Roll No. .....

Question Booklet Number

O. M. R. Serial No.

M. Sc. (Fourth Semester)

(NEP) EXAMINATION, 2025-26

PHYSICS

(Physics of Nanomaterials) (Elective)

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.

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. Combining TEM, XRD, and Raman spectroscopy for nanomaterials allows comprehensive :
   (A) Transmission, structural and rotational analysis
   (B) Electrical, structural, and vibrational analysis.
   (C) Structural, crystallographic, and chemical analysis
   (D) All of the above

2. Silver nanoparticles exhibit Surface plasmon resonance in :
   (A) Infrared region
   (B) Ultraviolet region
   (C) Visible region
   (D) X-ray region

3. Mean free path in nanomaterials is often :
   (A) Longer than bulk due to fewer defects
   (B) Shorter than bulk due to surface scattering
   (C) Negligible
   (D) Infinite

4. In a quantum well, the motion of electrons is restricted in :
   (A) A line
   (B) A plane
   (C) A cyllinder
   (D) None of the above

5. Optical properties of Nanostructured metals are dominated by :
   (A) Lattice vibrations
   (B) Electron spin only
   (C) Bulk conductivity
   (D) Surface plasmon resonance

6. Semiconductor nanomaterials exhibit size-dependent band gap because :
   (A) Electron effective mass decreases with decreasing size
   (B) Electron density decreases with decreasing size
   (C) Confinement increases energy separation
   (D) Band gap varies linearly with size

7. Gold nanoparticles crystallize in FCC structure with lattice parameter 0.408 nm. What the largest atomic diameter that will fit in tetrahedral void ?
   (A) 0.016 nm
   (B) 0.032 nm
   (C) 0.048 nm
   (D) 0.064 nm

8. 0D nanomaterials include :
   (A) Nanosheets
   (B) Nanowires
   (C) Quantum dots
   (D) Nanofibers

9. Chemical reduction methods are widely used to synthesize :
   (A) Thin films
   (B) Nanoparticles
   (C) Graphene sheets
   (D) All of the above

10. Hydrothermal and Solvo-thermal methods are preferred because :

(A) They allow size-controlled synthesis and low crystallinity

(B) They require ball milling for high crystallinity

(C) They allow shape-controlled synthesis and high crystallinity

(D) They only produce bulk powders for oxides

11. SEM combined with Energy Dispersive X-ray Spectroscopy provides :

(A) Surface roughness and elemental structure

(B) Surface morphology and elemental composition

(C) Elemental ionization and band gap

(D) Optical images with rotational spectra

12. Raman D-band in carbon nanomaterials indicates :

(A) Defects or disorder

(B) Radial breathing

(C) Presence of diamond

(D) Tangential vibrations of carbon atoms

13. AFM can be operated in :

(A) Contact mode

(B) Tapping mode

(C) Non-contact mode

(D) All of the above

14. SEM is limited in resolving :

(A) Surface morphology

(B) Grain size

(C) Atomic scale features

(D) Nanoparticle aggregation

15. Atomic arrangement in nanomaterials can be studied by :

(A) TEM

(B) AFM

(C) STM

(D) All of the above

16. Which microscopy technique provides direct 3D surface topography ?

(A) AFM

(B) TEM

(C) SEM

(D) Optical microscopy

17. Transmission Electron Microscopy can provide :

(A) Surface roughness only

(B) IR absorption in nanoparticles

(C) Internal structure of nano-particles

(D) UV-Vis Transmission range

18. Infrared spectroscopy provides information about :

(A) Atomic lattice spacing

(B) Vibrational modes of bonds

(C) Electron diffraction from bonds

(D) Allowed electronic transitions

19. Crystallinity of nanoparticles affects :

(A) Color of solution only

(B) Magnetic field in semi-conductors

(C) XRD peak sharpness

(D) All of the above

20. X-ray Photoelectron Spectroscopy is used to study :

(A) Surface chemical composition and oxidation states

(B) Particle size and its distribution

(C) Lattice structure and size

(D) Electron microscopy images

21. Nanoparticle size can be determined by :

(A) XRD peak broadening

(B) TEM imaging

(C) Dynamic light scattering

(D) All of the above

22. Broadening of XRD peaks in nanomaterials is due to :

(A) Distribution of particle size only

(B) Small particle size and strain

(C) Magnetic field

(D) Surface roughness only

23. Surface structure at atomic resolution can be analyzed using :

(A) AFM and

(B) STM only

(C) Both (A) and (B)

