C : MATERIALS SCIENCE

Useful Data

Avogadro's number	: 6.023×10^{23} mol^{-1}
Boltzmann's constant (k_B)	: 1.38×10^{-23} J K^{-1}
Electron charge (e)	: 1.602×10^{-19} C
Gas Constant	: 8.314 J mol^{-1} K^{-1}
Electron rest mass	: 9.1×10^{-31} kg
Permittivity of vacuum (ε_0)	: 8.854×10^{-12} F m^{-1}
Planck's constant (h)	: 6.626×10^{-34} J s^{-1}
Bohr magneton (μ_B)	: 9.27×10^{-24} Am^2
Free space permeability (μ_0)	: $4\pi\times10^{-7}$ H m^{-1}
1 J = 6.242×10^{18} eV	
1 eV = 1.602×10^{-19} J	
1 cal = 4.2 J	

Q.1 – Q.9 carry one mark each.

Q.1. The number of lattice points in an ideal Perovskite unit cell is NPTEL Reference

(A) 1 (B) 2 (C) 4 (D) 5

Q.2. A Frenkel defect is NPTEL Reference

(A) a pair of cation and anion vacancy
(B) a pair of cation interstitial and cation vacancy
(C) a cation vacancy
(D) an anion vacancy

Q.3. The angle between the line vector of a screw dislocation and the Burgers vector is NPTEL Reference

(A) 0 degree (B) 45 degrees (C) 60 degrees (D) 90 degrees

Q.4. The addition of a network modifier to silica NPTEL Reference

(A) produces vacancies
(B) enhances the network structure
(C) disrupts the network structure
(D) increases the viscosity

Q.5. The best semiconductor material for LED in the visible range is NPTEL Reference

(A) Si (B) Ge (C) GaAs (D) $GaAs_{0.6}P_{0.4}$

Q.6. A plain carbon steel sample is water- quenched from 900°C to room temperature. Its microstructure will consist of NPTEL Reference

(A) pearlite (B) bainite (C) martensite (D) ferrite and pearlite

Q.7. Graphite at zero Kelvin is a

NPTEL Reference

(A) good conductor (B) insulator (C) semiconductor (D) semi-metal

Q.8. A high molecular weight polyethylene has an average molecular weight of 560,000g/mol. Its average degree of polymerization is

NPTEL Reference1

(A) 15,000 (B) 18,660 (C) 19,310 (D) 20,000

NPTEL Reference2

Q.9. In which region of the spectra crystal lattice absorption is very significant

NPTEL Reference

(A) ultraviolet (B) visible (C) microwave (D) infrared

Q.10 – Q.22 carry two marks each.

Q.10. Match the properties in **Column I** with appropriate units in **Column II**

NPTEL Reference1

Column I	**Column II**
P. viscosity	1. m^2s^{-1}
Q. diffusivity	2. $Kg\ mm^{-2}$
R. charge mobility	3. $Nm^{-2}s$
S. fracture toughness	4. $m^2V^{-1}s^{-1}$
	5. $MPa\sqrt{m}$

NPTEL Reference2

NPTEL Reference3

NPTEL Reference4

(A) P-3, Q-4, R-1, S-2 (B) P-4, Q-1, R-2, S-5
(C) P-5, Q-4, R-1, S-2 (D) P-3, Q-1, R-4, S-5

Q.11. Match the terms in **Column I** with the details of phase transformations in **Column II** (→ indicates cooling)

NPTEL Reference1

Column I	**Column II**
P. eutectic	1. $L + \alpha \rightarrow \beta$
Q. monotectic	2. $\gamma \rightarrow \alpha + \beta$
R. eutectoid	3. $L \rightarrow \alpha + \beta$
S. peritectic	4. $\alpha + \beta \rightarrow \gamma$
	5. $L1 \rightarrow \alpha + L2$

NPTEL Reference2

(A) P-1, Q- 5, R- 4, S-3 (B) P- 3, Q- 4, R- 2, S-1
(C) P- 3, Q-5, R- 2, S-1 (D) P- 5, Q- 2, R- 4, S-1

Q.12. Match the following materials in **Column I** with appropriate preparation technique given in **Column II**

NPTEL Reference1

Column I	**Column II**
P. single crystals of laser materials	1. sol-gel
Q. highly dense fine grained ceramics	2. melt spinning
R. nanocrystalline oxide powders	3. Bridgman-Stockbarger
S. metallic glasses	4. hot pressing
	5. Czochralski

