HW#11 due December 4

1. The constant A in Equation 19.2 $C_V = AT^3$ is $12\pi^4 R / 5\theta_D^3$, where R is the gas constant and θ_D is the Debye temperature (K). Estimate θ_D for aluminum, given that the specific heat is 4.60 J/kg-K at 15 K. The atomic weight of Al is 26.98 g/mol.

2. When a metal is heated, its density decreases. There are two sources that give rise to this decrease of ρ: (1) the thermal expansion of the solid and (2) the formation of vacancies (Section 4.2). Consider a specimen of gold at room temperature (20°C) that has a density of 19.320 g/cm^3.

(a) Determine its density upon heating to 800°C when only thermal expansion is considered.

(b) Repeat the calculation when the introduction of vacancies is taken into account. Assume that the energy of vacancy formation is 0.98 eV/atom and that the volume coefficient of thermal expansion, α_v is equal to $3\alpha_l$. α_l for gold is 14.2×10^{-6} $(°C)^{-1}$.

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

(a) Pure silver; sterling silver (92.5 wt% Ag–7.5 wt% Cu)

(b) Fused silica; polycrystalline silica

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

(d) Atactic polypropylene ($\overline{M}_w = 10^6$ g/mol); isotactic polypropylene ($\overline{M}_w = 10^5$ g/mol)

4. (a) Briefly explain why thermal stresses may be introduced into a structure by rapid heating or cooling.

(b) For cooling, what is the nature of the surface stresses?

(c) For heating, what is the nature of the surface stresses?