X-89

# ENTRANCE EXAMINATIONS, JUNE 2011
# QUESTION PAPER

## Integrated M.Tech./Ph.D. and Ph.D. (Nano Science and Technology)

Marks: 75
Time: 2.00 hrs

Hall Ticket no: [ ]

I. Write your Booklet Code and 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 both the question paper booklet and the OMR answer sheet at the end of the examination.

5. Calculators are 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 force acting on a particle in one dimension is $F = -2x - 6x^3$. The corresponding potential energy $V(x)$, assuming $V(0) = 0$, is

A. $2x^2 - 6x^4$
B. $x^2 + (3/2)x^4$
C. $2x^2 + 6x^4$
D. $-x^2 - (3/2)x^4$

2. The type of atomic bonding most common in typical semiconductors is

A. Metallic
B. Covalent
C. Ionic
D. Hydrogen

3. At Equicohesive temperature

A. Grains are stronger than grain boundaries
B. Grain boundaries are stronger than grains
C. Both grains and grain boundaries are expected to have equal strength
D. All the grains are of equal size

4. In Hall-Petch equation, $\sigma_y=\sigma_i+kd^{-1/2}$, the relative hardening contribution of the grain boundaries is described by:

A. $\sigma_y$ (yield stress)
B. $\sigma_i$ (frictional stress)
C. d, grain diameter
D. k, locking parameter

5. The primary requirement for age-hardening is

A. A decrease in solubility of precipitating phase in the matrix with decrease in temperature
B. An increase in solubility of precipitating phase in the matrix with decrease in temperature
C. A decrease in solubility of the precipitating phase in the matrix with increase in temperature
D. The ability of the coherent precipitates to coarsen rapidly

6. An elemental superconductor is a perfect

A. Diamagnet
B. Ferromagnet
C. Dielectric
D. Paramagnet

7. The concept of "Cottrell atmosphere" is useful in explaining

A. Strain ageing phenomenon
B. Shape memory effect
C. Hall-Petch effect
D. Raman effect

8. Slip begins when the shearing stress on the slip plane in the slip direction reaches a threshold value called

A. Critical resolved shear stress
B. Pierls-Nabarro stress
C. Endurance limit
D. 0.2% offset yield strength

9. It is given that $(\log_2 x)(\log_3 x)(\log_5 x) = (\log_2 x)(\log_3 x) + (\log_3 x)(\log_5 x) + (\log_5 x)(\log_2 x)$ and $x \neq 1$. Then $x$ is

A. 10
B. 30
C. 31
D. 100

10. pH value of a solution containing equal concentrations of hydrogen and hydroxyl ions will be

A. 0
B. 10
C. 7
D. 14

11. Solid $CO_2$ is called "dry ice" because

A. The critical temperature of $CO_2$ is above 25 °C
B. The boiling point of liquid $CO_2$ is above 100 °C
C. At 25 °C and 1 atm, only solid and vapor phases of $CO_2$ are in equilibrium
D. The melting point of liquid $CO_2$ is above 0 °C

12. Determinant of $\begin{pmatrix} 3 & 1 & 2 \\ 1 & 2 & 1 \\ 3 & 1 & 2 \end{pmatrix}$ is

A. 0
B. 1
C. 20
D. -10

13. A method used to produce semiconductor grade material is

A. Floating zone refining
B. Laser ablation
C. Vacuum arc melting
D. Vacuum induction melting

14. Hot working of a metallic material is carried out

A. Above its recrystallization temperature
B. Below its recrystallization temperature
C. At its recrystallization temperature
D. At its melting temperature

15. The ceramic that can be used as a cutting tool

A. Yittria
B. Titania
C. Alumina
D. Magnesia

16. During chain growth polymerization, the molecular weight of the polymer

A. Increases with conversion
B. Decreases with conversion
C. Does not change with conversion
D. First increases and then decreases with conversion

17. $C_{60}$ has

A. 12 pentagons and 18 hexagons
B. 12 pentagons and 20 hexagons
C. 10 pentagons and 20 hexagons
D. 14 pentagons and 18 hexagons

18. Tetragonal phase $ZrO_2$ can be stabilized down to room temperature by adding a small amount of

A. $Y_2O_3$
B. Be
C. La
D. Sn

19. Polygonization is the phenomenon where

A. Dislocations disappear into grain boundaries,
B. Dislocations are generated by the operation of Frank-Read sources
C. Mobile dislocations present in the material are rearranged in cell walls
D. Dislocations form tangles

