ECE 113A
Professor Burke (15400) Section A
Homework #2 Solutions and Grading Criteria

1) A thin metal resistor as shown in the figure below has a resistance of 1kO. It is 1mm long, 10 µm wide, and 1 µm thick.

a) Calculate the resistivity (?), in units of O-m. **(10 pts total)**

2 pts $A = Wt$
2 pts $= (10\mu m \times 1\mu m)(1m^2/10^{12}\ \mu m^2) = 1x10^{-11} m^2$
2 pts $? = RA/l$
2 pts $= [(1000O)(1x10^{-11} m^2)]/[(1mm)(1m/1000mm)]$
2 pts $= 1x10^{-5}\ O\text{-}m$

b) Now express the resistivity in units of µO-cm, a more common unit **(10 pts total)**

2 pts $1\ O = 10^6\ \mu O$
2 pts $1\ m = 10^2\ cm$
4 pts $? = (10^{-5}\ O\text{-}m)(10^6\ \mu O/O)(10^2 cm/m)$
2 pts $= 1x10^3\ \mu O\text{-}cm$

2) For Si at 300K, do the following: (Use cm^{-3} as your units.)

a) $N_D = 10^{17} cm^{-3}$; $N_A << N_D$. Calculate the equilibrium electron concentration (n) and hole concentration (p). **(15 pts total)**

Since $N_A << N_D$ and $n_i << N_D$:
6 pts $n = N_D = 10^{17} cm^{-3}$
6 pts $p = n_i^2/n$
3 pts $= (10^{10} cm^{-3})^2/10^{17} cm^{-3} = 10^3 cm^{-3}$

b) $N_D = 10^{15} cm^{-3}$; $N_A << N_D$. Calculate the equilibrium electron concentration (n) and hole concentration (p). **(15 pts total)**

Since $N_A << N_D$ and $n_i << N_D$:
6 pts $n = N_D = 10^{15} cm^{-3}$
6 pts $p = n_i^2/n$
3 pts $= (10^{10} cm^{-3})^2/10^{15} cm^{-3} = 10^5 cm^{-3}$

c) $N_A = 5x10^{17} cm^{-3}$; $N_D << N_A$. Calculate the equilibrium electron concentration (n) and hole concentration (p). **(15 pts total)**

Since $N_A << N_D$ and $n_i << N_D$:
6 pts $p = N_A = 5x10^{17} cm^{-3}$
6 pts $n = n_i^2/p$
3 pts $= (10^{10} cm^{-3})^2/5x10^{17} cm^{-3} = 2x10^2 cm^{-3}$

d) $N_A = 10^{14} cm^{-3}$; $N_D << N_A$. Calculate the equilibrium electron concentration (n) and hole concentration (p). **(15 pts total)**

Since $N_A << N_D$ and $n_i << N_D$:
6 pts $p = N_A = 10^{14} cm^{-3}$
6 pts $n = n_i^2/p$
3 pts $= (10^{10} cm^{-3})^2/10^{14} cm^{-3} = 10^6 cm^{-3}$

3) For the silicon sample at T = 300K shown below, given $N_D = 10^7\ cm^{-3}$, $N_A << N_D$,

a) Find the resistivity ? of the Si to within 10%. For units, use O-cm. **(10 pts total)**

10 pts *Off the graph: $? = 7.8x10^{-2}\ O\text{-}cm$*
Allowed values are $(7.41\text{-}8.19x10^{-2}\ O\text{-}cm)$
Full credit also received if resistivity is calculated from the equation.

b) Calculate the resistance R_{AB} in units O, for the following geometry: **(10 pts total)**

2 pts $A = Wt$
2 pts $= (1mm \times 250\mu m)(1cm/10mm)(1cm/10^4\ \mu m) = 2.5x10^{-3}\ cm^2$
4 pts $R = ?l/A = (7.8x10^{-2}\ O\text{-}cm)(1cm)/(2.5x10^{-3}\ cm^2)$
2 pts $= 31.2\ O$
Range of R excepted is: 29.6-32.8 O due to errors from graph readings.