Semiconductor Electronics and Devices Important Questions With Answers

NEET Physics 2023

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1. In a p-n junction diode, change in temperature due to heating:
   a) Does not affect resistance of p-n junction b) Affects only forward resistance
   c) Affects only reverse resistance **d) Affects the overall V-I characteristics of P-N junction**

   Solution : -
   As a result of heating, temperature increases which generates large number of electron-hole pairs which lead to increase in conductivity. As current increases $I=I_0(e^{-qv/KT})$, overall resistance of diode changes which affects forward and reversed biasing.

2. In a common emitter transistor amplifier the audio signal voltage across the collector is 3 V. The resistance of collector is 3 kΩ If current gain is 100 and the base resistance is 2 kΩ, the voltage and power gain of the amplifier is:
   a) 200 and 1000 b) 15 and 200 **c) 150 and 15000** d) 20 and 2000

   Solution : -
   Given:
   Current gain (β) = 100
   So Voltage gain: $A_v = \beta \times (R_c/R_b)$
   $A_v = 100(3/2) = 150$
   Power gain = $A_v \times \beta$
   Power gain = 150 (100) = 15000
   So correct option is 150 and 15000.

3. For CE transistor amplifier, the audio signal voltage across the collector resistance of 2kΩ is 4V. If the current amplification factor of the transistor is 100 and the base resistance is 1 kΩ, then the input signal voltage is
   a) 10 mV **b) 20 mV** c) 30 mV d) 15 mV

   Solution : -
   Current gain for transistor is given by $\beta=I_C/I_B$ Using Ohm's law for finding output current across collector and input voltage across base of transistor: Given:
   R_C = 2 kΩ
   V_0 = 4 V
   Now $I_C = 4\ V/R_C = 4\ V/2\ k\Omega = 2\ mA$
   Now amplification, $\beta = I_C/I_B = 100$
   Further $I_B = I_C/100 = 2 \times 10^{-5}$ A
   Now input voltage: $V_{in} = I_B \times R_i$
   $= 2 \times 10^{-5} \times 1\ k\Omega = 20$ mV

4. The barrier potential of a P-N junction depends on:
   (1) type of semi conductor material
   (2) amount of doping

(3) temperature

Which one of the following is correct?

a) (2) only b) (2) and (3) only **c) (1), (2) and (3)** d) (1) and (2) only

Solution : -

Barrier potential depends on difference in Fermi levels in n and p sides. If different materials are used, then there is an additional potential from intrinsic difference in electron affinity. It also depends upon temperature.

5. In a common emitter (CE) amplifier having a voltage gain G, the transistor used has trans conductance 0.03 mho and current gain 25. If the above transistor is replaced with another one with trans conductance 0.02 mho and current gain 20, the voltage gain will be:

   a) 2G/3 b) 1.5G c) G/3 d) 5G/4

   Solution : -

   Formula for trans conductance g_m is

   gm= $\frac{\beta}{r_i}$

   Formula for voltage gain A

   A = $\beta \frac{R_L}{r_i}$

   $A=g_mR_L \Rightarrow G=g_mR_L$

   $\Rightarrow G \propto g_m$

   $\Rightarrow \frac{G_2}{G_1} = \frac{g_{m_2}}{g_{m_1}}$

   $\Rightarrow \frac{0.02}{0.03} \times G \Rightarrow \frac{2}{3}$G

6. The input resistance of a silicon transistor is 100 Ω. Base current is changed by 40 μA which results in a change in collector current by 2 mA. This transistor is used as a common emitter amplifier with a load resistance of 4 kΩ. The voltage gain of the amplifier is :

   a) 3000 b) 4000 c) 1000 **d) 2000**

   Solution : -

   We see that current gain (β) :

   $\beta=\Delta I_C/\Delta I_B= 2 \times 10^{-3}/40 \times 10^{-6}= 50$

   Further voltage gain = $\beta (R_{out}/R_{in})$

   $= 50 [4 \times 10^3/100] = 2000$

7. Pure Si at 500 K has equal number of electrons n_e and holes. n_h concentration of 1.5×10^{16} m^{-3}. Doping by Indium increases nh to 4.5×10^{22} m^{-3}. The doped semiconductor is of :

   a) n-type wit electron concentration $n_e = 5 \times 10^{22}$ m^{-3} b) p-type wit electron concentration $n_e = 2.5 \times 10^{10}$ m^{-3}

   c) n-type wit electron concentration $n_e = 2.5 \times 10^{23}$ m^{-3}

   d) n-type wit electron concentration $n_e = 5 \times 10^9$ m^{-3}

   Solution : -

   $(n_i)^2= n_e \times n_h$

   $(1.5 \times 10^{16})^2 = n_e (4.5 \times 10^{22})$

   So $n_e = 5 \times 10^9$

   Now $n_h = 4.5 \times 10^{22}$

   $\Rightarrow n_h >> n_e$

   Hence, semiconductor is p-type and $n_e = 5 \times 10^9 m^{-3}$

8. If a small amount of antimony is added to germanium crystal:

   a) it becomes a p-type semiconductor b) the antimony become an acceptor atom

   c) there will be more free electrons than holes in the semiconductor d) its resistance is increased

   Solution : -

If a small amount of antimony is added to germanium crystal, crystal becomes n-type semiconductor. Hence, there will be more free electrons than holes.

