1.) Bandgap in eV = $\boxed{1.12V}$

$eV \to J = 1.12 \cdot 1.6\times10^{-19}C = \boxed{1.792 J}$

2.) $N_a = 2\times10^{17}/cm^3$
$N_D = 3\times10^{17}/cm^3$
$n_i = 10^{10}/cm^3$

$N_D > N_A$

$n = N_D - N_A + \frac{\sqrt{(N_D-N_A)^2+4n_i^2}}{2}$

$\boxed{n = 1\times10^{17}/cm^3}$

$p = \frac{n_i^2}{n} = \frac{(10^{10}/cm^3)^2}{1\times10^{17}/cm^3}$

$\boxed{p = 1000/cm^3}$

3.) $N_A = 5\times10^{16}/cm^3$
$N_D = 10^{16}/cm^3$
$n_i = 10^{10}/cm^3$

$N_A > N_D$ $p = N_A - N_D + \frac{\sqrt{(N_A-N_D)^2+4n_i^2}}{2}$

$p = 4\times10^{16}/cm^3$

$n = \frac{n_i^2}{p} = \frac{10^{10}/cm^3}{4\times10^{16}/cm^3} = \boxed{2500/cm^3 = n}$

4.) a.) $\left.\begin{array}{l} N_D = 1\times10^{16}/cm^3 \\ n_i = 1\times10^{10}/cm^3 \end{array}\right\}$ Silicon Wafer

b.) $N_D \gg n_i \to n \approx N_D$; $p \approx \frac{n_i^2}{N_D} = \frac{(10^{10}/cm^3)^2}{10^{16}/cm^3} = \boxed{10^4/cm^3 = p}$

c.) Boron must be added to convert to p type. This is due to Boron having 3 valence electrons. This has one bonding place that is unsatisfied and will accept an electron from Si atoms, leaving a whole in its place.

4.) d) $p = 5\times10^{15}/cm^3$

$N_D = 1\times10^{16}/cm^3$

$N_A = 1\times10^{10}/cm^3$

$n = \frac{n_i^2}{p} = \frac{(1\times10^{10}/cm^3)^2}{5\times10^{15}/cm^3}$

$\boxed{n \Rightarrow 20000/cm^3}$

$p - n = N_A - N_D$

$5\times10^{15}/cm^3 - 20{,}000/cm^3 = N_A - (1\times10^{16}/cm^3)$

$\boxed{N_A = 1.5\times10^{16}/cm^3}$

e.) $V_n(drift) = -\mu_n E = \frac{-500}{V\cdot s} \times \frac{20{,}000}{cm} = \boxed{-1\times10^7 cm/s}$

$J_n(drift) = -qnV_n = -1.6\times10^{-19} \times \frac{20{,}000}{cm^3} \times \frac{-1\times10^7 cm}{s}$

$\Rightarrow \boxed{3.2\times10^{-8} A/cm^2}$

$V_p(drift) = -\mu_p E = \frac{100 cm^2}{V\cdot s} \times \frac{20{,}000}{cm} = \boxed{2\times10^6 cm/s}$

$J_p(drift) = qpV_p = 1.6\times10^{-19} A\cdot s \times \frac{5\times10^{15}}{cm^3} \times \frac{2\times10^6 cm}{s}$

$\boxed{\Rightarrow 1600\ A/cm^2}$

5.) p-type Si wafer

$0.1\ \Omega cm$ $\boxed{\approx 3\times10^{17}/cm^3}$

6.) $\frac{200\ cm^2}{V\cdot s} \cdot \frac{x}{10\cdot 1\cdot 10^{-7}} = \frac{1\times10^7 cm}{s} \longrightarrow 10\ cm^2/s$

$\frac{10 cm^2}{s} = \frac{200 cm^2}{Vs}$ $\boxed{x = 0.05V}$

7.) $E = hc/\lambda$ $h = 6.626 \times 10^{-34}$ J

$c = 3 \times 10^{10}$ cm/s

Energy required $= 1.12(1.6 \times 10^{-19}\text{ J}) = \boxed{1.79 \times 10^{-19}\text{ J} = E}$

$E = hc/\lambda \rightarrow \lambda = \frac{hc}{E}$

$\Rightarrow \frac{6.626 \times 10^{-34}\text{ J}(3 \times 10^{10}\text{ cm/s})}{1.79 \times 10^{-19}\text{ J}}$

$\boxed{\lambda = 1.049 \times 10^{-6}\text{ m}}$

$\boxed{\lambda = 1.049\text{ mm}}$

8.) a.) Germanium has one more valence electron than Indium, so I would expect it to be a donor.

b.) Germanium has one less valence electron than phospherous, so I would expect Germanium to act as an acceptor.