(D) None of the above

24. Electron diffraction can provide :

(A) Crystallographic information at nanoscale

(B) Electrical conductivity

(C) Chirality of conducting nanotubes

(D) Surface roughness

25. X-Ray diffraction is primarily used to determine :

(A) Optical absorption and particle size

(B) Particle size and elemental composition

(C) Lattice parameter and crystal structure

(D) Magnetic structure

26. Lithography is commonly used in :

(A) Fabricating nanoscale electronic devices

(B) Ball milling

(C) Chemical reduction process

(D) Hydrothermal growth of quantum dots

27. Sol-gel derived nanomaterials are often used as :

(A) Catalysts and sensors

(B) Pallets for laser ablation

(C) Coating materials

(D) All of the above

28. Epitaxial growth requires :

(A) Substrate with compatible lattice structure

(B) Substrate with identical mass

(C) A non-conducting rough substrate

(D) Only vacuum

29. Ball milling can produce nanomaterials by :

(A) Mechanical attrition of powders

(B) Breaking molecules into atoms

(C) Hydrothermal reduction of material

(D) Sol-gel condensation of bulk particles

30. Top-down approaches are suitable for :

(A) OD nanoparticle synthesis only

(B) 2D and 1D nanomaterials

(C) Chemical reduction methods

(D) Hydrothermal synthesis

31. Microwave-assisted synthesis accelerates reactions due to :

(A) Very high vacuum

(B) Fast mechanical grinding

(C) Fast photon-induced etching

(D) Rapid and uniform heating

32. Solvo-thermal synthesis differs from hydrothermal synthesis because :

(A) It is a top-down method

(B) It requires ball milling

(C) It uses organic solvents

(D) It cannot work under heat

33. Etching in nanofabrication is used to :

(A) Remove selected material to create patterns

(B) Deposit metal traces on substrates

(C) Reduce band gap

(D) Decrease particle size

34. Epitaxial growth is mainly used for :

(A) Random nanoparticle formation

(B) Thin films deposition

(C) Same size Nanopowder production

(D) Hydrothermal synthesis

35. Chemical vapor deposition involves :

(A) Evaporation of material in vacuum

(B) Chemical reaction of gaseous precursors on a substrate

(C) Grinding of solids

(D) Laser ablation

36. Which rule determines allowed electronic transitions in a semiconductor ?

(A) Hund's rule

(B) Lande's interval rule.

(C) k-Selection rule

(D) Aufbau principle

37. In metals, electrical conductivity depends primarily on :

(A) Lattice vibrations only

(B) Band gap

(C) Surface roughness only

(D) Electron scattering and density of states at Fermi level

38. Interfaces in semiconductor devices are crucial because they :

(A) Never affect transport

(B) Only affect thermal conductivity

(C) Can introduce traps and recombination centers

(D) Only exist in metals

39. Grain boundaries in polycrystalline materials act as :

(A) Perfect conductors

(B) Barriers to electron transport

(C) No effect on electron motion

(D) Only thermal barriers

40. In classical theory, the variation of average energy of a free electron $< E >$ with temperature T is best described by :

