**Semiconductors & Communications (Chapter 14 & 15)**

VACUUM TUBES

1*. Thermionic emission* :

(i) The phenomenon of emission of electrons from the surface of metal when heated suitably, is called thermionic emission.

(ii) The electrons emitted due to the effect of thermal energy are called thermions.

(iii) The thermionic . current is given by Richardson-Dusmann's equation, I = AoST2 e-w/KT

where S = surface area of the metal; T = temperature of the surface in K; W = work function of the metal,

K -Boltzmann's constant and Ao = a constant depending upon the nature of emitter surface.

2. *Diode valve:*

(i) The simplest type of vacuum tube with two electrodes is known as diode.

(ii) The two electrodes are enclosed in a highly evacuated glass or metal envelope. One electrode is known as cathode which serves as the emitter of electrons and the other is known as plate or anode, which is generally a hollow metallic cylinder surrounding the cathode and serves as a collector of electrons.

(iii) The cathode of a diode valve may be directly or indirectly heated.

(iv) when the plate potential is not sufficient to attract all the electrons emitted from the cathode, the emitted

electrons tend to bunch up in the form of an electron cloud above the cathode. The cloud of negative electrons constitute space charge. The *space charge* exerts a repelling force on the electrons being emitted from the cathode.

3. *Triode valve*:

(i) Triode valve was discovered by Lee De Forest in 1907.

(ii) In a triode, a third electrode, called the *grid* is introduced between the plate and cathode.

(iii) The grid is in the form of a conducting cylindrical mesh surrounding the cathode.

(iv) Grid controls the electrons emitted by the cathode and hence named as *control grid*.

(v) The control grid is located nearer to cathode as compared to anode. The grid is usually operated on a slightly negative potential so that the electrons will pass between the grid wires without hitting the wire themselves.

SOLIDS

4. *Crystalline and amorphous solids*:

(i) The solids in which the atoms are arranged in a definite, regular and long range order,are said to be crystalline.

(ii) The solids in which the atoms are arranged in indefinite, irregular and short range order are said to be amorphous.

5. *Properties of crystalline solids*:

(i) They have sharp melting point, on account of equal strengths of all interatomic bonds.

(ii) They have characteristic geometrical shape, on account of negligibly small thermal motion of atoms.

(iii) They have a homogeneous composition.

(iv) Atoms in a crystalline solid have minimum potential energy (i.e., most negative).

(v) They have flat surfaces

(vi) They may be anisotropic as regards thermal conductivity, refractive index, elecffical conductivity, mechanical strength

6. *Properties of amorphous solids:*

(i) These solids do not have sharp melting points. (ii) They have no characteristic geometrical shape.

(iii) They may not have a homogeneous composition.

(iv) Different atoms in the amorphous solids may not be in stable equilibrium.

(v) They are isotropic as regards thermal conductivity, refractive index, electrical conductivity, mechanical

strength.

(vi) Different interatomic bonds may not have equal strengths.

7. *Crystal lattice*: A crystal structure is a periodic arrangement of atoms in space and is obtained by associating with every lattice point a unit assembly or basis of atoms, identical in composition, arrangement and orientation. Thus, crystal structure = space lattice + basis.

8. *Unit cell:*

(i) A unit cell is the smallest block or smallest structural unit of the arrangement of atoms in a crystal from which the entire structure can be built by repetition in three dimensions. It can be selected in various ways.

(ii) A unit cell in three dimensions is shown in the fig. 44.1. The following terms can be associated with a unit cell :

(a) OX, OY and OZ are called as crystallographic axes.

(b) The three sides a,b and c are called as primitive or lattice constants.

(c) The angles α, β and γ between crystallographic axes of unit cell are called as interfacial angles or interaxial angles

9. *The seven crystal systems*: On the basis of lengths and directions of the axes of symmetry all the crystals

may be classified into the following seven systems

10. *Different lattices in cubic crystals:*

(i) Simple (or primitive) cubic or cubic P type lattice:

There is one lattice point at each of the eight corners of the unit cell. There is no lattice point inside the unit cell.

(ii) Face centred cubic (FCC) or cubic F lattice: There is one lattice point at each of the eight corners and one lattice point at the centres of each of the six faces of the cubic cell. Thus, there is an extra point at the centre of each face.

(iii) Body centred cubic (BCC) or cubic I lattice:

There is one lattice point at each of the eight corners and one lattice point at the centre of each cell. There is a lattice point at the centre of each unit cell.

11. *Characteristics of cubic cells*:

(i) *Volume of unit cell:* lf a, b, c are the lattice constants of a unit cell, then volume V of a unit cell, V = abc. For the cubic cell, as a= b = c, so V = a3 .

(ii) Number of atoms per unit cell: The total number of atoms per unit cell is given by: N =Nb + Nf/2 + Nc/8

where Nb is the number of atoms centred in the body of the cell, Nf is the number of atoms centred in the face of the unit cell and Nc is the number of atoms centred at the corner.

(a) For simple cubic cell: Nb =0 Nf = 0 and Nc= 8 ; therefore N = 0 + 0/2 + 8/8 = 1

(b) For body centred cubic cell: Nb =1 Nf = 0 and Nc= 8 ; therefore N = 1 + 0/2 + 8/8 = 2

(c) For face centred cubic cell: Nb =0 Nf = 6 and Nc= 8 ; therefore N = 0 + 6/2 + 8/8 = 4

*Coordination number*: The number of atoms which surround a particular atom as its nearest neighbours is called coordination number.

(a) For simple cubic cell, the coordination number is six, because each atom has two neighbours along .each axis

(b) For the face centred cubic cell, every corner atom has four neighbours in each of the three planes XY,YZ and ZX. So, coordination number =3 x 4=12.

(c) For the body centred cubic cell, the atom in the body of the cell has eight neighbours at eight corners of the unit cell. So, coordination number is 8

(iv) Atomic radius: Let the radius be represented by r.

(a) For SCC, atoms touch along the edges. So, r + r = a or r =(a/2).

(b) For FCC, atoms touch along the face diagonals. So, r + 2r + r = √(a2 +a2) or r =(a/2√2).

(c) For BCC, atoms touch along the diagonals of the cube. So, r + 2r + r = √(a2 +a2+a2) or r = (a√3/4).

(v) *Atomic packing factor*: Atomic packing factor is defined as the ratio of volume occupied by the atoms to the volume of the unit cell.

(a) For SCC, there is one atom per unit cell. Hence, atomic packing factor = π/6

(b) For FCC, there are four Hence, atomic packing factor = π√2/6

(c) For BCC, there are two atoms per unit cell. Hence, atomic packing factor = π√3/8

*Density of crystal material:*

For SCC, d = A/Na3 ; For FCC, d = 4A/Na3 ; For BCC, d = 2A/Na3

Where A represents the atomic weight, d the density and N = Avogadro's number , a = each side

13. *Bonding in solids:*

(i) Ionic bond: formed between two atoms by transfer of one or more of valence electrons

- The ionic compounds in dry state do not conduct electricity. However, when dissolved in water, they conduct electricity.

(ii) Covalent bond: formed due to mutual sharing of valence electrons

(iii) Metallic bond:

(a) A metal can be assumed as an array of positive ions surrounded by an electron gas. The electrostatic force between the electrons and ions dominates over mutual repulsion between different electrons and different positive ions and thus holds the metal together.

(b) This bond is weak, non-directional.

(c) Metals are good conductors of electricity.

(d) When light energy falls on the metal surface, it is absorbed by free electrons which oscillate and give out e.m. waves of characteristic frequency in all directions giving a lustrous appearance.

Due to this property metals are opaque to light.

(iv) vander Waals' bond:

(a) This bond is due to the force between electric dipoles formed by the nucleus and the electron cloud.

(b) This bond is very weak. Hence, the solids having vander Waals' bonding possess low melting points and low boiling points.

(c) The materials having this bonding have low thermal and electrical conductivity. vander Waals' bonding possess low melting points and low boiling points.

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14. *Energy bands in solids:*

-The band formed by a series of energy levels containing the valence electrons is known as *valence band*. The valence band may be partially or completely filled up depending upon the nature of the crystal.

- The next higher permitted band is called *conduction* band. This band may be empty or partially filled. In conduction band, the electrons can move freely.

*15. Semiconductors:*

(a) The substances whose electrical conductivity lies between conductors and insulators are called semiconductors, e. g., carbon, silicon, germanium, cadmium sulphide, gallium arsenide.

(b) The electrical conductivity lies between that of good conductors like copper and good insulators like polythene.

(c) The conductivity of semiconductor increases with increase in temperature.

(d) In semiconductors, electrical conduction is due to electrons and holes.

(e) Semiconductors have negative temperature coefficient of resistance.

(f) The resistance of semiconductors decreases due to the addition of impurities.

(g) In semiconductors there is a small energy gap (=leV) between the valence band and the conduction band.

(h) At absolute zero temperature, conduction band is completely empty and the semiconductor behaves as an insulator.

16. *Intrinsic semiconductor:*

- A semiconductor in pure form is called intrinsic semiconductor.

- Intrinsic semiconductor has four electrons in the outermost orbit of atom and atoms are held together by covalent bond.

- The width of the forbidden band in pure semiconductor (examples are Ge, Si, . . .) is about I eV. For germanium it is 0.72 eV and for silicon it is l.l eV.

- The number of electrons in conduction band is equal to number of holes in the valence band.( I=Ie +Ih)

17. Extrinsic semiconductors:

(i) The addition of foreign impurity to an intrinsic semiconductor in controlled quantities to promote conductivity is termed as *doping*.

