

Roll No.

Question Booklet Number

O. M. R. Serial No.

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Question Booklet Number

M. Sc. (Fourth Semester)
(NEP) EXAMINATION, 2025-26
PHYSICS

(Physics of Liquid Crystals) (Elective)

Paper Code						
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Questions Booklet Series
D

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. For a nematic with positive dielectric anisotropy, the director tends to align :
 - (A) Parallel to electric field
 - (B) Perpendicular to electric field
 - (C) At 45° to electric field
 - (D) At -45° to electric field

2. The twist deformation term in Frank free energy is proportional to :
 - (A) $\left(\nabla \cdot \vec{n}\right)^2$
 - (B) $\left(\vec{n} \times \nabla \times \vec{n}\right)^2$
 - (C) $\left(\vec{n} \cdot \nabla \times \vec{n}\right)^2$
 - (D) None of the above

3. Which deformation is represented by $\nabla \cdot \vec{n}$?
 - (A) Twist
 - (B) Bend
 - (C) Splay
 - (D) None of the above

4. The heat capacity near the second-order transition in Landau theory shows :
 - (A) Divergence
 - (B) Finite discontinuity
 - (C) Zero value
 - (D) Exponential increase

5. Presence of the cubic term in I-N transition makes the transition :
 - (A) Second order
 - (B) Weakly first order
 - (C) Continuous
 - (D) Glassy

6. In nematic liquid crystals, the order parameter used in Landau-de Gennes theory is :
 - (A) Scalar density
 - (B) Vector polarization
 - (C) Second-rank traceless tensor
 - (D) Magnetization

7. In Landau theory, the condition for the first order transition is :
 - (A) $b > 0, c > 0$
 - (B) $b < 0, c > 0$
 - (C) $b = 0$
 - (D) $a > 0$

8. β for the order parameter in Landau mean-field theory is :
 - (A) $1/6$
 - (B) $1/4$
 - (C) $1/3$
 - (D) $1/2$

9. If $a = a_0(T - T_c)$, the equilibrium order parameter for $T < T_c$ is :
- (A) $\psi = 0$
- (B) $\psi = -\frac{a}{b}$
- (C) $\psi = \frac{a}{b}$
- (D) $\psi = \sqrt{\frac{-a}{2b}}$
10. For stability, which condition must be satisfied for the Landau free energy expansion for a second-order transition given by $F = F_0 + a\psi^2 + b\psi^4$:
- (A) $a > 0, b < 0$
- (B) $a < 0, b < 0$
- (C) $b > 0$
- (D) $a > 0$ only
11. The basic assumption of Landau theory the free energy near the phase transition can be written a :
- (A) Fourier series of temperature
- (B) Exponential function of entropy
- (C) Logarithmic function of volume
- (D) Power series in order parameter
12. In Landau theory for N-SmA transition, tricritical behaviour occurs when :
- (A) Fourth-order coefficient becomes zero
- (B) Second-order coefficient becomes zero
- (C) Sixth-order term vanishes
- (D) Order parameter becomes unity
13. The primary order parameter for the nematic-smectic A transition is :
- (A) Density
- (B) Magnetization
- (C) One-dimensional translational order
- (D) Polarization
14. According to van der Waals-type treatment of liquid crystals, orientational order arises due to :
- (A) Only Repulsive interaction
- (B) Only dipolar interaction
- (C) Hydrogen bonding
- (D) Balance between attractive and repulsive forces
15. The Maier-Saupe theory predicts the I-N transition to be :
- (A) Second order
- (B) Third order
- (C) First Order
- (D) Continuous without entropy change
16. In Maier-Saupe theory, if the mean-field interaction parameter increases, the clearing temperature :
- (A) Decreases
- (B) Increases
- (C) Remains unchanged
- (D) Increases and then decreases