(A) $< E > \propto T$

(B) $< E > \propto (1+T)$

(C) $< E > \propto (1 + T^2)$

(D) $< E > \propto (1+T)^2$

41. Surface states in semiconductors can :

(A) Trap charges and scatter electrons

(B) Increase electron mobility always

(C) Eliminate the band gap

(D) Have no effect on conductivity

42. An interface is :

(A) Edge of a single crystal

(B) Boundary between two different materials or phases

(C) Defect in the crystal

(D) A free surface

43. Term 'Surface Energy' is defined as :

(A) Energy required to remove an electron from the surface

(B) Thermal energy at the surfaces

(C) Energy required to create a unit area of surface

(D) Extra energy of bulk electrons

44. Mobility of electrons in a metal decreases with :

(A) Decreasing temperature

(B) Increasing scattering

(C) Increasing lattice perfection

(D) Decreasing scattering

45. The dominant scattering mechanism in metals at room temperature is :

(A) Electron-phonon scattering

(B) Electron-electron scattering

(C) Electron-magnon scattering

(D) None of the above

46. Diffusive transport occurs due to :

(A) External electric filed

(B) Random scattering with phonons, defects, or impurities

(C) Random scattering of electrons with magnons

(D) Uniform motion of electrons

47. According to band theory, an insulator generally has :

(A) Completely filled valence band and large band gap

(B) Partially filled conduction band

(C) Overlapping valence and conduction bands

(D) Completely empty valence band

48. Density of States (DoS) in a band describes :

(A) Number of atoms per unit volume

(B) Number of conduction electrons only

(C) Number of allowed electronic states per unit energy

(D) Mass density of electrons

49. The Free Electron theory of metals assumes :

(A) Electrons are tightly bound to atoms

(B) Electrons move freely inside the lattice without collisions

(C) Electrons are stationary

(D) Only holes contribute to conduction

50. How many Bravais lattices exist in three dimensions ?

(A) 3

(B) 7

(C) 14

(D) 32

51. A crystal lattice is defined as :

(A) Random arrangement of atoms in three dimensions

(B) Short-range arrangement of molecules

(C) Periodic arrangement of atoms in three dimensions

(D) Disordered arrangement of ions

52. Copper crystallizes in FCC structure with lattice parameter 3.61 Å, the diameter of the largest atom that will fit in octahedral void is :

(A) 0.52 Å

(B) 1.06 Å

(C) 1.6 Å

(D) 2.2 Å

53. In a BCC lattice, in which of the flowing planes there is no Bragg reflection ?

(A) (112)

(B) (202)

(C) (221)

(D) (211)

54. Which of the following has the highest packing factor ?

(A) Diamond cubic

(B) Simple cubic

(C) Body centered cubic

(D) Hexagonal closed packed structure

55. Which of the following crystal structures has least symmetry ?

(A) Tetragonal

(B) Rhombohedral

(C) Triclinic

(D) Monoclinic

56. In a one-dimensional lattice of interatomic separation a, the maximum wavelength of an electron that gets Bragg reflected is :

(A) $a/4$

(B) $a/2$

(C) a

(D) $2a$

57. The energy gap of a crystal which is transparent only to the light of wavelength longer than 510 nm is :

(A) 0.6 eV

(B) 1.2 eV

(C) 2.4 eV

(D) 4.8 eV

58. According to the band theory of solids :

(A) Insulators have overlapping bands

(B) Insulators become semi-conductors at high temperature

(C) Semiconductors have over-lapping band structure

(D) Metals have partially filled or overlapping bands

59. What does Bloch's theorem describe ?

(A) Defect states in solid

(B) Free electron motion

(C) Periodic wavefunctions in solids

(D) Atomic transitions

60. Which one of the following is a naturally occurring nanomaterial ?

(A) Titanium dioxide nanoparticles in sunflowers

(B) Gold nanorods

(C) Carbon nanotubes in circuits

(D) Volcanic ash particles

61. Transmission electron microscopy is used for :

(A) Measuring magnetic field

(B) Imaging of nanoparticles

(C) Measuring transmission from nanostructures

(D) Measuring resistivity of conducting nanotubes

62. Which equation is commonly used to determine crystallite size from XRD peak broadening ?

(A) Scherrer equation

(B) Brag equation

(C) Stokes-Einstein equation

(D) Arrhenius equation

63. In photoluminescence the energy of emitted photon is :

(A) Lower than absorbed photons

(B) Equal to absorbed photons

(C) Higher than absorbed photons

(D) Independent of material

64. Fullerenes are composed of carbon atoms arranged in ..... and ..... .

(A) chains, voids

(B) rings, chains

(C) hexagons, pentagons

(D) hexagons, pentagons and rings

65. Why are nano materials crucial for energy devices ?

(A) They prevent ionic movement

(B) They reduce surface area

(C) They are cheaper than all bulk materials

(D) They increase light absorption conductivity and stability

66. Who discovered carbon nanotubes ?

(A) Richard Feynman

(B) Alexey Ekimov

(C) Sumio Iijima

(D) Gerd Binnig

67. Which hybridization is responsible for flexibility of carbon nanotubes ?

(A) sp

(B) sp^2

(C) sp^3

(D) dsp^2

68. Which structure of carbon nanotube is metallic ?

(A) Zig-zag

(B) Chiral

(C) Armchair

(D) Random

69. In week confinement, the nano particle radius is :

(A) Smaller than Bohr radius

(B) Equal to Bohr radius

(C) Larger than Bohr radius

(D) Irrelevant to excitation motion

70. At absolute zero the Fermi Energy is the energy of :

(A) The lowest occupied state

(B) The highest occupied state

(C) The lowest unoccupied state

(D) A thermally excited state

71. The density of state in a zero dimensional quantum structure is best represented by :

(A) Constant value

(B) Step like function

(C) Dirac Delta functions

(D) None of the above.

