

## Material Science-2013

- Q1. What is the value of potential energy  $V$ , in a free electron gas theory of metals?
- (a) A constant (b) Infinite  
(c) It varies with the distance (d) Zero
- Q2. Which one of the following would not cause the broadening in spectral lines?
- (a) Doppler effect  
(b) Heisenberg's uncertainty  
(c) Absorption of electromagnetic radiation  
(d) Collisions
- Q3. If the gap between ground state and excited state energy levels of electrons in an atom is 1 eV. Estimate the wavelength of the light the atom will absorb? The value of the Planck's constant is  $6.6 \times 10^{-34}$  J.S.
- (a) 1nm (b)  $1.24\mu\text{m}$  (c) 1.24 angstrom (d) 1 cm
- Q4. For a particle in a box problem, if the width of the box is doubled, what will happen to the energy of the particle?
- (a) Double the original value  
(b) Zero  
(c) Half the original value  
(d) Quarter the original value
- Q5. Which one of the statements about density of states is not true?
- (a) Variation in the energy dependence of density of states is dimension independent.  
(b) Variation in the energy dependence of density of states in 3D follows  $E^{1/2}$   
(c) Variation in the energy dependence of density of states in 2D follows  $E^0$   
(d) Variation in the energy dependence of density of states in 1D follows  $E^{-1/2}$

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- Q6. Which one of the following is “not true” for commuting operators  $\hat{A}$  and  $\hat{B}$
- (a)  $\hat{A}\hat{B}\Psi = \hat{B}\hat{A}\Psi$       (b)  $[\hat{A}\hat{B} - \hat{B}\hat{A}]\Psi = 0$       (c)  $[\hat{A}\hat{B} - \hat{B}\hat{A}]\Psi \neq 0$       (d)  $[\hat{A}, \hat{B}] = 0$
- Q7. If  $\Psi$  is an eigenfunction of the two operators simultaneously, which one of the following statements is not true.
- (a) The two operators do not commute  
 (b)  $\Psi$  forms a complete orthonormal set  
 (c)  $\Psi$  can always be normalized  
 (d)  $\Psi$  in general be a complex function
- Q8. What is the value of  $[\hat{x}, \hat{p}_x^2]$ ?
- (a)  $-i2\hbar x^2$       (b)  $i2\hbar \hat{p}_x$       (c)  $i2\hbar \hat{p}_x^2$       (d)  $-i2\hbar x$
- Q9. The difference between the subsequent energy levels of a particle a in box follows the following trend as a function of an
- (a)  $n^2$       (b)  $n$       (c)  $2n^2$       (d)  $2n + 1$
- Q10. Find the total work done in moving a particle in a force field given by  $\mathbf{F}$  along the curve C, where  $\vec{F} = (x - y)\mathbf{i} + (x + y)\mathbf{j} + z\mathbf{k}$  and C is given by  $x = t, y = t, z = 2t^2 + 1$ .
- (a) 10      (b) 0      (c) 5      (d) 20
- Q11. Which one of the following is not correct?
- (a)  $\nabla \cdot (\nabla \phi) = \nabla^2 \phi$   
 (b)  $\nabla \times (\nabla \times A) = \nabla(\nabla \cdot A) - \nabla^2 A$   
 (c)  $\nabla \cdot (\nabla \times A) = 0$   
 (d)  $\nabla \times (\nabla \phi) = \phi$

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- Q12.  $\vec{A} = (ax + 3y)\mathbf{i} + (y - 3z)\mathbf{j} + (x - 2z)\mathbf{k}$  is solenoidal, what would be the value of  $a$ ?
- (a) 0                                      (b) 1                                      (c) -2                                      (d) 3
- Q13. If  $y(0) = \log 2$ , the solution of the differential equation  $y' = e^y \sin(x)$
- (a)  $y = -\log(1 - \cos(x))$                                       (b)  $y = (1 + \cos(x))$   
 (c)  $y = \log(1 + \cos(x))$                                       (d)  $y = -\log(1 + \cos(x))$
- Q14. Which of the given function is not analytic?
- (a)  $z^2$                                       (b)  $z^*$                                       (c)  $z$                                       (d)  $z^2 + z$
- Q15. Which one of the following is not true for a hydrogen atom?
- (a) The components of angular momentum do not commute with each other  
 (b) The components of angular momentum commute with the total angular momentum  
 (c) The total energy is independent of principle quantum number  $n$   
 (d) The energy level corresponding to the principal quantum number  $n$  has  $n^2$  fold degeneracy.
- Q16. What is the origin of van der Waals bonding?
- (a) Charge transfer  
 (b) Hydrogen bonding  
 (c) Permanent dipole moment  
 (d) Dynamic correlation among the fluctuating charge density
- Q17. Dauphine twinning in quartz is known as electrical twinning as it alters the
- (a) plezoelectric properties  
 (b) optical properties  
 (c) pyroelectric properties  
 (d) ferroelectric properties

