ECE215A/Materials206A Winter 2008
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Homework 1

1. From a good table of materials properties, find the highest and lowest values of the following quantities for *elemental solids* at or near 300 K:
(a) Compressibility in unit is Pa^{-1}.
(b) Bulk expansivity (or CTE) in unit of T^{-1}.
(c) Thermal conductivity at 300 K in unit of W/m-K.
(d) Electrical conductivity in units of S/m.

2. An ideal gas and a block of copper have equal volumes of 0.5 m^3 at 300 K and 1 atm pressure. The hydrostatic pressure on both is increased adiabatically and isothermally at 5 atm.
(a) In which process is the work greater?
(b) Find the work done on each sample if the compressibility of the copper is $0.7 \times 10^{-6}\ atm^{-1}$.
(c) Calculate the change in volume for each sample.
(Clues: treat the gas as being "ideal", such that PV=NRT where N is the number of moles and R is the ideal gas constant R = 8.31 J/mole-K.

3. A 1 cm^3 of copper and 1 cm^3 of crystalline Si are heated from 300 to 400 K.
(a) What change of hydrostatic pressure would be required to keep the volume of each constant?
(b) Given the constant volume, what would the total heat input δQ for each cube be?
(c) What change of volume would be required to keep the hydrostatic pressure constant?
(Clues: assume bulk expansivities: copper $\beta = 55 \times 10^{-6} / K$; for Si $\beta = 8.4 \times 10^{-6} / K$; specific heat capacities: Cu = 387 J/kg-K, Si = 700 J/kg-K; for Si $\kappa = 1.0 \times 10^{-6}\ atm^{-1}$).

4. Evaluate the maximum energy stored per unit volume and polarization (electric dipole moment per unit volume) in a parallel-plate capacitor filled with SiO_2 (glass), assuming $\varepsilon_r = 4.0$ and a maximum sustainable electric field of $5.0 \times 10^5\ V / cm$.

5. (Good exercise in statistical mechanics). A two-dim solid at temperature T is in the form of a square lattice with nominal neutral atoms having an occasional defect. The defect consists of a negatively charged impurity ion that substitutes a normal atom (i.e. substitutional impurity) and a positively charged smaller impurity ion that goes into the lattice interstitially mid-way to the next-nearest neighbors of the square lattice. Assume that the positive ion is small enough to occupy any of the four interstitial sites with equal probability in the absence of external forces. Now apply an electric field along the as shown to the right, and assuming that Maxwell-Boltzman statistics are valid.
   (a) Formulate the new probability of occupancy at each interstitial site.
   (b) Calculate the new occupancy probability for each state assuming a = 3.0 Ang, $E = 1.0 \times 10^8\ V / m$ and T = 300 K (note: $k_B = 1.38 \times 10^{-23}\ J / K$.