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Publisher and Distributor

Engineers Academy Publications

100-102, Ram Nagar, Bambala Puliya, Toll Tax,
Tonk Road, Pratap Nagar, Jaipur (Rajasthan)-302033
E-Mail : engineers.academy.india@gmail.com

ISBN : 978-93-93531-59-9

First Edition	:	**2019**
Second Edition	:	**2020**
Third Edition	:	**2025**

Price : ₹ 300.00

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UNIT-I

MATERIAL SCIENCE

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CHAPTER 1

BASICS OF ENGINEERING MATERIAL

OBJECTIVE QUESTIONS

1. In a Si crystal, the arrangement of atoms repeats periodically, this type of material is classified as
(a) Amorphous and non crystalline
(b) Non crystalline and epitaxial
(c) Amorphous and single crystal
(d) Epitaxial and single crystal

2. When BCC iron is heated, it changes to FCC iron resulting
(a) Increase in volume
(b) Contraction in volume
(c) No Change in volume
(d) Crack in the in material

3. Consider statements related to FCC structure
1. Co-ordination number is 12
2. APF is 0.74
3. There is an atom at the body center of the unit cell.
Which of the following statement are correct
(a) 1 and 2 (b) 2 and 3 (c) 1 and 3 (d) 1, 2, 3

4. Consider statement related diamond structure
1. Co-ordination number is 4
2. Packing efficiency is 34%
3. Crystallizes into diamond structure
Which of the following statement are correct
(a) 1 and 2 (b) 2 and 3 (c) 3 and 1 (d) 1, 2, 3

5. ***Assertion (A)*** : Atomic number of sodium is 11
Reason (R) : Sodium has a body centred cubic lattice
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true, but R is not the correct explanation of A
(c) A is true, but R is false
(d) R is true, but A is false

6. A material has FCC structure with atomic radius 1.06A°. calculate interplanar separation for {1, 1, 0} planes.
(a) 3.12 Å (b) 1.12 Å (c) 2.12 Å (d) 4.13 Å

7. For Rhombohedral structure, the lattice parameters are
(a) $a = b = c, \alpha = \beta = \gamma \neq 90^\circ$
(b) $a = b = c, \alpha = \beta = 90^\circ; \gamma \neq 90^\circ$
(c) $a = b \neq c, \alpha = \beta = 90^\circ ; \gamma = 120^\circ$
(d) $a \neq b \neq c, \alpha = \beta = \gamma = 90^\circ$

8. Read the following statements with respect to Single crystalline materials
1. Periodic and repeated arrangement of atoms is perfect
2. They are not existed naturally, they produced only artificially
3. Electronic micro circuit is made up of single crystalline material
Of the above the correct statements are:
(a) 1, 2 (b) 1, 2 & 3 (c) 1, 3 (d) 2, 3

9. Which of the following statements is/are true for the diamond structure?
1. Coordination number is four.
2. Packing fractions is 0.34
3. Copper crystallizes into diamond structure
4. Lattice is FCC.
(a) 1 only (b) 1, 2 and 4
(c) 2 and 3 (d) 2, 3 and 4

10. Read the following statements with respect to the polymers
1. In polymers, bonds between carbon atoms are double covalent bond
2. Bonds between carbon and hydrogen atoms are single covalent bond
3. Molecules that have double and triple covalent bonds are termed as saturated
4. Molecules that have single covalent bonds are termed as unsaturated
Of the above the correct statements are:
(a) 1, 2 (b) 2, 3 (c) 3, 4 (d) 4, 1

11. Fullerene or bucky ball is made up of carbon atoms.
(a) 100 (b) 20 (c) 75 (d) 60

12. Read the following statements with respect to the Nanomaterial.
1. Volume to surface area ratio is very large for nanomaterials.
2. The cut-off limit of human eye is 10^{-5} m.
3. Hardness of a SWNT is about 63×10^9 Pa.
4. Carbon nano tubes are cylindrical fullerenes
Of the above the correct statements are:
(a) 1, 2, 3 and 4 (b) 2 and 4
(c) 1, 2 and 4 (d) 2, 3 and 4

ANSWERS AND EXPLANATIONS

1. ***Ans. (d)***

2. ***Ans.***

BCC iron

$$a\sqrt{3} = 4r$$

$$r = a\sqrt{3}/4$$

FCC iron

$$a\sqrt{2} = 4r \;;\; a = 2\sqrt{2}r \;;\; r = \frac{a}{2\sqrt{2}}$$

Therefore there is contraction in volume.

3. ***Ans. (a)***

4. ***Ans. (d)***

5. ***Ans. (b)***

6. ***Ans. (c)***

Given data

$$r = 1.06\text{Å}$$

$$[l, m, n] = [1, 1, 0]$$

For FCC : $a\sqrt{2} = 4R$

$$\boxed{a = 2\sqrt{2}r}$$

$$d = \frac{a}{\sqrt{l^2 + m^2 + n^2}}$$

$$= 2r = 2 \times 1.06 \text{ Å}$$

$$= 2.12 \text{ Å}$$

7. ***Ans. (a)***

8. ***Ans. (c)***

9. ***Ans. (b)***

10. ***Ans. (a)***

11. ***Ans. (d)***

12. ***Ans. (d)***

13. ***Ans. (a)***

14. ***Ans. (a)***

15. ***Ans. (c)***

16. ***Ans. (a)***

17. ***Ans. (d)***

18. ***Ans. (a)***

Ionic crystals are hard and brittle.

19. ***Ans. (b)***

20.*(i)* ***Ans.***

∞, b, ∞,
∞, 1, ∞,
0, 1, 0,
[0, 1, 0,]

(ii) ***Ans.***

a, b, ∞,
1, 1, ∞,
1, 1, 0,
[1, 1, 0,]

(iii) ***Ans.***

$-a, \quad \frac{b}{3}, \quad \infty$

$-1, \quad \frac{1}{3}, \quad \infty$

1, 3, 0
[–1, 3, 0]

(iv) ***Ans.***

a, b, c,
1, 1, 1,
1, 1, 1,
[1, 1, 1,]

❑❑❑

CHAPTER 2

DIELECTRIC PROPERTIES OF MATERIAL

OBJECTIVE QUESTIONS

1. The number of atoms in volume of one cubic meter of hydrogen gas is 9.8×10^{26}. The radius of the hydrogen atom is 0.53 Å. Calculate the polarizability and relative permittivity.

(a) 1.66×10^{-35} F-m^2, 1.18

(b) 1.66×10^{-38} F-m^2 , 1.018

(c) 1.66×10^{-41} F-m^2, 1.0018

(d) 1.66×10^{-45} F-m^2, 1.00018

2. The dielectric constant of Helium, measured at 0°C and 1 atmospheric is $\epsilon_r = 1.0000684$. Under these conditions the gas contains 2.7×10^{25} atoms per m^3. Calculate the displacement x when a Helium atom is subjected to a field of 10^6 V/m.

(a) 7.5×10^{-17} m (b) 7.5×10^{-16} m

(c) 7.5×10^{-15} m (d) 7.5×10^{-14} m

3. What is the atomic polarizability of argon? Its susceptibility at 273 K and 1 atmospheric pressure is 4.35×10^{-4}, N = 2.7×10^{25} atom/m^3.

(a) 7.46×10^{-38} Farad m^2 (b) 5.13×10^{-30} Farad m^2

(c) 1.43×10^{-40} Farad m^2 (d) 1.11×10^{-42} Farad m^2

4. Which one of the following is the correct statement? The orientational polarizability in a polyatomic gas is proportional to

(a) Temperature T (b) 1/T

(c) T^2 (d) Independent of T

5. Match List-I (Polarization process) with List-II (Approximate frequency) and select the correct answer using the codes given below the lists :

	List-I		List-II
A.	Electronic polarization	**1.**	10^2 Hz
B.	Ionic polarization	**2.**	10^2 Hz
C.	Orientational polarization	**3.**	10^{13} Hz
D.	Space-charge polarization	**4.**	10^{15} Hz

Codes :	**A**	**B**	**C**	**D**
(a)	1	2	3	4
(b)	4	3	2	1
(c)	1	3	2	4
(d)	4	2	3	1

6. A long narrow rod has an atomic density 5×10^{28} atoms/m^3. Each atom has a polarizability of 10^{-40} farad m^2 each. Find the internal electric field when an axial field of 1 V/m is applied.

(a) 1.55 V/m(b) 2.23 V/m(c) 1.23 V/m(d) 3.23 V/m

7. The following data refers to a dielectric material $\epsilon_r = 4.94$, $n^2 = 2.69$, where n is the index of refraction. Calculate the ratio between electronic and ionic polarizabilities for this material.

