



PHYSICS

BOOKS - HC VERMA

SEMICONDUCTOR AND SEMICONDUCTOR DEVICES

Examples

1. The mean free path of conduction electrons in copper is about 4×10^{-8} m. for a copper block, find the electric field which can give, on an average, 1eV energy to a conduction electron.



[Watch Video Solution](#)

2. Calculate the resistivity of an n-type semiconductor from the following data: density of conduction electrons $= 8 \times 10^{13} \text{ cm}^{-3}$, density of holes

$= 5 \times 10^{12} \text{ cm}^{-3}$, mobility of conduction electron

$= 2.3 \times 10^4 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ and mobility of holes $= 100 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$.

 [Watch Video Solution](#)

3. The i-V characteristic of a p-n junction diode is shown in figure. Find the approximate dynamic resistance of the p-n junction when (a) a forward bias of 1 volt is applied, (b) a forward bias of 2 volt is applied.



 [View Text Solution](#)

4. Write the truth table for the logical function $Z = (X \text{ and } Y) \text{ or } X$.

 [Watch Video Solution](#)

Worked Out Examples

1. A doped semiconductor has impurity levels 30meV below the conduction band,(a)Is the material n-type or p-type? (b)In a thermal collision,and amount kT of energy is given to the extra electron loosely bound to the impurity ion and this electron is just able to jump into the conduction band. Calculate the temperature T.



[Watch Video Solution](#)

2. The energy of a photon of sodium light ($\lambda = 589nm$) equals the band gap of a semiconducting material. Find :

(a) the minimum energy E required to create a hole-electron pair.

(b) the value of $\frac{E}{kT}$ at a temperature of 300 K.



[Watch Video Solution](#)

3. A P type semiconductor has acceptor level 57 meV above the valence band. What is maximum wavelength of light required to create a hole ?



[Watch Video Solution](#)

4. The band gap in germanium is ($\Delta E = 0.68eV$). Assuming that the number of hole-electron pairs is proportional to $e^{-\Delta E/2kT}$, find the percentage increase in the number of charge carriers in pure germanium as the temperature is increased from 300K to 320K.

[Watch Video Solution](#)

5. The concentration of hole-electron pairs in pure silicon at $T=300K$ is 7×10^{15} per cubic metre, Antimony is doped into silicon in a proportion of 1 atom in 10^7 atoms. Assuming that half of the impurity atoms contribute electrons in the conduction band, calculate the factor by which the number of silicon atoms per cubic metre is 5×10^{28}

[Watch Video Solution](#)

6. A potential barrier of 0.5 V exists across a p-n junction

(i) If the depletion region is $5 \times 10^7 m$ wide. What is the intensity of the electric field in this region ?

(ii) An electron with speed $5 \times 10^5 m/s$ approaches the p-n junction from the n-side with what speed will it enter the p-side.



[Watch Video Solution](#)

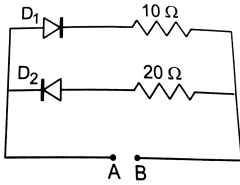
7. The reverse-biased current of a particular p-n junction diode increases when it is exposed to light of wavelength less than or equal to 600nm. Assume that the increases in carrier concentration takes place due to the creation of new hole-electron pairs by the light. Find the band gap.



[Watch Video Solution](#)

8. A 2V battery may be connected across the points A and B as shown in figure. Assume that the resistance of each diode is zero in forward bias

and infinity in reverse bias. Find the current supplied by the battery if the positive terminal of the battery is connected to (a) the point A (b) the point B.



[Watch Video Solution](#)

9. A change of 8.0mA in the emitter current brings a change of 7.9mA in the collector current. How much change in the base current is required to have the same change 7.9mA in the collector current? Find the values of (α) and (β) .



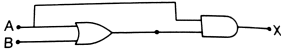
[Watch Video Solution](#)

10. A transistor is used in common-emitter mode in an amplifier circuit. When a signal 20mV is added to the base-emitter voltage, the base current changes by $20(\mu)\text{A}$ and the collector current changes by 2mA . The

load resistance is $5k(\Omega)$. Calculate (a) the factor (β) (b) the input resistance R_{BE} , (c) the transconductance and (d) the voltage gain .

