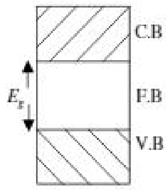
3. SEMICONDUCTOR DEVICES

SYNOPSIS

1. ENERGY BAND :

When the atoms are closely packed like in crystals, then the electrons in the outer most shells(valence electrons) possess a range of closely spaced energies called energy band.



i) Valence Band :

a) The range of energies possessed by the valence electrons is called as valence band.

b) This band may be partially filled or completely filled with electrons depending on the nature of crystal.

c) It is the highest filled energy band. (highest energy level of valence band)

ii) Conduction Band :

a) The range of energies possessed by the conduction electrons is called as conduction band.

b) This band may be empty or may be partially filled with electrons.

c) It is the lowest unfilled energy band. (Lowest energy level of conduction band)

iii) Forbidden Band :

A part of the energy band which is not occupied by any electron is known as forbidden band.

iv) Forbidden energy gap :

a) The energy gap between the valence band and the conduction band is called as forbidden energy gap.

b) No electron will exist with an energy level in forbidden gap.

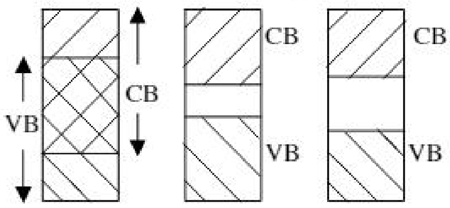
c) The minimum energy required to push an electron from valence band to conduction band is equal to forbidden energy gap.

d) Greater is the forbidden energy gap, more tightly the valence electrons are bound to the nucleus.

2. FERMI ENERGY LEVEL [FEL] :

a) Fermi energy level in a semiconductor is equal to an average energy level of all the charge carriers in it at a temperature greater than zero kelvin.

b) The highest energy level which an electron can occupy at 0 K is called Fermi energy level.



fig(a) fig(b) fig(c)

i) Conductors :

a) The conduction band and valence band overlap one over the other. Ex: metals.

b) For conductors, forbidden energy gap is 0 eV.

c) $E_g << kT$

ii) Semi-conductors :

a) The forbidden energy gap between the conduction band and valence band is very small (about 1eV). Ex. Si & Ge

b) For silicon forbidden energy gap is 1.1 eV and for germanium 0.72 eV.

c) $E_g \approx kT$

iii) Insulators :

a) The conduction band and valence band are separated(about 5-9 eV) by large forbidden gap. Ex : Diamond.

b) For diamond, forbidden energy gap is 6 eV

c) $E_g \gg kT$

3. IMPORTANT PROPERTIES OF SEMICONDUCTORS :

i) At 0 kelvin, pure semiconductor behave as perfect insulator.

ii) In semi-conductors, as the forbidden energy gap is small and at room temperature, some of the electrons can cross the energy gap and reach conduction band causing electrical conductivity.

iii) The conductivity of semiconductors lies between the conductivity of conductors and insulators.

iv) On increasing the temperature, the conducti-vity of semiconductors increases or resistivity decreases. (for conductors, the conductivity decreases or resistivity increases on increasing the temparature)

v) On adding suitable impurities to the semi-conductors (called doping), their conductivity increases by large amounts.

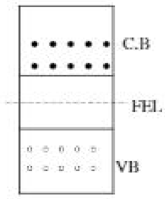
vi) The responsible charge carriers for conduction in semiconductors are both the free electrons and holes. (In conductors the responsible charge carries for conduction are only free electrons)

4. TYPES OF SEMICONDUCTORS :

The semi conductors are of two types (a) Intrinsic (b) Extrinsic

A pure semi-conducting material is known as intrinsic semi-conductor. When some impurities are added to it, the semi-conductor is known as extrinsic semi-conductor. The process of addition of impurities to a semi-conductor is called *doping*.

i) Intrinsic semiconductors :



a) Semi conductors in their pure form are called Intrinsic Semiconductors. Ex : Si and Ge, they are tetravalent.

b) The conductivity of intrinsic semi–conductor is relatively low.

c) At any temperature the numbers of holes in V.B and the number of free electrons in C.B. are equal. ($n_e = n_h$).

d) The fermi energy level lies exactly at the middle of the forbidden band.

e) The current contributed by the electrons is more than that of holes, because of their higher mobility.

f) Mobility of electrons is nearly twice to that of holes in Germanium and 4 times in silicon.

g) If n is the number of free electrons or holes per unit volume, A is the area of cross-section of the substance and v_e, v_h are the drift velocities of electrons and holes, then

$\boxed{I_e = neAv_e}$ (current due to electrons)

$\boxed{I_h = neAv_h}$ (current due to holes)

where e is the charge of electron.

h) The total current at any instant in semi-conductor is $I = I_e + I_h$

ii) Extrinsic semiconductors :

a) Semi–conductors with the presence of the impurities are called extrinsic semi conductors.

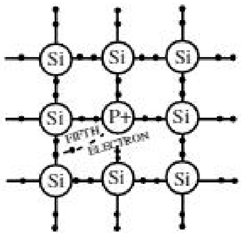
b) By adding trivalent or pentavalent impurities to a pure tetravalent semi conductor, its conductivity increases considerably.

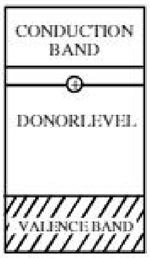
c) The process of adding the impurities is called doping.

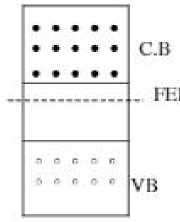
d) They are of two types (1) n-type (2) p-type.

n-type semi-conductor :

a) It is formed when a pentavalent impurity (donar impurity or V group elements) like Phosphorous, Arsenic, Antimony etc. are added in sufficient quantities to the pure form of Si or Ge crystal. [1 in 10^6 atoms or less]







b) Each impurity atom has five valence electrons. Out of five valence electrons, four electrons are needed to form covalent bonds with the adjacent germanium (or) Si atoms.

c) The fifth electron is very loosely bound and needs less amount of energy to become a free electron. Therefore excess electrons are available for conduction and conductivity of semiconductor increases.

d) Each impurity atom forms four covalent bonds with the four neighbouring Si or Ge atoms and it donates one free electron to the conduction band.

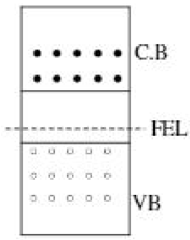
e) Electrons are majority charge carriers and holes are minority charge carriers. ($n_e >> n_h$).

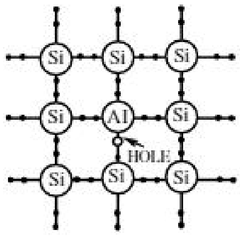
f) The fermi-energy level shifts nearer to the conduction band.

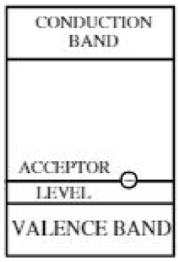
g) It is electrically neutral.

p-type semi-conductor

a) It is formed when a trivalent impurity (acceptor impurity or III group elements) like Boron, Alu minium, Galium, Indium etc are added in sufficient quantities [1 in 10^6 atoms or less] to the pure form of Si or Ge crystal.







b) Each impurity atom has three valence electrons and these three electrons form three covalent bonds with the neighbouring Si or Ge atoms. The fourth covalent bond is incomplete or empty, an additional hole (absence of electron) is created. Therefore, excess holes in addition to those formed due to thermal energy are available for conduction in the valence band and the conductivity of semiconductor increases.

c) Holes are majority charge carriers and electrons are minority charge carriers.($n_h >> n_e$).

d) The fermi-energy level shifts nearer to the valence band.

e) It is electrically neutral.

Similarly addition of a group 3 element, such as boron, aluminium etc., in silicon material increases the number of holes over the number of electrons. Group-3 elements (B, A*l*,In) are known as *acceptors* and the semi-conductingmaterial with group-3 element as impurity is known as *p-type semi-conductor* since it has large number of positive holes.

Note:

i) Conductivity of n-type > p-type > intrinsic semiconductors.

ii) With the increase of temperature, the ratio $\frac{n_e}{n_h}$ for n-type decreases, but $\left(\frac{n_e}{n_h} > 1\right)$

iii) With the increase of temperature, the ratio $\frac{n_e}{n_h}$ for p-type increases, but $\left(\frac{n_e}{n_h} < 1\right)$

Law of mass action: The addition of donors causes the number of electrons to increases in the *n*-type semi-conductor. What happens to the number of holes when donors are added ? A theoretical analysis of the problem leads to the result that under thermal equilibrium, the product of number of free electrons and number of free holes is constant which is independent of the amount of donor but it does depend on the temperature. This relationship is written as $n \times p = n_i^2$ and is known as the law of mass action. here, n_i is the intrinsic carrier density at the given temperature. For example, if in a n-type silicon the number of free electrons due to addition of donors 10^{16} per cm^3, at room temperature, then since $n_i = 10^{10}$ per cm^3, the number of holes will $(10^{10})^2/10^{16}$ i.e., 10^4 per unit cm^3. This semi-conductor is, therefore, a strongly *n*-type semi-conductor which majority carriers are electrons.

CONDUCTIVITY OF A SEMI-CONDUCTOR

We know that for a metallic conductor the electric conductivity is given by $\sigma = ne\mu_n$

where n is number of electrons per unit volume and μ_n is the mobility of the electrons. However, in semi-conductor there are two kinds of carriers i.e., electrons and holes and both contribute towards conductivity. Hence the conductivity of a semi-conductor is given by $\sigma = ne\,\mu_n + pe\,\mu_p$

where n, p are the concentrations of electrons and holes and μ_n, μ_p are their mobilities respectively.

For an intrinsic semi-conductor, since $n = p = n_i$ the conductivity is given by $\sigma = n_i e\,(\mu_n + \mu_p)$

5. P-N JUNCTION DIODE :

i) A p-n junction can be formed during the crystal growth in a pure semi-conductor, i.e., in the same crystal, one side of it is doped with a third group and another side with a fifth group impurity.

ii) Near the junction, the free electrons from n-region migrate towards p-region and the holes in p-region migrate towards n-region. This process is known as diffusion. This diffusion is due to concentration gradient.

iii) Due to diffusion, positive ions are left over in n-region and negative ions are left over in p-region, near the junction. These ions are immobile.

iv) Due to the immobile ions on either side of the junction an internal electric field is formed at the junction which is directed from n- region to p - region.

v) No charge carrier region formed at p-n junction due to the combination of electrons and holes is called **depletion layer**.

vi) The thickness of the depletion layer is of the order of one tenth of micrometer.

vii) When the depletion layer is sufficiently built up, it prevents the further diffusion of electrons from n side to p side and holes from p to n side i.e. it acts as a barrier.

viii)The potential difference across the barrier is called potential barrier or contact potential.

ix) The potential barrier for silicon is around 0.7 volts and for Germanium it is around 0.3 volts.

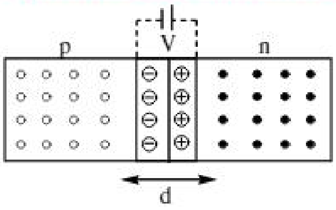
x) The potential barrier value lies in between 0.1 to 0.7 volts, which depends on (a) the nature of semi-conductor, (b) doping concentration, (c) temperature of the junction.

xi) If V is the barrier potential and d is the thick-ness of the depletion layer, then the electric field intensity across the junction is $\boxed{E = \frac{V}{d}}$ from n side to p side.

xii) The direction of electric field is always from n-side to p-side.

xiii)The p-n junction can be assumed to be equivalent to a condenser in which the depletion layer acts as a dielectric.

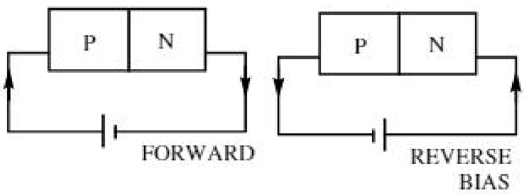
xiv)P-n junction diode can be used as rectifier, detector (demodulator), switch, capacitor, light emitting diode (LED).



Balance of Diffusion and Drift Currents in an Unbiased Diode

Diffusion: All electrons in the *n*-region of a *pn* junction do not have the same kinetic energy. Due to the potential barrier, most of the electrons having ordinary kinetic energies are prevented to diffusion into the *p*-region. However , there may be a small number of electrons in the *n*-region of *pn* junction will might be having sufficiently high kinetic energies. These electrons can surmount the potential barrier diffuse into the *p*-region. Similarly, there may be a few holes in the *p*-region of *pn* junction which of cross the potential barrier and diffuse into the *n*-region. The diffusion of these high energetic electrons/ holes give rise to a small diffusion current J_{DF} which flows from p-towards n-side of the junction.

Drift: In any semiconductor electron-hole pairs are continuously formed due to thermal collisions. However, as the process of recombination goes on simulateneously and continuously, we have centre number of free carriers at any instant in a given region of the semi-conducting material. This picture quite true for all regions of *pn* junction, but it needs modification for the chrge depleted region.



In the charge depleted region, electron-holes are formed as usual but their recombination is inhibited due to (i) absence of opposite kind of free charge carriers. (ii) presence of electric field due to the immobile charges. The electric field insidethe charge depleted region so quickly imparts drift motions to the newly created electron hole pairs thay they have no chance to recombine with each other. Consequently a small drift current always flows in a *pn* junction, even when the *pn* junction is unbiased. The direction of this current is forn *n*-region to *p*-region through the junction as shown in fig. The drift current J_{DR} does depend on the number of carriers and hence temperature but it is independent of the applied voltage.

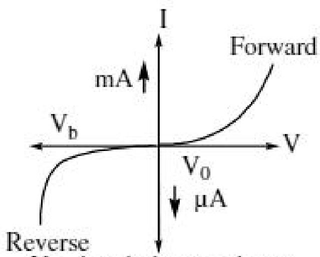
In an unbiased junction as the net current flow is zero, so we must have $|J_{DF}| = J_{DR}|$ hence J = 0

i.e., the current due to diffusion is exactly balanced by the current due to drift.

6. V-I CHARACTERISTICS OF P-N JUNCTION DIODE :

V_0(cut- in voltage or thresold or knee voltage are practically equal to barrier potential)

Note : Dynamic or a.c resistance of the diode is $R_{a.c} = \dfrac{\Delta V}{\Delta I}$



V_b - break down voltage
V_0 - knee voltage

7. RECTIFIER :

It is a device which converts A.C into D.C.

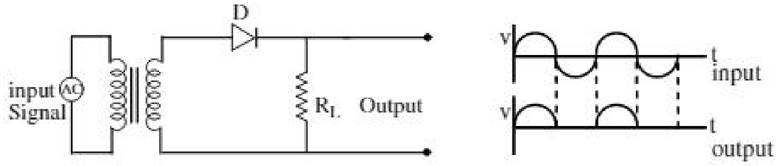
i) **Half wave Rectifier**

a) Only one diode is used.

b) It converts half cycle of applied A.C into D.C.

c) When a half wave rectifier is used to convert 'n' Hz A.C. into D.C., then the number of pulses per second present in the rectified voltage is 'n' only.

d) Half wave rectifier Circuit :



e) The out put is discontinuous and pulsating. This pulsation is called ripple.

f) Efficiency $(\eta) = \frac{\text{D.C power output}}{\text{A.C power input}}$

g) Efficiency$(\eta) = \left[\frac{0.406 \times R_L}{r_f + R_L}\right] \times 100\%$

h) $\eta_{max} = 40.6\%$ for an ideal diode.

ii) Full wave Rectifier :

a) Two diodes can be used.

b) It converts the whole cycle of applied input A.C. signal into .D.C. signal

c) When a full wave rectifier is used to convert 'n' Hz A.C. into D.C, then the no. of pulses per second present in the rectified voltage is 2n. i.e. the ripple frequency is twice that of input frequency

d) Output of full wave rectifier is continuous and pulsating.

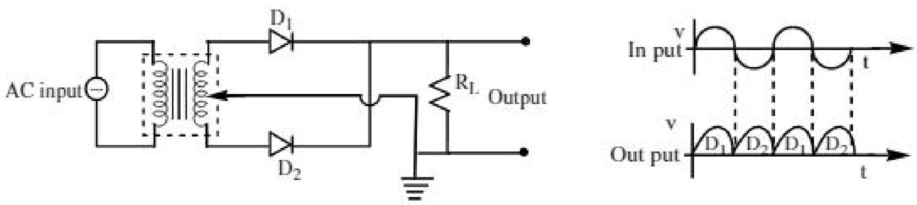
e) Efficiency $(\eta) = \frac{\text{D.C power output}}{\text{A.C power input}}$

f) Efficiency $(\eta) = \left(\frac{0.812 \times R_L}{r_f + R_L}\right) \times 100\%$

g) $\eta_{max} = 81.2\%$ for an ideal diode.

h) Though minimum two diodes are needed, only one diode conducts at a time.