(a) 1.736 (b) 2.736 (c) 0.736 (d) 3.736

8. On the application of the field $\bar{E}$, the modified field due to polarization P in solids and liquids having cubic symmetry is given by

(a) $\bar{E} + \frac{\bar{P}}{\epsilon_0}$ (b) $\bar{E} - \frac{\bar{P}}{\epsilon_0}$ (c) $\bar{E} + \frac{\bar{P}}{3\epsilon_0}$ (d) $\bar{E} - \frac{\bar{P}}{3\epsilon_0}$

9. Match List-I (Insulating Material) with List-II (Application) and select the correct answer using the codes given below:

	List-I		List-II
A.	Steatite	**1.**	Ceramic capacitor
B.	Rutile (Titaniumdioxide)	**2.**	Piezoelectric application
C.	Barium titanate	**3.**	Insulating materials for machine windings
D.	Teflon	**4.**	High frequency insulator

Codes :	**A**	**B**	**C**	**D**
(a)	4	3	2	1
(b)	2	1	4	3
(c)	4	1	2	3
(d)	2	3	4	1

10. The following properties are associated with ferroelectric materials :

1. Its susceptibility is negative.

2. The susceptibility is expressed as

$$\chi = \frac{C}{T - T_c}$$

where C = Curie constant and T_c = Curie temperature.

3. It has permanent dipoles oriented randomly.

Which of the above statements is/are correct?

(a) 1 only (b) 1 and 3 (c) 2 only (d) 1, 2 and 3

11. A dielectric material has the real part of the dielectric constant (ϵ_r') as 4 and its loss tangent is 0.004. What is the complex dielectric constant (ϵ_r^*) represented by?

(a) 4 + j0.016 (b) 4 – j0.016

(c) 4 + j0.001 (d) 4 – j0.001

12. A solid specimen of dielectric has relative permittivity ϵ_r = 4.2 and loss angle tan δ = 0.001 at 50 Hz frequency. If it is subjected to an electrical stress of 50 kV/cm, what is the heat generated in the specimen due to dielectric loss?

(a) 291 W/cm^3 (b) 5.82 mW/cm^3

(c) 19.5 W/cm^3 (d) 0.291 mW/cm^3

13. A solid specimen of dielectric has a dielectric constant of 4.8, and tan δ = 0.001 at a frequency of 50 Hz. If it is subjected to an alternating field of 60 kV/cm. Calculate the heat generated in the specimen due to dielectric loss.

(a) 1.480 mW/cm^3 (b) 2.480 mW/cm^3

(c) 3.480 mW/cm^3 (d) 0.480 mW/cm^3

14. For an applied voltage V(t) = V_0 cos ωt, the current through the lossy condenser is given by

(a) $(\varepsilon_0\varepsilon_r'' \omega V_0)$ cos ωt + $(\varepsilon_0\varepsilon_r' V_0\omega)$ sin ωt

(b) $(\varepsilon_0\varepsilon_r'' \omega V_0)$ cos ωt – $(\varepsilon_0\varepsilon_r' V_0\omega)$ sin ωt

(c) $(\varepsilon_0\varepsilon_r'' \omega V_0)$ sin ωt – $(\varepsilon_0\varepsilon_r' V_0\omega)$ cos ωt

(d) $(\varepsilon_0\varepsilon_r'' \omega V_0)$ sin ωt + $(\varepsilon_0\varepsilon_r' V_0\omega)$ cos ωt

15. A solid contains 5×10^{26} identical atoms per m^3, each with a polarisability of 2×10^{-40} Fm^2. Calculate the ratio of internal field to applied field (Assume Lorentz Law).

(a) 2.003 (b) 0.003 (c) 1.003 (d) 3.003

16. A parallel plate condenser has an area of 10 cm^2 and a separation of 0.1 mm. Polyethylene is used as dielectric. An AC voltage of frequency 1 MHz and amplitude = 2 volts, is applied to the condenser. Real part of ε'_r = 2.25 and loss tangent tan $\delta = 4 \times 10^{-4}$. Calculate the energy dissipated per second and find the elements of equivalent parallel RC such that R = X_C.

(a) 10^{-7} J/s, 10 MΩ (b) 10^{-7} J/s, 20 MΩ

(c) 10^{-6} J/s, 20 MΩ (d) 10^{-6} J/s, 10 MΩ

Linked Questions 17 & 18

An electrolytic condenser consisting of an oxidised aluminium sheet with an effective surface area of 400 cm^2, has a capacitance = 8 mF.

17. What is the field strength if ε_r = 8 and potential difference = 10V between A_1 and the electrolyte?

(a) 2.8×10^7 V/m (b) 2.8×10^6 V/m

(c) 2.8×10^8 V/m (d) 2.8×10^5 V/m

18. Calculate the total dipole moment P induced in the oxide layer and its susceptibility χ.

(a) 1.5×10^{-11}, 0.1×10^{-7}

(b) 2.5×10^{-11}, 0.1×10^{-8}

(c) 3.5×10^{-11}, 0.1×10^{-9}

(d) 2.5×10^{-11}, 0.1×10^{-6}

19. A material (ε_r = 6) having power factor of 0.05, is 1.2 cm thick and 75 sq cm area. At 30 MHz it requires 1200 watts for heating. Determine the voltage and current while heating. If the voltage is to be limited to 1500 volts, determine the possible frequency.

(a) 50 MHz (b) 60 MHz (c) 70 MHz (d) 40 MHz

20. A quartz piezoelectric crystal of thickness t = 2 mm and of voltage sensitivity g = 0.055 Vm/N is subjected to a pressure = 1.5 MN/m^2. Calculate the voltage output. Also find its charge sensitivity, if its permittivity $\varepsilon = 40.6 \times 10^{-12}$ F/m.

(a) 155 V, 2.23 pC/N (b) 166 V, 1.23 pC/N

(c) 175 V, 2.23 pC/N (d) 165 V, 2.23 pC/N

Linked Questions for 21-23

A $BaTiO_3$ pick-up has dimensions $5 \times 5 \times 1.25$ mm^3. The force acting on it = 5N. The charge sensitivity = 150 pC/N and its permittivity = 12.5×10^{-9} F/m, also Y(Young's modulus) = 12×10^6 N/m^2.

21. The strain is

(a) 0.0167 (b) 0.167 (c) 0.3167 (d) 0.2167

22. The voltage generated is

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

23. The value of capacitance is

(a) 200 pF (b) 250 pF (c) 300 pF (d) 360 pF

24. A Piezoelectric crystal with dimensions 5 mm × 5 mm × 1.5 mm and voltage sensitivity = 0.055 Vm/N is used for force-measurement F. Calculate F, if 100 volts is developed.

(a) 10N (b) 20N (c) 30N (d) 40N

25. A quartz crystal has a charge sensitivity of 2 pC/N, ε_r = 4.5, diameter of 10 mm and thickness, 2 mm. Find the output voltage due to an applied force of 100N. (Young's modulus = 9×10^{10} N/m^2).

(a) 137.8V (b) 147.8V (c) 157.8V (d) 127.8V

26. Read the following statements with respect to the Relative permittivity or dielectric constant

1. It is the ratio of permittivity of vacuum to the permittivity of dielectric fluid
2. Its value is greater than unity
3. It is one of the material property
4. Lower the dielectric constant then higher the storing capacity

Of the above the correct statements are:

(a) 1, 2, 3 & 4 (b) 1, 2

(c) 2, 3 (d) 3, 4

27. A solid specimen of dielectric has relative permittivity ϵ_r = 4.2 and loss angle tan δ = 0.001 at 50 Hz frequency. If it is subjected to an electrical stress of 50 kV/cm, what is the heat generated in the specimen due to dielectric loss?

(a) 291 W/cm^3 (b) 5.82 mW/cm^3

(c) 19.5 W/cm^3 (d) 0.291 mW/cm^3

40. What are the materials which exhibit electric polarization even in the absence of an applied electric field?

(a) Ferromagnetic

(b) Paramagnetic

(c) Ferroelectric

(d) Anti-ferroelectric

41. Consider the following statements with respect to a quartz crystal:

1. Quartz displays ferroelectric behaviour.

2. Quartz is used in electric oscillator circuits.

3. Quartz crystal is formed by repeating silicate tetrahedrons.

Which of the statements given above are correct?

