

Uva Wellassa University, Sri Lanka
End Semester Examination – June 2009
CHE 354-2 Functional Properties of Materials



Time: Two (02) hours

09-380-CHE 354-2

Total 05 Questions

Answer four (04) questions only

- 01). I. 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.
- II. For intrinsic gallium arsenide (GaAs), the room-temperature electrical conductivity is $10^{-6} (\Omega\text{-m})^{-1}$; the electron and hole mobilities are, respectively, 0.85 and $0.04 \text{ m}^2/\text{V}\cdot\text{s}$. Calculate the intrinsic carrier concentration of GaAs at room temperature. The magnitude of the charge of an electron is $1.6 \times 10^{-19} \text{ C}$.
- III. Will Zn act as a donor or acceptor when it is added to the compound semiconductor GaAs? (Zn is from group IIB and assume that Zn is a substitutional impurity). Very briefly explain your answer.
- IV. If a metallic material is cooled through its melting temperature at an extremely rapid rate, it will form a noncrystalline solid. Will the electrical conductivity of the noncrystalline metal be greater or less than its crystalline form? Very briefly explain your answer.
- (25 Marks)
- 02) I. With the help of schematic representation, explain the three main mechanisms of polarization.
- II. For solid lead titanate (PbTiO_3) what kinds of polarization are possible? Explain your answer.
- III. What do the terms *dielectric strength* and *dielectric loss* mean?
- IV. A potential of 10 V is applied across a parallel-plate capacitor of area of 500 mm^2 and a plate separation of 2.5 mm. If a material having a dielectric constant of 7.0 is positioned within the region between the plates, compute the capacitance, the dielectric displacement and the polarization.
- (25 Marks)
- 03). I. Briefly describe the phenomenon of electronic polarization by electromagnetic radiation.
- II. Distinguish between materials that are opaque, translucent, and transparent in terms of their appearance and light transmittance.

- III. The minimum and maximum wavelengths for visible light are about $0.4 \mu\text{m}$ and $0.7 \mu\text{m}$, respectively. Calculate the corresponding maximum and minimum band gap energy values for which absorption of visible light is possible. Note that the velocity of light in vacuum is $3 \times 10^8 \text{ m/s}$ and the Planck's constant is $4.13 \times 10^{-15} \text{ eVs}$.
- IV. Metals are generally opaque to visible light. However, they are transparent to high-frequency x-ray and γ -ray radiation? Briefly explain your answer. (25 Marks)
- 04). I. With the help of schematic representation very briefly describe the absorption and emission mechanisms in nonmetallic materials.
- II. Briefly explain why the magnitude of the absorption coefficient depends on the radiation wavelength
- III. The fraction of nonreflected radiation that is transmitted through a 10 mm thickness of a transparent material is 0.85. If the thickness is increased to 25 mm, what fraction of light will be transmitted?
- IV. Explain why the ruby has red tint color while sapphire appears colorless. (25 Marks)
- 05). I. Draw a rough sketch to the potential energy versus inter-atomic distance to demonstrate the increase in inter-atomic separation of a solid with rising temperature. Explain the phenomena.
- II. Very briefly explain why metals are typically better thermal conductors than ceramic materials
- III. For a ceramic material, is thermal shock more likely to occur on rapid heating or cooling? Explain your answer.
- IV. A machine part is made from a brass rod with its axial motion restrained by rigid end supports. If the brass rod is stress free at 25°C , what is the maximum temperature to which the rod can be heated without exceeding a compressive stress of 180 MPa. For brass, the modulus of elasticity is 98 GPa and the magnitude of the linear coefficient of thermal expansion is $21.0 \times 10^{-6} \text{ }^\circ\text{C}^{-1}$. (25 Marks)