9. In forward biasing of the p-n junction
   a) the positive terminal of the battery is connected to p-side and the depletion region becomes thick
   b) the positive terminal of the battery is connected to n-side and the depletion region becomes thin
   c) the positive terminal of the battery is connected to n-side and the depletion region becomes thick
   d) the positive terminal of the battery is connected to p-side and the depletion region becomes thin

   Solution : -
   In forward biasing of the p-n junction, the positive terminal of the battery is connected to p-side and the negative terminal of the battery is connected to n-side. The depletion region becomes thin.

10. A transistor is operated in common emitter configuration at V_C = 2 V such that a change in the base current from 100 μA - 300 μA produces a change in the collector current from 10 mA to 20 mA. The current gain is :
    a) 50 b) 75 c) 100 d) 25

    Solution : -
    Now current gain
    $\beta = \Delta I_C/\Delta I_B$
    So, β=10 mA/200 μA =500

11. Which one of the following bonds produces a solid that reflects light in the visible region and whose electrical conductivity decreases with temperature and has high melting point?
    a) metallic bonding b) van der Wall's bonding c) ionic bonding d) covalent bonding

    Solution : -
    In case of metal, conductivity decreases with increase in temperature and metal has high melting point.

12. A P-N photodiode is fabricated from a semiconductor with a band gap of 2.5 eV. It can detect a signal of wavelength
    a) 4000 nm b) 6000 nm **c) 4000 Å** d) 6000 Å

    Solution : -
    Now wavelength λ_{max}=hC/E
    λmax = 6.6 x 10^{-34} x 3 x 10^{8}/2.5 x 1.6 x 10^{-19}
    λ_{max} = 5000 Å
    Now the wavelength detected by photo diode be less than λ_{max}, hence it can detect a signal of wave length 4000 Å.

13. A P-N junction photodiode is made of a material with a band gap of 2.0 eV. The minimum frequency of radiation that can be absorbed by the material is nearly:
    a) 10 x 10^{14} Hz **b) 5 x 10^{14} Hz** c) 1 x 10^{14} Hz d) 20 x 10^{14} Hz

    Solution : -
    Energy gap E_g = 2.0 eV
    E_g = 2.0 x 1.6 x 10^{-19}J
    E_g = hf
    f = frequency of radiation
    So, 1 = E_g/h
    f = 3.2 x 10^{-19}/6.625 x 10^{-34} = 5 x 10^{14} Hz

14. A common emitter amplifier has a voltage gain of 50, an input impedance of 100Ω and an output impedance of 200 Ω The power gain of the amplifier is :
    a) 1000 **b) 1250** c) 100 d) 500

    Solution : -

Now Voltage gain= β x Impedance gain
50 = β x (200/100)
β = 25
Power gain = β x Voltage gain
= 25 x 50 = 1250

15. Zener diode is used for:
a) amplification b) rectification **c) stabilisation** d) producing oscillations in an oscillator

Solution : -

At a certain reverse bias voltage, zener diode allows current to flow through it and hence maintains the voltage supplied to any load. Hence, it is used for stabilisation.

16. Choose the only false statement from the following:
a) In conductors, the valence and conduction bands may overlap
b) Substances with energy gap of the order of 10 eV are insulators
c) The resistivity of semiconductor increases with increase in temperature.
d) The conductivity of semiconductor increases with increase in temperature

Solution : -

Option (a) is correct as in conductor conduction and valance band overlap and the conduction band is partially filled.
Option (b) is correct as insulators have energy gap of 5 -10 eV.
Option (c) is incorrect as resistivity decreases with increase in temperature.
Option (d) is correct as with increase in temperature, more and more electrons jump to conduction band, hence conductivity increases.

17. The output of OR gate is 1 :
a) if either input is zero b) if both inputs are zero **c) if either or both input are 1**
d) only if both inputs are 1

Solution : -

It is seen that output of OR gate is Y = A + B. If both or anyone has 1 input then output will be l.

18. In semiconductors, at room temperature:
a) the conduction band is completely empty
b) the valence band is partially empty and conduction band is completely filled
c) the valence band is partially empty and the conduction band is partially filled
d) the valence band is completely filled

Solution : -

In semiconductors, conduction band is empty and valence band is completely filled at 0 K and there will be no electron that can cross from valence band to conduction band at 0 K. At room temperature, certain electrons in valence band will jump over to conduction band due to small forbidden gap as 1 eV.

