Roll No. .....

Question Booklet Number

O. M. R. Serial No.

M. Sc. (Second Semester)
(NEP) EXAMINATION, 2025-26
CHEMISTRY
(Symmetry and Group Theory) (Elective)

Paper Code							
B	0	2	0	8	0	5	T

Questions Booklet Series
A

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.

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।

(Remaining instructions on the last page) **(शेष निर्देश अन्तिम पृष्ठ पर)**

(Only for Rough Work)

1. What is the symmetry operation that leaves a molecule unchanged ?

(A) Identity
(B) Reflection
(C) Rotation
(D) Inversion

2. What is the order of the point group C_{3v} ?

(A) 12
(B) 6
(C) 3
(D) 2

3. Which point group does the molecule H_2O belong to ?

(A) D_{2h}
(B) C_{2h}
(C) T_d
(D) C_{2v}

4. Which of the following is an example of a symmetry element ?

(A) Inversion centre
(B) Mirror plane
(C) Rotation axis
(D) All of the above

5. What is the term for the number of symmetry operations in a point group ?

(A) Dimension
(B) Rank
(C) Order
(D) Class

6. What is the symmetry operation represented by σ_h ?

(A) Rotation
(B) Inversion
(C) Vertical reflection
(D) Horizontal reflection

7. Which of the following point groups is Abelian ?

(A) T_d
(B) C_{3v}
(C) D_{2v}
(D) C_{2v}

8. What is the order of point group O_h ?

(A) 48
(B) 24
(C) 12
(D) 60

9. Which molecule belongs to the D_{4h} point group ?

(A) CH_4
(B) SF_4
(C) XeF_4
(D) BF_3

10. Which of the following Schoenflies symbols represents a molecule with a tetrahedral symmetry ?

(A) D_{4h}
(B) C_{uv}
(C) O_h
(D) T_d

11. The orthogonality theorem helps to :

(A) Determine the number of normal modes of vibration

(B) Calculate bond lengths in a molecule

(C) Compute dipole moments

(D) Verify whether two irreducible representations are orthogonal

12. Which Schoenflies symbol represents a molecule with an inversion centre ?

(A) D_{2h}

(B) C_s

(C) C_i

(D) C_{2h}

13. Which of the following statements is true about the orthogonality theorem ?

(A) It is used to determine the symmetry of molecular orbitals.

(B) It applies only to irreducible representations .

(C) It applies only to reducible representations.

(D) Both (A) and (B)

14. Which symmetry element is present in a linear molecule ?

(A) *i* centre

(B) c_∞ axis

(C) σ_h plane

(D) All of the above

15. What is the term for a symmetry aperation that combines rotation and reflection ?

(A) Reflection

(B) Proper Rotation

(C) Improper Rotation

(D) Inversion

16. What does the top-left entry in a character table represent ?

(A) The order of the group

(B) The identity operation

(C) The number of symmetry operations

(D) The dimension of the representation

17. What is the primary use of character table in spectroscopy ?

(A) To predict allowed transition

(B) To predict molecular geometry

(C) To determine bond lengths

(D) To calculate molecular vibrations

18. What is the significance of the direct product of irreducible representations in spectroscopy ?

(A) It determines the symmetry of molecular orbitals.

(B) It calculates the intensity of spectral lines.

(C) It predicts the number of IR-active vibrations.

(D) It determines the allowed transitions.

19. What is the role of character tables in Raman Spectroscopy ?

(A) To determine the frequency of Raman bands

(B) To calculate the intensity of Raman bands

(C) To determine the symmetry of molecular orbitals

(D) To predict the number of Raman-active vibrations

20. Which point group does the molecule NH_3 belong to ?

(A) C_{2v}

(B) D_{3h}

(C) C_{3v}

(D) T_d

21. What is the name of the subgroup that contains only the identity element ?

(A) Trivial subgroup

(B) Improper subgroup

(C) Normal subgroup

(D) Proper subgroup

22. Which of the following is NOT a property of a group ?

(A) Closure

(B) Existence of inverse

(C) Associativity

(D) Commutativity

23. What is the order of the group $G = \left[e, a, a^2, a^3 \right]$ where $a^4 = e$?

(A) 5

(B) 4

(C) 3

(D) 2

24. What is the minimum number of elements required to form a group ?

(A) 2

(B) 4

(C) 3

(D) 1

25. What is the character of the representation of the point group C_{3v} for the operation σ_v ?

(A) 1

(B) 0

(C) 2

(D) – 1

26. What is the representation of the group $C_2 = \left[E, C_2 \right]$ using 2 × 2 matrices ?

(A) E = [(1, 0), (0, 1)],
C_2 = [(– 1, 0), (0, – 1)]

(B) E = [(1, 0), (0, 1)],
C_2 = [(1, 0), (0, – 1)]

(C) E = [(1, 0), (0, 1)],
C_2 = [(– 1, 0), (0, 1)]

(D) E = [(1, 0), (0, 1)],
C_2 = [(1, 0), (0, 1)]

27. Which of the following is a property of matrix representations of groups ?

(A) The matrices must be unitary.

