IISc- 2012

Material Science

Q1. Large single crystals from aqueous solutions for laser applications could be grown using which of the following techniques

(a) Float zone (b) Crystal pulling

(c) Zone melting (d) Holden rotating crystallization

Q2. Optical quality *Nd: YAG* single crystals to be used in the design and fabrication of solid state lasers are generally grown from the melts using

(a) Czochralski technique (b) Bridgman-Stockbarger technique

(c) Verneuil technique (d) High temperature solution method

Q3. Zone melting technique is generally employed to obtain high purity materials prior to subjecting to crystal growth process for which the segregation coefficient is

(a) Equal to 1 (b) Less than 1 (c) Greater than 1 (d) Zero

Q4. Verneuil technique is commonly employed to grow ornamental quality single crystals of

(a) $BaTiO_3$ (b) $LiNbO_3$ (c) Ruby (d) All alkali halides

Q5. To establish a flat solid-liquid interface to achieve good growth rate is necessary in which of the following techniques for growth from the melt

(a) Bridgman-Stockbarger technique (b) Czochralski technique

(c) Zone melting technique (d) Float zone technique

Q6. For sensing stresses, one could employ

(a) Dielectrics (b) Metals (c) Polymers (d) Piezoelectrics

Q7. The formation of a solid product from powders is generally achieved by

(a) Adhesion (b) Welding (c) Sintering (d) Cold rolling

Q8. The driving force for sintering is

(a) Reduction in the stored energy of cold work

(b) Reduction in dislocation density

(c) Reduction in the total surface energy

(d) Increase in the reactivity of the material

Q9. Which of the following is least likely to affect solid state reactions between oxides

(a) Thermal conductivity of reactants (b) Oxygen partial pressure

(c) Particle size (d) Temperature

Q10. Which of the following processes is not important for sol-gel synthesis of silica

(a) Condensation (b) Polymerization (c) Hydrolysis (d) Densification

Q11. The crystals belonging to the point group indicated below would exhibit ferroelectric property at room temperature

(a) 4mm (b) 2/m (c) mmm (d) 6/m

Q12. The type of phase transition resulting in the appearance of dipole moments in a ferroelectric phase as a consequence of the spontaneous displacement of of ions in perovskite-based materials is known as

(a) Order-disorder transition (b) Displacive transition

(c) Crystallographic transition (d) Diffusive transition

Q13. The temperature dependence of eigen frequency for transverse optic vibration is called

(a) Short-range interaction (b) Long-range interaction

(c) Local electric field interaction (d) Soft-mode

Q14. It is difficult to remove the remnant polarization in a ferroelectric crystal until the applied electric field

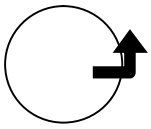
(a) in the opposite direction reaches a certain value

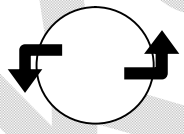
(b) is maintained well within the coercive field

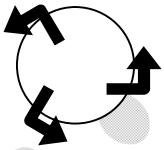
(c) is comparable with that of the internal field

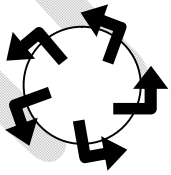
(d) in the same direction reaches a critical value

Q15. Which of the following is not compatible with the requirement of long range translational periodicity in crystals.

(a) 

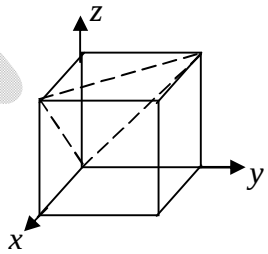
(b) 

(c) 

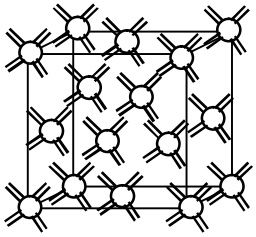
(d) 

Q16. A plane shown by the dashed lines in the figure below can be represented by which of the following set of indices in a cubic system.

(a) (21 21 21) (b) (21 21 $\bar{2}\bar{1}$) (c) (1 1 1) (d) ($\bar{1}$ 1 1)



Q17. The Bravais lattice corresponding to the crystal structure shown below is



(a) diamond cubic

(b) body centered cubic

(c) face centered cubic

(d) simple cubic

Q18. The possible sequences of stacking of close packed planes are

(a) ABABAB only (b) ABCABCABC only

(c) ABCABC and ABABAB only (d) Infinite

Q19. The radii of Cs^+ and Cl^- are 1.70 and 1.81 respectively? The expected coordination of Cl^{-1} would be

(a) 3 (b) 4 (c) 6 (d) 8

Q20. Iron oxide typically exhibits non-stoichiometry that can be expressed as $Fe_{1-x}O$. Which of the following statements is false?

