

GUJARAT TECHNOLOGICAL UNIVERSITY**BE - SEMESTER-V (NEW) EXAMINATION – WINTER 2023****Subject Code:3152113****Date:13-12-2023****Subject Name:Functional Materials****Time:10:30 AM TO 01:00 PM****Total Marks:70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.
4. Simple and non-programmable scientific calculators are allowed.

		MARKS
Q.1	(a) How one can define the word functional for functional materials?	03
	(b) Based on what parameters one can decide to categorize the functional material? Classify it.	04
	(c) What are the different properties of functional materials? Describe mechanical properties.	07
Q.2	(a) With example show the two applications of functional materials.	03
	(b) List the bonds. Which bonds are mostly deals with the semiconducting materials?	04
	(c) Describe the band theory for semiconductor based on 4sp ³ hybridization.	07
OR		
	(c) How do structure-property correlations affect the functionality of functional materials? Discuss.	07
Q.3	(a) What is the Pauli Exclusion principle?	03
	(b) Differentiate between direct and indirect band gap semiconductors.	04
	(c) Derive the formula for the density of state for electrons in 3D unit for uniform potential.	07
OR		
Q.3	(a) What is dielectric strength? Where it is used?	03
	(b) Explain the principle of piezoelectricity.	04
	(c) Write an expression for the Fermi-Dirac Statistic and explain the energy state $E < E_F$, and $E > E_F$.	07
Q.4	(a) Define ferroelectricity. Give one example of it.	03
	(b) Draw the B-H curve for the magnetic materials.	04
	(c) Establish the relationship between Fermi Energy function and Boltzmann approximation for silver. Given $m_e = 9.1 \times 10^{-31}$ Kg, $h = 6.626 \times 10^{-34}$ Js, $E_F = 5.5$ eV, $T = 300$ K, density of silver = 10.49 g/cc, Avogadro's no. = 6.023×10^{23} mol ⁻¹ .	07
OR		
Q.4	(a) When does a dielectric become a conductor?	03
	(b) Derive an expression for the drift velocity of free electrons in a conductor.	04
	(c) There are 10 electrons in a slab that measures 0.5 (a) nm X 1 (b) nm X 2 (c) nm. Each electron in the slab can be represented by a set of 3 quantum no (n_1 n_2 n_3) which are greater than zero and are related to the energy of slab and slab dimensions. Given: $E = \frac{h^2}{8 m_e} \left(\frac{n_1^2}{a^2} + \frac{n_2^2}{b^2} + \frac{n_3^2}{c^2} \right)$.	07

- (a) Assign quantum no. to the electrons. (Given lower energy states (1 1 1); (1 1 2); (1 1 3); (1 2 1); (1 2 2) & (1 1 4).
- (b) Deduce E_F from the energy distribution of electron.
- (c) Determine density of state at E_F including spin,
- (d) What is the total kinetic energy of electrons in the slab?
- (e) What is the average kinetic energy of electrons in the slab?

- Q.5**
- (a) List the applications of optically active materials. **03**
 - (b) In a p-type germanium, $n_i = 2.1 \times 10^{19} \text{ m}^{-3}$ density of boron $4.5 \times 10^{23} \text{ atoms/m}^3$. The electron and hole mobility are 0.45 and $0.2 \text{ m}^2/\text{vs}$ respectively. What is the conductivity before and after the addition of boron atoms? **04**
 - (c) List the smart materials. What is the shape memory effect in shape memory alloy? Discuss its applications. **07**

OR

- Q.5**
- (a) Define conductivity and resistivity. **03**
 - (b) Differentiate between intrinsic and extrinsic semiconductors. **04**
 - (c) Write a note on applications of functional materials in storage applications. **07**