(a) 1, 2 and 3 (b) Only 1 and 2

(c) Only 2 and 3 (d) Only 1 and 3

42. The correct relation is

(a) $P = \varepsilon_0(\varepsilon_r - 1)E$ (b) $P = \left(\frac{\varepsilon_0}{\varepsilon_r - 1}\right).E$

(c) $P = \left(\frac{\varepsilon_0}{\varepsilon_r + 1}\right).E$ (d) $P = \varepsilon_0(\varepsilon_r + 1)\,E$

43. Which one of the following material is not a piezo-electric material?

(a) $BaTiO_3$ (b) Quartz

(c) Rochelle salt (d) Yttrium garnet

44. If ε_r' and ε_r'' are the real and imaginary part of complex dielectric constant ε_r , and δ is loss angle, then

(a) $\tan\delta = \frac{\varepsilon_r'}{\varepsilon_r''}$ (b) $\tan\delta = \frac{\varepsilon_r''}{\varepsilon_r'}$

(c) $\tan\delta = \varepsilon_r', \varepsilon_r''$ (d) $\tan\delta = 1 - \varepsilon_r'$

45. The polarization P in a solid dielectric is related to the electric field E and the electric flux density D by the relation

(a) $E = \varepsilon_0 D + P$ (b) $D = E + \varepsilon_0 P$

(c) $D = \varepsilon_0 E + P$ (d) $D = \varepsilon_0(E + P)$

46. Consider the following statement, the dielectric constant of an insulator depends on

1. Applied voltage

2. Frequency of AC field

3. Temperature

4. Maximum current density in insulator.

Which of these statement are correct

(a) 1 and 2 (b) 2 and 3

(c) 3 and 4 (d) 1, 2, 3 and 4

47. The effective quality factor of the equivalent electrical circuit of the quartz crystal is of the order of

(a) 20 (b) 200 (c) 2,00,000 (d) 2000

48. Which capacitor store higher amount of energy?

(a) Air capacitor (b) Paper capacitor

(c) Mica Capacitor (d) Plastic film Capacitor

49. ***Assertion (A)*** : Ferroelectric Materials have spontaneous polarization.

Reason (R) : Above Curie temperature, $\varepsilon = \frac{C}{(T-\theta)}$ for ferro electric materials.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true, but R is not the correct explanation of A

(c) A is true, but R is false

(d) R is true, but A is false

50. The apparent capacitance at a high angular frequency ω of an air cored capacitor having capacitance C and inductance L is given by

(a) $C_{app} = \frac{C}{1+\omega^2 LC}$ (b) $C_{app} = \frac{C}{1-\omega^2 LC}$

(c) $C_{app} = \frac{L}{1-\omega^2 LC}$ (d) $C_{app} = \frac{L}{1+\omega^2 LC}$

51. Which of the following is the example for piezo-electric materials.

(a) Lead zirconate (b) Copper

(c) Potassium niobate (d) None of these

❑❑❑

ANSWERS AND EXPLANATIONS

1. ***Ans. (c)***

$$\alpha_e = 4\pi\epsilon_0 R^3$$
$$= 4(3.14)\ (8.854 \times 10^{-12}\ \text{F/m})\ (0.53 \times 10^{-10}\text{m})^3$$
$$= 1.66 \times 10^{-41}\ \text{F-m}^2$$
$$\epsilon_r = 1 + 4\ \pi NR^3$$
$$= 1 + 4(3.14)\ (9.8 \times 10^{26}/\text{m}^3)\ (0.53 \times 10^{-10}\text{m})^3$$
$$= 1.0018$$

2. ***Ans. (a)***

$$\epsilon_r = 1 + 4\pi NR^3$$

or $$R^3 = \frac{\epsilon_r - 1}{4\pi N}$$

$$\Rightarrow \quad R^3 = \frac{684 \times 10^{-7}}{4\pi \times 2.7 \times 10^{25}}$$

$$\therefore \quad R = 0.586 \times 10^{-10}\ \text{m}$$
$$\simeq 0.6 \times 10^{-10}\ \text{m}$$

For Helium $Z = 2$

we have,

$$x = \left(\frac{4\pi\epsilon_0 R^3}{Ze}\right)E$$

$$= \frac{4\pi \times 8.854 \times 10^{-12} \times (0.6)^3 \times (10^{-10})^3 \times 10^6}{2 \times 1.601 \times 10^{-19}}$$

$$= 7.5 \times 10^{-17}\ \text{m}$$

3. ***Ans. (c)***

$$P = N\alpha E = \epsilon_0(\epsilon_r - 1)E$$

$$\alpha = \frac{\epsilon_0\ (\epsilon_r - 1)}{N}$$

$$= \frac{8.854 \times 10^{-12} \times 4.35 \times 10^{-4}}{2.7 \times 10^{25}}$$

$$= 1.43 \times 10^{-40}\ \text{Farad m}^2$$

4. ***Ans. (b)***

$$\alpha_0 = \frac{p_p^2}{3kT} \quad \text{i.e., } \alpha_0 \propto \frac{1}{T}$$

where p_p = Permanent dipole moment.

5. ***Ans. (b)***

6. ***Ans. (c)***

$$N = 5 \times 10^{28}\ \text{atoms/m}^3$$

$$E_{int} = E + \frac{P}{3\epsilon_0}$$

$$E_{int} = E + \frac{N\alpha E_{int}}{3\epsilon_0}$$

$$E_{int}\left(1 - \frac{N\alpha}{3\epsilon_0}\right) = E$$

$$E_{int}\left(1 - \frac{5 \times 10^{28} \times 10^{-40}}{3 \times 8.854 \times 10^{-12}}\right) = 1$$

$$\Rightarrow\ E_{int}(1 - 0.1882) = 1$$

$$\Rightarrow \quad E_{int}(0.8118) = 1$$

$$\therefore \quad E_{int} = 1.23\ \text{V/m}$$

7. ***Ans. (a)***

$$\epsilon_r = 4.94,\ n^2 = 2.69$$

We know from Clausius Mosotti's relation that,

$$\frac{\epsilon_r - 1}{\epsilon_r + 2} = \frac{N(\alpha_e + \alpha_i)}{3\epsilon_0} \qquad ...(i)$$

Since, the measurements are done in the optical frequency region

$$\epsilon_r = n^2, \text{ and } \alpha_i = 0$$

or $$\frac{n^2 - 1}{n^2 + 2} = \frac{N\alpha_e}{3\epsilon_0} \qquad ...(ii)$$

From the above two relations (i) and (ii),

$$\frac{\epsilon_r - 1}{\epsilon_r + 2} \times \frac{n^2 + 2}{n^2 - 1} = \frac{\alpha_e + \alpha_i}{\alpha_e}$$

or $$1 + \frac{\alpha_i}{\alpha_e} = \frac{4.94 - 1}{4.94 + 2} \times \frac{2.69 + 2}{2.69 - 1}$$

$$= \frac{3.94 \times 4.69}{6.94 \times 1.69} = 1.576$$

or $$\frac{\alpha_i}{\alpha_e} = 0.576$$

or $$\frac{\alpha_e}{\alpha_i} = 1.736$$

8. ***Ans. (c)***

In the case of solids and liquids, internal field $\bar{E}_i$ is not equal to the applied external field $\bar{E}$,

(for gases $\bar{E}_i = \bar{E}$); and $\bar{E}_i = \bar{E} + \left(\frac{\gamma}{\epsilon_0}\right)\bar{P}$

For cubic symmetry, $\gamma = \frac{1}{3}$

$$\therefore \quad \bar{E}_i = \bar{E} + \frac{\bar{P}}{3\epsilon_0}$$

CHAPTER 3

MAGNETIC PROPERTIES OF MATERIALS

OBJECTIVE QUESTIONS

1. A Magnetic material has a magnetization of 6600 A/m and flux density of 0.0088 Wb/m^2. The relative permeability of the material is

(a) 18.38 (b) 17.38 (c) 19.38 (d) 20.38

2. Calculate the average magnetic moment in Bohr magnetron when a paramagnetic spin system is subjected to a uniform field at 10^6 A/m at 27°C.

(a) 2.81×10^{-3} (b) 1.81×10^{-3}

(c) 3.81×10^{-3} (d) 4.81×10^{-3}

3. Which of the following is related to Nonmagnetic?

1. Diamagnetic material

2. Paramagnetic material

3. Ferri magnetic material

4. Anti Ferro magnetic material

(a) 1, 2, 3 (b) 2, 3, 4

(c) 1, 3, 4 (d) 2, 1, 4

4. ***Statement (I):*** Soft magnetic materials are used in the fabrication of permanent magnets and hard magnetic materials are used in electromagnets.

