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ENGR145 HW8

**12.2)** 10 m Long Al wire
Voltage Drop = 1.0V
Current = 5 A

$V = IR \Rightarrow R = \frac{V}{I}$  $I = 5A,\ V = 1.0V$

$\rho = \frac{RA}{l} \Rightarrow \rho = \frac{VA}{Il}$  $l = 10m$

$\sigma = \frac{1}{\rho} \Rightarrow \sigma = \frac{I\cdot l}{V\cdot A}$  from table: $\sigma = 3.8\times10^{7}\ \Omega_m^{-1}$

wires can be assumed to be circular: $A = \pi r^2 = \pi(\frac{1}{2}d)^2 = \frac{\pi d^2}{4}$

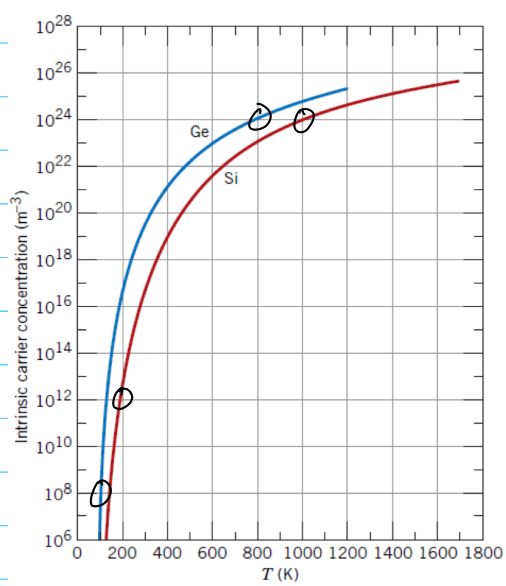
$$3.8\times10^{7}\frac{1}{\Omega m} = \frac{5A\cdot 10m}{1.0V(\frac{\pi}{4}d^2)} \Rightarrow 3.8\times10^{7}(\Omega m)^{-1}\cdot d^2 = \frac{5A\cdot10m}{\frac{1.0\pi}{4}V}$$

$$d^2 = \frac{5A\cdot10m}{\frac{\pi}{4}V(3.8\times10^{7}(\frac{V}{A}m)^{-1})} \Rightarrow d = \sqrt{\frac{5A\cdot10m(\frac{V}{A}m)}{\frac{\pi}{4}V(3.8\times10^{7})}} = 0.00129\,m$$

$$0.00129\,m \times \frac{1000mm}{1m} = 1.29mm \text{ diameter}$$

**12.8)** In metals, the energy band is connected in a way, meaning there is no gap that the electrons need to cross over. The electrons, as a result, can easily be excited and jump up to the next band level. This allows for great electrical conductivity. Semiconductors have a small gap between their conduction band and their valence band. For electricity to be conducted, an electron needs to have enough energy to jump up to this conduction band. The electrons cannot freely move up to a conductive location, so that is why these are called semiconductors. Insulators have a significant band gap that is larger than semiconductors. Their conduction and valence bands are so far apart that there is no amount of energy that can excite an electron into a conductive state. Electrical conductivity is proportional to band gap size.

**12.19)**




Boltzmen Constant: $k = 8.6173\times10^{-5}$ eV/K

$\ln(n_i) \propto -\frac{E_g}{2kT}$ ∴ $\ln(n_i)$ = rise, $\frac{1}{T}$ = run

$$\text{Slope} = \frac{\Delta \ln(n_i)}{\Delta \frac{1}{T}}$$

$$\text{Slope}_{Si} = \frac{\ln(10^{24}) - \ln(10^{12})}{\frac{1}{1000} - \frac{1}{200}} = -6907.75K$$

$-\frac{E_g}{2k} = -6907.75 \Rightarrow E_g = -2k\cdot -6907.75$

$\Rightarrow E_{g_{Si}} = -2(8.6173\times10^{-5}\,eV/K)(-6907.75K) = 1.19$

∴ $E_g = 1.19eV$ for Si

This is pretty close (~0.08eV) to the one presented in table 12.3 (1.11eV)

$$\text{Slope}_{Ge} = \frac{\ln(10^{24}) - \ln(10^{8})}{\frac{1}{800} - \frac{1}{100}} = -4210.44K\ ;\ \frac{-E_g}{2k} = -4210.44$$

$\Rightarrow E_{g_{Ge}} = -2(8.6173\times10^{-5}\,eV/K)(-4210.44K) = 0.726eV$ ∴ $E_g = 0.726eV$ for Ge

This is very close (~0.05) to the band gap provided in table 12.3 (0.67eV)

12.26) **A.** Donor impurities, or n-type dopants, have one extra valence electron, such as arsenic in silicon. This extra electron has no where to go so it is able to freely move around the electron structure. In semiconductors, this free electron is much easier to excite, so electrical conductivity is increased.

**B.** Acceptor Impurities, or p-type dopants, have one less valence electron, such as boron in silicon. This boron wants to have a full outer shell and bond to 4 silicons, so it takes one of the silicon's electrons. This leaves a hole in the silicons valence shell, which leads to electrons wanting to fill this extra whole and increased conductivity.