(ii) A doped intrinsic semiconductor is called as extrinsic semiconductor.

(iii) Extrinsic semiconductors are of two types: (a) p-type semiconductor, (b) n-type semiconductor.

n-type extrinsic semiconductor:

(i) When a small amount of pentavalent impurity (examples: phosphorus, arsenic, antimony, etc.) is added to an intrinsic semiconductor, we obtain an n-type extrinsic semiconductor.

(ii) The impurity atoms in n-type extrinsic semiconductor are called donor atoms, as they donate an extra electron to pure semiconductor or host lattice.

(iii) In the n-type semiconductor, the number of electrons in the conduction band > number of holes in the valence band.

(iv) In the n type semiconductor, electrons are called as majority charge carriers, whereas holes are called as minority charge carriers.

(v)There is no charge on r?-type semiconductor because it is formed by the combination of free negatively charged electrons and fixed positively charged donor ions.

(vi)In n-type semiconductor, the Fermi level shifts towards the conduction band.

19. *p-type extrinsic semiconductor*:

(i) When a small amount of trivalent impurity (examples: gallium, indium, boron, etc.) is added to an intrinsic semiconductor, we obtain a p-type extrinsic semiconductor.

(ii) The impurity atoms in p-type extrinsic semiconductor are called acceptor atoms, as they accept an electron from the host lattice.

(iii) In the p-type semiconductor, the number of holes in the valence band > number of electrons in the conduction band.

(iv) In the p-type semiconductor, holes are majority charge carriers while electrons are minority charge carriers.

(v) In p-type semiconductor, the Fermi level shifts towards the valence band.

(vi) There is no charge on p-type semiconductor also, because it is formed by the combination of free

positively charged holes and fixed negatively charged acceptor ions.

*SEMICONDUCTOR DEVICES*

20. **p-n Junction diode**:

(i) If a p-type semiconductor is suitably joined to an n-type semiconductor, the junction is called p-n junction and the device so formed is called p-n junction diode.

(ii) At the junction on both sides a region is formed which is depleted of charge carriers. This region is called depletion region whose thickness is about 10-6m.

(iii) An electric field is developed across the junction which is in a direction to oppose the further diffusion of electrons from n-side.

(iv) The potential developed across the barrier layer is called barrier potential. It is 0.7 volts for silicon diode and 0.3 volts for germanium diode.

(v) When no external source is connected to diode, it is called unbiased.

(vi) It has two electrodes, hence it is called diode.

(vii) Forward bias:

(a) When p-side is connected to positive terminal and n-side to negative terminal of battery, the diode is said to be forward biased.

(b) When battery voltage exceeds the barrier potential (0.7 volt for silicon and 0.3 volt for germanium), majority of charge carriers start crossing the junction.

(c) The electrons from n-side drift towards the junction and cross it and holes move in the opposite direction.

(d) The resistance of the junction in forward bias is quite low (= 26 ohm if I = 10-3 amp).

(e) Under proper forward biasing of a p-n junction diode the width of the depletion layer decreases or the barrier potential decreases and the diode conducts.

(f) When p-side is at higher potential than n-type, then also the diode conducts.

(viii) Reverse bias:

(a) When p-side is connected to negative terminal and n-side to positive terminal of battery the diode is said to be reverse biased.

(b) The battery acts as a reverse bias to majority charge carriers but as a forward bias to minority charge carriers.

(c) The minority charge carriers move across the junction. This constitutes reverse saturation current which is very small of the order of 1µA.

(d) The resistance of the junction in reverse bias is 10 kΩ.

(e) Under reverse biasing of a p-n junction diode, the width of depletion region increases or the barrier potential increases.

(ix) Breakdown and breakdown voltage:

(a) If the applied reverse voltage is increased gradually, then a stage is reached when covalent bonds in semiconductor are broken and a large number of charge carriers (electron-hole pairs) are generated which give rise to a sharp increase in reverse current. This phenomenon is called breakdown.

(b) The voltage at which breakdown occurs is called *breakdown voltage*.

(x) p-n junction diode is a one-way device which offers a low resistance when forward biased and behaves like an insulator when reverse biased. Thus, it can be used as a *rectifier*, i.e., for converting alternating current into direct current.

(xi) An ideal diode when forward biased offers zero resistance and acts as a short circuit. On the other hand, an ideal diode when reverse biased offers infinite resistance and acts as an open circuit.

(xii) The ratio of the change in junction voltage ΔVto that in junction current ΔI is called as dynamic resistance Rd of diode.

(xiii) *Knee voltage* is defined as the forward voltage at which the current through the junction starts increasing rapidly.

(xiv) Frequency becomes double in full wave rectifier whereas it remains same in half wave rectifier.

21. *Transistor*:

(i) The transistor is a semiconductor device. When a layer of p-type material is sandwitched between two layers of z-type material, the transistor is known as n-p-n transistor. Similarly, when a layer of n-type material is sandwitched between two layers of p-type material, the transistor is known as p-n-p transistor.

(ii) The transistor has three regions: (a) Emitter (b) Base and (c) Collector. Emitter is heavily doped in comparison to other regions and its main function is to supply majority charge carriers. The collector is moderately doped and its function is to collect majority charge carriers. The base is very lightly doped as compared to emitter or collector and is kept quite thin.

(iii) In most of the transistors, the collector region is made physically larger than emitter region. This is due to the fact that collector has to dissipate much greater power. Due to this difference, collector and emitter are not interchangeable.

(iv) As regards the symbols, arrowhead is always at the emitter which indicates the conventional direction of current flow.

(v) For transistor biasing, the emitter base junction is always forward biased while the collector base junction is always reverse biased.

(vi) Holes are majority charge carriers in a p-n-p transistor. Thus, only hole current plays an important role in the working of a p-n-p transistor.

(vii) Electrons are majority charge carriers in an n-p-n transistor. So, electrons are chiefly responsible for conduction of current in an n-p-n transistor.

(viii) A transistor can be connected in a circuit in the following three different configurations :

(a) Common Base (CB) (b) Common Emitter (CE) (c) Common Collector (CC)

(ix) Emitter current is always equal to the sum of base current and collector current, i.e., Ie = Ib +Ic .

(x) In *common base configuration*, the input signal is applied between emitter and base and output is obtained from collector and base. *When no signal is applied*, then the ratio of collector current to emitter current is called as DC alpha gain (αDC) of a transistor. (αDC) = Ic/Ie

When signal is applied, the ratio of change in collector current to the change in emitter current at constant collector base voltage is defined as current amplification factor - αAC = α = (ΔIc/ΔIe)VCB =constant . αAC is always less than one. Its value lies between 0.95 to 0.98.

(xi) In *common emitter configuration*, the input signal is applied between base and emitter and the output is

taken from collector and emitter. When signal is applied, the ratio of change in collector current to the change in base current is defined as the base current amplification factor βAC= (ΔIc/ΔIb). Almost in all transistors, the base current is less than 5% of emitter current. Thus, βAC is generally greater than 20.

(xii) *As βAC  is greater than αAC hence in most of the amplifiers, common emitter configuration is used.*

(xiii) α = β ( 1+β) and β = α /(1-α )

(xiv) (a) Voltage gain in common base configuration AV = (ΔIc/ΔIe) (Rout/Rin) = α (Rout/Rin) ;Here Rout>Rin and there is no phase difference between input and output signals

(b) Voltage gain in common emitter configuration, AV = β(Rout/Rin) = α (Rout/Rin) ;Here β>>1 and there is a phase difference of π between input and output signals.

22. Logic gates:

(i) The electronic circuits in which current and voltage signals vary continuously with time are called *analogue electronic circuits.*

(ii) The electronic circuits in which current and voltage signals have only two levels (either on or off) are *called digital circuits.*

(iii) A switch which can be closed or opened is known as a gate. The gate has two possible states. Mathematically, the two states are expressed by number I (one) and 0 (zero).

(iv) I (one) may be used to represent the gate as on, true, yes, closed, high . . . and 0 (zero) may be used to represent the gate as off, false, no, opened, low . . . .

(v) The circuits which are used to perform switching action are known as logic circuits or logic gates.

(vi) The most basic gates are called the OR gate, the AND gate and the NOT gate.

(vii) A table that shows all the input/output possibilities for a logic gate is called a truth table or the table of

combinations.

23. **Logic gates**

*A gate is a digital circuit that follows curtain logical relationship between the input and output voltages.* Therefore, they are generally known as *logic gates* — gates because they control the flow of information. The five common logic gates used are NOT, AND, OR, NAND, NOR. Each logic gate is indicated by a symbol and its function is defined by a *truth table* that shows all the possible input logic level combinations with their respective output logic levels. Truth tables help understand the behaviour of logic gates. These logic gates can be realised using semiconductor devices.

***(i) NOT gate***

This is the most basic gate, with one input and one output. It produces a ‘1’ output if the input is ‘0’ and vice-versa. That is, it produces an inverted version of the input at its output. This is why it is also known as an *inverter*. The commonly used symbol together with the truth table for this gate is given in Fig. 14.35.

***(ii) OR Gate***

An *OR* gate has two or more inputs with one output. The logic symbol and truth table are shown in Fig. 14.36. The output Y is 1 when either input A *or* input B *or* both are 1s, that is, if any of the input is high, the

output is high. Apart from carrying out the above mathematical logic operation, this *gate* can be used for modifying the pulse waveform

***(iii) AND Gate***

An *AND* gate has two or more inputs and one output. The output Y of AND gate is 1 only when input A *and* input B are both 1. The logic symbol and truth table for this gate are given in Fig. 14.38



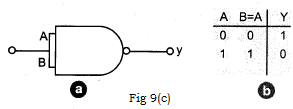
***(iv) NAND Gate***

This is an AND gate followed by a NOT gate. If inputs A *and* B are both ‘1’, the output Y is *not* ‘1’. The gate gets its name from this NOT AND behaviour. Figure 14.40 shows the symbol and truth table of NAND gate. NAND gates are also called *Universal Gates* since by using these gates you can realise other basic gates like OR, AND and NOT .

