D. J. SANGHVI COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRONICS ENGINEERING
EXC302: ELECTRONIC DEVICES SEM III
QUIZ 1 SET A

N.B. : **[Total Marks: 100]**

1) For every incorrect answer **50% marks** will be deducted.

2) While answering the numericals, writing formula is mandatory.

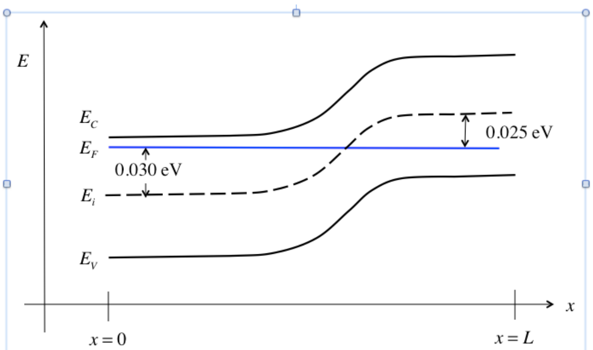
NAME: ____________________ **SAP ID:** ____________________

Given: $n_i = 1 \times 10^{10}/cm^3$, $\epsilon_s = 10^{-12}F/cm$, $\frac{KT}{q} = 0.026V$, $q = 1.6 \times 10^{-19}$ C

1. What does n_{po} mean ? **[01]**
   a) Equilibrium electron concentration in p-type semiconductor.
   b) Equilibrium hole concentration in p-type semiconductor.
   c) Equilibrium hole concentration in n-type semiconductor.
   d) Equilibrium electron concentration in n-type semiconductor.
   e) Equilibrium electron concentration

2. Which of the following statements is true about the magnitude of the electric field in the transition region of an PN junction ? **[01]**
   a) It is constant in space.
   b) It first decreases linearly, reaches a peak at the junction, then increases linearly.
   c) It first increases linearly, reaches a peak at the junction, then decreases linearly.
   d) It increases linearly from the N side to the P side.
   e) It decreases linearly from the N side to the P side.

3. For the energy band digram below, answer the following questions.



   a) Is the potential at $x = 0$ more or less positive than the potential at $x = L$? **[02]**
   Explain your answer.

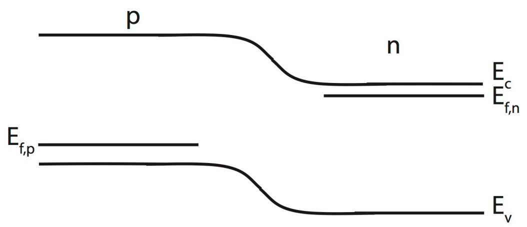
   b) What is the magnitude of the built-in potential? **[02]**

4. For a Si pn homojunction $N_A = 10^{17}/cm^3$ and $N_D = 10^{18}/cm^3$ at T=300K.

a) Calculate the built-in potential for the junction. **[02]**

b) Now calculate the depletion region width (in μm) for the junction. **[02]**

5. Consider the band diagram shown below, and then answer the following questions:



a) Is the semiconductor at equilibrium ? **[02]**

If yes, explain why ?

If no, explain why ?

b) What is the direction of electron diffusion ? **[02]**

The electrons diffuse from left to right

The electrons diffuse from right to left

There is no net electron diffusion current

c) What is the direction of electron drift? **[02]**

The electrons drift from left to right

The electrons drift from right to left

There is no net electron drift current

d) What is the direction of hole diffusion ? **[02]**

The holes diffuse from left to right

The holes diffuse from right to left

There is no net hole diffusion current

e) What is the direction of hole drift? **[02]**

The holes drift from left to right

The holes drift from right to left

There is no net hole drift current

6. You have a Si pn junction diode at room temperature with $N_A = 10^{19}/cm^3$ and $N_D = 10^{18}/cm^3$. (You may assume the following carrier mobilities for Silicon: $\mu_p = 70cm^2/Vs$ and $\mu_n = 250cm^2/Vs$. You may also assume a minority carrier lifetime of $\tau_n = \tau_p = 10^{-8}s$ for both electrons and holes, and $n_i = 10^{10}cm^{-3}$.)

   a) What is the diffusivity of the holes in the Silicon? **[01]**

   D_p (in cm^2/s):

   b) What is the diffusivity of the electrons in the Silicon? **[01]**

   D_n (in cm^2/s):

   c) What is the minority carrier diffusion length for holes? **[01]**

   L_p (in cm):

   d) What is the minority carrier diffusion length for electrons? **[01]**

   L_n (in cm):

   e) Calculate J_0 for the diode described above? **[02]**

   J_0 (in A/cm^2):

   f) Use the ideal diode equation to predict the current density when a forward bias of 0.45V is applied to the diode? **[02]**

