CHAPTER

14

Semiconductor Electronics; Materials, Devices and Simple Circuits

A Quick Recapitulation of the Chapter

1. **Metals** They have very low resistivity or high conductivity, $\rho \sim 10^{-2}\text{-}10^{-8}\ \Omega\text{m}$, $\sigma \sim 10^{2}\text{-}10^{8}\ \text{Sm}^{-1}$
2. **Semiconductors** They have resistivity or conductivity between metals and insulators.
   i.e., $\rho \sim 10^{-5}\text{-}10^{6}\ \Omega\text{m}$, $\sigma \sim 10^{+5}\text{-}10^{-6}\ \text{Sm}^{-1}$

   Types of Semiconductors

   Types of semiconductors are given below

   (i) **Element semiconductors** are available in natural form, *e.g.,* silicon and germanium.

   (ii) **Compound semiconductors** are made by compounding the metals, *e.g.,* CdS, GaAs, CdSe, InP, anthracene, polyaniline, etc.
3. **Insulators** They have high resistivity or low conductivity.
   i.e., $\rho \sim 10^{11}\text{-}10^{19}\ \Omega\text{m}$, $\sigma \sim 10^{-11}\text{-}10^{-19}\ \text{Sm}^{-1}$
4. **Fermi energy** It is the maximum possible energy possessed by free electrons of a material at absolute zero temperature (*i.e.,* 0 K).
5. *On the basis of purity, semiconductors are of two types*

   (i) **Intrinsic semiconductor** It is a pure semiconductor without any significant dopant species present.

   $$n_e = n_h = n_i$$

   where, n_e and n_h are number densities of electrons and holes respectively and n_i is called intrinsic carrier concentration.

   An intrinsic semiconductor is also called an **undoped semiconductor** or ***i*-type semiconductor**.

   (ii) **Extrinsic semiconductor** Pure semiconductor when doped with the impurity is known as extrinsic semiconductor.

   Extrinsic semiconductors are basically of two types

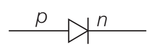
   (a) *n*-type semiconductor (b) *p*-type semiconductor

   Note Both the types of semiconductors are electrically neutral.
6. In ***n*-type semiconductor,** majority charge carriers are electrons and minority charge carriers are holes, *i.e.,* $n_e > n_h$. Here, we dope Si or Ge with a pentavalent element, then four of its electrons bond with the four silicon neighbours, while fifth remains very weakly bound to its parent atom.

7. In ***p*-type semiconductor**, majority charge carriers are holes and minority charge carriers are electrons, *i.e.,* $n_h > n_e$. In a *p*-type semiconductor, doping is done with trivalent impurity atoms *i.e.,* those atoms which have three valence electrons in their valence shell.
8. At equilibrium condition, $n_e n_h = n_i^2$
9. Minimum energy required to create a hole-electron pair, $h\nu \geq E_g$, where E_g is energy band gap.
10. A ***p-n* junction** is an arrangement made by a close contact of *n*-type semiconductor and *p*-type semiconductor.
11. A **semiconductor diode** is basically a *p-n* junction with metallic contacts provided at the ends for the application of an external voltage.

    A *p-n* junction diode is represented as the symbol.

    The direction of arrow indicates the conventional direction of current (when the diode is under forward bias).

12. The DC resistance of a junction diode, $r_{DC} = \frac{V}{I}$
13. The dynamic resistance of junction diode, $r_{AC} = \frac{\Delta V}{\Delta I}$
14. **Diode as rectifier** The process of converting alternating voltage or current into direct voltage or current is called rectification. Diode is used as a rectifier for converting alternating current or voltage into direct current or voltage.

    There are two ways of using a diode as a rectifier i.e.,

    (i) **Diode as a half-wave rectifier** Diode conducts corresponding to positive half cycle and does not conduct during negative half cycle. Hence, AC is converted by diode into unidirectional pulsating DC. This action is known as **half-wave rectification.**

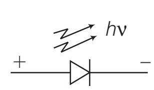
    (ii) **Diode as a full-wave rectifier** In the full-wave rectifier, two *p-n* junction diodes D_1 and D_2 are used.

    Its working is based on the principle that junction diode offers very low resistance in forward bias and very high resistance in reverse bias.
15. **Optoelectronic devices** Semiconductor diodes in which carriers are generated by photons. *i.e.,* photo-excitation, such devices are known as optoelectronic devices.

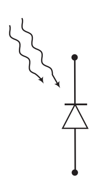
    These are as follows

    (i) **Light emitting diode (LED)** It is a heavily doped *p-n* junction diode which converts electrical energy into light energy.

    Its symbol is given by

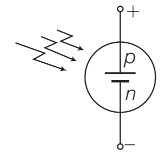
    

    (ii) **Photodiode** A photodiode is a special type of junction diode used for detecting optical signals. It is a reverse biased *p-n* junction made from a photosensitive material. Its symbol is given by

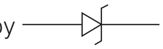
    

    (iii) **Solar cell** Solar cell is a *p-n* junction diode which converts solar energy into electrical energy.

    Its symbol is given by

16. **Zener diode** is a reverse biased heavily doped *p-n* junction diode. It is operated in breakdown region.

    Its symbol is given by  and is used as voltage regulator.
17. A transistor is a combination of two *p-n* junction joined in series. A junction transistor is known as bipolar junction transistor (BJT). Transistors are of two types *n-p-n* and *p-n-p*. The central block thin and lightly doped is called 'Base' while the other electrodes are emitter and collectors.
18. The emitter-base junction is forward biased while collector base junction is reversed biased.
19. The transistor can be in three configurations, common emitter (CE), common collector (CC) and common base (CB).
20. The plot between I_C and V_{CE} for fixed I_B is called **output characteristics** while the plot between I_C and I_B with V_{BE} fixed is known as input characteristics.
21. *Transistor parameters in* CE *configuration are*

    Input resistance, $r_i = \left|\frac{\Delta V_{BE}}{\Delta I_B}\right|_{V_{CE} = \text{constant}}$

    Output resistance, $r_o = \left|\frac{\Delta V_{CE}}{\Delta I_C}\right|_{I_B = \text{constant}}$

    Current amplification factor, $\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE} = \text{constant}}$
22. A transistor can be used as an amplifier. The voltage gain of CE configuration is

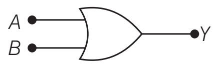
    $$A_V = \left(\frac{V_o}{V_i}\right) = \beta \frac{R_C}{R_B}$$

    where, R_C and R_B are respectively resistances in collector and base sides of the circuit.
23. In common base configuration, A_V current gain is $\alpha = \left|\frac{\Delta I_C}{\Delta I_E}\right|_{V_{CB} = \text{constant}}$.
24. Transistor can be used as an oscillator as well as a switch (is cut-off or saturation state).
25. A **logic gate** is a digital electronic circuit which follows a logical relationship between its input and output. A logic gate may have one or more inputs but has only one output.

Logic gates follow Boolean algebra, which consists of three basic operations, namely AND ($A \cdot B = Y$), OR ($A + B = Y$) and NOT ($\overline{A} = Y$).

(i) **OR gate** Boolean expression for OR gate is given by $Y = A + B$

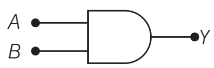
Logic symbol



(ii) **AND gate**

Boolean expression for AND gate is given by $Y = A \cdot B$

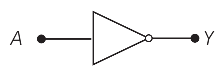
Logic symbol



(iii) **NOT gate**

Boolean expression for NOT gate is given by $Y = \overline{A}$

Logic symbol

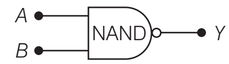


(iv) **NAND gate**

NAND gate is the combination of AND gate and NOT gate. Boolean expression for NAND gate is given by

$$Y = \overline{A \cdot B}$$

Logic symbol



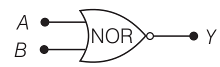
(v) **NOR gate**

Boolean expression for NOR gate is given by

$$Y = \overline{A + B}$$

The NOR gate is the combination of OR and NOT gate given by

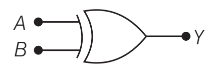
Logic symbol



(vi) **XOR gate**

Boolean expression for output/input of XOR gate is $Y = A \oplus B = \overline{A} \cdot B + A \cdot \overline{B}$

Logic symbol



Objective Questions Based on NCERT Text

Topic 1

Classification of Metals, Conductors and Semiconductors

1. For the flow of electrons in a vacuum tube, vacuum is required, because
(a) electrons are not ejected from cathode
(b) vacuum helps in extracting electrons from remaining gas molecules or atoms
(c) in vacuum work function of cathode is reduced
(d) electrons may lose their energy on collision with air molecules in their path

2. Semiconductor devices (diodes, transistors) are smaller than vacuum tubes because
(a) they are made from silicon /germanium crystals
(b) they have very high density
(c) large crystals of semiconductors have large resistance
(d) flow of charge carriers are within the solid itself

3. If a solid transmits the visible light and has a low melting point, it possesses
(a) metallic bonding (b) ionic bonding
(c) covalent bonding (d) van der Walls bonding

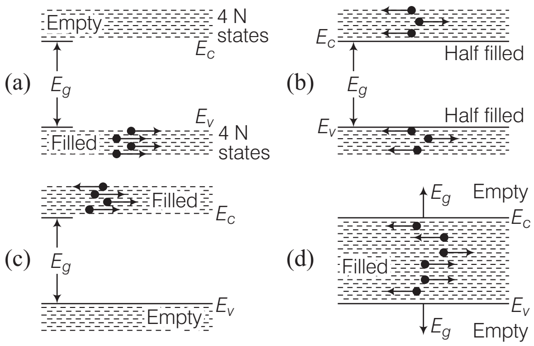
4. Bonding in a semiconductor is
(a) metallic (b) ionic
(c) van der Walls (d) covalent

5. The SI unit of conductivity is
(a) $(\Omega\ \text{m})^{-1}$ (b) Ωm^{-1} (c) Sm^{-1} (d) S

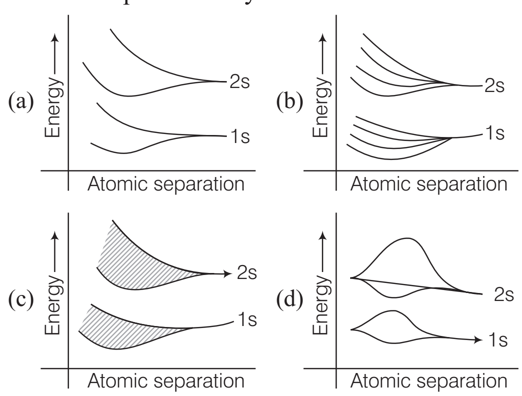
6. Correct one is
(a) $\sigma_{\text{semiconductor}} > \sigma_{\text{insulator}} > \sigma_{\text{metal}}$
(b) $\sigma_{\text{metal}} > \sigma_{\text{semiconductor}} > \sigma_{\text{insulator}}$
(c) $\sigma_{\text{semiconductor}} > \sigma_{\text{metal}} > \sigma_{\text{insulator}}$
(d) $\sigma_{\text{insulator}} > \sigma_{\text{semiconductor}} > \sigma_{\text{metal}}$
(here, σ represents conductivity.)

7. In a crystal, atomic separation is around 2 to 3A. At this separation due to interatomic interaction, energies of
(a) outermost electrons are changed
(b) innermost electrons are changed
(c) Both (a) and (b)
(d) None of the above

8. Following diagram shows energy band positions in a semiconductor at 0 K.



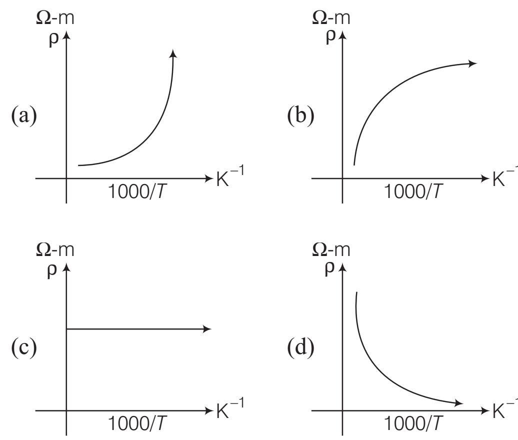
9. The splitting of 1s and 2s atomic energy levels when many atoms come together to form a solid is best represented by



10. Forbidden energy gap in a semiconductor is nearly equal to

(a) 1 eV (b) 6 eV (c) 0 eV (d) 3 eV

11. Which of these is a true graph showing a relation between resistivity ρ and temperature for semiconductor?



12. There is no hole current in good conductors, because they

(a) have large forbidden energy gap
(b) have no energy gap due to overlapping valence and conduction bands
(c) are full of electron gas
(d) have no valence band

13. A solid having upper most energy band partially filled with electrons is called

(a) insulator (b) semiconductor
(c) conductor (d) None of these

14. If the energy of a photon of sodium light ($\lambda = 580\,\text{nm}$) equals the band gap of semiconductor, the minimum energy required to create hole electron pair.

(a) 1.5 eV (b) 3.2 eV
(c) 2.1 eV (d) 4.1 eV

Topic 2
Intrinsic and Extrinsic Semiconductors

15. At elevated temperature, few of covalent bonds of Si or Ge are broken and a vacancy in the bond is created. Effective charge of vacancy or hole is

(a) positive
(b) negative
(c) neutral
(d) sometimes positive and sometimes negative

16. In pure form, Ge or Si, a semiconductor is called

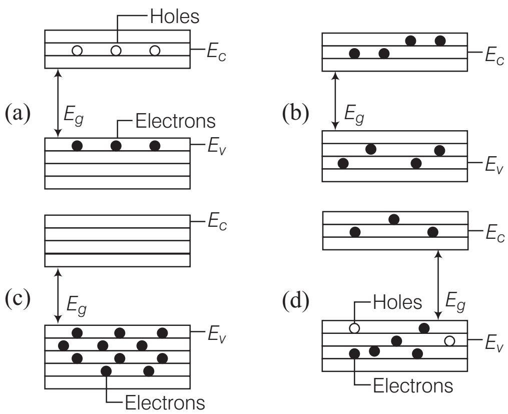
(a) intrinsic semiconductor, $n_e = n_h = n_i$
(b) extrinsic semiconductor, $n_e = n_h = n_i$
(c) doped semiconductor
(d) None of the above

(Here, n_e = number of free electrons, n_h = number of free holes, n_i = intrinsic carrier concentration)

17. If I is total current through an intrinsic semiconductor and I_e is electron current and I_h is hole current, then

(a) $I_e = \frac{I_h}{I}$ (b) $\frac{I_e}{I_h} = I$
(c) $I_e - I_h = I$ (d) $I_e + I_h = I$

18. Energy band gap diagram for an intrinsic semiconductor at temperature $T > 0$ K is



19. In equilibrium condition, the rate of generation of electron-hole pairs

(a) is more than rate of recombination of electron and hole pairs
(b) is less than rate of recombination of electron and hole pairs
(c) equals to rate of recombination of electron and hole pairs
(d) is always zero

20. In intrinsic semiconductor at room temperature, number of electrons and holes are

(a) equal (b) zero (c) unequal (d) infinite

21. A pure semiconductor behaves as a good conductor at

(a) room temperature (b) low temperature
(c) high temperature (d) Both (b) and (c)

22. At absolute zero, Si acts as

(a) non-metal (b) metal
(c) insulator (d) None of these

23. Si and Cu are cooled to a temperature of 300 K, then resistivity

(a) for Si increases and for Cu decreases
(b) for Cu increases and for Si decreases
(c) decreases for both Si and Cu
(d) increases for both Si and Cu

24. The energy gap for silicon is 1.14 eV and for zinc sulphide it is 3.6 eV.

From the above data, we conclude that

(a) silicon is transparent and zinc sulphide is opaque
(b) silicon is opaque and zinc sulphide is transparent
(c) both ZnS and Si are transparent
(d) both ZnS and Si are opaque

25. Doping is

(a) a process of adding an impurity to a pure semiconductor
(b) a process of obtaining semiconductor from its ore
(c) melting of a semiconductor
(d) purification of a semiconductor

26. Doping of intrinsic semiconductor is done

(a) to neutralise charge carriers
(b) to increase the concentration of majority charge carriers
(c) to make it neutral before disposal
(d) to carry out further purification

27. An *n*-type and *p*-type silicon can be obtained by doping pure silicon with

(a) arsenic and phosphorous, respectively
(b) indium and aluminium, respectively
(c) phosphorous and indium, respectively
(d) aluminium and boron, respectively

28. Which of the following statement is correct for an *n*-type semiconductor?

(a) The donor level lies below the bottom of the conduction band
(b) The donor level lies closely above the top of the valence band
(c) The donor level lies at the halfway mark of the forbidden energy gap
(d) None of the above

29. Number of electrons present in conduction band due to doping

(a) shows a heavy increase with increase of temperature
(b) shows a heavy decrease with increase of temperature
(c) independent of change in ambient temperature
(d) reduces to zero at temperature above room temperature

30. To make a *p*-type semiconductor, germanium is doped with

(a) gallium (b) boron
(c) aluminium (d) All of these

31. In a *p*-type semiconductor, the majority and minority charge carriers are respectively,

(a) protons and electrons
(b) electrons and protons
(c) electrons and holes
(d) holes and electrons

32. Which statement is correct?

(a) *n*-type germanium is negatively charged and *p*-type germanium is positively charged
(b) both *n*-type and *p*-type germanium are neutrals
(c) *n*-type germanium is positively charged and *p*-type germanium is negatively charged
(d) both *n*-type and *p*-type germanium are negatively charged

33. If n_e is number density of electrons in conduction band and n_h is number density of holes in valence band, then for an extrinsic semiconductor at room temperature, (n_i = number density of intrinsic pairs)

(a) $\frac{n_e}{n_h} = n_i^2$ (b) $\frac{n_h}{n_e} = n_i^2$
(c) $n_e n_h = n_i^2$ (d) $n_e + n_h = n_i^2$

34. Carbon is more resistive than germanium and silicon. Then, order of energy gap is

(a) C > Ge > Si (b) C > Si > Ge
(c) Si > GE > C (d) C = Si = Ge

35. Let a pure Si crystal has 5×10^{28} atoms m^{-3}. It is doped by parts per million concentration of pentavalent arsenic. If number of intrinsic pairs is $1.5 \times 10^{16}\, m^{-3}$, then number of holes in doped crystal is

(a) $4.5 \times 10^{9}\ m^{-3}$ (b) $\sim 10^{16}\ m^{-3}$
(c) $2.25 \times 10^{32}\ m^{-3}$ (d) $5 \times 10^{22}\ m^{-3}$

36. If n_e and n_h are the number of electrons and holes in a semiconductor heavily doped with phosphorous, then

(a) $n_e >> n_h$ (b) $n_e << n_h$ (c) $n_e \leq n_h$ (d) $n_e = n_h$

37. n_e and v_d be the number of electrons and drift velocity in a semiconductor. When the temperature is increased, then

(a) n_e increases and v_d decreases
(b) n_e decreases and v_d increases
(c) both n_e and v_d increase
(d) both n_e and v_d decrease

38. For extrinsic semiconductor,

(a) the conduction band and valence band overlap
(b) the gap between conduction band and valence band is more than 16 eV
(c) the gap between conduction band and valence band is near about 1 eV
(d) the gap between conduction band and valence band will be 100 eV and more

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

(a) tin, germanium, silicon (b) tin, silicon, germanium
(c) silicon, germanium, tin (d) silicon, tin, germanium

40. When the electrical conductivity of semiconductor is due to the breaking of its covalent bonds, then the semiconductor is said to be

(a) donor (b) acceptor (c) intrinsic (d) extrinsic

41. The forbidden energy gap in the energy bands of germanium at room temperature is about

(a) 1.1 eV (b) 0.1 eV (c) 0.67 eV (d) 6.7 eV

42. A Ge specimen is doped with Al. The concentration of acceptor atom is $\sim 10^{21}$ atoms per m^3. Given that the intrinsic concentration of electron hole pairs is $\sim 10^{19}$ per m^3, the concentration of electrons in the specimen is

(a) 10^{17} per m^3 (b) 10^{15} per m^3
(c) 10^{4} per m^3 (d) 10^{2} per m^3

43. Which of the following has negative temperature coefficient of resistance?

(a) Metal (b) Insulator
(c) Semiconductor (d) All of these

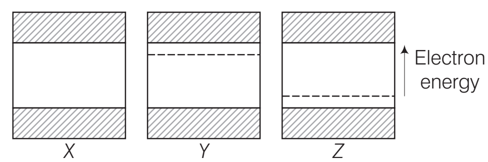
44. The relation between the number of free electrons in semiconductors (n) and its temperature (T) is

(a) $n \propto T^2$ (b) $n \propto T$
(c) $n \propto \sqrt{T}$ (d) $n \propto T^{3/2}$

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

(a) 1 (b) 10^{-1}
(c) 10^{-4} (d) 10^{-7}

46. The energy band diagrams for three semiconductor samples of silicon are as shown. We can then assert that



(a) sample X is undoped while samples Y and Z have been doped with a third group and a fifth group impurity, respectively
(b) sample X is undoped while both samples Y and Z have been doped with a fifth group impurity
(c) sample X has been doped with equal amounts of third and fifth group impurities while samples Y and Z are undoped
(d) sample X is undoped while samples Y and Z have been doped with a fifth and a third group impurity, respectively

47. In an n-type semiconductor, which of the following statement is true? **[NEET 2013]**

(a) Electrons are majority charge carriers and trivalent atoms are the dopants
(b) Electrons are minority charge carriers and pentavalent atoms are the dopants
(c) Holes are minority charge carriers and pentavalent atoms are the dopants
(d) Holes are majority charge carriers and trivalent atoms are the dopants

48. In an n-type silicon, which of the following statements is correct?

(a) Electrons are majority charge carriers and trivalent atoms are the dopants
(b) Electrons are minority charge carriers and pentavalent atoms are the dopants
(c) Holes are minority charge carriers and pentavalent atoms are the dopants
(d) Holes are majority charge carriers and trivalent atoms are the dopants

49. The number of silicon atoms per m^3 is 5×10^{28}. This is doped simultaneously with 5×10^{22} atoms per m^3 of arsenic and 5×10^{20} per m^3 atoms of indium. Given that $n_i = 1.5 \times 10^{16}\,m^{-3}$.

