

ENTRANCE EXAMINATIONS, 2016 QUESTION PAPER

Ph. D. (Materials Engineering)

Marks: 75

Time: 2.00 hrs

Hall Ticket no:

- I. Write your Hall Ticket Number on the OMR Answer Sheet given to you. Also write the Hall Ticket Number in the Space provided above.
 - II. Read the following instructions carefully before answering the questions.
 - III. This Question paper has TWO parts: PART 'A' and PART 'B'
1. Part 'A': It consists of 25 objective type questions of one mark each. There is a negative marking of 0.33 marks for every wrong answer. The marks obtained by a candidate in this part will be used for resolving tie cases.
 2. Part 'B': It consists of 50 objective questions of one mark each. There is no negative marking in this part.
 3. All questions are to be answered. Answers for these questions are to be entered on the OMR sheet, filling the appropriate circle against each question. For example, if the answer to a question is (d), it should be marked as below:



No additional sheets will be provided. Rough work can be done in the question paper itself and rough work sheets provided at the end of the booklet.

4. Hand over the OMR answer sheet at the end of the examination to the Invigilator.
5. Calculators are not permitted. Log tables are not allowed. Mobile phones are NOT permitted inside the Examination Hall.
6. This book contains 18 pages including this cover sheet.

PART A

1. The eigenvalues of the matrix $\begin{bmatrix} 1 & 2 \\ 4 & 3 \end{bmatrix}$ are
- A. 2, 1
 - B. 1, 3
 - C. 5, -1
 - D. 4, 3
2. The smallest positive integer 'n' for which $(1+i)^{2n} = (1-i)^{2n}$ is
- A. 2
 - B. 3
 - C. 4
 - D. 8
3. Let $f(x) = \frac{x^3 - 1}{x}$ then $f''(-4)$ is
- A. $\frac{55}{9}$
 - B. $\frac{1}{9}$
 - C. $\frac{65}{32}$
 - D. $\frac{63}{32}$
4. The area of the region that is bounded by the curve $y = \sqrt{x}$, the line $x = 1$ and the x -axis is (in square units)
- A. $\frac{3}{2}$
 - B. $\frac{2}{3}$
 - C. $\frac{1}{2}$
 - D. 1

5. Twenty persons are to sit at a round table. The probability of having a seating arrangement such that four persons can sit in between any two persons A and B is

A. $\frac{4}{19}$

B. $\frac{1}{5}$

C. $\frac{2}{19}$

D. $\frac{1}{20}$

6. The surface of the sun is at a temperature of 6000K and the peak of its emission spectrum occurs at 500 nm. If a body has a surface temperature of 300 K then the peak of its emission spectrum appears at

A. 10000 μ m

B. 10000 nm

C. 1000 nm

D. 1000 μ m

7. If an atom has filled $n = 1$ and $n = 2$ levels, then the number of electrons in the atom are

A. 2

B. 4

C. 8

D. 10

8. A thermodynamic system, initially at absolute temperature T_1 contains a mass ' m ' of water with specific heat capacity ' c '. If heat is added to the system until the temperature rises to T_2 , then the change in entropy of the water is (assuming water is incompressible)

A. $mc \ln \frac{T_2}{T_1}$

B. 0

C. $mc \frac{T_2^2}{T_1}$

D. $mc (T_2 - T_1)$

9. A spring of force constant k is stretched by a distance d by doing work, W . If the work required to stretch another spring by a distance $d/2$ is $2W$, then the force constant of the second spring is

- A. $4k$
- B. $0.5k$
- C. $2k$
- D. $8k$

10. A simple pendulum of length l is suspended from the ceiling of a lift in a tall building. If the lift is accelerating upwards with acceleration ' a ' then the time period, ' T ' for small oscillations of the pendulum is

- A. $T = 2\pi\sqrt{\frac{l}{g+a}}$
- B. $T = 2\pi\sqrt{\frac{l}{g-a}}$
- C. $T = 2\pi\sqrt{\frac{l}{g}}$
- D. $T = 2\pi\sqrt{\frac{l}{a}}$

11. Which one of the following is a one dimensional (1-D) nanomaterial

- A. Nanowire.
- B. Nanoparticle.
- C. Thin film.
- D. Graphene.