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- Q18. The crystal growth process in which the mole fraction of solvent is greater than the mole fraction of solute is understood to be
- (a) mono component process
  - (b) poly component growth process
  - (c) slow cooling method
  - (d) temperature differential method
- Q19. In horizontal zone- melting technique of growing single crystals from their melts
- (a) the entire material that is held in a boat is uniformly melted
  - (b) the temperature profile is arranged in such way that the dopant gets uniformly distributed over the entire volume of the growing crystal
  - (c) the temperature profile is chosen in such way that only a narrow molten zone is produced
  - (d) the temperature around the boat has to have a step like profile
- Q20. Most metallic single crystals could be pulled at much faster rate than their oxide counterparts using Czochralski technique because of their
- (a) moderate melting points
  - (b) high thermal conductivity
  - (c) high electrical conductivity
  - (d) low viscosity
- Q21. Which one of the following is known as crucible-less technique of growing single crystals from their melts?
- (a) Bridgman-Stockbarger
  - (b) Czochralski
  - (c) Kyropoulos
  - (d) Float-zone

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- Q22. Two photons travelling in the same direction are said to be coherent when
- (a) their phases and wavelengths are the same
  - (b) they are absorbed by an electron
  - (c) their wavelengths are the same
  - (d) their phase are the same
- Q23. Diamond has a broad optical transmission window because it has
- (a) low energy band gap
  - (b) high energy band gap
  - (c) high energy band gap and high energy vibration mode
  - (d) high energy band gap and very low energy vibration mode
- Q24. For a transparent material the ratio of reflected intensity to the incident intensity depends on
- (a) its absorption coefficient
  - (b) its refractive index only
  - (c) its absorption coefficient and transmission coefficients
  - (d) its high transmission coefficient
- Q25. Ferroelectric materials below their Curie temperatures
- (a) do not exhibit pockels effect
  - (b) are good laser hosts
  - (c) exhibit large Linear electro-optic effect
  - (d) exhibit kerr effect of very high magnitude
- Q26. Materials belonging to which one of the following point groups exhibit second order non-linear optical property?
- (a) 2                      (b)  $2/m$                       (c)  $4/m$                       (d)  $6/m$

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- Q27. A Fermi-chopper is used as a monochromator for
- (a) X-ray beam
  - (b) electron beam
  - (c) neutron beam
  - (d) visible light beam
- Q28. Which one of the following diffraction techniques has most surface sensitivity?
- (a) X-ray
  - (b) Electron
  - (c) neutron
  - (d) optical
- Q29. In photomultiplier tube, used for x-ray detection,
- (a) an incident photon generates many photons which are amplified further
  - (b) an incident photon generates many electrons which are directly used for detection
  - (c) an incident photon generates electrons which are further amplified in stages to generate more electrons
  - (d) an incident photon creates many photons and these photons are then used for generating more electrons and so on
- Q30. The inter-planar spacing for (110) plane of monoatomic FCC crystal of lattice constant  $2\text{\AA}$  is
- (a)  $1\text{\AA}$
  - (b)  $2\text{\AA}$
  - (c)  $\sqrt{2}\text{\AA}$
  - (d)  $\sqrt{3}\text{\AA}$
- Q31. Which one of the following diffraction peaks will be absent in a powder diffraction pattern for BCC-crystalline powder such as *Fe*
- (a) (110)
  - (b) (111)
  - (c) (200)
  - (d) (211)