17. In Maier-Saupe theory, the order parameter at nematic-isotropic transition is :
- (A) $S = 0.21$
 (B) $S = 0.33$
 (C) $S = 0.54$
 (D) $S = 0.43$
18. In Maier-Saupe theory, the interaction potential depends on :
- (A) $\cos \theta$
 (B) $\cos^2 \theta$
 (C) $\sin \theta$
 (D) $\tan \theta$
19. According to Onsager theory, the critical parameter for I-N transition is :
- (A) Temperature
 (B) Volume fraction
 (C) Pressure only
 (D) Molecular polarity
20. In Onsager's hard-rod model, the isotropic-nematic transition is driven by :
- (A) Attractive interaction
 (B) Steric repulsion and excluded volume
 (C) Dipole-dipole interaction
 (D) Hydrogen bonding
21. deGennes generalized the Landau theory to explain :
- (A) First order liquid crystal transition
 (B) Second order liquid crystal transition
 (C) Both (A) and (B)
 (D) None of the above
22. The SmA to nematic phase transition is typically :
- (A) Strongly first order
 (B) Weakly first order or second order
 (C) Always second order
 (D) Glass transition
23. Which theory successfully explains the weakly first-order nature of the N-I transition ?
- (A) Einstein theory
 (B) Landau-de Gennes theory
 (C) Debye-Hückel theory
 (D) Curie-Weiss law
24. At the clearing temperature, the orientational order parameter is :
- (A) 1
 (B) 0.5
 (C) 0
 (D) 0.1

25. The nematic-isotropic (N-I) phase transition is generally :
- (A) First order
 - (B) Second order
 - (C) Third order
 - (D) Glass transition
26. Liquid crystal polymer have :
- (A) High mechanical strength
 - (B) Low melt viscosity
 - (C) Excellent thermal stability
 - (D) All of the above
27. Which of the below system is not an example of lyotropic liquid crystal ?
- (A) Soap and water
 - (B) Salts of fatty acid
 - (C) Suspensions of rod-like viruses
 - (D) Sugar and water
28. The thread-like texture observed in polymeric nematics is called :
- (A) Marble texture
 - (B) Schlieren texture
 - (C) Threaded texture
 - (D) Mosaic texture
29. Polarized light passing through liquid crystal shows change in polarization state due to :
- (A) Refractive index
 - (B) Polarization
 - (C) Optical Anisotropy
 - (D) Viscosity
30. Main-chain polymer liquid crystals have mesogens :
- (A) Attached as side groups
 - (B) In the polymer backbone
 - (C) Dispersed in solvent
 - (D) In cross-linked network only
31. Bent-core liquid crystals has :
- (A) Only nematic phase
 - (B) Ferroelectric switching without chirality
 - (C) Discotic column formation
 - (D) Lyotropic behaviour
32. Bent-core liquid crystals are also called :
- (A) Calamitic LCs
 - (B) Discotic LCs
 - (C) Banana-shaped LCs
 - (D) Lyotropic LCs
33. Charge transport in discotic liquid crystals mainly occurs along :
- (A) Radial direction of disc
 - (B) Between alkyl chains
 - (C) Column axis
 - (D) Layer normal

34. Columnar mesophase is a characteristic feature of :
- (A) Calamatic LCs
 - (B) Discotic LCs
 - (C) Bent-core LCs
 - (D) Polymeric LCs
35. Grandjean texture is associated with :
- (A) SmA phase
 - (B) Nematic phase
 - (C) SmC* phase
 - (D) ChLC Phase
36. Focal conic fan texture is characteristic of :
- (A) Smectic phase
 - (B) Nematic phase
 - (C) Cholesteric phase
 - (D) Columnar phase
37. Schlieren texture is characteristic of :
- (A) Smectic phase
 - (B) Nematic phase
 - (C) Cholesteric phase
 - (D) Columnar phase
38. Monotropic liquid crystals :
- (A) Exist only in lyotropic form
 - (B) Appear only during cooling
 - (C) Appear only during heating
 - (D) Exist at all temperatures
39. In Enantiotropic liquid crystalline :
- (A) Mesophase appears only on cooling
 - (B) Mesophase appears only on heating
 - (C) Mesophase exists in both heating and cooling cycles
 - (D) No isotropic phase exists
40. Polymorphism in liquid crystals means
- (A) Existence of both solid and liquid phases
 - (B) Existence of multiple mesophases in the same compound
 - (C) Optical anisotropy
 - (D) Molecular chirality
41. The Nobel Prize (1991) related to liquid crystals was awarded to :
- (A) Chandrasekhar
 - (B) Pierre-Gilles de Gennes
 - (C) Helfrich
 - (D) Prost
42. Which liquid crystal phase exhibits both orientational order and two-dimensional positional order ?
- (A) Nematic phase
 - (B) Smectic Phase
 - (C) Both (A) and (B)
 - (D) Isotropic