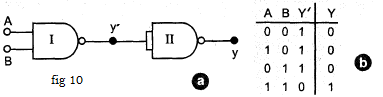


**(*v) NOR Gate***

It has two or more inputs and one output. A NOT- operation applied *after* OR gate gives a NOT-OR gate (or simply NOR gate). Its output Y is ‘1’ only when both inputs A and B are ‘0’, i.e., neither one input *nor* the other is ‘1’. The symbol and truth table for NOR gate is given in Fig. 14.42.

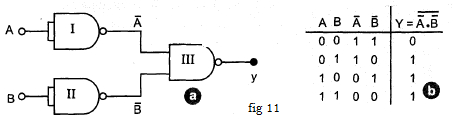
**NOT** gate is realised using **NAND** gate

**Answer :** If the two inputs of the NAND gate are joined to make one input as shown in Fig. 9(c). 28(a), then the NAND gate functions as a NOT gate.

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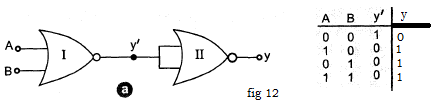
**AND** gate is realised using **NAND** gate

**Answer:** If the output y' of NAND gate is connected to the input of NOT gate (made from NAND joining two inputs), as shown in Fig. 10, then we get back an AND gate

**OR** gate is realised using **NAND** gate

**Answer:** If the input terminals of NAND gate are joined together we get NOT gate. Now if the inputs A and B

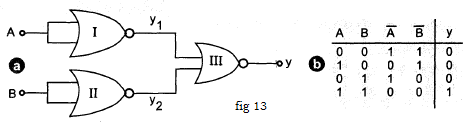
are inverted by using two NOT gates (obtained from NAND gates) and their outputs are jointly fed to the NAND gate as shown in Fig.11, we get the arrangement which works as OR gate

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a **OR** gate is realised using **NOR** gate

**Answer:** If the output y' of NOR gate is used as the input of NOT gate (made from NOR gate by joining two inputs), as shown in Fig. 12, we get back an OR gate.

**AND** gate is realised using **NOR** gate

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**Answer:** If the input terminals of NOR gate are joined together we get NOT gate. Now if the inputs A and B

are inverted by using two NOT gates (obtained from NOR gates) and their outputs are jointly fed to the NOR gate as shown in Fig. 13, we get the arrangement which works as AND gate

**Principles Of Communication**

1. *Analog communication*:

(i) Analog communication system involves analog electronic circuit, where the output voltage changes continuously according to input voltage variations.

(ii) In this communication, the output voltage can have an infinite number of values.

(iii) A continuously varying signal (voltage or current) is called an analog signal.

(iv) Due to many-valued output, the analog operation is less reliable.



2. Digital communication:

(i) Modem communication systems involve digital electronic circuits and digital signals.

(ii) A signal that can have only two discrete values is called a digital signal.

(iii) A square wave is a digital signal, because this signal has only two values, +5V and 0V.

(iv) Digital operation has only two states (i.e., ON or OFF). Fig 46.1

(v) Digital operation is more reliable than many-valued analog operation.

(vi) A digital circuit expresses the values in digits 1's or 0's. Hence, the name digital is given.

3. Radio communication:

- Audio signal cannot be sent directly over the air for appreciable distance, even after converting into electrical signal. At audio frequencies, the signal power is quite small and radiation is not practicable.

- The radiation of electrical energy is practicable only at high frequencies, e.g., above 2O kHz. Therefore, if audio signal is to be transmitted properly, some means must be devised which will permit transmission to occur at high frequencies while it simultaneously allows the carrying of audio signal. This is achieved by superimposing electrical audio signal on high frequency carrier wave. This process is called *Modulation*.

- At the radio receiver, the audio signal is extracted from the modulated wave by the process called *Demodulation.*

- The process of radio communication involves three steps, viz.:

(a) transmitter (b) transmission of radio waves (c) radio receiver

4. Modulation:

(i) The process of changing some characteristics (e.g., amplitude, frequency or phase) of a carrier wave in accordance with the intensity of the signal is known as modulation.

(ii) Modulation permits the transmission to occur at high frequency while it simultaneously allows the carrying of the audio signal.

(iii) *Need for modulation:*

(a) In order to radiate a frequency of 20 kHz directly into space, we would need an antenna length of 15,000 m. This is impractical. On the other hand, if a carrier wave of 1000 kHz is used to carry the signal, we need an antenna length of 300 m only.

(b) As the audio signal frequencies are small, therefore these cannot be transmitted over large distances if radiated directly into space (because of their small energy). But, when the audio signal is modified by a high frequency carrier wave, it permits the transmission over large distances.

(c) At audio frequencies, radiation is not practicable because of poor efficiency. However, efficient radiation of electrical energy is possible at high frequencies, thus making wireless communication feasible.

5. Types of modulation: (a) Amplitude modulation (b) Frequency modulation (c) Phase modulation

6. *Amplitude modulation*:

(i) When the amplitude of high frequency carrier wave is changed in accordance with the intensity of audio

signal, it is called amplitude modulation.

(ii) In amplitude modulation, only the amplitude of the carrier wave is changed but the frequency of the modulated wave remains the same, i.e., carrier frequency.

(iii) The ratio of change of amplitude of carrier wave to the amplitude of normal carrier wave is called the modulation factor m, i.e., Modulation factor, *m= amplitude change of carrier wave /amplitude of the unmodulated carrier wave*

(iv) Modulation factor determines the strength and quality of the transmitted signal. The greater is the degree of modulation (i.e-, m), the stronger and clearer will be the audio signal.

(v) *If the carrier is overmodulated (i.e., m >1), distortion will occur during reception*.

(vi) The instantaneous voltage of AM wave is: e = Ec coswct + (mEc/2) cos (wc +ws)t +(mEc/2) cos (wc - ws)t

Where Ec =amplitude of carrier ; mEc =amplitude of sgnal ;

wc  = angular velocity of carrier ws  = angular velocity of signal

(vii) Important points regarding AM wave:

- The AM wave contains three frequencies wc , wc +ws and wc - ws.

-wc +ws is called upper side band frequency. The lower side band frequency is wc - ws

In practical radio transmission, carier frequency is many times greater than the signal frequency. Hence, the side band frequencies are generally close to the carrier frequency.

- In amplitude modulation, band width is twice the signal frequency.

7. Power in AM wave:

- Equation of AM wave reveals that it has three components of amplitudes Ec ,(mEc/2) and (mEc/2) respectively. Obviously, power output must be distributed among these components.

- Power of carrier wave: Pc = Ec2/2R Total power of side bands: Ps = (mEc/2)2/4R = m2Pc/2

Total power of AM wave: Pc[ 1 + m2/2]

- As the signal is contained in side band frequencies, therefore useful power is in the side bands. Above equations show that side band power depends upon the modulation factor m. The greater the value of m, the greater is the useful power carried by side bands.

- (a) When m =0 power carried by side bands =0

(b) When m = 1/2 , power carried by side bands =11.1% of the total power of AM wave.

(c) When m =1, power carried by side bands =33.3% of the total power of AM wave.

-The side band power represents the signal content and the carrier power is that power which is required as the means of transmission.

(vii) It is worth noting that, Pc = Ec2/2R ; Ps = (mEc/2)2/4R = m2Pc/2

8. Limitations of amplitude modulation:

(i) Noisy reception (ii) Low efficiency (iii) Small operating range (iv) Lack of audio quality

9, Frequency modulation:

(i) In this modulation, it is only the frequency of the carrier wave which is changed and not its amplitude. The amount of change in frequency is determined by the amplitude of the modulating signal whereas rate of change is determined by the frequency of the modulating signal.

(ii) Following two points are worth noting regarding frequency modulation:

(a) Louder the audio signal, greater the frequency change in modulated carrier.

(b) The rate of frequency deviation depends on the , signal frequency.

(iii) The frequency of a FM transmitter without signal input is called the *resting frequency* or *centre frequency* and is the allotted frequency of the transmitter or carrier frequency.

(iv)When the signal is applied, the carrier frequency deviates up and down from its resting value . This change or shift either above or below the resting frequency is called frequency deviation (Δf ).

(v) The total variation in frequency from the lowest to the highest is called carrier swing (CS), i.e.,CS=2x(Δf )

(vi) A maximum frequency deviation of 75 kHz is allowed for commercial FM broadcasting stations in . the 88 to 168 MHz VHF band. Hence, FM channel width is 2 x 75 = 150 kHz. Allowing a 25 kHz guard band on either side, the channel width becomes = 2(75 + 25) =200KHz

(vii) In FM, the highest frequency transmitted is 15 kHz.

10. *Modulation factor or index:*

(i) It is given by the ratio, mf = frequency deviation/ modulating frequency = Δf/fm

(ii) Unlike amplitude modulation, the modulation factor here can be greater than unity.

11. *Pulse modulation*:

(i) Pulse modulation may be used to transmit analog information, such as continuous speech or data.

(ii) Pulse modulation may be subdivided into two categories: analog and digital.

(iii) The two types of analog pulse modulation: pulse amplitude and pulse-time modulation. Correspond roughly to amplitude and frequency modulation.