8. FULL WAVE RECTIFIER CIRCUIT WITH CENTRE TAPPED TRANSFORMER



The pulsating current in output can be made smooth using filter circuit.

9. DIFFERENT BREAKDOWNS IN P-N JUNCTION DIODE

i) Avalanche breakdown in reverse bias is due to

a) low doping of p-n junction diode.

b) the breaking of covalent bonds as a result of collision of electrons and holes with the valence electrons.

c) ionisation of atoms by the thermally generated electrons in the electric field.

d) For this break down higher reverse potential is required.

ii) Zener breakdown in reverse bias is due to

a) high doping of p-n junction diode.

b) the breaking of covalent bonds simultaneously

c) the release of free electrons due to the breaking of covalent bonds near the junction.

d) For this break down lower reverse potential is sufficient.

10. VARIOUS TYPES OF P-N JUNCTIONS :

i) Light Emitting Diode:(LED)

a) Diode is forward biased.

b) **Principle :** Production of light from electric current.

c) **Working :** Electromagnetic radiations are emitted on account of transition of electrons from conduction band to valence band.

d) used as photo - luminescent panels in road signs, indicator lights etc.

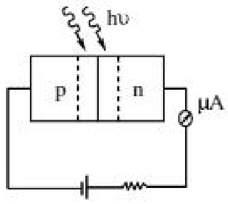
ii) Photodiode:

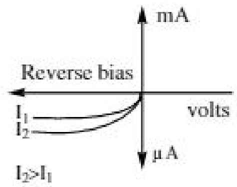
a) Diode is reverse biased.

b) **Principle :** Electric conduction from light.

c) **Working :** The covalent bonds break due to electro-magnetic radiations $(h\nu > E_g)$ and more electrons become free, hence conductivity increases

d) used as current controlling device, light meters etc.





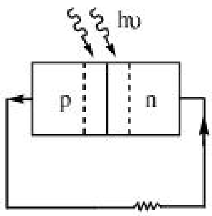
iii) Solar cell :

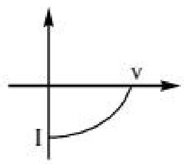
a) Diode is unbiased.

b) **Principle :** Production of potential difference by sun light.

c) **Working :** More number of electron- hole pairs are created due to electromagnetic radiations $(h\nu > E_g)$ and they move in opposite directions across the junction, hence p.d is developed across the diode.

d) Used in calculators, Solar arrays to generate electricity.





11. ZENER DIODE :

i) It is a properly doped P-n junction diode which is operated in the breakdown region in reverse bias mode.

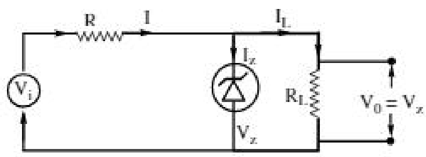
ii) Zener diode has a sharp breakdown voltage in the reverse bias condition. This voltage is called Zener Voltage (V_z).

iii) Silicon is prefered over germanium while constructing Zener diodes, due to its high thermal stability and current compatibility.

iv) The zener voltage of a junction diode depends on the amount of doping, nature of semiconductor, temperature etc.

v) If the doping is heavy, the depletion layer will be thin and zener voltage will be lesser and sharp.

vi) More number of electron – hole pairs are created due to the strong electric field at the junction at zener voltage, which increases the reverse current without change in voltage.



vii) For a lightly doped diode, the zener voltage is large.

viii) In forward bias, zener diode acts like an ordinary p-n junction diode.

ix) Zener diode is used as a voltage regulator. By changing doping concentration, zener diodes with widely different zener voltages can be designed.

x) Output voltage (V_o) = Zener Voltage (V_z) = constant

xi) For a given load, the current through load resistance $(I_L) = \dfrac{V_0}{R_L} = \dfrac{V_z}{R_L}$ = constant

xii) Voltage across series resistance (V) = input voltage – zener voltage ; $V = V_i - V_Z$.

xiii)Current through series resistance (R) is $\boxed{I = \frac{V}{R} = \frac{V_i - V_Z}{R}}$

xiv)Current through zener diode $(I_Z) = I - I_L$.

xv) If input voltage fluctuations occur, the series resistance 'R' controls the output voltage fluctuations so as to maintain constant voltage across load.

xvi) The voltage across the zener diode remains constant even if the load resistance R_L varies.

12. TRANSISTORS :

i) Transistor means transfer resistor i.e., it transfers current from low resistance circuit to high resistance circuit.

ii) Transistor consists of two p - n junctions joined back to back.

iii) Transistors are of two types : (i) p-n-p and (2) n - p - n

iv) Transistor consists of 3 regions. (a) Emitter (b) Base (c) Collector

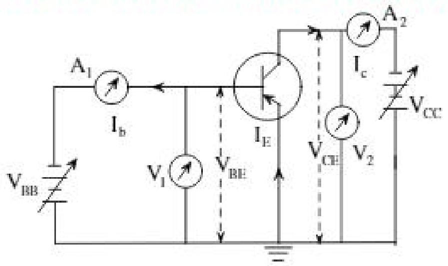
Emitter : It is heavily doped, moderate in size and supplies majority charge carriers to base. (i.e. it is a source of charge carriers)

Base : It is thinnest (order of 10^{-6}m) in size and lightly doped. It allows most of the charge carriers injected in to it to flow into collector without getting neutralized.

Collector : It is moderately doped, thickest in size and its function is to collect the majority charge carriers from base.

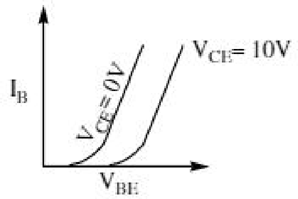
v) In a transistor, emitter region and collector regions cannot be interchanged.

13. P-N-PCOMMON-EMITTER TRANSISTOR CHARACTERISTICS :



i) **Input characteristics :**

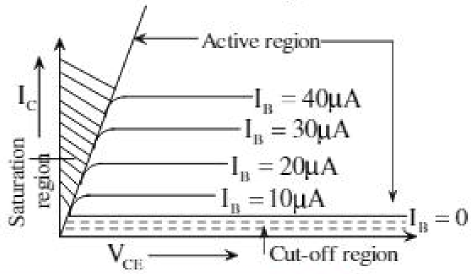
The curves showing the variation of base current (I_B) with base-emitter voltage (V_{BE}) at constant collector emitter voltage (V_{CE})



Input resistance in CE configuration transistor is $R_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$

ii) **Output characteristics :**

a) The curves showing the variation of collector current (I_C) with collector-emitter voltage (V_{CE}) keeping base current (I_B) constant.



b) The output resistance in C-E configuration transistor is $R_0 = \left(\frac{\Delta V_{CE}}{\Delta\ I_C}\right)_{I_B}$.

iii) In a transistor,

a) If the emitter - base junction is forward biased and collector - base junction is reverse biased, then the transistor is said to be in active region.In this region I_c is many times greater than I_b.

b) If both the junctions are forward biased, then the transistor is said to be in saturation region. In this region I_c is almost independent of I_b.

c) If both the junctions are reverse biased, then the transistor is said to be in cut-off region. In this region, I_c is almost zero.

iv) In common - emitter configuration transistor, the current gain is $\beta_{d.c.} = \frac{I_C}{I_B}, \beta_{a.c.} = \frac{\Delta I_C}{\Delta I_B}$.

v) The value of β is greater than one ($\beta > 1$)

vi) The practical value of 'β' lies in between 20 to 200.

vii) Relation between α, β : $\beta = \frac{\alpha}{1-\alpha}; \alpha = \frac{\beta}{1+\beta}; \frac{1}{\alpha} - \frac{1}{\beta} = 1$

viii) Transistors are used as oscillators, amplifiers, electronic switches etc.

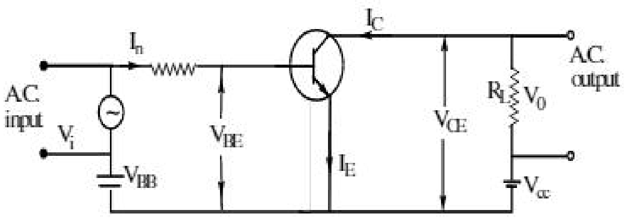
14. AMPLIFIER:

It is a device which is used to strengthen a weak signal into a strong signal.

i) **n-p-n Common-emitter transistor amplifier:**

a) In CE configuration, a small change in the base current produces a corresponding large change in collector current.

b) The amplifier which is used to rise the voltage level is called as voltage amplifier.Voltage gain



$$A_V = \frac{\Delta V_{CE}}{\Delta V_{BE}} = \frac{\Delta I_C}{\Delta I_B} \times \frac{R_L}{R_i} = \beta \times \frac{R_L}{R_i}$$

c) The amplifier which is used to rise the power level is called as power amplifier.

Power gain $(A_P) = \beta\ \ A_V = \beta \times \frac{\Delta V_{CE}}{\Delta V_{BE}} = \beta^2 \times \frac{R_L}{R_i}$

Note:

i) C-E configuration transistors are widely used as amplifiers because of its higher efficiency over the other configurations.

ii) Generally in an amplifier, n-p-n transistors in C-E configurations are used, because the mobility of electrons > mobility of holes.

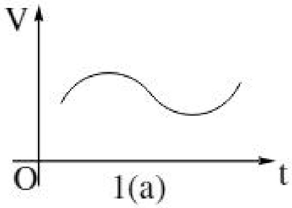
iii) In C-B amplifier, the phase difference between the input and output signals is zero.

iv) In C-E amplifier, the phase difference between the input and output signals is π.

15. LOGIC GATES :

The electronic circuits are of two types. They are analog and digital circuits.

i) **Analog circuits:**
The waveforms are continuous and a range of values of voltages are possible.
Ex: amplifier, oscillator circuits.



1(a)

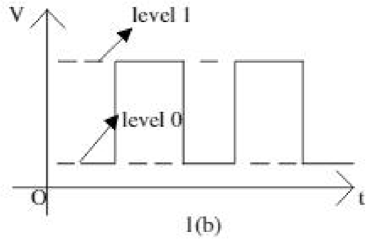
ii) **Digital circuits:**

a) The waveforms are pulsated and only discrete values of voltages are possible. **Ex:** logic gates.

b) In the decimal system, there are ten digits. They are 0,1,2,3,4,5,6,7,8,9.

c) In the binary system, there are only two digits 0 and 1.

d) Digital electronics is devoloped by represent-ing the low and high levels of voltages in pulsated waveform with binary digits 0 and 1 (called bits).



1(b)

e) The basic building blocks of digital circuits are called as logic gates, since they perform logic operations.

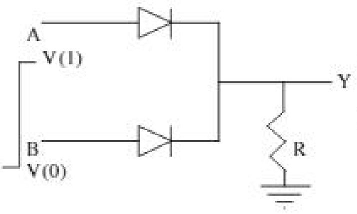
f) Generally the level 1 or high level is at $4 \pm 1\,\text{V}$ and level 0 or low level is at $0.2 \pm 0.2\,\text{V}$

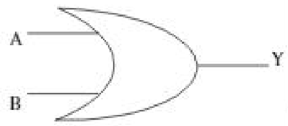
iii) **OR gate:**

a) An OR gate has two or more inputs with one output.

b) The Boolean expression is Y=A+B (Y equals A or B).

c) The output(Y) of OR gate will be 1 when the inputs A or B or both 1. two input OR gate circuit symbol truth table





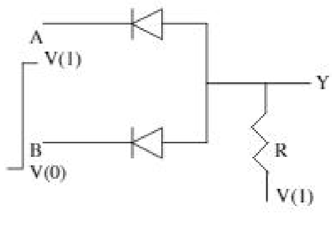
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

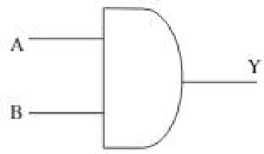
iv) **AND GATE :**

a) An AND gate has two or more inputs with one output.

b) The Boolean expression is Y = A.B (Y equals A and B).

c) The output(Y) of AND gate is 1 only when all the inputs are simultaneously 1.





circuit symbol

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

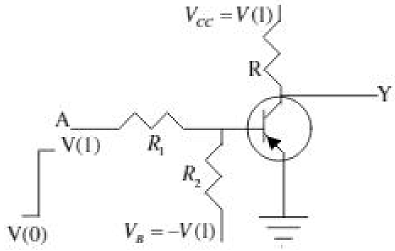
truth table

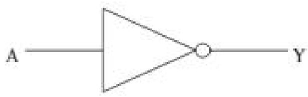
v) **NOT GATE :**

a) It has a single input and a single output.

b) The Boolean expression is $Y = \overline{A}$ (Y equals not A)

c) The output of NOT gate is the inverse of the input or it performs nagation operation.





A	Y
0	1
1	0

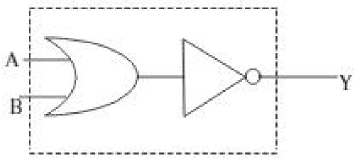
circuit symbol truth table

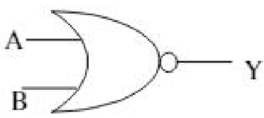
vi) NOR GATE

a) It has two or more inputs and one output.
A negation(NOT operation) applied after OR gate, gives a NOT-OR gate or simply NOR gate.

b) NOR gate output is inverse of OR gate output. The output of NOR gate is 1 only when all the in puts are simultaneously 0.

c) The Boolean expression is $Y = \overline{A + B}$





A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

two input NOR gate circuit symbol truth table

vii) NAND GATE

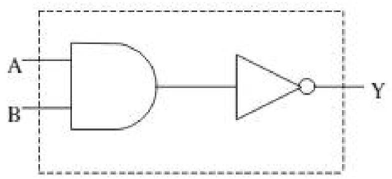
a) It has two or more inputs and one output. A negation(NOT operation) applied after AND gate, gives a NOT-AND gate or simply NAND gate.

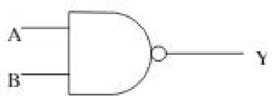
b) NAND gate output is inverse of AND gate output.

c) The Boolean expression is $Y = \overline{A.B}$

d) The output of NAND gate is 1 only when atleast one input is 0.

e) The NOR and NAND gates are considered as universal gates, because we can obtain all the gates like OR, AND and NOT by using either NOR or NAND gates repeatedly.





A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

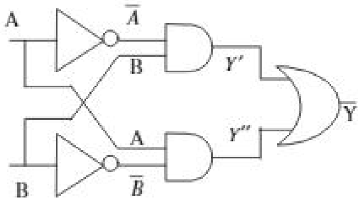
two input NAND gate circuit symbol truth table

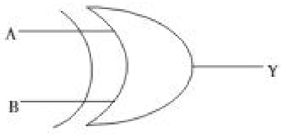
viii) XOR GATE

a) XOR gate is obtained by using OR, AND and NOT gates. It is also called exlusive OR gate.

b) The output of a two input XOR gate is 1only when the two inputs are different.

c) The Boolean equation is $Y = A.\overline{B} + B.\overline{A}$





A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

two input XOR gate circuit symbol truth table

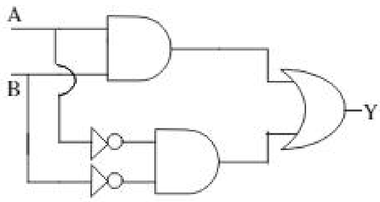
ix) XNOR GATE :

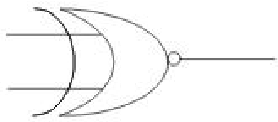
a) XNOR gate is obtained by using OR, AND and NOT gates.

b) It is also called exlusive NOR gate.

c) The output of a two input XNOR gate is 1 only when both the inputs are same.

d) The Boolean equation is $Y = A.B + \bar{A}.\bar{B}$ XNOR gate is inverse of XOR gate.





A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

two input XNOR gate circuit symbol truth table

16. THE BASIC RELATIONS FOR OR GATE:

i) $A + 0 = A$ ii) $A + 1 = 1$

iii) $A + A = A$ iv) $A + \bar{A} = 1$

17. THE BASIC RELATIONS FOR AND GATE :

i) $A.0=0$ ii) $A.1=A$

iii) $A.A=A$ iv) $A.\bar{A} = 0$

18. DE-MORGAN'S THEOREMS :

i) $\overline{A+B} = \bar{A}.\bar{B}$ ii) $\overline{A.B} = \bar{A} + \bar{B}$

iii) $\overline{\bar{A}+\bar{B}} = \bar{\bar{A}}.\bar{\bar{B}} = A.B$ iv) $\overline{\bar{A}.\bar{B}} = \bar{\bar{A}} + \bar{\bar{B}} = A + B$

Example : Verification of theorems with truth table.

