M.Sc. ELECTRONICS
First Semester
SEMICONDUCTOR MATERIALS AND DEVICES
(MSE - 103)

Duration: 3Hrs. **Full Marks: 70**

Part-A (Objective) =20
Part-B (Descriptive) =50

(PART-B: Descriptive)

Duration: 2 hrs. 40 mins. **Marks: 50**

Answer any *four* from *Question no.* 2 to 8
***Question no.* 1 is compulsory.**

1. Consider a sample of silicon at 300K doped at an impurity concentration of $N_d=10^{15}cm^{-3}$ and $N_a=10^{14}cm^{-3}$. Electron mobility in silicon is 1350 cm^2/V-sec and hole mobility is 480 cm^2/V-sec. Find out the followings: (3+3+4=10)
   a. Thermal equilibrium concentration of electrons
   b. Thermal equilibrium concentration of holes
   c. Drift current density if an electric field of 35V/cm is applied.
2. A silicon semiconductor is initially doped with donor concentrations of $N_d=5X10^{15}cm^{-3}$. Acceptor is to be added to form a compensated p-type materials. The sample should have resistance of 10kΩ and should be able to handle a current density of 50A/cm^2 when 5 volts is applied across the sample. Find out the acceptor doping concentration to achieve this specification. Limit the electric field to 100V/cm. (10)
3. Consider a PN junction at 300K with acceptor doping concentration $N_a=10^{18}cm^{-3}$ and donor doping concentration $N_d=10^{15}cm^{-3}$. Find out the built in potential barrier for (5+5=10)
   a. Silicon PN junction b. Gallium Arsenide PN junction

Intrinsic carrier concentration for silicon is $1.5X10^{10}$ cm^{-3} and that for gallium arsenide is $1.8X\ 10^{6}cm^{-3}$.

4.

a. Draw the circuit diagram of a positive clamper circuit using a diode and explain its operation. Draw the input and output voltage waveforms also. (2+3+2=7)

b. Draw the circuit diagram of a negative clamper (3)

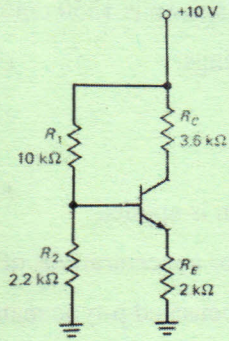
5. Explain in detail the Schmitt trigger and its application with suitable diagrams. (10)

6. In the circuit shown below find out the followings: (3+3+4=10)

a. Base voltage

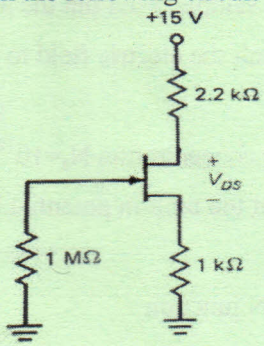
b. Emitter current

c. Collector emitter voltage.



7.

a. In the following circuit if the drain current is 3mA find out the followings:



i. Gate to source voltage.

ii. Drain voltage.

iii. Drain to source voltage. (3+2+2=7)

b. What do you mean by device transconductance parameter and process transconductance parameter in a MOSFET? (3)

8. Derive the close loop gain of operational amplifier circuit using a voltage series feedback. (10)

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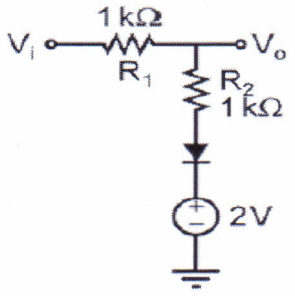
Duration: 20 minutes **Marks – 20**

(PART A - Objective Type)

I. Choose the correct answer: **1×20=20**

1. The diode in the circuit shown in Figure 1 has $V_{on} = 0.7V$ but is ideal otherwise. If $V_i = 5\sin(wt)$ Volts, the minimum and maximum values of V_o (in Volts) are, respectively,
   a. -5 and 2.7 b. 2.7 and 5
   b. -5 and 3.85 d. 1.3 and 5



2. Avalanche breakdown in a diode occurs when
   a. Potential barrier is reduced to zero.
   b. Forward current exceeds certain value.
   c. Reverse bias exceeds a certain value.
   d. None of these

