Uva Wellassa University, Sri Lanka
End Semester Examination - September 2012
SCT 343-2 Functional Properties of Materials

Time: Two (02) hours

Total 05 Questions
Answer **four (04)** questions only

01). i. With the help of schematic representations of electron energy band structures, briefly distinguish the differences in electrical conductivity between metals and insulators.

ii. Write down the expression for the *total resistivity* of a material as described by the Matthiessen rule.

iii. Explain the term *precipitation hardening* (age hardening) in materials technology.

iv. What will happen to the electrical conductivity of a metallic material if the material is cooled through its melting temperature at an extremely rapid rate to form a noncrystalline solid? Explain your answer.

v. Calculate the number of free electrons per cubic meter for a pure metal, assuming that there are 0.7 free electrons per each metal atom. The electrical conductivity, density and molar mass of this metal are 8×10^7 $(\Omega\text{-m})^{-1}$, 8.96 g/cm^3, 63.5 g/mol respectively. What is the electron mobility of this metal? The magnitude of electronic charge is 1.6×10^{-19} C and the Avogadro's number is 6.023×10^{23}.

(25 Marks)

02). i. What does the term *doping* mean in semiconductor industry?

ii. With the help of schematic representations of electron energy band structures, briefly explain the formation of donor and acceptor states, respectively, in n-type and p-type extrinsic semiconductors.

iii. High-purity germanium is doped with 3.5×10^{22} m^{-3} of boron atoms. If boron is a group IIIA element, will this boron doped germanium 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 0.058 m^2/Vs, calculate the room temperature electrical conductivity of this extrinsic semiconductor.

iv. Make a rough sketch to show the variation of *intrinsic carrier concentration* with *temperature* for silicon and germanium.

v. Name the two main factors that adversely affect the magnitude of carrier mobility of a semiconductor.

(25 Marks)

03). i. What does the term *dielectric strength* mean?

8

ii. List the three main mechanisms of polarization taking place in dielectric materials.

iii. Write down the expression for the *total polarization* for a dielectric material, comprised of all these three main mechanisms.

iii. A dielectric material having a dielectric constant of 1876 is positioned within a parallel-plate capacitor having an area of 2.9 cm^2 and a plate separation of 0.35 mm. If a potential of 6 V is applied across this capacitor, calculate the *capacitance*, the *magnitude of the charge stored on each plate* and the *dielectric displacement.* Note that the dielectric permittivity in vacuum is 8.85×10^{-12} F/m.

v. What are *ferroelectric materials*? Explain this using *barium titanate* as an example.

(25 Marks)

04). i. State the expression relating the *transmissivity* (T), *absorptivity* (A) and *reflectivity* (R), (the fractions of light transmitted, absorbed, and reflected by a material).

ii. Distinguish the difference between the *transparency, translucency* and *opaqueness* of materials.

iii. Express the relationship between the *index of refraction* and the *dielectric constant* for nonmagnetic transparent materials. If the refractive index of dense optical flint glass is 1.65, estimate its dielectric constant.

iv. Accordingly, explain how the addition of large ions (such as Ba or Pb) to a glass will increase the refractive index of the material significantly.

v. Furthermore discuss briefly the effectiveness of surface coating of lenses by dielectric materials to minimize reflection losses.

(25 Marks)

5). i. With the help of schematic representations, very briefly explain the absorption and emission mechanisms in nonmatalic materials.

ii. Compute the corresponding maximum and minimum band gap energy values for which absorption of visible light is possible. The minimum and maximum wavelengths for visible light are 400 nm and 700 nm, respectively. Plank's constant is 4.13×10^{-15} eVs and the velocity of light in vacuum is 3×10^8 m/s.

iii. Based on the band gap energy values calculated above, explain why some materials are opaque and some other materials are colourless under the visible light

iv. Why cadmium sulfide with a band gap of 2.4 eV, appears yellow-orange in colour?

v. What determine the characteristic colour of a transparent material?

(25 Marks)