

2017

MADE EASY
WORKBOOK



**Detailed Explanations of
Try Yourself Questions**

Electrical Engineering
Electrical Materials



MADE EASY
Publications

1

Crystalline Structures



Detailed Explanation of Try Yourself Questions

T1 : Solution:

[Ans. : (a)]

T2 : Solution:

(d)

Intercepts made by plane on 3 axis

$$\Rightarrow -A, \frac{B}{3}, \infty$$

\therefore Miller indices

$$\Rightarrow -1, 3, 0$$

MADE EASY
Publications

2

Dielectric Properties of Materials



Detailed Explanation of Try Yourself Questions

T1 : Solution

[Ans. : (b)]

T2 : Solution

(d)

$$V = gtP = 12 \times 10^{-3} \times 2 \times 10^{-3} \times 0.5 \times 10^6 = 12 \text{ V}$$

T3 : Solution

(d)

Permanent dipole moment

= 1.04 debye unit

= $1.04 \times 3.33 \times 10^{-30}$ coulomb-metre

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

Room temperature $T = 300$ K

$$\alpha_0 = \frac{P_p^2}{3kT} = \frac{(1.04 \times 3.33 \times 10^{-30})^2}{3 \times 1.38 \times 10^{-23} \times 300} = 0.966 \times 10^{-39} \text{ Farad-meter}^2$$

$$N = 10^{27} \text{ m}^{-3}$$

$$E = 10^6 \text{ V/m}$$

So orientational polarisation

$$P_0 = N\alpha_0 E$$

$$= 10^{27} \times 0.966 \times 10^{-39} \times 10^6$$

$$= 0.966 \times 10^{-6} \text{ Coulomb meter}^{-2}$$

T4 : Solution

(a)

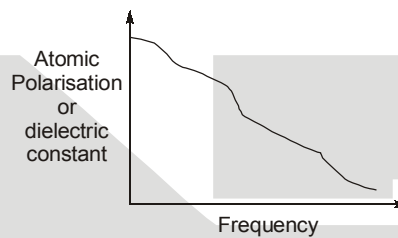
$$\tan \delta = \frac{\epsilon''}{\epsilon'} = 5 \times 10^{-4}$$

$$\therefore \epsilon'' = 10.5 \times 10^{-4} = 1.05 \times 10^{-3}$$

T5 : Solution

(c)

In an insulating material connected to an a.c. signal, the dielectric constant and atomic polarisation decrease with frequency.

**T6 : Solution**

(c)

Total polarizability

$$\alpha = \alpha_e + \alpha_i + \alpha_0$$

where $\alpha_e = 4 \pi \epsilon_0 R^3$ = electronic polarizability

α_i = ionic polarizability

$$\alpha_0 = \frac{p_p^2}{3 kT} = \text{orientational polarizability}$$

We see that orientational polarizability depends on the temperature.

E increases \longrightarrow radius R increases

R increases $\longrightarrow \alpha_e$ increases



3

Magnetic Properties of Materials



Detailed Explanation of Try Yourself Questions

T1 : Solution

[Ans. : (d)]

T2 : Solution

[Ans. : (b)]

T3 : Solution

[Ans. : (c)]

T4 : Solution

Data: $H = 10^6$ A/m, $T = 300$ K

$\mu_B =$ Bohr magneton $= 9.27 \times 10^{-24}$

$$\text{Magnetic moment} = \frac{\mu_0 H \mu_B}{kT} = \frac{1.257 \times 10^{-6} \times 10^6 \times 9.27 \times 10^{-24}}{1.38 \times 10^{-23} \times 300}$$

$$M_{300} = 2.81 \times 10^{-3} \mu_B$$

$$M_{4.2} = 0.2 \mu_B$$

T5 : Solution

(b)

$$\text{Intensity of magnetization} = \frac{\text{Total magnetic moment}}{\text{Volume}}$$

$$\text{Magnetic moment} = 2.5 \text{ A}\cdot\text{m}^2$$

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}} = \frac{6.6 \times 10^3}{7.9 \times 10^3} = 0.835 \text{ m}^3$$

$$\text{Intensity} = \frac{2.5}{0.835} \approx 2.99 = 3 \text{ A/m}$$

T6 : Solution

(a)

Permanent magnetic materials are those which retain a considerable amount of their magnetic energy after the magnetizing force has been removed, i.e. the materials which are difficult to demagnetize. Therefore for a permanent magnetic material, the residual induction and coercive field should be large.

T7 : Solution

(d)

Magnetic materials which have low coercive field are known as soft materials. Permanent magnets are made of hard materials which have a broad hysteresis loop (large coercive force), so that they are not subject to self-demagnetisation.