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- Q32. The position of an X-ray diffraction peak may be shifted with respect to the peak of a perfect crystal due to
- (a) homogenous strain
  - (b) inhomogenous strain
  - (c) small unstrained crystallites
  - (d) inhomogenously strained nano-sized crystallites
- Q33. Rayleigh criterion is used to determine
- (a) magnification
  - (b) intensity
  - (c) resolution
  - (d) aberration
- Q34. An X-ray beam having photons of wave vector  $K(|K| = 2\pi/\lambda)$  was scattered as  $K'(|K'| = 2\pi/\lambda)$  making an angle  $2\theta$  with respect to the incident beam. The momentum transfer between the material and the beam is
- (a) 0
  - (b)  $2\pi/\lambda$
  - (c)  $(2\pi/\lambda)\sin\theta$
  - (d)  $(4\pi/\lambda)\sin\theta$
- Q35. Which one of the following is false
- (a) reflection is a surface phenomenon while diffraction is due to scattering from all the atoms in the path of X-rays
  - (b) reflection takes place for all incident angles while diffraction takes place for specific angle known as Bragg angle
  - (c) for a very good flat crystal the reflected intensity is much smaller than the diffracted intensity
  - (d) diffraction depends on inter-planar spacing in the given crystal but not the reflection

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- Q36. For  $Cu - K_\alpha$  radiation the diffraction pattern of  $KCl$  powder will look like a simple cubic structure as  $K^+$  and  $Cl^-$  has same number of electrons. To determine the correct structure one has to do neutron diffraction or repeat the X-ray diffraction experiment by using the
- (a) same  $Cu - K_\alpha$  X-rays
  - (b)  $Mo - K_\alpha$  X-ray
  - (c)  $Fe - K_\alpha$  X-rays
  - (d) X-rays of wavelength close to the  $K$  - absorption edge of  $K$  or  $Cl$
- Q37. The Burgers vector of a screw dislocation in an  $FCC$  crystal is  $1/2[110]$ . The possible line direction for the dislocation is
- (a)  $[110]$
  - (b)  $[011]$
  - (c)  $[101]$
  - (d)  $[111]$
- Q38. Ordered phases (intermetallics) form when the heat of mixing between the components is
- (a) zero
  - (b) highly negative
  - (c) highly positive
  - (d) independent of composition
- Q39. A twist grain boundary is one where the two grains are rotated relative to each other about an axis that is
- (a) perpendicular to the boundary plane
  - (b) in the boundary plane
  - (c) at  $45^\circ$  to the boundary plane
  - (d) along a close packed direction of the crystal

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- Q40. At the melting point of a pure metal
- (a) the number of degrees of freedom is 1
  - (b) the critical size of nucleus is zero
  - (c) there is a finite driving force for solidification
  - (d) the free energies of the solid and liquid phases are equal
- Q41. An eutectic reaction is one where
- (a) a solid phase transforms to two solid phases on cooling
  - (b) a liquid phase transforms to two solid phases on cooling
  - (c) a solid phase transforms to another solid phase on cooling
  - (d) two liquid phases transform to a solid phase on cooling
- Q42. The slope of the plot between  $\log_{10} D$  vs  $1/T$  (where  $D$  is the diffusion coefficient and  $T$  is the absolute temperature) yields the
- (a) activation barrier for diffusion
  - (b) frequency factor for diffusion
  - (c) self-diffusion coefficient
  - (d) driving force for diffusion
- Q43. A Schottky defect in  $Al_2O_3$  involves
- (a) an  $Al^{3+}$  vacancy and an  $Al^{3+}$  interstitial
  - (b) an  $Al^{3+}$  vacancy and an  $O^{2-}$  interstitial
  - (c) an  $Al^{3+}$  vacancy and an  $O^{2-}$  interstitial
  - (d) two  $Al^{3+}$  vacancies and three  $O^{2-}$  vacancies
- Q44. The equilibrium shape of a crystal at 0 K is comprised of facets
- (a) with the lowest surface energy
  - (b) with lowest surface area
  - (c) with rounded edges
  - (d) without highest surface energy