Number of electrons and holes (in per metre cube of sample) are respectively,

(a) $4.95 \times 10^{22}, 4.54 \times 10^9$ (b) $4.54 \times 10^9, 4.54 \times 10^9$

(c) $4.54 \times 10^9, 4.95 \times 10^{22}$ (d) $4.95 \times 10^{22}, 4.95 \times 10^{22}$

50. 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^{28} atoms/m^3, then the number of acceptor atoms in silicon per cubic centimetre will be

(a) 2.5×10^{30} atoms per cm^3

(b) 1.0×10^{13} atoms per cm^3

(c) 1.0×10^{15} atoms per cm^3

(d) 2.5×10^{36} atoms per cm^3

51. The number of density of electrons and holes in pure silicon at 27°C are equal and its value is $2.0 \times 10^{16}\ m^{-3}$ on doping with indium the hole density increases to $4.5 \times 10^{22}\ m^{-3}$, the electron density in doped silicon is

(a) $10 \times 10^9\ m^{-3}$ (b) $8.89 \times 10^9\ m^{-3}$

(c) $11 \times 10^9\ m^{-3}$ (d) $16.78 \times 10^9\ m^{-3}$

Topic 3
p-n Junction and Semiconductor Diode

52. A p-n junction contains

(a) a p-type semiconductor is joined with an n-type semiconductor by glue

(b) a p-type semiconductor is bolted with an n-type semiconductor

(c) a p-type semiconductor is kept in touch with an n-type semiconductor

(d) a p-type semiconductor is formed with an n-type semiconductor on same semiconductor crystal wafer

53. Due to diffusion, the space charge region on either side of p-n junction is developed. This space charge region is called

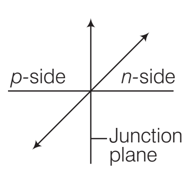
(a) dilution region (b) diffusion region

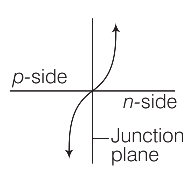
(c) depletion region (d) ionic region

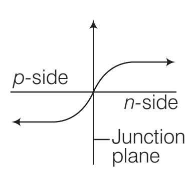
54. Thickness of depletion region is of order of

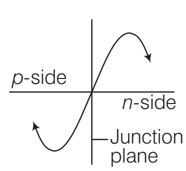
(a) $\sim 10^{-7}$ m (b) $\sim 10^{-10}$ m (c) $\sim 10^{-9}$ m (d) $\sim 10^{-3}$ m

55. Which of these graphs shows potential difference between p-side and n-side of a p-n junction in equilibrium?

(a)


(b)


(c)


(d)


56. Potential difference of p and n-side which prevents diffusion of electrons is called

(a) potential gradient

(b) potential difference

(c) barrier potential

(d) depletion potential

57. Can we take one slab of p-type semiconductor and physically join it to another n-type semiconductor to get p-n junction?

(a) Yes

(b) No

(c) It depends on the hole and electron concentrations on p and n-side

(d) Only when a p-type semiconductor is soldered with an n-type semiconductor

58. The depletion layer in the p-n junction region is caused by

(a) drift of holes

(b) diffusion of charge carriers

(c) migration of impurity ions

(d) drift of electrons

59. The barrier potential of a p-n junction depends on

(i) type of semiconductor material

(ii) amount of doping

(iii) temperature

Which one of the following is correct?

[CBSE AIPMT 2014]

(a) (i) and (ii) (b) (ii)

(c) (ii) and (iii) (d) (i), (ii) and (iii)

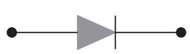
60. The electrical resistance of depletion layer is large because
(a) of strong electric field
(b) it has a large number of charge carriers
(c) it contains electrons as charge carriers
(d) it has holes as charge carriers

61. In an unbiased *p-n* junction, holes diffuse from the *p*-region to *n*-region because
(a) free electrons in the *n*-region attract them
(b) they moves across the junction by the potential difference
(c) hole concentration in *p*-region is more as compared to hole concentration in *n*-region
(d) All of the above

62. A Si based *p-n* junction has a depletion layer of thickness $1\mu m$ and barrier potential difference of *n*-side and *p*-side is 0.6 V.
The electric field in the depletion region is
(a) 0.6 Vm^{-1} (b) $6 \times 10^{-4} \text{ Vm}^{-1}$
(c) $6 \times 10^{5} \text{ Vm}^{-1}$ (d) $6 \times 10^{4} \text{ Vm}^{-1}$

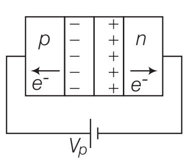
63. A diode is a
(a) piece of a covalent crystal
(b) piece of a semiconductor crystal with metallic contacts provided at two ends
(c) *p-n* junction with metallic contacts provided at two ends
(d) piece of a metal which is sprayed over by a semiconductor

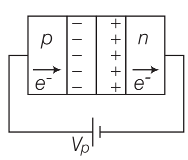
64. Symbol of a *p-n* junction diode is an arrow, its direction indicates



(a) nothing its just a symbol
(b) direction of flow of electrons
(c) direction of conventional current when it is forward biased
(d) direction of electric field

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

(a)


(b)


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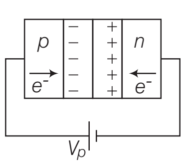

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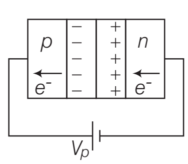


66. If V is applied potential difference in forward bias and V_0 is barrier potential of a *p-n* junction, then effective barrier height under forward bias is
(a) $V - V_0$ (b) $V_0 - V$ (c) $V_0 + V$ (d) V_0

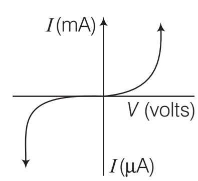
67. In forward bias, forward current obtained from the *p-n* junction diode is
(a) due to injection of electrons in *p*-side
(b) due to injection of holes in *n* -side
(c) both (a) and (b)
(d) due to flow of electrons from negative terminal of supply to its positive terminal

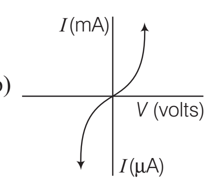
68. In a *p-n* junction diode,
(a) the current in the reverse biased condition is generally very small
(b) the current in the reverse biased condition is small but that in forward biased condition is independent of the bias voltage
(c) the reverse biased current is strongly dependent on the applied bias voltage
(d) the forward biased current is very small in comparison to reverse biased current

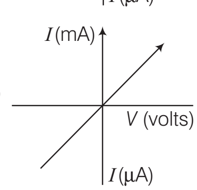
69. In a reverse biased *p-n* junction diode,
(a) current under reversed bias is not very much dependent on applied voltage
(b) current under reversed bias is directly proportional to applied voltage
(c) current initially depends on applied voltage, then it becomes independent
(d) no current flows in reversed bias

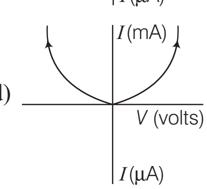
70. If reverse biasing potential is increased beyond a certain critical (breakdown) value, then
(a) diode gets destroyed due to overheating
(b) no current flows through the diode
(c) after breakdown a heavy current flows from *p* to *n*-side
(d) potential barrier becomes zero

71. Characteristic curve of a *p-n* junction is

(a)


(b)


(c)


(d)


72. Threshold or knee voltage for a forward biased germanium and silicon diodes have respective values
(a) 0.2 V, 0.7 V (b) 0.7 V, 1.1 V
(c) 1.2 V, 0.7 V (d) 0.7 V, 0.2 V

73. Diode primarily allows the flow of current only in one direction (forward bias). The forward bias resistance is low as compared to the reverse bias resistance. In a circuit, a diode acts like a

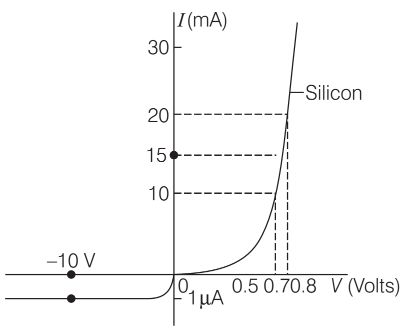
(a) valve (b) switch
(c) amplifier (d) multi-way passage

74. Dynamic resistance of a diode is given by

(a) $r_d = \dfrac{\Delta V}{\Delta I}$ (b) $r_d = -\dfrac{\Delta V}{\Delta I}$

(c) $r_d = \dfrac{\text{Threshold voltage}}{\text{Current}}$ (d) $r_d = \dfrac{\text{Breakdown voltage}}{\text{Current}}$

75. *V-I* characteristics of a silicon diode is shown.



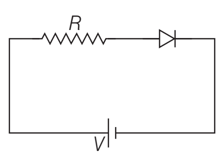
The ratio of resistance of diode at $I_D = 15$ mA and $V_D = -10$ V, is

(a) 10^{-3} (b) 10^{-4} (c) 10^{-5} (d) 10^{-6}

76. If no external voltage is applied across *p-n* junction, there would be

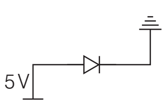
(a) no electric field across the junction
(b) an electric field pointing from *n*-type to *p*-type side across the junction
(c) an electric field pointing from *p*-type to *n*-type side across the junction
(d) a temporary electric field during formation of *p-n* junction that would subsequently disappear

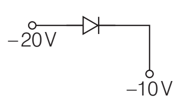
77. For the given circuit of *p-n* junction diode, which of the following statement is correct?

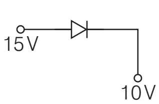


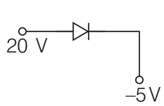
(a) In forward biasing, the voltage across *R* is *V*
(b) In forward biasing, the voltage across *R* is 2*V*
(c) In reverse biasing, the voltage across *R* is *V*
(d) In reverse biasing, the voltage across *R* is 2*V*

78. Which is reverse biased diode?

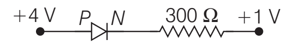
(a) 

(b) 

(c) 

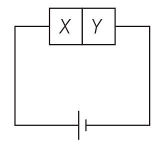
(d) 

79. In the circuit given below, the value of the current is



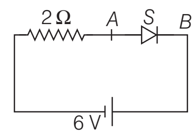
(a) 0 A (b) 10^{-2} A (c) 10^{2} A (d) 10^{-3} A

80. 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?



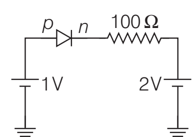
(a) *X* is *p*-type, *Y* is *n*-type and the junction is forward biased
(b) *X* is *n* -type, *Y* is *p*- type and the junction is forward biased
(c) *X* is *p*-type, *Y* is *n*-type and the junction is reverse biased
(d) *X* is *n*-type, *Y* is *p*-type and the junction is reverse biased

81. The diode shown in the circuit is a silicon diode. The potential difference between the points *A* and *B* will be



(a) 6 V (b) 0.6 V
(c) 0.7 V (d) 0 V

82. The current through an ideal *p-n* junction shown in the following circuit diagram will be



(a) zero (b) 1 mA
(c) 10 mA (d) 30 mA

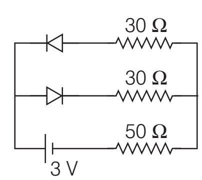
83. A potential barrier of 0.3 V exists across a *p-n* junction. If the depletion region is 1μm wide, what is the intensity of electric field in this region?

(a) 2×10^5 Vm^{-1} (b) 3×10^5 Vm^{-1}
(c) 4×10^5 Vm^{-1} (d) 5×10^5 Vm^{-1}

84. When the voltage drop across a *p-n* junction diode is increased from 0.65 V to 0.70 V, the change in the diode current is 5 mA. The dynamic resistance of diode is

(a) 5 Ω (b) 10 Ω (c) 20 Ω (d) 25 Ω

85. The circuit shown in the figure contains two diodes each with a forward resistance of 30 Ω and with infinite backward resistance. If the battery is 3 V, the current through the 50 Ω resistance (in ampere) is



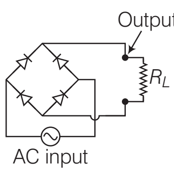
(a) 0 (b) 0.01 (c) 0.02 (d) 0.03

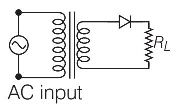
Topic 4

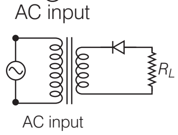
Application of Junction Diode as a Rectifier and Special Purpose *p-n* Junction Diodes

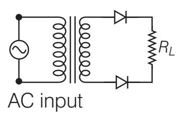
86. If an alternating voltage is applied across a diode in series with a load, then
(a) a continuous DC voltage appears across load
(b) an AC voltage appears across load
(c) a pulsating DC voltage appears across load
(d) no voltage appears across load

87. Which of this is a half-wave rectifier circuit?

(a)


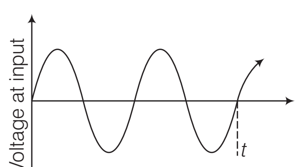
(b)


(c)


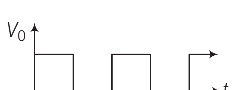
(d)


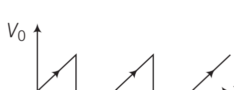
88. For any practical half-wave rectifier circuit,
(a) the reverse breakdown voltage of diode must be greater than peak AC voltage
(b) the reverse breakdown voltage of diode must be greater than rms AC voltage
(c) the reverse breakdown voltage must be greater than mean AC voltage
(d) the reverse breakdown voltage must be smaller than the rms AC voltage

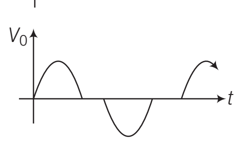
89. Input to an half-wave rectifier is given as follows

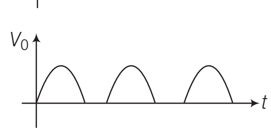


Its output will be

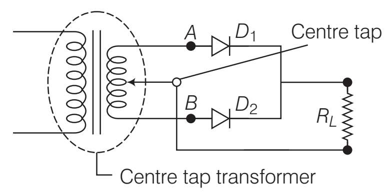
(a)


(b)


(c)


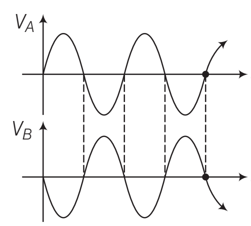
(d)


90. In the course of rectification of the AC cycle when the voltage at A (upper diode input) becomes negative with respect to centre tap, the voltage at B (lower diode input) would be positive. This implies voltage drop between A and centre tap is half. If a centre tap transformer is used with 2 diodes for full-wave rectification, then output voltage of rectifier is

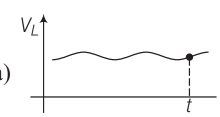


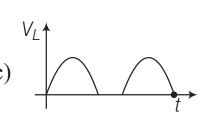
(a) $2\times$ secondary voltage of transformer
(b) $2/3\times$ secondary voltage of transformer
(c) $1/2\times$ secondary voltage of transformer
(d) $3/2\times$ secondary voltage of transformer

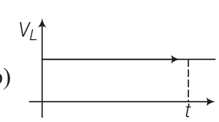
91. If two diodes are connected across two ends of secondary windings of a centre tap transformer as shown in figure. If inputs at A and B are as shown

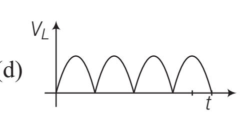


Then, output across load resistance will be

(a)


(c)


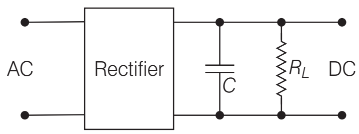
(b)


(d)


92. Output of a full-wave rectifier is
(a) pure DC voltage
(b) pure AC voltage
(c) pulsating DC voltage
(d) pulsating AC voltage

93. Filters are used alongwith a full-wave rectifier to
(a) remove AC part from the output
(b) remove DC part from the output
(c) mix AC and DC
(d) None of the above

94. In the given circuit,

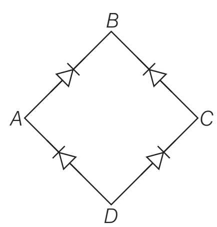


Capacitor C is used
(a) for storing potential energy
(b) as a bypass to DC component to get AC in R_L
(c) to remove sparking
(d) as a bypass to AC component to get DC in R_L

95. In a full-wave rectifier, input AC current has a frequency (ν). The output frequency of current is
(a) $\nu/2$ (b) ν
(c) 2ν (d) None of these

96. In comparison to a half-wave rectifier, the full-wave rectifier done by centre tapping gives lower
(a) efficiency (b) average
(c) output voltage (d) None of these

97. In the figure alongside, the input is across the terminals A and C and the output is across B and D. Then, the output is



(a) zero
(b) same as input
(c) full-wave rectified
(d) half-wave rectified

98. In case a single capacitor is connected in parallel with a load resistance of R_L, it gets discharged through the load. The rate of fall of voltage across the capacitor is proportional to
(a) $R_L C$ (b) $\frac{C}{R_L}$
(c) $\frac{1}{R_L C}$ (d) $\frac{R_L}{C}$

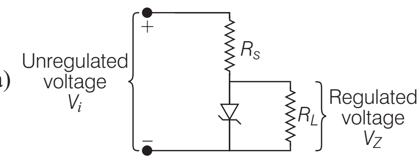
99. What is the ratio of output frequencies of full-wave rectifier and a half-wave rectifier, when an input of frequency 50 Hz is fed at input?
(a) 1 : 2 (b) 2 : 1 (c) 4 : 1 (d) 1 : 4

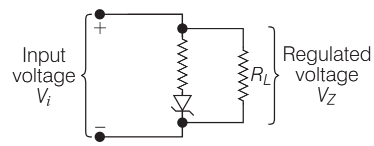
100. A zener diode which is used in reversed biased is used as a
(a) voltage regulator (b) voltage rectifier
(c) current regulator (d) current rectifier

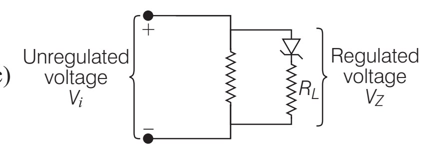
101. A zener diode differs from a p-n junction that
(a) zener diode is made from very lightly doped p-n junction
(b) zener diode is made from a heavily doped p-n junction
(c) zener diode is made from a metal piece
(d) zener diode is made from a heavily doped p-type semiconductor

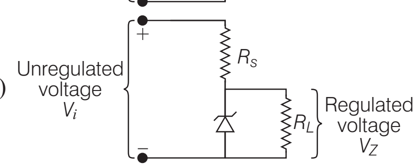
102. High current observed at breakdown of a zener diode due to emission and movement of electrons from p to n-side is known as
(a) thermionic emission (b) external field emission
(c) internal field emission (d) photoemission

103. Correct circuit using a zener diode as a voltage regulator is

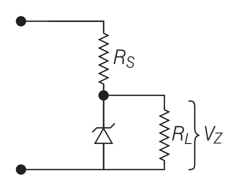
(a)


(b)


(c)


(d)


104. For a zener regulated power supply, a zener diode with zener voltage $V_z = 6.0$ V is used for regulation. The load current is to be 4.0 mA and the unregulated input 10.0 V. The value of series resistor R_s must be, it $I_Z / I_2 = 5$



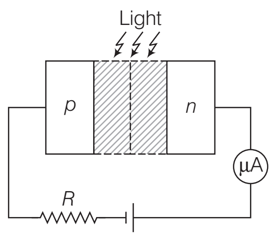
(a) 167 Ω (b) 120 Ω
(c) 250 Ω (d) 20 Ω

105. Optoelectronic devices are
(a) CFL's
(b) light based semiconductor diodes
(c) bulbs
(d) discharge tubes

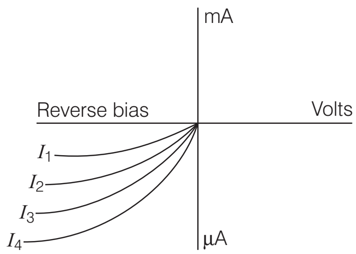
106. A photodetector is a
(a) photodiode used for detecting optical signals
(b) LED's which are used for detection of infrared signals
(c) an evacuated tube consisting of a photosensitive cathode
(d) None of the above

107. A photodiode converts
(a) variation in intensity of light into current amplitude variation
(b) variation of current amplitude into variation in intensity of emitted light
(c) variation of voltage into variation of current
(d) variation of intensity of light into variation of volume

108. A photodiode in reverse biased is irradiated with light of suitable frequency and current in circuit is measured.



Characteristics of diode for different illumination intensities I_1, I_2, I_3 and I_4 are drawn as follows.