Statement (II): If soft magnetic materials domain movement is easy, where as in hard magnetic materials domain movement is difficult.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)

(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I)

(c) Statement (I) is true but Statement (II) is false

(d) Statement (I) is false but Statement (II) is true

5. Match List-I with List-II and select the correct answer by using the codes given below the lists:

List-I

A. Shape memory alloys

B. Piezoelectric ceramics

C. Magnetostrictive materials

D. Electrorheological materials

List-II

1. The materials are responsive to the magnetic field and analogous to the piezoelectric

2. The materials expand and contract in response to an applied electric field

3. The materials are deformed and also reverse back to their original shapes

4. Liquids that experience drastic changes in viscosity upon the application of electric field

Codes:	A	B	C	D
(a)	4	2	1	3
(b)	3	2	1	4
(c)	1	3	2	4
(d)	3	4	1	2

6. Which of the given below is 'Perovskite' crystal structure?

(a) $BaTiO_3$ (b) Zns (c) ZrO_2 (d) NaC*l*

7. In curie law for paramagnetic materials, how is the susceptibility χ related to absolute temperature T ?

(a) $\chi \alpha T$ (b) $\chi \alpha 1/T$ (c) $\chi \alpha T^2$ (d) $\chi \alpha 1/T^2$

8. Bohr magnetron is unit of

(a) Magnetic energy

(b) Permanent dipole moment due to spin

(c) Polarizability (d) Hysteresis loss

9. Magnetic cores required for RF application have

(a) High hysteresis and eddy current losses.

(b) High hysteresis and low eddy current losses.

(c) Low hysteresis and high eddy current losses

(d) Low hysteresis and eddy current losses

10. Which of the following are the properties of ferromagnetic domains?

(a) Permanent Magnetization

(b) Atomic moments in individual domains are all aligned neither parallel nor perpendicular to one another below curie point temperature

(c) Each domain is magnetically saturated

(d) Above curie temperature, domains disrupt

11. ***Assertion (A):*** Resistivity of ferrites is very much lower than that of ferromagnetic materials.

Reason (R): Ferrites are chemical compounds and the electrons in them are subjected to the restrain of valence force:

(a) Both A and B are true and R is the correct explanation of A.

(b) Both A and B are true but R is not a correct explanation of A.

(c) A is true but R is false

(d) A is false but R is true

12. For iron, the ferromagnetic curie temperature is

(a) about 20 k (b) about 100 k

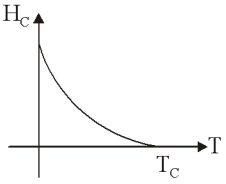
(c) about –20 k (d) about 1000 k

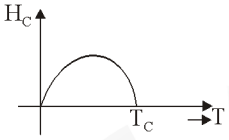
13. The magnetization 'M' of a superconductor in a field of H is

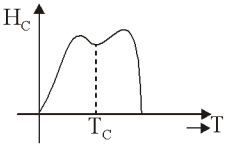
(a) extremely small (b) –H

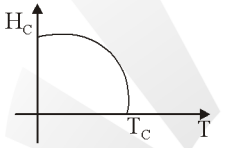
(c) –1 (d) zero

14. Which one of the following correctly represents the variation of critical magnetic field (H_c) with temperature for 0 superconductor?

(a) 

(b) 

(c) 

(d) 

15. Which one of the following is not a permanent magnetic material?

(a) Chromium steel (b) Silicon iron

(c) Cobalt steel (d) Alnico

16. What happens when a paramagnetic material is heated above curie temperature?

(a) it becomes diamagnetic

(b) it becomes non-magnetic

(c) it becomes ferromagnetic

(d) it becomes anti ferromagnetic

17. Find the magnitude of the magnetic flux density in a material for which magnetization is 2.8 A/m and susceptibility is 0.0025

(a) 1.41×10^{-3} Wb/m^2 (b) 2.52×10^{-3} Wb/m^2

(c) 2.93×10^{-3} Wb/m^2 (d) 3.49×10^{-3} Wb/m^2

18. The unit for MMF is

(a) A (b) Wb (c) T (d) V

19. The magnetic field exists around

(a) Moving charges (b) Static charges

(c) iron (d) copper

20. A large value of the exchange interaction energy in a ferromagnetic material implies

(a) large saturation magnetization

(b) high Curie temperature

(c) high melting point

(d) large diamagnetic susceptibility

21. Which one of the following materials can not be used for permanent magnets?

(a) Alnico (b) Barium Ferrite

(c) Carbon Steel (d) Iron Cobalt alloy

22. Match List-I with List-II and select the correct answer using the code given below the lists:

	List-I		**List-II**
A.	No eddy current loss	**1.**	Ferrimagnetic material
B.	Small hysteresis loss	**2.**	Soft magnetic material
C.	Large hysteresis loss	**3.**	Hard magnetic material
		4.	Non-ferrous material

Codes :	**A**	**B**	**C**
(a)	2	1	3
(b)	2	3	4
(c)	1	3	4
(d)	1	2	3

23. When certain percentage of silicon is added to iron, the resistivity of the iron increases by a factor of 5. If a transformer core is made out of this iron, as compared to the previous value when silicon was not added, the eddy current loss will be

(a) 77% (b) 80% (c) 83% (d) 86%

24. The material for the core in a power transformer must have

(a) high resistivity and low permeability

(b) low value of saturation magnetization and high resistivity

(c) high permeability and low resistivity

(d) high permeability and high saturation magnetization

25. Which of the following are the properties of ferromagnetic domains?

1. Permanent magnetization

2. Atomic moments in individual domains are all aligned neither parallel to nor perpendicular to one another below curie point temperature

3. Each domain is magnetically saturated

4. Above curie temperature, domains disrupt

Select the correct answer using the codes given below:

(a) 1 and 3 (b) 2 and 4

(c) 1, 3 and 4 (d) 3 and 4

26. ***Assertion (A):*** Resistivity of ferrites is very much lower than that of ferromagnetic materials.

Reason (R): Ferrites are chemical compounds and the electrons in them are subject to the restrain of valence forces.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

ANSWERS AND EXPLANATIONS

1. ***Ans. (b)***

Since, $B = \mu_0(H + M)$

$$H = \left(\frac{B}{\mu_0}\right) - M = \frac{0.0088}{4\pi \times 10^{-7}} - 6600$$

Magnetizing force (H) = 402.8 A/m

$\because$ $M = H(\mu_r - 1) = \chi_m H$

$\therefore$ Relative permeability is

$$\Rightarrow \quad \mu_r = \frac{M}{H} + 1 = \frac{6600}{402.8} + 1 = 17.38$$

2. ***Ans. (a)***

The magnetization for a paramagnetic spin system is given by

$$M = \frac{Np_B^2 \mu_0 H}{kT}$$

Magnetization per spin in Bohr magnetrons becomes

$$M' = \frac{M}{Np_B} = \frac{p_B \mu_0 H}{kT}$$

$$= 9.27 \times 10^{-24} \text{ Am}^2$$

$\because$ $\mu_0 = 4\pi \times 10^{-7}$ H/m

$H = 10^6$ A/m

where

p_B = Bohr magnetron

k = Boltzmann's constant

$= 1.38 \times 10^{-23}$ J/K

T = Temperature = 300 K (given)

So, $$M' = \frac{9.27 \times 10^{-24} \times 4\pi \times 10^{-7} \times 10^6}{1.38 \times 10^{-23} \times 300}$$

$= 2.81 \times 10^{-3}$ Bohr magnetron

3. ***Ans. (d)***

4. ***Ans. (d)***

5. ***Ans. (b)***

6. ***Ans. (a)***

7. ***Ans. (b)***

8. ***Ans. (b)***

9. ***Ans. (d)***

10. ***Ans. (c)***

11. ***Ans. (d)***

12. ***Ans. (d)***

13. ***Ans. (b)***

In superconductor B = 0

or $\mu(H + M) = 0$

$$\boxed{M = -H}$$

14. ***Ans. (d)***

$$H_C = H_0\left[1 - \left(\frac{T}{T_c}\right)^2\right]$$

15. ***Ans. (b)***

16. ***Ans. (a)***

17. ***Ans. (a)***

$$B = \mu_0(H + M)$$

$$= \mu_o\left(\frac{M}{\eta_m} + M\right) = \mu_o M\left(\frac{1}{\eta_m} + 1\right)$$

$$= 4\pi \times 10^{-7} \times 2.8 \times \left(\frac{1}{0.0025} + 1\right)$$

$B = 1.41 \times 10^{-3}$ Wb/m^2

18. ***Ans. (a)***

19. ***Ans. (a)***

20. ***Ans. (a)***

Higher the exchange interaction energy, higher will be area under B-H curve i.e. high saturation magnetization (because value of B at saturation will be very high).

21. ***Ans. (b)***

The dc resistivity of ferrites is many orders of the higher than that of iron; consequently it prevents penetration of magnetic flux into the material. Further, coercive force (H_C) for a high stability permanent magnet may be as high as 10^6 ampere-m^{-1} as compared to ferrites having as low as 1 ampere-m^{-1}.

22. ***Ans. (d)***

No eddy current loss : Ferrimagnetic material

Small hysteresis loss : Soft magnetic material

Large hysteresis loss : Hard magnetic material

23. ***Ans. (b)***

Let the resistivity of iron be ρ.