   J (in A/cm^2):

   g) Use the ideal diode equation to predict the current density when a reverse bias of -10V is applied to the diode? **[02]**

   J (in A/cm^2):

7. Indicate whether the following applied voltages produce a forward- or a reverse-biased p-n junction: **[02]**

   a) Positive voltage is applied to the p-side: ______________________

   b) Negative voltage is applied to the p-side: ______________________

   c) Positive voltage is applied to the n-side: ______________________

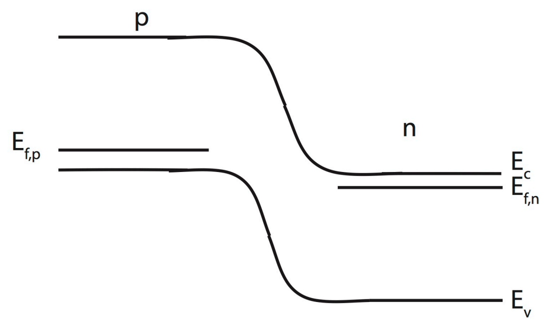
   d) Negative voltage is applied to the n-side: ______________________

8. Calculate the current through a silicon diode at room temperature for the following cases. Assume $I_0 = 2 \times 10^{-12}$ A.

    a) When a voltage of +0.5V is applied to the p-side of the junction. **[01]**

    a) When a voltage of -5V is applied to the p-side of the junction. **[01]**

9. Consider the band diagram shown below, and then answer the following questions:



What is the band diagram representing ? **[02]**

a) Forward-bias case.

b) Reverse-bias case.

c) Un-biased case.

10. What is the physical meaning of the area under E(x) vs x in a pn junction ?
(Note E(x) is the Electric field as a function of distance x) **[02]**

    a) It is the total doping density in the depletion region.

    b) It is equal to the band-gap of the semiconductor.

    c) It is the net space-charge density in the depletion region.

    d) It is the built-in potential of the junction.

11. A Si diode is symmetrically doped at $N_A = N_D = 10^{15} cm^{-3}$. Answer the following questions assuming room temperature, equilibrium conditions and the depletion approximation.

    Compute V_{bi} **[02]**

Compute x_n, x_p and W **[04]**

Compute E(x=0) **[02]**

Sketch ρ(x) vs. x **[02]**

12. Which of the following is true about impact ionization ? **[02]**
    - a) It is the cause of avalanche breakdown.
    - b) It can be initiated by either electrons or holes.
    - c) It generates both electrons and holes.
    - d) All of the above.
    - e) None of the above.

13. What effect does quantum mechanical tunneling have on a PN junction ? **[02]**
    - a) It can lead to reverse breakdown at low voltages.
    - b) It is the cause for zener breakdown.
    - c) It occurs in a heavily doped diode.
    - d) All of the above.
    - e) None of the above.

14. Which of the following is true about the small signal model of a PN junction ? **[02]**
    - a) It consists of a resistor in series with a capacitor.
    - b) It consists of a resistor in parallel with a capacitor.
    - c) It consists of a resistor in series with a inductor.
    - d) It consists of a resistor in parallel with a inductor.

15. Which of the following is true about the diffusion resistance in the small signal model of a PN junction diode ? **[02]**
    a) It has very large value in reverse bias and a very small value in forward bias.
    b) It is equal to $(dI_D/dV_A)^{-1}$
    c) In forward bias, it is very close to (V_T/I_D)
    d) All of the above.
    e) None of the above.

16. For a BJT in inverse active mode, which of the following is true. **[02]**
    a) Both the EB and BC junctions are reversed biased
    b) Both the EB and BC junctions are forward biased
    c) EB junction is forward biased and BC junction is reverse biased.
    d) EB junction is reverse biased and BC junction is forward biased.

17. How do you bias a BJT to put it into saturation mode and into cutoff mode? Why are these modes useful? **[02]**

18. For a BJT operating in forward-active mode, which of the following statements are correct? **[02]**
    a) $I_C \cong I_B$
    b) $I_B < I_E$
    c) $I_C < I_E$
    d) $I_E \cong I_c$
    e) The width of the Base W_B is much smaller than the minority carrier diffusion length L_p so that the minority carriers survive diffusion through the base.

19. Now consider a pnp BJT in which the base contact is floating (i.e not electrically connected to anything). We put the emitter at 0V and apply a negative voltage V_C to the collector. Which of the following statements are true: **[02]**
    a) A very large current flows between the emitter and the collector.
    b) A very small current flows between the emitter and the collector.
    c) No current flows between the emitter and the collector.
    d) The B-C junction is forward biased.
    e) The B-C junction is reverse biased.