14. Demodulation:

(i) The process of recovering the audio signal from the modulated wave is known as demodulation.

(ii) If the modulated wave after amplification is directly fed to the speaker, no sound will be heard. It is because the diaphragm of the speaker is not at all able to respond to high frequency of modulated wave. This implies that audio signal must be separated from the carrier at a suitable stage in the receiver and fed to the speaker for conversion into sound.

(iii) A demodulator or detector circuit performs essentially two functions:

(a) It rectifies the modulated wave, i.e., negative half of the modulated wave is eliminated.

(b) It separates the audio signal from the carrier.

15. Data communication:

Modem

(i) The modems are employed both at transmitting and receiving stations. The modem at the transmitting station changes the digital output from a computer to a form which can be .easily sent via a communication circuit, while the receiving modem reverses the process.

(ii) The name modem is a contraction of the terms *Modulator* and *DEModulator*. As the name implies, both functions are included in a modem.

16. Propagation of electromagnetic waves in atmosphere:

(i) Electromagnetic waves (radio waves) launched from a transmitting antenna travel outward and are not markedly affected by the surrounding atmosphere, rain, snow, etc.

(ii) Electromagnetic waves with frequencies extending from about 10 kHz to 300 GHz are classified as radio waves. These waves are further subdivided into smaller ranges for convenience.

(iii) Depending primarily on the frequency, a radio wave travels from the transmitting to the receiving antenna in several ways. On the basis of the mode of ' propagation, radio waves can be broadly classified

AS:

(a) ground or surface waves b) space or tropospheric waves and (c) sky waves

*(a) Ground or surface waves:*

(i) In ground wave propagation, radio waves are guided by the earth and move along its curved surface from the transmitter to receiver.

(ii) Ground wave propagation is useful only at low frequencies.

(iii) Below 500 kHz, ground waves can be used for communication within distances of about 1500 km from the transmitter.

(iv) AM radio broadcasts in the medium frequency band cover local areas and take place primarily by the ground wave.

(b) Space or tropospheric waves

(i) In space wave propagation, radio waves move in the earth's troposphere within about 15 km over the surface of the earth.

(ii) The space wave is made of two components: (a) a direct or line of sight wave

(b) the ground-reflected wave

(iii) The space wave is not continuously absorbed by the earth's surface. Hence, it can cover a greater range

than the ground wave.

*Sky waves*:

In sky wave propagation, radio waves transmitted from the transmitting antenna reach the receiving antenna after reflection from the ionosphere. Short wave transmission around the globe is possible through sky waves via successive reflections at the ionosphere and the earth surface.

17. Satellite communication:

(i) For sky wave propagation, usually the frequency band extending from 3 to 30 MHz is employed. Radio links over large distances over the earth's surface can be established by multi hop transmission. But reliable communication by means of sky waves is hampered due to problems like ionospheric disturbances, storms, etc. Artificial satellites offer reliable communication links over long distances.

(ii) An artificial satellite is hurled into space in a circular orbit in the equatorial plane at a height of 36000 km above the surface of the earth. The period of revolution of the satellite round the earth is 24 hours. So, to an observer on the earth's surface the satellite appears to be stationary.

(iii) In satellite communication, the wave containing information is transmitted to the satellite from a transmitter located on the earth's surface. The signal is processed by the equipment kept in the satellite, amplified and retransmitted towards the receiving point on the surface of earth.

(iv) In satellite communication, FM is used and the carrier frequency is a few GHz. For such high frequencies, the antenna size is small and the signal is not significantly absorbed by the ionosphere. A large area on the earth's surface can be covered by the transmitter stationed on the artificial satellite.

Remote-sensing and its applications:

(i) The technique of collecting information about an object from a distance, without making a physical contact with that object, is called remote-sensing.

(ii) Applications of remote-sensing satellite:

(a) It makes possible the repeated survey of vast areas in a very short time even if the area is otherwise inaccessible.

(b) Ground-water surveys (c) Forest surveys

(d) Preparing wasteland maps (e) Drought assessment

(0 Estimation of crop yields (g) Detection of crop diseases

(h) Spying work for military purposes

19. Optical communication: Optical fibre

(i) A light beam acting as a carrier wave is capable of carrying far more information than radio waves and microwaves. In order to have an efficient communication system, one would require a guiding medium in which the information carrying light wave could be transmitted. This guiding medium is an optical fibre.

(ii) The optical fibres are hair-thin strands of specially coated glass. The diameter of each fibre is about 10-4 cm with refractive index 1.7. They can transit a laser or other light beam from one end to the other as a result of repeated total internal reflections at the glass boundary. Each fibre can carry as many as 2000 telephone conversations with extremely low losses.

(iii) Optical fibre communication is the transmission of information by the conversion of an electrical signal to an optical signal, the transmission of this optical signal along the length of optical fibre and then its reconversion to an electrical signal.

(iv)The basic raw material used in the fabrication of low loss fibres is silica, which is easily available in nature, whereas copper constitutes the basic raw material for co-axial cables.

**Home Assignment- Semiconductors**

**Notes**

1. What do you mean by conduction band and valence band and what are their characteristics for conductors ,insulators and semi conductors?
2. What do you mean by an intrinsic semiconductor ?Give some examples ?
3. What do you mean by doping?
4. What do you mean by an extrinsic semiconductor ?
5. Name the majority and minority carriers in p & n type of semiconductor?
6. Define diffusion , drift current , depletion region and barrier potential?
7. Explain in brief what will happen at the p-n junction under forward bias? Also draw V-I graph ?
8. Explain in brief what will happen at the p-n junction under reverse bias? Also draw V-I graph ?
9. What do you mean by breakdown voltage, threshold voltage or cut-in voltage, reverse saturation current & dynamic resistance for p-n junctions?
10. What do you mean by a rectifier?
11. Explain the working of half wave rectifier ?
12. Explain the working of a full wave rectifier ?
13. What do you mean by filters and why they are used in rectifier circuits?
14. Explain the working of zener diode alongwith graph?
15. Explain with the help of a circuit diagram , how a zener diode works as voltage regulator?
16. Write a note on Photodiodes ,LED & solar cells.
17. Explain different regions of a junction transistor? Also elaborate different types alongwith diagrams ?
18. Explain the working of a transistor as a common base amplifier ?
19. What is the relationship between emitter current, base current and collector current in a transistor and why is that so, name the law which governs this relationship?
20. Explain and plot the input & output characteristics of common emitter transistor?
21. Write the expressions for *Input resistance* (*ri*) , *Output resistance (r*o) & *Current amplification factor* (β) of common emitter transistor?
22. Explain cut-off, active and saturation region for a CE transistor using a graph ?
23. Explain the working of a transistor as a switch?
24. What do you mean by small signal voltage gain *A*Vof an amplifier?
25. Explain the working of a transistor as common emitter amplifier and derive expressions for ac current gain, voltage gain Av & power gain Ap?
26. What is the difference between analogue and digital signal ?
27. Define a Logic gate ?
28. With the help of logic symbol and truth table explain the following logic gates :
    1. NOT gate (ii) OR Gate (iii) AND Gate (iv) NAND Gate (v) NOR Gate
29. Which logic gate is known as universal gate and why?
30. What do you mean by an Integrated circuit?
31. Why are the NAND (or NOR) gates called as digital building blocks?
32. Discuss how a NOT gate can be obtained using NAND gate?
33. Discuss how an AND gate can be obtained using NAND gate?
34. Discuss how an OR gate can be obtained using NAND gate?
35. Discuss how an OR gate can be obtained using NOR gate?
36. Discuss how an AND gate can be obtained using NOR gate?

**NCERT**

1. Why are Si and GaAs are preferred materials for solar cells?
2. In half-wave rectification, what is the output frequency if the input frequency is 50 Hz. What is the output frequency of a full-wave rectifier for the same input frequency.
3. For a CE-transistor amplifier, the audio signal voltage across the collected resistance of 2 kΩ is 2 V. Suppose the current amplification factor of the transistor is 100, find the input signal voltage and base current, if the base resistance is 1 kΩ.
4. Two amplifiers are connected one after the other in series (cascaded).The first amplifier has a voltage gain of 10 and the second has a voltage gain of 20. If the input signal is 0.01 volt, calculate the output ac signal.
5. p-n photodiode is fabricated from a semiconductor with band gap of 2.8 eV. Can it detect a wavelength of 6000 nm?
6. You are given the two circuits as shown in Fig. 14.44. Show that circuit (a) acts as OR gate while the circuit (b) acts as AND gate.
7. Write the truth table for a NAND gate connected as given in Fig. 14.45. Hence identify the exact logic operation carried out by this circuit.
8. You are given two circuits as shown in Fig. 14.46, which consist of NAND gates. Identify the logic operation carried out by the two circuits.



1. Write the truth table for circuit given in Fig. 14.47 below consisting of NOR gates and identify the logic operation (OR, AND, NOT) which this circuit is performing.

(Hint: A = 0, B = 1 then A and B inputs of second NOR gate will be 0

and hence Y=1. Similarly work out the values of Y for other combinations of A and B. Compare with the truth table of OR, AND, NOT gates and find the correct one.)

1. Write the truth table for the circuits given in Fig. 14.48 consisting of NOR gates only. Identify the logic operations (OR, AND, NOT) performed by the two circuits.

