G-95

ENTRANCE EXAMINATIONS, FEBRUARY 2014
QUESTION PAPER

M.Tech./Ph.D.(Materials Engineering)

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 the OMR answer sheet at the end of the examination to the Invigilator.

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.

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PART 'A'

1. Yield stress is a

   A. structure sensitive parameter
   B. structure insensitive parameter
   C. measure of ductility
   D. none of these three

2. As $T \rightarrow 0K$, $C_p \rightarrow$

   A. ∞
   B. 1
   C. 0
   D. 0.5

3. In cgs system of units electronic polarizability has the dimension of

   A. length
   B. volume
   C. area
   D. none

4. Burgers vector of a circular prismatic dislocation loop in fcc structure with lattice parameter a is

   A. 0.5a
   B. a/2[110]
   C. a/3 [111]
   D. zero

5. Nitriding is a process for

   A. annealing
   B. normalizing
   C. case hardening
   D. spheroidizing

6. Frenkel defect is

   A. a pair of two interstitials
   B. a pair of two vacancies
   C. a pair of a vacancy and an interstitial
   D. a pair of two dislocations

7. Metallic glasses are

A. high strength glasses
B. rapidly quenched metals
C. glasses with metallic impurities
D. metals which are in clay for

8. A donor in semiconducting silicon is a dopant of valency

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

9. The upper limit of the wavelength of X-ray radiation that can produce diffraction from the planes with Milles indices (400) of a simple cubic crystal with lattice constant a = 4.4 Angstrom is

A. 2.2 Angstrom
B. 1.1 Angstrom
C. 0.55 Angstrom
D. 4.4 Angstrom

10. The melting point of pure iron under ambient pressure is

A. 1529 K
B. 1529°C
C. 1529°F
D. 1529 R

11. Which of the followings is a first order phase transition?

A. A liquid-gas phase transition at the critical point
B. A paramagnet-ferromagnetic phase transition in zero external magnetic field
C. A normal metal-superconductor phase transition
D. A liquid-gas phase transition away from the critical point

12. German silver is an alloy of

A. silver
B. antimony
C. gallium
D. copper, zinc and nickel

13. What is the 2nd nearest neighbor distance in a FCC lattice with unit cell parameter "a",

A. $a/\sqrt{2}$
B. $a/2$
C. a
D. $\sqrt{2}/a$

14. Crystal structure of the equilibrium phase of one of the following is not FCC

A. Ag
B. Cd
C. Au
D. Cu

15. If "r" is the radius of the atoms and "a" is the lattice parameter of a solid having a cubic structure, which one of the following relations is true for a BCC structure?

A. $a = 2r$
B. $a = 2r\sqrt{2}$
C. $a = 2r\sqrt{3}$
D. $a = 4r/\sqrt{3}$

16. "Cottrell atmosphere" is associated with interstitial

A. hydrogen
B. oxygen
C. carbon
D. argon

17. If *A* stands for the mass number and *C* for the macroscopic absorption cross section, then a good neutron moderator should have

A. low *A* and high *C*
B. high *A* and low *C*
C. high *A* and high *C*
D. low *A* and low C

18. If $D_{surface}$, $D_{grainboundary}$ and $D_{lattice}$ represent the coefficient of diffusion of atoms along external surface, grain boundary and bulk of a material respectively, then one of the following is true

A. $D_{surface} > D_{grainboundary} > D_{lattice}$
B. $D_{surface} < D_{grainboundary} < D_{lattice}$
C. $D_{surface} < D_{grainboundary} > D_{lattice}$
D. $D_{surface} > D_{grainboundary} < D_{lattice}$

19. Solder is made of

A. Pb & Sn
B. Pb & Al
C. Pb & Ag
D. Pb & Cu

20. Si has diamond structure with unit cell parameter a = 5.42Å. The interatomic separation is

A. 1.22 Å
B. 2.35 Å
C. 3.83 Å
D. 5.42 Å

21. For most metals, the strain hardening exponent will have values in the range of

A. 5 – 10
B. 1 – 5
C. 0.1 – 0.5
D. 0.01 -- 0.05

22. The change ΔG in the Gibbs free energy G is related to the change ΔH in enthalpy H and change ΔS in entropy S by the relation $\Delta G=$