12. According to the Madelung energy ordering rule, the electronic configuration of Nickel which is in the first transition series of the periodic table is

- A. $[\text{Ar}]3d^94s^1$
- B. $[\text{Ar}]3d^84s^2$
- C. $[\text{Ar}]3d^{11}4s^1$
- D. $[\text{Ar}]3d^{10}4s^1$

13. Which of the following is known as Lucas Reagent?

- A. Mixture of Anhydrous ZnCl_2 and Concentrated HCl .
- B. Mixture of cold Br_2 and CCl_4 solution.
- C. Concentrated AgNO_3 solution .
- D. Concentrated KMnO_4 solution.

14. A solid is composed of spherical particles of diameter less than 10 nm. The technique that can be used to measure the size of these particles is

- A. X-Ray diffraction.
- B. Transmission Electron Microscopy.
- C. Ultraviolet-Visible spectrometry.
- D. Raman Spectroscopy.

15. Na and Na^+ differ in all of the following, except

- A. Number of electrons.
- B. Number of Protons.
- C. Radius.
- D. Net electronic charge.

16. In a p-type semiconductor the majority charge carriers are

- A. holes.
- B. electrons.
- C. neutrons.
- D. protons.

17. Which of the following materials does not have covalent bonds?

- A. Polymer.
- B. Si.
- C. Cu.
- D. Diamond.

18. A crystalline solid is polymorphic if it

- A. exists in the same crystal structure under all conditions.
- B. exists in different crystal structures depending on temperature.
- C. has atoms distributed in random patterns.
- D. has different microstructures at different temperatures.

19. Bronze is an alloy of the elements,

- A. Cu and Zn.
- B. Cu, Sn and Zn.
- C. Cu and Sn.
- D. Sn and Pb. .

20. The Miller indices for the octahedral plane in a simple cubic crystal are

- A. (100)
- B. (110)
- C. (111)
- D. (211)

21. The number of slip systems for gold are

- A. 15
- B. 12
- C. 6
- D. 3

22. The concentration of CO₂ required for culturing animal cells is
- A. 1-4%
 - B. 5-10%
 - C. 11-15 %
 - D. 18-20%
23. The Southern Blotting technique depends on
- A. Sequences of probe DNA and experimental DNA.
 - B. Similarities between the probe RNA and experimental RNA.
 - C. Similarities between the probe protein and experimental protein.
 - D. The molecular mass of proteins.
24. Formation of mRNA from DNA is called
- A. Transformation.
 - B. Transduction.
 - C. Translation .
 - D. Transcription.
25. If a DNA nucleotide has a sequence AGCTTCGA then the sequence of other chain would be
- A. TCGAAGCT.
 - B. GCTAAGCT.
 - C. TAGCATAT.
 - D. GATCCTAG.

PART B

26. DNA molecules make a complete turn after every
- A. 20 Å
 - B. 34 Å
 - C. 3.4 Å
 - D. 10 base pairs
27. During DNA replication, the reunion or recoiling of separated DNA strands is prevented by
- A. Helix destabilizing protein.
 - B. Single strand binding protein.
 - C. Both (A) and (B).
 - D. Rep protein.
28. The codons which may be present at the 3' end of mRNA is
- A. UAA.
 - B. UAG.
 - C. UGA.
 - D. Any one of these.
29. The site that binds amino acid in tRNA is
- A. 5' end.
 - B. -CCA 3' end.
 - C. DHU loop.
 - D. Anticodon loop.
30. If the DNA sequence is TAG, then the sequence in anticodon of tRNA is
- A. ATG.
 - B. ATC.
 - C. UAG.
 - D. UAC.

31. Monoclonal antibodies are typically made by cell culture that involves fusing
- A. Myeloma cells.
 - B. Hybridoma cells.
 - C. Monocytes.
 - D. Adipocytes .
32. Which one of the following organisms is used for the large scale production of recombinant insulin?
- A. Plasmodium.
 - B. Agrobacterium.
 - C. Rhizobium .
 - D. *E. Coli*.
33. Glucose is added to tissue culture medium as a
- A. Growth regulator.
 - B. Carbon source.
 - C. Nitrogen source
 - D. Solidifying agent.
34. In genetic engineering, a chimera is
- A. an enzyme that links DNA molecules.
 - B. a single organism composed of cells from different zygotes.
 - C. a virus that infects bacteria.
 - D. a fungi.
35. The technique in which charged molecules are separated based on varying rates of migration through a solid matrix when subjected to an electric field is known as
- A. photo-reactivation.
 - B. gel electrophoresis.
 - C. autoradiography.
 - D. electroplating.
36. Using the fermentation process, which of the following can be produced from carbohydrate?
- A. Glucoses.
 - B. Amino acids.
 - C. Proteins.
 - D. Alcohols.