**Exemplar**

1. Why are elemental dopants for Silicon or Germanium usually chosen from group XIII or group XV?
2. Sn, C, and Si, Ge are all group XIV elements. Yet, Sn is a conductor, C is an insulator while Si and Ge are semiconductors. Why?
3. The amplifiers X, Y and Z are connected in series. If the voltage gains of X, Y and Z are 10, 20 and 30, respectively and the input signal is 1 mV peak value, then what is the output signal voltage (peak value)
   1. if dc supply voltage is 10V? (ii) if dc supply voltage is 5V?
4. In a CE transistor amplifier there is a current and voltage gain associated with the circuit. In other words there is a power gain. Considering power a measure of energy, does the circuit violate conservation of energy?
5. Three photo diodes D1, D2 and D3 are made of semiconductors having band gaps of 2.5eV, 2eV and 3eV, respectively. Which ones will be able to detect light of wavelength 60000A?
6. Two car garages have a common gate which needs to open automatically when a car enters either of the garages or cars enter both. Devise a circuit that resembles this situation using diodes for this situation.
7. How would you set up a circuit to obtain NOT gate using a transistor?
8. Explain why elemental semiconductor cannot be used to make visible LEDs.

**Communications**

1. Draw flowchart showing different parts of communication system?
2. Define the following :

|  |  |  |  |
| --- | --- | --- | --- |
| Transducer | Signal | Noise | Transmitter |
| Attenuation | Bandwidth | Demodulation | Amplitude Modulation |

1. What do you mean by Hertz and Marconi antenna ?
2. What is the necessity of modulation?
3. What do you mean by AM,FM,PM,PAM,PDM,PWM, & PPM ?
4. What do you mean by amplitude modulation index ? Write it’s expression ?
5. What is value of band width in amplitude modulation?
6. Write value of amplitude modulation index in terms of Amax and Amin?
7. Compare AM & FM?
8. Draw flow chart of processes adopted in production of AM wave ?
9. What do you mean by square law device ?
10. What do you mean by band pass filter?
11. What do you mean by MODEM ?
12. What do you mean by Ground wave or Surface wave propagation ? Write it’s advantages and disadvantages ?
13. What do you mean by Sky wave propagation or Ionospheric Propagation?
14. What do you mean by Plasma frequency or critical frequency in Sky wave propagation?
15. What do you mean by MUF & skip distance in Sky wave propagation?
16. What do you mean by Space or Tropospheric wave propagation ?
17. What is the relation between signal coverage distance and height of antenna?
18. What do you mean by Microwave link or line of sight propagation?
19. What do you mean by satellite communication?
20. What do you mean by geo synchronous and polar satellite?
21. What is remote sensing ?
22. What do you mean by internet ?
23. What do you mean by SIM ?
24. What do you mean by GPS and write some of it’s advantages?

**NCERT Solved**

1. A transmitting antenna at the top of a tower has a height 32 m and the height of the receiving antenna is 50 m. What is the maximum distance between them for satisfactory communication in LOS mode? Given radius of earth 6.4 × 106 m.
2. A message signal of frequency 10 kHz and peak voltage of 10 volts is used to modulate a carrier of frequency 1 MHz and peak voltage of 20 volts. Determine (a) modulation index, (b) the side bands produced.

**NCERT (Unsolved)**

1. Is it necessary for a transmitting antenna to be at the same height as that of the receiving antenna for line-of-sight communication? A TV transmitting antenna is 81m tall. How much service area can it cover if the receiving antenna is at the ground level?
2. A carrier wave of peak voltage 12V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have a modulation index of 75%?
3. For an amplitude modulated wave, the maximum amplitude is found to be 10V while the minimum amplitude is found to be 2V. Determine the modulation index, μ. What would be the value of μ if the minimum amplitude is zero volt?

**Exemplar**

1. Which of the following would produce analog signals and which would produce digital signals?

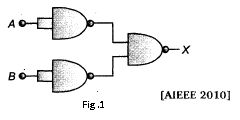
(i) A vibrating tuning fork. (ii) Musical sound due to a vibrating sitar string.

(iii) Light pulse. (iv) Output of NAND gate.

1. Would sky waves be suitable for transmission of TV signals of 60 MHz frequency?
2. Two waves A and B of frequencies 2 MHz and 3 MHz, respectively are beamed in the same direction for communication via sky wave. Which one of these is likely to travel longer distance in the ionosphere before suffering total internal reflection?
3. The maximum amplitude of an A.M. wave is found to be 15 V while its minimum amplitude is found to be 3 V. What is the modulation index?
4. Compute the *LC* product of a tuned amplifier circuit required to generate a carrier wave of 1 MHz for amplitude modulation.
5. Why is a AM signal likely to be more noisy than a FM signal upon transmission through a channel?
6. A TV transmission tower antenna is at a height of 20 m. How much service area can it cover if the receiving antenna is (i) at ground level, (ii) at a height of 25 m? Calculate the percentage increase in area covered in case (ii) relative to case (i).

**Objective Questions**

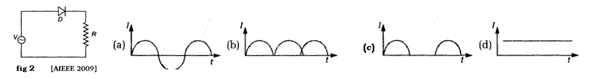
1.The output of an OR gate is connected to both the inputs of an NAND gate. The combination will serve as (a) OR gate (b) NOT gate (c) NOR gate (d) AND gate [AIEEE 2011]

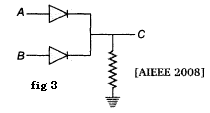


2. The combination of gates shown below( Fig1) yields

(a) OR gate (b) NOT gate

(c) XOR gate (d) AND gate [AIEEE 2010]

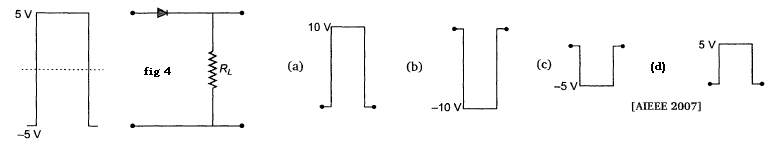
3.A p-n junction (D) shown in the figure 2 can act as a rectifier. An alternating current source (V) is connected in the circuit



4. In the adjacent circuit fig 3, A and B represent two inputs and C represents the output,

The circuit represents (a) NOR gate (b) AND gate (c) NAND gate (d) OR gate

5. If in a p-n junction diode, a square input signal of 10 V is applied as shown in fig 4..Then the output signal across RL will be



6.Carbon, silicon and germanium have four valence electrons each. At room temperature which one of the following statements is most appropriate ? [AIEEE 2007]

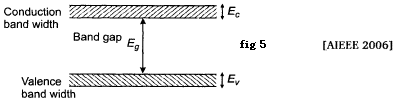
(a) The number of free conduction electrons is significant in C but small in Si and Ge.

(b) The number of free conduction electrons is negligibly small in all the three.

(c) The number of free electrons for conduction is significant in all the three.

(d) The number of free electrons for ' conduction is significant only in Si and Ge but small is C.

7. In a common-base mode of a transistor, the collector current is 5.488 mA for an emitter current of 5.60 mA. The value of the base current amplification factor (β) will be (a) 49 (b) 50 (c) 51 (d) 48

8. If the lattice constant of this semiconductor (fig 5)is decreased, then which of the following is correct ?

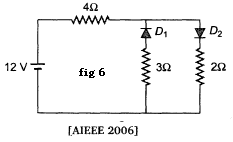
(a) All EG,EC, EV will increase

( b) EC, EV increase, but EG decrease

(c) EC, EV decrease, but EG increase

(d) All EG,EC, EV will decrease

9.A solid which is not transparent to visible light and whose conductivity increases with temperature is formed by (a) ionic binding (b) covalent binding (c) vander Waals' binding (d) metallic binding [AIEEE 2006]

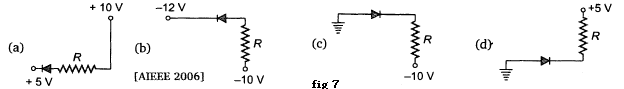
10. If the ratio of the concentration of electrons to that of holes in a semiconductor is 7/5 and the ratio of currents is 7/4, then what is the ratio of their drift velocities ? [AIEEE 2006]

(a) 5/8 (b) 4/5 (c) 5/4 (d) 4/7

11.The circuit has two oppositely connected ideal diodes in parallel. What is the current flowing in the circuit(fig 6) ?

(a) 1.71 A (b) 2 A (c) 2.31 A (d) 1.33 A

12. In the fig 7, which one of the diodes is reverse biased ?



13. 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 : [AIEEE 2005]

(a) 1.1eV (b) 2.5eV (c) 0.5eV (d) 0.7eV

14.In a common base amplifier, the phase difference between the input signal voltage and output voltage is (a) π/4 (b) π (c) 0 (d) π/2 [AIEEE 2OO5]

15.In a full wave rectifier circuit operating from 50 Hz mains frequency, the fundamental frequency in the ripple would be (a) 50Hz (b) 25Hz (c) 100Hz (d) 70.7Hz [AIEEE 2OO5]

16. When n-p-n transistor is used as an amplifier [AIEEE 2OO4]

(a) electrons move from base to collector (b) holes move from emitter to base

(c) electrons move from collector to base (d) holes move from base to emitter

17. Amorphous solids show:

(a) homogeneous composition (b) sharp melting points

(c) equal strengths of all interatomic bonds (d) different freezing and melting points

18. A piece of copper and germanium are cooled from room temperature to 77 K, the resistance of

(a) each of them increases (b) each of them decreases [AIEEE 2OO4]

(c) copper decreases and germanium increases (d) copper increases and germanium decreases

19. When p-n junction diode is forward biased, then [AIEEE 2OO4]

(a) the depletion region is reduced and barrier height is increased

(b) the depletion region is widened and barrier height is reduced

(c) both the depletion region and barrier height are reduced

(d) both the depletion region and barrier height are increased

20. The difference in the variation of resistance with temperature in a metal and a semiconductor arises essentially due to the difference in the [AIEEE 2003]