20. You have a silicon pnp bipolar junction transistor in which you measure a base current of 50μA when the collector current is 3mA in forward-active mode.

    a) What is the emitter current? **[01]**

    i_E (in mA): -------------

    b) What is the common emitter current gain of the transistor? **[01]**

    β: -------------

    b) What is the common base current gain of the transistor? **[01]**

    α: -------------

21. How are the PN junctions biased in the forward-active region of a pnp BJT? **[02]**

    a) E-B: forward biased B-C: reverse biased

    b) E-B: forward biased B-C: forward biased

    c) E-B: reverse biased B-C: reverse biased

    d) E-B: reverse biased B-C: forward biased

22. Which of the following would be considered as a good value of β ? **[02]**

    a) 0.099

    b) 0.99

    c) 1.5

    d) 5

    e) 300

23. Which of the following would be considered as a good value of α ? **[02]**

    a) 0.099

    b) 0.99

    c) 1.5

    d) 5

    e) 300

24. Which of the following would be considered as a good value of emitter injection efficiency (γ) w.r.t BJT ? **[02]**

    a) 0.099

    b) 0.99

    c) 1.5

    d) 5

    e) 300

25. Which of the following is the definition of the emitter injection efficiency γ of an NPN BJT ? **[02]**

a) $\gamma = I_{EP}/\,(I_{EP} + I_{EN})$

b) $\gamma = I_{EN}/\,(I_{EP} + I_{EN})$

c) $\gamma = I_{CN}/\,(I_{EN})$

d) $\gamma = I_{CP}/\,(I_{EP})$

26. Which of the following is the definition of the base transport factor b or α_T of an NPN BJT ? **[02]**

a) $\alpha_T = I_{EP}/\,(I_{EP} + I_{EN})$

b) $\alpha_T = I_{EN}/\,(I_{EP} + I_{EN})$

c) $\alpha_T = I_{CN}/\,(I_{EN})$

d) $\alpha_T = I_{CP}/\,(I_{EP})$

27. What is the order of highest doping, next highest doping and lightest doping in a BJT? **[02]**

a) Emitter,base,collector

b) Emitter,collector,base

c) Base,collector,emitter

d) Collector,base,emitter

28. How is the transconductance of a transistor defined ? **[02]**

a) The change in output current divided by the change in output voltage.

b) The change in output voltage divided by the change in output current.

c) The change in input current divided by the change in input voltage.

d) The change in output current divided by the change in input voltage.

29. Which two of the following would increase the emitter injection efficiency ? **[02]**

a) Increasing the emitter doping

b) Increasing the base doping

c) Increasing the collector doping

d) Decreasing the emitter doping

e) Decreasing the base doping

30. Derive the relation: $\beta = \alpha/(1 - \alpha)$ **[02]**

31. Which of the following are Non-ideal effects in BJT ? **[01]**

a) Base width modulation

b) Constant energy band-gap.

c) Low level injection.

d) Non-uniform base doping.

e) High level injection.

32. Draw the symbol of following : **[02]**

a) NPN BJT

b) PNP BJT

c) PN diode

d) Zener diode

33. In ED lab, you have performed experiment on Zener as voltage regulator ? **[02]**

a) What was the definition of load regulation

B) What was the formula of load regulation

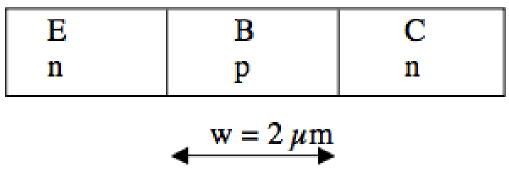
34. In ED lab, you have performed experiment on npn BJT input I-V and output I-V characteristics in common emitter configuration ? **[02]**

Plot those input and output I-V characteristics.

35. Consider a Silicon npn BJT with the following doping levels:

Emitter $N_{D,E} = 10^{19} cm^{-3}$
Base $N_{A,B} = 10^{16} cm^{-3}$
Collector $N_{D,C} = 10^{16} cm^{-3}$

Note that B and C have the same doping level. The width W of the p-type base region is $2\mu m$, as shown on the diagram.



1. Which junction has the larger depletion region? **[02]**

   a) The emitter-base junction has the larger depletion region.

   b) The base-collector junction has the larger depletion region.

   c) The depletion regions are of equal size.

   d) We don't have enough information to determine which depletion region is larger.

2. What is the width of the B-C depletion region in the unbiased case? **[02]**

   (Please use $n_i = 1 \times 10^{10}/cm^3$ for the intrinsic carrier concentration of Si.)

3. Suppose we reverse bias the BC junction by applying 5V. What is the width of the B-C depletion region? **[02]**

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