Greatest intensity is
(a) I_1 (b) I_2 (c) I_3 (d) I_4

109. When LED is forward biased, then electrons move from n to p and electron-hole combination occurs near junction plane. If E_g is energy gap between conduction band and valence band, then released energy (E) due to electron-hole combination will be
(a) $E = E_g$ (b) $E > E_g$ (c) $E \le E_g$ (d) $E \ge E_g$

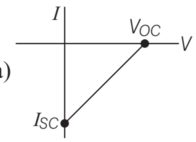
110. An LED cannot be used in reverse biased as a voltage regulator because
(a) reverse breakdown voltage is very low for them
(b) reverse breakdown voltage is very high for them
(c) they do not breakdown for any voltage
(d) None of the above

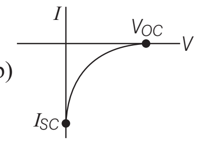
111. Semiconductors used to fabricate LED to produce visible light must have energy gap E_g such that
(a) $1.1\text{ eV} < E_g$ (b) $E_g > 3\text{ eV}$
(c) $1.8\text{ eV} < E_g < 3\text{ eV}$ (d) $1.1\text{ eV} < E_g < 2.8\text{ eV}$

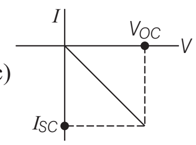
112. Substance used to make red LEDs is
(a) silicon
(b) germanium
(c) gallium arsenide phosphide
(d) indium phosphide

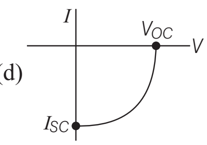
113. A solar cell is
(a) photodetector (b) photovoltaic device
(c) light emitting diode (d) photogenerator

114. I-V characteristics of a solar cell is best represented by

(a)


(b)


(c)


(d)


115. To fabricate solar cell, material used have an energy gap of
(a) around 0.7 eV (b) less than 1 eV
(c) around 1.5 eV (d) less than 0.7 eV

116. A p-n junction photodiode is fabricated from a semiconductor with a band gap of 2.8 eV. It can detect a wavelength nearing to
(a) 5200 Å (b) 4400 Å (c) 6200 Å (d) 7500 Å

117. For a photodiode, the conductivity increases when a wavelength less than 620 nm is incident on it. The band gap of crystal used to fabricate the diode is
(a) 1.12 eV (b) 1.8 eV (c) 2.0 eV (d) 1.62 eV

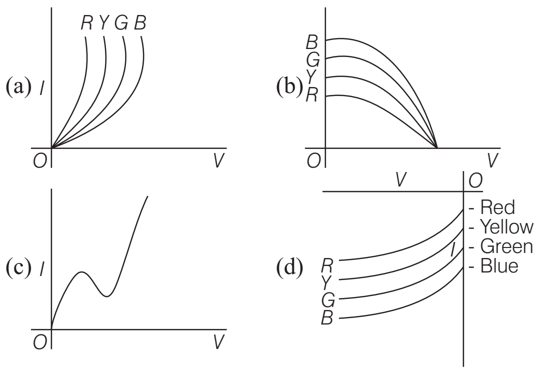
118. In an LED, when it glows, electron moves from A to B, when an appropriate bias is applied. A and B are respectively,
(a) conduction band, valence band
(b) valence band, conduction band
(c) conduction band, connecting wires
(d) connecting wires, conduction band

119. Photodetectors and LED's are used in
(a) road construction works
(b) optical telecommunication links
(c) power generation from falling water near dam
(d) radio transmitters

120. Two different semiconductors A and B are used to make 'red' and 'violet' LED's, respectively. Then, ratio of energy gaps of semiconductors must be
(a) $\frac{E_A}{E_B} > 1$ (b) $\frac{E_A}{E_B} < 1$
(c) $E_A = E_B$ (d) $E_A > 3\text{ eV}$ and $E_B < 1.5\text{ eV}$

121. LED's are not used for room lighting (although they are used for automobile bulbs and in industrial lighting) because
(a) our eyes are not comfortable with very intense light
(b) our eyes are not comfortable with monochromatic light
(c) LED's are much costlier than bulbs tubelights and CFL's
(d) LED manufacture in mass production will be a very polluting process

122. The I-V characteristics of an LED is **[JEE Main 2013]**



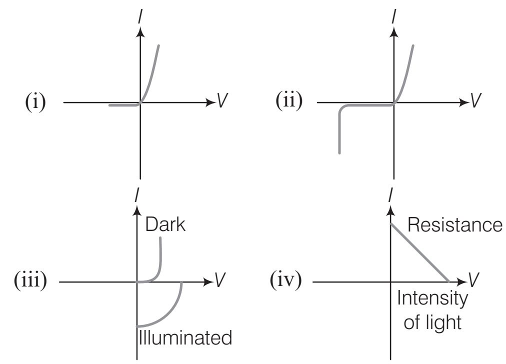
123. A p-n photodiode is made of a material with a band gap of 2 eV. The minimum frequency of the radiation that can be absorbed by the material is nearly

(Take $hc = 1240$ eV-nm)

(a) 1×10^{14} Hz (b) 20×10^{14} Hz

(c) 10×10^{14} Hz (d) 5×10^{14} Hz

124. Identify the semiconductor devices whose characteristics are as given below in the order (i), (ii), (iii), (iv). **[JEE Main 2016]**

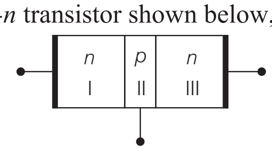


Topic 5
Junction Transistor

125. A transistor has

(a) two doped regions forming a large p-n junction
(b) three doped regions forming two p-n junctions
(c) two p-n junctions connected by a conducting wire
(d) None of the above

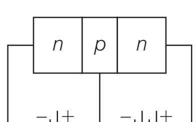
126. For an n-p-n transistor shown below,



Regions marked I, II and III are respectively,

(a) emitter,collector, base
(b) base, collector, emitter
(c) emitter, base, collector
(d) collector, emitter, base

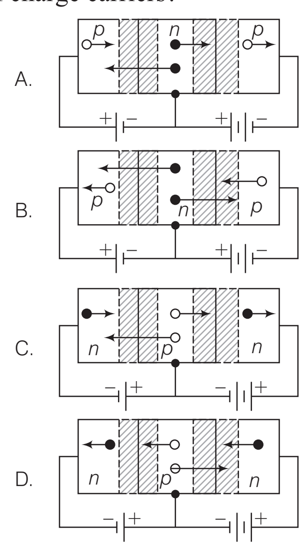
127. When a transistor is biased as follows.



Then, it is said to be in

(a) solid state
(b) active state
(c) inactive state
(d) passive state

128. Let '•' shows an electron and '○' shows a hole, then which of the following shows correct direction of motion of charge carriers?

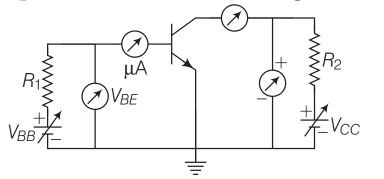


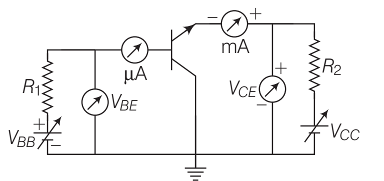
(a) A and B (b) B and C (c) A and C (d) B and D

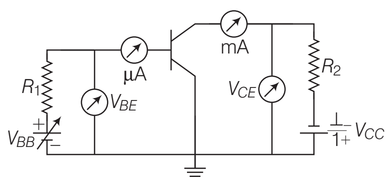
129. In active state of a transistor, the emitter base junction acts as a ...A... resistance and base-collector junction acts like a ...B... resistance. Here, A and B refer to

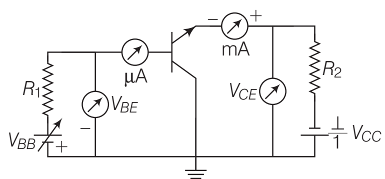
(a) low, low (b) low, high
(c) high, low (d) high, high

130. Correct circuit to study input-output characteristics of an *n-p-n* transistor in CE configuration is

(a)


(b)


(c)


(d)


131. For a transistor, which is correct?

(a) $V_{CE} = V_{CB} + V_{BE}$ (b) $V_{BE} = V_{CB} + V_{CE}$
(c) $V_{CB} = V_{CE} + V_{BE}$ (d) $V_{CE} = V_{CB} - V_{BE}$

132. For a silicon base transistor, V_{CE} must be sufficiently larger than

(a) 21 V (b) 0.7 V
(c) 0.1 V (d) 20 V

133. In an *n-p-n* transistor in CE configuration, when V_{CE} is increased, then

(a) I_B increases and I_C increases proportionally
(b) I_B increases and I_C remains constant
(c) effect on I_B is negligible but I_C increases
(d) Both I_B and I_C remain nearly constant

134. In a common-emitter (CE) amplifier having a voltage gain G, the transistor used has transconductance 0.03 mho and current gain 25. If the above transistor is replaced with another one with transconductance 0.02 mho and current gain 20, the voltage gain will be **[NEET 2013]**

(a) $\frac{2}{3}G$ (b) $1.5G$
(c) $\frac{1}{3}G$ (d) $\frac{5}{4}G$

135. Input resistance (r_i) of a transistor in CE configuration is

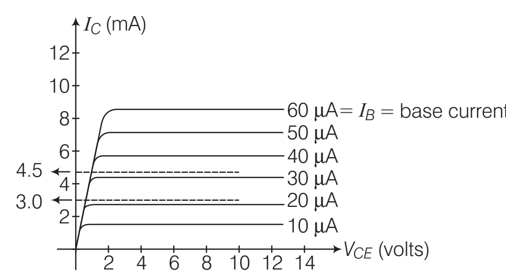
(a) $\left[\frac{\Delta V_{BE}}{\Delta I_B}\right]_{V_{CE}}$ (b) $\left[\frac{\Delta V_{CE}}{\Delta I_B}\right]_{V_{BE}}$
(c) $\left[\frac{\Delta V_{BB}}{\Delta I_B}\right]_{V_{BE}}$ (d) $\left[\frac{\Delta V_{BC}}{\Delta I_B}\right]_{V_{CE}}$

136. An *n-p-n* transistor is connected in common-emitter configuration in a given amplifier. A load resistance of 800 Ω is connected in the collector circuit and the voltage drop across it is 0.8V. If the current amplification factor is 0.96 and the input resistance of the circuits is 192 Ω, the voltage gain and the power gain of the amplifier will respectively be **[NEET 2016]**

(a) 3.69, 3.84 (b) 4, 4
(c) 4, 3.69 (d) 4, 3.84

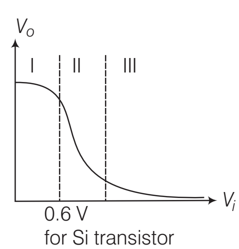
137. If β_{DC} for a transistor is

(a) $\frac{\Delta I_C}{\Delta I_B}$ (b) $\frac{\Delta I_B}{\Delta I_C}$ (c) $\frac{I_C}{I_B}$ (d) $\frac{I_B}{I_C}$

138.


The output characteristics of a typical *n-p-n* transistor in CE configuration are shown. When $V_{CE} = 10$ V and $I_C = 4.0$ mA, then ratio of β_{AC} and β_{DC} is

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

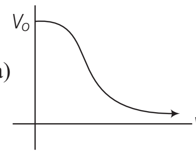
139.


In above transfer characteristics of an *n-p-n* transistor in CE configuration; cut-off region, active region, saturation region respectively, are

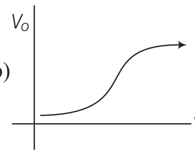
(a) II, III and I
(b) III, I and II
(c) III, II and I
(d) I, II and III

140. For an *n-p-n* transistor in CE configuration, correct graph showing variation of output voltage with variation of input voltage is

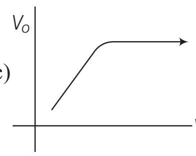
(a)



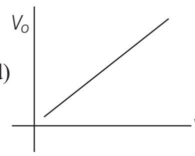
(b)



(c)



(d)



141. For an *n-p-n* transistor used as amplifier, the power gain A_P is given by (A_V = voltage gain)

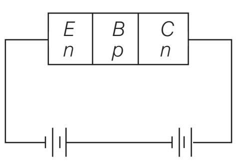
(a) $A_P = (\beta_{AC})^2 \times A_V$ (b) $A_P = \dfrac{1}{\beta_{AC}} A_V$

(c) $A_P = \beta_{AC} \times A_V$ (d) $A_P = \dfrac{1}{(\beta_{AC})^2} A_V$

142. For a CE transistor amplifier, the audio signal voltage across collector resistance of 2.0 kΩ is 2.0 V. Suppose the current amplification factor of the transistor is 100. What should be the value of R_B in series with V_{BB} supply of 2.0 V, if DC base current has to be 10 times the signal current? ($V_{BE} = 0.6$ V)

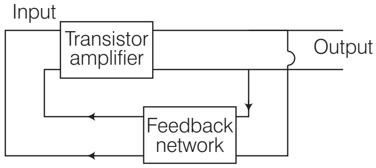
(a) 14 kΩ (b) 24 kΩ
(c) 34 kΩ (d) 44 kΩ

143. In an *n-p-n* transistor, the collector current is 24 mA. The possible emitter current (in mA) is

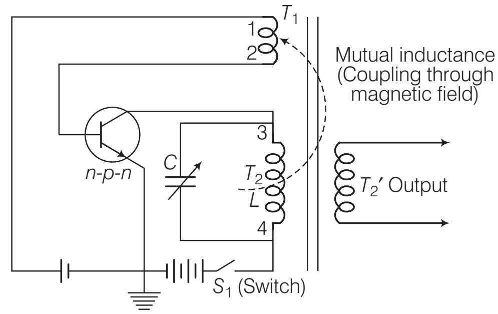


(a) 36 (b) 20
(c) 16 (d) 6

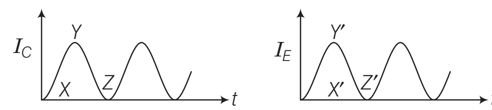
144. For tuned collector oscillator, using an *n-p-n* transistor, from rise and fall (or built up) of I_C, I_E current graphs. It can be concluded



(a)



(b)



(i) (ii)

(c)

(a) both I_C, I_E increase initially
(b) both I_C, I_E decrease but I_E decreases
(c) initially I_C increases but I_E decreases
(d) initially I_C decreases but I_E increases

145. Refer figure of Q. 144, after maximum collector current, there is no further change in collector current, the magnetic field around T_2 ceases to grow. As soon as the field becomes static, there will be no further feedback from T_2 to T_1. Without continued feedback, the ...*A*... current begins to fall. Consequently, collector current decreases from *Y* to *Z*. However, a decrease of collector current causes the magnetic field to decay around the coil T_2. Thus, T_1 is now seeing a ...*B*... field in T_2 (opposite form what it saw when field was growing at the initial start position).

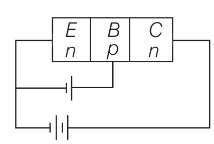
Here, *A* and *B* refer to

(a) emitter, rising (b) emitter, decaying
(c) collector, rising (d) collector, decaying

146. In a common emitter transistor, the current gain is 80. If change in base current is 250 μA, then change in collector current will be

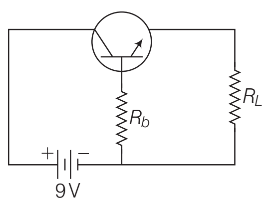
(a) $(80 \times 250)\,\mu$A (b) $(250 - 80)\,\mu$A
(c) $(250 + 80)\,\mu$A (d) $(250/80)\,\mu$A

147. In case of an *n-p-n* transistor, the collector current is always less than the emitter current because



(a) collector side is reverse biased and emitter side is forward biased
(b) after electrons are lost in the base and only remaining ones reach the emitter back
(c) collector side is forward biased and emitter side is reverse biased
(d) collector being reverse biased attracts less electrons

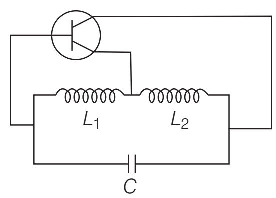
148. In a transistor circuit shown here, the base current is 35 μA.



The value of resistance R_b is

(a) 123.5 kΩ
(b) 257 kΩ
(c) 380.5 kΩ
(d) cannot be found from given data

149. For the given circuit,

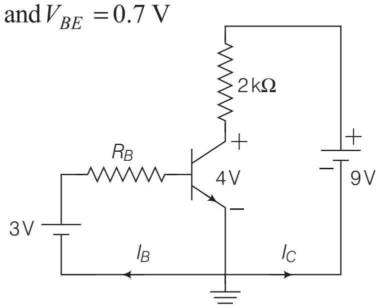


Frequency of oscillation is

(a) $f = \frac{1}{2\pi}\sqrt{\frac{1}{(L_1 + L_2)C}}$ (b) $f = \frac{1}{2\pi\sqrt{(L_1 - L_2)C}}$

(c) $f = \frac{1}{2\pi\sqrt{L_1 L_2 \cdot C}}$ (d) $f = \frac{1}{2\pi\sqrt{\left(\frac{L_1 + L_2}{2}\right)C}}$

150. For the given circuit, if current amplification factor $\beta = 90$ and $V_{BE} = 0.7$ V



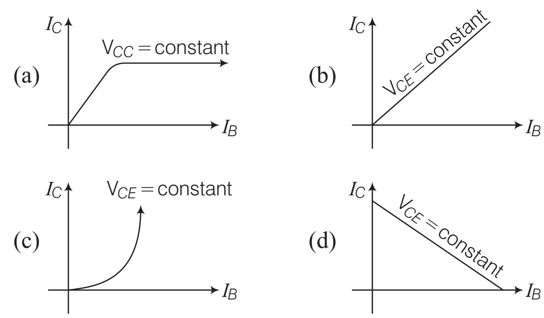
Then, base resistance R_B is

(a) 180 kΩ (b) 185 kΩ
(c) 82 kΩ (d) 190 kΩ

151. A circuit containing transistor is such that $I_B = 10\,\mu$A and $I_C = 5$ mA,

(a) transistor can be used as amplifier with $\beta_{DC} = 10$
(b) transistor can be used as amplifier with $\beta_{DC} = 100$
(c) transistor can be used as amplifier with $\beta_{DC} = 250$
(d) transistor cannot be used as amplifier

152. For a common-emitter *n-p-n* transistor following is a true relationship between I_B and I_C. In active region.



153. The current gain for a 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

154. The power gain for common base amplifier is 800 and the voltage amplification factor is 840. The collector current when base current is 1.2 mA, is

(a) 24 mA (b) 12 mA (c) 6 mA (d) 3 mA

155. The input signal given to a CE amplifier having a voltage gain of 150 is $V_i = 2\cos\left(15\,t + \frac{\pi}{3}\right)$. The corresponding output signal will be **[CBSE AIPMT 2015]**

(a) $300\cos\left(15\,t + \frac{\pi}{3}\right)$ (b) $75\cos\left(15\,t + \frac{2\pi}{3}\right)$

(c) $2\cos\left(15\,t + \frac{5\pi}{3}\right)$ (d) $300\cos\left(15\,t + \frac{4\pi}{3}\right)$

156. A transistor has a current gain of 30. If the collector resistance is 6 kΩ, input resistance is 1 kΩ, its voltage gain is

(a) 90 (b) 180 (c) 45 (d) 360

157. The input resistance of a transistor is 1000 Ω on charging its base current by 10 μA, the collector current increases by 2 mA. If a load resistance of 5 kΩ is used in the circuit, the voltage gain of the amplifier is

(a) 100 (b) 500 (c) 1000 (d) 1500

158. In an *n-p-n* circuit transistor, the collector current is 10 mA. If 80% electrons emitted reach the collector, then

(a) the emitter current will be 7.5 mA
(b) the base current will be 2.5 mA
(c) the base current will be 3.5 mA
(d) the emitter current will be 15 mA

159. When the voltage drop across a *p-n* junction diode is increased from 0.65 V to 0.70 V, then change in the diode current is 5 mA. The dynamic resistance of the diode is

(a) 20 Ω (b) 50 Ω (c) 10 Ω (d) 80 Ω

Topic 6

Digital Electronics and Logic Gates

160. Analog signals are
(a) continuous waveforms (b) discrete value signals
(c) intermittent signals (d) erratic waveforms

161. Digital signals are
(a) continuous waveforms
(b) discrete value signals
(c) intermittent signals
(d) erratic waveforms

162. A NOT gate is called an invertor, because
(a) it produces an output which changes with time
(b) it produces 1 as output when input is 0 and *vice-versa*
(c) it produces no output for any input
(d) it has only a single input

163. Truth table for an OR gate is

(a)

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

(b)

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

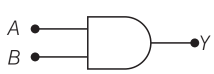
(c)

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

(d)

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

164. Truth table for the logic gate whose symbol shown is



(a)

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

(b)

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

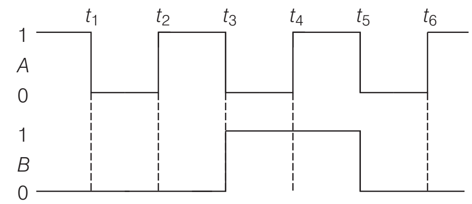
(c)

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

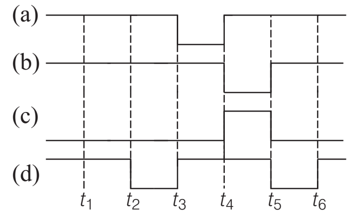
(d)

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

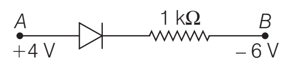
165. Inputs to a NAND gate are *A* and *B* are made as below.



