24BVD1092

VIT

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

CHENNAI

Final Assessment Test(FAT) - NOV/DEC 2025

Programme	**B.Tech.**	Semester	**Fall Semester 2025-26**
Course Code	**BEVD101L**	Faculty Name	**Prof. Anisha Natarajan**
Course Title	**Electronic Materials**	Slot	**C1+TC1**
		Class Nbr	**CH2025260100500**
Time	**3 hours**	Max. Marks	**100**

Instructions To Candidates

- Write only your registration number in the designated box on the question paper. Writing anything elsewhere on the question paper will be considered a violation.
- Physical constants:
- Electronic charge: 1.602×10^{-19} C
- Mass of the electron in free space: 9.10939×10^{-31} kg
- Avogadro's number: 6.0221×10^{23} mol^{-1}
- Boltzmann constant: 1.3807×10^{-23} J K^{-1}
- Absolute permittivity: 8.8542×10^{-12} F/m
- Planck's constant: 6.6261×10^{-34} J s
- Absolute permeability: $4\pi \times 10^{-7}$ H/m

Course Outcomes

CO1: Learn and understand the concept of crystal structures and their defects.
CO2: Know the classical and quantum theory of materials.
CO3: Learn and understand the optical and thermal properties of materials.
CO4: Know the dielectric, ferroelectric, and magnetic properties of materials.
CO5: Understand the concept of superconductivity in materials.
CO6: Gain knowledge about various kinds of nanomaterials.

Section - I
Answer all Questions (1 × 10 Marks)

01. a) In chest radiology, a patient's chest is exposed to X-rays, and the X-rays passing through the patient are recorded on a photographic film to generate an X-ray image of the chest for medical diagnosis. The average wavelength of X-rays in chest radiology is about 0.02 nm. Numerous measurements indicate that the patient, on average, is exposed to a total radiation energy per unit area of roughly 0.1 μJ cm^{-2} for one chest X-ray image. Find the photon energy used in chest radiology, and the average number of photons incident on the patient per unit area (per cm^2). (5 marks)
b) Using necessary mathematical formulations, derive the one-dimensional time independent Schrodinger wave equation. (5 marks)

[10] (CO2/K3)

Section - II
Answer all Questions (6 × 15 Marks)

02. a) A diffraction analysis experiment is performed on a sample of BCC crystal structure on the plane (110). Given that the wavelength λ of the first order (n=1) X-ray, equals 1.54×10^{-10} m, the incidence angle of the X-ray $\theta = 19.3°$ and the atomic weight of the sample = 92.9 g/mol, calculate the atom radius and density of the sample. (9 marks)
b) Determine Miller indices of the planes A, B and C in Figure 1 given below. (6 marks)

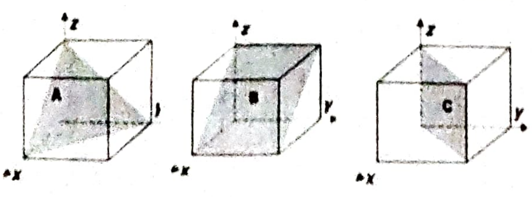

Figure 1

[15] (CO1/K4)

03. a) The electron drift mobility in silver has been measured to be 54 cm^2/Vs at 27 °C. The atomic mass and density of Ag are given as 107.87 amu or g/mol and 10.50 g/cm^3, respectively. Assuming that each Ag atom contributes one conduction electron, calculate the resistivity and thermal conductivity of Ag at 27 °C. Lorentz number is 2.44 $\times 10^{-8}\ W\Omega K^{-2}$. (8 marks)
b) What are the principal successes and failures of classical free electron theory of metals? (7 marks)

[15] (CO2/K4)

04. a) A ray of light which is traveling in a glass medium of refractive index n1 = 1.460 becomes incident on a less dense glass medium of refractive index n2 = 1.440. Suppose that the free-space wavelength λ of the light ray is 1400 nm, what should be the minimum incidence angle for total internal reflection? What is the phase change in the reflected wave for perpendicular polarization and penetration depth of the evanescent wave into medium 2 when $\theta_i = 85°$? (8 marks)
b) Using the concept of phonon density of states, explain in detail how the Debye's model can correctly predict the specific heat capacity of materials in low and high temperature regions. Validate your answer using necessary equations. (7 marks)

[15] (CO3/K4)

05. a) A solenoid is 0.4 m long and has a diameter of 0.6 m. It has a single layer of 1000 turns and carries a current of 0.5 mA. Find the magnetic field at the center of the solenoid and the value of magnetic moment. What will be the magnetic field if an iron core of relative permeability 6000 is inserted into the solenoid? (8 marks)
b) How does the magnetic field inside a solenoid change when an iron core is inserted into it? Explain your answer using appropriate diagrams and equations. (7 marks)

[15] (CO4/K3)

06. a) With appropriate diagrams, explain Meissner effect and the characteristic properties of a superconductor below its critical temperature. (8 marks)
b) The superconducting transition temperature of Lead is 7.2 K. The initial field at 0 K is 64 $\times 10^3$ A/m. Calculate the critical field at 5 K. At what temperature will the critical magnetic field of Lead drop to 45 $\times 10^3$ A/m? (7 marks)

