Uva Wellassa University of Sri Lanka
Faculty of Science and Technology
Department of Science and Technology
300 level 2nd Semester Examination – Jan 2019
SCT 354-2 Functional Properties of Materials

Instructions to candidates
Duration: 02 hours
Number of questions: 4 Essay Questions
Mark allocation: 400 marks
Answer all questions.
Scientific calculators are allowed. Index No:

Planck's constant, $h = 6.63 \times 10^{-34}$ J s, Electric permittivity of a vacuum, $\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}, Magnetic permeability of a vacuum, $\mu_o = 1.26 \times 10^{-6}$ H m^{-1}, Speed of light, $c = 3 \times 10^{-8}$ m s^{-1}

1.

i. Write down the Ohms law.

(20 marks)

ii. Prove that the current density (J) is given by, $J = \sigma E$ where, σ is the conductivity and E is the electric field intensity.

(20 marks)

iii. The electrical resistivity of a binary-phase metal alloy is 3.2×10^{-7} Ω m and mass fractions of two phases in the alloy are equal. The density and electrical resistivity of the 1st phase is 8.0 g cm^{-3} and 4.1×10^{-7} Ω m respectively. The density of the 2nd phase is 6.0 g cm^{-3}.

a. What is the electrical resistivity of the 2nd phase?
b. What is the conductivity of the alloy?
c. A cylindrical pellet with a diameter of 1 cm and length of 2 cm is prepared by using the above mentioned alloy. What is the resistance of the pellet?
d. What would be the current flow if the potential difference between two ends of the pellet is 0.01 V?
e. What is the current density?
f. What is the magnitude of the electric field across the ends of the pellet?

(60 marks)

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2. A semiconductor diode is prepared by adding small quantities of phosphorus and boron to adjacent layers of a crystal of silicon.

(i) What happens to the charge carrier concentration and the electrical conductivity of silicon after adding phosphorus or boron?

(10 marks)

(ii) Using relevant figures, explain how the presence of phosphorus and boron modify the conductivity in silicon.

(30 marks)

(iii) Explain the (electrical) behavior close to the boundary of the two adjacent layers prepared by adding phosphorus and boron.

(10 marks)

(iv) What happens when a p-n junction diode is forward biased?

(20 marks)

(v) What happens when a p-n junction diode is reverse biased?

(20 marks)

(vi) Name two applications of a p-n junction diode.

(10 marks)

3.

i. What are the types of magnetism?

(25 marks)

ii. Show the behavior of different types of magnetisms on a schematic graph of magnetic flux density (***B***) versus magnetic field strength (***H***).

(25 marks)

iii. Derive the relationship between magnetic susceptibility and relative permeability respectively.

(20 marks)

iv. The magnetization (***M***) of a metal alloy is 4.1×10^3 A m^{-1} under an ***H*** field of 48 A m^{-1}. What is the magnetic susceptibility (χ_m) of the alloy?

(15 marks)

v. What is the relative permeability μ_r of the alloy?

(15 marks)

4.

i. Prove that materials having bandgap energies greater than 3.1 eV are transparent to the visible light (wavelength 400-700 nm)

(20 marks)

ii. What is the maximum bandgap energy of a material that all the spectrum of visible light can be absorbed?

(10 marks)

iii. The fraction of non-reflected light that is transmitted through a 200 mm thickness of glass is 0.98. Calculate the absorption coefficient of this material.

(20 marks)

iv. Diamond has a dielectric constant (ε_r) of 5.5 and a magnetic susceptibility of -2.17×10^{-5} at frequencies within the visible range.

   a. Compute the velocity of light in diamond.

   b. What can you say about the magnetic behavior of Diamond?

(20 marks)

v. The transmissivity (T) of a transparent material with a thickness of 15 mm to normal incident light is 0.80. If the index of refraction of this material is 1.5, calculate the thickness of material that gives a transmissivity of 0.70. All reflection losses should be considered.

(30 marks)