Output of the NAND gate is

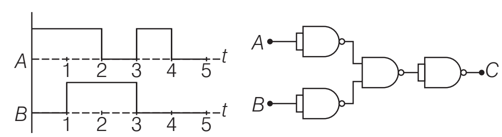


166. Consider the junction diode as ideal. The value of current flowing through *AB* is **[NEET 2016]**

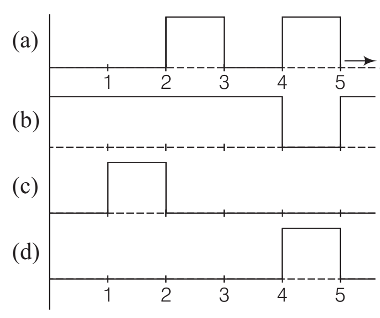


(a) 10^{-2} A (b) 10^{-1} A
(c) 10^{-3} A (d) 0 A

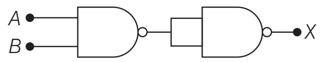
167. Inputs *A* and *B* are given to show combination of gates



Then, output *C* is

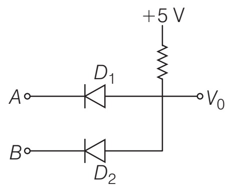


168. The output (X) of the logic circuit shown in figure will be **[NEET 2013]**



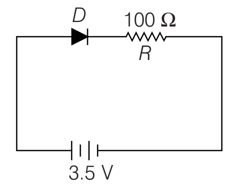
(a) $X = \overline{\overline{A}} \cdot \overline{\overline{B}}$ (b) $X = \overline{A \cdot B}$
(c) $X = A \cdot B$ (d) $X = \overline{A + B}$

169. See the circuit shown in the figure. Name the gate that the given circuit resembles.



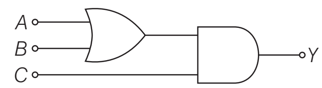
(a) NAND (b) AND (c) OR (d) NOR

170. In the given figure, a diode D is connected to an external resistance $R = 100\ \Omega$ and an emf of 3.5 V. If the barrier potential developed across the diode is 0.5 V, the current in the circuit will be **[CBSE AIPMT 2015]**



(a) 30 mA (b) 40 mA (c) 20 mA (d) 35 mA

171. To get output 1 for the following circuit, the correct choice for the input is **[NEET 2016]**



(a) $A = 1, B = 0, C = 0$ (b) $A = 1, B = 1, C = 0$
(c) $A = 1, B = 0, C = 1$ (d) $A = 0, B = 1, C = 0$

Special Format Questions

I. Assertion and Reason

■ **Directions** (Q. Nos. 172-176) *In the following questions, a statement of assertion is followed by a corresponding statement of reason. Of the following statements, choose the correct one.*

(a) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.
(c) Assertion is correct but Reason is incorrect.
(d) Assertion is incorrect but Reason is correct.

172. Assertion The conductivity of an intrinsic semiconductor depends on its temperature.

Reason The conductivity of an intrinsic semiconductor is slightly higher than that of a lightly doped p-type semiconductor.

173. Assertion A zener diode is used to obtain voltage regulation.

Reason When zener diode is operated in reverse bias after a certain voltage (breakdown voltage), the current suddenly increases, but potential difference across diode remains constant.

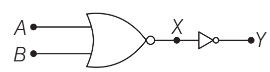
174. Assertion In a transistor, the base is made thin.

Reason A thin base makes the transistor stable.

175. Assertion In an oscillator, the feedback is in the same phase which is called as positive feedback.

Reason If the feedback voltage is in opposite phase, the gain is greater than one.

176. Assertion



This circuit acts as OR gate.

Reason Truth table for two input OR gate is

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

II. Statement Based Questions Type I

■ **Directions** (Q. Nos. 177-187) *In the following questions, a statement I is followed by a corresponding statement II. Of the following statements, choose the correct one.*

(a) Both Statement I and Statement II are correct and Statement II is the correct explanation of Statement I.
(b) Both Statement I and Statement II are correct but Statement II is not the correct explanation of Statement I.
(c) Statement I is correct but Statement II is incorrect.
(d) Statement I is incorrect but Statement II is correct.

177. Statement I An electron on p-side of a p - n junction moves to n-side just an instant after drifting of charge carriers occurs across junction plane.

Statement II Drifting of charge carriers reduces the concentration gradient across junction plane.

178. Statement I In equilibrium condition, p-side of a p-n junction is at positive potential.

Statement II A p-type semiconductor contains more holes than electrons.

179. Statement I The applied voltage (in forward bias of a p-n junction) mostly drops across the depletion region and the voltage drop across the p-side and n-side of the junction is negligible.

Statement II Resistance of depletion region is large compared to resistance of n or p-side.

180. Statement I In forward bias, as voltage increases beyond threshold voltage, the forward current increases significantly.

Statement II By Ohm's law states $V \propto I$.

181. Statement I A diode can be used to rectify alternating voltages.

Statement II A p-n junction allows current to pass only when it is in reverse bias.

182. Statement I To filter out AC ripple from a given pulsating DC voltage, an inductor is connected in series and a capacitor is connected in parallel with load resistance.

Statement II For AC inductor has high reactance and a capacitor has a low reactance when frequency is high.

183. Statement I A solar cell is made in wafer's shape (of large area).

Statement II By increasing area, work-function of electron is decreased.

184. Statement I When a light based p-n junction is radiated with light of frequency ν such that $h\nu > E_g$, it produces an emf with p side becoming more negative than n-side.

Statement II Junction field separates electron-hole pairs generated due to photon absorption and sweep them to different regions.

185. Statement I In a typical transistor, $I_E = I_C + I_B$ $\Rightarrow I_E \approx I_C$.

Statement II Base region of a transistor is very thin and lightly doped with I_B current small, collector current I_C is large.

186. Statement I When an n-p-n transistor in CE configuration is being used as a switch, it is operated in cut-off region or in saturation region.

Statement II In cut-off region, here V_i is low but V_o is high. In saturation region, here V_i is high but V_o is low.

187. Statement I A logic gate is a digital circuit.

Statement II They are called gates, because they do not allow current through them.

Statement Based Questions Type II

188. Semiconductor devices have the advantage over vacuum tubes of

I. small size. II. long life and reliable.
III. low power use. IV. low cost.

Advantages of semiconductor devices are

(a) I, II, III and IV (b) II, III and IV
(c) I, III and IV (d) I and IV

189. Consider four statements.

I. Inside crystal, because of difference of position, each electron has different energy; this makes energy bands in crystals.
II. Energy levels of valence electrons are included in valence band.
III. Energy level above the valence band is conduction band.
IV. In metals, conduction band and valence band overlap.

Correct statements are

(a) I and II (b) I, II and IV
(c) II and III (d) I, II, III and IV

190. Due to diffusion of electrons from n to p-side,

I. electron-hole combination across p - n junction occurs.
II. an ionised acceptor is left in the p-region.
III. an ionised donor is left in the n-region.
IV. electrons of n-side comes to p-side and electron-hole combination takes place in p-side.

Correct options are

(a) I and II (b) II and III
(c) II and IV (d) II, III and IV

191. Which of the given statements are correct regarding unbiased p-n junction?

I. Drift and diffusion currents occur p to n-side.
II. Initially, diffusion current is large and drift current is small.
III. Finally, diffusion and drift currents grow to be equal in magnitude.
IV. Under equilibrium there is no net current across p-n junction plane.

(a) I and IV (b) I, II and III
(c) II, III and IV (d) All of these

192. Which of these are correct?

I. In forward biasing, holes from p-side crosses junction and reach n-side.
II. In forward biasing, electrons from n-side crosses junction and reach p-side.

III. In n-side, holes are minority charge carriers.
IV. In p-side, electrons are minority charge carriers.

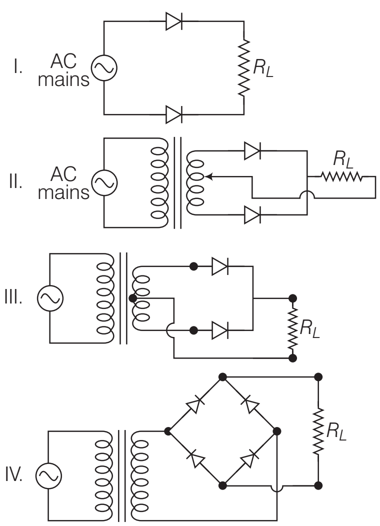
(a) I, II and III (b) I, III and IV
(c) II, III and IV (d) I, II, III and IV

193. Consider the following statements I and II and identify the correct choice of the given answers.

I. The width of the depletion layer in a p-n junction diode increases in forward biased.
II. In an intrinsic semiconductor, the fermi energy level is exactly in the middle of the forbidden energy gap.

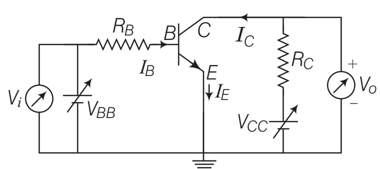
(a) I is true and II is false (b) Both I and II are false
(c) I is false and II is true (d) Both I and II are true

194. Following of these are circuits used for full-wave rectification,



(a) I, II and III (b) II, III and IV
(c) I, III and IV (d) I, II and IV

195. For the circuit given, an n-p-n transistor is being used as a switch in CE configuration.



Which of the following are correct?

I. $V_{BB} = I_B R_B + V_{BE}$
II. $V_{CE} = V_{CC} - I_C R_C$
III. $V_i = I_B R_B + V_{BE}$
IV. $V_o = V_{CC} - I_C R_C$

(a) I, II and IV (b) II, III and IV
(c) I, II and III (d) I, II, III and IV

196. In an oscillator,

I. we get AC output without any external input signal.
II. output is self sustained.
III. feedback can be achieved by inductive coupling (through mutual inductance) or L-C or R-C networks.

Incorrect statement is

(a) Only I
(b) Only II
(c) Only III
(d) None of these

197. Which of these gates can be formed using a NOR gate?

I. AND II. OR
III. NOT IV. NAND

(a) I and II (b) II and III
(c) I, II and IV (d) All I, II, III, and IV

III. Matching Type

198. Before invention of transistor, vacuum tubes were used and these were named according to number of electrodes they have.

Now, match these with number of electrodes

Column I	Column II
A. Pentode	1. 2
B. Tetrode	2. 3
C. Triode	3. 4
D. Diode	4. 5

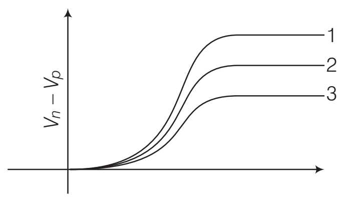
	A	B	C	D
(a)	1	2	3	4
(b)	2	3	4	1
(c)	3	4	1	2
(d)	4	3	2	1

199. Match the elements or compounds with their respective energy gaps values. (Energy gap existing between conduction and valence bands)

Column I	Column II
A. Diamond	1. 1.1 eV
B. Aluminium	2. 0.71 eV
C. Germanium	3. 0.03 eV
D. Silicon	4. 6 eV

	A	B	C	D
(a)	1	2	3	4
(b)	2	1	4	3
(c)	4	3	1	2
(d)	4	3	2	1

200. Following shows a plot of potential difference of *n*-side and *p*-side of a *p*-*n* junction (battery, in forward biased)



Then, match the following columns.

Column I	Column II
A. Without battery	1. 1
B. Low potential battery	2. 2
C. High potential battery	3. 3

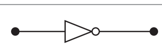
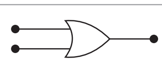
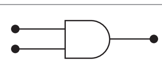
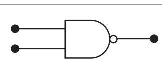
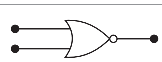
	A	B	C		A	B	C
(a)	1	2	3	(b)	2	1	3
(c)	2	3	1	(d)	1	3	2

201. Match the following columns.

Column I	Column II
A. Moderate size and heavily doped	1. Base
B. Very thin and lightly doped	2. Collector
C. Moderately doped and of large size	3. Emitter

	A	B	C
(a)	1	2	3
(b)	1	3	2
(c)	3	1	2
(d)	3	2	1

202. Match the following symbols with their names.

Column I		Column II
A.		1. OR
B.		2. AND
C.		3. NAND
D.		4. NOR
E.		5. NOT

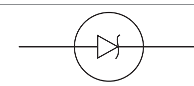
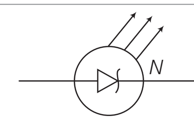
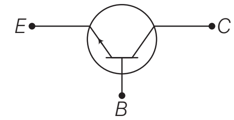
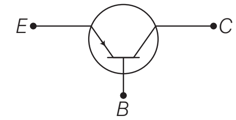
	A	B	C	D	E
(a)	1	2	3	4	5
(b)	3	1	2	4	5
(c)	5	1	2	5	4
(d)	5	1	2	3	4

203. Match the inputs of Column I with their respective outputs from Column II for a NOR gate

Column I	Column II
A. 0, 0	1. 0
B. 0, 1	2. 1
C. 1, 0	
D. 1, 1	

	A	B	C	D		A	B	C	D
(a)	1	1	2	2	(b)	1	1	1	2
(c)	2	2	2	1	(d)	2	1	1	1

204. Match the following Column I with Column II.

Column I	Column II	
A. *n*-*p*-*n* transistor	1.	
B. *p*-*n*-*p* transistor	2.	
C. Light emitting diode	3.	
D. Zener diode	4.	

	A	B	C	D		A	B	C	D
(a)	3	4	2	1	(b)	4	2	1	3
(c)	2	4	3	1	(d)	4	3	2	1

IV. Passage Based Questions

■ **Directions** (Q. Nos. 205-209) *These questions are based on the following situation. Choose the correct options from those given below.*

The input and output resistances in a common-base amplifier circuits are 400 Ω and 400 kΩ, respectively. The emitter current is 2 mA and current gain is 0.98.

205. The collector current is

(a) 1.84 mA (b) 1.96 mA
(c) 1.2 mA (d) 2.04 mA

206. The base current is

(a) 0.012 mA (b) 0.022 mA
(c) 0.032 mA (d) 0.042 mA

207. Voltage gain of transistor is

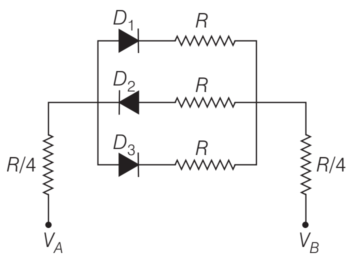
(a) 960 (b) 970
(c) 980 (d) 990

208. Power gain of transistor is
(a) 950 (b) 960 (c) 970 (d) 980

209. If peak voltage of input AC source is 0.1 V. The peak voltage of the output will be
(a) 9.8 V (b) 98 V (c) 980 V (d) 970 V

■ **Directions** (Q. Nos. 210-211) *These questions are based on the following situation. Choose the correct options from those given below.*

Three ideal p - n junction diodes D_1, D_2 and D_3 are connected as shown in the circuit. The potentials V_A and V_B can be changed.

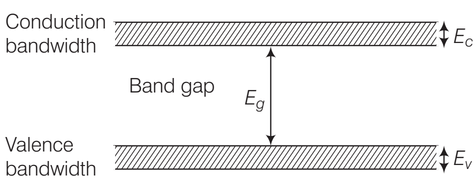


210. If V_A is kept at −10 V and V_B at −5 V, the effective resistance between A and B becomes
(a) R (b) $R/2$ (c) $3R$ (d) $3R/2$

211. If $V_A = -5$ V and $V_B = -10$V, then the resistance between A and B will be
(a) R (b) $R/2$ (c) $3R$ (d) $3R/2$

V. More than One Option Correct

212. If the lattice constant of this semiconductor is decreased, then which of the following are incorrect?



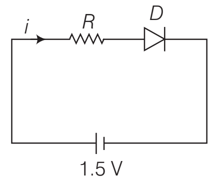
(a) All E_c, E_g, E_v increase
(b) E_c and E_v increase, but E_g decrease
(c) E_c and E_v decrease, but E_g increase
(d) All E_c, E_g, E_v decrease

213. Choose correct option(s) from the following.
(a) Substances with energy gap of the order of 10 eV are insulators
(b) The conductivity of a semiconductor increases with increase in temperature
(c) In conductors the valence and conduction bands may overlap
(d) The resistivity of a semiconductor increases with increase in temperature

214. Which of the following statement concerning the depletion zone of an unbiased *p-n* junction is (are) true?
(a) The width of the zone is independent on the densities of the dopants (impurities)
(b) The width of the zone is dependent on the densities of the dopants
(c) The electric field in the zone is produced by the ionized dopant atoms
(d) The electric field in the zone is produced by the electrons in the conduction band and the holes in the valence band

215. The impurity atoms with which pure silicon should be doped to make a p-type semiconductor, are those of
(a) phosphorus (b) boron
(c) antimony (d) aluminium

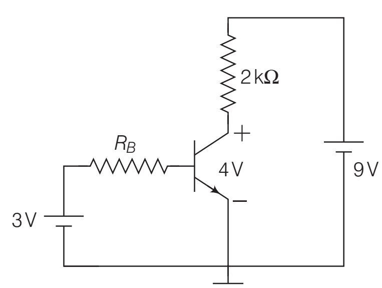
216. The diode used in the circuit shown in the figure has a constant voltage drop of 0.5 V at all current and a maximum power rating of 100 milliwatt. The value of maximum current in the circuit is I when voltage across resistance R is V_R and the value of resistance in R, thus which of the following are correct?



(a) $I = 200$ mA, $V_R = 1$ V (b) $I = 200$ mA, $R = 5\ \Omega$
(c) $I = 100$ mA, $V_R = 2$ V (d) $I = 100$ mA, $R = 10\ \Omega$

217. In an n- p-n transistor circuit, the collector current is 10 mA. If 90% of the electrons emitted reach the collector
(a) the emitter current will be 9 mA
(b) the base current will be 1 mA
(c) the emitter current will be 11 mA
(d) the base current will be −1 mA

218. Consider the following circuit. It $V_{BE} = 0.7$ V



and $\beta = 90$, then which of the following are correct?
(a) $I_C = 2.5$ mA (b) $I_B = 27.8$ mA
(c) $R_B = 82$ kΩ (d) $I_C = 1.2$ mA

NCERT & NCERT Exemplar Questions

NCERT

219. When a forward bias is applied to a p-n junction. It

(a) raises the potential barrier
(b) reduces the majority carrier current to zero
(c) lowers the potential barrier
(d) None of the above

220. For transistor action, which of the following statements are correct?

(a) Base, emitter and collector regions should have similar size and doping concentrations
(b) The base region must be very thin and lightly doped
(c) The emitter junction is forward biased and collector junction is reverse biased
(d) Both the emitter junction as well as the collector junction are forward biased

221. In an n-type silicon, which of the following statements is true?

(a) Electrons are majority charge carriers and trivalent atoms are the dopants
(b) Electrons are minority charge carriers and pentavalent atoms are the dopants
(c) Holes are minority charge carriers and pentavalent atoms are the dopants
(d) Holes are majority charge carriers and trivalent atoms are the dopants

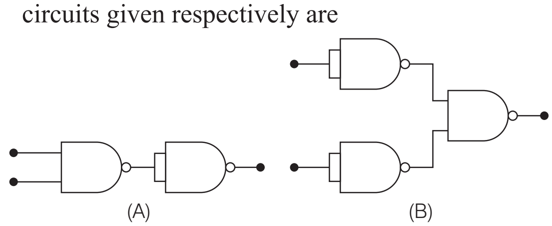
222. Carbon, silicon and germanium have four valence electrons each. These are characterised by valence and conduction bands separated by energy band gap respectively equal to $(E_g)_C, (E_g)_{Si}$ and $(E_g)_{Ge}$. Which of the following statement is true?

