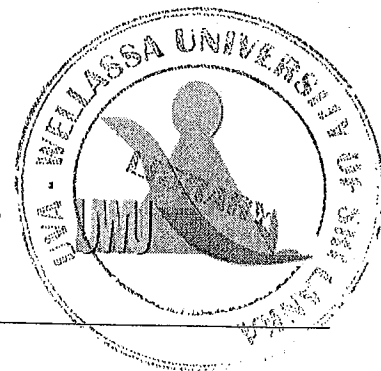


Uva Wellassa University, Sri Lanka  
End Semester Examination – July 2010  
CHE 354-2 Functional Properties of Materials

- Repeat -

Time: Two (02) hours



Total 05 Questions

Answer four (04) questions only

- 1).
  - i. List two mechanisms of thermal energy absorption responsible for the total heat capacity of a solid.
  - ii. Draw a rough sketch to show the temperature dependence of the heat capacity at constant volume ( $C_v$ ) for a solid material.
  - iii. Very briefly explain why metals are typically better thermal conductors than ceramic materials.
  - iv. A machine part is made from a metal rod with its axial motion restrained by rigid end supports. If the metal rod is stress free at  $27^\circ\text{C}$ , what is the maximum temperature to which the rod can be heated without exceeding a compressive stress of 180 MPa. For this metal, the modulus of elasticity is  $1 \times 10^{11}$  Pa and the magnitude of the linear coefficient of thermal expansion is  $2.0 \times 10^{-5} \text{ }^\circ\text{C}^{-1}$ .
- 2).
  - i. Briefly distinguish the difference between the *intrinsic semiconductors* and *extrinsic semiconductors*.
  - 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. What does the term *doping* mean in semiconductor industry? List two common methods of doping.
  - iv. High-purity silicon is doped with  $10^{23} \text{ m}^{-3}$  of arsenic atoms. Arsenic being a group VA element, will this arsenic doped silicon be n-type or p-type? If the magnitude of the electron charge is  $1.6 \times 10^{-19} \text{ C}$  and the electron mobility at room temperature is  $0.07 \text{ m}^2/\text{Vs}$ , calculate the room-temperature electrical conductivity of this material.
- 3).
  - i. List the three main mechanisms of polarization.
  - ii. With the help of a rough sketch, very briefly explain the mechanism by which charge storing capacity is increased by the insertion of a dielectric material within the plates of a capacitor.

- iii. A dielectric material having a dielectric constant of 85 is positioned within a parallel-plate capacitor having an area of  $8.3 \times 10^{-4} \text{ m}^2$  and a plate separation of  $2.7 \times 10^{-4} \text{ m}$ . If a potential of 12 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  $8.85 \times 10^{-12} \text{ F/m}$ .
- iv. What does the term *dielectric loss* mean?
- 4). i. Visible light having a wavelength of 600 nm appears orange. Compute the frequency and energy of a photon of this light. Note that the velocity of light in vacuum is  $3 \times 10^8 \text{ m/s}$  and Plank's constant is  $4.13 \times 10^{-15} \text{ eVs}$ .
- ii. Briefly describe the absorption and emission mechanisms in metallic materials with the help of a schematic representation.
- iii. What determines the characteristic colors of metals?
- iv. Briefly explain the reason for bright silvery appearance of aluminum and silver metals.
- 5). i. What are the two main consequences of electronic polarization in transparent materials?
- ii. Compute the corresponding maximum and minimum band gap energy values for which absorption of visible light is possible. Assume that the minimum and maximum wavelengths for visible light are 400 nm and 700 nm, respectively. Plank's constant is  $4.13 \times 10^{-15} \text{ eVs}$  and the velocity of light in vacuum is  $3 \times 10^8 \text{ m/s}$ .
- iii. Are the elemental semiconductors silicon (Si) and germanium (Ge) transparent to visible light? The band gap energies for Si and Ge are 1.11 eV and 0.67 eV, respectively. Explain your answer.
- iv. With a rough sketch of the *transmittance as a function of wavelength* for sapphire and ruby, explain why ruby has red tint color while sapphire appears colorless.