(B) The matrices must be orthogonal.

(C) The matrices must satisfy the group multiplication table.

(D) All of the above

28. What is the character of the matrix representation of the identify operation E in any point group ?

(A) Depends on the point group

(B) 0

(C) 1

(D) – 1

29. What is the purpose of using matrix representations in group theory ?

(A) To simplify calculations

(B) To visualize symmetry operations

(C) To predict molecular properties

(D) All of the above

30. Which of the following is an example of an irreducible representations ?

(A) A 4 × 4 matrix representation of of T_d

(B) A 2 × 2 matrix representation of of C_{2h}

(C) A 1 × 1 matrix representation of of C_2

(D) A 3 × 3 matrix representation of of C_{3v}

31. In the point group C_{3v}, what is the conjugacy class of the operation C_3 ?

(A) $\left[C_3, \sigma_v\right]$

(B) $\left[C_3, C_3^2, E\right]$

(C) $\left[C_3\right]$

(D) $\left[C_3, C_3^2\right]$

32. In the point group D_{4h}, how many conjugacy classes are there ?

(A) 10

(B) 14

(C) 8

(D) 5

33. What is the point symmetry group of a molecule with a trigonal planar shape ?

(A) C_{2v}

(B) D_{3h}

(C) C_{3v}

(D) T_d

34. Which of the following molecules belong to the point group $C_{\infty v}$?

(A) NH_3

(B) CH_4

(C) CO_2

(D) H_2O

35. Which of the following point groups has a centre of inversion ?

(A) T_d

(B) C_{2v}

(C) D_{2d}

(D) C_{2h}

36. Which point group has a 4-fold rotation axis ?

(A) C_{4v}

(B) C_4

(C) D_4

(D) All of the above

37. What is the name of the theorem that states the number of irreducible representations equals the number of classes ?

(A) Lagrange's Theorem

(B) Great Orthogonality Theorem

(C) Cauchy's Theorem

(D) None of the above

38. What is the symmetry element associated with a reflection operation ?

(A) Identity element

(B) Inversion centre

(C) Mirror plane

(D) Rotation axis

39. How many symmetry operations are associated with a C_3 axis ?

(A) 4

(B) 3

(C) 2

(D) 1

40. What is the symbol for a vertical mirror plane ?

(A) C_2

(B) σ_d

(C) σ_h

(D) σ_v

41. What is the symmetry operation associated with an S_4 axis ?

(A) Rotation by 180° followed by inversion

(B) Rotation by 180° followed by reflection

(C) Rotation by 90° followed by inversion

(D) Rotation by 90° followed by reflection

42. What is the symbol for the totally symmetric representations ?

(A) A_1

(B) B_1

(C) A_2

(D) E

43. What does the Mulliken symbol "A" represent in a character table ?

(A) A triply degenerated representation

(B) A doubly degenerated representation

(C) A singly degenerated representation symmetric about the principal axis

(D) A singly degenerated representation antisymmetric about the principal axis

44. How is character table used to predict IR activity ?

(A) By checking if the vibration has the same symmetry as xy, xz or yz.

(B) By checking if the vibration is totally symmetric.

(C) By checking if the vibration has the same symmetry as x, y or z.

(D) By checking if the vibration is antisymmetric.

45. What is the significance of the first row in a character table ?

(A) It determines the point group.

(B) It gives the characters for the identity operation.

(C) It lists the symmetry operations.

(D) It represents the totally symmetric representations.

46. What is the dimension of a representation ?

(A) The size of the matrices in the representation

(B) The order of the group

(C) The number of group elements

(D) The number of matrices in the representation

47. What is the Mulliken symbol for a doubly degenerated representation ?

(A) T

(B) E

(C) B

(D) A

48. What is the character of a representation ?

(A) The sum of the eigenvalues of the representation matrix

(B) The product of the eigenvalues of the representation matrix

(C) The determinant of the representation matrix

(D) The trace of the representation matrix

49. What is the symmetry element associate with a C_3 rotation ?

(A) A mirror plane

(B) A 3-fold rotation axis

(C) An inversion centre

(D) A 2-fold rotation axis

50. How many symmetry operations are associated with a C_4 axis ?

(A) 1

(B) 2

(C) 4

(D) 3

51. What is the point group of a molecule with a C_2 axis and a σ_v plane ?

(A) D_{2h}

(B) C_{2h}

(C) C_2

(D) C_{2v}

52. What is the symmetry operation associated with an S_2 axis ?

(A) Rotation by 90° followed by reflection

(B) Inversion (*i*)