20. The lowest density in a powder metallurgy product is its

A. Green density
B. Theoretical density
C. Sintered density
D. Smear density

21. Eutectoid reaction is given by:

A. Liquid1↔Solid+Liquid2
B. Liquid1↔Liquid2+Liquid3
C. Liquid1↔Solid1+Solid2
D. Solid1↔Solid2+Solid3

22. A system for specifying crystallographic planes in a unit cell

A. Burgers vector
B. Miller indices
C. Refractive index
D. Covalent bonding

23. A satellite of mass $m$ orbits a planet of mass $M$ in a circular orbit of radius R. The time required for one revolution is

A. Independent of $M$
B. Proportional to $\sqrt{m}$
C. Linear in R
D. Proportional to $R^{3/2}$

24. Gibbs free energy of a gas, expressed as a function of Pressure $P$ and temperature $T$, is given by $G(T,P) = RT\log\left(\frac{P}{P_0}\right) - AP$ where $A$ and $P_0$ are constants. Entropy of the gas is given by

A. $R\log\left(\frac{P}{P_0}\right)$
B. $R\log\left(\frac{P}{P_0}\right) - \frac{AP}{T}$
C. $RT^2\log\left(\frac{P}{P_0}\right) - APT$
D. $-R\log\left(\frac{P}{P_0}\right)$

5. If $(\log_2 x)(\log_3 x)(\log_4 x) = (\log_2 x)(\log_3 x) + (\log_4 x)(\log_2 x)$ and $x \neq 1$, then $x$ is

A. 9
B. 26
C. 24
D. 64

## PART 'B'

26. Fuel cells are based on a principle which is the converse of

A. Oxidation,
B. Electrolysis
C. Photosynthesis
D. None of these

27. Near net-shape components are manufactured by

A. Hot isostatic pressing
B. Hot pressing
C. Activated sintering
D. Hydrostatic extrusion

28. *n*-type semi-conductor is obtained by doping Si with

A. B
B. Al
C. Ga
D. Sb

29. The following is correct in case of nanocrystalline materials with respect to those of conventional grain size

A. The density is high
B. The melting point is high
C. The weight is more
D. The grain boundary specific area is more

30. Cassiterite is an important source of

A. Titanium
B. Tantalum
C. Tungsten
D. Tin

31. Hall-Héroult process is associated with the production of

A. Titanium
B. Aluminium
C. Cadmium
D. Plutonium

32. Graphite flakes are important microstructural feature in

A. Nodular cast iron
B. White cast iron
C. Grey cast iron
D. Hypo-eutectoid steel with 0.7% carbon

33. The concept of entropy is introduced by:

A. Zeroeth law of thermodynamics
B. First law of thermodynamics
C. Second law of thermodynamics
D. Third law of thermodynamics

34. Sensitization in stainless steels is associated with

A. Depletion of Chromium to less than 12% at grain boundaries
B. Depletion of Nickel to less than 8% at grain boundaries
C. Depletion of Carbon to less than 0.2% at grain boundaries
D. Depletion of Titanium to less than 0.5% at grain boundaries

35. The slope of stress-strain curve in the elastic region gives

A. Yield strength
B. Youngs' modulus
C. Toughenss
D. Resilience

36. A powder metallurgy processing route is

A. Mechanical alloying
B. Melt spinning
C. Levitation
D. Short peening

37. Electron back scattered diffraction is a technique based on

A. Optical microscopy
B. Scanning electron microscopy
C. Atomic force microscopy
D. X-ray diffraction

38. Magnetic flux is expressed by

A. Ampere
B. Volts
C. Weber
D. Weber/$m^2$

39. Defects in electronic circuits can be studied by

A. Magnetic particle inspection
B. Thermography
C. Ultrasonic testing
D. Holography

40. The following has the highest Co-efficient of Thermal Expansion

A. Plastics
B. Ceramics
C. Tin
D. Tungsten

41. The limit of resolution of a microscope is given by

A. The wavelength of the radiation
B. Magnifying power of the eyepiece
C. Aperture size
D. Polarization of the radiation

42. Which of the following is a Fermi particle

A. Electron
B. Phonon
C. Photon
D. Poloron

43. Maxwells' equations describe

A. Electromagnetism
B. Kinetic theory
C. Heat transfer
D. Dislocation motion

44. Phase diagram can be used to identify

A. The phase field of different equilibrium phases
B. The composition of different phases
C. Mechanical properties of different phases
D. The phase field of meta-stable phases

45. X-ray diffraction is used for

A. The evaluation of composition of the material
B. Phase identification
C. Chemical state identification
D. The determination of specific gravity of the material

46. Killed steels are

A. Fully de-oxidized
B. Partially de-oxidized
C. De-phosphorized
D. De-sulphurized

47. Atomic resolution can be achieved in

A. Optical microscope
B. Scanning electron microscope
C. Field ion microscope
D. Stereo microscope

48. Electrical conductivity is decided by

A. The electronic structure of the element
B. The atomic number of the element
C. Structure of the nucleus
D. None of the above