A. $\Delta H + S\,\Delta T$
B. $T\Delta S - \Delta H$
C. $\Delta H + T\Delta S$
D. $\Delta H - T\Delta S - S\Delta T$

23. A collection of N two-level systems are in thermal equilibrium with a heat bath. When the temperature of the heat bath approaches infinity, the number of systems in the excited state approaches

A. N/2
B. zero
C. 3N /4
D. N

24. Yield point phenomenon observed in annealed low carbon steel is due to presence of

A. substitutional impurities
B. interstitial impurities
C. vacancies
D. none of the above

25. One of the most deadly poisons, which cannot be traced easily is

A. Iron
B. Cobalt
C. Uranium
D. Polonium

PART 'B'

26. The temperature coefficient of electrical resistivity ($d\rho/dT$) for metals is,

A. Positive
B. Negative
C. Zero
D. None of these

27. One of the following requires least amount of activation energy

A. Homogenous nucleation
B. Heterogeneous nucleation
C. Spinodal decomposition
D. All the above

28. A parallel plate condenser has a capacitance of 2μF. The permittivity of the dielectric is 100 and applied voltage is 1000 V. Find the energy stored in polarizing the dielectric.

A. 1 J
B. 0.01 J
C. 0.99 J
D. 1.01 J

29. Thermal expansion in solids with increasing temperature is a consequence of

A. Pressure of the electron gas
B. Dislocations in the lattice
C. Anharmonicity of the effective interatomic interaction
D. None of the above

30. The Hamiltonian of a collection of N particles $\sum_{i=1}^{3N}(a_j p_j^2 + b_j q_j^2)$ is . Here p_j and q_j denote the momentum and position vectors of particle j, and a_j and b_j are constants. If the particles are subject to laws of classical Physics, the specific heat capacity of the collection is

A. 3Nk
B. 3Nk/2
C. 2 Nk
D. Nk/2

31. Maximum number of phases in a ternary system at constant temperature and pressure is

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

32. The lattice parameters in a crystal are 0.12 nm, 0.18 nm and 0.2 nm. In this crystal, a plane with Miller indices (231) cuts an intercept 0.12 nm along the X-axis. Find the length of the intercept along Y-axis.

A. 0.4 nm
B. 0.18 nm
C. 0.12 nm
D. 0.24 nm

33. The possible values of the total angular momentum J resulting from the addition of two angular momenta $J_1 = 1$ and $J_2 = 2$ are,

A. 1,2
B. 1,3
C. 0,1,2
D. 1,2,3

34. Let S, U, N and V denote respectively the entropy, internal energy, number of particles and volume of a single component system in thermodynamic equilibrium. A possible equation for the entropy of the system is

A. $S = NV/U$
B. $S = UV+N$
C. $S = (UVN)^{1/3}$
D. $S=UNV$

35. Crystal structure is chosen for a periodic arrangement of atoms on the basis that the

A. unit cell has minimum volume
B. unit cell is primitive
C. unit cell exhibits the full symmetry of the structure
D. none of the above

36. An electron has a speed of 4×10^5 m/s, accurate to 0.01% with what fundamental accuracy can the position of the electron can be located? (Given $m_e = 9.1 \times 10^{-31}$kg, Planck constant $h = 6.625 \times 10^{-34}$ Js)

A. 3.64×10^{-5}m
B. 1.82×10^{-5}m
C. 0.91×10^{-5}m
D. 9.1×10^{-5}m

37. While working with the thermodynamics of deformation process occurring at constant T, the following should be considered:

A. Gibbs free energy
B. Helmholtz free energy
C. The ratio of Gibbs and Helmholtz free energies
D. The difference of Gibbs and Helmholtz free energies