37. Glucose + galactose produces

- A. Cellulose.
- B. Lactose.
- C. Sucrose.
- D. Fructose.

38. According to the Lewis definition, which one is correct?

- A. $F^{(-)}$ (base) + BF_3 (acid) $\rightarrow BF_4^{+1}$
- B. F (acid) + BF_3 (base) $\rightarrow BF_4^{-1}$
- C. $F^{(-)}$ (base) + BF_3 (acid) $\rightarrow BF_4^{-1}$
- D. $F^{(-)}$ (acid) + BF_3 (acid) $\rightarrow BF_4^{-1}$

39. Which one of the structures below corresponds to that for an unsaturated compound?

- A. $CH_3CHCHCH_3$
- B. CH_3CH_3
- C. $CH_3CH_2CH_3$
- D. CH_4

40. The compound that yields H^+ ions as the only positive ions in an aqueous solution is

- A. KOH.
- B. CH_3OH .
- C. NaOH.
- D. CH_3COOH .

41. Which of the following processes can be classified as "Top-down" processes for the fabrication of nano-devices?

- A. Physical vapor deposition.
- B. Chemical vapor deposition.
- C. Lithography and etching.
- D. Sol-gel.

42. In graphene, the type of hybridization of orbitals responsible for bonding in the x-y plane is
- A. sp^2 .
 - B. sp^3 .
 - C. sp .
 - D. Both sp^2 and sp^3 .
43. The "Piranha solution" used in the cleaning of semiconductor wafers involves a mixture of
- A. HF and H_2O_2
 - B. HCl and H_2O_2
 - C. H_2SO_4 and H_2O_2
 - D. HNO_3 and H_2O_2
44. The combination of which of the following contributes to the thermal conductivity of a solid?
- A. Protons and electrons.
 - B. Electrons and phonons.
 - C. Neutrons and electrons.
 - D. Plasmons and phonons.
45. If the band gap of a solid is 10 eV, it is most likely to be a
- A. Insulator.
 - B. Semiconductor.
 - C. Metal.
 - D. Semi metal.
46. Acceptor levels are present in which type of the following semiconductors
- A. n-type.
 - B. p-type.
 - C. Both n and p- type.
 - D. Intrinsic.

47. A modern electronic appliance in which a MEMS device is not found is
- A. Mobile phone.
 - B. Digital light processing display.
 - C. Air conditioner.
 - D. Electrochromic window.
48. The optical band gap of a semiconductor material can be estimated by a measurement of
- A. absorption coefficient.
 - B. photoconductivity.
 - C. scattering coefficient.
 - D. electronic conductivity.
49. An element that can be used as a dopant to produce p-type silicon is
- A. Phosphorous.
 - B. Aluminum.
 - C. Carbon.
 - D. Hydrogen.
50. The D-band peak in the Raman spectrum of graphene is generally attributed to the presence of
- A. Low electron density.
 - B. sp^2 hybridization.
 - C. Disorder.
 - D. Zero band gap.
51. The material which is currently being considered for room temperature thermoelectric applications is
- A. Bismuth Telluride.
 - B. Alumina.
 - C. Silicon carbide.
 - D. Silicon nitride.

52. The wavelength of radiation which can be used to determine crystal structure is of the order of
- A. 1000 microns.
 - B. 0.0001 microns.
 - C. 10 microns.
 - D. 0.01 microns.
53. The *in-situ* growth of carbon nanotubes is not possible by which of the following processes?
- A. Chemical vapor deposition.
 - B. Arc discharge.
 - C. Spin coating.
 - D. Sputtering.
54. A physical method by which n-type doping of a semiconductor material can be carried out is
- A. Annealing with NH_3 gas.
 - B. Chemical reaction with NH_3 .
 - C. Environmental N_2 at room temperature.
 - D. Etching with nitrogen containing gas.
55. If the depth of a surface crack, causing fracture in a brittle material, is increased by a factor of 2, then the fracture strength
- A. decreases by a factor of $\sqrt{2}$.
 - B. decreases by a factor of 2.
 - C. increases by a factor of $\sqrt{2}$.
 - D. does not change.
56. The fraction of pearlite in a 0.55% C steel is
- A. 0.55
 - B. 0.31
 - C. 0.69
 - D. 0.02