(a) Such non-stoichiometry will be accompanied with a decrease in density

(b) Such non-stoichiometry will be accompanied with a increase in density

(c) Such non-stoichiometry can be looked upon as a solid solution of Fe_2O_3 and FeO

(d) Such non-stoichiometry is accompanied by the formation of holes.

Q21. Amorphous materials crystallize because there is

(a) a reduction in enthalpy and entropy

(b) an increase in enthalpy and entropy

(c) a reduction in enthalpy and an increase in entropy

(d) an increase in enthalpy and a reduction in entropy

Q22. In scanning electron microscopy, topographic studies are best done by using

(a) secondary electron contrast (b) backscattered electron contrast

(c) Auger electron contrast (d) *X*-ray contrast

Q23. Which one of the following reflections will be absent in the *X*-ray diffraction?

(a) 100 (b) 200 (c) 110 (d) 220

Q24. Which one of the following cannot be obtained by *X*-ray diffraction?

(a) Texture (b) Dislocation density

(c) Stress (d) Surface area

Q25. Which one of the following statements regarding a peak in an *X*-ray diffraction pattern is incorrect?

(a) The position of the peak is determined by Bragg's "reflection" law

(b) The position of the peak is determined by the Laue conditions

(c) The peak intensity is not affected by ordering

(d) The peak intensity is affected by ordering

Q26. The incident and diffracted wave vectors are related by

(a) a reciprocal lattice vector

(b) a real lattice vector

(c) a sum of the real and reciprocal lattice vectors

(d) an inverse of the reciprocal lattice vector

Q27. The second derivative of the potential energy versus distance curve at the minima is a measure of the

(a) Elastic modulus of the material

(b) Poisson's ratio of the material

(c) Work hardening coefficient of the material

(d) Lattice parameter of the material

Q28. ZrO_2 is an excellent sensor for oxygen due to its

(a) Low thermal conductivity (b) Good Creep Strength

(c) Oxygen vacancies (d) High adsorption of oxygen

Q29. An oxide material with a stoichiometry of M:O::1:1 can possibly have a

(a) Corundum structure (b) Rutile structure

(c) Fluorite Structure (d) Rocksalt structure

Q30. For a cation to anion radius ratio of 0.25, the likely coordination of the anion around the cation is

(a) Triangular (b) Tetrahedral (c) Octahedral (d) Cuboctahedral

Q31. For a single component system, the maximum number of phases that can coexist is

(a) 1 (b) 2 (c) 3 (d) 4

Q32. Dendritic solidification of a pure metal requires

(a) Constitutional supercooling

(b) Rapid Solidification

(c) Suitable temperature gradient in the liquid phase

(d) Presence of impurities

Q33. A possible unit of diffusion coefficient is

(a) m/s (b) m^2/s (c) mol/s (d) mol/m/s

Q34. Which of the following is NOT a factor for deciding the formation of solid solutions

(a) Difference in melting point (b) Difference in valency

(c) Difference in size (d) Difference in structure

Q35. The equilibrium shape of an FCC crystal

(a) Is made up of only (111) planes

(b) Is made up of only (100) planes

(c) Is made up of both (111) and (100) planes

(d) Is made up of (110) planes

Q36. Which of these test can be used to detect internal cracks in metals

(a) Dye penetration test (b) Ultrasonic test

(c) Atomic Force Microscopy (d) Tensile test

Q37. Which of these statements about edge dislocations is FALSE?

(a) They can cross slip

(b) They can dissociate into partials

(c) The dislocation line is perpendicular to the Burgers vector

(d) They can be visualized in terms of insertion of an extra half plane

Q38. The Hamiltonian of simple harmonic oscillator H, is defined in terms of raising (a^+) and lowering (a) operators as, $H = \left(a^+a + \frac{1}{2}\right)\hbar\omega$ then the value of $\langle 0|aa^+aHa^+aa^+|0\rangle$ is

(a) 0 (b) 3/2 $\hbar\omega$ (c) 5/2 $\hbar\omega$ (d) $\hbar\omega$

Q39. If the momentum operators $\hat{p}_x$ and $\hat{p}_y$ commute, which one of the following statement is not correct

(a) $\hat{p}_x$ can be measured precisely

(b) $\hat{p}_y$ can be measured precisely

(c) $\hat{p}_x$ and $\hat{p}_y$ can not be measured precisely simultaneously

(d) $\hat{p}_x$ and $\hat{p}_y$ can be measured precisely simultaneously

Q40. Which one of the following statement is not true for the density of states (DOS)?

