**1. An aluminum wire 10 m long must experience a voltage drop of less than 1.0 V when a current of 5 A passes through it. Using data from Table 18.1 of the text or elsewhere, determine the minimum diameter of the wire required.**

V = IR (equation 18.1), = RA/lw (equation 18.2). Combining and rearranging gives V = I lw /A, or A = I lw /V. Since A= d2/4, and =3.8 107 (-m)-1 for Aluminum (Table 18.1), (=1/) solving for d given V=1 V, I=5 A gives d = 4.1 mm

**2. a) Using the data from Figure 18.8 in the text, determine the values of o and a from Equation 18.10 (t = o + aT) for pure copper. Take the temperature T to be in degrees Celsius.**

**b) Determine the value of A in equation 18.11 (o = A ci(1-ci)) for nickel as an impurity in copper, using the data in Figure 18.8.**

**c) Using the results of parts (a) and (b), estimate the electrical conductivity of copper containing 2.50 at% Ni at 120 C.**

For pure copper in Figure 18.8, values for resistivity for pure copper (bottom curve) are rest = {{-175,5/12},{-150,7/12},{-100,11/12},{-50,15.5/12},{0,20/12},{50,24/12}}, for T in C and resistivity in 10-8 Ohm m. Plotting on a line: ListPlot[rest]

Fitting to a line: line = Fit[rest, {1,x},x] gives line = 1.66+0.0071 T (10-8 Ohm m)

Plotting both together shows good fit:



From data of resistivity as a function of composition at some temperature, again look at Figure 18.8. At -100 C (although contribution seems to be nearly independent of T), determine values of impurity contribution i to resistivity:

resi = {{0,0},{0.0112,16.5/12},{0.0216,31/12},{0.0332,46/12}}

ListPlot[resi]

Fitting to the expected relationship a x (1-x):

linei=FindFit[resi,a x(1-x),{a},x]

gives a = 120.6

Plotting to verify:



So total = t + i + d

ignoring d (evidently = 0 for this problem) and substituting from above gives

total = 0 + aT + A ci (1-ci) = 1.66 + 0.0071 T + 120.6 ci (1-ci)

So for T = 120 C, ci = 0.025, expression gives: total = 5.45 (10-8 Ohm m) at 120 C , ci = 2.5 at% Ni

**3. At room temperature, the electrical conductivity of PbS is 25 (-m)-1, and the electron and hole mobilities are 0.06 and 0.02 m2/V-s, respectively. Calculate the intrinsic carrier concentration for PbS at room temperature.**

 = n e e + p e h (equation 18.13). If intrinsic, n=p, so

25 (-m)-1 = n e (0.06 m2/V-s) + n e (0.02 m2/V-s)

basic charge e=1.6 10-19 C

Solving for n = p = 1.95 x 1021 / m3

**4. The room temperature electrical conductivity of a silicon specimen is found to be**

**500 (-m)-1. The hole concentration is known to be 2 x 1022 m-3. Using the electron and hole mobilities for silicon in Table 18.3, compute the electron concentration. Is this specimen an intrinsic, n-type extrinsic, or p-type extrinsic semiconductor?**

500 (-m)-1 = n e e + p e h. From Table 18.3, e = 0.145 m2/V-s, and h = 0.05 m2/V-s. p is given in problem, so second term in expression is = 160 (-m)-1. That means first term = 340 (-m)-1. Given value of e, solving for n gives 1.46 x 1022 /m3. Since this is just slightly less than p, sample is a lightly p-doped extrinsic semiconductor.

**5. At temperatures between 540 C and 727 C the activation energy and pre-exponential for the diffusion coefficient of Na+ in NaCl are 170,000 J/mol and 4 x 10-4 m2/s, respectively. Calculate the mobility for an Na+ ion at 600 C.**

D = D0 exp(-Q/RT), so 4 10-4 m2/s (exp(-170000 J/(8.314 J) /(600+273 K)) = 2.69 10-14 m2/s.

So I = nI e DI/kT. nI = 1 (monovalent), so l = 3.57 10-13 m2/s. Solution to give correct units requires looking up value of k = 1.38 10-23 J/K = 1.38 10-23 m2 kg/(s2 K), and C = kg m2/(V s2).

**6. Consider a parallel-plate capacitor having an area of 3200 mm2, a plate separation of 1 mm, and a material with a dielectric constant of 3.5 positioned between the plates.**

**a) What is the capacitance of this capacitor?**

**b) What voltage would be required to have 2 x 10-8 C of charge stored on each plate?**

C = 0 r A/l (from equations 18.26 and 18.27). 0 is 8.85 10-12 Farad/m (from Wikipedia, inside front cover of text). So C = 2.41 10-9 Farad. V=Q/C = 2 10-8/(2.41 10-9 Farad = C/V) = 8.3 Volts