Also, ferrimagnetic material such as ferrites do not have eddy current loss.

T8 : Solution

(b)

Because cast iron has lower permeability than silicon steel.



4

Conductive Materials and Superconductors



Detailed Explanation of Try Yourself Questions

T1 : Solution

[Ans. : (c)]

T2 : Solution

(c)

$$H_c = 64 \times 10^3 \left[1 - \left(\frac{5}{7.26} \right)^2 \right] = 33.64 \times 10^3 \text{ Amp/m}$$

T3 : Solution

Relevant equations are

(i)
$$v_d = \frac{J}{n \times e} = \frac{I}{Ane};$$

(ii)
$$\lambda = T_c \bar{v};$$

(iii)
$$T_c = \frac{\lambda}{\bar{v}} = \frac{m}{ne^2 \rho}$$

The number of conduction electrons per $\text{m}^3 = n$

$$n = \frac{N_d \times \rho \times n_a}{\text{Cu Atomic wt.}} = \frac{6.023 \times 10^{23} \times 8960 \times 1}{63.54} = 8.5 \times 10^{25} / \text{m}^3$$

$$\text{The drift speed} = v_d = \frac{J}{ne} = \frac{I}{Ane} = \frac{10}{(\pi r^2)n \times e}$$

$$= \frac{10}{\pi(0.08)^2 \times 10^{-4} \times 8.5 \times 10^{25} \times 1.602 \times 10^{-19}} = 0.365 \text{ m/sec}$$

$$\text{Mean free collision time} = T_c = \frac{\lambda}{\bar{v}} = \frac{m}{ne^2\rho}$$

$$T_c = \frac{9.1 \times 10^{-31}}{8.5 \times 10^{25} \times (1.602 \times 10^{-19})^2 \times 2 \times 10^{-8}}$$

$$[\rho = 2 \times 10^{-8} \text{ ohm-metre at } 20^\circ\text{C}]$$

$$= 2.086 \times 10^{-11} \text{ sec}$$

$$\lambda = T_c \times \bar{v} = 2.086 \times 10^{-11} \times 1.6 \times 10^6$$

$$= 3.34 \times 10^{-5} \text{ m}$$

T4 : Solution

(b)

$\chi = \mu_r - 1$, for superconductor $\mu_r = 0$ which is referred as perfect diamagnetism.

MADE EASY
Publications

5

Semiconductor Materials



Detailed Explanation of Try Yourself Questions

T1 : Solution

(a)

Since hall voltage developed is proportional to the product of applied magnetic field and the current flow through the crystal, the device can be used to multiply two signals.

T2 : Solution

(d)

We have

resistivity

$$\rho_i = 0.47 \Omega\text{m} = \frac{1}{\sigma_i}$$

$$\mu_e = 0.38 \text{ m}^2 \text{ volt}^{-1} \text{ sec}^{-1}$$

$$\mu_h = 0.18 \text{ m}^2 \text{ volt}^{-1} \text{ sec}^{-1}$$

$$\sigma_i = n_i e(\mu_e + \mu_h)$$

$$n_i = \frac{\sigma_i}{e(\mu_e + \mu_h)} = \frac{1}{e\rho_i(\mu_e + \mu_h)}$$

substituting the values we have

$$n_i = 2.38 \times 10^{19} \text{ m}^{-3}$$

T3 : Solution

(d)

$$D_e = \left(\frac{kT}{e} \right) \mu_e$$

$$D_h = \left(\frac{kT}{e} \right) \mu_h$$

$$D_e = \left(\frac{1.38 \times 10^{-23} \times 300}{1.6 \times 10^{-19}} \right) 0.17 = 44 \times 10^{-4} \text{ m}^2 \text{ sec}^{-1}$$

$$D_h = \left(\frac{1.38 \times 10^{-23} \times 300}{1.6 \times 10^{-19}} \right) 0.025 = 6.47 \times 10^{-4} \text{ m}^2 \text{ sec}^{-1}$$

T4 : Solution

$$\text{Hall effect voltage} = V_H = Bvd$$

$$V_H = \frac{B \times I}{\rho w} = \frac{B \times I}{w \times n \times e}$$

$$V_H = 150 \mu\text{V}, B = 1.2 \text{ tesla}, I = 50 \text{ A}, w = 0.5 \text{ mm},$$

$$\begin{aligned} n &= \frac{B \times I}{w \times e \times V_H} \\ &= \frac{1.2 \times 50}{0.5 \times 10^{-3} \times 1.6 \times 10^{-19} \times 150 \times 10^{-6}} \\ &= \frac{60}{120 \times 10^{-28}} = 0.5 \times 10^{28} / \text{m}^3 \end{aligned}$$