(a) The DOS of a three-dimension electron gas depends on square root of energy

(b) The DOS of a two-dimensional electron gas is independent of energy

(c) The DOS of a one-dimensional electron gas depends on square root of inverse energy

(d) The DOS of a one-dimensional electron gas depends on square root of energy

Q41. The total energy per ion pair of a ionic crystal is given by, $u(r) = -\frac{ae^2}{r} + \frac{C}{r^m}$ where a, e and C are Madelung constant, electronic charge and a constant, respectively. The cohesive energy at the equilibrium ion pair distance r_0 is given by,

(a) $u(r_0) = \frac{ae^2 r_0^{m-1}}{2m}$ (b) $u(r_0) = \frac{ae^2 r_0^{m-1}}{m}$

(c) $u(r_0) = \frac{ae^2 r_0}{2m}$ (d) $u(r_0) = \frac{a^{m-1} e^2 r_0^{m-1}}{m}$

Q42 Phonon spectra of a crystal can be measured by the following experiment

(a) Neutron scattering

(b) Positron annihilation

(c) Angle-resolved photoemission spectroscopy

(d) Nuclear Magnetic Resource (NMR)

Q43. $\psi(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right)$ represents the normalized wave function for a one-dimensional particle-in-a-box of dimension L, the average position of an object $\langle x \rangle$ is

(a) 0 (b) $2L$ (c) $\sqrt{\frac{L}{2}}$ (d) $\frac{L}{2}$

Q44. The electrons have wave functions that are very extended in comparison to the separation between the atoms. This is true for following type of bonding

(a) Covalent (b) Kubas-type

(c) Metallic (d) Van der Waals type

Q45. The eigenvalues of the matrix

$$\begin{bmatrix} 1 & 2 & 0 \\ 2 & -1 & -2 \\ 0 & -2 & 1 \end{bmatrix} \text{ are}$$

(a) 1, 2, 3 (b) 1, -3, 3 (c) 1, -3*i*, 3*i* (d) 3, -*i*, *i*

Q46. Fourier Transform $F(\alpha)$ of a function $f(x) = e^{-ax}$ is

(a) $\frac{a}{\alpha^2 + a^2}$ (b) $\frac{a}{\alpha^2 - a^2}$ (c) $e^{-ia\alpha}$ (d) $e^{ia\alpha}$

Q47. The number of edge dislocations must emerge to produce total 20 microns wide slip steps in the Cr (BCC, atomic radius, R = 0.125 nm):

(a) 8 (b) 800 (c) 8000 (d) 80,000

Q48. The character (edge/screw/mixed) of a line defect with the line $\{\vec{t} = [\bar{1}01]\}$ and Burgers vector $\{\vec{b} = [101]\}$ will be

(a) edge

(b) screw

(c) mixed

(d) cannot be defined with the given information

Q49. If a ductile metal has a tensile strength of 500 MPa, the shear strength of the same metal is expected to be around

(a) 350 MPa (b) 850 MPa (c) 500 MPa (d) 1000 MPa

Q50. A dislocation will glide on a crystal plane with

(a) maximum atomic density and with largest interplanar spacing

(b) minimum atomic density and with largest interplanar spacing

(c) maximum atomic density and with smallest interplanar spacing

(d) minimum atomic density and with smallest interplanar spacing

Q51. An example of the age-hardenable material is

(a) Duralumin (Al-4.5% Cu) (b) Al

(c) Cu-Zn (d) Cu-Sn alloy

Q52. Crazing, as opposed to cracking is observed during tensile loading of

(a) metals (b) ceramics (c) polymers (d) glasses

Q53. Martensite has higher hardness due to

(a) precipitation hardening (b) solid solution hardening

(c) Dispersion hardening (d) age hardening

Q54. The fatigue strength for completely reversed stress cycle i.e. with equal peak stress (both on tension and compression) would be

(a) higher than that of the tensile strength

(b) would be much lower than the tensile strength

(c) would be nearly equal to that of the tensile strength

(d) none of the above

Q55. A low angle grain boundary can be described as the specific arrangement of

(a) edge dislocations

(b) screw dislocations

(c) mixed dislocations

(d) cracks

Q56. Stress and strain are both

(a) scalars (b) vectors

(c) tensors of first order (d) tensors of second order

Q57. The creep of a metal (melting point = T_m) occurs at

(a) $T > 0.5T_m$ (b) $T < 0.5T_m$ (c) $T \sim 0.5T_m$ (d) $T > 0.75T_m$

Q58. Viscoelasticity is observed in

(a) metals (b) ceramics (c) polymers (d) glasses

Q59. Density of a quantum wire depends on the energy (E) as

(a) $\sqrt{E}$ (b) $1/\sqrt{E}$ (c) $\delta(E)$ (d) $E^{3/2}$

Q60. Which one of the property of nanomaterials is governed by Hall-Petch relation?