49. A metal that will melt if you hold it in your hand is

A. Gallium
B. Sodium
C. Lead solder
D. Indium

50. A quantum dot is a nanomaterial of dimension

A. Four
B. One
C. Zero
D. Two

51. According to Stefan-Boltzmann law, the heat loss is proportional to

A. T
B. $T^2$
C. $T^4$
D. $T^6$

52. "Curie temperature" is a useful concept for

A. A superplastic material
B. Ferro-magnetic material
C. Ferro-elastic material
D. Dielectric material

53. Let $[x]$ denote the largest integer not exceeding $x$. Then the integral

$$\int_0^{1000} dx \exp(-x+[x]) \quad \text{is}$$

A. $\frac{1000(e-1)}{e}$

B. $\frac{\exp(-1000)-1}{1000}$

C. $\frac{\exp(-1000)-1}{e-1}$

D. $\frac{e-1}{1000}$

54. A gas has an equation of state $PV =$ constant. Work done $\Delta W$ is obtained by integrating $-PdV$ between initial $(V_i)$ and final $(V_f)$ values. $\Delta W$ is proportional to

A. $\frac{1}{V_f} - \frac{1}{V_i}$

B. $(V_i V_f)^{1/2}$

C. $\ln\left(\frac{V_i}{V_f}\right)$

D. $\frac{V_i - V_f}{V_i + V_f}$

55. A function $f(x) = x(x-1)$ has

A. A minimum at $x = 1$

B. A maximum at $x = 1$

C. A minimum at $x = \frac{1}{2}$

D. A zero at $x = -1$

56. For materials with uniform grain size distribution, at a magnification of 100X, the ASTM grain size number is derived from

A. Number of grains/cm$^2$

B. Number of grains/inch$^2$

C. Number of grains/mm$^2$

D. Number of grains/nm$^2$

57. The processing method used to produce near net shape products

A. Powder extrusion

B. Directional solidification

C. Hot isostatic pressing

D. Continuous casting

58. The energy of neutrons that cause fission in thermal nuclear reactors is

A. > 0.1 MeV
B. 0.25 eV
C. 25 KeV
D. 14 MeV

59. Among the following types of power stations, which contributes the least to the global warming?

A. A coal-fired power station
B. A gas-fired power station
C. A nuclear power station
D. An oil-fired power station

60. The metallic materials that are widely being used for hip joints in human body

A. Titanium-alloys
B. Mild steel
C. Copper alloys
D. Niobium alloys

61. A material used to make a thermocouple

A. Platinum-(Platinum-Rhodium)
B. Thoria dopped Tungsten
C. Molybdenum Disilicide
D. Super Kanthal

62. At room temperature, the following has the lowest toughness

A. Reinforced plastics
B. Thermoplastics
C. Thermosets
D. Glasses

63. "Buckey balls" are made of

A. $C_{60}$ molecules
B. A metallic glass
C. A polymeric material
D. Superconductors

64. The distortion produced by point defects in lattice is classified as

A. Local
B. Global
C. Surface
D. None of these

65. Dislocations in metals are characterized by

A. Etch-pitting
B. Transmission Electron Microscopy
C. both A and B
D. None of these

66. For a particular crystal structure, the slip plane is that plane having the

A. Dense atomic packing
B. More number of interstitials
C. More number of vacancies
D. Combination of B and C

67. The selection of aerospace materials is based on

A. Low fracture toughness
B. High strength to weight ratio
C. High density
D. Ability to continuously cast the material

68. Presence of super-lattice line/peak in an X-ray diffractogram of a solid indicates the presence of

A. Overaged precipitates
B. Nucleation of precipitates
C. Long rage ordering
D. Immiscibility of alloying elements

69. Short peening is process to introduce

A. Compressive residual stresses in the surface
B. Tensile residual stresses in the surface
C. Compressive residual stresses in the bulk
D. Combination of both B and C

70. Transgranular fracture surface of a sample tested under tensile loading shows

A. Striations
B. Dimples
C. Cleavage facets
D. Wedge cracks

71. The symmetry in quasi-crystals is

A. 3 fold
B. 4 fold
C. 5 fold
D. 6 fold

72. In fiber reinforced materials, the function of fiber is

A. To provide high modulus to the composite
B. To provide high ductility to the composite
C. To reduce the strength of the composite
D. To increase the overall density of the composite

73. Cyaniding treatment enriches the surface of a material with

A. Carbon and Nitrogen
B. Boron and Nitrogen
C. Sulphur and Nitrogen
D. Carbon and Sulphur

74. The following shows high impact energy absorbed in a Charpy V notch teste

A. FCC metals
B. Low strength BCC metals
C. High strength BCC metals
D. HCP metals

75. The following represents condensed phase rule

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