NPTEL Reference2

NPTEL Reference3

NPTEL Reference4

(A) P- 5, Q- 4, R- 1, S- 2 (B) P-3, Q- 5, R- 2, S- 1
(C) P- 2, Q- 1, R- 4, S- 5 (D) P-5, Q- 2, R- 1, S- 4

Q.13. Match the statement given in **Column I** with the most suitable material given in **Column II**

NPTEL Reference1

Column I	**Column II**
P. biocompatible ceramic material	1. zinc
Q. magnetic material with very high B-H product	2. titanium
R. nonstick coating on aluminum	3. $Nd_2Fe_{14}B$
S. sacrificial coating on steel	4. $Ca_{10}(PO_4)_6(OH)_2$
	5. $BaFe_{12}O_{19}$
	6. polytetrafluoroethylene
	7. polyethylene terephthalate

NPTEL Reference2

NPTEL Reference3

NPTEL Reference4

(A) P-4, Q- 3, R- 7, S- 2 (B) P - 2, Q- 5, R- 6, S- 1
(C) P- 4, Q- 3, R- 6, S- 1 (D) P - 6, Q- 5, R- 7, S- 6

Q.14. A 99% pure copper wire has resistance of 0.1 Ω at 0.1 K, and 20 Ω at 300 K. For 100% pure, perfect copper wire of the same size, the estimated resistance at 0.1 K and 300 K is

NPTEL Reference

(A) ~ zero and 19.9 Ω (B) ~ zero and 20.1 Ω (C) 0.1 and 19.9 Ω (D) 0.1 and 20.1 Ω

Q.15. A 12.0 mm diameter aluminum alloy test bar is subjected to a load of 110 kN. If the diameter of the bar is 10.5 mm at this load, the true strain will be

NPTEL Reference1

(A) 0.134 (B) 0.306 (C) 0.267 (D) 0.767

Q.16. If the effective magnetic moment of Fe^{3+} is equal to 5 μ_B, the magnetic moment in μ_B per formula of γ- Fe_2O_3 (which is inverse spinel with cation defects on the octahedral site) is

NPTEL Reference2

(A) zero (B) 2.5 (C) 5 (D) 10

NPTEL Reference

Common Data Questions

Common Data for Questions 17 and 18:

A unidirectional carbon fiber epoxy matrix composite contains 60 vol % carbon fibers. The density of carbon fiber is 1790 kg/m^3 and that of the epoxy matrix is 1200kg/m^3. The tensile moduli of the carbon fiber and the epoxy matrix are 340 GPa and 4.50 GPa respectively.

Q.17. The density of the composite in the units of kg/m^3 is

NPTEL Reference

(A) 1495 (B) 1554 (C) 1672 (D) 1790

Q.18. The tensile modulus of elasticity of the composite under iso-strain condition is

NPTEL Reference

(A) 5.5 GPa (B) 11.0 GPa (C) 102.9 GPa (D) 205.8 GPa

Common Data for questions 19 and 20:

For a type II superconductor (at 4 K), the lower critical field (B_{C1}) and thermodynamic critical field (B_C) are respectively 0.001 Tesla and 0.10 Tesla.

Q.19 The upper critical field (B_{C2}) in Tesla is NPTEL Reference

(A) 0.10 (B) 0.33 (C) 1.00 (D) 10.00

Q.20 The maximum energy that can be stored per unit volume (Jm^{-3}) in the superconductor is NPTEL Reference

(A) 3.979×10^3 (B) 50.00×10^3 (C) 7.96×10^3 (D) 1.326×10^3

Linked Answer Questions:

Statement for linked Answer Questions 21 and 22:

For Cu metal, the conduction electron density, $n = 8.45 \times 10^{28}\ m^{-3}$. NPTEL Reference

Q.21 The energy of the electrons at the Fermi level (E_F) is

(A) 3.50 eV (B) 7.028 eV (C) 8.45 eV (D) 49.0 eV

Q.22 The density of states (DOS), for $1cm^3$ of Cu, at Fermi level per meV is NPTEL Reference

(A) 1.20×10^{19} (B) 1.80×10^{19} (C) 1.20×10^{22} (D) 1.81×10^{22}

END OF SECTION – C