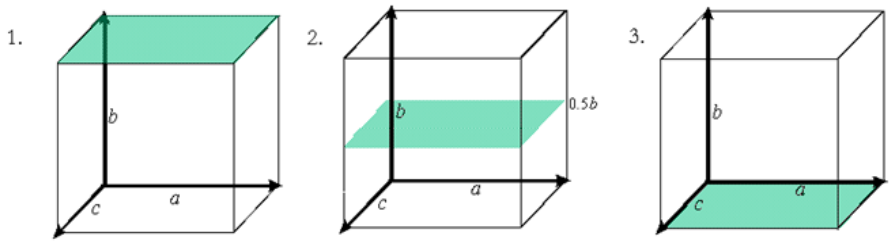
End-Sem Examination
Odd Semester - 2017-18
Semiconductor Devices and Circuits (SEMI)
B.Tech. (ECE) 2nd Year

LNMIIT
The LNM Institute of Information Technology

Time: 3 Hrs **Total Marks: 50**

All Questions are compulsory and Self-Explanatory.

Q1. Discuss all the steps to determine the Miller Indices of a plane. Also, determine the miller indices for the following planes: **[2 + 3]**



- Intercepts are $\infty, 1, \infty$
- Miller indices of the plane are:

$$\left(\frac{1}{\infty}\frac{1}{1}\frac{1}{\infty}\right) = (010)$$

- Intercepts are $\infty, 1/2, \infty$
- Miller indices of the plane are:

$$\left(\frac{1}{\infty}\frac{1}{1/2}\frac{1}{\infty}\right) = (020) = (010)$$

3 ---> 1

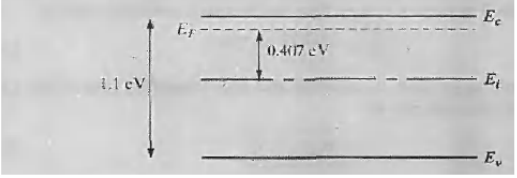
Q2. A Si sample is doped with 10^{17} As atoms/cm^3. What is the equilibrium hole concentration p_0 at 300 K? Where is E_F relative to E_i ? For your calculation you can use $n_i = 1.5 \times 10^{10}$ cm^{-3}, kT = 0.0259 eV. **[2]**

Since $N_d \gg n_i$, we can approximate $n_0 = N_d$ and

$$p_0 = \frac{n_i^2}{n_0} = \frac{2.25 \times 10^{20}}{10^{17}} = 2.25 \times 10^3 \text{ cm}^{-3}$$

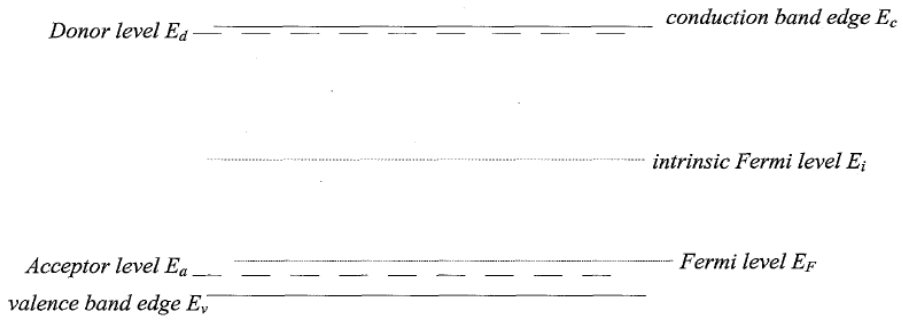
$$E_F - E_i = kT \ln \frac{n_0}{n_i} = 0.0259 \ln \frac{10^{17}}{1.5 \times 10^{10}} = 0.407 \text{ eV}$$

The resulting band diagram is:



Q3. Define the Hall Effect in n-type semiconductor. How do we identify the type of a material with the help of the Hall Effect? List down the 4 applications of Hall Effect. **[3 +2 +2]**
You can refer to Hall Effect Slides

Q4. The equilibrium band diagram for a doped direct gap semiconductor is shown below. Is it n-type, p-type or not enough information provided? **[1]**
Ans: P type