(a) Mechanical (b) Optical (c) Electronic (d) Magnetic

Q61. Assuming that the effective masses of a material $M1$ is greater than that of another material $M2$ then the change of band gap ΔE_g of nanomaterials of the same conversions is

(a) $\Delta E_g\,(M1) > \Delta E_g\,(M2)$ (b) $\Delta E_g\,(M1) < \Delta E_g\,(M2)$

(c) $\Delta E_g\,(M1) = \Delta E_g\,(M2) \neq 0$ (d) $\Delta E_g\,(M1) = \Delta E_g\,(M2) = 0$

Q62. Which material can be used for infrared (IR) photodetector?

(a) ZnS (b) CdS (c) CdSe (d) HgCdTe

Q63. Which one of the component is not so essential for the synthesis of metal nanoparticles by a chemical route?

(a) metal salts (b) solvents (c) reducing agents (d) stabilizers

Q64. The hybridization that prevails in fullerene is

(a) *sp*2 (b) *sp*3 (c) *sp* (d) *sp*2 and *sp*3

Q65. The correct order of the density of diamond, graphite and carbon nanotube (CNT) is

(a) diamond > graphite > CNTs (b) graphite > diamond > CNTs

(c) CNTs > diamond > graphite (d) diamond > CNTs > graphite

Q66. Typical band gap of semiconducting single walled carbon nanotube is of the order of

(a) 10 eV (b) 1 eV (c) 0.1 eV (d) 0.01 eV

Q67. If the transition temperature of a superconductor is 30 K, then the superconducting energy gap according to BCS theory, is

(a) 2.6 meV (b) 5.2 meV (c) 9.1 meV (d) 26 meV

Q68. A superconductor in the mixed state exhibits

(a) prefect diamagnetism (b) diamagnetism

(c) paramagnetism (d) ferromagnetism

Q69. Which superconductor has the highest value of critical temperature?

(a) Hg (b) Nb_3Sn (c) K_3C_{60} (d) $YB_2Cu_3O_7$

Q70. The atoms that are located at the body centres of the cubic unit cells of the $YB_2Cu_3O_7$ superconductor are

(a) Y (b) Ba (c) Cu (d) O

Q71. Switching times with a Josephson junction are of the order of

(a) 10^{-15} *s* (b) 10^{-2} *ns* (c) 0.1 μs (d) 1 μs

Q72. If one wants to have a transparent material throughout the visible range of the electromagnetic spectrum, the band gap should be

(a) 2 eV (b) 3 eV (c) 1 eV (d) 1.5 eV

Q73. Self-focusing in optical fibers could be achieved by designing the fiber in such a way that

(a) the refractive index at the center of the fiber is greater than at the surface

(b) the refractive index is the same throughout its cross section

(c) the refractive index at the center is smaller than at the surface

(d) the fiber has different thicknesses at different points

Q74. Cubic crystals are optically isotropic because

(a) the lattice parameters are equal

(b) these crystals have four three-fold axes

(c) the refractive index is identical for all vibration directions

(d) these are highly refractive

Q75. When the molecular groups in a material are linear or nearly linear and parallel to each other

(a) birefringence would be negative

(b) birefringence would be zero

(c) no change in the polarization of the light that passes through

(d) birefringence would be positive

Q76. Silicon and Germanium do not transmit visible light while these are excellent infrared windows because of their

(a) semiconducting nature (b) narrow band gaps

(c) high energy band gaps (d) low energy vibration modes

Q77. Materials for far-infrared transmission should posses

(a) large masses and weak bonding (b) light masses

(c) light masses and weak bonding (d) strong bonding

Q78. KCl on irradiation with electrons produces

(a) yellow colour (b) blue colour (c) F-center (d) white light

Q79. Materials belonging to which of the following would exhibit linear electro-optic effect

(a) mm2 (b) mmm (c) 4/m (d) 2/m

Q80. In a He-Ne laser, lasing occurs between the s- and p- levels of neon and produces

(a) two characteristic wavelength

(b) three characteristic wavelength

(c) only one wavelength

(d) yellow light

Q81. The second order non-linear optical susceptibility tensor would have the non-vanishing elements similar to those of