38. Solute occupying substitutional sites in a solvent is responsible for

A. precipitation hardening
B. dispersion hardening
C. interstitial hardening
D. none of the above

39. The crystal structure of diamond is

A. Bcc with one atom basis
B. Simple cubic with a basis of two atoms at fractional coordinates (000) and (111)/2
C. Fcc with a basis of two atoms at fractional coordinats (000) and (111)/2
D. FCC with a basis of two atoms at fractional coordinates (000) and (111)/4

40. The chemical potential of a component "i" in a solution containing "n" components is given by

A. $\mu_i = \left(\frac{\partial G}{\partial n_i}\right)$ at constant T, P and $\{n_j\}_{j \neq i}$
B. $\mu_i = \left(\frac{\partial G}{\partial n_i}\right)$ at constant S, P and $\{n_j\}_{j \neq i}$
C. $\mu_i = \left(\frac{\partial G}{\partial n_i}\right)$ at constant T, V and $\{n_{jj \neq i}$
D. $\mu_i = \left(\frac{\partial G}{\partial n_i}\right)$ at constant S, V and $\{n_j\}_{j \neq i}$

41. A particle bounces freely back and forth along the x-axis between impenetrable walls located at $x = -a$ and $x = a$. The potential energy of the particle is zero inside the box (that is, for $|x| < a$). If the energy of the particle is 1/4 eV when it is in its lowest energy state, energy of its first excited state is

A. 8 eV
B. 2 eV
C. 4 eV
D. 1 eV

42. The specific heat of nonmagnetic insulating crystals varies at low temperatures as

A. AT^3
B. $BT+CT^3$
C. $D\exp(E/T)$
D. Remains unchanged with temperature

43. Rails are produced using

A. flat rolls
B. forging
C. section rolls
D. extrusion

44. The earth moves around the Sun in a nearly circular orbit in 365 days. If the Sun were four times as massive as it is now, then for the present Earth-Sun distance, the duration of a year would be approximately

A. 730 days.
B. 258 days.
C. 516days.
D. 182.5 days.

45. Magnetic field of an infinitely long ideal solenoid of radius R carrying current I,

A. increases inside as the radial distance from the axis increases and zero outside the solenoid
B. is constant inside and zero outside the solenoid
C. is constant inside and decays as $1/r$ outside the solenoid
D. is constant inside and decays exponentially outside

46. Deep drawing is the result of

A. uniaxial compression
B. multi-axial tension
C. sheet product being subjected to a changing stress state
D. hammering

47. One of the following is not a strengthening method

A. grain refinement
B. spinodal decomposition
C. precipitation hardening
D. dispersion hardening

48. No IR absorption is seen for nitrogen molecule because,

A. its polarizability is zero
B. it has no vibrational levels
C. it has no rotational levels
D. its dipole moment is zero

49. Squeezing operation involves

A. tension
B. compression
C. torsion
D. tension – compression

50. Isomorphous system is one in which all components are

A. partially soluble in solid, liquid and vapour phase
B. completely soluble in vapour and liquid phase
C. completely soluble only in solid phase
D. completely soluble in solid, liquid and vapour phase

51. Let the wave function of a Hydrogen atom be given by $\psi(\bar{r}) = (\psi_{100} + 2\,\psi_{210})/\sqrt{5}$, where the subscripts correspond to the values of the quantum numbers (nlm). The expectation value of the energy of this system in terms of energy of the lowest eigen state is

A. $0.4\,E_{100}$
B. $0.3\,E_{100}$
C. $2.0\,E_{100}$
D. $0.25\,E_{100}$

52. Is a laboratory at rest on the Earth's surface an inertial frame of reference?

A. No, because it is accelerated as a consequence of the Earth's rotation on its axis and revolution around the Sun
B. Yes, because it is accelerated as a consequence of the Earth's rotation on its axis and revolution around the Sun
C. No, because it is not accelerated as a consequence of the Earth's rotation on its axis and revolution around the Sun
D. Yes, because it is not accelerated as a consequence of the Earth's rotation on its axis and revolution around the Sun

53. The function $f(z) = z/2 + 2/z$ of the complex variable z maps the unit circle centered at the origin to

A. another circle of radius 0.5 centered at the origin
B. another circle of radius 2 units centered at the origin
C. unit circle centered at $z = 2$
D. line segment