43. Thermotropic liquid crystals depend primarily on :
- (A) Pressure
 - (B) Concentration
 - (C) Temperature
 - (D) Magnetic field
44. Which type of liquid crystal is formed by dissolving amphiphilic molecules in a solvent ?
- (A) Lyotropic
 - (B) Polyotropic
 - (C) Thermotropic
 - (D) Metallotropic
45. Cholesteric liquid crystals are also known as :
- (A) Discotic nematics
 - (B) Lyotropic crystals
 - (C) Chiral nematics
 - (D) Thermotropic smectics
46. In which phase molecules are arranged in layers ?
- (A) Nematic
 - (B) Smectic
 - (C) Cholesteric
 - (D) Blue phase
47. Which phase of liquid crystal shows only orientational order ?
- (A) Smectic
 - (B) Nematic
 - (C) Cholesteric
 - (D) Columnar
48. Who classified liquid crystals into nematic, smectic, and cholesteric phases ?
- (A) Reinitzer
 - (B) Lehmann
 - (C) Friedel
 - (D) Pierre-Gilles de Gennes
49. The term '*liquid crystal*' was coined by :
- (A) Otto Lehmann
 - (B) Georges Friedel
 - (C) Daniel Vorländer
 - (D) Pierre-Gilles de Gennes
50. Liquid crystals were first discovered by :
- (A) Michael Faraday
 - (B) Friedrich Reinitzer
 - (C) Otto Lehmann
 - (D) Georges Friedel

51. Liquid crystals widely used in drug delivery systems are :
- (A) Lyotropic
 - (B) Thermotropic
 - (C) Both (A) and (B)
 - (D) None of the above
52. PDLC has application in :
- (A) Tunable focus lens
 - (B) Laser beam steering
 - (C) Projection display
 - (D) Smart Windows
53. PDLC stands for :
- (A) Polymer Dispersed Liquid Crystal
 - (B) Polymer Diffused Liquid Crystal
 - (C) Polymer Divided Liquid Crystal
 - (D) Polymer Doped Liquid Crystal
54. LC writing tablets consume power only during erasing and not during writing because :
- (A) They operate in emissive mode
 - (B) The device stores charge like a capacitor
 - (C) The LC material has zero anisotropy
 - (D) The written state is optically stable due to bistability
55. The phase of liquid crystal in LC based writing pads is :
- (A) Nematic
 - (B) Cholesteric
 - (C) Smectic
 - (D) None of the above
56. LC droplets used for detecting proteins or DNA rely on :
- (A) Surface-induced configurational transition
 - (B) Increase in conductivity
 - (C) Change in viscosity
 - (D) Change in elastic constant
57. The presence of biomolecules at the LC-aqueous interface generally causes :
- (A) Increase in positional order
 - (B) Transition from isotropic to crystalline phase
 - (C) Distortion of the director field
 - (D) Formation of disclination lines only
58. Liquid crystal phase commonly used in biological sensing applications ?
- (A) Nematic
 - (B) Cholesteric
 - (C) Smectic
 - (D) Discotic