(a) $(E_g)_{Si} < (E_g)_{Ge} < (E_g)_C$ (b) $(E_g)_C < (E_g)_{Ge} > (E_g)_{Si}$
(c) $(E_g)_C > (E_g)_{Si} > (E_g)_{Ge}$ (d) $(E_g)_C = (E_g)_{Si} = (E_g)_{Ge}$

223. In an unbiased p-n junction, holes diffuse from the p-region to n-region because

(a) free electrons in the n-region attract them
(b) they move across the junction by the potential difference
(c) hole concentration in p-region is more as compared to n-region
(d) All of the above

224. Identify the logical operations carried out by the two circuits given respectively are



(a) A-AND, B-NOT (b) A-AND, B-OR
(c) A-NAND, B-NOT (d) A-NOT, B-OR

225. For a transistor amplifier, the voltage gain

(a) remains constant for all frequencies
(b) is high at high and low frequencies and constant in the middle frequency range
(c) is low at high and low frequencies and constant at mid frequencies
(d) None of the above

226. For a CE-transistor amplifier, the audio signal voltage across the collector resistance of $2\,k\Omega$ 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 $1\,k\Omega$

(a) $V_{in} = 1V, I_B = 5\mu A$ (b) $V_{in} = 0.01V, I_B = 10\mu A$
(c) $V_{in} = 1.5V, I_B = 5\mu A$ (d) $V_{in} = 1.3V, I_B = 10\mu A$

227. 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 V, calculate the output AC signal.

(a) 2 V (b) 3 V (c) 4 V (d) 5 V

228. In an intrinsic semiconductor, the energy gap E_g is 1.2 eV. Its hole mobility is much smaller than electron mobility and independent of temperature. What is the ratio between conductivity at 600 K and that at 300 K?

Assume that the temperature dependence of intrinsic carrier concentration n_i is given by

$$n_i = n_o \exp - \left(\frac{E_g}{2k_B T} \right)$$

where n_o is a constant.

(a) 0.5×10^2 (b) 2.1×10^3
(c) 1.1×10^5 (d) 3.2×10^4

229. In a p-n junction diode, the current I can be expressed as

$$I = I_0 \exp \frac{eV}{k_B T} - 1$$

where, I_0 is called the reverse saturation current. V is the voltage across the diode and is positive for forward bias and negative for reverse bias and I is the current through the diode, k_B is the Boltzmann constant $(8.6 \times 10^{-5}$ eV/K) and T is the absolute temperature. If for a given diode $I_0 = 5 \times 10^{-12}$ A and $T = 300$ K, then what will be the forward current at a forward voltage of 0.6 V?

(a) 0.063A (b) 0.832A
(c) 0.0763A (d) None of these

230. A hole is
(a) an anti-particle of electron
(b) a vacancy created when an electron leaves a covalent bond
(c) absence of free electrons
(d) an artificially created (particle)

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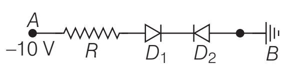
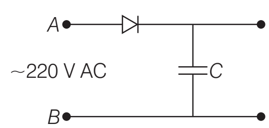
231. Conductivity of a semiconductor increases with increase in temperature, because
(a) number density of free charge carriers increases
(b) relaxation time increases
(c) both number density of free charge carriers and relaxation time increases
(d) number density of free charge carriers increases relaxation time decreases but effect of decrease in relaxation time is much less than increase in number density

232. Assuming diodes to be ideal,



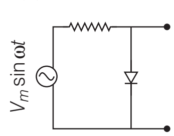
(a) D_1 is forward biased and D_2 is reverse biased, so current flows from A to B
(b) D_2 is in forward bias and D_1 is in reverse bias and hence no current flows from B to A and *vice-versa*
(c) D_1 and D_2 both are in forward bias, so current flows from A to B
(d) D_1 and D_2 both are in reverse bias, so no current flows from A to B

233. A 220 V AC supply is connected between points A and B.



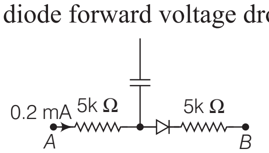
What will be potential difference across capacitor C?
(a) 220 V (b) 110 V (c) 0 V (d) $220\sqrt{2}$ V

234. Output of the circuit shown below will be



(a) zero all the times
(b) like half wave rectifier with positive cycles in output
(c) like half wave rectifier with negative cycles in output
(d) like that of a full wave rectifier

235. In the circuit shown, the voltage difference between A and B it the diode forward voltage drop is 0.3V



(a) 1.3 V (b) 2.3 V (c) 0 (d) 0.5 V

236. In the depletion region of a diode,
I. there are no mobile charges.
II. equal number of holes and electrons exist making the region neutral.
III. recombination of electron and holes takes place.
IV. immobile charged ions exists.
The correct options are
(a) I, II and III (b) II, III and IV
(c) I, II and IV (d) I, III and IV

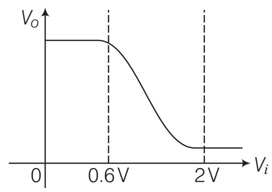
237. To reduce the ripples in a rectifier circuit with capacitor filter, which of these must be done?
I. R_L should be increased.
II. Input frequency should be decreased.
III. Input frequency should be increased.
IV. Capacitors with high capacitance should be used.
(a) I, II and III (b) I, III and IV
(c) II, III and IV (d) I, II and IV

238. What happens during regulation action of a zener diode?
I. The current and voltage across the zener remains constant.
II. The current through series resistance (R_s)changes.
III. The zener resistance is constant.
IV. The resistance offered by zener changes.
Correct ones are
(a) I and IV (b) II and III (c) II and IV (d) I and II

239. The breakdown in a reverse biased *p-n* junction diode is more likely to occurs due to
I. large velocity of minority charge carriers, if the doping is small.
II. large velocity of minority charge carriers, if the doping is large.
III. strong electric field in depletion region, if the doping concentration is small.
IV. strong electric field in depletion region, if the doping concentration is large.
Correct ones are
(a) I and IV (b) II and III
(c) I and III (d) II and IV

240. Consider an *n-p-n* transistor with its base-emitter junction forward biased and collector base junction reverse biased, which of these are correct?
I. Electrons cross over from emitter to collector.
II. Holes move from base to collector.
III. Electrons move from emitter to base.
IV. Electrons from emitter move out of base without going to collector.
(a) I and III (b) I and II
(c) I and IV (d) II and III

241. Base biased CE transistor has the transfer characteristics as shown



Which of the following statements are correct?

I. At $V_i = 0.4$ V, transistor is in active state.

II. At $V_i = 1$ V, transistor can be used as an amplifier.

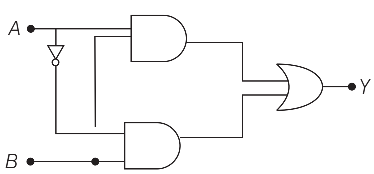
III. At $V_i = 0.5$V, it can be used as a switch turned off.

IV. At $V_i = 2.5$V, it can be used as a switch turned on.

(a) I, II and III (b) II, III and IV

(c) I, II and IV (d) I, III and IV

242. For given circuit, truth table is



(a)

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

(b)

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

(c)

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

(d)

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

243. In an *n-p-n* transistor in CE configuration, $I_C = 10$ mA. If 95% of electrons from emitter reaches the collector, which of these are correct?

I. $I_E = 8$ mA II. $I_E = 10.53$ mA

III. $I_B = 0.53$ mA IV. $I_B = 2$ mA

(a) I and IV (b) II and IV

(c) II and III (d) I and III

244. When an electric field is applied across a semiconductor, then

I. electrons move from lower energy level to higher energy level in the conduction band.

II. electrons move from higher energy level to lower energy level in the conduction band.

III. holes in the valence band move from higher energy level to lower energy level.

IV. holes in the valence band move from lower energy level to higher energy level.

Out of these, correct statements are

(a) I and III

(b) I and II

(c) II and IV

(d) I and IV

Answers

1.	(d)	**2.**	(d)	**3.**	(d)	**4.**	(d)	**5.**	(c)	**6.**	(b)	**7.**	(a)	**8.**	(a)	**9.**	(c)	**10.**	(d)	**11.**	(d)	**12.**	(b)	**13.**	(c)	**14.**	(c)	**15.**	(a)
16.	(a)	**17.**	(d)	**18.**	(d)	**19.**	(c)	**20.**	(a)	**21.**	(c)	**22.**	(c)	**23.**	(b)	**24**	(b)	**25.**	(a)	**26.**	(b)	**27.**	(c)	**28.**	(a)	**29.**	(c)	**30.**	(d)
31.	(d)	**32.**	(b)	**33.**	(c)	**34.**	(b)	**35.**	(a)	**36.**	(a)	**37.**	(a)	**38.**	(c)	**39.**	(a)	**40.**	(c)	**41.**	(c)	**42.**	(a)	**43.**	(c)	**44.**	(d)	**45.**	(d)
46.	(d)	**47.**	(c)	**48.**	(c)	**49.**	(a)	**50.**	(c)	**51.**	(b)	**52.**	(d)	**53.**	(c)	**54.**	(a)	**55.**	(c)	**56.**	(c)	**57.**	(b)	**58.**	(b)	**59.**	(d)	**60.**	(a)
61.	(c)	**62.**	(c)	**63.**	(c)	**64.**	(c)	**65.**	(d)	**66.**	(b)	**67.**	(c)	**68.**	(a)	**69.**	(a)	**70.**	(a)	**71.**	(a)	**72.**	(a)	**73.**	(a)	**74.**	(a)	**75.**	(d)
76.	(b)	**77.**	(a)	**78.**	(b)	**79.**	(b)	**80.**	(d)	**81.**	(a)	**82.**	(a)	**83.**	(b)	**84.**	(b)	**85.**	(c)	**86.**	(c)	**87.**	(b)	**88.**	(a)	**89.**	(d)	**90.**	(c)
91.	(d)	**92.**	(c)	**93.**	(a)	**94.**	(d)	**95.**	(c)	**96.**	(c)	**97.**	(c)	**98.**	(c)	**99.**	(b)	**100.**	(a)	**101.**	(b)	**102.**	(c)	**103.**	(d)	**104.**	(a)	**105.**	(b)
106.	(a)	**107.**	(a)	**108.**	(d)	**109.**	(c)	**110.**	(a)	**111.**	(c)	**112.**	(c)	**113.**	(b)	**114.**	(d)	**115.**	(c)	**116.**	(b)	**117.**	(c)	**118.**	(a)	**119.**	(b)	**120.**	(b)
121.	(b)	**122.**	(a)	**123.**	(d)	**124.**	(a)	**125.**	(b)	**126.**	(c)	**127.**	(b)	**128.**	(c)	**129.**	(b)	**130.**	(a)	**131.**	(a)	**132.**	(b)	**133.**	(c)	**134.**	(a)	**135.**	(a)
136.	(d)	**137.**	(c)	**138.**	(a)	**139.**	(d)	**140.**	(a)	**141.**	(c)	**142.**	(a)	**143.**	(a)	**144.**	(a)	**145.**	(b)	**146.**	(a)	**147.**	(a)	**148.**	(b)	**149.**	(a)	**150.**	(c)
151.	(c)	**152.**	(b)	**153.**	(a)	**154.**	(a)	**155.**	(d)	**156.**	(b)	**157.**	(c)	**158.**	(b)	**159.**	(c)	**160.**	(a)	**161.**	(b)	**162.**	(b)	**163.**	(d)	**164.**	(b)	**165.**	(b)
166.	(a)	**167.**	(d)	**168.**	(c)	**169.**	(b)	**170.**	(a)	**171.**	(c)	**172.**	(c)	**173.**	(a)	**174.**	(c)	**175.**	(c)	**176.**	(a)	**177.**	(c)	**178.**	(c)	**179.**	(a)	**180.**	(b)
181.	(c)	**182.**	(a)	**183.**	(c)	**184.**	(d)	**185.**	(a)	**186.**	(a)	**187.**	(c)	**188.**	(a)	**189.**	(d)	**190.**	(d)	**191.**	(c)	**192.**	(d)	**193.**	(c)	**194.**	(b)	**195.**	(d)
196.	(d)	**197.**	(d)	**198.**	(d)	**199.**	(d)	**200.**	(a)	**201.**	(c)	**202.**	(d)	**203.**	(d)	**204.**	(a)	**205**	(b)	**206.**	(d)	**207.**	(c)	**208.**	(b)	**209.**	(b)	**210.**	(d)
211.	(a)	**212.**	(a,b,d)	**213.**	(a,b,c)	**214.**	(b,c)	**215.**	(b,d)	**216.**	(a,b)	**217.**	(b,c)	**218.**	(a,b,c)	**219.**	(c)	**220.**	(b,c)	**221.**	(c)	**222.**	(c)	**223.**	(c)	**224.**	(b)	**225.**	(c)
226.	(b)	**227.**	(a)	**228.**	(c)	**229.**	(a)	**230.**	(b)	**231.**	(d)	**232.**	(b)	**233.**	(d)	**234.**	(b)	**235.**	(b)	**236.**	(c)	**237.**	(b)	**238.**	(c)	**239.**	(a)	**240.**	(a)

Hints *and* Explanations

1. (*d*) In a vacuum tube, the electrons are supplied by a heated cathode and the controlled flow of these electrons in vacuum is obtained by varying the voltage between its different electrodes.

Vacuum is required in the inter-electrode space; otherwise the moving electrons may lose their energy on collision with the air molecules in their path.

2. (*d*) The supply and flow of charge carriers in the semiconductor devices are within the solid itself.

No external heating or large evacuated space is required by the semiconductor devices, so they have small sizes.

3. (*d*) A van der Waals solid transmits light and has a low melting point.

4. (*d*) Semiconductors have 4 valency and so they form covalent bonds.

5. (*c*) The SI unit of conductivity is Siemen per metre (Sm^{-1}).

6. (*b*)

(i) **Metal** They possess very low resistivity (or high conductivity).

$$\rho \sim 10^{-2} - 10^{-8}\ \Omega\text{-m}$$
$$\sigma \sim 10^{2} - 10^{8}\ \text{Sm}^{-1}$$

(ii) **Semiconductor** They have resistivity or conductivity intermediate to metal and insulator.

$$\rho \sim 10^{-5} - 10^{6}\ \Omega\text{-m}$$
$$\sigma \sim 10^{5} - 10^{-6}\ \text{Sm}^{-1}$$

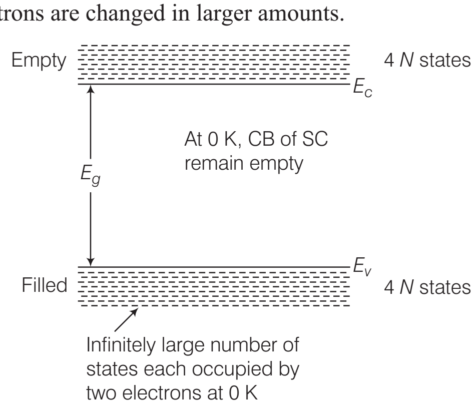
(iii) **Insulator** They have high resistivity (or low conductivity).

$$\rho \sim 10^{11} - 10^{19}\ \Omega\text{-m}$$
$$\sigma \sim 10^{-11} - 10^{-19}\ \text{Sm}^{-1}$$

As, $10^8 > 10^5 > 10^{-19}, \sigma_{\text{metal}} > \sigma_{\text{semiconductor}} > \sigma_{\text{insulator}}$

7. (*a*) Due to atomic interactions, the energies of outermost electrons are changed in larger amounts.

8. (*a*)



9. (*c*) Energy level splits into more finer levels and for many atoms they form nearly continuous bands.

10. (*d*) For a semiconductor, $0 < E_g \le 3\,\text{eV}$

For metal $E_g \sim 0$ and for insulator $E_g > 3\,\text{eV}$.

Forbidden energy gap in semiconductor is maximum energy gap allowed.

11. (*d*) For a semiconductor, conductivity increases with temperature or more electron-hole pairs are created due to thermal agitation.

So, $\rho \propto \dfrac{1}{T} \Rightarrow \sigma \propto T \Rightarrow \dfrac{1}{\rho} \propto T$

12. (*b*) In good conductors, which are metals there is no gap between valence band and conduction band. Hence, no holes exist.

13. (*c*) In a conductor, uppermost band is occupied by conduction electrons. Uppermost band is conduction band.

14. (*c*) Using $E = E_g = \dfrac{hc}{\lambda} = \dfrac{6.6 \times 10^{-34} \times 3 \times 10^8}{580 \times 10^{-9}}\,\text{J}$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{580 \times 10^{-9} \times 1.6 \times 10^{-19}}\text{eV} = 2.1\text{eV}$$

15. (*a*) In semiconductor as the temperature increases, more thermal energy becomes available to electrons and some of these electrons may break away (becoming free electrons contributing to conduction).

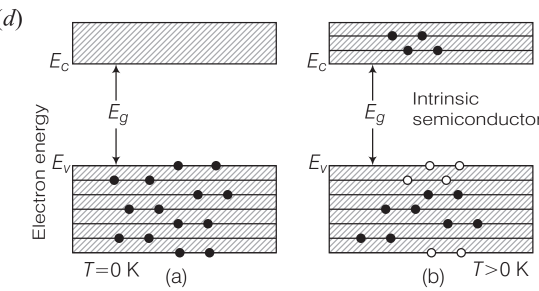
The thermal energy effectively ionises only a few atoms in the crystalline lattice and creates a vacancy in the bond. These holes behave as positive charge carriers.

16. (*a*) Pure semiconductors are called intrinsic semiconductors $n_e = n_n = n_i$.

17. (*d*) Total current is the sum of hole current and electron current in semiconductor. Electrons move opposite to hole, but current in same direction.

$$I = I_e + I_h$$

18. (*d*)



19. (*c*) In equilibrium condition, there is no net current through the semiconductor. This shows that the rate of generation of electron-hole pairs is equal to rate of recombination of electron-hole pairs.

20. (*a*) An intrinsic semiconductor will behave like an insulator at $T = 0$ K. It is the thermal energy at higher temperature ($T > 0$ K), which excites some electrons from the valence band to the conduction band. These thermally excited electrons at $T > 0$ K, partially occupy the conduction band. These have come from the valence band leaving equal number of holes there.

21. (*c*) Number density of electron-hole pairs is increased with temperature, so at high temperature semiconductors have higher conductivity.

22. (*c*) Semiconductors have negative temperature coefficient of resistance *i.e.,* the resistance of a semiconductor decreases with the increase in temperature and *vice-versa* . Silicon is actually an insulator at absolute zero of temperature but it becomes a good conductor at high temperatures. Because on increasing temperatures of semiconductor some of the electrons jumps from valence band to conduction band.

23. (*a*) Resistivity of a metal is directly proportional to temperature because its temperature coefficient is positive and resistivity of semiconductor is inversely proportional to temperature due to its negative temperature coefficient. This implies that with decrease in temperature, resistivity of metal decreases while that of semiconductor increases.

So, resistivity of Si increases but that of Cu decreases.

24. (*b*) For visible region, $450 \le \lambda \le 750$ nm

Hence, photon energy ranges from few 1.7 to 2.8 eV.

$$\left(\text{using } hc = 1240 \text{ eV-nm}, E = \frac{hc}{\lambda}\right)$$

As for silicon most of the photons have a higher energy, so they excite electrons (electrons absorb photons) Hence, light cannot pass through silicon. Silicon is opaque.

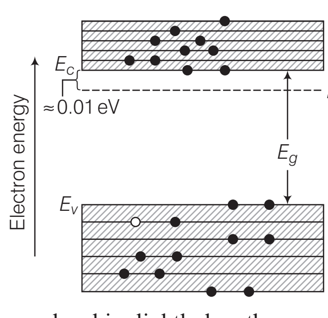
But as photons are not absorbed in ZnS, they pass through it and so zinc sulphide is transparent.