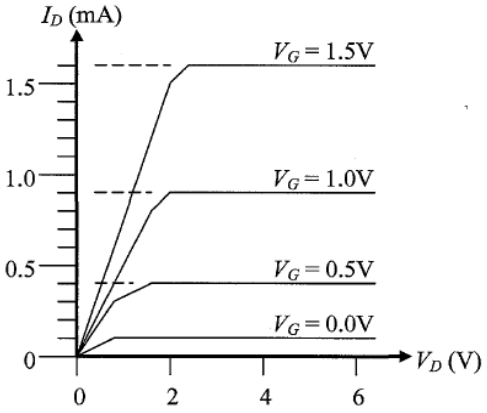
What if any of the following conditions by themselves could lead to the above band diagram? Choose the correct answer from the following: **[1]**

a) Very high temperature

b) Very high acceptor doping

c) Very low acceptor doping

Q5. Consider the following MOSFET characteristic:



a) Is this an n-channel or p-channel device? **[1]**
Ans: n-channel

b) Does this appear to be a long-channel or short-channel device? **[1]**
Ans: Long Channel

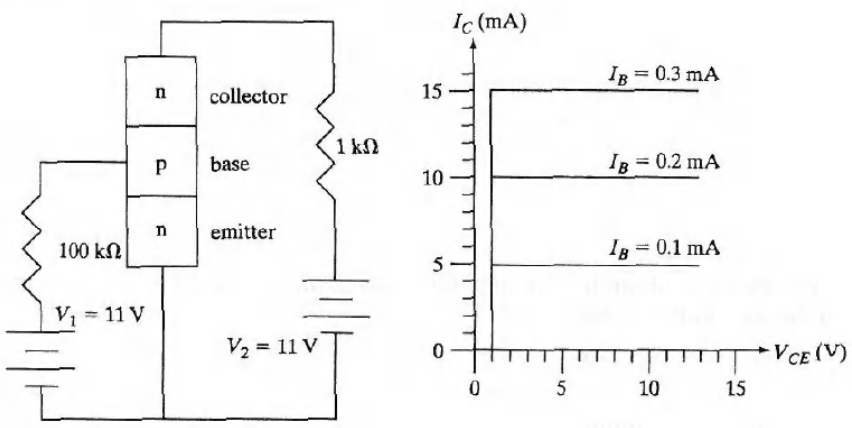
c) What is the apparent threshold voltage V_T ? **[1]**
- 0.5

d) Is this a depletion mode or enhancement mode MOSFET? **[1]**
depletion mode

Q6. (a) What is threshold voltage in MOSFET? Derive the *Threshold Voltage* equation for NMOS. Apply the substrate biasing V_{SB} to the derived equation and write down the final equation for the *Threshold Voltage.* **[1 + 3 + 2]**
Ans: Threshold voltage definition and derivation you can refer to book.

(b) Calculate the threshold voltage V_{T0} at V_{SB} = 0, for a polysilicon gate n-channel MOS transistor, with the following parameters: substrate doping density $N_A = 10^{16}$ cm^{-3}, polysilicon gate doping density N_D = 2 x 10 cm^{-3}, gate oxide thickness t_{ox} = 50 nm and oxide-interface fixed charge density N_{ox} 4 x 10^{10} cm^{-2}. kT/q = 0.026 eV, n_i = 1.45 x 10^{10} cm^{-3}, Φ_F(gate) = 0.55 V, ε_0= 8.845x10^{-14} Fcm^{-1}, $\varepsilon_{si}/\varepsilon_0$= 11.7, q = 1.6 x 10^{-19} C **[4]**
Ans: V_{T0} = 0.40 V

Q7. Consider the following bipolar junction transistor (BJT) circuit and somewhat idealized transistor characteristics where, in particular, the voltage drop across the forward biased base-emitter junction is assumed to be constant and equal to 1 V for simplicity.



a) What is the (common-emitter) gain β ? **[2]**
ans: 50

b) Draw the load line on the transistor characteristics. **[2]**
V_{CE}= 0 -> Ic = 11 mA **Ic = 0mA -> V_{CE}= 11 V**

c) What is the collector-emitter voltage drop in this circuit within half a volt? **[2]**

$$I_B \frac{(11-1)V}{100k\Omega} = 0.1mA \rightarrow V_{CE} = 6V$$

d) If voltage V_t could be changed, what value of V_t would drive BJT in this circuit to the edge of saturation? **[2]**

I_B=0.2 mA at onset of saturation.

$$\frac{V_1 - 1V}{100k\Omega} = 0.2mA \rightarrow V_1 = 21V$$

Q8. Discuss the breakdown mechanisms in a lightly doped and heavily doped p-n junction under reverse biased condition. **[2 + 2]**

Ans: Lightly Doped --- Avlanche Breakdown and Heavily doped --- Zener Break down (discussion)

Q9. Write the short note one the followings: **[2 + 2 + 2 + 2]**

(a) Channel Length Modulation
(b) Drain Induced Barrier Lowering
(c) Excess Charge Carriers in Semiconductors
(d) Continuity Equation

For these ans you can refer to book