59. Liquid crystals are used in biosensing due to :
- (A) Electrical conduction
 - (B) Interaction with surface molecules
 - (C) Fluorescence
 - (D) None of the above
60. A major advantage of liquid-crystal-based tunable photonic crystals is :
- (A) Fast electro-optic response
 - (B) Low voltage operation
 - (C) Compact device
 - (D) All of the above
61. The central wavelength from a cholesteric liquid crystal is given by :
- (A) $\lambda = n.P/2$
 - (B) $\lambda = n.P$
 - (C) $\lambda = 2n.P$
 - (D) $\lambda = 4n.P$
62. SLMs are widely used in :
- (A) Optical data storage
 - (B) Holography and adaptive optics
 - (C) Nuclear reactors
 - (D) X-ray imaging
63. SLM modulates :
- (A) Phase only
 - (B) Amplitude only
 - (C) Both (A) and (B)
 - (D) None of the above
64. Liquid crystal temperature sensors mainly work due to :
- (A) Phase retardation
 - (B) Plane of polarization
 - (C) Selective reflection
 - (D) Selective transmittance
65. The liquid crystal used in 7-segment displays operates in :
- (A) TN mode
 - (B) IPS mode
 - (C) VA mode
 - (D) ChLC Mode
66. In a 7-segment LCD, each segment is controlled by :
- (A) Separate electrodes
 - (B) Single electrode
 - (C) Seven electrodes
 - (D) Crossed electrodes
67. A 7-segment LCD display is commonly used to display :
- (A) Images
 - (B) Alphabets
 - (C) Numerical digits
 - (D) Colour patterns

68. A nematic liquid crystal switching is based on :
- (A) Electrically controlled birefringence
 - (B) Electrically controlled luminescence
 - (C) Electrically controlled scattering
 - (D) Electrically controlled reflection
69. The contrast in an LCD mainly depends on :
- (A) Molecule size of LC
 - (B) Polarizer and alignment quality
 - (C) Colour filter quality
 - (D) All of the above
70. The advantage of VA displays over other LCDs is :
- (A) Low cost
 - (B) Wide viewing angle
 - (C) High Contrast
 - (D) Fast response
71. The advantage of IPS displays over other LCDs is :
- (A) Low cost
 - (B) Wide viewing angle
 - (C) High Brightness
 - (D) Fast response
72. In normally white mode TN LCDs, the phase difference produced is :
- (A) 0
 - (B) $\pi/4$
 - (C) $\pi/2$
 - (D) π
73. Polarizers in LCD are used for :
- (A) Generation and filtering of polarized light
 - (B) Colour generation
 - (C) Modulation of polarized light
 - (D) All of the above
74. In TN LCD, the angle between the director on the two surfaces is :
- (A) 0°
 - (B) 45°
 - (C) 60°
 - (D) 90°
75. Working principle of a twisted nematic (TN) LCD is based on :
- (A) Scattering
 - (B) Rotation of polarized light
 - (C) Reflection
 - (D) Kerr Effect

76. Nematic order parameter S for perfectly aligned molecules is :
- (A) 0
 (B) $1/2$
 (C) $-1/2$
 (D) 1
77. At the nematic-isotropic transition temperature, the birefringence becomes :
- (A) Maximum
 (B) Non zero Minimum
 (C) Zero
 (D) Infinite
78. The order parameter in nematic liquid crystals is defined as :
- (A) $S = \langle \cos \theta \rangle$
 (B) $S = \frac{1}{2} (3 \langle \cos^2 \theta \rangle - 1)$
 (C) $S = \langle \sin^2 \theta \rangle$
 (D) $S = \langle \tan \theta \rangle$
79. The relation between birefringence and order parameter is :
- (A) $\Delta n \propto 1/S$
 (B) $\Delta n \propto S$
 (C) $\Delta n \propto S^2$
 (D) $\Delta n \propto \sqrt{S}$
80. If the thickness is doubled, the phase retardation becomes :
- (A) Half
 (B) Double
 (C) Same
 (D) Four times
81. The twist elastic constant K_{22} is measured using :
- (A) Planar aligned Cell
 (B) Vertical aligned Cell
 (C) Twisted aligned cell
 (D) All of the above
82. Elastic constants in liquid crystals are the order of :
- (A) 10^{-6} N
 (B) 10^{-8} N
 (C) 10^{-10} N
 (D) 10^{-12} N
83. Polarized light passing through vertical aligned LC cell faces a phase difference of :
- (A) π
 (B) $\pi/2$
 (C) 0
 (D) 2π

