1 > E_2 > E_3$ produce spectral lines of frequencies ν_{12}, ν_{23} and ν_{13}, then which of the following statements is correct according to Ritz combination principle ?

(A) $\nu_{13} = \nu_{12} + \nu_{23}$

(B) $\nu_{13} = \nu_{12} - \nu_{23}$

(C) $\nu_{23} = \nu_{12} + \nu_{13}$

(D) $\nu_{12} = \nu_{13} + \nu_{23}$

89. The wave number difference of Diffuse and Fundamental series limit values is equal to wave number of first line of diffuse series. This is :

(A) Rydberg Schuster law

(B) Runge's law

(C) Ritz law

(D) Lande-interval rule

90. The wave number difference of principal and sharp series limit values is equal to wave number corresponding to :

(A) First line of Principal series

(B) First line of Sharp series

(C) First line of Diffuse series

(D) First line of Fundamental series

91. Which transition results Principal series of spectral lines for sodium ?

(A) $ns \rightarrow 3p$; $n = 4, 5, 6,$ ....

(B) $np \rightarrow 3s$; $n = 3, 4, 5,$ ....

(C) $nd \rightarrow 3s$; $n = 3, 4, 5,$ ....

(D) $nf \rightarrow 3p$; $n = 3, 4, 5,$ ....

92. Which statement is not true for alkali spectra ?

(A) It consists of Principal, Sharp, Diffuse and Fundamental series of lines. Sharp and Diffuse series have common convergence limit.

(B) Principal and Sharp series correspond to doublet spectra while Diffuse and Fundamental series correspond to compound doublet spectra.

(C) Alkali spectra is obtained under selection rule $\Delta l = \pm 1$ and $\Delta j = 0, \pm 1$.

(D) Its fine structure spectra can be explained on the basis of coupling between nuclear spin and total angular momentum of electron.

93. What will be spectroscopic terms for p^5 electron system ?

(A) $^1P_{3/2}$, $^2P_{5/2}$

(B) $^2P_{3/2}$, $^3P_{5/2}$

(C) $^2P_{1/2}$, $^2P_{3/2}$

(D) $^3P_{1/2}$, $^2P_{3/2}$

94. What will be the vale of n, l, s, j and multiplicity (m) for spectroscopic term 2 $^3P_2$?

(A) $n = 2, l = 3, s = 1, j = 2, m = 3$

(B) $n = 3, l = 2, s = 0, j = 3, m = 2$

(C) $n = 3, l = 1, s = 0, j = 3, m = 2$

(D) $n = 2, l = 1, s = 1, j = 2, m = 3$

95. Which spectroscopic term is possible corresponding to completely filled orbital/subshell under vector atom model ?

(A) $^1S_0$

(B) $^2P_0$

(C) $^3D_0$

(D) $^4F_0$

96. The value of Rydberg constant and fine structure constant are equal to :

(A) 1.097×10^7 m^{-1}; 1/137

(B) 1.097×10^7 cm^{-1}; 1/137

(C) 1.097×10^7 m^{-1}; c/137

(D) 1.097×10^7 cm^{-1}; c/137

97. If n and j are principal and inner quantum numbers, then shift of energy with Bohr energy level in terms of wave number under Dirac theory for hydrogen atom is equal to :

(A) $\frac{5.84}{n^3}\left(\frac{1}{j}-\frac{3}{4n}\right)$

(B) $\frac{5.84}{n^3}\left(\frac{1}{j+1/2}-\frac{3}{4n}\right)$

(C) $\frac{5.84}{n^3}\left(\frac{1}{j-1/2}-\frac{3}{4n}\right)$

(D) $\frac{5.84}{n^4}\left(\frac{3}{4n}-\frac{1}{j}\right)$

98. If α, z and n are fine structure constant, atomic number and principal quantum number, then magnitude of spin-orbit coupling energy is proportional to :

(A) $\frac{\alpha^2 Z^4}{n^3}$

(B) $\frac{\alpha^2 Z^3}{n^4}$

(C) $\frac{\alpha^3 Z^2}{n^4}$

(D) $\frac{\alpha^4 Z^3}{n^2}$

99. If L and S are orbital and spin angular momentum, then spin-orbit interaction energy for hydrogen like atom is proportional to :

(A) $\vec{L} \bullet \vec{S}$

(B) $\vec{L} \times \vec{S}$

(C) $\vec{L} + \vec{S}$

(D) $L^2 + S^2$

100. Which statement is not true for H_α line of Hydrogen ?

(A) It arises with transition $n = 3 \rightarrow n = 2$ and has 6563Å wavelength.

(B) Fine structure of H_α line under Hansen's Experiment has five spectral lines.