A	$\bar{A}$	B	$\bar{B}$	$A.B$	$\overline{A.B}$	$\bar{A}.\bar{B}$	$\overline{\bar{A}.\bar{B}}$	$\bar{\bar{A}}.\bar{\bar{B}}$	$A+B$	$\overline{A+B}$	$\bar{A}+\bar{B}$	$\overline{\bar{A}+\bar{B}}$	$\bar{\bar{A}}+\bar{\bar{B}}$
0	1	0	1	0	1	1	0	0	0	1	1	0	0
1	0	0	1	0	1	0	1	0	1	0	1	0	1
0	1	1	0	0	1	0	1	0	1	0	1	0	1
1	0	1	0	1	0	0	1	1	1	0	0	1	1

LECTURE SHEET

LEVEL-I (MAIN)

EXERCISE-I

(Band Theory of solids, Classification of solids, Intrinsic semiconductors, Extrinsic semiconductors (P-Type and N-Type)

Straight Objective Type Questions

1. The semiconductors are generally

   1) Monovalent 2) Divalent 3) Trivalent 4) tetravalent

2. In semiconductors, which of the following relations is correct at thermal equilibrium ?

   1) $n_i = n_e = n_h$ 2) $n_i^2 = n_e n_h$ 3) $n_i = \frac{n_e}{n_h}$ 4) $n_i = n_e + n_h$

3. In insulators

   1) the valence band is partially filled with electrons
   2) the conduction band is partially filled with electrons
   3) the conduction band is filled with electrons and valence band is empty
   4) the conduction band is empty and the valence band is filled with electrons

4. Fermi energy level is

   1) the minimum energy of electrons at 0K 2) the maximum energy of electrons at 273K
   3) the maximum energy of electrons at 0K 4) the minimum energy of electrons at 273K

5. In a good conductor, the energy gap between the conduction band and valence band is :

   1) Infinity 2) Wide 3) Narrow 4) Zero

6. A pure semiconductor has

   1) An infinite resistance at 0^0C
   2) A finite resistance which does ot depend upon temperature
   3) A finite resistance which increases with temperature
   4) A finite resistance which decreases with temperature

7. The forbidden energy gap in semiconductors

   1) lies just below the valence band 2) lies just above the conduction band
   3) is the same as the valence band 4) lies b/w the valence band and the conduction band

8. An n-type semiconductor is electrically

   1) Positive 2) Negative
   3) May be positive or negative 4) Neutral

9. The energy gap for an isulator may be

   1) 1.1eV 2) 0.02eV 3) 6eV 4) 0.7eV

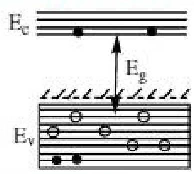
10. At asbsolute zero temperature, a crystal of pure germanium

    1) behaves as perfect conductor 2) behaves as perfect insulator
    3) contains no electron 4) none of the above

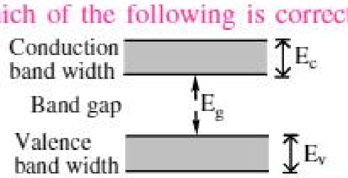
11. Three semiconductors are arranged in the increasing order of their energy gap as follows : The correct arrangement is

    1) Tellurium, germanium, silicon 2) Tellurium, silicon, germanium
    3) Silicon, germanium, tellurium 4) Silicon, tellurium, germanium

12. In an intrinsic semiconductor
    1) only electron are responsible for flow of current
    2) both holes and electron carry current
    3) both holes and electron carry current with electrons being majority carriers
    4) only holes are responsible for flow current
13. In a semiconductor the forbidden energy gap between the valence band and the conduction band is of the order of
    1) 1 eV 2) 5 eV 3) 1 keV 4) 1 MeV
14. With rise in temperature the electrical conductivity of intrinsic semiconductor
    1) increases 2) decreases
    3) first increases and then decreases 4) first decreases and then increases
15. In an intrinsic semiconductor, the density of conduction electrons is $7.07\times10^{15}m^{-3}$. When it is doped with indium, the density of holes becomes $5\times10^{22}m^{-3}$. Find the density of conduction electons in doped semiconductor
    1) Zero 2) $1\times10^{9}m^{-3}$ 3) $7\times10^{15}m^{-3}$ 4) $5\times10^{22}m^{-3}$
16. Which of the following is not a semiconductor?
    1) Selenium 2) Arsenic 3) Silicon 4) None of these
17. In an unbiased p-n junction which of the following is correct?
    1) p-side is at higher potential than n-side
    2) n-side is higher potential than p-side
    3) Both p-side and n-side are at the same potential
    4) Any of the above is possible depending upon the carrier density in the two sides
18. The conductivity of a pure semiconductor can be increased by
    1) increasing temperature 2) mixing trivalent impurity
    3) mixing pentavelent impurity 4) All of the above
19. A semiconductor is known to have an electron concentration of 8×10^{13} per cm^3 and hole concentration of 5×10^{12} per cem^3. The semiconductor is
    1) n-type 2) p-type 3) intrinsic 4) none of these
20. At ordinary temperature, the electrical conductivity of semiconductors in mho/metre is in the range
    1) 10^3 to 10^4 2) 10^6 to 10^9 3) 10^{-6} to 10^{-10} 4) 10^{-10} to 10^{-16}
21. What is the name of the level formed due to impurity atom in the forbidden energy gap near the valence band in a *p*-type semiconductor ?
    1) Donor level 2) Acceptor level 3) Conduction level 4) Forbidden level
22. In the energy band diagram of material shown in fig below the open circles and filled circles denote holes and electrons respectively. The material is



    1) an insulator
    2) a metal
    3) an *n*-type semiconductor
    4) a *p*-type semiconductor
23. In the lattice constant of this semiconductor is decreased, then which of the following is correct ?



    1) All E_c, E_g and E_v decrease
    2) All E_c, E_g and E_v increase
    3) E_c and E_v increase, but E_g decrease
    4) E_c and E_v decrease, but E_g increase

24. Regarding a semiconductor which one of the following is wrong ?
    1) There are no free electrons at room temperature
    2) There are no free electrons at 0K
    3) The number of free electrons increases with rise of temperature
    4) The charge carriers are electrons and holes

25. Which of the following statements is true for an *n*-type semi-conductor ?
    1) The donor level lies closely below the bottom of the conduction band
    2) The donor level lies closely above the top of the valence band
    3) The donor level lies at the halfway mark of the forbidden energy gap
    4) None of the above

26. Carbon, silicon and germanium have four valence electrons each. At room temperature which one of the following statements is most appropriate ?
    1) The number of free electrons for conduction is significant only in Si and Ge but small in C
    2) The number of free conduction electrons is significant in C but small in Si and Ge
    3) The number of free conduction electrons is negligibly small in all the three
    4) The number of free electrons for conduction is significant in all the three

27. The electrical conductivity of a semiconductor increases when electromagnetic radiation of wavelength shorter than 2480 nm is incident on it. The band gap in (eV) for the semiconductor is
    1) 0.5 eV 2) 0.7 eV 3) 1.1eV 4) 2.5 eV

28. If the ratio of the concentration of electrons to that of holes in a semiconductor is 7/5 and the ratio of currents is 7/4, then what is the ratio of their drift velocities ?
    1) 4/7 2) 5/8 3) 4/5 4) 5/4

EXERCISE-II

(p-n junction diode and characteristics)

Straight Objective Type Questions

1. In a *p-n* junction diode, holes diffuse from *p*-region to *n*-region because :
    1) the free electrons in the *n*-region attract them
    2) they are swept across the junction by potential difference
    3) there is a greater concentration of holes in *p*-region as compared to *n*-region
    4) none of these

2. The potential barrier at a *p-n* junction is due to the charges on either side of the junction. These charges are
    1) fixed donor and acceptor ions
    2) minority carriers
    3) majority carriers
    4) both majority and minority carriers

3. The depletion layer in the *p-n* junction is caused by
    1) drift of holes 2) diffusion of charge carriers
    3) migration of impurity ions 4) drift of electrons

4. The thickness of the depletion layer is of the order of
    1) a micron 2) a millimetre 3) a nanometre 4) a picometre

5. In a forward biased *p-n* junction diode, current inside the junction diode is due to drift of
   1) free electrons
   2) both types of majority carriers
   3) both types of minority carriers
   4) donor atoms

6. In a semiconducting diode, the reverse biased current is due to drift of free electrons and holes caused by
   1) thermal excitations only
   2) impurity atoms only
   3) both 1 and 2
   4) neither 1 nor 2

7. In a forward biased *p-n* junction, the current is of the order of
   1) ampere 2) milliampere 3) microampere 4) manoampere

8. In the reverse biased *p-n* junction, the current is of the order of
   1) ampere 2) milliampere 3) microampere 4) manoampere

9. When a *p-n* junction is forward biased its resistance is
   1) very small 2) very large 3) infinite 4) zero

10. A *p-n* junction diode cannot be used for
    1) rectification
    2) amplification
    3) obtaining light radiation
    4) detecting light intensity

11. In a semiconductor diode, the barrier potential offers opposition to only
    1) majority carriers in both regions
    2) minority carriers in both regions
    3) free electrons in the *n*-region
    4) holes in the *p*-region

12. The number of minority carriers crossing the junction of a diode depends primarily on the
    1) concentration of doping impurities
    2) magnitude of potential barrier
    3) magnitude of the forward bias voltage
    4) rate of thermal generation of electron-hole pair

13. The electrical resistance of depletion layer is large because
    1) it has immobile ions
    2) it has a large number of charge carriers
    3) it contains electrons as charge carriers
    4) it has holes as charge carriers

14. When a *p-n* junction is reverse biased
    1) electrons and holes are attracted towards each other and move towards the depletion region
    2) electrons and holes move away from the junction of depletion region
    3) height of the potential barrier decreases
    4) no change in current take place

15. The reverse biasing in junction diode
    1) decreases the potential barrier
    2) increases the potential barrier
    3) increases the number of minority charge carriers
    4) increases the number of majority charge carriers

16. In a semiconductor diode, *p*-side is earthed and to *n*-side is applied a potential of –2 volt, the diode shall
    1) conduct 2) not conduct 3) conduct partially 4) break down

17. Avalanche breakdown in a semiconductor diode occurs when
    1) forward current exceeds a certain value
    2) reverse bias exceeds a certain value
    3) forward bias exceeds a certain value
    4) the potential barrier is reduced to zero

18. A semiconducting device is connected in a series circuit with a battery and a resistance. A currents is found to pass through the circuit. If the polarity of the battery is reversed, the current drops to almost zero. The device may be

1) a *p-n* junction
2) an intrinsic semiconductor
3) a *p*-type semiconductor
4) an *n*-type semiconductor

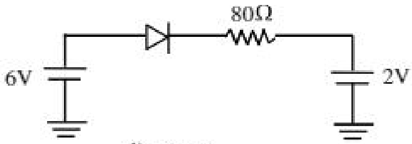
19. Rectifier is used to convert

1) electrical energy into mechanical energy
2) heat energy into electrical energy
3) high voltage into two voltage
4) AC and DC

20. Germanium diode

1) may be used as a rectifier because it offers a relatively low resistance for a forward bias and very high resistance for a reverse bias
2) may be used as a rectifier because it offers a relatively high resistance for a forward bias and very low resistance for a reverse bias
3) cannot be used as rectifier
4) may be used as an amplifer

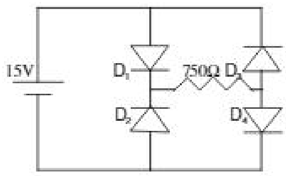
21. The resistance of the diode in the forward biased condition is 20Ω and infinity in the reverse biased condition. The current in the given circuit is



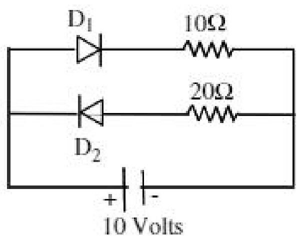
1) 20mA
2) 40mA
3) 50mA
4) zero

22. Four silicon diodes are connected as shown in the fig. Assuming the diodes to be ideal. The current through the resistor is

1) 0.02A
2) 0.08A
3) 0.04A
4) zero



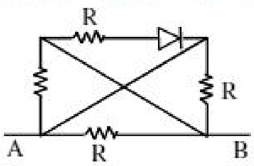
23. Assuming that the resistance of each diode is zero in forward biased condition and infinity in the reverse biased condition, the current in the circuit is



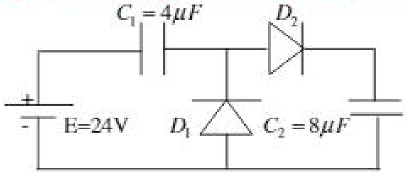
1) 1A
2) 2A
3) 0.5A
4) zero

24. In the given circuit, the equilavent resistance between A and B is (if A has negative potential and B has positive potential)

1) R/4 Ω
2) R/3 Ω
3) 4R Ω
4) 3R Ω

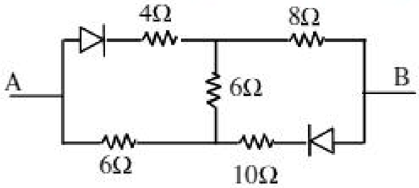


25. In the circuit shown, the potential drop across each capacitor is (assuming the two diodes are ideal)



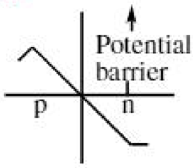
1) 16V, 8V
2) 10V, 8V
3) 5V, 6V
4) 6V, 0V

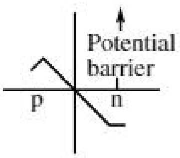
26. In the given circuit, the equivalent resistance between A and B is (if A has positive potential and B has negative potential)

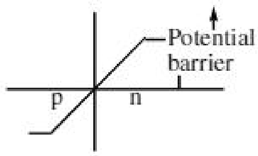


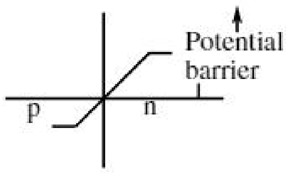
1) 11 Ω
2) 34/3 Ω
3) 10 Ω
4) 8 Ω

27. In a forward biased *p-n* junction diode, the potential barrier in the depletion region will be of the form

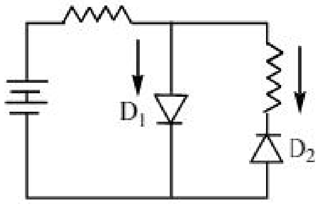
1) 

2) 

3) 

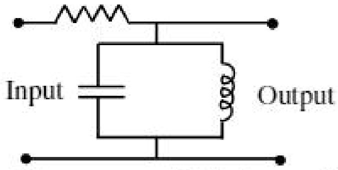
4) 

28. In the diode circuit given :



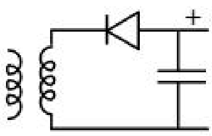
1) D_1 and D_2 are reverse biased
2) D_1 and D_2 are forward biased
3) D_1 is reverse biased and D_2 is forward biased
4) D_1 and D_2 will not conduct

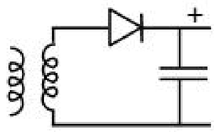
29. The circuit shown below acts as :

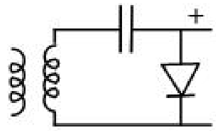


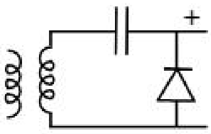
1) tuned filter 2) low pass filter 3) high pass filter 4) rectifier

30. Which of the following diagrams represents of a half-wave rectifier?

1) 

2) 

3) 

4) 

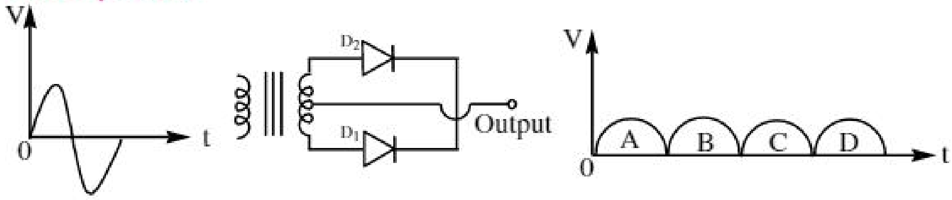
31. The current in a diode is related to the voltage V by the equation

1) $I \propto V^{1/2}$ 2) $I \propto V^{3/2}$ 3) $I \propto V^2$ 4) $I \propto V$

32. The relation between the forward current I_f and saturation current I_s for *p-n* junction diode is

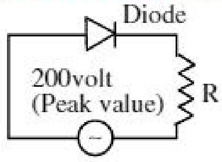
1) $I_f = I_s(e^{(qV/KT)} - 1)$ 2) $I_f = I_s\left[\frac{qV}{KT} - 1\right]$ 3) $I_f = I_s$ 4) $I_f I_s = 1$

33. A full wave rectifier circuit along with the output is shown in the given diagram. The contribution(s) from the diode D_1 is (are)



1) C 2) A,C 3) B,D 4) A,B,C,D

34. A sinusoidal voltage of peak value 200volt is connected to a diode and resistor R in the circuit shown so that half wave rectification occurs. If the forward resistance of the diode is negligible compared to R, the rms value of voltage across R is approximately

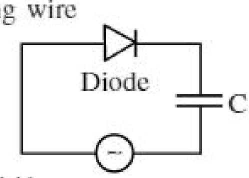


1) 200 2) $100\sqrt{2}$ 3) $100/\sqrt{2}$ 4) 283

35. If the two ends *p* and *n* of a *p-n* diode junction are joined by a wire

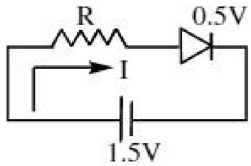
1) there will not be a steady current in the circuit
2) there will be a steady current from *n*-side to *p*-side
3) there will be a steady current from *p*-side to *n*-side
4) there may not be a current depending upon the resistance of the connecting wire

36. A sinusoidal voltage of rms value of 200 volt is connected to the diode and a capacitor C in the circuit shown so that half wave rectification occurs. The final potential difference in volt across C is



1) 500 2) 200 3) 283 4) 141

37. The diode used in the circuit shown in the figure has a constant voltage drop of 0.5V at all currents and a maximum power rating of 100 milliwatts. What should be the value of the resistor R, connected in series with the diode, for obtaining maximum current ?