54. Average energy per particle of a free electron gas in three dimensions at 0 K is related to the Fermi energy E_F as

A. E_F
B. $1/2\ E_F$
C. $3/5\ E_F$
D. $1/3\ E_F$

55. Dislocations are nucleated by

A. Frank – Nabarro sources
B. Frank – Reed sources
C. Cottrell – Bilby sources
D. Johnston – Gilman sources

56. Solution of the differential equation $dx(t)/dt = x^2$ with the initial condition $x(0)=1$ is

A. $1/(1-t)$
B. t^2
C. $1/(1+t)$
D. $1+t^3/3$

57. Dielectric loss in ferrites is

A. very high
B. very low
C. zero
D. infinity

58. The probability that a state which is 0.2 eV above the Fermi energy is occupied in a metal at 700K is,

A. 96.2%
B. 62.3%
C. 3.5%
D. 37.7%

59. The alloying element that stabilizes austenite (FCC phase) in stainless steels is

A. Chromium
B. Nickel
C. Aliminium
D. Titanium

60. The crystal structure of martensite in steels is

A. tetragonal
B. base centered tetragonal
C. body centered tetragonal
D. face centered tetragonal

61. If the real part of an analytic function is xy, its imaginary part can be

A. $(y^2 - x^2)/2$
B. $(x^2 - y^2)/2$
C. $(y^2 + x^2)/2$
D. $(xy)^2$

62. Magnetization is nonlinearly related to the applied magnetic field in

A. diamagnetic materials
B. paramagnetic materials
C. ferromagnetic materials
D. all of the above

63. A piece of semiconducting material is introduced into a circuit. If the temperature of the material is raised the circuit current will

A. cease to flow
B. decrease
C. remain the same
D. increase

64. Senzimir mills are found in

A. cold rolling plans
B. hot rolling plants
C. extrusion plants
D. pilgering plants

65. The derivative with respect to x of the function x^{2x} is

A. $2\,(1+\log_e(x))\;x^{2x}$
B. $2x\;x^{2x-1}$
C. $2\;x^{2x}$
D. none of the above

66. Maximum velocity of a dislocation in a solid cannot exceed that of

A. light
B. sound
C. a viscous liquid
D. hot water

67. Calculate the no. of atoms per nm^2 surface area are the in (110) plane in FCC Cu with a lattice constant $a = 3.61 \times 10^{-10}m$

A. 21.6 atom/nm^2
B. 43.2 atom/nm^2
C. 10.8 atom/nm^2
D. 5.4 atom/nm^2

68. In simple metals the phonon contribution to the electrical resistivity at temperature T is

A. directly proportional to T above Debye temperature and to T^3 well below it
B. inversely proportional to T for all temperatures
C. independent of T for all temperatures
D. directly proportional to T above Debye temperature and to T^5 well below it

69. Compared to the slab method, the finite element analysis is

A. more accurate
B. less accurate
C. of similar accuracy
D. not useful

70. In a dielectric, the power loss is proportional to the following function of frequency ω

A. ω
B. ω^2
C. $\frac{1}{\omega}$
D. $\frac{1}{\omega^2}$

71. A ferromagnetic material has a Curie temperature of 100K. Then

A. its susceptibility is doubled when it is cooled from 300K to 200K
B. all the atomic magnets in it get oriented in the same direction above 100K
C. the plot of inverse susceptibility versus temperature is linear with a slope T_c
D. the plot of its susceptibility versus temperature is linear with intercept T_c

72. The stress and strain are second order tensors. What is the order of the elastic modulus tensor?

A. 2
B. 0
C. 3
D. 4

73. The partial derivative $\left(\frac{\partial G}{\partial P}\right)$ of the Gibbs free energy with respect to pressure keeping temperature and number densities constant is equal to

A. -S
B. V
C. S
D. -V

74. No. of degrees of freedom for a diatomic gas molecule are

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

75. For a solid, the critical magnetic field in the superconducting state

A. does not depend upon temperature
B. increases as the temperature increases
C. increases as the temperature decreases
D. none of the above