[Watch Video Solution](#)

11. Construct the truth table for the function X of A and B represented by figure.



[Watch Video Solution](#)

Short Answer

1. How many 1s energy states are present in one mole of sodium vapour? Are they all filled in normal conditions? How many 3s energy states are present in one mole of sodium vapour? Are they all filled in normal conditions?

[Watch Video Solution](#)

2. There are energy bands in a solid. Do we have really continuous energy variation in a band or do we have very closely spaced but still discrete energy level ?

 [Watch Video Solution](#)

3. The conduction band of a solid is partially filled at 0 K. will it be a conductor, a semiconductor or an insulator?

 [Watch Video Solution](#)

4. In semiconductors, thermal collisions are responsible for taking a valence electron to the conduction band. Why does the number of conduction electrons not go on increasing with time as thermal collisions continuously take place?

 [Watch Video Solution](#)

5. When an electron goes from the valence band to the conduction band in silicon, its energy is increased by 1.1eV. the average energy exchange in a thermal collision is of the order of kT which is only 0.026eV at room temperature. How is a thermal collision able to take some of the electrons from the valence band to the conduction band ?



[Watch Video Solution](#)

6. What is the resistance of an intrinsic semiconductor at 0K?



[Watch Video Solution](#)

7. We have valence electrons and conduction electrons in a semiconductor. Do we also have valence holes and conduction holes?



[Watch Video Solution](#)

8. When a p-type impurity is doped in a semiconductor, a large number of holes are created. This does not make the semiconductor charged. But when holes diffuse from the p-side to the n-side in a p-n junction, the n-side gets positively charged. Explain.

 [Watch Video Solution](#)

9. The drift current in a reverse-biased p-n junction increases in magnitude if the temperature of the junction is increased. Explain this on the basis of creation of hole-electron pairs.

 [Watch Video Solution](#)

10. An ideal diode should pass a current freely in one direction and should stop it completely in the opposite direction. Which is closer to ideal-vacuum diode or a p-n junction diode?

 [Watch Video Solution](#)

11. Consider an amplifier circuit using a transistor. The output power is several times greater than the input power. Where does the extra power come from?



[Watch Video Solution](#)

Objective 1

1. Electric conduction in a semiconductor takes place due to

- A. electrons only
- B. holes only
- C. both electrons and holes
- D. neither electrons nor holes

Answer: C



[Watch Video Solution](#)

2. An electric field is applied a semiconductor. Let the number of charge carriers density is 'n' and the average drift speed be v. If the temperature is increased.

- A. both n and v will increase
- B. n will increase but v will decrease
- C. v will increase but n will decrease
- D. both n and v will decrease.

Answer: D



[Watch Video Solution](#)

3. Let n_p and n_e be the number of holes and conduction electrons in an intrinsic semiconductor.

- A. $n_p > n_e$
- B. $n_p = n_e$

C. $n_p < n_e$

D. $n_p \neq n_e$

Answer: B



[Watch Video Solution](#)

4. Let n_p and n_e be the number of holes and conduction electrons in an extrinsic semiconductor.

A. $n_p > n_e$

B. $n_p = n_e$

C. $n_p < n_e$

D. $n_p \neq n_e$

Answer: D



[Watch Video Solution](#)

5. P type semiconductor is :-

- A. positive charged
- B. negatively charged
- C. uncharged
- D. uncharged at 0K but charged at higher temperatures.

Answer: C



Watch Video Solution

6. When an impurity is doped into an intrinsic semiconductor, the conductivity of the semiconductor

- A. increases
- B. decreases
- C. remains the same
- D. becomes zero

Answer: A



Watch Video Solution

7. If the two ends of a p-n junction are joined by a wire ,

- A. there will not be a steady current in the circuit
- B. there will be a steady current from the n-side to the p-side
- C. there will a steady current from the p-side to the n-side
- D. there may or nay not be a current depending upon the resistance of the connecting wire.