(a) crystal structure (b) variation of the number of charge carriers with temperature

(c) type of bonding (d) variation of scattering mechanism with temperature

21. In the middle of the depletion layer of reverse biased p-n junction, the [AIEEE 2003]

(a) electric field is zero (b) potential is maximum

(c) electric field is maximum (d) potential is zero

22. At absolute zero, Si acts as (a) non-metal (b) metal (c) insulator (d) None of these

23. The part of a transistor which is most heavily doped to produce large number of majority carriers is:

(a) emitter (b) base (c) collector (d) can be any of the above three [AIEEE 2002]

24. The energy band gap is maximum in [AIEEE 2002]

(a) metals (b) superconductors (c) insulators (d) semiconductors

25. By increasing the temperature, the specific resistance of a conductor and a semiconductor

(a) increases for both (b) decreases for both [AIEEE 2002]

(c) increases, decreases respectively (d) decreases, increases respectively

26. Application of a forward bias to a p- n junction: (a) widens the depletion zone

(b) increases the potential difference across the depletion zone

(c) increases the number of donors on the n side (d) increases the electric field in the depletion zone

27. Carbon, silicon and germanium atoms have four valence electrons each. Their valence and conduction bands are separated by energy band gaps represented by EC, ESi and EGe. respectively. Which one of the following relationships is true in their case? (a) EC > ESi (b) EC < ESi (c) EC = ESi (d) EC < EGe

28. Copper has face centred cubic (fcc) lattice with interatomic spacing equal to 2.54A0 .The value of lattice constant for this lattice is: (a) 2.54A0 (b) 3.59A0 (c) 1.27A0 (d) 5.08A0

29 Which of the following logic gates is an universal gate?(a) OR (b) XOR (c) AND (d) NAND

30.In a semiconducting material, the mobility of electrons and holes are µe and µh respectively. Which of the following is true? (a) µe > µh (b) µe < µh (c) µe = µh (d) µe <0 ; µh >0

31. The voltage gain of the following amplifier fig44.28 is:

(a) 10 (b) 100 (c) 1000 (d) 9.9

32. Which of the following is an amorphous solid (a) Glass (b) Diamond (c) Salt (d) Sugar



33. In the diode circuit given in fig 44.30

(a) D1 and D2 are reverse biased (b) D1 and D2 are forward biased

(c) D2 is reverse biased and D1 is forward (d) D1 and D2 will not conduct

34. A transistor-oscillator using a resonant circuit with an inductor L (of negligible resistance) and a capacitor C in series produce oscillations of frequency f . If L is doubled and C is changed to 4C, the frequency will be: (a) f/2 (b) f/4 (c) 8f (d) f/2√2

35. The following figure 44.32 (i) shows a logic gate circuit with two inputs A and B and output C. The voltage waveforms of A, B and C are as shown in the figure 44.32 (ii) given below. The logic circuit gate is :

(a) OR (b) AND (c) NAND (d) NOR

36. A transistor is operated in common emitter configuration at constant collector voltage Vc =1.5 V, such that a change in the base current from 100 µA to 150 µA produces a change in the collector current from 5 mA to l0 mA. The current gain β is: (a) 50 (b) 67 (c) 75 (d) 100

37. A Light Emitting Diode (LED) has a voltage drop of 2 volt across it and passes a current of l0 mA when it operates with a 6 volt battery through a limiting resistor R. The value of R is: (UPSEE 2006)

(a) 40 kΩ (b) 4 kΩ (c) 200 kΩ (d) 400 kΩ

38. In a transistor, the collector current is always less than the emitter current because:

(a) collector side is reverse biased and the emitter side is forward biased

(b) a few electrons are lost in the base and only remaining ones reach the collector

(c) collector being reverse biased, attracts less electrons

(d) collector side is forward biased and emitter side is reverse biased

39. In a germanium crystal equal number of aluminium and arsenic atoms are added, then:

(a) it remains an intrinsic semiconductor (b) it becomes a n-type semiconductor

(c) it becomes a p-type semiconductor (d) it becomes an insulator

40.The term liquid crystal refers to a state that is intermediate between:

(a) crystalline solid and amorphous solid (b) crystalline solid and vapour

(c) amorphous liquid and its vapour (d) a crystal immersed in a liquid

41. A solid which is transparent to visible light and whose conductivity increases with temperature is formed by: (a) metallic bonding (b) ionic bonding (c) covalent bonding (d) vander Waals' bonding

42. A p-n-p transistor is said to be in active region of operation, when:

(a) both emitter junction and collection junction rue forward biased

(b) both emitter junction and collection junction are reverse biased

(c) emitter junction is forward biased and collector junction is reverse biased

(d) emitter junction is reverse biased and collector junction is forward biased

43. One serious drawback of semiconductor devices is :

(a) they pollute the environment (b) they cannot be used with high voltage

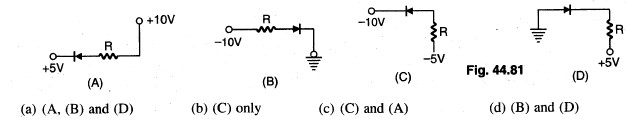
(c) they are costly (d) they do not last for long time

44. The circuit in fig 44.75 cannot be used as :

(a) high-pass filter (b) low-pass filter

(c) band-pass filter (d) both high-pass, low-pass filter

45.In the following figure 44.81, which diodes are forward biased,



46. Why do we prefer indirectly heated cathode to the directly heated cathode?

(a) Equality of potential throughout the cathode (b) Continuous emission of electrons

(c) Availability of filament material (d) Due to some other reasons

47. Thermionic valves are evacuated because:

(a) a lot of heat is produced, if air is present (b) free path of electron is negligible

(c) electrons cannot be produced in the presence of air (d) none of the above

48. The static amplification factor of a triode valve depends upon:

(a) temperature of cathode (b) temperature of anode

(c) plate voltage applied (d) relative positions of cathode grid and plate

49. In a family of triode characteristics, the plate resistance is directly proportional to:

(a) the slope of the grid voltage-plate current characteristics

(b) slope of plate voltage-plate current characteristics

(c) reciprocal of slope of grid voltage-plate current characteristics

(d) reciprocal of slope of plate voltage-plate current characteristics

50. At constant plate potential if the grid is moved closer to the plate, the amplification factor of the triode:

(a) increases (b) decreases (c) remains unchanged (d) may increase or decrease depending upon grid bias

51. The material used for making thermionic cathode must have:

(a) low work function and low melting point (b) low work function and high melting point

(c) high work function and high melting point (d) high work function and low melting point

52. For having amplification without distortion, the grid voltage is adjusted near:

(a) upper band of the mutual characteristic (b) lower band of the mutual characteristic

(c) the cut-off stage (d) the middle of the straight steep part of the curve

53. The difference in the working of an amplifier and a step-up transformer is:

(a) amplifier also increases power which is not possible with transformer

(b) amplifier decreases the power whereas the transformer increases the power

(c) amplifier keeps the power constant whereas the transformer decreases the power

(d) amplifier keeps the power constant whereas the transformer increases the power

54. While using triode as an amplifier, we avoid making the grid positive, because:

(a) the mutual characteristic is not straight (b) it decreases the plate current

(c) it affects the amplification factor (d) of some other reason

55. In comparison to a half-wave rectifier, the full wave rectifier gives lower:

(a) efficiency (b) average DC (c) average output voltage (d) none of these

56. Three triodes having the amplification factors of 12, 18 and 36 with mutual conductance’s 3, 6 and 4 mA/V respectively are operated in parallel. The equivalent mutual conductance of the combination is:

(a) 13 milli-mho (b) (12 x3 + 18 x 6 + 36 x 6) mho

(c)( 1/3 +1/6+1/4) milli-mho (d)( 12/3 +18/6 + 36/4) milli-mho

57. An oscillator is nothing but an amplifier with:

(a) positive feedback (b) large gain (c) no feedback (d) negative feedback

58. The plate current in a triode will become zero if the amplitude of the negative voltage applied on the grid is: (a) Vp/µ (b) µ Vp (c) µ /Vp (d) Vp/rp

59. The unit cubic cell of Al has a lattice parameter equal to 4.5 x 10-10 metre. The number of unit cells in an aluminium foil of volume 1 x 10-6 metre3 is: (a) 1024 (b) 10-24 (c) 108 (d) 10-8

60. Copper has fcc structure. Its atomic weight is 63.5 and atomic radius is 1.273 A; then the density is:

(a) 3.6 x 10-10 kg/m3 (b) 8782 kg/m3 (c) 4391 kg/m3 (d) 2195 kg/m3

61. A Ge specimen is doped with Al. The concentration of acceptor atoms is =1021 atoms/m3. Given that the intrinsic concentration of electron-hole pairs is =1019/m3, the concentration of electrons in the specimen is:

(a) 1017/m3 (b) 1015/m3 (c) 104/m3 (d) 102/m3

62. When m-type semiconductor is heated:

(a) number of electrons increases while that of holes decreases

(b) number of holes increases while that of electrons decreases

(c) number of electrons and holes remain same (d) number of electrons and holes increase equally

63. On increasing the reverse bias to a large value in a p-n junction diode current:

(a) increases slowly (b) remains fixed (c) suddenly increases (d) decreases slowly

64. The cause of the potential barrier in a p-n junction diode is:

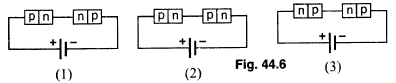
(a) depletion of positive charges near the junction (b) concentration of positive charges near the junction

(c) depletion of negative charges near the junction

(d) concentration of positive and negative charges near the junction

65. A semiconducting device is connected in a series circuit with a battery and a resistance. A current 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: (a) a p-n junction (b) an intrinsic semiconductor

(c) a p-type semiconductor (d) an n-type semiconductor

66. The p-n junctions can be connected in series by three methods as shown in the figure 44.6 given below. If the potential difference in the junctions is the same, then the correct connections will be:

(a) in circuits (1) and (2) (b) in circuits (2) and (3)

(c) in circuits (1) and (3) (d) only in the circuit (l)

67. The part of a transistor which is heavily doped to produce a large number of majority carriers is:

(a) base (b) emitter (c) collector (d) none of these

68. The current gain of the common-base n-p-n transistor is 0.96. what is the current gain if it is used as common-emitter amplifier? (a) 16 (b) 24 (c) 20 (d) 32

69. The current gain for a transistor used in common-emitter configuration is 98. If the load resistance be 1 MΩ and the internal resistance be 600 Ω, what is the voltage gain?