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- Q45. Which one of the following type of dislocations can cross-slip?
- (a) Edge dislocations
  - (b) Screw dislocations
  - (c) Mixed dislocations
  - (d) Sessile dislocations
- Q46. The enthalpy of vacancy formation in copper is 83.7 kJ/mol. The equilibrium concentration of vacancies ( $n_v / n_o$ ) in copper is
- (a)  $10^{-1}$
  - (b)  $10^{-3}$
  - (c)  $10^{-10}$
  - (d)  $10^{-30}$
- Q47. The number of degrees of freedom in a three phase field in a ternary alloy is
- (a) 1
  - (b) 2
  - (c) 3
  - (d) 4
- Q48. A symmetric grain boundary is thermally grooved with a groove angle of  $120^\circ$ . If the surface energy of the material is  $1 J / m^2$ , the grain boundary energy is
- (a)  $1 J / m^2$
  - (b)  $2 J / m^2$
  - (c)  $0.5 J / m^2$
  - (d)  $10 J / m^2$
- Q49. Gold has a melting point of  $1063^\circ C$  and its latent heat of fusion is 12.7 kJ/mol. The entropy change due to freezing of one mole of gold is
- (a) 9.5 J/K
  - (b) -9.5 J/K
  - (c) 11.9 J/K
  - (d) -11.9 J/K
- Q50. Van Hove singularity is not associated with
- (a) vibrational properties of materials
  - (b) electronic properties of materials
  - (c) optical properties of materials
  - (d) magnetic properties of materials

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- Q51. Two-probe resistance measurement technique is usually chosen over-probe technique for measurement of
- (a) very high resistance (~mega-ohm)
  - (b) very low resistance (~milli-ohm)
  - (c) medium resistance (~ohm)
  - (d) resistance associated with superconductors
- Q52. Diamagnetic response of the materials is due to
- (a) orbital motion of the electrons
  - (b) spin of the electrons
  - (c) Fermi-contact interaction
  - (d) defects in the materials
- Q53. The motion of an electron in an electromagnetic field is governed by
- (a) Coulomb Force law
  - (b) Gauss' law
  - (c) Lenz's law
  - (d) Lorentz force law
- Q54. Magnetic shape anisotropy is due to
- (a) demagnetizing field
  - (b) spin-orbit interaction
  - (c) spin motion of the electrons
  - (d) orbital motion of the electrons
- Q55. For the magnetic field measurement, Gauss-meters employ the principle of
- (a) double exchange
  - (b) super exchange
  - (c) Jahn-Teller effect
  - (d) Hall effect

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- Q56. Transformer cores contain materials which are
- (a) soft ferromagnetic having high electrical resistance
  - (b) hard ferromagnetic having high electrical resistance
  - (c) soft ferromagnetic having low electrical resistance
  - (d) hard ferromagnetic having low electrical resistance
- Q57. In computer hard discs the storage medium is
- (a) diamagnetic material
  - (b) ferromagnetic material
  - (c) antiferromagnetic material
  - (d) paramagnetic material
- Q58. The electromagnets may be used to
- (a) increase the linear acceleration of an electron
  - (b) increase the speed of the electron
  - (c) bend the path of the electron
  - (d) decrease the speed of an electron
- Q59. The kinetics of solid-state reaction increases due to increase in the
- (a) diffusion coefficient of ions
  - (b) number of point defects
  - (c) number of line defects
  - (d) vapour pressure of constituents
- Q60. The driving force associated with the sintering of powder compacts is provided by
- (a) an increase in grain size
  - (b) a decrease in porosity
  - (c) a reduction in surface energy
  - (d) a decrease in viscosity

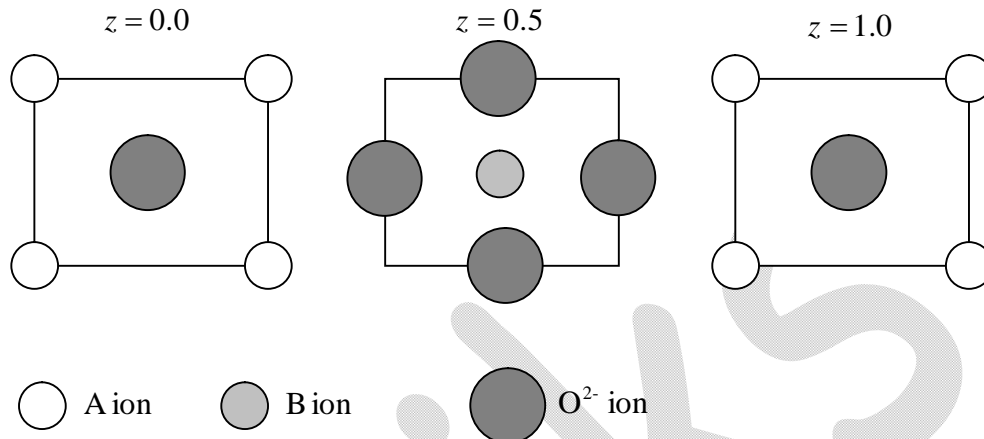
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Q61. In a cubic lattice the position of ions in x-y plane at various z-levels is given below. The general chemical formula of the compound would be