1) 1.5Ω 2) 5Ω 3) 6.67Ω 4) 200Ω

38. The voltage gain in common-base configuration is

1) $A = \alpha(R_2/R_1)$ 2) $A = \beta(R_2/R_1)$ 3) $A = \alpha$ 4) $A = \beta$

EXERCISE-III

(Miscellaneous Applications of p-n diode, Zener diode, Photo diode, LED, Solar cell)

Straight Objective Type Questions

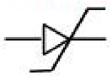
1. Zener diode functions in

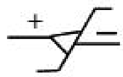
1) forward biased condition 2) reverse biased condition
3) both forward and reverse biased 4) none of the above

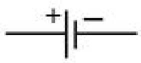
2. Zener diode is used for

1) rectification 2) amplification 3) stabilization 4) modulation

3. The correct sympol for zener diode is

1)  2) 

3) 

4) 

4. Consider the following statements A and B and identify the correct answer.

A) A zener diode is preferably connected in reverse bias.
B) The potential barrier of a *p-n* junction lies between 0.1 to 0.3V approximately.

1) A and B are correct 2) A and B are wrong
3) A is correct, but B is wrong 4) A is wrong, but B is correct

5. A zener diode when used as a voltage regulator is connected

i) in forward bias ii) in reverse bias iii) in parallel with load iv) in series with load

1) (i) and (iii) are correct 2) (ii) and (iii) are correct

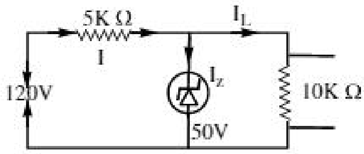
3) only (i) is correct 4) only (iv) is correct

6. Why is there sudden increase in current in zener diode ?

1) due to rupture of bonds 2) resistance of depletion lays becomes less

3) due to high doping 4) none of the above

7. In the figure shown, the currents through the series resistance and load resistance are respectively



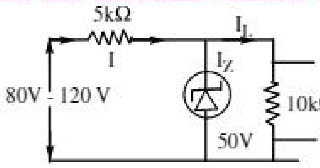
1) 9mA, 14mA

2) 14mA, 5mA

3) 1mA, 14mA

4) 1mA, 6mA

8. In the figure shown, the maximum and minimum currents through Zener diode are



1) 5mA, 1mA 2) 14mA, 6mA 3) 14mA, 5mA 4) 9mA, 1mA

9. A zener diode has a breakdown voltage of 9.1 volts with a maximum power dissipation of 364 milliwatts. What is the maximum current the diode can handle?

1) 40 mA 2) 50 mA 3) 60 mA 4) 70 mA

10. To measure light intensity we use

1) LED with forward bias 2) LED with reverse bias

3) photodiode with reverse bias 4) photodiode with forward bias

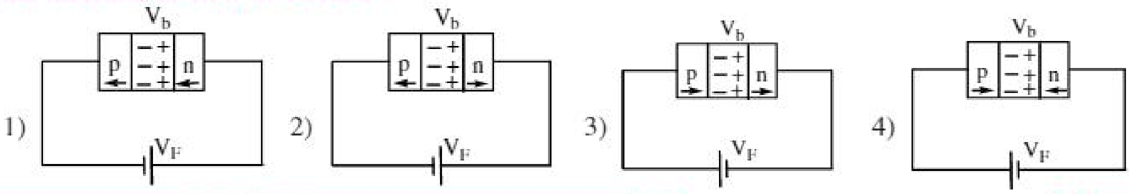
11. The temperature coefficient of a zener mechanism is

1) negative 2) positive 3) infinity 4) zero

12. A Light Emitting Diode(LED) has a voltage drop of 2 volt across it and passes a current of 10mA when it operates wtith a 6 volt battery through a limiting resistor R. The value of R is

1) 10kΩ 2) 4kΩ 3) 200Ω 4) 400Ω

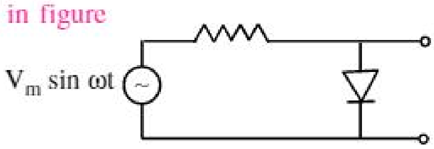
13. If the case of forward biasing of *p-n* junction, which one of the following figures correctly depicts the direction of flow of carriers ?



14. For a junction diode, the ratio of forward current (I_f) and reverse current is [I_e = electronic charge, V = voltage applied across junction, k = Boltzmann constant, T = temperature in kelvin]

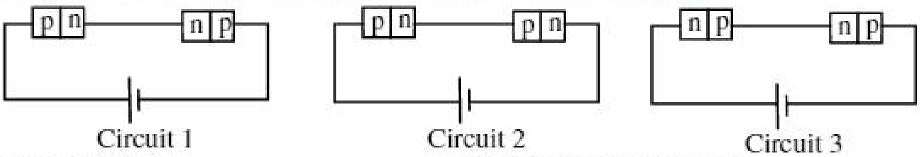
1) $e^{-V/kT}$ 2) $e^{V/kT}$ 3) $(e^{eV/KT}-1)$ 4) $(e^{V/KT}-1)$

15. The output of the given circuit in figure



1) would be zero at all times
2) would be like a half-wave rectifier with positive cycle in output
3) would be like a half-wave rectifier with negative cycle in output
4) would be like that of a full wave rectifier

16. Two identical *p-n* junction may be connected in series with a battery in the three ways as shown in the adjoining figure. The potential drop across the *p-n* junctions are equal in



1) circuit 1 and circuit 2 2) circuit 2 and circuit 3
3) circuit 3 and circuit 1 4) circuit 1 only

17. Assertion (A) : The resistivity of a semiconductor increases in temperature.

Reason (R) : In a conducting solid, the rate of collisions between free electrons and ions increases with increases of temperature

1) If both A and R are true and the R is correct explanation of the A
2) If both A and R are true and the R is not correct explanation of the A
3) If A is true but R is false 4) If A is false but the R is true

EXERCISE-IV

(Transistors)

Straight Objective Type Questions

1. In a *p-n-p* transistor *p*-type crystal acts as

1) emitter only 2) base only
3) collector only 4) either emitter or collector

2. In a *n-p-n* transistor *p*-type crystal acts as

1) emitter only 2) base only
3) collector only 4) either emitter or collector

3. The dopping of the base of transistor is

1) equal to that of emitter or collector 2) sightly more than that of emitter or collector
3) less than that of emitter and collector 4) much more than that of emitter or collector

4. Transistors are made from

1) conductors 2) insulators
3) non-metals 4) doped semiconductors

5. Transistors are essentially
   1) power driven devices
   2) current driven devices
   3) voltage driven devices
   4) reistance driven devices

6. The base of the transistor is made thin and is doped with least impurity atoms, because
   1) about 95% charge carriers may cross
   2) 100% charge carriers may cross
   3) the transistor may be saved from high currents
   4) None of these

7. Choose the correct statement in case of a transistor
   1) The emitter-base junction is forward biased while base-collector junction is reverse biased
   2) Resistance of the emitter-base junction is very high while that of the base collector junction is very low
   3) The base is made very thin and highly doped
   4) both the emitter and collector are equally doped

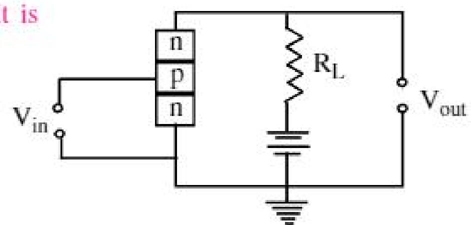
8. In a transistor
   1) length of emitter is greater than that of collector
   2) length of collector is greater than that of emitter
   3) length of base is greater than that of emitter
   4) length of base is greater than that of collector

9. One way in which the operation of an *n-p-n* transistor differ from that of a *p-n-p*
   1) the emitter junction is reverse biased in *n-p-n*
   2) the emitter junction injects minority carriers into base region of the *p-n-p*
   3) the emitter injects holes into the base of the *p-n-p* and electrons into the base regions of *n-p-n*
   4) the emitter injects holes into the base of *n-p-n*

10. *n-p-n* transistors are preferred to *p-n-p* transistors because :
   1) they have low cost
   2) they have low dissipation energy
   3) they are capable of handling large power
   4) electrons have high mobility than holes

11. In an *n-p-n* transistor, the emitter current is
   1) slightly more than collector current
   2) slightly less than collecor current
   3) equal to the collector current
   4) equal to the base current

12. An *n-p-n* transistor circuit is arranged as shown in figure. It is



   1) a common-base amplifier circuit
   2) a common-emitter amplifier circuit
   3) a common-collector amplifier circuit
   4) none of the above

13. A transistor connected in common-base configuration has
   1) a low input resistance and high output resistance
   2) a high input resistance and low output resistance
   3) a low input resistance and low output resistance
   4) a high input resistance and high output resistance

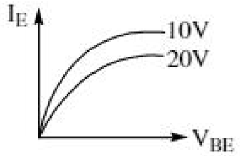
14. Which of the following is correct ?
 1) The input resistance of transistor is very small 2) The output resistance of transistor is very large
 3) The amplifier increases the AC power 4) All of the above

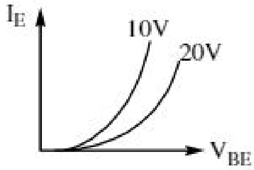
15. The power gain is highest when transistor is used an
 1) CB configuration 2) CE configuration 3) CC configuration 4) equal in all cases

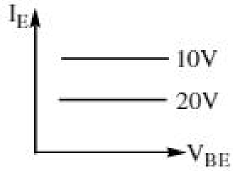
16. Compared to CB amplifier, the CE amplifier has
 1) lower input reistance 2) higher output resistance
 3) lower current amplification 4) higher output resistance

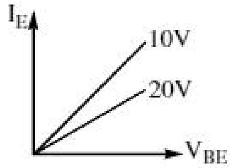
17. Which of the following configurations has the higher voltage gain ?
 1) CB configuration 2) CE configuration 3) CC configuration 4) equal in all cases

18. In common-base transistor, characteristic curve is

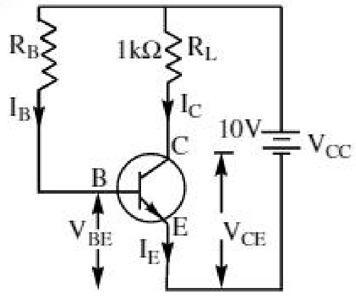
1) 

2) 

3) 

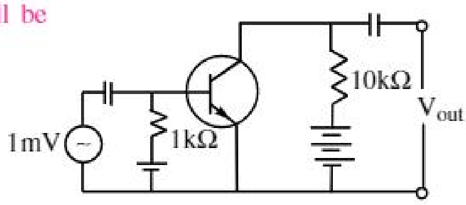
4) 

19. In the circuit shown in fig the current gain $\beta = 100$ for the transistor. What would be the bias resistance R_B so that $V_{CE} = 5V$? (Neglect V_{BE})



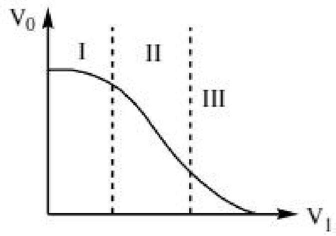
 1) $2 \times 10^3\,\Omega$ 2) $2 \times 10^5\,\Omega$ 3) $1 \times 10^6\,\Omega$ 4) $500\,\Omega$

20. In the common-emitter configuration, an *n-p-n* transistor with current gain = 100 is used. The output voltage of the amplifier will be



 1) 10 mV 2) 0.1 V 3) 1.0 V 4) 10 V

21. Transfer characteristics [output voltage (V_0) virsus input voltage (V_1)] for a base biased transistor in CE configuration is as shown in fig. For using transistor as a switch, it is used

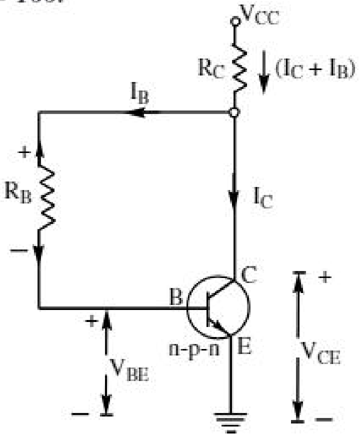


 1) in region III
 2) both in region I and III
 3) in region II
 4) In region I

Linked Comprehension Type Questions

Passage-I :

Fig. shows an n-p-n transistor connected to two resistors R_B and R_C and a battery V_{CC}. I_B and I_C are the base and collector currents where $I_B << I_C$ and $I_C/I_B = \beta$ (current gain of a transistor in CE configuration). Use this description to answer the following three questions. Take $V_{CC} = 10V$, $R_B = 500k\Omega$, $R_C = 500\Omega$, $\beta = 100$.



22. The base current (I_B) is

1) 8μA 2) 18 mA 3) 18.2μA 4) 8 mA

23. The emitter current (I_E) is approximately

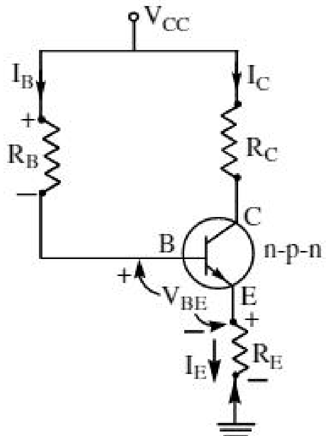
1) 1.82 mA 2) 18 mA 3) 8 mA 4) 8μA

24. The collector voltage (V_C) is

1) 18 V 2) 10 V 3) 1.8 V 4) 9.1 V

Passage-II:

Fig.shows a bias circuit with emitter resistor. In this circuit, we have three resistors R_C, R_B and R_E along with an n-p-n transistor and a battery V_{CC}. Further, $\beta = (I_C/I_B)$ is much greater than 1. As such $I_E = I_B + I_C = I_B + \beta I_B = (\beta + 1)I_B \approx \beta I_B = I_C$. Use this description to answer the following three questions. Take $V_{CC} = 10V$, $R_B = 1M\Omega$, $R_C = 2k\Omega$, $R_E = 1k\Omega$ and $\beta = 100$.