72. In hydrothermal analysis reactions are carried out :

(A) At low temperature in vacuum

(B) In the presence of enzymes

(C) With UV radiation

(D) Under high temperature and pressure in aqueous medium

73. Which synthesis method allows deposition of monolayers on a substrate ?

(A) Microemulsion

(B) Evaporation

(C) Melt mixing

(D) Ball milling

74. Why does resistivity increase in nanowires ?

(A) High voltage

(B) Electron- electron interaction

(C) Magnetic scattering

(D) Surface scattering

75. At nanoscale, the lattice constant tends to …….. due to surface …… .

(A) decrease, stress

(B) increase, tensión

(C) remain same, neutrality

(D) vanish, stress

76. What is a primitive cell ?

(A) The shape of the atoms

(B) The unit with most atoms

(C) Smallest repeating unit in a lattice

(D) Largest volume of a crystal

77. Electron confinement occurs when the size of the material is comparable to electrons :

(A) Avogadro length

(B) Energy band separation

(C) Mean free path

(D) de Broglie wavelength

78. What is the key feature of 1D nanomaterial ?

(A) Isotropic behavior

(B) No electrical activity

(C) Anisotropic properties

(D) All of the above

79. The most common method used to fabricate carbon nanotubes is :

(A) Electric-arc discharge

(B) Sol gel method

(C) Solvo-thermal synthesis

(D) None of the above

80. Ultrapure films or particles can be produced by :

(A) Sol gel method

(B) Solvo-thermal synthesis

(C) Physical vapour deposition

(D) None of the above

81. Choose the correct option for technique used in Physical vapour deposition :

(A) Evaporation only

(B) Sputtering only

(C) Ablation only

(D) All of the above

82. Formation of an oxide network through polycondensation reactions of a molecular precursor in a liquid is called :

(A) Sputtering

(B) Chemical vapor deposition

(C) Sol-Gel Process

(D) Metal-organic CVD

83. In Photo assisted CVD the heat input can be in the form of :

(A) RF heating

(B) Arc lamps

(C) Microwave

(D) None of the above

84. As the nano-particle size decreases, surface area to volume ratio :

(A) Increases

(B) Decreases

(C) Remains same

(D) Cannot say

85. Chirality of semiconducting carbon nanotubes can be determined using :

(A) Energy dispersive analysis of X rays

(B) Particle Size Analyzer

(C) Scanning Electron Microscopy

(D) Photoluminescence Spectra

86. Surface morphology up to 0.2 nm can be measured using :

(A) X-ray photoelectron spectroscopy

(B) Scanning Electron Microscopy

(C) Atomic Force Microscopy

(D) None of the above

87. Which of the following is an example of Bottom-up synthesis approach for nanomaterials ?

(A) Chemical vapour deposition

(B) Ball milling

(C) Lithography

(D) None of the above

88. Which is the correct option for the two-dimensional nano structures ?

(A) Diamond

(B) Graphene

(C) Carbon fiber

(D) Gold dot

89. The energy needed to add one negatively charged electron to a quantum dot having capacitance is known as :

(A) Work function

(B) Binding energy

(C) Charging energy

(D) Electron affinity

90. At what diameter (approximately) does a silver particle achieve quantum confinement at 38°C ?

(A) 2 nm

(B) 6 nm

(C) 12 nm

(D) 24 nm

91. A discrete density-of-states function belongs to :

(A) Bulk

(B) Quantum-wire

(C) Quantum-dot

(D) Quantum-well

92. The possible structures of Nanotubes are :

(A) Armchair only

(B) Zig-zag only

(C) Chiral only

(D) All of the above

93. Which of the following is not true for Fullerenes ?

(A) They are the third crystalline form of carbon

(B) They are solids made entirely of carbon

(C) They have a cage structure

(D) None of the above

94. Which of the following describes a one-dimensional structure ?

(A) Graphene

(B) Nanocomposite

(C) Nanowhisker

(D) None of the above

95. Quantum dots follow the quantization of potential wells in :

(A) zero-dimension

(B) one-dimension

(C) two-dimension

(D) three-dimension

96. How many tubes of graphite does single-walled nanotubes consists of ?

(A) 0

(B) 1

(C) 2

(D) 3

97. Which one of the following is an example for top-down approach ?

(A) Ball milling technique

(B) Sol-gel process

(C) Agglomeration

(D) None of the above

98. Which atomic or nanoparticle crystal lattice has the greatest number of nearest neighbors ?

(A) Simple Cubic

(B) BCC

(C) FCC

(D) ZnS (Diamond)

99. Nanomaterials are materials with at least one dimension in the range :

(A) 1-100 μm

(B) 1-100 nm

(C) 100-1000 nm

(D) 1-10 mm

100. Nanotechnology is an interdisciplinary field which combines :

(A) Only physics and biology

(B) Only chemistry and medicine

(C) Physics, chemistry, biology and engineering

(D) Only computer science

(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।