On adding silicon, resistivity of iron is 5ρ.

Eddy current loss

$$= \frac{5\rho - \rho}{5\rho} \times 100$$

$$= \frac{4}{5} \times 100$$

$$= 80\%$$

24. ***Ans. (d)***

The material for the core in a power transformer must have high permeability and high saturation magnetization.

25. ***Ans. (c)***

In ferromagnetic material, all domains are aligned parallel to each other below curie temperature.

CHAPTER 4

CONDUCTING MATERIALS

OBJECTIVE QUESTIONS

1. A uniform silver wire has a resistivity of 1.54×10^{-8} ohm-m at room temperature, for an electric field along the wire of 1 volt/cm. compute the average drift velocity of the electrons, assuming there are 5.8×10^{28} conduction electrons per m^3.

(a) 1.699 ms^{-1} (b) 2.699 ms^{-1}

(c) 0.699 ms^{-1} (d) 3.699 ms^{-1}

2. The following data is known for copper metal,

Density = 8.92 g/cc

Resistivity = 1.73×10^{-8} ohm-m

Atomic weight = 63.5

The average time of collision of the electrons in copper.

(a) 2.42×10^{-12} sec (b) 2.42×10^{-14} sec

(c) 2.42×10^{-13} sec (d) 2.42×10^{-15} sec

3. Read the following statements with respect to the super conductivity:

1. It is characterized by zero resistance of infinite conductance
2. By increasing the temperature from 0K to higher, the electrical resistivity reduces to zero.
3. Cu, Ag, Au elements are best conductors in the normal state but does not become super conductors.
4. The expulsion of magnetic flux when super conducting material is placed in a magnetic field is called MEISSNER Effect.

Of the above the correct statements are:

(a) 1, 2, 3, 4 (b) 1, 2

(c) 1, 3, 4 (d) 1, 2, 3

4. Charpy test is conducted to measure

(a) hardness (b) fracture toughness

(c) fatigue resistance (d) brittleness

5. The equipment used for measurement of Hardness of rubber and very thin sheets is

(a) Vickers hardness (b) Moh hardness testing

(c) Schores schaloriscope (d) Barcol hardness testing

6. Read the following statements with respect to the Magnetic particle Testing Method:

1. This method is useful for all type of material
2. If it is a Non-Destructive method
3. This method is used for detecting surface and subsurface discontinuities in ferro- magnetic materials

Of the above the correct statements are:

(a) 1, 2 & 3 (b) 2 & 3 (c) 1 & 2 (d) None

7. The given below is not a characteristic property of ceramic material

(a) High temperature stability

(b) High mechanical strength

(c) Low elongation

(d) Low hardness

8. Ceramic resonators use which one of the following?

(a) Barium titanate

(b) Silicon

(c) Piezo-electric quartz crystal

(d) Zirconium titanate

9. Match List-I (Application) with List-II (core materials) and select the correct answer using the codes given below the lists:

	List -I		List- II
A.	Power Transformer	1.	Si-Fe Alloy
B.	Audio Transformer	2.	Permalloy
C.	Pulse Transformer	3.	Ferrite
		4.	Supermalloy
D.	Welding Transformer	5.	Hypersil

Codes:	**A**	**B**	**C**	**D**
(a)	1	3	4	5
(b)	2	3	4	5
(c)	1	2	3	4
(d)	2	3	5	4

10. The correct sequence of the following materials in the increasing order of conductivity is

(a) silicon doped with boron- silver-Aluminium-intrinsic silicon

(b) Intrinsic Silicon-Aluminium-Silver-Silicon doped with Boron

(c) Aluminium - intrinsic Silicon-Silicon doped with boron-Silver

(d) Intrinsic Silicon-Silicon doped with Boron Aluminium-Silver

ANSWERS AND EXPLANATIONS

1. ***Ans. (c)***

The number of silver conduction electrons/m^3

$= 5.8 \times 10^{28}$

$\therefore \quad n = 5.8 \times 10^{28}$

$\sigma = n\ e\ \mu$

Mobility, $\mu = \dfrac{\sigma}{ne} = \dfrac{1}{\rho ne}$

$\Rightarrow \quad \mu = \dfrac{1}{1.54\times10^{-8}\times5.8\times10^{28}\times1.6\times10^{-19}}$

$\therefore \quad \mu = 6.99 \times 10^{-3}\ m^2\ volt^{-1}\ sec^{-1}$

and average drift velocity

$v_d = \mu E$

$\because \quad E = 1\ V/cm = 10^2\ V/m$

Now, $v_d = 6.99 \times 10^{-3} \times 10^2$

$v_d = 0.699\ ms^{-1}$

2. ***Ans. (b)***

$$\text{Molar volume} = \frac{\text{Atomic Weight}}{\text{Density}}$$

$$= \frac{63.5}{8.92}\times10^{-6}$$

$$= 7.12\times10^{-6} m^3$$

Valence electrons per unit volume (N) is,

$$N = \frac{\text{Avogadro's number}}{\text{Molar volume}}$$

$$= \frac{6.025\times10^{23}}{7.12\times10^{-6}}$$

$$= 8.46\times10^{28} m^{-3}$$

Mobility (μ_e)

$$= \frac{\sigma}{Ne} = \frac{1}{\rho Ne}$$

$$= \frac{1}{1.73\times10^{-8}\times8.46\times10^{28}\times1.6\times10^{-19}}$$

$= 4.27 \times 10^{-3}\ m^2V^{-1}sec^{-1}$

Average time of collision,

$$\tau = \frac{m\sigma}{Ne^2} = \frac{m}{\rho Ne^2}$$

$$= \frac{9.1\times10^{-31}}{1.73\times10^{-8}\times8.46\times10^{28}\times(1.6\times10^{-19})^2}$$

$= 2.42 \times 10^{-14}$ sec

3. ***Ans. (c)***

4. ***Ans. (b)***

5. ***Ans. (c)***

6. ***Ans. (b)***

7. ***Ans. (d)***

8. ***Ans. (c)***

9. ***Ans. (a)***

10. ***Ans. (d)***

11. ***Ans. (a)***

Quartz $\rightarrow$ used for high frequency oscillation.

Si $\rightarrow$ used in integrated circuit because of two regions.

(i) At high temperature it reacts with oxygen and form SiO_2 which is a very good dielectric.

(ii) High power handling capacity.

GaAs $\rightarrow$ is a direct band gap material having larger carrier life time so suitable for designing of laser.

Nichrome $\rightarrow$ used as heating element.

12. ***Ans. (d)***

De broglie wavelength is

$$\lambda \propto \frac{1}{\text{Momentum}}$$

$$\lambda = \frac{h}{p}$$

where $p = mv$

13. ***Ans. (a)***

Lepidolite mica is a hard & brittle. This is unsuitable for electric insulation.

14. ***Ans. (b)***

In a superconductor,

(i) Entropy decreases on going from normal state to superconducting state.

(ii) There is a marked drop in the thermal conductivity when superconductivity sets in.

15. ***Ans. (a)***

16. ***Ans. (b)***

$R_2 = R_1\ (1 + \alpha\ \Delta T)$

where

α = Temperature coefficient

R_1 = Resistance at 0°C

R_2 = Resistance

at T°C, $R_2 = 1.1\ \Omega$

$1.1 = 1(1 + 10^{-3}\ T)$

$\Rightarrow \quad T = \dfrac{1.1-1}{10^{-3}} = 100°C$

CHAPTER 5

SEMICONDUCTORS

OBJECTIVE QUESTIONS

1. Read the following statements with respect to the intrinsic semiconductor:

1. It is a pure semiconductor and at 0K it is a perfect insulator.

2. At room temperature it has equal number of electrons and holes.

3. In this conductor Fermi energy level lies in mid way between the conduction band and valence band.

4. Intrinsic-semiconductor is used in transistor and electronic products.

Of the above, the correct statements are:

(a) 1, 2, 3, 4 (b) 1, 2, 3

(c) 2, 3, 4 (d) None of the above

2. Which of the following materials are smart materials ?

1. Shape memory alloys

2. Piezolectric ceramics

3. Composite materials

4. Electro-rheological

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

3. Which of the following statements are true for a semiconductor that is used as a photoconductor?

1. It should have no doping

2. It should have large response time

3. It should have an energy band gap value that matches with frequency of light that is used to excite the photoconductors

Select the correct answer using the codes given above

(a) 1, 2 and 3 (b) 1 and 2

(c) 2 and 3 (d) 1 and 3

4. The resistance of photoconductor

(a) increases with increase in light intensity

(b) decreases with increase in light intensity

(c) may increase or decrease with increase in light intensity

(d) None

5. Consider the following statement:

Extrinsic semiconductors show high electrical conductivity because the impurities are

1. High conductivity

2. Highly mobile

3. Highly charged

Which of these statements are NOT correct ?