[15] (CO5/K3)

07. a) Classify the quantum structures based on dimensional confinement of electrons. (3 marks)
b) Elaborate the applications of various nanomaterials in the following areas using appropriate diagrams.
i) Optoelectronics (4 marks)
ii) Medicine and biomedical imaging (4 marks)
iii) Energy (4 marks)

[15] (CO6/K2)

BL-Bloom's Taxonomy Levels - (K1-Remembering,K2-Understanding,K3-Applying,K4-Analysing,K5-Evaluating,K6-Creating)

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CHENNAI

Reg. No 24BVD1104

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Programme	B.Tech.	Semester	Fall Semester 2025-26
Course Code	BEVD101L	Faculty Name	Prof. Anisha Natarajan
Course Title	Electronic Materials	Slot	C2+TC2
		Class Nbr	CH2025260100501
Time	3 hours	Max. Marks	100

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Section - I
Answer all Questions (1 × 10 Marks)

01. a) Consider an electron confined to an infinite one-dimensional potential energy well of width 1 nm. Calculate the energies of the electron in the first three levels. Plot the possible wavefunctions and electron probability distributions corresponding to the first three energy levels. (5 marks)
b) How can quantum theory explain the existence of forbidden energy gaps between allowed energy levels? What is meant by Brillouin zone? (5 marks)

[10] (CO2/K3)

Section - II
Answer all Questions (6 × 15 Marks)

02. a) A real space lattice has a unit cell volume V_c and its reciprocal space unit cell volume is V_g. Show that $V_g \times V_c = 8\pi^3$ (5 marks)
b) The metal Niobium has a BCC crystal structure. If the angle of diffraction for the (211) set of planes occurs at 76° (first-order reflection) when monochromatic X-radiation having a wavelength of 0.1659 nm is used, compute:
(i) the interplanar spacing for this set of planes (5 marks)
(ii) Find the relationship between lattice constant and radius of the Niobium atom and estimate the atomic radius. (5 marks)

[15] (CO1/K4)

03. a) Calculate the free electron concentration, mobility and drift velocity of electrons in an Aluminium wire of length 5 m, resistance of 60 mΩ that carries a current of 15 A. Al has 3 free electrons. Atomic weight of Al = 26.98 grams per mole and density= 2.7×10^3 kg/m^3. The resistivity of Aluminium at room temperature is approximately 2.65×10^{-8} Ω m. (8 marks)

b) Calculate the magnitude of Hall voltage for a rectangular p-type semiconductor bar when the magnetic field $B = 0.5$ T, current $I = 3$ A, width of the sample $w = 2$ mm and the carrier concentration $n = 5 \times 10^{21}$ m^{-3}. (7 marks)

[15] (CO2/K4)

04. a) Consider a linear lattice with parameter a formed by identical atoms of mass m. Each atom is submitted to a force (spring) constant β by nearest neighbors. Find the equation of motion governing the displacement of atom n. Calculate the dispersion relation $\omega(K)$ for the lattice waves using a plane wave solution, where K is the wave vector. (7 marks)

b) Spectroscopic ellipsometry measurements on a silicon crystal at a wavelength of 620 nm show that the real and imaginary parts of the complex relative permittivity are 15.2254 and 0.172, respectively. Find the complex refractive index. What is the reflectance at this wavelength for normal incidence? What is the phase velocity? (8 marks)

[15] (CO3/K4)

05. a) The following experimental observations were made related to certain magnetic materials. Read these observations carefully and identify the reason for the same. Explain in detail.

i) Placing a watch glass of water over the poles of a strong magnet causes the water's surface to depress between the poles, where the field is strongest, as the water is repelled. (3 marks)

ii) Liquid oxygen, when poured between the poles of a strong magnet, is weakly attracted and hangs as if suspended in the field. (3 marks)

iii) Stroking a large iron nail with a strong magnet aligns the magnetic domains within the nail. The nail can then attract other small objects, like paper clips. (3 marks)

b) A solid material has a total polarizability of 2.4×10^{-40} F m^2 per atom. The density of the material is 2.7×10^3 kg m^{-3}, and its molar mass is 27 g/mol. Calculate the relative permittivity of the material. (6 marks)

[15] (CO4/K4)

06. a) What is a Josephson junction? Explain how a constant supercurrent can flow through a Josephson junction. (7 marks)

b) The critical field for Niobium is 1×10^5 A/m at 8 K and 2×10^5 A/m at absolute zero. Find the transition temperature of this element. (8 marks)

[15] (CO5/K3)

07. a)What is meant by Quantum confinement? Explain its key characteristics. (8 marks)

b)How does quantum confinement affect the energy levels and optical properties of nanomaterials? (7 marks)

[15] (CO6/K2)

BL-Bloom's Taxonomy Levels - (K1-Remembering,K2-Understanding,K3-Applying,K4-Analysing,K5-Evaluating,K6-Creating)

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