25. (*a*) Process of adding an impurity is called doping.

26. (*b*) Doping increases concentration of majority charge carriers.

27. (*c*) To form an *n*-type semiconductor doping is done by using a pentavalent impurity like phosphorous and to form a *p*-type semiconductor doping is done by using a trivalent impurity like indium.

28. (*a*)



Donor energy level is slightly less than energy level lowest to conduction band.

29. (*c*) The number of electrons made available for conduction by dopant atoms depends strongly upon the doping level and is independent of any increase in ambient temperature.

30. (*d*) Gallium, boron and aluminium all are trivalent impurities. These impurities make germanium *p*-type semiconductor.

31. (*d*) In a *p* -type semiconductor, holes are majority charge carriers and electrons are minority charge carriers.

32. (*b*) In both *n*-type and *p*-type semiconductors, number of electrons is exactly equal to number of protons. Both are neutrals.

33. (*c*) At room temperature, the density of holes in the valance band is predominantly due to impurity in the extrinsic semiconductor. The electron and hole concentration in a semiconductor in thermal equilibrium is given by

$$n_e n_h = n_i^2$$

34. (*b*) The four bonding electrons of C, Si or Ge lie, respectively, in the second, third and fourth orbit. Hence, energy required to take out an electron from these atoms (*i.e.,* ionisation energy E_g) will be least for Ge, followed by Si and highest for C.

35. (*a*) Total number of atoms $= 5 \times 10^{28}\ \text{m}^{-3}$

For every 10^6 atoms, 1 A-s is doped.

1 A-s contributely $1e^-$

$$Ne = 5 \times 10^{28}/10^6 = 5 \times 10^{22}$$

Since, $\quad n_e n_h = n_i^2$

The number of holes

$$n_h = (2.25 \times 10^{32}) / (5 \times 10^{22}) = 4.5 \times 10^9\ \text{m}^{-3}$$

36. (*a*) Phosphorous is pentavalent, it donates electron.

$\therefore \quad n_h << n_e$

37. (*a*) Increase of temperature causes more electrons to leave valance band and reach conduction band, so n_e increases.

But increase of temperature causes lattice vibrations and so v_d decreases as number of collisions increases.

38. (*c*) Doping does not change energy gap, it is still around 1 eV.

39. (*a*) E_g, Si = 1.1 eV

$$E_g, \text{Ge} = 0.7 \text{ eV} \Rightarrow E_g, \text{Sn} = 0.45 \text{ eV}$$

40. (*c*) In intrinsic semiconductor, conductivity occurs due to excitation of electrons when they absorb energy and break covalent bonds.

41. (*c*) For Ge, the energy gap, E_g is 0.7 eV.

42. (*a*) $n_i^2 = n_e n_h$, for extrinsic semiconductor

$$\Rightarrow \quad (10^{19})^2 = n_e\,(10)^{21} \quad \Rightarrow \quad n_e = \frac{10^{38}}{10^{21}} = 10^{17}\ \text{m}^{-3}$$

43. (*c*) Conductivity of a semiconductor increases with temperature.

So, they have negative value of temperature coefficient α.

44. (*d*) Relation is found empirically it is, $n \propto T^{3/2}$.

45. (*d*) Dopant concentration is usually 1 to 10 ppm (parts per million)

$$\Rightarrow \qquad \frac{1}{10^7} \approx 10^{-7}$$

46. (*d*) X shows an undoped semiconductor,
Y shows an n-type semiconductor,
Z shows a p-type semiconductor.

47. (*c*) The n-type semiconductor can be produced by doping an impurity atom of valence 5, *i.e.,* pentavalent atoms. *i.e.,* phosphorous.

48. (*c*) In an n-type silicon, dopants are pentavalent atoms, electrons are majority charge carriers and holes are minority charge carriers.

49. (*a*) $N = 5 \times 10^{28}$ atoms/m^3, A = acceptor, indium, D = donor, arsenic

$$N_A = 0.05 \times 10^{22} \text{ atoms/m}^3$$

$$\Rightarrow \qquad N_D = 5 \times 10^{22} \text{ atoms/m}^3$$

$$n_i = 1.5 \times 10^{16} \text{ m}^{-2}$$

$$\Rightarrow \quad N_D - N_A = n_e - n_h \quad \text{and} \quad n_e n_h = n_i^2$$

$$\therefore \qquad N_D - N_A = n_e - \frac{n_i^2}{n_e}$$

$$\Rightarrow \qquad n_e^2 - (N_D - N_A)n_e - n_i^2 = 0$$

$$\Rightarrow \quad n_e = \frac{(N_D - N_A) + \sqrt{(N_D - N_A)^2 + 4n_i^2}}{2}$$

On substituting values, we get, $n_e = 4.95 \times 10^{22}/\text{m}^3$

$$\therefore \qquad n_h = \frac{n_i^2}{n_e} = \frac{(1.5 \times 10^{16})^2}{4.95 \times 10^{22}} = 4.54 \times 10^9 \text{m}^{-3}$$

Observe that doping level $\dfrac{10^{22}}{10^{28}} = 10^{-6}$ ppm nearly

50. (*c*) Number of Si atoms $= 5 \times 10^{28}$ atoms/m^3

Number of indium atoms = Number of indium atoms for 1 silicon atom × Total number of Si atoms

$$= \frac{5 \times 10^{28}}{5 \times 10^7} = 1 \times 10^{21} \text{ atoms/m}^3 = 1 \times 10^{15} \text{ atoms/cm}^3$$

51. (*b*) Using $\quad n_e \times n_h = n_i^2$

here $\qquad n_i = 2 \times 10^{16} \text{m}^{-3}$

$$n_h = 4.5 \times 10^{22} \text{m}^{-3}$$

$$\therefore \qquad n_e = \frac{n_i^2}{n_h} = \frac{(2 \times 10^{16})^2}{4.5 \times 10^{22}}$$

$$n_e = 8.89 \times 10^9 \text{m}^{-3}$$

52. (*d*) Consider a thin p-type silicon (p-Si) semiconductor wafer. By adding precisely a small quantity of pentavalent impurity, part of the p-Si wafer can be converted into n-Si. So, p-n junction is formed.

53. (*c*) When a hole diffuses from $p \to n$ due to the concentration gradient. It leaves behind an ionised acceptor (negative charge) which is immobile. As the holes continue to diffuse, a layer of negative charge (or negative space-charge region) on the p-side of the junction is developed. Similarly, a layer of positive space-charge is developed on n-side because of electron departure. This space-charge region on either side of the junction together is known as depletion region.

54. (*a*) Thickness of depletion region is around 10^{-7} m.

55. (*c*) p -side is at negative potential and n-side is at positive potential. Also, central layer is at zero potential. Potential at small distance from junction on both sides becomes constant.

56. (*c*) Potential tends to prevent the movement of electron from the n-region into the p-region, it is often called barrier potential.

57. (*b*) No, A p-n junction is formed when a p-type semiconductor is formed alongwith an n-type semiconductor on a single intrinsic semiconductor.

58. (*b*) It is caused by diffusion of charge carriers.

60. (*a*) **E** opposes movement of charge.

61. (*c*) Diffusion and drift current of electrons and holes is due to concentration difference.

62. (*c*) Using $\left|\dfrac{dV}{dr}\right| = E$, we get

$$V = Ed$$

or $$E = \frac{V}{d} = \frac{0.6 \text{ V}}{1 \times 10^{-6} \text{ m}} = 6 \times 10^5 \text{ Vm}^{-1}$$

63. (*c*) A semiconductor diode is basically a p-n junction with metallic contacts provided at the ends for the application of an external voltage. It is a two terminal device.

64. (*c*) The direction of arrow indicates the conventional direction of current (when the diode is under forward bias).

65. (*d*) In forward biasing, electrons from n-side cross depletion region and reach p-side.

66. (*b*) Effective potential barrier will be $(V_0 - V)$. *i.e.,* potential barrier decreases.

67. (*c*) Due to concentration gradient, the injected electrons on p-side diffuse from the junction edge of p-side to the other end of p-side. Likewise, the injected holes on n-side diffuse from the junction edge of n-side to the other end of n-side.

This motion of charged carriers on either side gives rise to current. The total diode forward current is sum of hole diffusion current and conventional current due to electron diffusion.

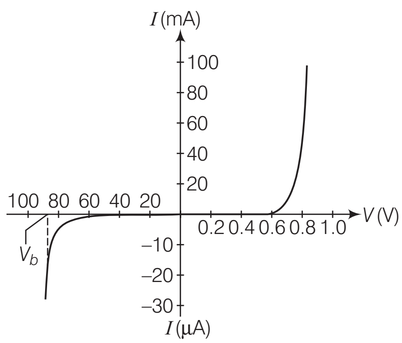
68. (*a*) In RB potential barrier increases hence movement of majority carrier decreases. But strong **E** pushes the movement of minority carrier towards their respective side and contributes small current.

69. (*a*) The diode reverse current is not very much dependent on the applied voltage. Even a small voltage is sufficient to sweep the minority charge carriers from one side of the junction to the other side of the junction.

The current is not limited by the magnitude of the applied voltage but is limited due to the concentration of the minority charge carrier on either side of the junction.

70. (*a*) The current under reverse bias is essentially voltage independent upto a critical reverse bias voltage, known as breakdown voltage (V_{br}). When $V = V_{brr}$, the diode reverse current increases sharply from n to p side.
Even a slight increase in the bias voltage causes large change in the current. If the reverse current is not limited by an external circuit, the p-n junction will get destroyed. Once it exceeds the rated value, the diode gets destroyed due to overheating.

71. (*a*) Typical V-I characteristics of a silicon diode are as shown.



72. (*a*) In forward bias, the current first increases very slowly, almost negligibly till the voltage across the diode crosses a certain value.
After the characteristic voltage, the diode current increases significantly (exponentially), even for a very small increase in the diode bias voltage. This voltage is called the threshold voltage or knee voltage (~ 0.2 V for germanium diode and ~ 0.7 V for silicon diode).

73. (*a*) By allowing current only in forward bias it acts like a one way valve.

74. (*a*) A p - n junction diode primarily allows the flow of current only in one direction (forward bias). The forward bias resistance is low as compared to the reverse bias resistance. For diodes, we define a quantity called dynamic resistance as the ratio of small change in voltage ΔV to a small change in current ΔI,

$$r_d = \frac{\Delta V}{\Delta I}$$

75. (*d*) From the graph, at $I = 20$ mA

$$V = 0.8 \text{ V}$$

and $$I = 10 \text{ mA}, V = 0.7 \text{ V}$$

$$r_{FB} = \frac{\Delta V}{\Delta I} = \frac{0.1 \text{ V}}{10 \text{ mA}} = 10\,\Omega$$

Also, at $$V = -10 \text{ V}, I = -1\,\mu\text{A}$$

$$r_{RB} = \frac{10 \text{ V}}{1\,\mu\text{A}} = 1 \times 10^7\,\Omega$$

$\therefore$ $$\text{Ratio} = \frac{r_{FB}}{r_{RB}} = \frac{10}{10^7} = 10^{-6}$$

76. (*b*) Without an external bias an electric field exists which points from n to p-side and opposes any diffusion of electrons.

77. (*a*) In forward biasing a negligible potential drop occurs in diode, so potential drop across resistance R is V.

78. (*b*) In reverse bias, $V_{p\text{-side}} - V_{n\text{-side}}$ = Negative

79. (*b*) Diode is in forward bias , so resistance = 0

So, $$I = \frac{V}{R} = \frac{4-1}{300} = \frac{3}{300} = 10^{-2} \text{ A}$$

80. (*d*) Arsenic is pentavalent, X is n-type and indium is trivalent and Y is p - type.
So, the junction is in reverse bias.

81. (*a*) Diode is in reverse bias, current = 0, potential difference across $R = 0; V_{AB} = 6$ V

82. (*a*) Current is zero as batteries cause p-n junction in reverse bias.

83. (*b*) Electric field, $E = \dfrac{V}{d} = \dfrac{0.3}{1 \times 10^{-6}} = 3 \times 10^5 \text{ Vm}^{-1}$

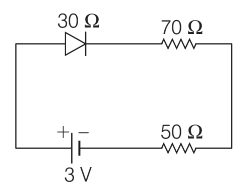
84. (*b*) Dynamic resistance is, $r_d = \dfrac{\Delta V}{\Delta I}$

here, $\Delta V = 0.7\text{V} - 0.65\text{V} = 0.05$ V

$\Delta I = 5\text{mA} = 5 \times 10^{-3}$ A

$\therefore$ $$r_d = \frac{0.05}{5 \times 10^{-3}} = 10\,\Omega$$

85. (*c*) In the circuit, the upper diode D_i is reverse biased and lower diode D_2 is forward biased. Thus, there will be no current across upper diode function. The effective circuit will be shown as



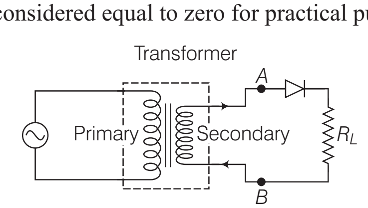
Total resistance,

$$R = 50 + 30 + 70 = 150\,\Omega$$

Current in circuit, $I = \dfrac{V}{R} = \dfrac{3\text{V}}{150\,\Omega} = 0.02$ A

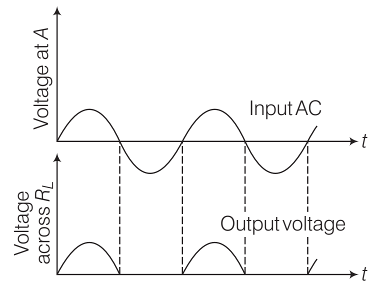
86. (*c*) If an alternating voltage is applied across a diode in series with a load, a pulsating voltage will appear across the load only during the half cycles of the AC input during which the diode is forward biased.

87. (*b*) In a half-wave rectifier, the secondary of a transformer supplies the desired AC voltage across terminals A and B. When the voltage at A is positive, the diode is forward biased and it conducts. When A is negative, the diode is reverse biased and it does not conduct.
The reverse saturation current of a diode is negligible and can be considered equal to zero for practical purposes.



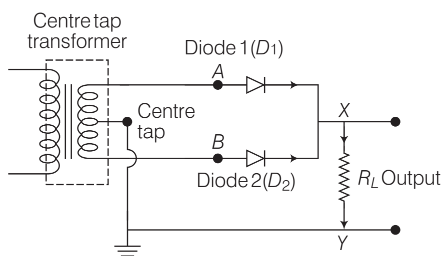
88. (*a*) The reverse breakdown voltage of the diode must be sufficiently higher than the peak AC voltage at the secondary of the transformer to protect the diode from reverse breakdown.

89. (*d*)



Input AC voltage and output waveforms from the half-wave rectifier circuit

90. (*c*) Due to centre tapping potential reaching the diodes is only half of secondary voltage. It is clear from its circuit's diagram.



91. (*d*)

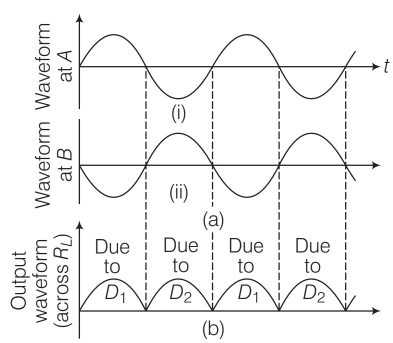


Fig. (a) Input waveform given to diode D_1, at A and to diode D_2 at B. Fig. (b) output waveform across the load R_L connected in the full-wave rectifier circuit

92. (*c*) The rectified voltage is in the form of pulses of the shape of half sinusoids. Though, it is unidirectional, it does not have a steady value.

93. (*a*) To get steady DC output from the pulsating voltage normally, a capacitor is connected across the output terminals (parallel to the load R_L).

One can also use an inductor in series with R_L for the same purpose. Since, these additional circuits appear to filter out the AC ripple and give a pure DC voltage, so they are called filters.

94. (*d*) As, $X_C = \frac{1}{C\omega}$, for AC component when ω is high, then X_C is less and, so a capacitor let AC part bypass through it, so only DC part reaches R_L, the load resistance.

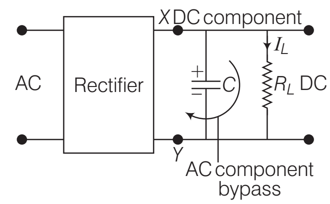


Fig. (a) A full-wave rectifier with capacitor filter

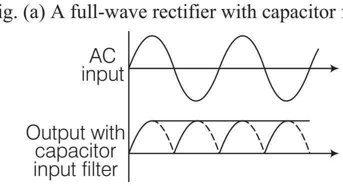


Fig. (b) Input and output voltage of rectifier in (a)

95. (*c*) In full wave rectification, output frequency is double of that of input frequency.

96. (*c*) In this question, full wave rectification is done by using a centre tap transformer.

So, output voltage is $\frac{1}{2}$ that of an half wave rectifier.

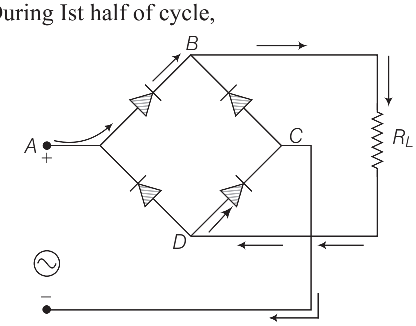
+• $v/2$ } diff $= \frac{v}{2}$

centre• 0

–• $-v/2$ } diff $= \frac{v}{2}$

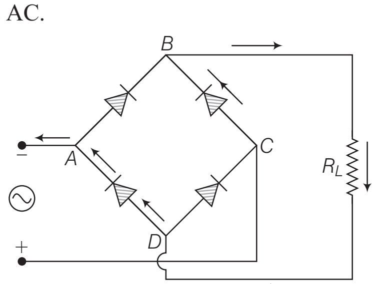
} diff $= v$

97. (*c*) During Ist half of cycle,



During IInd half of cycle,

Clearly, current through R_L is unidirectional, in both halves of input AC.

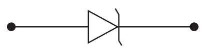


98. (*c*) Rate of discharge is inversely proportional to time constant of the circuit. More value of time constant implies slow discharge.

99. (*b*) For full-wave rectifier, frequency = 2 × input frequency for half-wave rectifier frequency = input frequency.

$$\therefore \quad \text{Ratio} = \frac{2}{1}$$

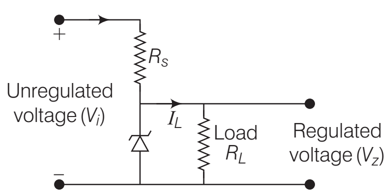
100. (*a*) Zener diode is a special purpose semiconductor diode. It is designed to operate under reverse bias in the breakdown region and used as a voltage regulator. The symbol for Zener diode is shown in figure.



101. (*b*) Zener diode is fabricated by heavily doping both *p*-sides and *n*-sides of the junction. Due to this, depletion region formed is very thin ($< 10^{-6}$ m) and the electric field of the junction is extremely high ($\sim 5 \times 10^6$ V/m) even for a small reverse bias voltage.

102. (*c*) When the reverse bias voltage $V = V_z$, then the electric field strength is high enough to pull valence electrons from the host atoms on the *p*-side which are accelerated to *n*-side. These electrons account for high current observed at the breakdown. The emission of electrons from the host atoms due to the high electric field is known as internal field emission or field ionisation.

103. (*d*) Zener diode must be attached in reverse bias



Zener diode as DC voltage regulator

104. (*a*) The value of R_s should be such that the current through the Zener diode is much larger than the load current. This is to have good load regulation. I_z = 20 mA. The total current through R_s is, therefore, 24 mA. The voltage drop across R_s is $10.0 - 6.0 = 4.0$ V. This gives
$R_s = 4.0 \text{ V} / (24 \times 10^{-3}) \text{ A} = 167 \, \Omega$

105. (*b*) Semiconductor diodes in which charge carriers are generated by photons (photo-excitation) are called optoelectronic devices. Optoelectronic devices are

(i) photodiodes used for detecting optical signal (photodetectors). Used near automatic doors.

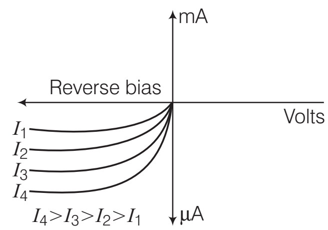
(ii) light Emitting Diodes (LED) which convert electrical energy into light.

(iii) photovoltaic devices which convert optical radiation into electricity (solar cells).

106. (*a*) A photodetector detects any change in intensity of light by changing either potential difference across it or by changing current through it.

107. (*a*) The variation of intensity results in change in number of incident photons (per second) and hence a corresponding change in generation rate of electron and holes occurs. This causes a change in current amplitude.