84. If the cell thickness is doubled, the relaxation time will :
- (A) remain same
 - (B) double
 - (C) become half
 - (D) become four times
85. The relaxation time after removing the electric field depends on :
- (A) Applied voltage
 - (B) Elastic constant and rotational viscosity
 - (C) Dielectric anisotropy only
 - (D) All of the above
86. The rise time of a nematic liquid crystal primarily depends on :
- (A) Rotational viscosity and applied electric field only
 - (B) Elastic constant only
 - (C) Cell thickness only
 - (D) All of the above
87. Polarized light with polarization plane parallel to LC director passing through perfectly planar aligned LC cell faces a phase difference of :
- (A) π
 - (B) $\frac{\pi}{2}$
 - (C) 0
 - (D) 2π
88. The splay Freedericksz transition in a planar cell is governed by which elastic constant ?
- (A) K_{11}
 - (B) K_{22}
 - (C) K_{33}
 - (D) K_{23}
89. Strong surface anchoring leads to :
- (A) Immediate switching at zero field
 - (B) No Freedericksz transition
 - (C) Lower threshold voltage
 - (D) Higher threshold voltage
90. Homeotropic alignment is obtained when director is :
- (A) Parallel to the substrate
 - (B) Perpendicular to the substrate
 - (C) Tilted at a small angle
 - (D) Helically twisted
91. The backflow effect in nematic liquid crystals refers to :
- (A) Flow caused by temperature gradient
 - (B) Director rotation inducing fluid flow
 - (C) Electric field induced turbulence
 - (D) Density wave propagation

92. The magnitude of elastic constants has the following order :
- (A) $K_{11} > K_{22} > K_{33}$
 (B) $K_{33} > K_{22} > K_{11}$
 (C) $K_{33} > K_{11} > K_{22}$
 (D) $K_{22} > K_{11} > K_{33}$
93. The threshold voltage will increase if :
- (A) Cell thickness increases
 (B) Dielectric anisotropy increases
 (C) Permittivity increases
 (D) Elastic constant increases
94. If the dielectric anisotropy increases, the threshold voltage will :
- (A) Increase
 (B) Decrease
 (C) Remain same
 (D) Be zero
95. Which of the following shows liquid crystallinity ?
- (A) Polyimides
 (B) Surfactants with aliphatic tail
 (C) Surfactants with aromatic tail
 (D) None of the above
96. Vertical alignment of liquid crystals in a cell can be obtained by :
- (A) Polyimides
 (B) Surfactants with aliphatic tail
 (C) Surfactants with aromatic tail
 (D) None of the above
97. Liquid crystal can be aligned in planar configuration in a cell by :
- (A) Polyimides
 (B) Lecithin
 (C) Acetone
 (D) Ethanol
98. Which theory describes the hydrodynamics of nematic liquid crystals ?
- (A) Navier-Stokes theory
 (B) Leslie-Ericksen theory
 (C) Debye theory
 (D) Landau theory
99. The threshold voltage for Freedericksz transition depends on :
- (A) Elastic constant and dielectric anisotropy
 (B) Density only
 (C) Viscosity only
 (D) Order parameter only
100. Optical birefringence in nematic liquid crystals is :
- (A) $n_o - n_e$
 (B) $n_o + n_e$
 (C) n_o/n_e
 (D) $n_o^2 - n_e^2$

(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।