OMR Answer Sheet No.

Question Booklet Number

8118

M.Sc. (Sem.-VIII) Examination, 2022-23

Booklet Series

A

Physics

Molecular and Laser Spectroscopy

[Time : 1 : 30 Hours
[समय : 1 : 30 घण्टे
[Maximum Marks : 75
[अधिकतम अंक : 75

(To be filled in by the Candidate / निम्न पूर्तियाँ परीक्षार्थी स्वयं भरें)

Roll No. (in figures) ______________
अनुक्रमांक (अंकों में)

Roll No. (in words) ______________
अनुक्रमांक (शब्दों में)

Enrolment No. (in figures) ______________

Name of College ______________
कॉलेज का नाम

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Signature of Invigilator
कक्ष निरीक्षक के हस्ताक्षर

Instructions to the Examinee :

1. Do not open the booklet unless you are asked to do so.
2. The booklet contains 75 questions. Examinee is required to answer any 50 questions in the OMR Answer-Sheet provided and not in the question booklet. In case Examinee attempts more than 50 Questions, ***first*** 50 attempted questions will be evaluated. All Questions carry equal marks.

   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 immediately replaced.

(Remaining Instructions on last page)

परीक्षार्थियों के लिए निर्देश :

1. प्रश्न-पुस्तिका को तब तक न खोलें जब तक आपसे कहा न जाए।
2. प्रश्न-पुस्तिका में 75 प्रश्न हैं। परीक्षार्थी को किन्हीं 50 प्रश्नों को दी गई OMR उत्तर-पत्रक पर ही हल करना है। परीक्षार्थी द्वारा 50 से अधिक प्रश्नों को हल करने की स्थिति में, ***प्रथम*** 50 उत्तरों को ही मूल्यांकित किया जाएगा। सभी प्रश्नों के अंक समान हैं।
3. प्रश्नों के उत्तर अंकित करने से पूर्व प्रश्न-पुस्तिका तथा OMR उत्तर-पत्रक को सावधानीपूर्वक देख लें। दोषपूर्ण प्रश्न-पुस्तिका, जिसमें कुछ भाग छपने से छूट गये हों या प्रश्न एक से अधिक बार छप गये हों या किसी भी प्रकार की कमी हो, उसे तुरन्त बदल लें।

(शेष निर्देश अन्तिम पृष्ठ पर)

1. The energy change in a vibrational transition is of the order of:
   - (A) 0.1 eV
   - (B) 5.0 eV
   - (C) 10.0 eV
   - (D) 0.005 eV

2. The electronic spectra of molecule lies in:
   - (A) Microwave region
   - (B) Visible region
   - (C) Near infra-red region
   - (D) Far infra-red region

3. The near infra-red spectra of molecule is due to:
   - (A) Electronic transition
   - (B) Rotational transition
   - (C) Vibrational transition
   - (D) Band transition

4. The rotational spectra of a molecule falls in the wave length range:
   - (A) 200Å-3000Å
   - (B) 4000Å-8000Å
   - [illegible]-100cm
   - (D) 1[illegible]500μ

5. The vibrational energy levels of a molecule are:
   - (A) Discrete and equidistant
   - (B) Discrete but not equidistant
   - (C) Continuous
   - (D) All are possible

6. The vibrational energy of a molecule in its ground state is:
   - (A) $\frac{1}{2}h\nu_0$
   - (B) $h\nu_0$
   - (C) $\frac{3}{2}h\nu_0$
   - (D) Zero

7. The near infrared spectra consists of bands. The line missing at the band is known as:
   - (A) Null line
   - (B) Zero gap
   - (C) Both (A) and (B)
   - (D) None of these

8. If fundamental band of HCl^{35} lies at 3.46μ, then the wavelength of the corresponding band of HCl^{37} is:
   - (A) 5.78μ
   - (B) 3.69μ
   - (C) 4.64μ
   - (D) 3.45μ

9. The frequency of the $1720 cm^{-1}$ peak is:

(A) 15.45×10^{14} Hz

(B) 16.51×10^{12} Hz

(C) 17.47×10^{14} Hz

(D) 51.63×10^{12} Hz

10. The correct order of energies of different transition is:

(A) Electronic > Vibrational > Rotational.