108. (*d*) When intensity is increased, reverse saturation current also increases.



I-*V* characteristics of a photodiode for different illumination intensity $I_4 > I_3 > I_2 > I_1$.

109. (*c*) When the diode is forward biased, electrons are sent from $n \to p$.
Thus, at the junction boundary on either side of the junction, excess minority charge carriers are there which recombins with majority charge carriers near the junction. On recombination, the energy equal to or slightly less than the band gap are emitted.

110. (*a*) The reverse breakdown voltages of LEDs are very low. typically around 5 V. So, care should be taken that high reverse voltages do not appear across them.

111. (*c*) As, emitted energy = Band gap value when an electron moves from conduction band to valance band.
If λ is wavelength of emitted radiation, then

$$E_g = \frac{hc}{\lambda}$$

$$\Rightarrow \quad \lambda = \frac{hc}{E_g}$$

Taking $hc = 1240$ eV-nm and $450 \text{ nm} \le \lambda \le 750$ nm for visible region, we get

$$450 \le \lambda \le 750$$

$$\Rightarrow \quad 450 \le \frac{hc}{E_g} \le 750$$

$$\Rightarrow \quad E_g \le \frac{hc}{450} = \frac{1240 \text{ eV - nm}}{450 \text{ nm}} \approx 2.8 \text{ eV}$$

$$\text{and} \quad E_g \ge \frac{hc}{750}$$

$$= \frac{1240 \text{ eV nm}}{750 \text{ nm}} \approx 1.7 \text{ eV}$$

$$\text{So,} \quad 1.8 \le E_g \le 3 \text{ eV}$$

112. (*c*) For red LEDs,
$GaAs_{0.6} \, P_{0.4}$ – Gallium Arsenic Phosphide (E_g = 1.9 eV) is used. This corresponds to $\lambda \approx 700$ nm.

113. (*b*) Solar cells uses light energy (photons) to generate an emf.

114. (*d*) Solar cell supplies current to load. So, I-V characteristics is drawn in fourth quadrant.

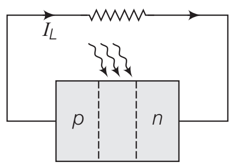


Fig. (a) Depletion region

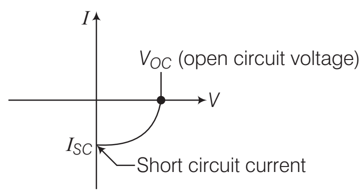


Fig. (b) I-V characteristics of a solar cell

115. (*c*) Semiconductors with band gap closed to 1.5 eV are ideal materials for solar cell fabrication. Solar cells are made with semiconductors like Si (E_g = 1.1 eV), GaAs (E_g = 1.43 eV). CdTe (E_g = 1.45 eV), $CuInSe_2$ (E_g = 1.04 eV) etc.

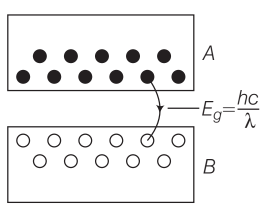
The important criteria for the selection of a material for solar cell fabrication are (i) band gap (~ 1.0 to 1.8 eV), (ii) high optical absorption (~ 10^4 cm^{-1}).

116. (*b*) As, we know that wavelength

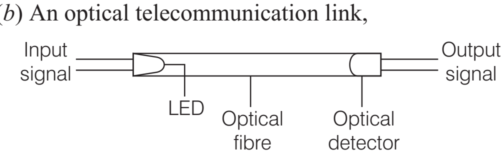
$$\lambda = \frac{hc}{E_g} = \frac{1240 \text{ eV-nm}}{2.8 \text{ eV}} = 440 \text{ nm} \approx 4400 \text{ Å}$$

117. (*c*) $\because E_g = \frac{hc}{\lambda} = \frac{1240 \text{ eV - nm}}{620 \text{ nm}} = 2.0 \text{ eV}$

118. (*a*) Electron moves from conduction to valence band, in LED when it glows



119. (*b*) An optical telecommunication link,



120. (*b*) In red LED, $\lambda_R = \frac{hc}{E_R}$

In violet, LED $\lambda_V = \frac{hc}{E_V} \Rightarrow \frac{E_R}{E_V} = \frac{\lambda_V}{\lambda_R} < 1$

121. (*b*) Light from an LED is highly monochromatic.

122. (*a*) For same value of current, higher value of voltage is required for higher frequency.

123. (*d*) Here, E_g = 2 eV

Wavelength of radiation corresponding to this energy,

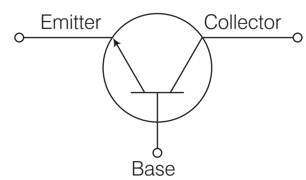
$$\lambda = \frac{hc}{E_g} = \frac{1240 \text{ eV-nm}}{2\text{eV}} = 620 \text{ nm}$$

$$\text{Frequency, } \nu = \frac{c}{\lambda} = \frac{3 \times 10^8 \text{ ms}^{-1}}{620 \times 10^{-9} \text{ m}} = 5 \times 10^{14} \text{ Hz}$$

125. (*b*) A transistor has three doped regions forming two *p-n* junctions between them. Obviously, there are two types of transistors.

(i) *n-p-n* transistor (ii) *p-n-p* transistor

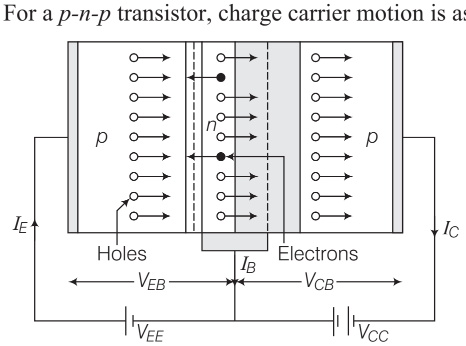
126. (*c*) ***n-p-n* transistor** Here, two segments of *n*-type semiconductor (emitter and collector) are separated by a segment of *p*-type semiconductor (base).



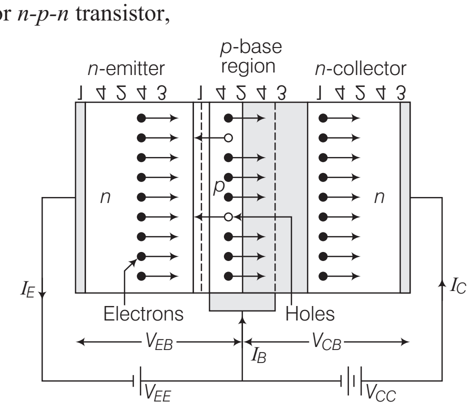
Emitter	Base	Collector

127. (*b*) The transistor works as an amplifier with emitter-base junction forward biased and base collector junction reversed bias, a transistor is said to be in active state.

128. (*c*) For a *p-n-p* transistor, charge carrier motion is as

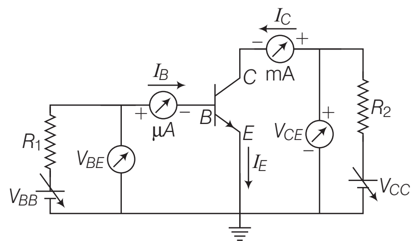


For *n-p-n* transistor,



129. (*b*) Low; High. When emitter-base junction is forward biased and base-collector junction is reverse biased, then transistor, is said to be active state. In active state of transistor the emitter-base junction acts as low resistance while the base collector junction acts as high resistance.

130. (*a*) Observe that emitter (E) is connected to both batteries, so it is common. Emitter E-n side is connected to negative of V_{BB} battery, collector C-n side is connected to positive of V_{CC} battery, active state.



Circuit arrangement for studying the input and output characteristics of *n-p-n* transistor in CE configuration

131. (*a*) For a transistor,

$$V_{CE} = V_{CB} + V_{BE}$$

132. (*b*) V_{CE} must be sufficiently larger than 0.7 V.

133. (*c*) I_B does not depend on V_{CE}. So, when V_{CE} is increased, I_B remains constant. I_C increases till saturation.

134. (*a*) As $A_V = \beta \dfrac{R_L}{R_i}$ $\quad \left(\because g_m = \dfrac{\Delta I_c}{\Delta V} = \dfrac{\Delta I_c}{\Delta I_B R_i} \right)$

or $\quad G = \left(\dfrac{\beta}{R_i} \right) R_L \quad \left(\because g_m = \dfrac{\beta}{R_i} \right)$

$\Rightarrow \quad G = g_m R_L \quad \Rightarrow \quad G \propto g_m$

$\therefore \quad \dfrac{G_2}{G_1} = \dfrac{g_{m_1}}{g_{m_2}} \quad \Rightarrow \quad G_2 = \dfrac{0.02}{0.03} \times G$

$\therefore$ Voltage gain, $G_2 = \dfrac{2}{3} G$

135. (*a*) **Input resistance** (r_i) This is defined as the ratio of change in base emitter voltage (ΔV_{BE}) to the resulting change in base current (ΔI_B) at constant collector-emitter voltage (V_{CE}). This is dynamic (ac resistance).

$$r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B} \right)_{V_{CE}}$$

136. (*d*) Given, resistance across load, $R_L = 800\ \Omega$

Voltage drop across load, $V_L = 0.8$ V

Input resistance of circuit, $R_i = 192\ \Omega$

Collector current is given by

$$I_C = \frac{V_L}{R_L} = \frac{0.8}{800} = \frac{8}{8000} = 1 \text{ mA}$$

$\because$ Current amplification $= \dfrac{\text{Output current}}{\text{Input current}} = \dfrac{I_C}{I_B} = 0.96$

$\Rightarrow \quad I_B = \dfrac{1 \text{ mA}}{0.96}$

$\because$ Voltage gain,

$$A_V = \frac{V_L}{V_{in}} = \frac{V_L}{I_B R_i} = \frac{0.8 \times 0.96}{10^{-3} \times 192} = 4 \quad \Rightarrow \quad A_V = 4$$

and power gain,

$$A_P = \frac{I_C^2 R_L}{I_B^2 R_i} = \left(\frac{I_C}{I_B} \right)^2 \cdot \frac{R_L}{R_i} = (0.96)^2 \times \frac{800}{192}$$

$$A_P = 3.84$$

137. (*c*) $\because \beta_{DC} = \dfrac{I_C}{I_B}$

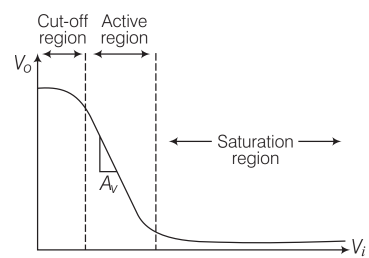
138. (*a*) $\because \beta_{AC} = \left(\dfrac{\Delta I_C}{\Delta I_B} \right)_{V_{CE}}$

$\Rightarrow \quad \beta_{DC} = \dfrac{I_C}{I_B}$

Ratio= $\beta_{AC} : \beta_{DC} = 150{:}150 = 1{:}1$

139. (*d*) It is said to be in cut-off state for small V_i, active for intermediate V_i, saturation for large V_i.

140. (*a*) With increasing V_i, V_o decreases.



Transfer characteristics

141. (*c*) Power gain, $A_P = \beta_{AC} \times A_v$

142. (*a*) The output AC voltage is 2.0 V. So, the AC collector current, $i_C = 2.0/2000 = 1.0$ mA. The signal current through the base is, therefore given by $i_B = \dfrac{i_C}{\beta} = \dfrac{1.0 \text{ mA}}{100} = 0.010$ mA.

The DC base current has to be $10 \times 0.010 = 0.10$ mA.

$$V_{BB} = V_{BE} + I_B R_B \quad \Rightarrow \quad R_B = (V_{BB} - V_{BE}) / I_B$$

Assuming $V_{BE} = 0.6$ V

$$R_B = (2.0 - 0.6)/0.10 = 14\ \text{k}\Omega$$

143. (*a*) $i_E = i_B + i_C \Rightarrow \quad i_E > i_B$

So, according to the question, the possible emitter current is 36.

144. (*a*) Initially, both I_C and I_E increase.

145. (*b*) Emitter current begins to fall, T_1 is seeing decaying field in T_2.

146. (*a*) β = Current gain $= \dfrac{\Delta i_c}{\Delta i_b}$

$\Rightarrow \quad \Delta i_c = \beta \times \Delta i_b = (80 \times 250)\ \mu\text{A}$

147. (*a*) $i_E = i_B + i_C \Rightarrow i_C = i_E - i_B$.

Emitter side is forward biased, collector side is reverse biased.

148. (*b*) $V_b = i_b R_b$

$$\Rightarrow \quad R_b = \frac{9}{35 \times 10^{-6}} = 257 \text{k}\Omega$$

149. (*a*) Inductors are in series,

$\therefore \quad L_{eq} = L_1 + L_2$

and frequency of oscillator $= \frac{1}{2\pi}\sqrt{\frac{1}{L_{eq}C_{eq}}} = \frac{1}{2\pi\sqrt{(L_1 + L_2)C}}$

150. (*c*) From Kirchhoff's loop rule in output loop,

$9 - 4 = I_C R_C$

As, $R_C = 2\text{k}\Omega$,

$$\Rightarrow \quad I_C = \frac{5}{2 \times 10^3} = 2.5 \text{ mA} \quad \Rightarrow I_B = \frac{I_C}{\beta} = \frac{2.5}{90} = 27.8\,\mu\text{A}$$

$V_{BE} = 0.7\text{ V}$

From Kirchhoff, loop rule in input loop,

$$I_B R_B = 3 - 0.7 \quad \Rightarrow R_B = \frac{2.3}{27.8} \times 10^6 = 82 \text{ k}\Omega$$

153. (*a*) DC current gain in common base amplifier is given by

$$\alpha = \frac{i_C}{i_E}$$

where, i_C is collector current and i_E is emitter current.

Given, $\alpha = 0.96$, $i_E = 7.2\text{ mA}$

$\therefore \quad i_C = 0.96 \times 7.2 \text{ mA} = 6.91 \text{ mA}$

As, $\quad i_E = i_B + i_C$

$\therefore$ Base current, $i_B = i_E - i_C = 7.2 - 6.91 = 0.29 \text{ mA}$

154. (*a*) Current gain, $\alpha = \frac{\text{power gain}}{\text{voltage gain}} = \frac{800}{840} = \frac{20}{21}$

Now, $\beta = \frac{\alpha}{1 - \alpha} = \frac{20/21}{1 - (20/21)} = 20$

As $\quad \beta = \frac{I_C}{I_B} = I_C = \beta I_B = 20 \times 1.2 = 24 \text{ mA}$

155. (*d*) Input signal of a CE amplifier, $V_i = 2\cos\left(15t + \frac{\pi}{3}\right)$

Voltage gain, $A_V = 150$

As CE amplifier gives phase difference of π between input and output signals.

So, $\quad A_V = \frac{V_0}{V_i}$

$\Rightarrow \quad V_0 = A_V V_i$

$$V_0 = 150 \times 2\cos\left(15t + \frac{\pi}{3} + \pi\right)$$

$$V = 300\cos\left(15t + \frac{4\pi}{3}\right)$$

156. (*b*) Voltage gain = Current gain $\times$ Resistance gain

$$= \text{Current gain} \times \frac{R_C}{R_I} = 30 \times \frac{6}{1} = 180$$

157. (*c*) Current gain, $\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$

and voltage gain, $A_V = \frac{\beta \times R_{out}}{R_{in}}$

here, $R_{in} = 1000\,\Omega$, $\Delta I_B = 10\,\mu\text{A} = 10^{-5}\text{ A}$

$$R_{out} = 5\text{ k}\Omega = 5 \times 10^3\,\Omega$$

$\Delta I_C = 2\text{ mA} = 2 \times 10^{-3}\text{ A}$

$$\beta = \frac{2 \times 10^{-3}}{10^{-5}} = 200$$

Hence, $\quad A_V = \frac{200 \times 5 \times 10^3}{1000} = 1000$

158. (*b*) Here, $I_C = 80\%$ of $I_E = \frac{80 I_E}{100}$

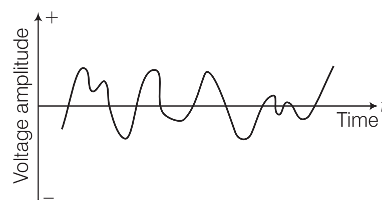
or $\quad I_E = \frac{I_C}{0.8} = \frac{10}{0.8} = 12.5 \text{ mA}$

$$I_B = I_E - I_C = 12.5 - 10 = 2.5 \text{ mA}$$

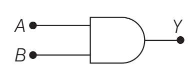
159. (*c*) Dynamic resistance,

$$r_d = \frac{\Delta V}{I\Delta} \quad \Rightarrow \quad r_d = \frac{0.05 \times 1000}{5}\,\Omega = 10\,\Omega$$

160. (*a*) An analog signal is a continuous waveform as

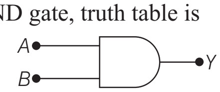


164. (*b*) **AND gate** An AND gate has two or more inputs and one output. The output Y of AND gate is 1 only when input A and input B are both 1. The logic symbol and truth table for this gate is given by



Input		**Output**
A	***B***	***Y***
0	0	0
0	1	0
1	0	0
1	1	1

165. (*b*) For an NAND gate, truth table is



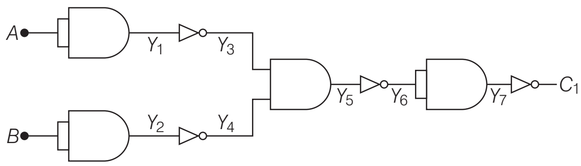
Input		**Output**
A	***B***	***Y***
0	0	1
0	1	1
1	0	1
1	1	0

So, no output occurs when both inputs are at higher potentials (1). Till time t_4, output (1) occurs because both inputs do not become (1) together.

166. (*a*) Let us assume that current through the diode is *I*.
From the given condition,

$$I = \frac{V_A - V_B}{R} = \frac{4-(-6)}{1\,k\Omega} = \frac{10}{1 \times 10^3} = 10^{-2}\,A$$

167. (*d*) Given circuit is



A	*B*	Y_1	Y_2	Y_3	Y_4	y_5	y_6	y_7	*C*
0	0	0	0	1	1	1	0	0	1
0	1	0	1	1	0	0	1	1	0
1	0	1	0	0	1	0	1	1	0
1	1	1	1	0	0	0	1	1	0

Observing, this is NOR gate.
So, output waveform is option (d).

168. (*c*) $X = \overline{\overline{AB}} = A \cdot B$ (*i.e.,* AND gate)

If the output X of NAND gate is connected to the input of NOT gate (made from NAND gate by joining two inputs) from the given figure, then we get back an AND gate.

169. (*b*) It is an AND gate.

A	*B*	$\overline{A}$	$\overline{B}$	$X = \overline{A} + \overline{B}$	$\overline{X} = Y$
0	0	1	1	1	0
0	1	1	0	1	0
1	0	0	1	1	0
1	1	0	0	0	1

171. (*c*) The resultant Boolean expression of the above logic circuit will be

$$Y = (A + B) \cdot C$$

So, we have seen that among the given options, only option (c) is the correct choice, *i.e.*,

Output, $Y = 1$ only when inputs $A = 1, B = 0$ and $C = 1$.

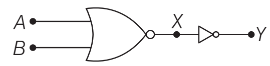
172. (*c*) The conductivity of an intrinsic semiconductor is less than that of a lightly doped *p*-type semiconductor.

173. (*a*) Zener diode is a special purpose diode. In reverse bias, after a certain voltage, current suddenly increases in Zener diode. This property is used to obtain voltage regulation.

174. (*c*) In a transistor, the base is made thin and lightly doped so that the majority charge carriers coming from emitter may pass on to the collector and very few form electron-hole combination in base.

175. (*c*) In an oscillator, the feedback is in the same phase, *i.e.,* positive feedback. If the feedback voltage is in opposite phase, *i.e.*, negative feedback, the gain is less than one and it can never work as oscillator. It will be an amplifier with reduced gain.

176. (*a*)



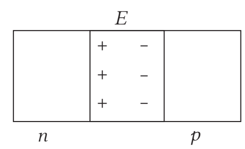
Truth table for given circuit is

A	*B*	$X = \overline{A + B}$	$Y = \overline{X}$
0	0	1	0
0	1	0	1
1	0	0	1
1	1	0	1

Hence, the given circuit acts as OR gate.

177. (*c*) Due to diffusion of electrons, positive space-charge region on *n*-side of the junction and negative space charge region on *p*-side of the junction, an electric field directed from positive charge towards negative charge develops. Electric field is from *n*-side to *p*-side. Due to this field, an electron on *p*-side of the junction moves to *n*-side and a hole on *n*-side of the junction moves to *p*-side. The motion of charge carriers due to the electric field is called drift. Thus, a drift current, which is opposite in direction to the diffusion current starts. Concentration gradient is due to doping of sides. It is not affected by drift of charge carriers.