(a) 1 and 2 (b) 2 and 3 (c) 1 and 3 (d) 1, 2 and 3

6. On which of the following factors does the electrical conductivity of a semiconductor depend?

1. Carrier concentration

2. Carrier mobility

3. Sign of the carrier

Select the correct answer using the codes given below:

(a) 1 and 2 (b) 1 and 3 (c) 2 and 3 (d) 1, 2 and 3

7. ***Assertion (A):*** An insulator has a high value of resistivity and with increasing temperature the value of its resistivity decreases exponentially.

Reason (R): With increasing temperature, the value of the energy band gap decreases.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

8. ***Assertion (A):*** A doped semiconductor will behave as a perfect insulator at zero Kelvin but its electrical conductivity will rise if the temperature is slowly increased above zero Kelvin.

Reason (R): The rise in electrical conductivity is mainly, due to increased ionization as the temperature is raised above zero Kelvin.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

9. ***Assertion (A):*** Energy released when an electron jumps from a higher to a lower level is usually in the form of photons.

Reason (R): Energy released when an electron jumps from a higher to a lower level is absorbed by the nucleus.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

ANSWERS AND EXPLANATIONS

1. ***Ans. (a)***

2. ***Ans. (c)***

3. ***Ans. (a)***

4. ***Ans. (b)***

5. ***Ans. (a)***

Impurity are not of high conductivity as P(pentavalent atom) and n-type impurity is not a very good conductor. Impurity atoms are also not exhibit high mobility normally immobile.

6. ***Ans. (a)***

$$\sigma = ne\ (\mu_e + \mu_h)$$

i.e. $\sigma \propto n(\mu_e + \mu_h)$

7. ***Ans. (d)***

An insulator has high value of Resistivity and with increasing temperature, energy band gap decreases by a small value. Therefore resistivity decreases but only by a small amount not exponentially.

8. ***Ans. (a)***

Doped semiconductor at 300 Kelvin has completely filled valance band and empty conduction band. Therefore, it behave as perfect insulator at zero Kelvin.

At room temperature, some electrons gain enough kinetic energy to move from valence band to conduction band and conductivity increases.

9. ***Ans. (c)***

A is correct but R is not correct

A : In case of direct band gap material when e^- falls from conduction band to valence, energy is released in the form of photon.

R : In case of indirect band gap material when e^- falls from conduction band to valence band, energy is released in the form heat.

10. ***Ans. (a)***

Both are correct and R is also the reason for A. Glazing is always done to make surface smooth and absorbent because if surface will not be smooth moisture will be collected from atmosphere on surface discontinuities and result in electrical breakdown.

11. ***Ans. (c)***

Band gap energy of GaAs, $E_g = 1.43$ eV

$$E_g = \frac{hc}{\lambda}$$

$$\lambda = \frac{6.626\times10^{-34}\times3\times10^{8}}{1.43\times1.6\times10^{-19}}$$

$$= 8.688 \times 10^{-7}\ \text{m}$$

$$= 8688\ \text{Å}$$

The emitted wavelength is in infrared region.

12. ***Ans. (a)***

13. ***Ans. (b)***

14. ***Ans. (c)***

Critical wavelength, $\lambda_c = \frac{1.24}{E_g}\mu m$

where E_g is the band gap energy in eV.

For Ge, E_g at room temperature is 0.72 eV

For Si, E_g at room temperature is 1.1 eV.

For GaAs, E_g at room temperature is 1.43 eV

$\because$ E_g : GaAs > Si > Ge

$\therefore$ λ_c : Ge > Si > GaAs

15. ***Ans. (d)***

16. ***Ans. (a)***

17. ***Ans. (b)***

18. ***Ans. (a)***

19. ***Ans. (c)***

20. ***Ans. (a)***

❑❑❑

CHAPTER 6

POLYMERS AND CERAMICS

OBJECTIVE QUESTIONS

1. Read the following statements with respect to the polymers
1. In polymers, bonds between carbon atoms are double covalent bond
2. Bonds between carbon and hydrogen atoms are single covalent bond
3. Molecules that have double and triple covalent bonds are termed as saturated
4. Molecules that have single covalent bonds are termed as unsaturated

Of the above the correct statements are :
(a) 1, 2 (b) 2, 3 (c) 3, 4 (d) 4, 1

2. Polymer chains composed of two or more different repeat units is called_____.
(a) Isomerism (b) Homopolymer
(c) Copolymer (d) Linear polymer

3. Rubber is the best example for
(a) Linear polymer (b) Branched polymer
(c) Cross linked polymer (d) Network polymer

4. The printed circuit boards are prepared by
(a) Glass ceramics (b) Bakelite
(c) Phenology (d) Wood

5. Which of the given material is used as an abrasive grinding ?
(a) WC (b) MgO
(c) $BaTiO_2$ (d) High strength steel

6. Strong covalent bonds are observed in
(a) Thermo plasts (b) Thermo sets
(c) Elastomers (d) All polymers

7. Which of the following is the unique to polymeric material ?
(a) Elasticity (b) Viscoelasticity
(c) Plasticity (d) None

8. Kevlar is commercial name for
(a) Glass Fiber (b) Carbon fibers
(c) Aramid fibers (d) Cermets

9. Due to it's excellent permeability to air/gas and oxidation resistance, the tubes of automobile tyres are made up of
(a) Cold SBR (b) Bunai N
(c) Buna S (d) Butyl rubber

10. Which of the following is thermoplastic polymers?
(a) Nylon (b) Bakelite
(c) Polystyrene (d) Terylene

11. The given below is not a major contributor of engineering ceramics
(a) SiC (b) SiO_2 (c) Si_3N_4 (d) Al_2O_3

12. The given below is not a characteristic property of ceramic material
(a) High temperature stability
(b) High mechanical strength
(c) Low elongation
(d) Low hardness

13. Which of the following ceramic product is mostly used as pigment in paints ?
(a) TiO_2 (b) SiO_2 (c) UO_2 (d) ZrO_2

14. Most of the commercial glasses consist of
(a) Lime (b) Soda (c) Silica (d) All

15. Ceramics can conduct
(a) Heat (b) Electricity
(c) Both (a) and (b) (d) Do not conduct both

16. Roof of a basic electric furnace is made up of
(a) Chromites (b) Super duty fire clay
(c) Silica (d) All of the above

17. Match List-I with List-II and select the correct answer by using the codes given below the lists :

List-I (Ceramics)
1. Borosilicate
2. Fiber glass
3. Fused silica
4. Optical Flint

List-II (Properties)
A. High melting temperature and very low coefficient of expansion
B. Thermally shock and chemically resistant and used in ovenware
C. Easily drawn into fiber, glass resin composites
D. High density and high index of refraction and used in optical lenses.

Codes :	A	B	C	D
(a)	3	1	2	4
(b)	2	3	1	4
(c)	3	1	2	4
(d)	4	2	1	3

CHAPTER 7

NANO MATERIALS

OBJECTIVE QUESTIONS

1. 10 nm = _____ m

(a) 10^{-8} (b) 10^{-7} (c) 10^{-9} (d) 10^{-10}

2. Carbon atoms make _____ type of bond with other carbon atoms.

(a) Covalent (b) Ionic (c) Metallic (d) Hydrogen

3. Fullerene or bucky ball is made up of _____ carbon atoms.

(a) 100 (b) 20 (c) 75 (d) 60

4. Which ratio decides the efficiency of nano substance?

(a) Weight/volume (b) Surface area/volume

(c) Volume/weight (d) Pressure/volume

5. Read the following statements with respect to the Nanomaterial.

1. Volume to surface area ratio is very large for nanomaterials.

2. The cut-off limit of human eye is 10^{-5}m.

3. Hardness of a SWNT is about 63×10^9 Pa.

4. Carbon nano tubes are cylindrical fullerenes. Of the above the correct statements are

(a) 1, 2, 3 and 4 (b) 2 and 4

(c) 1, 2 and 4 (d) 2, 3 and 4

6. Which of the given below are nano materials

1. Dendrimers **2.** Nano tubes

3. Quantum dots **4.** Fullerenes

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

7. Read the following statements with respect to the super conductivity :

1. For nanotube, a small shear force will change in conductivity

2. Conductivity of multi walled nanotube is same as single wall nano tube

3. Melting point is less than steel rod

Of the above the correct statements are :