- (a)  $A_8BO_6$                       (b)  $A_2B_2O_7$                       (c)  $ABO_3$                       (d)  $AB_2O_4$

Q62. By using X-ray diffraction one cannot obtain

- (a) crystal structure                      (b) type of bonding  
(c) residual stress                      (d) grain size

Q63. Band gap of a semiconductor nanocrystal (keeping the same lattice structure)

- (a) increases with decreasing size  
(b) decreases with decreasing size  
(c) is same as that of bulk  
(d) is always material dependent

Q64. Measurement of furnace temperature in the RT-2000° C range is based on the principle of

- (a) thermal expansion coefficient                      (b) variation of electrical resistance  
(c) Seebeck effect                      (d) Peltier effect

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- Q65. According to Pilling-Bedworth (P-B) rule the oxide layer of a metal surface forms a passive protective layer if P-B ratio (R)
- (a)  $R = 0$                       (b)  $R < 1$                       (c)  $1 < R < 2$                       (d)  $R > 2$
- Q66. Mg, Zn and Al are used as sacrificial materials for steel pipes because they are
- (a) cathodic with respect to Fe                      (b) anodic with respect to Fe  
(c) more conductive than Fe                      (d) softer than Fe
- Q67. Fiber reinforced plastic (FRP) made of glass fiber and epoxy has superior mechanical toughness due to
- (a) high strength of glass fiber  
(b) high weight of polymeric component  
(c) weak interface between dispersed phase in the matrix  
(d) strong bonding between dispersed phase and the matrix
- Q68. Composite materials are commonly used for Aerospace applications because of their high
- (a) corrosion resistance                      (b) ductility  
(c) Poisson's ratio                      (d) specific strength
- Q69. At what fraction of the melting point of a material, the powder compacts sinter well without undergoing a change in shape?
- (a) 0.66                      (b) 0.50                      (c) 0.25                      (d) 0.75
- Q70. Elastomers are
- (a) thermosetting polymers  
(b) thermoplastic polymers  
(c) linear chain polymers with cross linking  
(d) cis-polymers

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- Q71. A polythelene sample is found to have an average molecular weight of 22400 amu. What is the degree of polymerization?
- (a) 800 (b) 1000  
(c) 2240 (d) 1120
- Q72. A typical semiconductor such as Ge is formed by what kind of bonds?
- (a) Covalent  
(b) Ionic  
(c) van der Waals  
(d) Metallic
- Q73. When a pentavalent impurity is added to Si, it becomes
- (a) an insulator  
(b) a conductor  
(c) an intrinsic semiconductor  
(d) an n-type semiconductor
- Q74. An n-type semiconductor is
- (a) positively charged  
(b) negatively charged  
(c) electrically neutral  
(d) positively charged or negatively charged
- Q75. When a pure semiconductor is heated, its resistance
- (a) increases  
(b) decreases linearly  
(c) decreases exponentially  
(d) remains the same

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- Q76. How many independent ways exists to plastically deform a material?
- (a) 1
  - (b) 2
  - (c) 3
  - (d) 4
- Q77. Which one of the following describes the toughness of a material?
- (a) capability to bear load without fracture
  - (b) crack growth resistance
  - (c) ability to resist crushing under impact loading
  - (d) ability to resist high temperature deformation
- Q78. Fatigue strength of a material is its capability to withstand
- (a) cyclic loading
  - (b) continuous loading
  - (c) sudden applied load
  - (d) its own weight
- Q79. Work hardening is
- (a) generation and movement of dislocations
  - (b) crystallization
  - (c) amorphization
  - (d) cooling
- Q80. Auxetic materials are defined as having Poisson's ratio
- (a) positive
  - (b) negative
  - (c) zero
  - (d) can be any value from positive to negative