Answer: A



Watch Video Solution

8. The drift current in a p-n junction is

- A. from the n-side to the p-side
- B. from the p-side to the n-side
- C. from the n-side to the p-side if the junction is forward-biased and in the opposite direction if it is reverse-biased.
- D. from the p-side to the n-side if the junction is forward-biased and in the opposite direction if it is reverse-biased.

Answer: A



Watch Video Solution

9. The diffusion current in a p-n junction is

- A. from the n-side to the p-side
- B. from the p-side to the n-side
- C. from the n-side to the p-side if the junction is forward-biased and in the opposite direction if it is reverse-biased.

D. from the p-side to the n-side if the junction is forward-biased and in the opposite direction if it is reverse-biased.

Answer: B

 [Watch Video Solution](#)

10. Diffusion current in a p-n junction is greater than the drift current in magnitude

- A. if the junction is forward-biased
- B. if the junction is reverse-biased
- C. if the junction is unbiased
- D. in no case.

Answer: A

 [Watch Video Solution](#)

11. A hole diffuses from the p-side to the n-side in a p-n junction. This means that

- A. a bond is broken on the n-side and the electron freed from the bond jumps to the conduction band
- B. a conduction electron on the p-side jumps to a broken bond to complete it
- C. a bond is broken on the p-side and the electron freed from the bond jumps to a broken bond on the p-side to complete it.
- D. a bond is broken on the p-side and the electron freed from the bond jumps to a broken bond on the n-side to complete it.

Answer: C



[Watch Video Solution](#)

12. In a transistor,

- A. the emitter has the least concentration of impurity
- B. the collector has the least concentration of impurity
- C. the base has the least concentration of impurity
- D. all the three regions have equal concentrations of impurity.

Answer: C

 [Watch Video Solution](#)

13. An incomplete sentence about transistors is given below :The emitter-....junction is_ and the collector -...junction is _ .The appropriate words for the dotted empty positions are, respectively

- A. collector'and 'base'
- B. base'and 'emitter'
- C. collector'and 'emitter'
- D. base' and 'base'

Answer: D



[Watch Video Solution](#)

Objective 2

1. In a semiconductor,

- A. there are no free electrons at 0K
- B. there are no free electrons at any temperature
- C. the number of free electrons increases with temperature
- D. the number of free electrons is less than that in a conductor.

Answer: A::B::D



[Watch Video Solution](#)

2. In a p-n junction with open ends,

- A. there is no systematic motion of charge carriers
- B. holes and conduction electrons systematically go from the p-side to the n-side and from the n-side to p-side respectively
- C. there is no net charge transfer between the two sides
- D. there is a constant electric field near the junction .

Answer: B::C::D



Watch Video Solution

3. The impurity atoms with which pure silicon may be increased by

- A. phosphorus
- B. boron
- C. antimony
- D. aluminium

Answer: B::D



[Watch Video Solution](#)

4. The electrical conductivity of pure germanium can be increased by

- A. increasing the temperature
- B. doping acceptor impurities
- C. doping donor impurities
- D. irradiating ultraviolet light on it.

Answer: A::B::C::D



[Watch Video Solution](#)

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

- A. An intrinsic semiconductor
- B. a p-type semiconductor
- C. an n-type semiconductor
- D. a p-n junction

Answer: D

 [Watch Video Solution](#)

6. A semiconductor is doped with a donor impurity
- A. The hole concentration increases.
 - B. The hole concentration decreases.
 - C. The electron concentration increases.
 - D. the electron concentration decreases.

Answer: B::C::D

 [Watch Video Solution](#)

7. Let i_E , I_C and i_B represent the emitter current, the collector current and the base current respectively in a transistor. then

- A. i_C is slightly smaller than i_E
- B. i_C is slightly greater than i_E
- C. i_B is much smaller than i_E
- D. i_B is much greater than i_E .