(a) 1, 2 & 3 (b) 2, 3 (c) 1, 2 (d) None

8. Which of the given below materials are naturally occurring nano materials.

(a) Volcanic ash (b) Dust from the coal mines

(c) Cosmetic talc (d) All of the above

9. 'Quantum Dots' relates with

(a) Quantum physics (b) Bio technology

(c) Nano technology (d) Microbiology

10. Read the following statements with respect to the carbon allotropres

1. Diamond and graphite, both are naturally occurring carbon materials.

2. Diamond and graphite have entirely different chemical properties but their properties are same.

3. Diamond is a non-conductor of electricity where as graphite is a good conductor of electricity.

Of the above the correct statements are :

(a) 1, 2 & 3 (b) 1, 3 (c) 1, 3 (d) 2, 3

11. Composition of cores of pencils (penci) leads.

(a) Graphite (b) Graphite and clay

(c) Graphite and lead (d) Clay and lead

12. In Buckministerfullerene, the carbon atoms are arranged

(a) 20 hexagons and 40 pentagons

(b) 30 hexagons and 30 pentagons

(c) 20 hexagons and 12 pentagons

(d) 12 hexagons and 20 pentagons

13. Which of the given below materials can produce carbondioxide by burning in oxygen.

1. Diamond

2. Fullerene

3. Graphite

4. CNT

(a) 1, 2, 3 (b) 2 Only (c) 3 Only (d) 1, 2, 3 & 4

14. Which of the given below carbon materials are Amorphous carbon materials

1. Coke

2. Wood charcoal

3. Sugar char coal

4. Carbon black

(a) 1 Only (b) 2, 3, 4 (c) 1, 3, 4 (d) 1, 2, 3 & 4

Directions : Each of the next Three items consists of two statements, one labeled as the 'Statement (I)' and the other as 'Statement (II)'. You are to examine these two statements carefully and select the answer to these items using the codes given below :

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).

(b) Both Statement (I) and Statement (II) are individually true and Statement (II) is not the correct explanation of Statement (I).

(c) Statement (I) is true but Statement (II) is false.

(d) Statement (I) is false but Statement (II) is true.

15. ***Statement-I :*** Large Quantum dots emit blue and green colours.

Statement-II : Large Quantum dot emit larger wavelength.

Select the correct answer

16. ***Statement-I :*** Dendrimers are the nano materials used in drug delivery, energy harvesting, gene transfection.

Statement-II : Dendrimers have three components, a central core, an interior dendritic structure and an exterior surface with functional surface groups.

17. ***Statement-I :*** Graphite is a good conductor of electricity.

Statement-II : Graphite contain free electrons.

18. Match List-I with List-II and select the correct answer by using the codes given below the lists :

List-I	**List-II**
1. Nanoshell	**A.** 100 nm
2. Hydrogen atom	**B.** 2000 nm
3. E.Coli bacteria	**C.** 90 nm
4. Transistor	**D.** 0.1 nm

(a) 1-A, 2-C, 3-D, 4-B

(b) 1-B, 2-A, 3-C, 4-D

(c) 1-A, 2-D, 3-B, 4-C

(d) 1-C, 2-D, 3-B, 4-A

19. Match List-I with List-II and select the correct answer by using the codes given below the lists :

List-I	**List-II**
1. Biotechnology	**A.** Quantum dots
2. Material science	**B.** Spintronics
3. Information technology	**C.** Gene therapy
	D. Swam robotics

(a) 1-C, 2-D, 3-A (b) 1-C, 2-B, 3-A

(c) 1-C, 2-A, 3-B (d) 1-A, 2-B, 3-D

20. Match List-I with List-II and select the correct answer by using the codes given below the lists

List - I (Nano Structure)	**List - II (Nano Scale Dimension)**
A. Thin films	**1.** 1-50 nm
B. Nano tubes	**2.** 1-10 nm
C. Quantum dots	**3.** 1-100 nm
D. Aerogels	**4.** 1-100 nm

Codes :

	A	**B**	**C**	**D**
(a)	1	2	3	4
(b)	3	4	2	1
(c)	2	4	1	3
(d)	1	4	3	2

❑❑❑

ANSWERS AND EXPLANATIONS

1.	*Ans. (a)*	**6.**	*Ans. (d)*	**11.**	*Ans. (b)*	**16.**	*Ans. (a)*
2.	*Ans. (a)*	**7.**	*Ans. (a)*	**12.**	*Ans. (c)*	**17.**	*Ans. (a)*
3.	*Ans. (d)*	**8.**	*Ans. (a)*	**13.**	*Ans. (d)*	**18.**	*Ans. (c)*
4.	*Ans. (b)*	**9.**	*Ans. (c)*	**14.**	*Ans. (d)*	**19.**	*Ans. (c)*
5.	*Ans. (d)*	**10.**	*Ans. (c)*	**15.**	*Ans. (d)*	**20.**	*Ans. (b)*

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UNIT-II

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CHAPTER 1

SEMICONDUCTOR ANALYSIS

OBJECTIVE QUESTIONS

1. Under high electric field, in a semiconductor with increasing electric field

(a) The mobility of charge carriers decreases.

(b) The mobility of charge carriers increases.

(c) The velocity of the charge carriers saturates.

(d) The velocity of charge carriers increases,

2. In integrated circuits, the design of electronic circuits is based on the approach of use of

(a) maximum number of resistors in the circuit.

(b) large sized capacitor.

(c) Minimum chip area irrespective of the type of components in the design.

(d) use of only bipolar transistors.

3. Diffusion of impurities in a semiconductor is carried out in a furnace through which a steady stream of impurity atoms is passed during the entire diffusion process. What would be the type of profile of the impurity atoms inside the semiconductor?

(a) Linear

(b) Gaussian

(c) Complementary error function

(d) Exponential

4. Diffusion of impurities in a semiconductor is carried out in a furnace through which a steady stream of impurity atoms is passed during the entire diffusion process. What would be the type of the profile of the impurity atoms inside the semiconductor?

(a) Linear

(b) Gaussian

(c) Complementary error function

(d) Exponential

5. A silicon sample is uniformly doped with 10^{16} phosphorous atoms/cm^3 and 2×10^{16} boron atom /cm^3. If all the dopants are fully ionized, the material is

(a) n-type with carrier concentration of $10^{16}/cm^3$

(b) p-type with carrier concentration of $10^{16}/cm^3$

(c) p-type with carrier concentration of $2\times10^{16}/cm^3$

(d) n-type with carrier concentration of $2\times10^{16}/cm^3$

6. The probability that an electron in a metal occupies the fermi level at any temperature ($> 0^oK$)

(a) 0 (b) 1 (c) 0.5 (d) 0.1

7. Fermions are the particles, which obey

(a) Maxwell-Boltzmann's statistics

(b) Bose-Einstein's statistics

(c) Hiesenberg's uncertainty principle

(d) Pauli's exclusion principle

8. Excess carriers are generated in a sample of N-type semiconductors by shining light at one end. The current flow in the sample will be made up of

(a) diffusion flow of carriers

(b) drift flow of carriers

(c) both diffusion and drift flow of carriers

(d) neither diffusion nor drift flow of carriers

9. Given that the band gap of cadmium sulphide is 2.5 eV, the maximum photon wavelength, for electron-hole pair generation will be

(a) 5400 μm (b) 540 μm (c) 5400 Å (d) 540Å

10. A semiconductor is irradiated with light such that carries are uniformly generated throughout its volume. The semiconductor isn-typewith $N_D = 10^{19}$ per cm^3. If the access electron concentration in the steady state is $\Delta n = 10^{15}$ per cm^3 and if $Z_p = 10\mu$ sec (minority carier life time) the generation rate due to irradiation

(a) is 10^{20} e-h pairs/cm^3/sec

(b) is 10^{24} e-h pairs/cm^3/sec

(c) is 10^{10} e-h pairs/cm^3/sec

(d) cannot be determined as the given data is insufficient

11. The drift velocity of electrons in silicon

(a) Is proportional to the electrical field for value of electrical field

(b) Is independent of the electric field

(c) Increases at low values of the electric field and decreases at high value of electric field exhibiting negative

(d) Increases linearly with electric field at the value of electric field and gradually saturates at higher values of electric field

12. A long specimen of p-type semiconductor material

(a) is positively charged

(b) is electrically neutral

(c) has an electrical field directed along its length

(d) acts as a dipole

13. If an intrinsic semiconductor is doped with a very small amount of boron, then in the exirinsic semiconductor set formed, the number of electrons and holes will

(a) decrease

(b) increase and decrease respectively

(c) increase

(d) decrease and increase respectively

14. At a given temperature a semiconductor with intrinsic carrier concentration $n_i=10^{16}/m^3$ is doped with a donor dopant of concentration $N_D = 10^{26}/m^3$. Temperature remaining the same the hole concentration in the doped semiconductor is

(a) $10^{26}/m^3$ (b) $10^{16}/m^3$ (c) $10^{14}/m^3$ (d) $10^{6}/m^3$

[DRDO-2008]

15. At room temperature the diffusion and drift con stants for holes in a P-type semiconductor were measured to be $D_p=10$ cm^2/s and $\mu_p=1200$ $cm^2/$ V-s, respectively. If the diffusion constant of electrons in an N-type semiconductor at the temperature is $D_n=20$ cm^2/s, the drift constant for electrons in it is

(a) $\mu_n= 2400$ cm^2 /v-s

(b) $\mu_n= 1200$ cm^2/V-s

(d) $\mu_n=1000$ $cm^2/$ V-s

(c) $\mu_n = 600$ $cm^2/$ V-s

[DRDO-2008]

16. At room temperature, which one of the following band gap energy E_g corresponds to that of a semiconductor?

(a) $E_g = 0eV$ (b) $E_g = 1.2eV$

(c) $E_g = 5eV$ (d) $E_g = 9eV$

[DRDO-2009]

17. Resistivity of an n-type Si material at a particular temperature is 0.625Ω-cm. The electron and hole mobilities in that material at the same temperature are $\mu_n=1600cm^2/$ V-s and $\mu_P=500$ $cm^2/$ V-s, re spectively. Which one of the following best repre sents the donor dopant concentration N_D?

