MATRL 100A: Structure and Properties I, Assignment 7. Due on Wednesday, December 6th.

Chapter 19

1. To what temperature would 15 kg of aluminum be raised if it started at 25°C and 900 kJ of heat is supplied. The specific heat of aluminum is $0.897 \, \mathrm{J \, g^{-1} \, K^{-1}}$.

2. You need to fit a 10.00 mm steel ball bearing into a 9.95 mm diameter circular hole in an aluminum plate. To what temperature can you heat both the bearing and the plate such that the bearing just fits into the hole in the plate? The initial measurements are made at 25°C, and the linear thermal expansion coefficients of steel and aluminum are $12.3 \times 10^{-6} \, \mathrm{°C^{-1}}$ and and $23.1 \times 10^{-6} \, \mathrm{°C^{-1}}$ for steel and aluminum respectively.

3. For each of the following pairs of materials, decide which has the larger thermal conductivity. Justify your choices.

   (a) Pure silver or sterling silver (92.5 wt% Ag-7.5 wt% Cu)

   (b) Fused (amorphous) silica or polycrystalline silica

   (c) Linear and syndiotactic poly(vinyl chloride) (DP = 1000) or linear and syndiotactic polystyrene (DP = 1000)

   (d) Atactic polypropylene ($M_w = 10^6 \, \mathrm{g \, mol^{-1}}$) or
   isotactic polypropylene ($M_w = 10^5 \, \mathrm{g \, mol^{-1}}$)

Chapter 18

4. Compute the electrical conductivity of a 1.5 mm diameter cylindrical silicon specimen 50 mm long in which a current of 0.15 A passes in an axial direction. A voltage drop of 45 V is measured across the specimen.

5. Sketch a plot of carrier concentration *vs* temperature for extrinsic and intrinsic silicon (don't indicate any absolute numbers). Label the dopant concentration on the extrinsic curve.

   (a) Which material has a higher conductivity?

   (b) How does the difference in conductivity change with temperature?

6. Sketch rough diagrams (similar to figure 18.4 in Callister) of the band structure for the material groups below. Label the conduction band, valence band, band gap (if present), and Fermi energy in your diagrams.

   (a) Metals

   (b) Insulators

    (c) Intrinsic semiconductor

    (d) n-doped semiconductor

    (e) p-doped semiconductor

Chapter 21

7. Photons with a frequency of $400\,\text{THz}$ ($T = \text{tera} = 10^{12}$) are in the infrared range. Calculate the wavelength and energy of this light.

8. A $1\,\text{mm}$ thick silicon carbide (SiC) wafer is placed in the path of a near-UV laser beam with wavelength $410\,\text{nm}$ at normal incidence. At this wavelength, SiC has a refractive index of 2.75 and absorption coefficient of $10\,\text{cm}^{-1}$. If the surrounding medium is air, calculate the fraction of light that is reflected, absorbed, and transmitted.