1) Consider a Haynes-Shockley experiment on a p-type silicon bar. If a pules of electrons I injected at sx=0, t=0, and of the maximum of the electron pluse reaches a probe at x= 100μm at t=10 ns, determine electron mobility and diffusion coefficient using whatever method you like. Assume that a voltage of 10 V is maintained between the two ends of the 1 cm long bar.

$$\mathcal{E} = \frac{10V}{1cm} = 10^{1+2}\frac{V}{m} = 10^{3}\frac{V}{m}$$

$$V_d = \frac{100\mu m}{10ns} = 10^{-4+8}\frac{m}{s} = 10^{4}\frac{m}{s}$$

$$V_d = \mu\mathcal{E} \Rightarrow \mu = \frac{V_d}{\mathcal{E}} = \frac{10^{4}\frac{m}{s}}{10^{3}\frac{V}{m}} = \boxed{10^{1}\frac{m^2}{V\text{-}s} = \mu}$$

$$= 10^{5}\frac{cm^2}{V\text{-}s}$$

$$\frac{D}{\mu} = \frac{kT}{e} \Rightarrow D = \frac{kT}{e}\mu$$

$$= \frac{1.38\times10^{-23}\ 300\ J}{1.6\ 10^{-19}\ C}\ 10^{1}\frac{m^2}{V\text{-}s} = \cdots$$

Easier

$$= 0.029\ V \times 10^{1}\frac{m^2}{V\text{-}s} = \boxed{0.29\frac{m^2}{s} = D}$$

$$= 2.9\ 10^{3}\frac{cm^2}{s}$$

2) Sketch the band diagram for an abrupt junction at thermal equilibrium for the following N-p junction: (N) $Al_{0.35}Ga_{0.65}As$ doped so that E_C-E_F = 0.2 eV; (p) GaAs doped so that E_F-E_V=0.1 eV. Indicated clearly (qualitative):

a. Which side has the larger depletion region
b. Which side has the larger potential drop

Indicate quantitatively:

c. Label quantitatively the difference between EC on both sides
d. Label quantitatively the different between EV on both sides

Other features only need to be drawn qualitatively.

GaAs E_G = 1.42eV

$Al_{0.35}Ga_{0.65}As$ E_G = 1.424 + 0.35 × 1.247 eV

1.247 × 0.35 ≈ 0.44

1.25 × 0.3 = .375   1.25 × .05 = .0625   .375 + .063 = 0.438

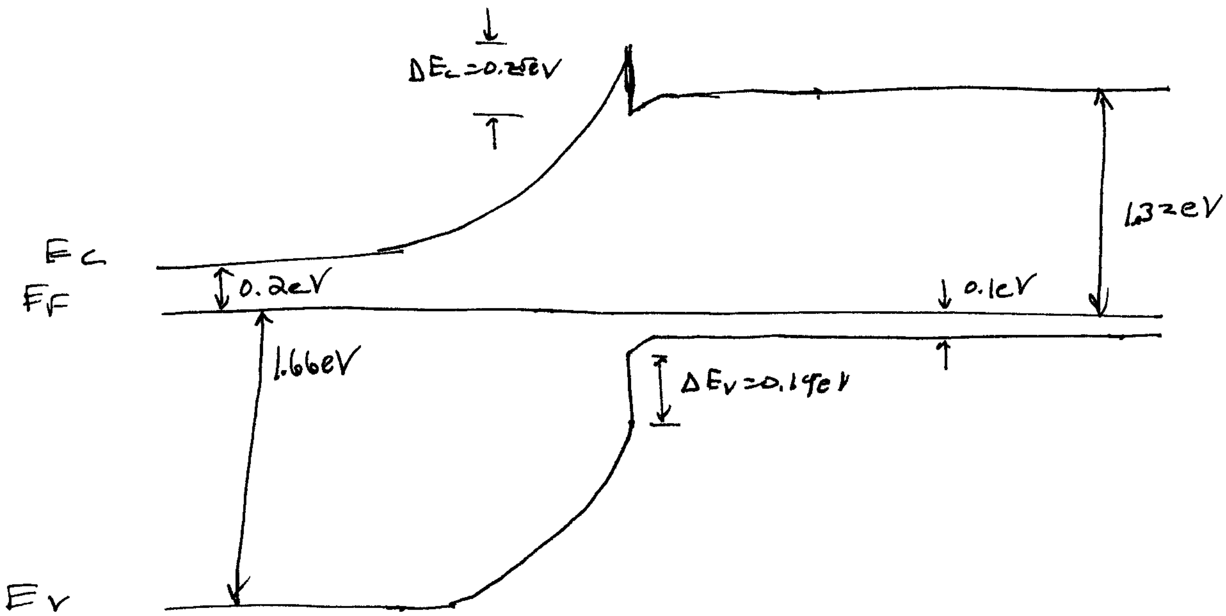
E_G = 1.424 + .44 = 1.864 ≈ 1.86 eV ΔE_G = 0.44 eV

ΔE_V = 0.55 × 0.35 ≈ 0.165 + 0.028 ≈ 0.19eV

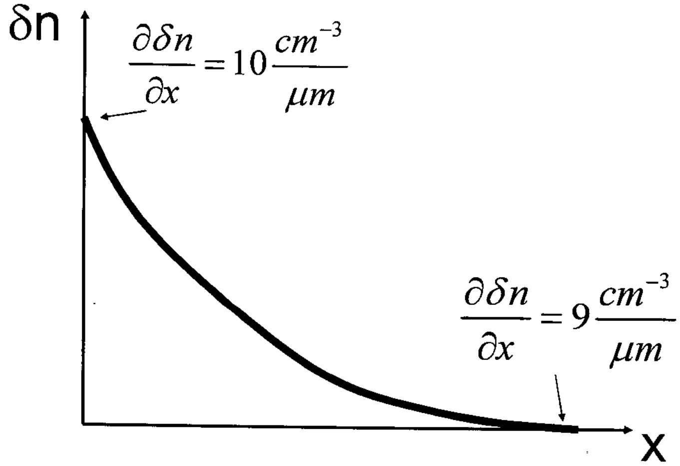
0.55 × 0.3 = 0.165   0.55 × 0.05 = 0.0275

$\Delta E_C + \Delta E_V = \Delta E_G \Rightarrow \Delta E_C = 0.25eV$

Depletion region larger in lighter doped region = AlGaAs region.


Ec
EF
Ev
0.2eV
1.66eV
ΔEv=0.14eV
0.1eV
1.32eV

3) For the hypothetical density of electrons in the p region of an npn transistor biased in active mode, find the value of β.



$$I_E \propto \left.\frac{\partial \delta n}{\partial x}\right|_{x=0}$$

$$I_C \propto \left.\frac{\partial \delta n}{\partial x}\right|_{x=W_B}$$

$$\Rightarrow \frac{I_E}{I_C} = \frac{10}{9} \Rightarrow I_E = \frac{1}{0.9} I_C$$

$$I_E = I_B + I_C$$

$$\Rightarrow I_C \frac{1}{0.9} = I_B + I_C$$

$$\Rightarrow \frac{I_C}{I_B} = \frac{1}{\frac{1}{0.9} - 1} = \boxed{9 = \beta}$$

4) What is the definition of the cutoff frequency?

Frequency at which $\frac{i_{out}}{i_{in}} \equiv h_{21}$ drops to unity (or 0dB).