25. The base current (I_B) is

1) 18μA 2) 9.09μA 3) 18 mA 4) 1.8 mA

26. The collector current (I_C) is
1) 0.8 mA 2) 10.9 μA 3) 0.909 mA 4) 10 mA

27. The emitter current (I_E) is approximately
1) 0.81 mA 2) 11μA 3) 11 mA 4) 0.909 mA

EXERCISE-V

(Logic Gate)

Straight Objective Type Questions

1. Which of the following logic gates the given truth table represents?

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

1) NOT gate 2) NOR gate 3) OR gate 4) AND gate

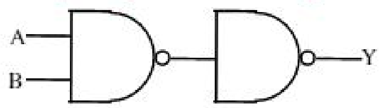
2. Which of the following logic gates the given truth table represents

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

1) XOR gate 2) NOR gate 3) AND gate 4) OR gate

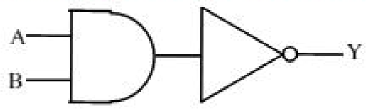
3. The following truth table corresponds to the logic gate with A and B as inputs and X as output
A 0 0 1 1
B 0 1 0 1
X 0 1 1 1
1) NAND 2) OR 3) AND 4) XOR

4. The arrangement shown in figure performs the logic function of



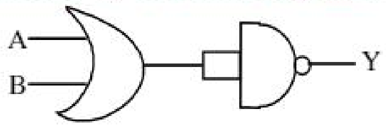
1) AND gate 2) NAND gate 3) OR gate 4) XOR gate

5. The name of the gate obtained by the combination as shown is



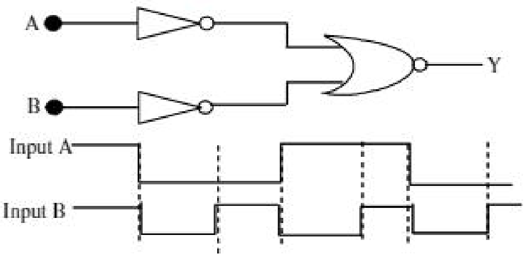
1) NAND 2) NOR 3) NOT 4) XOR

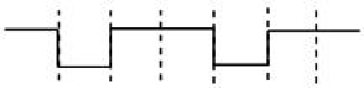
6. Identify the gate represented by the block diagram is

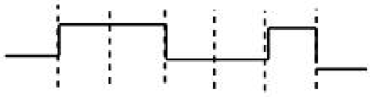


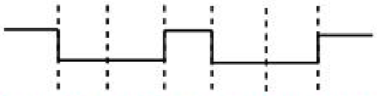
1) AND 2) NOT 3) NAND 4) NOR

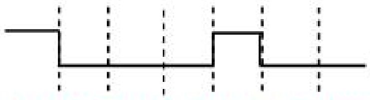
7. The logic circuit shown below has the input waveforms 'A' and 'B' as shown. Pick out the current output waveform.



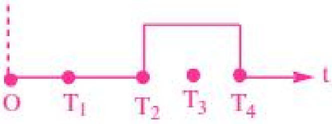
1) 

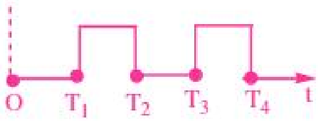
2) 

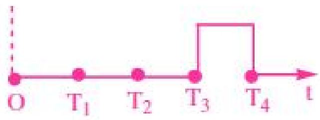
3) 

4) 

8. The given figures shows the wave forms for two inputs A and B and that for the output Y of a logic circuit. The logic circuit is

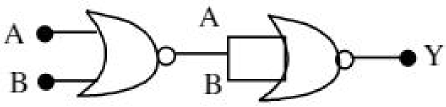
A) 

B) 

Y) 

1) An AND gate 2) An OR gate 3) A NAND gate 4) An NOT gate

9. In the following circuit, the output Y for all possible inputs A and B is expressed by the truth table



1)

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

2)

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

3)

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

4)

A	B	Y
0	0	0
0	1	1
1	0	0
1	1	1

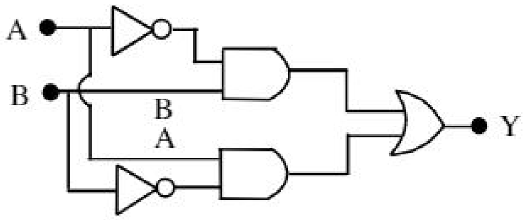
10. The truth table given below is for

(A and B are the input, Y is the out put)

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

1) NOR
2) AND
3) XOR
4) NAND

11. The truth table for the following logic circuit is



1)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

2)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

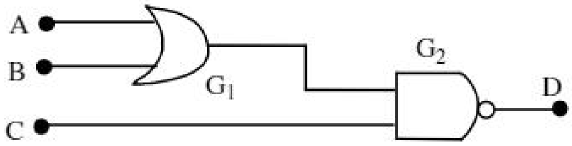
3)

A	B	Y
0	0	1
0	1	0
1	0	1
1	1	0

4)

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	1

12. For the given combination of gates, if the logic states of inputs A, B, C are as follows A =B + C = 0 and A = B = 1, C = 0 then the logic states of output D are



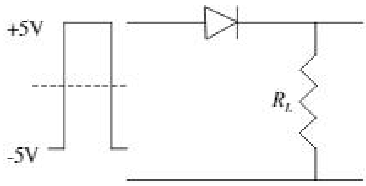
1) 0, 0

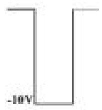
2) 0, 1

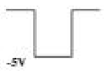
3) 1, 0

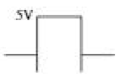
4) 1, 1

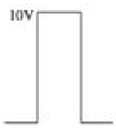
13. If a p-n junction diode, a square input signal of 10V is applied as shown, then the output signal across R_L will be



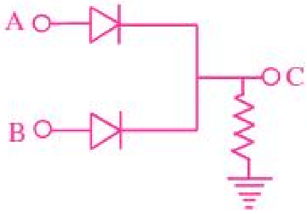
1) 

2) 

3) 

4) 

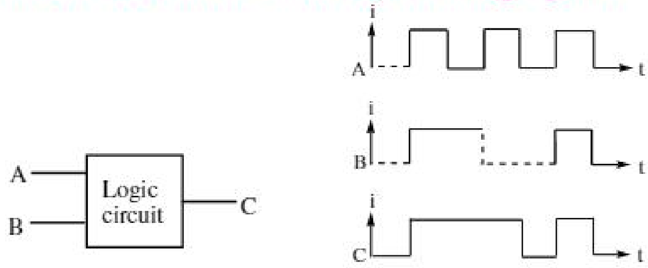
14. In the circuit below, A and B represent two inputs and C represents the output.



The circuit represents

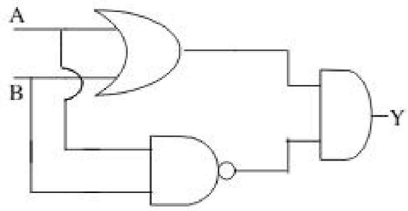
1) AND gate
2) NAND gate
3) OR gate
4) NOR gate

15. The following figure shows a logic gate circuit with two inputs A and B and the output C. The voltage waveforms of A, B and C are as shown below. The logic gate is



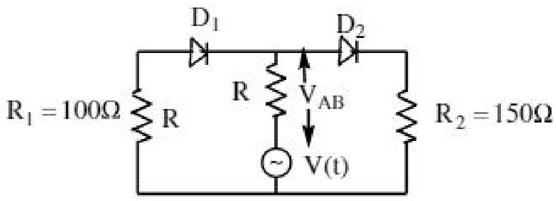
1) ORgate 2) AND gate 3) NAND gate 4) NOR gate

16. The following configuration of gates is equivalent to



1) NAND gate 2) XOR gate 3) OR gate 4) NOR gate

17. In the circuit given below, V(t) is the sinusoidal voltage source, voltage drop $V_{AB}(t)$ across the resistance R is



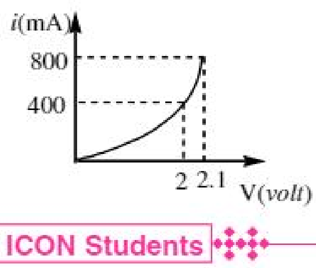
1) Is half wave rectfied
2) Is full wave rectified
3) Has the same peak value in the positive and negative half cycles
4) Has different peak values during positive and negative half cycle

Numerical Value Type Questions

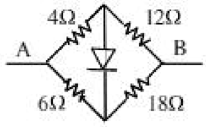
18. The probability of finding an electron in Fermi energy level is (in %)

19. In extrinsic p and n-type semiconductor materials, the ratio of the impurity atoms to the pure semiconductor atoms is about

20. The i–V characteristic of a P–N juction diode is shown below. The approximate dynamic resistance of the P–N junction when a forward bias of 2 *volt* is applied (in Ω)



21. In the figure shown the equivalent resistance between A and B is (in Ω)



22. If a zener diode (V_Z = 5V and I_Z = 10mA) is connected in series with a resistance and 20V is applied across the combination, then the maximum resistance one can use without spoiling zener action is (in Ω)

23. Three photodiodes D_1, D_2 and D_3 are made of semiconductors having band gaps of 2.5eV, 2eV and 3eV, respectively. Which one will be able to detect light of wavelength of 6000A° (in eV)?

KEY SHEET (LECTURE SHEET)

LEVEL-I (MAIN)

EXERCISE-I

1) **4**	2) **1**	3) **4**	4) **3**	5) **4**	6) **1**	7) **4**	8) **4**	9) **3**	10) **2**
11) **3**	12) **2**	13) **1**	14) **1**	15) **2**	16) **2**	17) **2**	18) **4**	19) **1**	20) **1**
21) **2**	22) **4**	23) **4**	24) **1**	25) **1**	26) **1**	27) **1**	28) **4**		

EXERCISE-II

1) **3**	2) **1**	3) **2**	4) **1**	5) **2**	6) **1**	7) **2**	8) **3**	9) **1**	10) **2**
11) **1**	12) **4**	13) **1**	14) **2**	15) **2**	16) **1**	17) **2**	18) **1**	19) **4**	20) **1**
21) **2**	22) **1**	23) **1**	24) **1**	25) **1**	26) **1**	27) **4**	28) **3**	29) **1**	30) **2**
31) **2**	32) **1**	33) **2**	34) **2**	35) **3**	36) **4**	37) **2**	38) **2**		

EXERCISE-III

1) **3**	2) **3**	3) **1**	4) **3**	5) **2**	6) **1**	7) **1**	8) **2**	9) **1**	10) **3**
11) **1**	12) **4**	13) **4**	14) **3**	15) **3**	16) **2**	17) **4**			

EXERCISE-IV

1) **4**	2) **2**	3) **3**	4) **4**	5) **2**	6) **1**	7) **1**	8) **2**	9) **3**	10) **4**
11) **1**	12) **2**	13) **1**	14) **4**	15) **2**	16) **4**	17) **1**	18) **2**	19) **2**	20) **3**
21) **2**	22) **3**	23) **1**	24) **4**	25) **2**	26) **3**	27) **4**			

EXERCISE-V

1) **4**	2) **2**	3) **2**	4) **1**	5) **1**	6) **4**	7) **4**	8) **1**	9) **4**	10) **4**
11) **1**	12) **4**	13) **3**	14) **3**	15) **1**	16) **2**	17) **4**	18) **50**	19) **0.10**	20) **0.25**
21) **9.60**	22) **20**	23) **2.06**							

PRACTICE SHEET

LEVEL-I (MAIN)

EXERCISE-I

(Band Theory of solids, Classification of solids, Intrinsic semiconductors, Extrinsic semiconductors (P-Type and N-Type)

Straight Objective Type Questions

1. An n-type semiconductor is
   1) negatively charged
   2) positively charged
   3) neutral
   4) negatively or positively charged depending upon the amount of impurity

2. In an n-type semiconductor donor valence band is
   1) above the conduction band of the host crystal
   2) below the valence band of the host crystal
   3) close to the conduction band of the host crystal
   4) close to the valence band of the host crystal

3. In a p-type semiconductor, the acceptor valence band is
   1) above the conduction band of the host crystal
   2) below the conduction band of the host crystal
   3) close to the conduction band of the host crystal
   4) close to the valence band of the host crystal

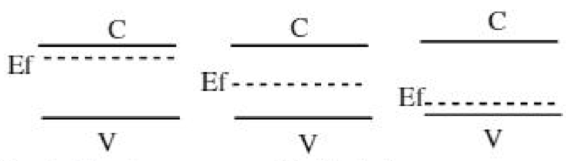
4. The drift velocity of holes as compared to that of electrons is
   1) less 2) more 3) equal 4) more or equal

5. The energy gap of silicon is 1.14eV. The maximum wavelength at which silicon will begin absorbing energy is
   1) 10888A° 2) 1088.8A° 3) 108.88A° 4) 10.888A°

6. When n-type semiconductor is heated :
   1) number of electrons increases while that of holes decreases
   2) number of holes increases while that of electrons decreases
   3) number of electrons and holes remain same
   4) number of electrons and holes increase equally

7. A p-type semiconductor has acceptor levels 57meV above the valence band. The wavelength of light required to create a hole is :
   1) 57A° 2) 0.57×10^{-3}A° 3) 11.61×10^{-33}A° 4) 217100A°

8. The band diagrams of three semiconductors are given in the figure. From left to right they are respectively



   1) n-intrinsic-p 2) p-intrinsic-n 3) intrinsic-p-n 4) intrinsic-n-p

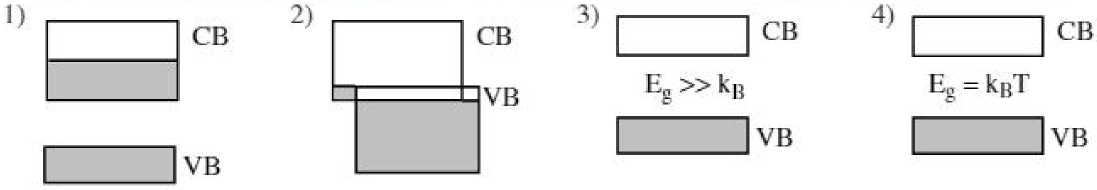
9. The electrical conductivity of a semiconductor increases with electromagnetic radiation of wavelength shorter than 2480 nm is incident on it. The band gap in (eV) for the semiconductor is
   1) 0.5 eV 2) 0.7 eV 3) 1.1 eV 4) 2.5 eV

10. Identify the property of which is not the characteristic for a semiconductor ?
   1) At a very low temperature, it behave like an insulator
   2) At higher temperature two types of charge carriers will cause conductivity
   3) The charge carriers are electrons holes in the valence band at higher temperature
   4) The semiconductor is electrically neutral

11. The length of germanium rod is 0.928cm and its area of cross-section is $1mm^2$. If for germanium $n_i = 2.5 \times 10^{19} cm^3$, $\mu_h = 0.19 m^2V^{-1}s^{-1}$. Its resistance is
   1) $2.5k\Omega$ 2) $4.0k\Omega$ 3) $5.0k\Omega$ 4) $10.0k\Omega$

12. The ratio of electron and hole current in a semiconductor is 7/4 and the ratio of drift velocities of electrons and holes is 5/4, then ratio of concentrations of electrons and holes will be
   1) 5/7 2) 7/5 3) 25/49 4) 49/25

13. Which of the energy band diagrams shown below corresponds of that of a semiconductor ?



14. When a semiconductor is subjected to an electric field, a current begins to flow through it which is composed of the movement of
   1) only *n*-type carriers 2) only *p*-type carriers
   3) both *n*-type and *p*-type carriers 4) neither *n*-type nor *p*-type carriers

EXERCISE-II

(p-n junction diode and characteristics)

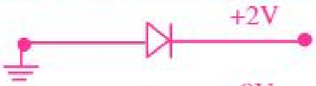
Straight Objective Type Questions

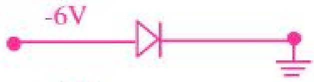
1. In an unbiased p-n junction, holes diffuse from the p-region to n-region because
   1) free electrons in the n-region attract them.
   2) they move across the junction by the potential difference.
   3) hole concentration in p-region is more as compared to n-region.
   4) all the above.

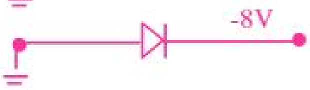
2. Which of the following junction diodes are forward biased?