(B) Vibrational > Electronic > Rotational

(C) Rotational > Vibrational > Electronic

(D) Vibrational > Rotational > Electronic

11. The rotational energies of a diatomic molecule of rotational constant 'B' are:

(A) B, 2B, 3B, 4B, ...

(B) 0,2B, 6B, 12B, ...

(C) 0,2B, 4B, 6B, ...

(D) B, 4B, 9B, 16B, ...

12. The transition rules for vibrational-rotational spectra are:

(A) $\Delta n=0, \Delta J=0$

(B) $\Delta n=\pm1, \Delta J=\pm1$

(C) $\Delta n=0, \Delta J=\pm1$

(D) $\Delta n=\pm1, \Delta J=0$

13. In infra-red spectrum, the frequency interval between two successive lines is:

(A) B/h

(B) 2B/h

(C) B

(D) 4B/h

14. The allowed rotational energies of a rigid rotator is given by:

(A) $E_r = \frac{1}{2}mv^2$

(B) $E_r = \frac{J^2h}{8\pi}$

(C) $E_r = \frac{1}{2}IW^2$

(D) $E_r = \frac{Jh^2}{8\pi}$

15. The frequency, whatever mentioned in molecular spectra, is expressed in the unit of:

(A) Energy

(B) Plank's constant

(C) Wave length

(D) Wave number

16. Homo nuclear molecule have:

(A) Net dipole moment

(B) Absorb infrared radiation

(C) Emits infrared radiation

(D) No net dipole moment and hence there is no absorption of infrared radiation.

17. In the rotational Raman spectrum of HCl the displacements from the exciting line are represented by:

$\Delta v = \pm (62.4 + 41.6J)\ \text{cm}^{-1}$

The rotational constant for HCl molecule is:

(A) $10.2\ \text{cm}^{-1}$

(B) $10.2\ \text{m}^{-1}$

(C) $10.2\ \text{mm}^{-1}$

(D) $10.4\ \text{cm}^{-1}$

18. The spacing between the vibrational levels of a CO molecule is 8.45×10^{-2} ev, calculate the value of the force constant K of the bond in CO molecule ($\mu = 1.14 \times 10^{-26}$ Kg):

(A) 178.2 N/M

(B) 187.1 N/M

(C) 19.0 N/M

(D) 191.6 N/M

19. The reduced mass of HCl molecule is:

(A) 1.61×10^{-27} gm.

(B) 1.61×10^{-27} kg

(C) 2.77×10^{-29} kg

(D) 0.97×10^{-27} gm.

20. Pure rotational spectrum of a dia atomic molecules consist of:

(A) Two equally spaced lines

(B) Three equally spaced lines

(C) Many equally spaced lines

(D) No regular pattern

21. The first line (J=0) in rotational spectra of CO appears at rotational frequency $v_r = 3.84$. Then the rotational constant 'B' has the value:

(A) $11.52\ \text{cm}^{-1}$

(B) $7.68\ \text{cm}^{-1}$

(C) $1.92\ \text{cm}^{-1}$

(D) $1.46\ \text{cm}^{-1}$

22. The reduced mass of CO is 1.1×10^{-23} gm and its moment of inertia is 1.45673×10^{-39} gm-cm^2. Then the bond length of CO is:

(A) 1.28Å

(B) 2.58Å

(C) 1.28×10^{-16} cm

(D) 1.131×10^{-8} cm

23. The molecule will be oblate symmetric top, if:

(A) $I_a \neq I_b \neq I_c$

(B) $I_a = I_b = I_c$

(C) $I_a = I_b > I_c$

(D) $I_a = I_b < I_c$

24. Which of the following sets, represents the set of principal moment of inertia:

(A) I_{xx}, I_{yy}, I_{zz}

(B) I_{xx}, I_{xy}, I_{xz}

(C) I_{yx}, I_{yy}, I_{yz}

(D) I_{zx}, I_{zy}, I_{zz}

25. At ordinary temperature the molecules remain in their:

(A) Lowest vibrational level

(B) Highest vibrational level

(C) Can remain in any vibrational level

(D) Does not show any type of vibrations.

26. For a non-rigid rotator correct relation is:

(A) $F(J)=BJ(J+1)-DJ^2(J+1)^2$

(B) $F(J)=2B\,J(J+1)-DJ^2$

(C) $F(J)=B\,J\,(J+1)-DJ^2$

(D) None of these

27. With principal axes transformation, which of the following is not possible:

(A) $I_{xx}=0$

(B) $I_{xy}=0$

(C) $I_{xz}=0$

(D) $I_{yz}=0$

28. If the principal moment of inertia are $I_a=I_b=I_c=I$, then the molecule will be:

(A) Spherical top

(B) Symmetric top

(C) Assymmetric top

(D) Linear and diatomic

29. On increasing the value of rotational quantum number J, for a non-rigid rotator, the separation between spectral lines:

(A) Increases

(B) decreases

(C) Remains constant

(D) All are possible

30. The eigen values for energies of a linear harmonic oscillator, with vibrational quantum number 'v' is given by:

(A) $E_v = hcw\left(v + \frac{1}{2}\right)$

(B) $E_v = \frac{1}{2} hcwv$

(C) $E_v = hcwv$

(D) $E_v = \frac{1}{2} m\, hcwv$

31. The selection rule for pure rotational spectra is:

(A) $\Delta J=0$

(B) $\Delta J=\pm 1$

(C) $\Delta J=\pm 2$

(D) $\Delta J=0,\pm 2$

32. Which of the following molecules is infra-red active:

(A) H_2

(B) HCl

(C) N_2

(D) All of these

33. The selection rule for the transition in the spectra of a molecule as an anharmonic oscillator is given by:

(A) $\Delta v=\pm 1$

(B) $\Delta v=0,\pm 1$

(C) $\Delta v=\pm 1, \pm 2\ \pm 3, \ldots\ldots$

(D) $\Delta v=\pm 2, \pm 4, \pm 6, \ldots\ldots$

34. There is no infrared absorption for nitrogen molecules because:

(A) Its polarizability is zero

(B) It has no vibrational level

(C) It has no rotational level

[✓ (D) Its dipole moment is zero]

35. Raman effect occurs due to the interaction of:

(A) Electrons with molecules

(B) Electrons with atoms

[✓ (C) Photons with molecules]

(D) Photons with electrons

36. The correct expression for energy level of rigid rotator is given by:

[✓ (A) $E = \frac{h^2}{8\pi^2 I} J(J+1)$]

(B) $E = \frac{h^2}{8\pi^2 m} J(J+1)$

(C) $E = \frac{h^2}{8\pi^2} J(J+1)$

(D) $E = \frac{h^2 I}{8\pi^2} J(J+1)$

37. The IR region most widely used for qualitative analysis is:

(A) mid.IR

[✓ (B) near IR]

(C) far IR

[✓ (D) All of the above]

38. CH_3Cl molecule is an example of:

(A) Asymmetric top

[✓ (B) Symmetric top]

(C) Prolate

(D) None of these

39. Which of the following is a tunable laser?

(A) Argon laser

[✓ (B) Dye laser]

(C) Semiconductor laser

(D) CO_2 laser

40. At an absolute temperature T, the ratio of number of atoms N_2 in excited state to the number of atoms in ground state N_1, can be given by:

(A) $e^{-kT/\Delta E}$

(B) $\frac{1}{e^{-kT/\Delta E}}$

(C) $e^{-\Delta E/kT}$ •

(D) $\frac{1}{e^{-\Delta E/kT}}$

41. The dependence of Doppler broadened line width of a laser transition on temperature T is given by:

(A) T

(B) $T^{-1/2}$

(C) $T^{1/2}$

(D) T^2

42. The first stokes line of a rotational Raman spectrum is observed at 12.96 cm^{-1}. Considering rigid rotator approximation, the rotational constant is given by:

(A) 6.48 cm^{-1}

(B) 3.24 cm^{-1}

(C) 2.16 cm^{-1}

(D) 1.62 cm^{-1}

43. The selection rule for pure rotational Raman spectra is:

(A) $\Delta J=0$

(B) $\Delta J=\pm 1$

(C) $\Delta J=\pm 2$ •

(D) $\Delta J=0,\pm 1$

44. According to classical theory of Raman effect the induced dipole moment is given by the relation $\vec{P} = \alpha\vec{E}$. Where α is:

(A) Polarizability •

(B) Permittivity

(C) Permiability

(D) Intensity

45. All vibrations producing a change in the electric dipole moment of molecule yield:

(A) Raman spectra •

(B) Infrared spectra

(C) Ultra-violet spectra

(D) X-ray spectra

46. Which of the following lines are most intense?

(A) Stokes line

(B) Rayleigh lines

(C) Anti-Stokes line

(D) All are same intense

47. Raman effect is due to the scattering of:

(A) Molecules

(B) Atoms

(C) Electrons

(D) Photons

48. Raman spectrum is said to consists of stokes lines, when:

(A) $\Delta\nu<0$

(B) $\Delta\nu>0$

(C) $\Delta\nu=0$

(D) Independent of $\Delta\nu$

49. The purity of spectral line with wavelength λ and coherence length L, is given by:

(A) $Q=L/\lambda$

(B) $Q=\lambda/L$

(C) $Q=\lambda^2/\Delta\lambda$

(D) $Q=\lambda/\Delta\lambda$

50. Raman lines are:

(A) Strongly polarised

(B) Partially polarised

(C) Unpolarised

(D) None of these

51. In pure rotational Raman spectra, the Raman Shift $\Delta\bar{\nu}$ given by:

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

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

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

(D) $\Delta\bar{\nu}=\pm 2B(2J+3)$

52. Elastic scattering of photons is called as:

(A) Raman Scattering

(B) Atmospheric scattering

(C) Rayleigh scattering •

(D) Conserved scattering

53. Light of wave length 1.5 μm incident on a material with a characteristic Raman frequency of 20×10^{12} Hz. results in a stokes, shifted line of wavelength.

(A) 1.47 μm.

(B) 1.57 μm.

(C) 1.67 μm.

(D) 1.77 μm.

54. The spectral lines of same frequency as that of incident beam, are called:

(A) Stokes lines

(B) Anti stokes lines

(C) Rayleigh lines •

(D) Raman lines

55. With exciting line 2536Å, a Raman line for a sample is observed at 2612Å. What will be the value of Raman shift in cm^{-1}.

(A) 1147 cm^{-1}

(B) 1047 cm^{-1}

(C) 1100 cm^{-1}

(D) 1002 cm^{-1}

56. In Raman effect, the relation between the Wavelength (λ_s) of scattered radiation and the wavelength (λ_i) of the incident radiation is given by:

(A) $\lambda_s=\lambda_i$

(B) $\lambda_s<\lambda_i$ only

(C) $\lambda_s>\lambda_i$ only

(D) $\lambda_s<\lambda_i$ only $\lambda_s>\lambda_i$ both •

57. In fluoroscence:

(A) The incident photon is completely absorbed by the molecule. •

(B) The incident photon is scattered.

(C) The incident photon is not absorbed by the molecule.