(a) 90 (b) 95 (c) 100 (d) None of these

70. For a transistor, the current amplification factor is 0.8. The transistor is connected in common-emitter configuration. The change in the collector current when the base current changes by 6 mA is:

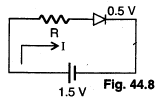
(a) 6 mA (b) 4.8 mA (c) 24 mA (d) 8 mA

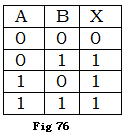
71. In a common-emitter amplifier, output resistance is 5000 Ω and input resistance is 2000 Ω. If peak value of signal voltage is 10 mV and β = 50 ,then the peak value of output voltage is:

(a)5x10-6 volt (b) 2.5 x 10-4 volt (c)1.25 volt (b) 125 volt

72. The transfer ratio β of a transistor is 50. The input resistance of the transistor when used in common-emitter configuration is 1 kΩ .The peak value of collector AC current for an AC input voltage is of 0.01V peak is : (a) 100 µA (b) 250 µA (c) 500 µA (d) 800 µA

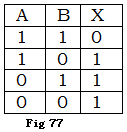
73. What is the voltage gain in a common-emitter amplifier where input resistance is 3Ω and load resistance is 24Ω.(take β =0.6) (a) 8.4 (b) 4.8 (c) 2.4 (d) 1.2

74. The diode shown in fig 44.8 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 ? (a) 1.5 Ω (b) 5 Ω (c) 6.67 Ω (d) 200 Ω

75. A transistor having a β equal to 80 has a change in base current of 250µA, then the change in collector current is: (a) (250/80) µA (b) (250+80) µA (c) (250-80) µA (d) (250x80) µA

76. The following truth table( fig 76) corresponds to the logic gate:

(a) NAND (b) AND (c) XOR (d) OR

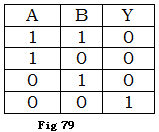


77. The following truth table (fig 77) corresponds to the logic gate:

(a) NAND (b) AND (c) XOR (d) OR

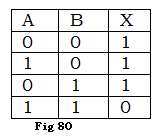
78. How many NAND gates are used to form AND gate?

(a) 1 (b) 2 (c) 3 (d) 4

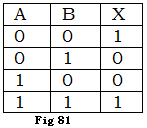


79. The following truth table (fig 79) belongs to which one of the following four gates?

(a) OR (b) NAND (c) XOR (d) NOR

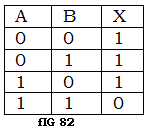
80. The following truth table (fig 80) belongs to which one of the following four gates?

(a) NAND (b)AND (c) OR (d) NOR



81. The following truth table (fig 81) belongs to which one of the following four gates?

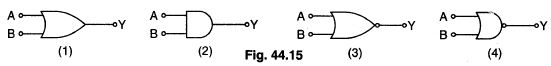
(a) XOR (b)AND (c) XNOR (d) OR

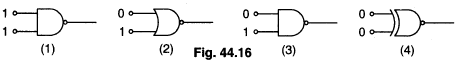


82. The following truth table (fig 82) belongs to which one of the following four gates?(a) XOR (b)OR (c) AND (d) NAND

83. Given below Fig 44.15 are four logic gate symbols. Those for OR, NOR and NAND are respectively

(a) l, 4,3 (b) 4, 1,2 (c) 1, 3, 4 (d) 4,2, 1





84. Which of the gates in fig 44.16 will have an output of 1?

85. In a transistor circuit, when the base current is increased by 50 micro-ampere keeping the collector voltage fixed at 2 volt, the collector current increases by 1 mA. The current gain of the transistor is:

(a) 20 (b) 40 (c) 60 (d) 80

86. A common emitter transistor amplifier has a current gain of 50. If the load resistance is 4 kΩ and input resistance is 500 Ω, the voltage gain of the amplifier is: (a) 160 (b) 200 (c) 300 (d) 400

87. The current gain for transistor working as common-base amplifier is 0.96. If the emitter current is 7.2 mA, then the base current is: (a) 0.29 mA (b) 0.35 mA (c) 0.39 mA (d) 0.43 mA

88. The dominant contribution to current comes from holes in case of :(a) metals

(b) intrinsic semiconductors (c) p-type extrinsic semiconductors (d) n-type extrinsic semiconductors



89. The ratio of thermionic currents (I/I0)for a metal when the temperature is slowly increased from T0 to T is as shown in fig 44.19 .Then, which one is correct

(a) A (b) B (c) C (d) D

90. The dominant mechanisms for motion of charge carriers in forward and reverse biased silicon p-n junction are : (a) drift in both forward and reverse bias

(b) diffusion in both forward and reverse bias (c) diffusion in forward bias while drift in reverse bias

(d) drift in forward bias while diffusion in reverse bias

91. In the given transistor circuit fig 44.23, the base current is 35 µA. The value of Rb is:

(a) 100 kΩ (b) 200 kΩ (c) 300 kΩ (d) 400 kΩ)

92. One serious drawback of semiconductor devices is, that:

(a) they are costly (b) they pollute the environment

(c) they do not last for long time (d) they cannot be used to withstand high voltage

93. The logic behind NOR gate is that it gives:

(a) low output when both inputs are low (b) high output when both inputs are low

(c) high output when both inputs are high (d) none of the above

94. Logic gates are the building blocks of a:

(a) digital system (b) analog system (c) abacus system (d) none of these

95. At 0 K temperature, a p-type semiconductor:

(a) does not have any charge carriers (b) has few holes and few free electrons

(c) has few holes but no free electrons (d) has equal number of holes and free electrons

96. Barrier potential of a p-n junction diode does not depend upon:

(a) temperature (b) forward bias (c) doping density (d) diode design

97. An n-p-n transistor conducts when:

(a) both collector and emitter are positive with respect to the base

(b) both collector and emitter are negative with respect to the base

(c) collector is positive and emitter is at the same potential as the base

(d) collector is positive and emitter is negative with respect to the base

98. lf a full wave rectifier circuit is operating from 50Hz mains, then fundamental frequency in the ripple will be: (a) 50 Hz (b) 70.7 Hz (c) 100 Hz (d) 25 Hz



99. Fig 44.24 performs the logic function of: (a) OR gate (b) XOR gate (c) AND gate (d) NAND gate

100. The difference in the variation of resistance with temperature in a metal and a semiconductor arises essentially due to the difference in: (a) type of bonding (b) crystal structure

(c) scattering mechanism with temperature (d) number of charge carriers with temperature

101. When p-n junction diode is forward biased, then: (AIEEE 2004)

(a) the depletion region is reduced and barrier height is increased

(b) the depletion region is widened and barrier height is decreased

(c) both the depletion region and barrier height are reduced

(d) both the depletion region and barrier height are increased

102. An n-type semiconductor is formed by adding impurity materials:

(a) aluminium, boron or selenium (b) aluminium, boron or indium

(c) phosphorus, antimony or arsenic (d) cobalt, aluminium or selenium

103. 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: (AIEEE 2005)

(a) 0.5 (b) 0.7 (c) 1.1 (d) 2.5

104. Choose only false statement from the following.

(a) In conductors the valence and conduction bands overlap.

(b) Substances with energy gap of the order of 10 eV are insulators.

(c) The resistivity of a semiconductor increases with increase in temperature.

(d) The conductivity of a semiconductor increases with increase in temperature.