(a) Electro-optic tensor (b) Piezoelectric tensor

(c) Stress tensor (d) Elasto-optic tensor

Q82. To increase the permeability of iron, it is necessary to

(a) Add carbon to it (b) Purify it

(c) Add cobalt to it (d) Add nickel to it

Q83. The Fermi energy of metal is of the order of

(a) 3 eV (b) 30 eV (c) 0.03 eV (d) 0.003 eV

Q84. The Hall coefficient of an elemental metal at two temperatures, T_1 and T_2 is R_1 and R_2, respectively. Given that $T_1 > T_2$ and both are less than 300 K,

(a) $R_1 > R_2$ (b) $R_1 < R_2$ (c) $R_1 >> R_2$ (d) $R_1 = R_2$

Q85. Some metals become superconductors at a sufficiently low temperature. Such a change is an example of a

(a) zeroth order phase transition (b) first order phase transition

(c) second order phase transition (d) metallic glass transition

Q86. Electronic devices can be fabricated using either of the semiconductors, Ge or Si. Given that the bandgap of Ge is 0.67 eV and that Si is 1.1 eV,

(a) the highest possible operating temperature of Si devices is greater than that of Ge devices

(b) the highest possible operating temperature of Ge devices is greater than that of Si devices

(c) the highest operating temperature is the same for both Ge and Si devices

(d) the operating temperature of semiconductor devices is unrelated to the bandgap

Q87. Gray tin crystallizes in the diamond structure, and has a unit cell of edge 0.649 nm. Measurements show that there are 2×10^{25} conduction electrons per m^3 in a sample of gray tin. The fraction of electrons in the sample activated to the conduction electron band is, therefore, approximately

(a) 0.0002 (b) 0.1 (c) 0.025 (d) 0.008

Q88. The superconducting energy gap of indium is about 1 meV. Therefore, we may expect a superconducting sample of indium to absorb electromagnetic radiation in the following part of the spectrum

(a) Radio waves (b) Microwaves (c) Infrared (d) Ultraviolet

Q89. Metals are transparent to:

(a) Radio waves (b) Gamma rays (c) Ultraviolet rays (d) Microwaves

Q90. The functioning of optical fibers depends on

(a) Extraordinary rays of light (b) Total internal reflection of light

(c) The diffraction of light (d) The specular reflection of light

Q91. The following element becomes an antiferromagnet at a sufficiently low temperature

(a) Mn (b) Ni (c) Cu (d) Cr

Q92. The semiconductor used in the fabrication of the CPU of a lap top computer today is

(a) Ge (b) Si (c) GaAs (d) SiC

Q93. The ratio of the resistance of a metal at room temperature (R_1) to its resistance at liquid helium temperature (R_0) is called the residual resistivity ratio, denoted by RRR. That is, RRR = R_1/R_0. When a metal such as copper is made extremely pure, its RRR is

(a) very small (b) approximately equal to 1

(c) approximately equal to 10 (d) much greater than 10

Q94. In an Arrhenius plot for an intrinsic semiconductor, ln(conductivity) is plotted against reciprocal temperature, yielding a straight line, from the slope of which the energy bandgap E_g of the semiconductor can be extracted. The slop of the straight line is

(a) $-(E_g/2k_B)$ (b) $+(E_g/2k_B)$ (c) $+(2E_g/k_B)$ (d) $-(2E_g/k_B)$

Q95. The potential energy of an electron in a *p*-*n* junction is

(a) low on the *n*-side and high on the *p*-side

(b) low on the *p*-side and high on the *n*-side

(c) the same on each side, with a minimum at the junction

(d) the same on each side, with a maximum at the junction

Q96. In 3d transition elements, the "crystal field" due to the charges on neighbouring ions in the solid causes

(a) the spin magnetic moment to become negligible

(b) the spin magnetic moment to be a maximum

(c) the orbital magnetic moment to become negligible

(d) the orbital magnetic moment to become maximum

Q97. Which of these is not a correct definition of polarization?

(a) The net dipole moment per unit volume

(b) The surface charge per unit area

(c) The movement of atoms giving rise to a dipole

(d) The net charge per dipole moment

Q98. The formation of domain in a ferroelectric material is

(a) To reduce the stray field energy

(b) To reduce the dislocation strain energy

(c) To reduce the grain size

(d) To grow the crystals in a regular manner

Q99. The application of a mechanical stress to a piezoelectric does not cause which of these?

(a) The formation of a dipole moment

(b) The movement of atoms

(c) Development of polarization

(d) Generation of an internal current

Q100. Poling of a dielectric causes

(a) Alignment of ferroelectric dipoles to give a net polarization in a piezoelectric

(b) Production of a non-polarized dielectric

(c) Increase in the dipole moment in each unit cell

(d) Production of a pole