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- Q81. What is the meaning of impact and impulse?
- (a) Both are force per time  
(b) Impact is force per time; and impulse is a product of force and time  
(c) Impact is a product of force and time; and impulse is force per time  
(d) Both are product of force and time
- Q82. Ability of a material to absorb energy when it is deformed and release energy upon unloading is known as
- (a) ductility (b) hardness  
(c) resilience (d) Young's modulus
- Q83. Unit of specific strength is same as that of
- (a) pressure (b) force (c) acceleration (d) velocity
- Q84. The transition temperature of a BCS superconductor with an average atomic mass of 199.5 is 4.185 K. What is the transition temperature for an average atomic mass of 203.4?
- (a) 4.185 (b) 4.145 (c) 4.226 (d) 4.105
- Q85. The voltage required to produce 483.6 MHz through a Josephson junction is
- (a)  $1nV$  (b)  $1\mu V$  (c)  $1mV$  (d)  $1V$
- Q86. Structure of  $C_{60}$  fullerite is
- (a) face center cubic (b) body center cubic  
(c) primitive cubic (d) base center cubic
- Q87. Melting temperature of strained nanoparticles having the same structure as that of bulk is
- (a) higher than that of bulk (b) lower than that of bulk  
(c) does not change (d) always  $2/3$  times that of bulk

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- Q88. Anharmonic oscillation of atoms is responsible for
- (a) specific heat (b) thermal conductivity  
(c) thermal expansion (d) elastic modulus
- Q89. Ionic character of a chemical bond depends on
- (a) distance between atoms (b) size of the atoms  
(c) Fermi level of the material (d) electronegativity of the atoms
- Q90. By decreasing the size of a magnetic nano-particle the Curie temperature
- (a) decreases (b) increases  
(c) does not change (d) first decreases then increases
- Q91. Raman effect is suppressed in
- (a) semiconductors (b) dielectrics (c) metals (d) insulators
- Q92. A material transforms from FCC to HCP structure at the temperature  $T$ . Which one of the following is correct?
- (a) FCC phase is highly brittle than HCP phase  
(b) HCP phase is highly brittle than FCC phase  
(c) Both phases have constant brittleness  
(d) Both phases have zero brittleness
- Q93. A radio placed inside a closed aluminium box will
- (a) receive the transmission signal and work as usual  
(b) not receive the transmission signal due to the presence of electron plasma  
(c) not receive the transmission signal due to crystal structure of aluminium  
(d) not receive the transmission signal due to the paramagnetic nature of aluminium

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- Q94. The fraction of electrons excited across the energy gap of 0.7 eV in Ge, at room temperature is
- (a) 0 (b)  $1.4 \times 10^{-6}$   
(c)  $1.6 \times 10^{-8}$  (d)  $1.03 \times 10^{-12}$
- Q95. Which type of diode acts as a voltage-controlled capacitor?
- (a) Schottky diode (b) Zener diode  
(c) Varacter diode (d) Tunnel diode
- Q96. van der Waals interaction in crystals comprising inert gas atoms varies with distance as
- (a)  $1/R^2$  (b)  $1/R^3$  (c)  $1/R^4$  (d)  $1/R^6$
- Q97. In dielectric the value of local electric field that acts at the site of an atom is
- (a) much higher than that of the macroscopic electric field  
(b) lower than that of the macroscopic electric field  
(c) equal to that of the macroscopic electric field  
(d) negative
- Q98. The dipolar polarizability has its origin in molecules associated with permanent electric dipole moment in the materials of the following kind
- (a) NaCl (b) MgO (c) BaTiO<sub>3</sub> (d) Diamond
- Q99. At the transition temperature of a ferroelectric material the free energy of the paraelectric and ferroelectric phases are
- (a) zero (b) equal  
(c) always positive (d) twice that of each phase
- Q100. A contribution to the heat capacity is large in magnetic materials at the temperature at which magnetic moments
- (a) are ordered (b) are disordered  
(c) are antiparallel to each other (d) become zero

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