11.8) a.) Al is in group III

Ge is in group IV

so Ge doped with Al is p-type

b.) Se has 2 more outer e's than Si so

Si doped with Se is n-type.

11.10) $E = \frac{hc}{\lambda} = \frac{1240\ eV \cdot nm}{574\ nm} = 2.16\ eV$

11.12) $10^9\ w = 0.3(200\ w/m^2)\ A$

$\Rightarrow A = 1.7 \times 10^7\ m^2$

$\approx 4\ km \times 4\ km$

4)

a.) $N = \frac{m N_A}{M} = \frac{\rho V N_A}{M} =$

$$= \frac{(2.33\ g/cm^3)(100\ nm \times 10^{-7}\ cm/nm)^3 \left(6.02 \times 10^{23}\ \frac{atoms}{mol}\right)}{28\ g/mol}$$

$= 5.01 \times 10^7$ Si atoms

b.) $\Delta E = \frac{13\ eV}{4 \times 5.01 \times 10^7} = 6.5 \times 10^{-8}\ eV$

assuming energy levels fill the band uniformly

5.)

a.) $E_1 = -\frac{1}{2}\left(\frac{Ke^2}{\hbar}\right)^2 \frac{m}{K^2}\frac{1}{(1)^2}$

$$= -\frac{1}{2}\frac{\left[9\times10^9 \frac{N\cdot m^2}{C^2}\left(1.6\times10^{-19}C\right)^2\right]^2}{\left(1.1\times10^{-34}\,Js\right)^2}\frac{0.2\times9.11\times10^{-31}kg}{(11.8)^2}$$

$$= -3.12\times10^{-21}\,J = -0.0195\,eV$$

b.) $r_n = \frac{n^2\hbar^2}{mKZe^2}$ for hydrogen

$$= \frac{n^2 a_0}{Z}$$ where a_0 = Bohr radius

accounting for effective mass of e^- and dielectric constant of Si,

$$r_1 = a_0 \frac{m}{m^*}K \qquad K \sim 11.8$$

$$r_{1_{As}} = (0.0529\,nm)\left(\frac{1}{0.2}\right)(11.8) = 3.12\,nm$$

c.) $E_g(Si) = 1.11\,eV$

$$E_1/E_g = \frac{0.195}{1.11} = 2\%$$

6.) $\lambda = \dfrac{m^* v}{n \rho e^2}$

where $v = \left(\dfrac{3KT}{m^*}\right)^{1/2} = \left(\dfrac{3 \times 1.38 \times 10^{-23}\ J/K \times 300\ K}{0.2 \times 9.11 \times 10^{-31}}\right)^{1/2}$

$= 2.61 \times 10^5\ m/s$

So

$$\lambda = \frac{0.2\,(9.11 \times 10^{-31}\ kg)(2.61 \times 10^5\ m/s)}{(10^{+22}\ 1/m^3)(5 \times 10^{-3}\ \Omega \cdot m)(1.6 \times 10^{-19}\ C)^2}$$

$= 3.7 \times 10^{-8}\ m = \underline{37\ nm}$

for Cu, $v_F = \left(\dfrac{2E_F}{me}\right)^{1/2} = \left(\dfrac{2 \times 7.00\ eV}{9.11 \times 10^{-31}\ kg}\right)^{1/2}$ ← to b6 9.4

$= 1.57 \times 10^6\ m/s$

$n = 8.47 \times 10^{28}/m^3$ (to b6 9.3)

$\rho = 1.72 \times 10^{-8}$ (To b6 11.1)

$\Rightarrow \lambda = \underline{39\ nm}$

7.) Si: $1s^2\ 2s^2\ 2p^6 \mid 3s^2\ 3p^2$ ($4e^-$s outside $n=2$)

($3e^-$s)

a.) Al has $3s^2\ 3p \Longrightarrow$ p-type

b.) P has $3s^2\ 3p^3 \Longrightarrow$ n-type

($5e^-$s)