Answer: A::C



Watch Video Solution

8. In a normal operation of a transistor,

- A. the base-emitter junction is forward-biased
- B. the base-collector junction is forward-biased
- C. the base-emitter junction is reverse-biased

D. the base-collector junction is reverse-biased.

Answer: A::D



[Watch Video Solution](#)

9. An AND gate can be prepared by repetitive use of

A. NOT gate

B. OR gate

C. NAND gate

D. NOR gate

Answer: C::D



[Watch Video Solution](#)

1. In a p-n junction ,

- A. new holes and conduction electrons are produced continuously throughout the material
- B. new holes and conduction electrons are produced continuously throughout the material except in the depletion region
- C. holes and conduction electrons recombine continuously throughout the material
- D. holes and conduction electrons recombine continuously throughout the material except in the depletion region.

Answer: A:D



[Watch Video Solution](#)

1. Calculate the number of states per cubic metre of sodium in 3s band.

The density of sodium is 1013 kg m^{-3} . How many of them are empty?



[Watch Video Solution](#)

2. In a pure semiconductor the number of conduction electrons is

6×10^{19} per cubic metre. How many holes are there in a sample of size

$1 \text{ cm} \times 1 \text{ cm} \times 1 \text{ mm}$?



[Watch Video Solution](#)

3. Indium antimonide has a band gap of 0.23 eV between the valence and

the conduction band. Find the temperature at which kT equal the band

gap.



[Watch Video Solution](#)

4. The band gap for silicon is 1.1eV.(a)Find the ratio of the band gap to kT for silicon at room temperature 300K.(b)At what temperature does this ratio become one tenth of the value at 300K?(Silicon will not retain its structure at these high temperatures.)



[Watch Video Solution](#)

5. When a semiconducting material is doped with an impurity, new acceptor levels are created. In a particular thermal collision, a valence electron receives an energy equal to $2kT$ and just reaches one of the acceptor levels. Assuming that the energy of the electron was at the top edge of the valence band and that the temperature T is equal to 300K, find the energy of the acceptor levels above the valence band.



[Watch Video Solution](#)

6. The band gap between the valence and the conduction bands in zinc oxide (ZnO) is 3.0eV. Suppose an electron in the conduction band

combines with a hole in the valence band and the excess energy is released in the form of electromagnetic radiation. Find the maximum wavelength that can be emitted in this process.

 [Watch Video Solution](#)

7. Suppose the energy liberated in the in the recombination of a hole-electron pair is converted into electromagnetic radiation. If the maximum wavelength emitted is 820nm, What is the band gap?

A. 0.5 e V

B. 2.5 e V

C. 1.5 e V

D. 15 e V

Answer: C

 [Watch Video Solution](#)

8. find the maximum wavelength of electromagnetic radiation which can create a hole-electron pair in germanium. The band gap in germanium is 0.65 eV.



[Watch Video Solution](#)

9. In a photodiode, the conductivity increases when the material is exposed to light. It is found that the conductivity changes only if the wavelength is less than 620 nm. What is the band gap?



[Watch Video Solution](#)

10. Let $(\Delta)E$ denote the energy gap between the valence band and the conduction band. The population of conduction electrons (and of the holes) is roughly proportional to $e^{-\Delta E/2kT}$. Find the ratio of the concentration of conduction electrons in diamond to that in silicon at room temperature 300 K. (ΔE) for silicon is 1.1 eV and for diamond is

6.0eV. How many conduction electrons are likely to be in one cubic meter of diamond ?

 [Watch Video Solution](#)

11. The conductivity of a pure semiconductor is roughly proportional to $\frac{T^3}{2} e^{-\Delta E / 2kT}$ where ΔE is the band gap. The band gap for germanium is 0.74eV at 4K and 0.67eV at 300K. By what factor does the conductivity of pure germanium increase as the temperature is raised from 4K to 300K?

 [Watch Video Solution](#)

12. Estimate the proportion of boron impurity which will increase the conductivity of a pure silicon sample by a factor of 100. Assume that each boron atom creates a hole and the concentration of holes in pure silicon at the same temperature is 7×10^{15} holes per cubic metre. Density of silicon is 5×10^{28} atoms per cubic metre.