(C) Identity (E)

(D) Rotation by 180° followed by reflection

53. What is the result of applying a σ_h operation twice ?

(A) E (identity)

(B) *i* (inversion)

(C) σ_h

(D) C_2

54. What is the point group of a molecule with a C_3 axis and three C_2 axis ?

(A) D_3

(B) D_{2h}

(C) D_{3d}

(D) C_{3v}

55. How many classes are in the point group C_{2v} ?

(A) 4

(B) 3

(C) 5

(D) 2

56. What is the result of applying a C_2 rotation followed by a σ_h reflection ?

(A) S_2

(B) *i* (inversion)

(C) σ_v

(D) E (identity)

57. What is the symbol "*h*" in the Great Orthogonality Theorem ?

(A) The number of classes

(B) The order of group

(C) The dimension of the representation

(D) The number of symmetry operations

58. What is the relation between the Great Orthogonality Theorem and character table ?

(A) It is unrelated to character tables.

(B) It is a consequence of character tables.

(C) It is a alternative to character tables.

(D) It is used to construct character tables.

59. Which is credited with the development of the Great Orthogonality Theorem ?

(A) Herzberg

(B) Wigner

(C) Mulliken

(D) None of the above

60. What is a conjugacy relation in group theory ?

(A) A relation where two elements are conjugate if one is rotation of the other.

(B) A relation where two elements A and B are conjugate if there exists an element X such that $A = XBX^{-1}$.

(C) A relation where two elements are conjugate if they commute.

(D) A relation where two elements are conjugate if they are identical.

61. What is the relation between the number of conjugacy classes and irreducible representations ?

(A) The number of conjugacy classes is greater.

(B) They are equal.

(C) The number of irreducible representations is greater.

(D) There is no relation.

62. Which of the following is an example of a conjugacy class ?

(A) The set of all elements in a group

(B) The set of all rotations by 90° in a group

(C) The set of all reflections in a group

(D) The identity element alone

63. What is a conjugacy class ?

(A) A set of elements that are conjugate to each other.

(B) A set of elements that are inverses to each other.

(C) A set of elements that commute with each other.

(D) A set of elements that are identical.

64. What is the significance of conjugacy class in spectroscopy ?

(A) They determine molecular geometry.

(B) They predict allowed transitions.

(C) They calculate molecular energies.

(D) They help to construct character tables used in spectroscopy.

65. What is the number of conjugacy class in the point group C_{2v} ?

(A) 5

(B) 3

(C) 2

(D) 4

66. Which of the following groups has conjugacy classes [E], [C_2], [σ_v , σ'_v] ?

(A) C_{2v}
(B) D_2
(C) C_{2h}
(D) D_{2h}

67. In a group, if A and B are conjugate, what can be said about their orders ?

(A) They have the same order.
(B) They have different orders.
(C) A has a higher order than B.
(D) B has a higher order than A.

68. Which of the following is used to determine conjugacy classes ?

(A) Symmetry operations
(B) Molecular geometry
(C) Multiplication table of the group
(D) Character table

69. How many conjugacy classes are in the point group T_d ?

(A) 5
(B) 3
(C) 4
(D) 2

70. In the point group D_4, which operations are typically in the same conjugacy class ?

(A) C_2 and C_4
(B) E and C_2
(C) C_4 and C_4^3
(D) σ_v and σ_d

71. What is the conjugacy class of the identity element E in any group ?

(A) Depends on the group
(B) (E)
(C) The whole group
(D) Empty set

72. Which point group does a planer molecule like BF_3 belong to ?

(A) D_{3h}
(B) C_{2v}
(C) T_d
(D) C_{3v}

73. Which of the following point groups is centrosymmetric ?

(A) C_i
(B) D_{2h}
(C) C_{2h}
(D) All of the above

74. What is the point group of an octahedral molecule like SF_6 ?

(A) T_d
(B) C_{4v}
(C) O_h
(D) D_{4h}

75. A molecule belongs to the C_{nv} point group. What does this imply ?

(A) It has an inversion centre
(B) It has $n\,C_2$ axis perpendicular to C_n
(C) It has a C_n axis and horizontal mirror plane
(D) It has a C_n axis and n vertical mirror planes