(C) Fine structure of H_α line can be explained on the basis of Dirac theory based on spin-orbit coupling.

(D) Sommerfeld relativistic model explains all the fine structure spectral line of H_α.

(Only for Rough Work)

4. Four alternative answers are mentioned for each question as—A, B, C & D in the booklet. The candidate has to choose the correct answer and mark the same in the OMR Answer-Sheet as per the direction :

   Example :

   Question :

   Q. 1 Ⓐ ● Ⓒ Ⓓ
   Q. 2 Ⓐ Ⓑ ● Ⓓ
   Q. 3 Ⓐ ● Ⓒ Ⓓ

   Illegible answers with cutting and over-writing or half filled circle will be cancelled.

5. Each question carries equal marks. Marks will be awarded according to the number of correct answers you have.
6. All answers are to be given on OMR Answer Sheet only. Answers given anywhere other than the place specified in the answer sheet will not be considered valid.
7. Before writing anything on the OMR Answer Sheet, all the instructions given in it should be read carefully.
8. After the completion of the examination candidates should leave the examination hall only after providing their OMR Answer Sheet to the invigilator. Candidate can carry their Question Booklet.
9. There will be no negative marking.
10. Rough work, if any, should be done on the blank pages provided for the purpose in the booklet.
11. To bring and use of log-book, calculator, pager and cellular phone in examination hall is prohibited.
12. In case of any difference found in English and Hindi version of the question, the English version of the question will be held authentic.

Impt. : On opening the question booklet, first check that all the pages of the question booklet are printed properly. If there is any discrepancy in the question Booklet, then after showing it to the invigilator, get another question Booklet of the same series.

4. प्रश्न-पुस्तिका में प्रत्येक प्रश्न के चार सम्भावित उत्तर—A, B, C एवं D हैं। परीक्षार्थी को उन चारों विकल्पों में से सही उत्तर छाँटना है। उत्तर को OMR आन्सर-शीट में सम्बन्धित प्रश्न संख्या में निम्न प्रकार भरना है :

   उदाहरण :

   प्रश्न :

   प्रश्न 1 Ⓐ ● Ⓒ Ⓓ
   प्रश्न 2 Ⓐ Ⓑ ● Ⓓ
   प्रश्न 3 Ⓐ ● Ⓒ Ⓓ

   अपठनीय उत्तर या ऐसे उत्तर जिन्हें काटा या बदला गया है, या गोले में आधा भरकर दिया गया, उन्हें निरस्त कर दिया जाएगा।

5. प्रत्येक प्रश्न के अंक समान हैं। आपके जितने उत्तर सही होंगे, उन्हीं के अनुसार अंक प्रदान किये जायेंगे।
6. सभी उत्तर केवल ओ. एम. आर. उत्तर-पत्रक (OMR Answer Sheet) पर ही दिये जाने हैं। उत्तर-पत्रक में निर्धारित स्थान के अलावा अन्यत्र कहीं पर दिया गया उत्तर मान्य नहीं होगा।
7. ओ. एम. आर. उत्तर-पत्रक (OMR Answer Sheet) पर कुछ भी लिखने से पूर्व उसमें दिये गये सभी अनुदेशों को सावधानीपूर्वक पढ़ लिया जाये।
8. परीक्षा समाप्ति के उपरान्त परीक्षार्थी कक्ष निरीक्षक को अपनी OMR Answer Sheet उपलब्ध कराने के बाद ही परीक्षा कक्ष से प्रस्थान करें। परीक्षार्थी अपने साथ प्रश्न-पुस्तिका ले जा सकते हैं।
9. निगेटिव मार्किंग नहीं है।
10. कोई भी रफ कार्य, प्रश्न-पुस्तिका के अन्त में, रफ-कार्य के लिए दिए खाली पेज पर ही किया जाना चाहिए।
11. परीक्षा-कक्ष में लॉग-बुक, कैलकुलेटर, पेजर तथा सेल्युलर फोन ले जाना तथा उसका उपयोग करना वर्जित है।
12. प्रश्न के हिन्दी एवं अंग्रेजी रूपान्तरण में भिन्नता होने की दशा में प्रश्न का अंग्रेजी रूपान्तरण ही मान्य होगा।

महत्वपूर्ण : प्रश्नपुस्तिका खोलने पर प्रथमत: जाँच कर देख लें कि प्रश्न-पुस्तिका के सभी पृष्ठ भलीभाँति छपे हुए हैं। यदि प्रश्नपुस्तिका में कोई कमी हो, तो कक्षनिरीक्षक को दिखाकर उसी सिरीज की दूसरी प्रश्न-पुस्तिका प्राप्त कर लें।