Watch Video Solution

13. The product of the hole concentration and the conduction electron concentration turns out to be independent of the amount of any impurity doped. The concentration of conduction electrons in germanium is 6×10^{19} per cubic per cubic metre. When some phosphorus impurity is doped into a germanium sample, the concentration of conduction electrons increases to 2×10^{28} per cubic metre. Find the concentration of the holes in the doped germanium.



Watch Video Solution

14. The conductivity of an intrinsic semiconductor depends of temperature as $(\sigma) = (\sigma_0)e^{-\Delta E/2kT}$, where (σ_0) is a constant. find the temperature at which the conductivity of an intrinsic germanium semiconductor will be double of its value at $T=300$ K. Assume that the gap for germanium is 0.650 eV and remains constant as the temperature os increased.





[Watch Video Solution](#)

15. A semiconducting material has a band gap of 1 eV. Acceptor impurities are doped into it which create acceptor level 1 meV above the valence band. Assume that the transition from one energy level to the other is almost forbidden if kT is less than $1/50$ of the energy gap. Also, if kT is more than twice the gap, the upper levels have maximum population. The temperature of the semiconductor is increased from 0 K. The concentration of the holes increases with temperature and after a certain temperature it becomes approximately constant. As the temperature is further increased the hole concentration again starts increasing at a certain temperature, Find the order of the temperature range in which the hole concentration remains approximately constant.



[Watch Video Solution](#)

16. In a p-n junction, the depletion region is 400 nm wide and an electric field of $5 \times 10^5 \text{ V m}^{-1}$ exists in it (a) Find the height of the potential

barrier, (b) What should be the minimum kinetic energy of a conduction electron which can diffuse from the n-side to the p-side?

 [Watch Video Solution](#)

17. The potential barrier exists across the junction is 0.2 volt. What minimum kinetic energy a hole should have to diffuse from the p-side to the n-side if (a) the junction is unbiased, (b) the junction is forward-biased at 0.1 volt and (c) the junction is reverse-biased at 0.1 volt?

 [Watch Video Solution](#)

18. In a p-n junction, a potential barrier of 250 meV exists across the junction. A hole with a kinetic energy of 300 meV approaches the junction. Find the kinetic energy of the hole when it crosses the junction if the hole approached the junction (a) from the p-side and (b) from the n-side.

 [Watch Video Solution](#)

19. When a p-n junction is reverse-biased, the current becomes almost constant at $25(\mu)\text{A}$. When it is forward biased at 200 mV , a current of $75(\mu)\text{A}$ is obtained. Find the magnitude of diffusion current when the diode is (a) unbiased, (b) reverse-biased at 200 mV and (c) forward-biased at 200 mV .



[Watch Video Solution](#)

20. The drift current in a p-n junction is $2.0(\mu)\text{A}$. Estimate the number of electrons crossing a cross section per second in the depletion region.



[Watch Video Solution](#)

21. The current-voltage characteristic of an ideal p-n junction diode is given by

$$i = i_0(e^{eV/kT} - 1)$$

where the drift current i_0 equals $10(\mu)\text{A}$. Take the temperature T to be

300K.(a)Find the voltage v_0 for which $e^{eV/kT} = 100$. One can neglect the term 1 for voltages greater than this value (b)Find an expression of the dynamic resistance of the diode as a function of V for $V > V_0$.(c)Find the voltage for which the dynamic resistance is $2.0(\Omega)$



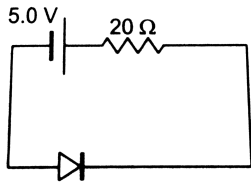
[Watch Video Solution](#)

22. Consider a p-n junction diode having the characteristic $i = i_0(e^{eV/kT} - 1)$ where $i_0 = 20(\mu)A$. The diode is operated at $T=300K$. (a)Find the current through the diode when a voltage of 300 mV is applied across it in forward bias, (b)At what voltage does the current double?