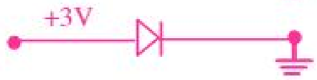
   1) c only 2) b & c only 3) a,b & c only 4) b & d only

3. Which of the following junction diodes are reverse biased?

a) 

b) 

c) 

d) 

1) a and b only 2) c and d only 3) a and c only 4) b and d only

4. In a p-n junction diode made with Ge, the thickness of deplition layer is 2×10^{-6} m and barrier potential is 0.3V. The strength of the electric field at the junction is

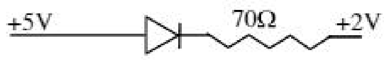
1) 0.6×10^{-6} Vm^{-1} from n to p side 2) 0.6×10^{-6} Vm^{-1} from p to n side

3) 1.5×10^{5} Vm^{-1} from n to p side 4) 1.5×10^{5} Vm^{-1} from p to n side

5. The junction diode shown in fig is ideal. The current in the circuit is

1) 50A 2) 30A 3) 50mA 4) 30mA

6. The current from below circuit if forward resistance of the diode is 30Ω



1) 0.01A 2) 0.03A 3) 0.5A 4) 0.1A

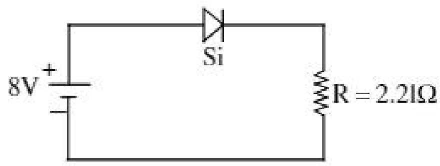
7. A cell of emf 4.5V is connected to a junction diode whose barrier potential is 0.7V. If the external resistance in the circuit is 190Ω, then the current in the circuit is

1) 20mA 2) 2mA 3) 0.2mA 4) 0.02mA

8. An ideal p-n junction diode can withstand currents up to 10mA under forward bias. The diode has a potential difference of 0.5V across it which is assumed to be independent of current. What is the maximum voltage of the battery used to forward bias the diode when resistance of 200Ω is connected in series with it

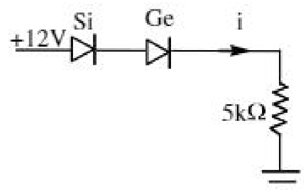
1) 5V 2) 4V 3) 2.5V 4) 1.25V

9. The potential difference across the diode is



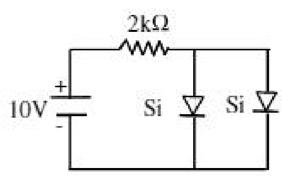
1) 8 V
2) 8.7 V
3) 7.3 V
4) 0.7 V

10. The current flow through the resitence in the given circuit is



1) 2.2 mA
2) 3.2 mA
3) 2.4 mA
4) 3 mA

11. The current following through the resistance in the given circuit is

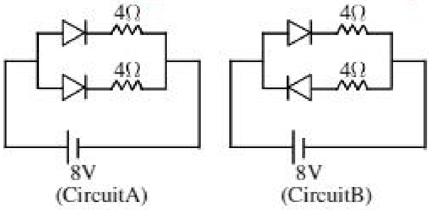


1) 4.65 mA
2) 5 mA
3) 4.8 mA
4) 5.2 mA

12. The potential barrier of a P-N junction diode is 50 me V, When an electron having energy 400 meV travels from P to N, after crossing the junction the energy of the electron is

1) 450 meV 2) 350 meV 3) 400 meV 4) 300 meV

13. Currents following in each of the following circuits A and B respectively are

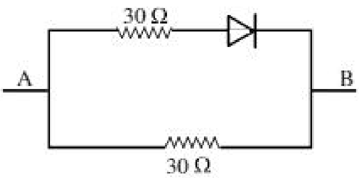


1) 1A, 2A 2) 2 A, 1 A 3) 4 A, 2 A 4) 2 A, 4 A

14. In a silicon diode, the reverse current increases from 10μA to 20μA, when the reverse voltage changes from 2V to 4V. The reverse ac resistance of the diode is

1) $1\times10^5\Omega$ 2) $3\times10^5\Omega$ 3) $2\times10^5\Omega$ 4) $4\times10^5\Omega$

15. If V_A and V_B denote potentials of A and B, then the equivalent resistance between A and B in the adjoining circuit is (the diode is ideal)



1) 15Ω if $V_A > V_B$

2) 30Ω if $V_A < V_B$

3) Both 1 and 2

4) neither 1 nor 2

16. A full–wave p–n diode rectifier uses a load resistor of 1500Ω. No filter is used. The forward bias resistance of the diode is 10Ω. The efficiency of the rectifier is

1) 81.2% 2) 40.6% 3) 80.4% 4) 40.2%

17. A half-wave rectifier is used to convert 'n' Hz A.C into D.C, then the number of pulses per second present in the rectified voltage is

1) n 2) n/2 3) 2n 4) 4n

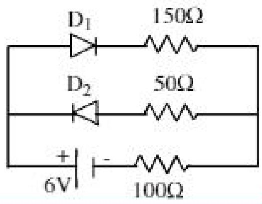
18. A full-wave rectifier is used to convert 'n'Hz A.C into D.C, then the number of pulses per second present in the rectified voltage is

1) n 2) n/2 3) 2n 4) 4n

19. The applied A.C power to a half-wave rectifier is 200W. The D.C power output obtained is 50W. The rectification efficiency is

1) 12.5% 2) 25% 3) 37.5% 4) 50%

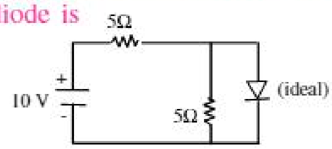
20. The circuit shown in the figure contains two diodes each with a forward resistance of 50 ohm and with infinite backward resistance. If the battery voltage is 6V, the current through the 100 ohm resistance (in ampere) is,



1) zero 2) 0.02

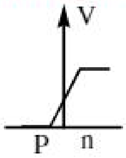
3) 0.03 4) 0.036

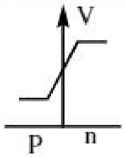
21. In the given circuit the current flow through the P–N junction diode is

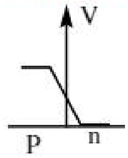


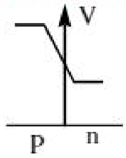
1) 2 A
2) 1 A
3) Zero
4) 1.5 A

22. In a forward biased PN-junction diode, the potential barrier in the depletion region is of the form

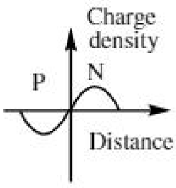
1) 

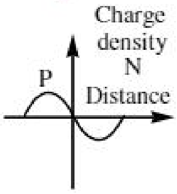
2) 

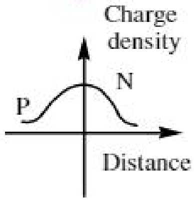
3) 

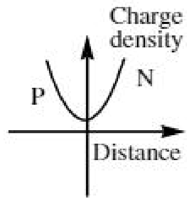
4) 

23. The curve between charge density and distance near P–N junction will be

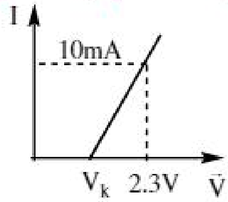
1) 

2) 

3) 

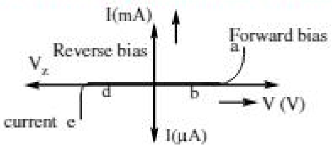
4) 

24. The resistance of a germanium junction diode whose V – I is shown in figure is ($V_k = 0.3$ V)



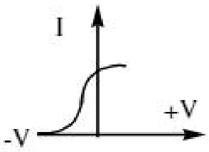
1) $5 k\Omega$
2) $0.2 k\Omega$
3) $2.3 k\Omega$
4) $\left(\frac{10}{2.3}\right) k\Omega$

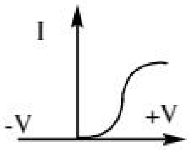
25. The graph given below represents the I – V characteristics of a zener diode. Which part of the characteristics curve most relevant for its operation as a voltage regulator.

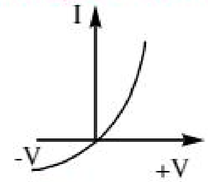


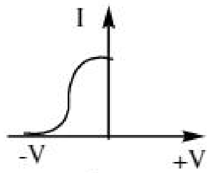
1) ab 2) bc 3) cd 4) de

26. Different voltages are applied across a P-N junction and the currents are measured for each value. Which of the following graphs is obtained between voltage and current

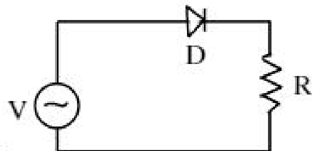
1) 

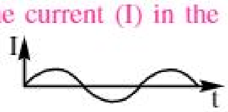
2) 

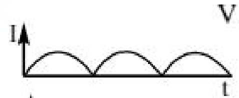
3) 

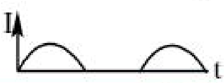
4) 

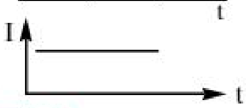
27. A p–n junction (D) shown in the figure can act as a rectifier. An alternating current source (V) is connected in the circuit The current (I) in the resistor (R) can be shown by



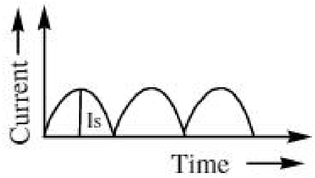
1) 

2) 

3) 

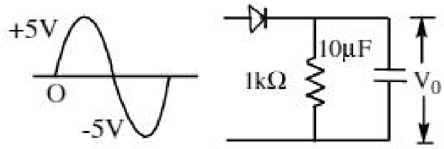
4) 

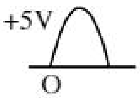
28. The output current versus time curve of a rectifier is shown in the figure. The average value of the output current in this case is

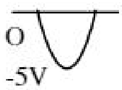


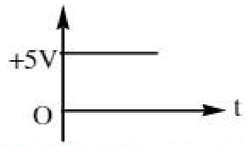
1) 0
2) i_0 / π
3) $2i_0 / \pi$
4) i_0

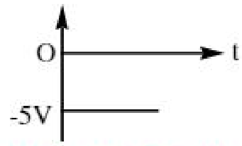
29. The output in the circuit of figure is taken across a capacitor. It is as shown in figure



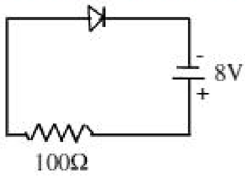
1) 

2) 

3) 

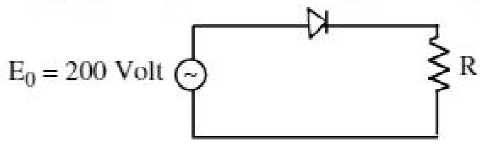
4) 

30. A source voltage of 8V drives the diode in fig. through a current-limiting resistor of 100 ohm. Then the magnitude of the slope load line on the V–I characteristics of the diode is



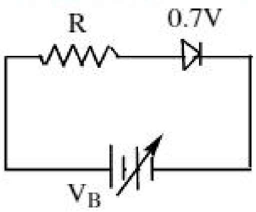
1) 0.01
2) 100
3) 0.08
4) 12.5

31. A sinusoidal voltage of peak value 200 volt is connected to a diode and resistor R in the circuit shown so that half wave rectification occurs. If the forward resistance of the diode is negligible compared to R the rms voltage (in *volt*) across R is approximately



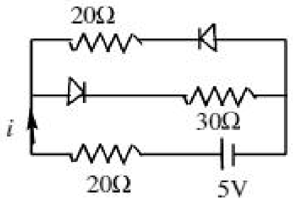
1) 200
2) 100
3) $\frac{200}{\sqrt{2}}$
4) 280

32. The junction diode in the following circuit requires a minimum current of 1 mA to be above the knee point (0.7 V) of its I–V characteristic curve. The voltage across the diode is independent of current above the knee point. If $V_B = 5V$, then the maximum value of R so that the voltage is above the knee point, will be



1) 4.3kΩ
2) 860kΩ
3) 4.3kΩ
4) 860Ω

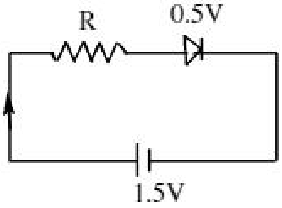
33. Current in the circuit will be



1) $\frac{5}{40}$ A 2) $\frac{5}{50}$ A

3) $\frac{5}{10}$ A 4) $\frac{5}{20}$ A

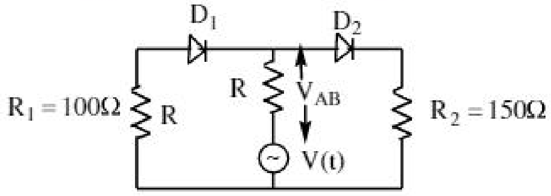
34. The diode used in the circuit shown in the figure has a constant voltage drop of 0.5 V at all currents and a maximum power rating of 100 milliwatts. What should be the value of the resistor R, connected in series with the diode for obtaining maximum current



1) 1.5Ω 2) 5Ω

3) 6.67Ω 4) 200Ω

35. In the circuit given below, V(t) is the sinusoidal voltage source, voltage drop $V_{AB}(t)$ across the resistance R is



1) Is half wave rectfied 2) Is full wave rectified

3) Has the same peak value in the positive and negative half cycles

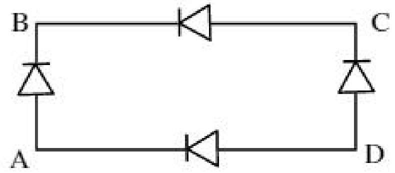
4) Has different peak values during positive and negative half cycle

EXERCISE-III

(Miscellaneous Applications of p-n diode)

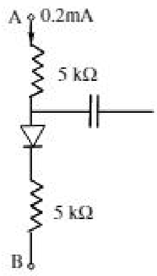
Straight Objective Type Questions

1. As shown is figure, the input is across the terminal A and C and the output is across B and D. Then the output is



1) zero 2) same as the input 3) half-wave rectified 4) full wave rectified

2. In the circuit shown in figure. If the diode forward voltage drop is 0.3V, the voltage difference between A and B is



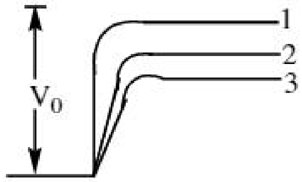
1) 1.3 V

2) 2.3 V

3) 0

4) 0.5 V

3. In figure V_0 is the potential barrier across a *p-n* junction, when no battery is connected across the junction



1) 1 and 3 both correspond to forward bias of junction

2) 3 corresponds to forward bias of junction and 1 corresponds to reverse bias of junction

3) 1 corresponds to forward bias and 3 corresponds to reverse bias to junction

4) 3 and 1 both correspond to reverse bias of junction

4. Wire P and Q have the same resistance at a ordinary room temperature. When heated resistance of P increases and that of Q decreases. We conclude that

1) P is sermiconductor and Q is conductor

2) P is conductor and Q is semiconductor

3) P is *n*-type semiconductor and Q is *p*-type semiconductor

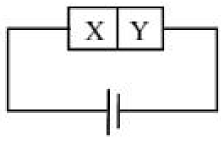
4) None of the above

5. The emitter-base junction in the transistor is

1) forward biased 2) reverse biased

3) either forward or reverse biased 4) neither forward nor reverse biased

6. A semiconductor X is made by doping a germanium crystal with arsenic (Z = 33). A second semiconductor Y is made by doping germanium with indium (Z = 49). The two are joined end to end and connected to a battery as shown. Which of the following statements is correct ?