(D) The photon get back reflected.

58. The minimum energy states required to achieve population inversion is:

(A) 05

(B) 04

(C) 03

(D) 02

59. The number of photons emitted per second from a 1 watt Ar-ion laser operating at 488 nm is approximately.

(A) 10.23×10^{19}

(B) 2.46×10^{18}

(C) 10.23×10^{17}

(D) 2.46×10^{15}

60. In a Ruby laser population inversion is achieved by applying:

(A) Magnetic field

(B) Electronic field

(C) Both magnetic and electro static field

(D) [illegible]ical burning

61. The ratio of He:Ne gases in helium-neon laser is:

(A) 1:10

(B) 10:1

(C) 5:1

(D) None of these

62. In meta stable energy state molecule can stay upto.

(A) 10^{-6} sec.

(B) 10^{-8} sec.

(C) 10^{-10} sec.

(D) 10^{-12} sec.

63. The coherence length of sodium D_2 line (λ=5890Å) is 2.5 cm. The coherence time will be:

(A) 7.5×10^{6} s.

(B) 1.2×10^{-10} s.

(C) 1.2×10^{10} s.

(D) 8.3×10^{-11} s.

64. Which one of the following will result symbolically the stimulated emission process? (* excited condition)

(A) Atom + photon→atom*

(B) Atom*+photon→atom*

(C) Atom*→atom+photon

[✓ (D) Atom*+photon→atom+2photon]

65. The half width $\Delta\lambda$ of a spectral line of wavelength λ is related with coherence length L, as:

(A) $\Delta\lambda=\lambda^2/L$

(B) $\Delta\lambda=\lambda L$

(C) $\Delta\lambda=L/\lambda$

(D) $\Delta\lambda=\lambda/L$

66. The most commonly used laser for Raman spectroscopy is:

(A) Dye laser

[✓ (B) Semiconductor laser]

(C) Ruby laser

(D) He-Ne laser

67. Which of the following is an example of optical pumping:

[✓ (A) Ruby laser]

(B) Dye laser

(C) Semiconductor laser

(D) Free electron laser

68. Which law is used for achieving the relation between the Einstein's coefficients?

[✓ (A) Uncertainty principle]

(B) Einstein's equation

(C) Newton's law

(D) Planck's radiation law

69. If N_1 atoms are in ground state and N_2 atoms are in excited state, at an absolute temperature T. Then for laser action:

(A) $N_1>N_2$

[✓ (B) $N_1<N_2$]

(C) $N_1=N_2$

(D) $N_2=0$

70. Einstein's coefficients A and B are related as:

(A) $\frac{A_{12}}{B_{12}} = \frac{8\pi h\nu}{c}$

(B) $\frac{A_{12}}{B_{12}} = \frac{4\pi h\nu^2}{c}$

(C) $\frac{A_{12}}{B_{12}} = \frac{8\pi h\nu^3}{c^3}$ •

(D) $\frac{A_{12}}{B_{12}} = \frac{4\pi h\nu}{c^2}$

71. In semiconductor laser, if D is the separation of two reflecting surfaces of resonant cavity, then the purity of laser beam of wavelength λ is:

(A) λ/2D

(B) 2λ/D

(C) D/2λ

(D) 2D/λ

72. Argon laser is a:

(A) Gas laser •

(B) Liquid laser

(C) Solid state laser

(D) Semiconductor laser

73. A semiconductor LASER crystal of length 5 cm, refractive index 1.8 is used as an optical source. Determine the frequency separation of the modes:

(A) 1.6 GHz

(B) 1.2 GHz

(C) 2 GHz

(D) 2.8 GHz

74. Which of the following is a unique property of LASER:

(A) Directional

(B) Speed

(C) Coherence •

(D) Wavelength

75. The most suitable Raman source is:

(A) LASER •

(B) Sodium lamp

(C) Scattered light source

(D) Reflected light