(a) 2.5×10^{13} cm^{-3} (b) $6.25 - 10^{13}$ cm^{-3}

(c) 6.25×10^{15} cm^{-3} (d) $2.5 - 10^{16}$ cm^{-3}

[DRDO-2009]

18. The diffusion constant and mobility for electrons in a semiconductor material at a given tempera ture are 20 $cm^2/$ s and 1600 cm^2/V-s, respectively. The thermal voltage $V_T$for a diode made of this material at the temperature is

(a) 125 mV (b) 32 mV (c) 12.5 mV (d) 3.2 mV

[DRDO-2009]

19. The ratio of the electrical resistance of a material at 300 K to Its electrical resistance at 4 K is 5. This material could be

(a) an intrinsic semiconductor

(b) an extrinsic semiconductor

(c) an insulator

(d) a conductor

[IAS-2000]

20. If two semiconductor specimen have carrier con centration and 'n_1' and 'n_2' their Hall cofficientsare R_1 and R_2 respectively, then

(a) $\frac{R_1}{R_2}=\left(\frac{n_1}{n_2}\right)^{1/2}$ (b) $\frac{R_1}{R_2}=\frac{n_1}{n_2}$

(c) $\frac{R_1}{R_2}=\frac{n_2}{n_1}$ (d) $\frac{R_1}{R_2}=\left(\frac{n_2}{n_1}\right)$

[IAS-2000]

21. Electrons in completely filled band

(a) take part in the process of conduction

(b) take part in the process of conduction at low temperature only

(c) do not take part in the process of conduction

(d) take part in the process of conduction at high temperatures only

[IAS-2000]

22. Match List-I with List IIand select the correct answer using the codes given below this lists:

	List-I		**List-II**
A.	Diffusion	**1.**	Coduction band
B.	Drift	**2.**	Valence band
C.	Free electrons	**3.**	Fick's law
D.	Holes	**4.**	Electric field

(a) A-3 B-4 C-2 D-1

(b) A-4 B-3 C-2 D-1

(c) A-3 B-4 C-1 D-2

(d) A-4 B-3 C-1 D-2

[IAS-2001]

23. The contact between aluminum (AI) and moderately doped silicon (Si) will be

(a) AI-pSi ohmic and A1-nSi schottky

(b) AI-pSi ohmic and A1-nSi ohmic

(c) AI-pSi schottky and A1-nSi ohmic

(d) AI-pSi schottky and A1-nSi schottky

[IAS-2001]

24. Cosider the flollowing statements in respect of energy bands in a solid :

1. Energy bands at high energy have more wdith than those bands at low energy

2. Low energy bands correspond to valence electrons

3. There are always some energy bands that are not filled.

Which of these statments is/ are correct

(a) 1, 2 and 3 (b) 1 and 2

(c) only 2 (d) 1 and 3

[IAS-2002]

25. Match List I (name) with List II (Fabri-cation property) and seiect the correct answer using the codes given below the lists:

List-I (Name)

A. Intrisic

B. p-type semicoductor

C. n-type semiconductor

D. Extrinsic semiconductor

List-II (Fabrication/Property)

1. Acceptor type semiconductor of impurity is added to semiconductor

2. Donor type of impurity is added to semiconductor

3. Doped semiconductor

4. Electric property is same as that of pure semiconductor

(a) A-4 B-3 C-2 D-1

(b) A-2 B-1 C-4 D-3

(c) A-2 B-3 C-4 D-1

(d) A-4 B-1 C-2 D-3

[IAS-2002]

26. Temperature coffiecient of resistivity in an intrinic semiconductor is

(a) Positive and has a large value

(b) Negative and has a large value

(c) Positive and has a small value

(d) Negative and has a small value

[IAS-2002]

27. Which is the correct sequence of the devices in the increasing order of turn-off times?

(a) MOSFET-IGBT-BJT-SCR

(b) GBT-MOSFET-BJT-SCR

(c) SCR-BJT-MOSFET-IGBT

(d) MOSFET-BJT-IGBT-SCR

[IAS-2006]

28. Which one of the following is the correct statement?

The Hall coefficent of an n-type semiconductor is

(a) negative and varies with temprature

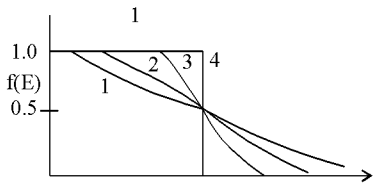
(b) negative and constant

(c) positive and constant

(d) positive and varies with temprature

[IAS-2006]

29.



Fermi Dirac distribution function is plotted for four different temprature (T) as curves labelled 1 to 4.

Match List-I with List-II and select the correct answer using the code given below the lists:

List-I	List-II
(a) 0 K	**1.** Curve-1
(b) 50 K	**2.** Curve-2
(c) 300 K	**3.** Curve-3
(d) 400 K	**4.** Curve-4

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	1	3	4	2
(c)	4	3	2	1
(d)	4	1	2	3

[IAS-2006]

30. Match List-I with List-II and select the correct answer using the code given below the lists:

List-I

A. Thermal voltage

B. Current flow due to concentration gradient of charge carriers

C. Rate of charge of carrier concentration

D. Electric field intesity in terms of charge density

List-II

1. Continuity equation

2. Poisson's equation

3. Einstein equation

4. Diffusion equation

Codes:

	A	B	C	D
(a)	3	4	1	2
(b)	1	4	2	3
(c)	3	1	4	2
(d)	1	2	3	4

[IAS-2006]

ANSWERS AND EXPLANATIONS

1. *Ans. (a)*

2. *Ans. (c)*

3. *Ans. (c)*

4. *Ans. (c)*

5. *Ans. (b)*

6. *Ans. (b)*

7. *Ans. (d)*

8. *Ans. (a)*

9. *Ans. (c)*

10. *Ans. (a)*

$$\frac{dp}{dt} = \frac{10^{15}}{10 \times 10^{-6}} = 10^{20} e - h \quad \text{pairs/cm}^3\text{/s}$$

11. *Ans. (d)*

12. *Ans. (b)*

13. *Ans. (d)*

14. *Ans. (d)*

15. *Ans. (a)*

16. *Ans. (b)*

17. *Ans. (c)*

18. *Ans. (c)*

19. *Ans. (d)*

20. *Ans. (c)*

21. *Ans. (c)*

22. *Ans. (c)*

23. *Ans. (a)*

24. *Ans. (a)*

25. *Ans. (d)*

26. *Ans. (b)*

27. *Ans. (b)*

28. *Ans. (d)*

29. *Ans. (c)*

30. *Ans. (a)*

31. *Ans. (d)*

32. *Ans. (c)*

33. *Ans. (c)*

34. *Ans. (d)*

35. *Ans. (b)*

36. *Ans. (d)*

37. *Ans. (c)*

38. *Ans. (c)*

39. *Ans. (b)*

40. *Ans. (d)*

41. *Ans. (a)*

42. *Ans. (a)*

43. *Ans. (a)*

44. *Ans. (d)*

45. *Ans. (d)*

46. *Ans. (d)*

47. *Ans. (a)*

48. *Ans. (d)*

49. *Ans. (d)*

50. *Ans. (b)*

51. *Ans. (c)*

52. *Ans. (b)*

53. *Ans. (b)*

54. *Ans. (b)*

55. *Ans. (d)*

56. *Ans. (c)*

57. *Ans. (c)*

58. *Ans. (b)*

59. *Ans. (d)*

60. *Ans. (a)*

61. *Ans. (a)*

62. *Ans. (b)*

❑❑❑