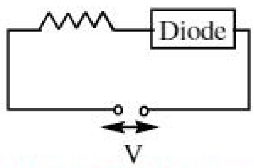
1) X is *p*-type, Y is *n*-type and the junction is forward biased

2) X is *n*-type, Y is *p*-type and the junction is forward biased

3) X is *p*-type, Y is *n*-type and the junction is reverse biased

4) X is *n*-type, Y is *p*-type and the junction is reverse biased

7. For a given circuit of ideal *p-n* junction diode which of the following is correct ?



1) In forward biasing, the voltage across R is V

2) In reverse biasing, the voltage across R is V

3) In forward biasing the voltage across R is 2V

4) In reverse biasing the voltage across R is 2V

8. The dominate mechanisms for motion of charge carriers in forward and reverse biased silicon *p-n* junction are

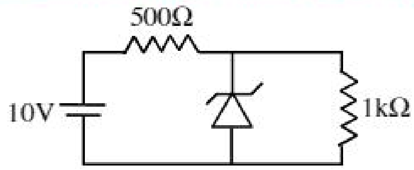
1) drift in both forward and reverse bias

2) diffusion in both forward and reverse bias

3) diffusion in forward bias and drift in reverse bias

4) drift in forward bias while diffusion in reverse bias

9. The circuit of a simple constant voltage supply using a Zener diode. The constant voltage available across the Zener diodes is 5V. The current flowing through the $1k\Omega$ load is

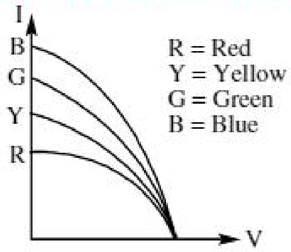


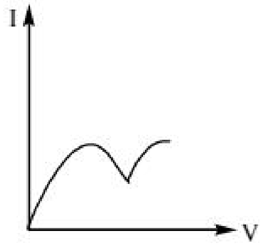
1) 20 mA 2) 15 mA 3) 25 mA 4) 5mA

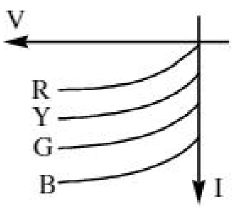
10. In full-wave rectifier circuit operating from 50Hz mains frequency, the fundamental frequency in the ripple would be

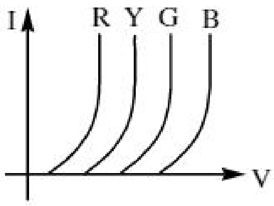
1) 50 Hz
2) 25 Hz
3) 100 Hz
4) 70.7 Hz

11. The I-V characteristic of an LED is

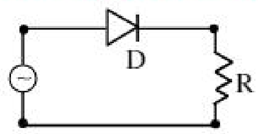
1) 

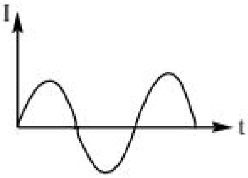
2) 

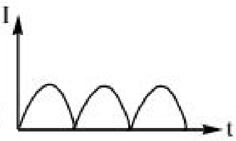
3) 

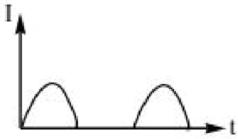
4) 

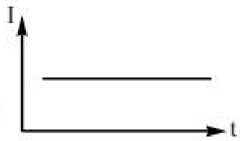
12. A *p-n* junction (D), shown in fig can act as a rectifier. An alternating current source (V) is connected in the circuit. The current (I) in the resistor (R) can be shown by



1) 

2) 

3) 

4) 

13. The breakdown in a reverse biased *p-n* junction diode is more likely to occur due to

1) large velocity of the minority charge carriers, if the doping concentration is small
2) large velocity of the minority charge carriers, if the doping concentration is large
3) strong electric field in a depletion region, if the doping concentration is small
4) strong electric field in the depletion region, if the doping concentration is large

14. What happens during regulation action of a Zener diode ?
   1) The current in and voltage across the Zener remains fixed
   2) The current through the series resistance (R_s) changes
   3) The Zener resistance is constant
   4) The resistance offered by the Zener diode changes

15. In the deplection region of a diode
   1) there are no mobile charges
   2) equal number of holes and electrons exist, making the region neutral
   3) recombination of holes and electrons has taken place
   4) immobile charged ions exist

16. To reduce the ripples in a rectifier circuit with capacitor filter
   1) R_L should be increased
   2) input frequency should be decreased
   3) input frequency should be increased
   4) capacitors with high capacitance should be used

17. When an electric field is applied across a semiconductor
   1) electrons move from lower energy level to higher energy level in the conduction band
   2) electrons move from higher energy level to lower energy level in the conduction band
   3) holes in the valence band move from higher energy level to lower energy level
   4) holes in the valence band move from lower energy level to higher energy level

18. The breakdown in a reverse biased *p-n* junction diode is more likely to occur due to
   1) large velocity of the minority charge carriers if the doping concentration is small
   2) large velocity of the minority charge carriers if the doping concentration is large
   3) strong electric field in a deplection region if the doping concentration is small
   4) strong electric field in a deplection region if the doping concentration is large

19. Match the following Column-I with Column-II

Column - I

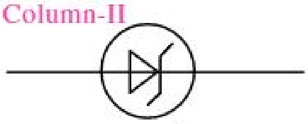
I) *n-p-n* junction

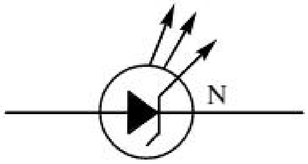
II) *p-n-p* transistor

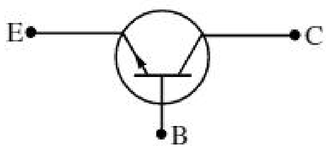
III) Light emitting diode

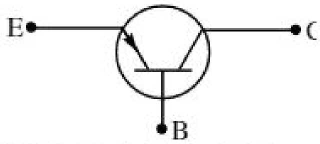
IV) Zener diode

Column-II

A) 

B) 

C) 

D) 

   1) I-A, II-B, III-C, IV-D
   2) I-D, II-A, III-B, IV-C
   3) I-C, II-D, III-B, IV-A
   4) I-B, II-A, III-C, IV-D

EXERCISE-IV

(Transistors)

Straight Objective Type Questions

1. In the symbol for a transistor, the arrow head points in the direction of flow of
   1) holes 2) electrons 3) majority carriers 4) minority carriers

2. The emitter of a transistor is doped the heaviest because it
   1) acts as a supplier of charge carriers 2) dissipates maximum power
   3) has a large resistance 4) has a small resistance

3. Out of the common-base, common-emitter and common-collector configuration of the transistor amplifier, the voltage gain in highest in
   1) common-base 2) common-collector
   3) common-emitter 4) equal in all the cases

4. The current gain of common-emitter transistor amplifier is
   1) less than one 2) more than one 3) equal to one 4) zero

5. The current gain of common-base transistor amplifier is
   1) less than one 2) more than one 3) equal to one 4) infinite

6. In common-emitter transistor amplifier, the phase difference b/w output voltage and input voltage is
   1) zero 2) 180° 3) 90° 4) 45°

7. For a transistor, in a common-emitter arrangement, the AC current gain β is given by
   1) $\beta = (\Delta I_c / \Delta I_B), V_c = \text{constant}$ 2) $\beta = (\Delta I_B / \Delta I_c), V_c = \text{constant}$
   3) $\beta = (\Delta I_c / \Delta I_e), V_c = \text{constant}$ 4) $\beta = (\Delta I_e / \Delta I_c), V_c = \text{constant}$

8. For a transistor in a common-base arrangement, the alternating current gain α is given by
   1) $\alpha = (\Delta I_c / \Delta I_B) V_c = \text{constant}$ 2) $\alpha = (\Delta I_B / \Delta I_c) V_c = \text{constant}$
   3) $\alpha = (\Delta I_c / \Delta I_e) V_c = \text{constant}$ 4) $\alpha = (\Delta I_e / \Delta I_c) V_c = \text{constant}$

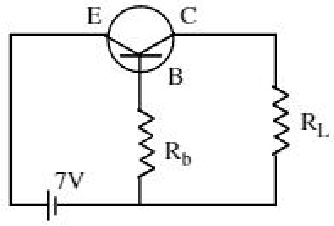
9. A common emitter transistor amplifier has a current gain of 50. If the load resistance is 4kΩ and input resistance is 500Ω, the voltage gain of the amplifier is
   1) 160 2) 200 3) 300 4) 400

10. The reverse voltage ratio of a common emitter transistor circuit is represented as
    1) $\left(\frac{\Delta V_{be}}{\Delta V_{cc}}\right)_{I_b}$ 2) $\left(\frac{\Delta V_{be}}{\Delta I_b}\right)_{V_{cc}}$ 3) $\left(\frac{\Delta I_e}{\Delta I_b}\right)_{V_{cc}}$ 4) $\left(\frac{\Delta V_{ce}}{\Delta I_b}\right)_{V_{cc}}$

11. The current gain for transistor working as common-base amplifier is 0.96. If the emitter current is 72mA, then the base current is
    1) 0.29 mA 2) 0.35 mA 3) 0.39 mA 4) 0.43 mA

12. In a common base configuration of a transistor $(\Delta I_c / \Delta I_e) = 98$, then current gain in common emitter configuration of transistor will be
    1) 49 2) 98 3) 4.9 4) 24.5

13. In the given transistor circuit, the base current is $35\mu A$. The value of R_b is



1) 100 kΩ 2) 200 kΩ 3) 300 kΩ 4) 400 kΩ

14. The correct relationship between the two current gain α, β and in a transistor is

1) $\beta = \frac{\alpha}{1+\alpha}$ 2) $\alpha = \frac{\beta}{1-\beta}$ 3) $\alpha = \frac{\beta}{1+\beta}$ 4) $\alpha = \frac{1+\beta}{\beta}$

EXERCISE-V

(Logic Gate)

Straight Objective Type Questions

1. In Boolean expression which gate is expressed as $Y = \overline{A+B}$

1) OR 2) NAND 3) AND 4) NOR

2. What will be the inputs of A and B for Boolean expression $(\overline{A+B}) + (\overline{A.B}) = 0$?

1) 0,0 2) 0,1 3) 1,0 4) 1,1

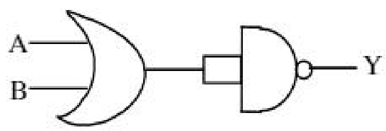
3. In the given Boolean expression, $Y = A.\overline{B} + B.\overline{A}$, if A=1, B=1 then Y will be

1) 0 2) 1 3) 11 4) 10

4. Given below are four logic gate symbols. Those for OR, NOR and AND are respectively

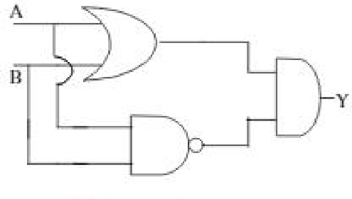
1) i, iv, iii 2) iv, i, ii 3) iii, ii, i 4) i, iii, ii

5. Identify the gate represented by the block diagram is



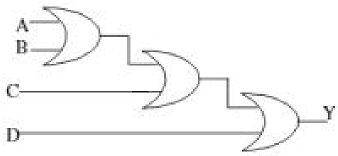
1) AND 2) NOT 3) NAND 4) NOR

6. The following configuration of gates is equivalent to



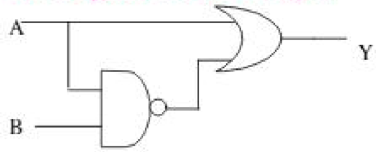
1) NAND gate
2) XOR gate
3) OR gate
4) NOR gate

7. The expression Y in the following circuit is



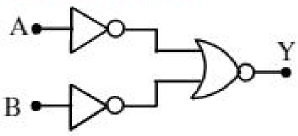
1) ABCD
2) B + ACD
3) AB + CD
4) A + B + C + D

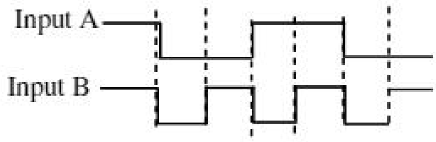
8. The output of the combination of the gates shown in fig is

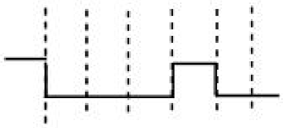


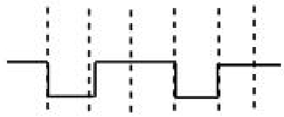
1) $A+\overline{A.B}$ 2) $A.B+\bar{A}.\bar{B}$ 3) $(A+B).\overline{(A.B)}$ 4) $(A+B)\overline{(A+B)}$

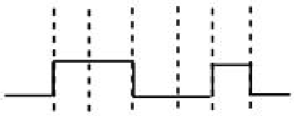
9. The logic circuit shown below has the input waveforms 'A' and 'B' as shown. Pick out the correct output waveform

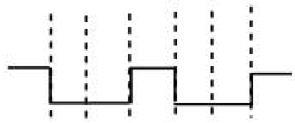




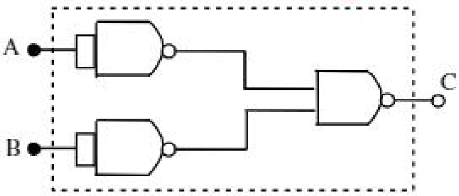
1) 

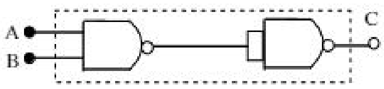
2) 

3) 

4) 

10. The combination of 'NAND' gates shown here under (figure) are equivalent to



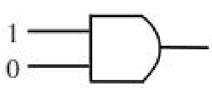


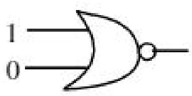
1) An OR gate and an AND gate respectively
2) An AND gate and a NOT gate respectively
3) An AND gate and an OR gate respectively
4) An OR gate and a NOT gate respectively

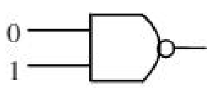
11. How many NAND gates are used to form an AND gate

1) 1 2) 2 3) 3 4) 4

12. Which of the following gates will have an output of 1

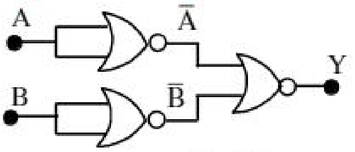
1) 

2) 

3) 

4) 

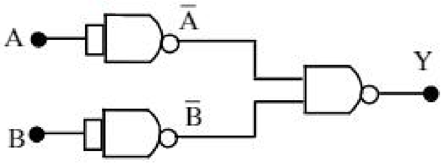
13. Identify the operation performed by the circuit given below



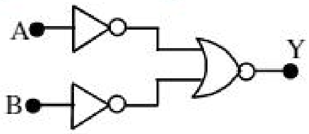
1) NOT 2) AND 3) OR 4) NAND

14. The combination of the gates shown in the figure below produces

1) NOR gate
2) OR gate
3) AND gate
4) XOR gate



15. Which logic gate is represented by the following combination of logic gates



1) OR 2) NAND 3) AND 4) NOR

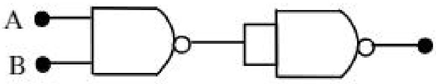
16. The symbolic representation of four logic gates are given below

i)  ii)  iii)  iv) 

The logic symbols for OR, NOT and NAND gates are respectively

1) iii, iv, ii 2) iv, i, iii 3) iv, ii, i 4) i, iii, iv

17. The arrangement shown in the figure performs the logic function of



1) AND gate 2) OR gate 3) NAND gate 4) NOR

EXERCISE-VI

(Miscellaneous)

Straight Objective Type Questions

1. In a semiconductor diode, the barrier potential offers opposition to only

1) majority carriers in both regions
2) minority carriers in both regions
3) free electrons in the n-region
4) holes in the p-region

2. Application of a forward bias to a p-n junction

1) increases the number of donors on the *n*-side
2) increases the electric field in the depletion zone
3) increases the potential difference across the depletion zone
4) widens the deplection zone

3. The depletion (or space-charge) region in a junction diode contains charges that are
   1) mostly majority carriers
   2) mostly minority carriers
   3) mobile donor and acceptor ions
   4) fixed donor and acceptor ions

4. In a *p-n* junction diode, not connected to any circuit
   1) the potential is the same every where
   2) the *p*-type side is at a higher potential than the *n*-type side
   3) there is an electric field at the junction directed from the *n*-type side to the *p*-type side
   4) there is an electric field at the junction directed from the *p*-type side to the *n*-type aide

5. What accounts for the flow of charge carriers in forward and reverse biasing of silicon *p-n* diode ?
   1) Drift in forward bias and diffusion in reverse bias
   2) Drift in reverse bias and diffusion in forward bias
   3) Drift in both reverse and forward bias
   4) Diffusion in both forward and reverse bias

6. The depletion layer in the *p-n* junction region is caused by
   1) drift of holes 2) diffusion of charge carriers
   3) migration of impurity ions 4) drift of electrons

7. The current-voltage relation for a diode is given by : $I = (e^{1000V/T} - 1)$mA, where the applied voltage V is in volts and the temperature T is in degree kelvin. If a student makes an error measuring + 0.01V while measuring the current of 5mA at 300K, what will be error in the value of current in mA ?
   1) 0.5 mA 2) 0.005 mA 3) 0.2 mA 4) 0.02 mA

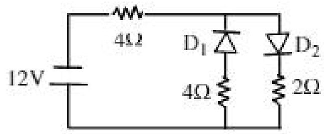
8. A light emitting diode (LED) has a voltage drop of 2V across it and passes a current of 10mA when it operates with a 6V battery through a limiting resistor R. The value of R is
   1) 40 kΩ 2) 4 kΩ 3) 200 Ω 4) 400 Ω

Numerical Value Type Questions

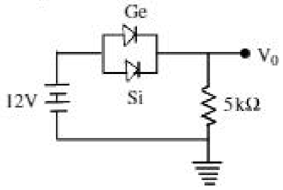
9. A silicon specimen is made into a *p*-type semiconductor by doping on an average one indium atom per 5×10^7 silicon atoms. If the number density of atoms in the silicon specimen is 5×10^{26} atoms/metre^3 then the number of acceptor atoms in silicon per cubic metre will be $N \times 10^{15}$. Find N

10. In full-wave rectifier two p-n junction diodes are used. Each diode has internal resistance equal to 20Ω. If the load resistance of 980Ω used in the full-waverectifier, then its efficiency is nearly (in %)

11. The circuit has two oppositely connected ideal diodes in parallel. What is the current flowing in the circuit (in A)



12. Ge and Si diodes conduct at 0.3 V and 0.7 V respectively. In the following figure if Ge diode connection is reversed, the value of V_0 changes by (in Volts)