3. A forward potential of 10V is applied to a Si diode. A resistance of 1 KΩ is also in series with the diode. The current is
   a. 10 mA b. 0.7 mA c. 9.3 mA d. 0

4. If the doping level in a ordinary PN junction diode is increased, the width of depletion layer.....
   a. remains the same b. decreases
   c. Increases d. none of the above

5. The PIV rating of each diode in a bridge rectifier is .....that of the equivalent centre-tap rectifier
   a. one-half b. the same as
   c. twice d. four times

6. A half-wave rectifier has an input voltage of 240 V r.m.s. If the step-down transformer has a turn ratio of 8:1, what is the peak load voltage? Ignore diode drop.
   a. 27.5 b. 86.5 V c.30 V d. 42.5 V

7. The use of negative feedback .....
   a. reduces the voltage gain of an Op-amp
   b. makes the Op-amp oscillate
   c. makes linear operation possible
   d. both (a) and (c)

8. The effective channel length of a MOSFET in saturation decreases with increase in
   a. increase in source doping concentration
   b. drain to source voltage
   c. the gate oxide thickness
   d. the channel length

9. A Zener diode, when used in voltage stabilization circuits, is biased in
   a. Reverse bias region below the breakdown voltage
   b. Reverse breakdown region
   c. Forward bias region
   d. Forward bias constant current mode

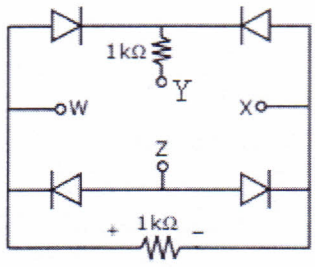
10. A silicon PN junction is forward biased with a constant current at room temperature. When the temperature is increased,
    a. The forward bias voltage across the PN junction Increases.
    b. The forward bias voltage across the PN junction Decreases.
    c. Current through the PN junction increases due to increase in minority carrier
    d. None of the above.

11. For a BJT the common base current gain $\alpha = 0.98$. This BJT is connected in the common emitter mode and operated in the active region with a base drive current I_B =10mA. The collector current I_C for this mode of operation is
    a. 0.49A b. 0.99A c. 0.98A d. 1.01A

12. The intrinsic Fermi energy level in silicon does not lie exactly at the midgap energy because,
    a. Effective mass of electron and hole are different
    b. Effective density of states function of electron and hole are different
    c. Silicon is an indirect band gap semiconductor
    d. Both (a) and (b)

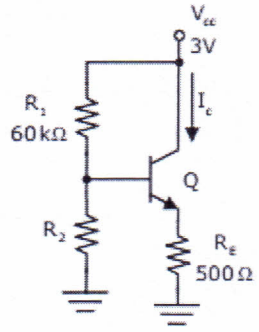
13. In a silicon sample Fermi energy is 0.25eV below conduction band. The effective density of states function in the conduction band at room temperature is $2.8X10^{19}$ cm^{-3}. The probability that a state in conduction band is occupied by an electron is
    a. 10^{-6} b. $6.43X10^{-5}$ c. .05 d. 0.9

14. A voltage 1000sinωt Volts is applied across YZ. Assuming ideal diodes, the voltage measured across WX in Volts, is



a. sin ωt
b. (sin t sin t / 2 ω + ω)
c. (sin t sin t / 2 ω − ω)
d. 0 for all values of t

15. In the circuit shown below, the silicon npn transistor Q has a very high value of β . The minimum required value of R_2 should be greater than _____kΩ to produce I_C =1mA is



a. 20
b. 30
c. 40
d. 25

16. What should be the value of input resistance for an ideal voltage amplifier circuit?
a. Zero
b. Unity
c. Infinity
d. Unpredictable

17. What is the phase-shift between input and output voltages of CE amplifier?
a. 90°
b. 120°
c. 180°
d. 270°

18. Generally, the resistance of thermistor decreases
a. Linearly with an increase in temperature
b. Linearly with the decrease in temperature
c. Exponentially with an increase in temperature
d. Exponentially with the decrease in temperature

19. The n^- region in a vertical cross-section of a typical n-p-n bipolar power transistor is also known as
a. Emitter drift region
b. Base drift region
c. Collector drift region
d. None of the above

20. Multivibrators belong to the category of
a. Square wave oscillators
b. Triangular wave oscillators
c. Ramp wave oscillators
d. Sinusoidal oscillators

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