57. A dislocation in a metal represents
- A. A weakness of the metal.
 - B. Point defect in the metal.
 - C. Volume defect in the metal.
 - D. Line defect in the metal.
58. In the tensile test of steel, necking starts at a point corresponding to the
- A. lower yield stress.
 - B. upper yield stress.
 - C. ultimate tensile stress.
 - D. onset of fracture.
59. If the lattice parameter of a BCC crystal is ' a ', then its atomic diameter will be
- A. a
 - B. $\frac{a}{2}$
 - C. $a\frac{\sqrt{3}}{4}$
 - D. $a\frac{\sqrt{2}}{4}$
60. Martensitic transformations in steels
- A. are diffusion controlled.
 - B. are shear processes.
 - C. yield products of different compositions.
 - D. yield a hard product in carbon steels.
61. The constituent of steel that is softest and has the lowest strength is
- A. austenite.
 - B. pearlite.
 - C. ferrite.
 - D. cementite.

62. The reaction that yields two solid phases on cooling a single solid phase is

- A. eutectoid.
- B. peritectoid.
- C. eutectic.
- D. congruent .

63. Slow plastic deformation of metal under a constant stress at relatively high temperature is known as

- A. creep.
- B. fatigue.
- C. endurance.
- D. non plastic deformation.

64. The angle between $[111]$ and $[200]$ planes in a cubic crystal is close to

- A. 45°
- B. 30°
- C. 55°
- D. 90°

65. The most desirable method of increasing the yield strength of mild steel is

- A. Grain refinement.
- B. Cold working.
- C. Solute addition.
- D. Precipitation hardening .

66. A tensile load of 50 N is applied on a fibre-reinforced composite of cross-section area 1mm^2 . The stress on the parallel fibers when the load axis is perpendicular to the arrangement of fibres, is

- A. 100 N/mm^2
- B. 121 N/mm^2
- C. 242 N/mm^2
- D. 50 N/mm^2

67. If 'V' is the volume of any arbitrary shaped solid object, then its linear dimension, L will scale as

- A. $V^{1/2}$
- B. V^2
- C. V^3
- D. $V^{1/3}$

68. An electric field 'E' is applied on a metal having electrical conductivity ' σ '. The total energy dissipated per unit volume of the metal is

- A. σE^2
- B. σE
- C. $\sigma^2 E$
- D. $\sigma^2 E^2$

69. According to Gibbs Phase rule, if P= number of phases, C = number of components of chemically independent constituents, then the number of degrees of freedom, F is given by

- A. $F = C + P - 2$
- B. $F = P - C + 2$
- C. $F = C - P + 2$
- D. $F = C - P - 1$

70. If each lattice point of a simple cubic lattice is occupied by a single atom of radius 'r' then the areal density of the (100) plane is proportional to

- A. $\frac{1}{r}$
- B. $\frac{1}{r^2}$
- C. $\frac{1}{r^{1/2}}$
- D. r^2

71. If the minimum kinetic energy of photo electrons emitted from a metal surface is 2 eV, then the stopping potential is

- A. 1 V
- B. 2 V
- C. 3 V
- D. 4V

72. Which of the following is not correct about the properties of non-deionized water?

- A. It has a high molar concentration, so it provides an inexhaustible supply of H⁺ ions.
- B. It has a large dielectric constant that allows ionic substances to dissolve producing charged species.
- C. It has a low dielectric constant.
- D. It has a very small dissociation constant.

73. The resolving power of an optical microscope can be increased by

- A. Decreasing the numerical aperture.
- B. Increasing the wave length of the source.
- C. Increasing the distance between the objective lens and specimen.
- D. Increasing the refractive index of the medium separating the object and aperture.

74. The mean kinetic energy (E) of conduction electrons in metals at room temperature, T is (k = Boltzmann constant)

- A. $E = kT$
- B. $E \ll kT$
- C. $E = \frac{3}{2}kT$
- D. $E = \frac{1}{2}kT$

75. The Maxwell equation that defines Ampere's Law is (H is the magnetic field, D is the displacement current and J is the current density)

A. $\nabla \times \vec{H} = \frac{\partial \vec{D}}{\partial t} - \vec{J}$

B. $\nabla \times \vec{H} = \frac{\partial \vec{D}}{\partial t} + \vec{J}$

C. $\nabla \cdot \vec{H} = 0$

D. $\nabla \cdot \vec{H} = \frac{\partial \vec{D}}{\partial t} + \vec{J}$