13. What is the voltage gain in a common-emitter amplifier, where input resistance is 3Ω and load resistance 24Ω? (Take $\beta = 0.6$)

KEY SHEET (PRACTICE SHEET)

LEVEL-I (MAIN)

EXERCISE-I

1) **3** 2) **4** 3) **3** 4) **1** 5) **1** 6) **3** 7) **4** 8) **2** 9) **1** 10) **3**
11) **2** 12) **2** 13) **4** 14) **3**

EXERCISE-II

1) **3** 2) **2** 3) **1** 4) **3** 5) **4** 6) **2** 7) **1** 8) **3** 9) **4** 10) **1**
11) **1** 12) **1** 13) **3** 14) **3** 15) **3** 16) **3** 17) **1** 18) **3** 19) **2** 20) **2**
21) **1** 22) **2** 23) **1** 24) **1** 25) **4** 26) **3** 27) **3** 28) **3** 29) **3** 30) **3**
31) **2** 32) **1** 33) **2** 34) **2** 35) **4**

EXERCISE-III

1) **4** 2) **2** 3) **2** 4) **2** 5) **1** 6) **4** 7) **1** 8) **3** 9) **4** 10) **3**
11) **4** 12) **3** 13) **1,4** 14) **2,4** 15) **2,3** 16) **1,2,4** 17) **1,3** 18) **1,4** 19) **3**

EXERCISE-IV

1) **1** 2) **1** 3) **3** 4) **2** 5) **1** 6) **2** 7) **1** 8) **3** 9) **4** 10) **1**
11) **1** 12) **1** 13) **2** 14) **3**

EXERCISE-V

1) **4** 2) **4** 3) **1** 4) **4** 5) **4** 6) **2** 7) **4** 8) **1** 9) **1** 10) **1**
11) **2** 12) **3** 13) **2** 14) **2** 15) **3** 16) **3** 17) **1**

EXERCISE-VI

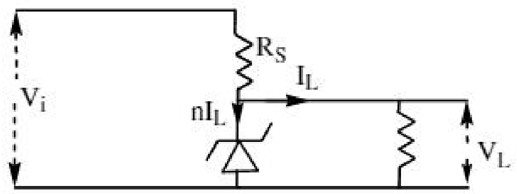
1) **1** 2) **1** 3) **4** 4) **3** 5) **2** 6) **2** 7) **3** 8) **4** 9) **1.0** 10) **79.57**
11) **2** 12) **0.4** 13) **4.80**

ADDITIONAL PRACTICE EXERCISE

LEVEL-I (MAIN)

Straight Objective Type Questions

1. The value of the resistor R_S, needed in the dc voltage regulator circuit shown here equals

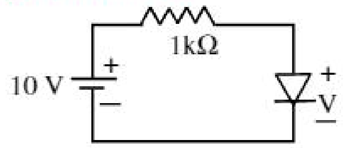


1) $(V_i - V_L)/nI_L$ 2) $(V_i + V_L)/nI_L$ 3) $(V_i - V_L)/(n+1)I_L$ 4) $(V_i + V_L)/(n+1)I_L$

2. In a forward biased p-n junction, the sequence of events that best describes the mechanism of current flow is
   1) injection, and subsequent diffusion and recombination of minority carriers
   2) injection, and subsequent drift and generation of minority carriers
   3) extraction, subsequent diffusion and generation of minority carriers
   4) extraction and subsequent drift and recombination of minority carriers

3. The I-V characteristics of the diode in the circuit given below are

$$i = \begin{cases} \dfrac{V-0.1}{500}\text{A}, & V \geq 0.7\text{V} \\ 0.\text{A}, & V < 0.7\text{V} \end{cases}$$



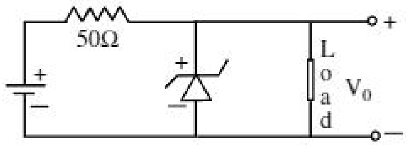
The current in the circuit is

1) 10 mA 2) 9.3 mA 3) 6.67 mA 4) 6.2 mA

4. In a P type material the Fermi level is 0.3eV above the valence band. The concentration of accepter atoms is increased. The new position of Fermi level is likely to be
   1) 0.5 eV above the valance band 2) 0.2 eV above the valance band
   3) Below the valance band 4) None of the above

5. A small concentration of minority carriers is injected into a homogeneous semiconductor crystal at one point. An electric field of 10V/cm is applied across the crystal and this moves the minority carriers a distance of 1cm in 20 μsec. The mobility (in cm^2/V - sec) will be
   1) 1,000 2) 2,000 3) 5000 4) 500000

6. A zener diode in the circuit shown in below figure has a minimum current of 5mA, and a maximum allowed power dissipation of 300mW. What are the minimum and maximum load currents than can be drawn safely from the circuit, keeping the output voltage V_0 constant at 6V ?

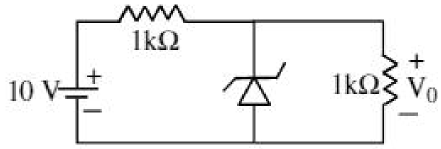


1) 0 mA, 18 mA 2) 10 mA, 55 mA 3) 5mA, 110mA 4) 60 mA, 180 mA

7. A P-N junction is in series with 100 ohms resistor, is forward biased. So that a current of 100mA flows. If the voltage across this combination is instantaneously reversed at t = 0 current through diode is approximately given by

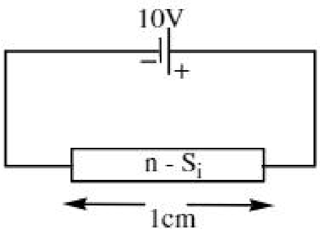
1) 0 mA 2) 200 mA 3) 100 mA 4) 50 mA

8. In the circuit shown below, the Zener diode is ideal and the zener voltage is 6V. The output voltage V_0 (in volts) is



1) 3 V 2) 5 V 3) 7 V 4) 10 V

9. A dc voltage of 10 V is applied across an n-type silicon bar having a rectangular cross-section and length of 1 cm as shown in figure. The donor doping concentration N_D and mobility of electrons μ_m are $10^{16} cm^{-3}$ and $1000 cm^2 V^{-1} s^{-1}$, respectively. The average time (in μS) taken by the electrons to move from one end of the bar to other end is ____



1) $10 \mu s$ 2) $100 \mu s$ 3) $1000 \mu s$ 4) $10000 \mu s$

10. Drift current in semiconductors depends upon

1) Only the electric field
2) Only the carrier concentration
3) Both the electric field and the carrier concentration
4) Neither the electric field nor the carrier concentration

11. A thin p-type silicon sample is uniformly illuminated with light which generates excess carriers. The recombination rate is directly proportional to

1) The minority carrier mobility 2) The minority carrier recombination lifetime
3) The majority carrier concentration 4) The excess minority carrier concentration

12. The electrical conductivity of a semiconductor increases if electromagnetic radiation of wavelength shorter then 2066nm is incident on it. The band gap energy (in eV) for the semiconductor is very nearly equal to

1) 0.5 2) 0.6 3) 0.8 4) 1.2

13. Two initially identical samples A and B of pure germanium are doped with donors to concentrations 1×10^{20} and 3×10^{20} respectively. If the hole concentration is 9×10^{12} then, the hole concentration in B at the same temperature will be

1) $3 \times 10^{12} m^{-3}$ 2) $7 \times 10^{12} m^{-3}$ 3) $11 \times 10^{12} m^{-3}$ 4) $27 \times 10^{12} m^{-3}$

14. The width of the depletion layer of junction
    1) decreases with light doping
    2) increases with heavy doping
    3) is independent of applied voltage
    4) is increased under reversed bias

15. When a junction diode is connected in reverse bias, then avalanche breakdown occurs mainly due to
    1) collision
    2) doping
    3) ionization
    4) recombination of e-h pairs

16. When forward bias is applied to a *p-n* junction, then what happens to the potential barrier V_B, and the width of charge depleted region x
    1) V_B, increases, x decreases
    2) V_B, decreases, x increases
    3) V_B, increases, x increases
    4) V_B, decreases, x decreases

17. In a transistor amplifier
    1) the power dissipated at the base - collector junction is much higher than that dissipated at the emitter - base junction
    2) the power dissipated at the base - collector junction is much lower that dissipated at the emitter - base junction
    3) the power dissipated is the same at both the junction
    4) there is no power dissipated at any junction

18. An unknown transistor needs to be identified as a npn or pnp type. A multimeter, with +ve and –ve terminals, is used to measure resistance between different terminals of transistor. If terminal 2 is the base of the transistor then which of the following is correct for a pnp transistor ?
    1) +ve terminal 2, –ve terminal 1, resistance high
    2) +ve terminal 3, –ve terminal 2, resistance high
    3) +ve terminal 2, –ve terminal 3, resistance low
    4) +ve terminal 1, –ve terminal 2, resistance high

19. A pnp transistor is used in common-emitter mode in an amplifier circuit, A change of $40\,\mu A$ in the base current brings as change of 2mA in the collector current and 0.4V in base-emitter voltage. If a load resistance of $6\,\Omega$ is used. Then find the voltage gain of the amplifier will be
    1) 500
    2) 300
    3) 200
    4) 100

20. The part of a transistor which is most heavily doped to produce large number of majority carriers is
    1) emitter
    2) base
    3) collector
    4) all the three are equal doped

21. In the common base made of a transistor, the collector current is 5.488 mA for an emitter current of 5.60mA. The value of the base current amplification factor (β) will be
    1) 48
    2) 49
    3) 50
    4) 51

22. Light Emitting Diode is
    1) A lightly dope p-n junction diode connected in Reverse Bias
    2) A lightly doped p-n junction diode connected in Forward Bias
    3) A heavily doped p-n junction diode connected in Forward Bias
    4) A heavily doped p-n junction diode connected in Reverse Bias

23. For LED's to emit light in visible region of electromagnetic light, it should have energy band gap in the range of
    1) 1.7 eV to 3.0 eV
    2) 0.5 eV to 0.8 eV
    3) 0.9 eV to 1.6 eV
    4) 0.1 eV to 0.4 eV

24. A red LED emits light at 0.1 watt uniformly around it. The amplitude of the electric field of the light at a distance of 1 m from the diode is

1) 1.73 V/m 2) 2.45 V/m 3) 5.48 V/m 4) 7.75 V/m

25. Group-I lists four types of P-N junction diodes. Match each device in Group-I with one the options in Group-II to indicate the bias condition of that device in its normal mode of operation

Group - I	Group - II
P) Zener diode	1) Forward bias
Q) Solar cell	2) Reverse bias
R) LED	3) No external bias

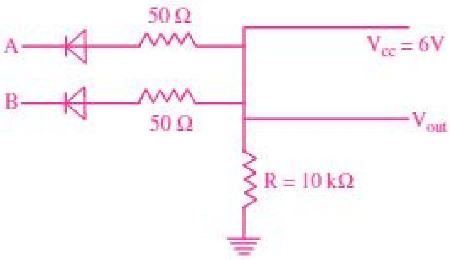
1) P-1, Q-2, R-1 2) P-2, Q-3, R-1 3) P-2, Q-2, R-1 4) P-2, Q-1, R-3

26. The truth table given in figure represents

1) NAND gate
2) OR gate
3) NOR gate
4) AND gate

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

27.

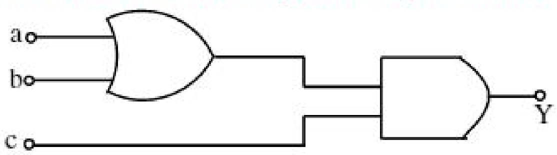


Given : A and B are input terminals. Logic 1 = > 5V; Logic 0 = < 1 V

Which logic gate operation, the following circuit does ?

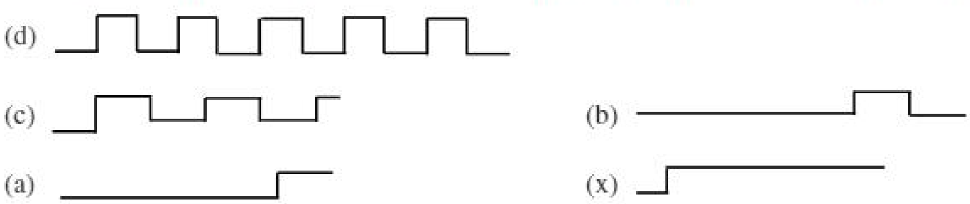
1) AND gate 2) NOR gate 3) OR gate 4) XOR gate

28. To get an output of 1 from the circuit shown in figure the input must be



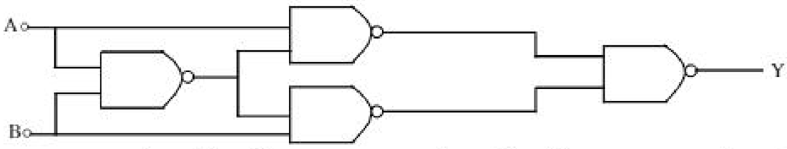
1) a = 0, b = 0, c = 1 2) a = 1, b = 0, c = 0 3) a = 1, b = 0, c = 1 4) a = 0, b = 1, c = 0

29. In a,b,c,d are inputs to a gate and x is its output, then, as per the following time graph, the gate is



1) NOT 2) AND 3) OR 4) NAND

30. Truth table for system of four NAND gates as shown in figure is



1)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

2)

A	B	Y
0	0	0
0	1	0
1	0	1
1	1	1

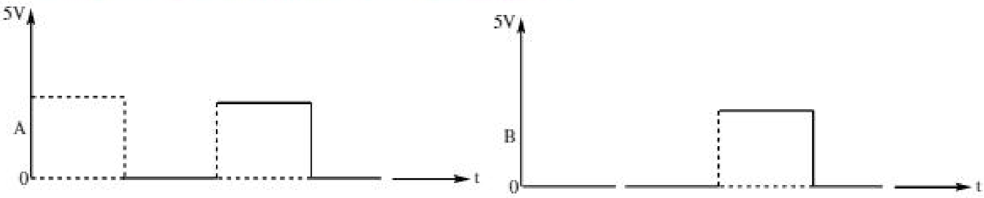
3)

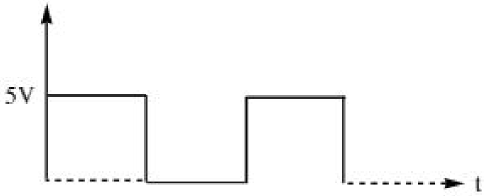
A	B	Y
0	0	1
0	1	1
1	0	0
1	1	0

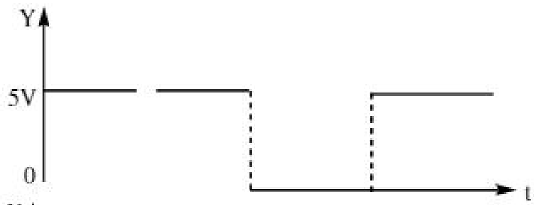
4)

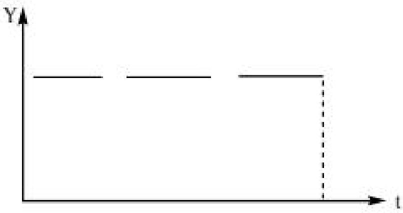
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

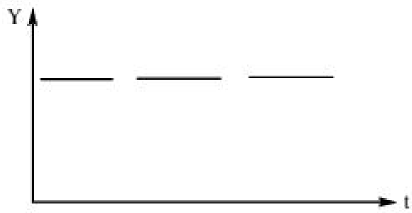
31. The real time variation of input signals A and B are as shown ahead. If the inputs are fed into NAND gate, then select the output signal from the following :



1) 

2) 

3) 

4) 

32. The output equation of Ex-Nor GATE is (where A and B are having their usual meaning)

1) $X = AB + \bar{A}\bar{B}$ 2) $X = \bar{A}B + \bar{B}\bar{A}$ 3) $X = \overline{AB + \bar{B}\bar{A}}$ 4) $X = \overline{AB} + \bar{A}B$

KEY SHEET (ADDITIONAL PRACTICE EXERCISE)

LEVEL-I (MAIN)

1) **3**	2) **1**	3) **4**	4) **2**	5) **3**	6) **2**	7) **3**	8) **2**	9) **2**	10) **3**
11) **4**	12) **2**	13) **1**	14) **4**	15) **1**	16) **4**	17) **1**	18) **1**	19) **2**	20) **1**
21) **2**	22) **3**	23) **1**	24) **2**	25) **2**	26) **2**	27) **1**	28) **3**	29) **3**	30) **1**
31) **2**	32) **1**								