76. What is the point group of HCl ?

(A) C_i

(B) $D_{\infty h}$

(C) $C_{\infty v}$

(D) None of the above

77. Which of the following is a chiral point group ?

(A) C_2

(B) D_2

(C) C_1

(D) All of the above

78. Which point group does a trigonal bipyramidal molecule like PCl_5 belong to ?

(A) O_h

(B) T_d

(C) C_{3v}

(D) D_{3h}

79. A molecule has a C_4 axis and a σ_h plane. What is its point group ?

(A) C_{4v}

(B) D_{4h}

(C) C_{4h}

(D) D_{2d}

80. Which point group does an ethane (C_2H_4) molecule belong to ?

(A) C_{2v}

(B) D_{2d}

(C) C_{2h}

(D) D_{2h}

81. A molecule has no symmetry elements except E. What is its point group ?

(A) C_5

(B) C_i

(C) C_2

(D) C_1

82. A molecule belongs to the D_{nd} point group. What does this imply ?

(A) It has a C_n axis and $n\,\sigma_v$ planes.

(B) It has a C_n axis, nC_2 axis, a σ_h plane.

(C) It has a C_n axis, nC_2 axis and $n\,\sigma_d$ planes.

(D) It has an inversion centre and $n\,\sigma_d$ planes.

83. How are Mulliken's symbols used in character tables ?

(A) To indicate molecular orbitals

(B) To label symmetry operations

(C) To label irreducible representations

(D) To show vibrational modes

84. What is the significance of the character χ (R) in a representation ?

(A) It indicates the symmetry of a molecular orbital.

(B) It is trace of the matrix representation operation R.

(C) It gives the number of atoms moving under operation R.

(D) All of the above

85. What does it mean if a vibration has a character of "0" under a symmetry operation ?

(A) The vibration is unaffected.

(B) The vibration is symmetric.

(C) The vibration is forbidden.

(D) The vibration is antisymmetric.

86. What is the significance of the orthogonality relations of characters ?

(A) They determine point groups.

(B) They predict molecular geometry.

(C) They help to reduce representations.

(D) They calculate energies.

87. What is the relation between the characters of an operation and its inverse ?

(A) They are complex conjugate.

(B) They are reciprocals.

(C) No relation.

(D) They are equal.

88. What does a character of –1 for a symmetry operation indicate ?

(A) The function is antisymmetric.

(B) The function is unchanged.

(C) The function is degenerate.

(D) The function is symmetric.

89. What does it mean if a representation is reducible ?

(A) It is one dimensional.

(B) It is irreducible.

(C) It has no symmetry.

(D) It can be broken into simple representations.

90. In a character table, what do the rightmost columns often list ?

(A) Basis functions

(B) Symmetry operations

(C) Mulliken symbols

(D) Vibrational modes

91. In C_{4v} point group, which irreducible representation has the following representation metrices ?

$E = [1], C_4 = [1], C_2 = [1], \quad \sigma_v = [1], \quad \sigma_d = [-1]$

(A) A_2

(B) A_1

(C) B_2

(D) B_1

92. If G is a group of order P (prime), what can be said about G ?

(A) G is abelian.

(B) G has no subgroups.

(C) G is cyclic.

(D) Both (A) and (C)

93. What is the order of the alternating group A_4 ?

(A) 24

(B) 12

(C) 8

(D) 6

94. In a finite group, what is true about the order of a conjugacy class ?

(A) It is equal to [G].

(B) It divides [G].

(C) It is greater than [G].

(D) No relation

95. In the symmetric group S_3, how many conjugacy classes are there ?

(A) 3

(B) 4

(C) 6

(D) 2

96. In a molecule with a centre of inversion (i) what happens to a point (x, y, z) ?

(A) It goes to $(-x, -y, -z)$.

(B) It goes to (x, y, z).

(C) It goes to (y, z, x).

(D) It stays the same

97. What is the result of applying two symmetry operations successively ?

(A) Always the identity operation

(B) Never a symmetry operation

(C) Another symmetry operation

(D) Depends on the operation

98. What is the proper rotation (C_n) in symmetry operations ?

(A) Rotation by 180°

(B) Rotation by 360°/n

(C) Reflection through a plane

(D) Inversion through a point

99. What is the symmetry operation that combines rotation and a reflection ?

(A) Proper rotation (C_n)

(B) Improper relation (S_n)

(C) Identity (E)

(D) Inversion (i)

100. What is the point group of benzene (C_6H_6) ?

(A) D_{3h}

(B) C_{6v}

(C) D_{6h}

(D) C_{6h}

(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 (A) ● (C) (D)
Q. 2 (A) (B) ● (D)
Q. 3 (A) ● (C) (D)

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 (A) ● (C) (D)
प्रश्न 2 (A) (B) ● (D)
प्रश्न 3 (A) ● (C) (D)

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 प्रथमतः 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।