**Communications**

105. In frequency modulation:

(a) the amplitude of modulated wave varies as frequency of carrier wave

(b) the frequency of modulated wave varies as amplitude of modulating wave

(c) the amplitude of modulated wave varies as amplitude of carrier wave

(d) the frequency of modulated wave varies as frequency of modulating wave

(e) the frequency of modulated wave varies as frequency of carrier wave

106. Audio signal cannot be transmitted because:

(a) the signal has more noise (b) the signal cannot be amplified for distance communication

(c) of the transmitting antenna length (d) none of the above

107.In which of the following remote-sensing technique is not

(a) Forest density (b) Pollution

(c) Wetland mapping (d) Ground-water survey (e) Medical treatment

108. If the area to be covered for TV telecast is doubled then height of transmitting antenna (TV tower) will have to be: (a) doubled (b) halved (c) quadrupled (d) kept unchanged

109. Refractive index of ionosphere is: (a) zero (b) more than one (c) less than one (d) one

110. The rms value of the electric field of the light coming from the sun is 720 N/c. The average total energy density of the electromagnetic wave is: (AIEEE 2006)

(a) 3.3 x 10-3 J/m3 (b) 4.5 x 10-6 J/m3  (c) 6.3 x 10-9 J/m3  (d) 81.3 x 10-12 J/m3

111. To cover a population of 20 lakh, a transmission tower should have a height: (radius of the earth = 6400 km, population per square km = 1000: (a) 25 m (b) 50 m (c) 75 m (d) 100 m (e) 39 m

112. Electromagnetic waves with frequencies greater than the critical frequency of ionosphere cannot be used for communication using sky wave propagation, because:

(a) the refractive index of the ionosphere becomes very high for f>fc

(b) the refractive index of the ionosphere becomes very low for f> fc

(c) the refractive index of the ionosphere very high for f < fc (d) none of the above

113. An antenna is of height 500 m. What will be its range? (Radius of the earth is 6400 km)

(a) 800 km (b) 100 km (c) 50 km (d) 80 km

114. Which of the following device is full duplex?

(a) Mobile phone (b) Walky-talky (c) loud speaker (d) Radio

115. In optical communication system operating at 1200 nm, only 2% of the source frequency is available for TV transmission having a bandwidth of 5 MHz. The number of TV channels that can be transmitted is:

(a) 2 million (b) 10 million (c) 0.1 million (d) 1 million (e) 0.5 million

116. The sky wave propagation is suitable for radio waves of frequency

(a) upto 2 MHz (b) from 2 MHz to 20 MHz (c) from 2 MHz to 30 MHz (d) from 2 MHz to 80 MHz

117. Modulation is the process of superposing: (a) low frequency audio signal on high frequency waves

(b) low frequency radio signal on low frequency audio waves (c) high frequency radio signal d) high frequency audio signal waves (e) low frequency radio signal waves

118. The optical fibres have an inner core of refractive index n1 and a cladding of refractive index n2, such that(a) n1 = n2 (b) n1 ≤ n2 (c) n1 < n2 (d) n1 > n2 (e) n1 ≥ n2

119. In satellite communication: 1. the frequency used lies between 5 MHz and 10 MHz.

2. the uplink and downlink frequencies are different.

3. the orbit of geo-stationary satellite lies in the equatorial plane at an inclination of 00.

In the above statements.

(a) Only 2 and 3 true (b) All are true (c) Only 2 true (d) Only 1 and 2 true (e) Only I true

120. The principle used in the transmission of signals through an optical fibre is:

(a) total internal reflection (b) reflection (c) refraction (d) dispersion (e) interference

121. Which of the following statement is wrong

(a) Ground wave propagation can be sustained at frequencies 500 kHz to 1500 kHz.

(b) Satellite communication is useful for the frequencies above 30 MHz.

(c) Sky wave propagation is useful in the range of 30 to 40 MHz.

(d) Sky wave propagation takes place through tropospheric space.

(e) The phenomenon involved in sky wave propagation is total internal reflection.

122. A signal wave of frequency 12 kHz is modulated with a carrier wave of frequency 2.51 MHz. The upper and lower side band frequencies are respectively : (a) 2512 kHz and 2508 kHz (b) 2522 kHz and 2488 kHz

(c) 2502 kHz and 2498 kHz (d) 2522 kHz and 2498 kHz (e) 2512 kHz and 2488 kHz

123. A TV tower has a height of 75 m. What is the maximum distance upto which this TV transmission can be received? (Radius of the earth = 6.4 x 106 m)

(a) 30.98 km (b) 38.98 km (c) 40.98 km (d) 50.98 km

124.Advantages of optical fibre communications over two wire transmission line or co-axial cable transmission are:

(a) low band width, low transmission loss (b) high band width, high transmission loss

(c) high band width, low transmission loss (d) low band width, high transmission loss

125.A radio station has two channels. One is AM at 1020 kHz and the other FM at 89.5 MHz. For good results you will use:(a) longer antenna for the AM channel and shorter for the FM

(b) shorter antenna for the AM channel and longer for the FM

(c) same length antenna will work for both

(d) information given is not enough to say which one to use for which

126. The communication using optical fibres is based on the principle of:

(a) total internal reflection (b) Brewster angle (c) polarization (d) resonance

127.Electromagnetic waves of frequencies higher than 9√2 MHz are found to be not reflected by the ionosphere on a particular day at a place. The maximum electron density in the ionosphere is:

(a) √5 x 1012 m-3 (b) √2 x 1012 m-3 (c) 2 x 1012 m-3 (d) 5 x 1012 m-3 (e)3x1012m-3

128.Which one of the following statement is wrong?

(a) Radio waves in the frequency range 30 MHz to 60 MHz are called sky waves.

(b) Radio horizon of the transmitting antenna for space wave is dT = √(2RhT)

(c) Within the skip distance neither the ground waves nor the sky waves are received.

(d) The principle of optical fibre communication is total internal reflection.

(e) Optical fibre communication is free from electrical disturbances.

129.A diode AM detector with the output circuit consisting of R = 1 kΩ and C = 1 µF would be more suitable for detecting a carrier signal of:(a) 0.1 kHz (b) 0.5 kHz (c) 1 kHz (d) 0.75 kHz (e) l0 kHz

130.In amplitude modulation, the band width is:

(a) twice the audio signal frequency (b) thrice the audio signal frequency

(c) thrice the carrier wave frequency (d) twice the carrier wave frequency

131. In a typical optical fibre, the difference between the refractive indices of core and cladding is of order of

:(a) 10-5 (b) 10-6 (c) 10-1 (d) 10-3

132.If both the length of the antenna and the wavelength of the signal to be transmitted are doubled, then the power radiated by the antenna

(a) is doubled (b) is halved (c) remains constant (d) is quadrupled (e) increases 16 times

133. If the maximum amplitude of an amplitude modulated wave is 25 V and the minimum amplitude is 5 V, then the modulation index is (a) 1/5 (b) 1/3 (c) 3/2 (d) 2/5 (e) 2/3

134. A modem is a:(a) modulating device only (b) demodulating device

(c) modulating and demodulating device (d) transmitting device (e) receiving device

135. A carrier frequency of 1MHz and peak value of 10 V is amplitude modulated with a signal frequency of 10 kHz with peak value of 0.5 V. Then, the modulation index and the side band frequencies are:

(a) 0.05 and 1 ± 0.010 MHz (b) 0.5 and 1 ± 0.010 MHz

(c) 0.05 and 1 ± 0.005 MHz (d) 0.5 and 1 ± 0.005 MHz (e) 0.05 and 1 ± 0.100 MHz

136. The TV telecast is to cover a radius of 120 km (given the radius of the earth = 6400 km), the height of the transmitting antenna is : (a) 1280m (b)1125m (c) 1560m (d)79m (e) 1050m

137. Identify the incorrect statement from the following :

(a) AM detection is carried out by using a rectifier and an envelop detector

(b)) pulse position denotes the time of rise or fall of the pulse amplitude

(c) Modulation index µ is kept ≥ 1, to avoid distortion

(d) Facsimile (FAX) scans contents of the document to create electronic signals.

(e) detection is the process of recovering the modulating signal from the modulated wave

138. The distance of coverage of a transmitting antenna is 12.8 km. Then the height of antenna is

(a) 6.4 m (b)12.8 m (c) 3.2 m (d)16 m (e) 25.6 m

139. If Ec = 20 sin105πt , and Em = 10 sin400πt are carrier and modulating signals, the modulation index is

(a) 56 % (b) 30 % (c) 50% (d) 48% (e) 60%

140. 1000 kHz carrier wave is amplitude modulated by the signal frequency 200 - 4000 Hz. The channel width of this case is: (a) 8 kHz (b) 4 kHz (c) 7.6 kHz (d) 3.8 kHz (e) 400 kHz

141. A laser device produces amplification in the :

(a) microwave region (b) ultraviolet or visible region (c) infrared region (d) none of the above

**Answers Objective (Semiconductor & Communications)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1. C | 1. D | 1. C | 1. D | 1. D | 1. D |
| 1. A | 1. C | 1. B | 1. C | 1. B | 1. D |
| 1. C | 1. C | 1. C | 1. D | 1. D | 1. C |
| 1. C | 1. B | 1. A | 1. C | 1. A | 1. C |
| 1. C | 1. C | 1. A | 1. B | 1. D | 1. A |
| 1. B | 1. A | 1. C | 1. D | 1. B | 1. D |
| 1. D | 1. B | 1. C | 1. A | 1. C | 1. C |
| 1. B | 1. A | 1. C | 1. A | 1. D | 1. D |
| 1. D | 1. B | 1. B | 1. D | 1. A | 1. A |
| 1. D | 1. A | 1. A | 1. A | 1. A | 1. B |
| 1. A | 1. D | 1. C | 1. D | 1. A | 1. B |
| 1. B | 1. B | 1. D | 1. B | 1. C | 1. C |
| 1. B | 1. B | 1. D | 1. D | 1. A | 1. B |
| 1. D | 1. A | 1. C | 1. D | 1. C | 1. C |
| 1. A | 1. D | 1. A | 1. C | 1. A | 1. A |
| 1. B | 1. D | 1. B | 1. A | 1. C | 1. D |
| 1. D | 1. C | 1. C | 1. D | 1. C | 1. C |
| 1. A | 1. C | 1. B | 1. D | 1. E | 1. A |
| 1. C | 1. B | 1. B | 1. A | 1. D | 1. A |
| 1. D | 1. C | 1. A | 1. D | 1. A | 1. A |
| 1. C | 1. D | 1. A | 1. C | 1. A | 1. A |
| 1. C | 1. A | 1. E | 1. A | 1. D | 1. C |
| 1. E | 1. C | 1. A | 1. B | 1. C | 1. B |
| 1. C | 1. A | 1. B |  |  |  |

**Explanations – Semiconductor**