178. *(c)* The loss of electrons from the *n*-region and the gain of electrons by the *p*-region causes a difference of potential across the junction of the two regions. The polarity of this potential is such as to oppose further flow of carriers so that a condition of equilibrium exists.



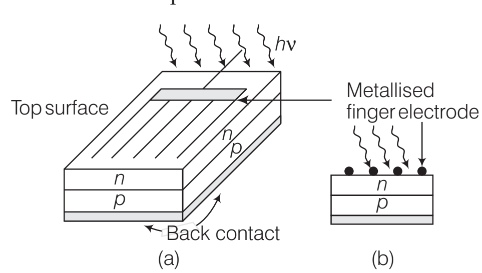
179. *(a)* As resistance of depletion region is large, potential drop occurs mainly in depletion region.

180. *(b)* In forward bias, forward current is obtained due to removal of barrier potential by externally applied potential. Ohm's law states $V \propto I$, not valid for diode.

181. *(c)* From the V-I characteristics of a junction diode, we see that it allows current to pass only when it is forward biased. So, if an alternating voltage is applied across a diode the current flows only in that part of the cycle when the diode is forward biased.

182. *(a)* As, $X_L = L\omega$, inductive reactance is high at high frequency for AC and for capacitor, $X_C = 1/C\omega$.

183. *(c)* Solar cells are made wafer shape as a large area ensures more incident solar power.



Typical *p*-*n* junction solar cell

184. *(d)* The generation of emf by a solar cell, when light falls on, it is due to the following three basic processes generation, separation and collection (i) generation of electron-hole pairs due to light (with $h\nu > E_g$) close to the junction; (ii) separation of electrons and holes due to electric field of the depletion region.

Electrons are swept to *n*-side and holes to *p*-side; (iii) the electrons reaching the *n*-side are collected by the front contact and holes reaching *p*-side are collected by the back contact. Thus, *p*-side becomes positive and *n*-side becomes negative giving rise to photovoltage.

186. *(a)* In the case of Si transistor, as long as input V_i is less than 0.6 V, the transistor will be in cut-off state and current I_C will be zero.

Hence, $V_o = V_{CC}$

When V_i becomes greater than 0.6 V, the transistor is in active state with some current I_C in the output path and the output V_o decreases as the term $I_C R_C$ increases. With increase of V_i, I_C inreases almost linearly and, so V_o decreases linearly till its value becomes less than about 1.0 V.

187. *(c)* A gate is a digital circuit that follows certain logical relationship between the input and output voltages. Therefore, they are generally known as logic gates because they control the flow of information. The five common logic gates used are NOT, AND, OR, NAND and NOR.

188. *(a)* They are small in size, consume low power, operate at low voltages and have long life and high reliability.

189. *(d)* In a solid, electron's energies are very different from that in an isolated atom. Inside the crystal, each electron has a unique position and no two electrons see exactly the same pattern of surrounding charges. Because of this, each electron will have a different energy level.

These different energy levels with continuous energy variation form what are called energy bands. The energy band which includes the energy levels of the valence electrons is called the valence band. The energy band above the valence band is called the conduction band.

Some electrons from the valence band may gain external energy to cross the gap between the conduction band and the valence band. Then, these electrons will move into the conduction band.

At the same time they will create vacant energy levels in the valence band where other valence electrons can move. Thus, the process creates the possibility of conduction due to electrons in conduction band as well as due to vacancies in the valence band. In metals, conduction band and valence band overlap.

190. *(d)* When an electron diffuses from $n \rightarrow p$, it leaves behind an ionised donor (species which has become ion by donating electron) on *n*-side.

This ionised donor (positive charge) is immobile as it is bonded to the surrounding atoms. As the electrons continue to diffuse from *n*-*p*, a layer of positive charge (or positive space-charge region) on *n*-side of the junction is developed. On *p*-side atom receiving electrons are ionised acceptor.

191. (*c*) Initially, diffusion current is large and drift current is small. As the diffusion process continues, the space-charge regions on either side of the junction extend, thus increasing the electric field strength and hence drift current.

This process continues until the diffusion current equals the drift current. Thus, a *p*-*n* junction is formed. In a *p*-*n* junction under equilibrium there is no net current.

192. *(d)* In forward biasing due to the applied voltage, electrons from *n*-side cross the depletion region and reach *p*-side (where they are minority charge carriers).

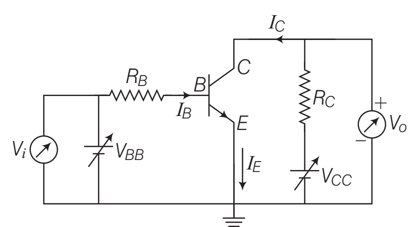
Similarly, holes from *p*-side cross the junction and reach the *n*-side (where they are minority charge carriers). This process under forward bias is known as minority charge carrier injection. At the junction boundary, on each side, the minority charge carrier concentration increases significantly compared to the locations far from the junction.

193. *(c)* In forward bias, if depletion layer's width decreases, fermi energy level is in the middle of forbidden gap in intrinsic semiconductor.

194. *(b)* The circuit using two diodes gives output rectified voltage corresponding to both the positive as well as negative half of the AC cycle.

Hence, it is known as full-wave rectifier. There is another circuit of full-wave rectifier which does not need a centre tap transformer but needs four diodes. It is called a bridge rectifier.

195. *(d)* Applying Kirchhoff's voltage rule to the input and output sides of this circuit, we get



$$V_{BB} = I_B R_B + V_{BE}$$

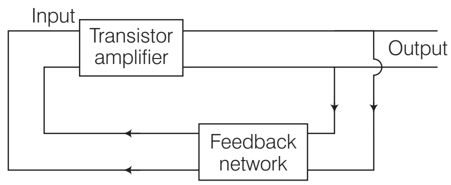
and $$V_{CE} = V_{CC} - I_C R_C$$

We shall treat V_{BB} as the DC input voltage V_i and V_{CE} as the DC output voltage V_o. So, we have

$$V_i = I_B R_B + V_{BE}$$

and $$V_o = V_{CC} - I_C R_C .$$

196. (*d*) In an oscillator, we get AC output without any external input signal. In other words, the output in an oscillator is self-sustained. To attain this, an amplifier is taken. A portion of the output power is returned back (feedback) to the input in phase with the starting power (this process is termed as positive feedback) as shown in figure. The feedback can be achieved by inductive coupling (through mutual inductance) or *LC* or *RC* networks.



197. *(d)* A 'NOR' gate, like an 'NAND' gate is universal gate, is also universal gate. AND, OR, NOT, NAND gates can be made using NOR gates.

199. *(d)* The given materials in decreasing order of conductivity are Al > Ge > Si > Diamond (C), so aluminium has least energy gap and carbon has largest. Diamond has energy gap 6 eV. E_g (Germanium) = 0.71eV.

203. *(d)* Truth table for NOR gate is given by,

Input		Output
A	*B*	*Y*
0	0	1
0	1	0
1	0	0
1	1	0

205. (*b*) As, $I_C = \alpha I_E = 0.98 \times 2 = 1.96$ mA

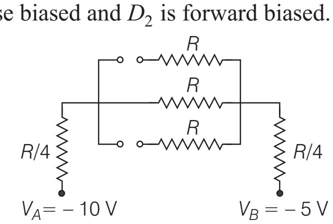
206. (*d*) As, $I_B = I_E - I_C = 2 - 1.96 = 0.04$ mA

207. (*c*) As, $A_V = \alpha \dfrac{R_o}{R_i} = 0.98 \times \dfrac{(400 \times 10^3}{400} = 980$

208. (*b*) Power amplification, $a_P = \alpha A_V = 0.98 \times 980 = 960$

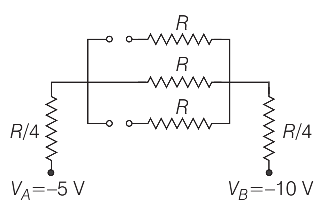
209. (*b*) As, $V_o = V_i \times$ voltage gain $= 0.1 \times 980 = 98$V

210. (*d*) When $V_A = -10$ V and $V_B = -5$ V, ideal diodes D_1 and D_3 are reverse biased and D_2 is forward biased.



Since, ideal diode in reverse bias has infinite resistance (*i.e.,* open circuited) and during forward bias it has zero resistance (*i.e.,* short-circuited) Therefore, the given circuit may be shown as in figure.

$$\therefore \quad R_{AB} = \frac{R}{4} + R + \frac{R}{4} = \frac{3R}{2}$$



211. (*a*) When $V_A = -5$ V and $V_B = -10$ V

D_2 is reverse biased and D_1 and D_3 get forward biased, then

$$R_{AB} = \frac{R}{4} + \frac{R}{2} + \frac{R}{4} = R$$

212. (*a, b, d*) If lattice constant of semiconductor is decreased, then E_c and E_v decrease but E_g increases.

213. (*a, b, c*) (a) In insulators, energy gap is of the order of 5 to 10 eV and it is practically impossible to impart this much amount of energy to the electrons in valence band so as to jump to conduction band.

So, choice (a) is correct.

(b) In semiconductors, with the rise in temperature more electrons from valence band jump to conduction band and this results in increase in conductivity. So, choice (b) is correct.

(c) In conductors, the conduction band is either partially filled or the conduction band overlaps on the valence band. So, choice (c) is correct.

(d) In semiconductors, resistivity decreases with increase in temperature. So, choice (d) is wrong.

216. (*a,b*) Current in circuit, $i = \dfrac{P}{V_d} = \dfrac{100 \times 10^{-3}}{0.5}$

(V_d = voltage drop across diode)

$= 200 \times 10^{-3}$ A

Voltage across resistance R, $V' = 1.5 - 0.5 = 1.0$ V

Thus, resistance $\quad R = \dfrac{V'}{i} = \dfrac{1}{200 \times 10^{-3}} = 5\ \Omega$

217. (*b, c*) $I_C = 10$ mA

$$I_C = 90\% \text{ of } I_E$$

$$10 = \frac{90}{100} I_E$$

$$I_E = 11 \text{ mA}$$

$$\therefore \quad I_E = I_B + I_C$$

$$I_B = 1 \text{mA}$$

218. (*a,b,c*) Applying loop law at output port,

$$9 - 4 = I_C R_C$$

or $\quad I_C = 2.5$ mA

$$I_B = \frac{I_C}{\beta} = \frac{2.5}{90} = 2.78 \times 10^{-5} \text{ A} = 27.8\ \mu\text{A}$$

Since, the transistor operates in active region therefore

$$V_{BE} = 0.7 \text{ V}$$

Applying loop law at input port, $I_B = \dfrac{3 - 0.7}{R_B}$

$$R_B = \frac{2.3 \times 10^5}{2.78} = 82 \text{ k}\Omega$$

219. *(c)* When a forward bias is applied across the *p-n* junction, the applied voltage opposes the barrier voltage. Due to this, the potential barrier across the junction is lowered.

220. (*b*) For a transistor, $\beta = \frac{I_C}{I_B} \Rightarrow I_B = \frac{I_C}{\beta}$ base region is thin, so that majority carrier of emitter will reach the collector.

$$R_{\text{input}} = \frac{V_{\text{input}}}{I_B} = \frac{V_{\text{input}}}{I_C} \cdot \beta$$

i.e., $$R_{\text{input}} \propto \frac{1}{I_C}$$

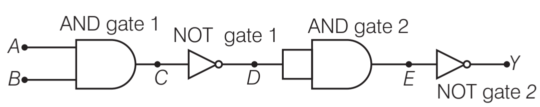
Therefore, R_{input} is inversely proportional to the collector current. For high collector current, the R_{input} should be small for which the base region must be very thin and lightly doped for a transistor action, the emitter junction is forward biased and collector junction is reverse biased.

221. (*c*) In an *n*-type semiconductor, it is obtained by doping the Ge or Si with pentavalent atoms. In *n*-type semiconductor, electrons are majority charge carriers and holes are minority charge carriers.

222. (*c*) The energy band gap is largest for carbon, less for silicon and least for germanium.

223. (*c*) In an unbiased *p*-*n* junction, the diffusion of charge carriers across the junction takes place from higher concentration to lower concentration. Therefore, hole concentration in *p*-region is more as compared to *n*-region.

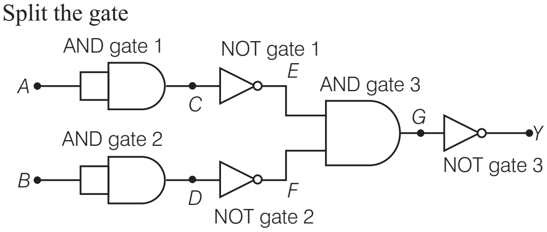
224. (*b*)



A	*B*	*C*	*D*	*E*	*Y*
0	0	0	1	1	0
0	1	0	1	1	0
1	0	0	1	1	0
1	1	1	0	0	1

So, this logic operation as AND gate.

(b) Split the gate



A	*B*	*C*	*D*	*E*	*F*	*G*	*Y*
0	0	0	0	1	1	1	0
1	0	1	0	0	1	0	1
0	1	0	1	1	0	0	1
1	1	1	1	0	0	0	1

So, this logic operation resembles to OR gate.

225. (*c*) The voltage gain is low at high and low frequencies and constant at mid frequencies.

226. (*b*) Given, collector resistance $R_{\text{output}} = 2\text{ k}\Omega = 2000\,\Omega$

Current amplification factor of the transistor, $\beta_{\text{AC}} = 100$

Audio signal voltage, $V_{\text{output}} = 2\text{ V}$

Input (base) resistance, $R_{\text{input}} = 1\text{ k}\Omega = 1000\,\Omega$

$\because$ Voltage gain, $A_V = \frac{V_{\text{output}}}{V_{\text{input}}} = \beta_{\text{AC}} \frac{R_{\text{output}}}{R_{\text{input}}}$

$\therefore$ Input signal voltage, $V_{\text{input}} = \frac{V_{\text{output}}}{\beta_{\text{AC}}(R_{\text{output}}/R_{\text{input}})}$

$$= \frac{2}{100(2000/1000)} = 0.01\text{ V}$$

Base (input) current, $I_B = \frac{V_{\text{input}}}{R_{\text{input}}} = \frac{0.01}{1000} = 10 \times 10^{-6}\text{ A}$

$$= 10\,\mu\text{A}$$

227. (*a*) Given, voltage gain of first amplifier, $A_{V_1} = 10$

Voltage gain of second amplifier, $A_{V_2} = 20$

Input voltage, $V_i = 0.01\text{ V}$

Total voltage gain, $A_V = \frac{V_o}{V_i} = A_{V_1} \times A_{V_2}$

$$\therefore \quad \frac{V_o}{0.01} = 10 \times 20$$

$$V_o = 2\text{ V}$$

228. (*c*) Given, intrinsic carrier concentration $n_i = n_o e^{-E_g/2k_BT}$

and energy gap $E_g = 1.2\text{ eV}$

$$k_B = 8.62 \times 10^{-5}\text{ eV/K}$$

For $T = 600\text{ K}$,

$$n_{600} = n_o e^{-E_g/2k_B \times 600} \quad \ldots\text{(i)}$$

For $T = 300\text{ K}$,

$$n_{300} = n_0 e^{-E_g/2k_B \times 300} \quad \ldots\text{(ii)}$$

Dividing Eq. (i) by Eq. (ii), we get

$$\frac{n_{600}}{n_{300}} = e^{\left[-\frac{E_g}{2k_B}\left(\frac{1}{600} - \frac{1}{300}\right)\right]} = e^{\frac{E_g}{2k_B}\left(\frac{1}{300} - \frac{1}{600}\right)}$$

$$= e^{\frac{1.2}{2 \times 8.62 \times 10^{-5}}\left(\frac{1}{600}\right)}$$

$$= e^{11.6} = (2.718)^{11.6} \quad (\because e = 2.718)$$

$$= 1.1 \times 10^5$$

Let the conductivities are σ_{600} and σ_{300}.

$$\frac{\sigma_{600}}{\sigma_{300}} = \frac{n_{600}}{n_{300}} = 1.1 \times 10^5 \quad (\because \sigma = en\mu_e)$$

229. (*a*) Given, $I_0 = 5 \times 10^{-12}\text{ A}, T = 300\text{ K}$

$$k_B = 8.6 \times 10^{-5}\text{ eV/K}$$

$$= 8.6 \times 10^{-5} \times 1.6 \times 10^{-19}\text{ J/K}$$

Given, voltage $V = 0.6\text{ V}$

$$\therefore \quad \frac{eV}{k_BT} = \frac{1.6 \times 10^{-19} \times 0.6}{8.6 \times 10^{-5} \times 1.6 \times 10^{-19} \times 300} = 23.26$$

The current I through a junction diode is given by

$$I = I_o e^{\left[\frac{eV}{2k_BT} - 1\right]} = 5\times 10^{-12}(e^{23.26} - 1)$$
$$= 5\times 10^{-12}(1.259\times 10^{10} - 1)$$
$$= 5\times 10^{-12}\times 1.259\times 10^{10} = 0.063 \text{ A}$$

231. *(d)* When temperature increases, number density of free charge carriers increases and mean relaxation time decreases due to increased lattice vibrations. Effect of decrease in relaxation time is much less as compared to effect of increase in number density.

232. (*b*) In the given circuit, *p*-side of *p-n* junction, D_1 is connected to lower voltage and *n*-side of D_1 to higher voltage. Thus, D_1 is reverse biased. The *p*-side of *p-n* junction D_2 is at higher potential and *n*-side of D_2 is at lower potential. Thus, D_2 is forward biased.

Hence, no current flows through the junction B to A.

233. (*d*) As *p-n* junction conducts during positive half cycle only, the diode connected here will work in positive half cycle. Potential difference across C = peak voltage of the given AC voltage $V_0 = V_{\text{rms}}\sqrt{2} = 220\sqrt{2}$ V

234. *(b)* Each positive half passes through the diode and so output only contains positive halves of voltage.

235. (*b*) Diode is forward biased, no current goes through side branch after capacitor is charged.

$\therefore V_{AB} = I_{AB}\times R_{AB} = 0.2\times 10^{-3}\times 10\times 10^3 = 2\text{ V}$

Option (b) is most appropriate, extra 0.3 V occurs due to diode.

236. *(c)* In depletion region, after equilibrium, no recombination can occur as electrons and holes are not 'free'. In depletion region, there are immobile charged ions and but no mobile charges; equal number of holes and electrons exists.

237. *(b)* Ripple factor (r) of a full-wave rectifier using capacitor filter is given by $r = \dfrac{1}{4\sqrt{3}R_LC}$

i.e., $r \propto \dfrac{1}{R_L}$

$\Rightarrow$ $r \propto \dfrac{1}{C}, r \propto \dfrac{1}{\nu}$

Thus, to reduce r, R_L should be increased, input frequency ν should be increased and capacitance C should be increased.

238. *(c)* Resistance of Zener diode changes at breakdown voltage and current through R_s increases after breakdown due to increased movement of minority carrier.

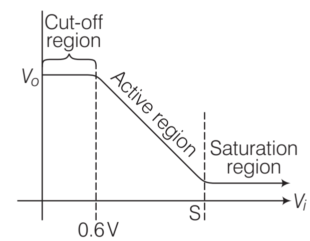
239. *(a)* In reverse biasing, the minority charge carriers will be accelerated due to reverse biasing which on striking with atoms cause ionization resulting secondary electrons and thus more number of charge carriers.

When doping concentration is large, there will be large number of ions in the depletion region, which will give rise to a strong electric field.

241. *(b)* $V_i = 1$ V, active state

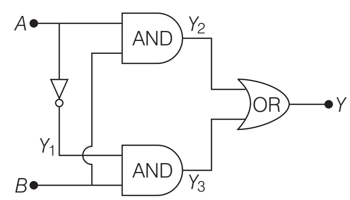
$V_i = 0.5$V, cut-off region $I_C = 0$

$V_i = 2.5$ V



The transistor circuit in active state can be used as an amplifier.

242. *(c)* It is a combination of AND gates.



A	*B*	Y_1	Y_2	Y_3	*Y*
0	0	1	0	0	0
0	1	1	0	1	1
1	0	0	0	0	0
1	1	0	1	0	1

243. *(c)* As, $I_E = I_B + I_C$

100% 10% 95%

So, $I_E \times \dfrac{95}{100} = I_C$

$\Rightarrow$ $I_E = \dfrac{100\times 10}{95} = 10.53$ mA

Also, $I_B = 10.53 - 10 = 0.53$ mA

244. (*a*) When electric field is applied across a semiconductor, the electrons in the conduction band get accelerated and acquire energy. They move from lower energy level to higher energy level.

While the holes in valence band move from higher energy level to lower energy level, where they will be having more energy.