International Islamic University Chittagong

Department of Electrical and Electronic Engineering

B.Sc. Engineering in EEE

Midterm Examination, Spring 2024

Course Code: **EEE 3515** Course Title: **Electrical Properties of Materials**

Time: 1 hour 30 minutes Full Marks: 30

(i) Answer all the questions. The figures in the right-hand margin indicate full marks.

(ii) Course Outcomes (COs) and Bloom's Levels (BL) are mentioned in additional Columns.

Course Outcomes (Cos) of the course	
COs	**CO Statements (*At the end of the course, students will be able to*)**
CO1	**Reflect** a basic understanding of crystal structure, lattice geometry, quantum mechanical behavior of electrons, molecular orbital theories.
CO2	i) **Determine** Miller indices, Crystal directions and planar concentration of crystals. ii) **Apply** the concept of dielectric and magnetic material properties and their applications to determine various dielectric constants.
CO3	**Demonstrate** the working principle of superconductor and their applications.

Bloom's Levels (BL) of the Questions						
Letter Symbols	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**
Meaning	Remember	Understand	Apply	Analyze	Evaluate	Create

1.	(a)	Distinguish between FCC, BCC and HCP structure in terms of the number of atoms, effective number of atoms, coordination number, atomic packing factor, and figure of the crystal structure.	CO2	C2	5
1.	(b)	i. What do you understand by planar concentration? ii. Determine the planar concentration of (110) and (111) of a Cu FCC crystal.	CO2	C3	5
		OR			
1.	(a)	i. What is the significance of Miller indices, and how can one determine the Miller indices of a plane? ii. Draw the plane for the Miller indices of (210) and (040) plane.	CO2	C2	5
1.	(b)	Is the statement 'The Miller indices for parallel planes cannot be the same unless they are separated by the unit cell parameter' true or false? Explain your logical justifications in writing, including any required figures.	CO2	C3	5
2.	(a)	Explain Matthiessen's rule for explaining different scattering mechanisms with the symbolic meaning and prove that $\rho=T+I$. Also, discuss the residual resistivity for other scattering mechanisms.	CO1	C2	4+1
2.	(b)	Calculate the drift mobility and mean scattering time of conduction electrons in copper at room temperature, given that the conductivity of copper is $5.9\times10^5\ \Omega^{-1}\ cm^{-1}$. The density of copper is 8.96 g cm^{-3} and its atomic mass is 63.5 g mol^{-1}. If the mean speed of the conduction electrons in Cu is roughly 1.6×10^6 m s^{-1}, what is the mean free path between collisions?	CO1	C5	5

3.	(a)	i. "Increasing the intensity of light (for the same frequency) does not increase the kinetic energy, but rather the number of electrons with the same kinetic energy"- Explain this statement using Einstein's interpretation of the photoelectric effect, with suitable diagrams.	CO2	C4	5
		ii. A golf ball is travelling at a velocity of 20 ms^{-1}. Find the wavelength of the ball. Is it possible to get diffraction pattern by firing a stream of golf ball towards a wall?			
3.	(b)	In the photoelectric experiment, green light with a wavelength of 522 nm is the longest wavelength of radiation that can cause the photoemission of electrons from a clean sodium surface.	CO1	C5	5
		i. What is the work function of sodium, in electron volts?			
		ii. If UV (ultraviolet) radiation with a wavelength of 250 nm is incident on the sodium surface, what will be the kinetic energy of the photoemitted electrons in electron-volts?			
		iii. Suppose the UV light with a wavelength of 250 nm has an intensity of 20 mW cm^{-2}. If the emitted electrons are collected by applying a positive bias to the opposite electrode, what will be the photoelectric current density?			