[Watch Video Solution](#)

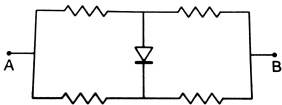
23. Calculate the current through the circuit and the potential difference across the diode shown in figure .The drift current for the diode is $20\mu A$.



[▶ Watch Video Solution](#)

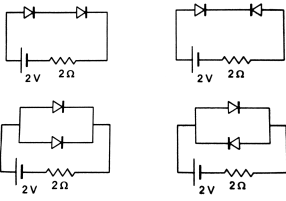
24. Each of the resistance shown in figure has a value of 20Ω . Find the equivalent resistance between A and B. Does it depend on whether the point A or B is at higher potential ?

In problem 25 to 30, assume that the resistance of each diode is zero in forward bias and is infinity in reverse bias.



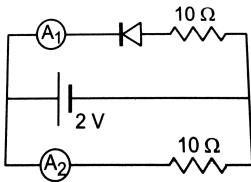
[▶ Watch Video Solution](#)

25. Find the current through the resistance in the circuits shown in figure



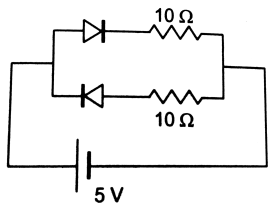
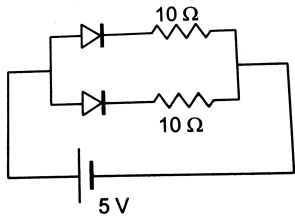
[▶ Watch Video Solution](#)

26. What are the readings of the ammeter A_1 and A_2 shown in figure. Neglect the resistances of the meters.



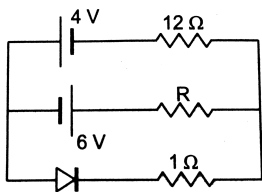
[▶ Watch Video Solution](#)

27. Find the current through the battery in each of the circuit shown in figure



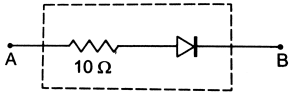
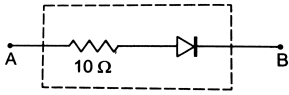
[▶ Watch Video Solution](#)

28. Find the current through the resistance R in figure. If (a) $R = 12\ \Omega$ (b) $R = 48\ \Omega$.



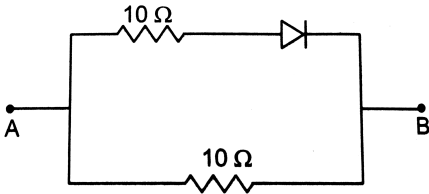
[▶ Watch Video Solution](#)

29. Draw the current-voltage characteristics for the device shown in figure between the terminal A and B.



[▶ Watch Video Solution](#)

30. Find the equivalent resistance of the network shown in figure



[▶ Watch Video Solution](#)

31. When the base current in a transistor is changed from $30\mu A$ to $80\mu A$

A

, thecol $\leq c \rightarrow r$ urrentischan $\geq df$ or $m1.0mA \rightarrow 3.5mA$. $F \in dt$ hecuc

beta`.

 [Watch Video Solution](#)

32. A load resistor of $2k\Omega$ is connected in the collector branch of an amplifier circuit using a transistor in common-emitter mode. The current gain $\beta = 50$. The input resistance of the transistor is $0.50k\Omega$. If the input current is changed by $50\mu A$, (a) by what amount does the output voltage change by, (b) by what amount does the input voltage change and (c) what is the power gain?

 [Watch Video Solution](#)

33. Let $X = \overline{ABC} + \overline{BCA} + \overline{CAB}$. Evaluate X for

(a) $A = 1, B = 0, C = 1$

(b) $A = B = C = 1$

(c) $A = B = C = 0$



[Watch Video Solution](#)



Watch Video Solution

34. Design a logical circuit using AND, OR and NOT gates to evaluate $A\overline{B}\overline{C} + B\overline{C}A$.



Watch Video Solution

35. Show that $AB + \overline{A}\overline{B}$ is always 1.



Watch Video Solution