Uva Wellassa University, Sri Lanka
End Semester Examination – September 2011

SCT 343-2 Functional Properties of Materials

Time: Two (02) hours

Total **06** Questions
This question paper contains three parts as Part A, Part B and Part C
Answer only **four (04)** questions **selecting at least one question** from each of the part

PART A

01). i. Make schematic representation to distinguish the differences in electron energy band structure among metals, semiconductors and insulators.

ii. Calculate the number of free electrons per cubic meter for a metal, assuming that there are 0.9 free electrons per each metal atom. The electrical conductivity and density of this metal are 9×10^7 $(\Omega\text{-m})^{-1}$ and 6.6 g/cm^3, respectively. What is the electron mobility of this metal? The magnitude of the electron charge is 1.6×10^{-19} C and the Avogadro's number is 6.022×10^{23} mol^{-1}.

iii. What does the term *doping* mean in semiconductor terminology? Name two common methods of doping.

iv. High-purity silicon is doped with 10^{20} m^{-3} of arsenic atoms. Arsenic is a group VA element. Will this arsenic doped silicon be n-type or p-type? If the magnitude of the electron charge is 1.6×10^{-19} C and the electron mobility at room temperature is 0.12 m^2/Vs, calculate the room-temperature electrical conductivity of this material.

(25 marks)

02). i. List the three main mechanisms of polarization.

ii. For solid lead titanate ($PbTiO_3$) what kinds of polarization are possible? Explain your answer.

iii. Make a rough sketch to show the variation of the dielectric constant of a dielectric material with the frequency of an alternating electric field.

iv. A dielectric material having a dielectric constant of 117 is positioned within a parallel-plate capacitor having an area of 3.5×10^{-4} m^2 and a plate separation of 5.0×10^{-4} m. If a potential of 20 V is applied across this capacitor, c ulate the *capacitance*, the *magnitude of the charge stored on each plate* and th *dielectric displacement.* Note that the dielectric permittivity in vacuum is 8.85×10^{-12} F/m.

(25 marks)

PART B

03). i. From an electronic perspective note and briefly explain the two sources of magnetic moments in materials.

ii. Briefly explain the nature and source of diamagnetism, paramagnetism and ferromagnetism.

iii. How the temperature influence on magnetic behavior of materials.

iv. What is saturation magnetization?

v. Compute the *saturation magnetization* and the *saturation flux density* for cobalt, which has a net magnetic moment per atom of 1.72 Bohr magnetons and a density of 8.90 g/cm^3.

(25 marks)

04). i. Describe magnetic hysteresis and why it occurs for ferromagnetic and ferrimagnetic materials.

ii. Schematically sketch on a single plot the *B*-versus-*H* behavior for a ferromagnetic material at 0 K, at a temperature just below its Curie temperature, and at a temperature just above its Curie temperature. Briefly explain why these curves have different shapes.

iii. Note the distinctive magnetic characteristics for both soft and hard magnetic materials.

iv. The following data are for a transformer steel:

H (A/m)	B (teslas)	H (A/m)	B (teslas)
0	0	200	1.04
10	0.03	400	1.28
20	0.07	600	1.36
50	0.23	800	1.39
100	0.70	1000	1.41
150	0.92		

(a) Construct a graph of *B* versus *H*.
(b) What are the values of the initial permeability and initial relative permeability?
(c) What is the value of the maximum permeability?

(25 marks)

PART C

05). i. Distinguish are opaque, translucent, and transparent materials in terms of their appearance and light transmittance.

ii. The index of refraction of Al_2O_3 is anisotropic. Suppose that visible light is passing from one grain to another of different crystallographic orientation and at normal incidence to the grain boundary. Calculate the reflectivity at the boundary if the indices of refraction for the two grains are 1.757 and 1.779 in the direction of light propagation.

iii. Describe the main atomic and electronic interactions related to optical phenomena?

iv. The transmissivity T of a 20 mm thick transparent material to normally incident light is 0.85. If the index of refraction of this material is 1.6, compute the thickness of material that will yield a transmissivity of 0.75. All reflection losses should be considered.

(25 marks)

06). Briefly describe the following phenomena.

i. Luminescence.
ii. Photoconductivity.
iii. Laser.
iv. Optical fibers in communication.

(25 marks)

8