19. In P-N junction photocell, the value of the photoelectromotive force produced by monochromatic light is proportional to:
a) voltage applied at the P-N junction b) the barrier voltage at the P-N junction
c) intensity of the light falling on the cell d) frequency of the light falling on the cell

Solution : -

Electromotive force depends on intensity of light that falls on it and does not depend on the frequency.

20. Reverse bias applied to a junction diode:
a) increases the minority carrier current b) lower the potential barrier **c) raise the potential barrier**
d) increases the majority carrier current

Solution : -

In reverse bias, the size of the depletion region increases thereby increasing the potential barrier.

21. An N-P-N transistor conducts when:

a) both collector and emitter :are negative with respect to the base.

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

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

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

Solution : -

When the collector is positive and emitter is negative w.r.t. base, it causes forward biasing for each junction, which causes conduction of current.

22. If a full wave rectifier circuit is operating from 50 Hz mains, the fundamental frequency in the ripple will be.

a) 100 Hz b) 25 Hz c) 50 Hz d) 70.7 Hz

Solution : -

In case of full wave rectifier,

Fundamental frequency = 2 x main frequency

= 2 x 50 =100 Hz

23. In p-n junction:

a) The potential of the p and n side becomes higher alternately

b) The p-side is at higher electrical potential than the n-side

c) The n-side is at higher electrical potential than the p-side

d) Both the p and n sides are at the same potential

Solution : -

For conduction, p-n junction must be forward biased. For this p-side should be connected to higher potential and n-side to lower potential.

24. For a common emitter circuit if I_C/I_E = 0.98 then current gain for common emitter circuit will be.

a) 49 b) 98 c) 4.9 d) 25.5

Solution : -

$\beta=\frac{\alpha}{1-\alpha}$

$\beta=\frac{0.98}{1-98}$ $(\because \propto=\frac{\triangle I_C}{\triangle I_E}=0.98)$

$\beta=49$

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

a) a p-n junction b) an intrinsic semi-conductor c) a p-tpe semi-conductor d) an n-type semiconductor

Solution : -

In reverse bias, the current through a p-n junction is almost zero.

26. When an n-p-n transistor is used as an amplifier then:

a) the electrons flow from emitter to collector b) the holes flow from emitter to collector

c) the electrons flow from collector to emitter d) the electrons flow from battery to emitter

Solution : -

In n-p-n transistor, charge carriers are free electrons which tends to flow from emitter to collector.

27. When Arsenic is added as an impurity to silicon the resulting material is:

a) n-type semiconductor b) p-type semiconductor c) n-type conductor d) insulator

Solution : -

Arsenic contains 5 electrons in its outermost shell. When Arsenic is doped in silicon there is one electron extra in Silicon Crystal. Hence, such type of semi conductor is n-type semiconductor.

28. Which of the following is added as an impurity, into the silicon, produces n-type semiconductor?
a) Phosphorous b) Aluminium c) Magnesium d) Both b and c

Solution : -
From above options, phosphorous is pentavalent while silicon is tetravalent. When silicon is doped with pentavalent impurity, it forms n-type semiconductor

29. An oscillator is nothing but an amplifier with:
a) positive feedback b) negative feedback c) large gain d) no feedback

Solution : -
A positive feedback from output to input in an amplifier provides oscillations of constant amplitude.

30. When p-n junction diode is reverse biased the flow of current across the junction is mainly due to:
a) diffusion of charges **b) drift of charges** c) depends on the nature of material
d) both drift and diffusion of charges

Solution : -
When p-n junction is reverse biased, the flow of current is due to drifting of thermally generated charge carriers across the junction.

31. The part of the transistor which is heavily doped to produce large number of majority carriers is:
a) emitter b) base c) collector d) any of the above depending upon the nature of transistor

Solution : -
Function of emitter is to supply the majority carriers, hence it is heavily doped.

32. A piece of copper and other of germanium are cooled from room temperature to 80 K, then:
a) resistance of each will increase b) resistance of copper will decrease
c) resistance of copper will increase while that of germanium will decrease
d) resistance of copper will decrease while that of germanium will increase

Solution : -
Copper is a conductor, so, its resistance decreases on decreasing temperature as thermal oscillations decreases, where as germanium is semiconductor, therefore, on decreasing temperature resistance increases.

33. 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

Solution : -
Diffusion of charge carriers.

34. When n-type semiconductor is heated:
a) number of electrons increases while that of holes decreases
b) number of holes increases while that of electrons decreases
c) number of electrons and holes remain same **d) number of electrons and holes increases equally**

Solution : -
Due to heating, when a free electron is produced then Simultaneously a hole is also produced.

35. In good conductors of electricity the type of bonding that exist is
a) Van der Walls b) covalent c) ionic **d) metallic**

36. The manifestation of band structure in solids is due to
a) Heisenberg uncertainty principle **b) Pauli's exclusion principle** c) Bohr's correspondence principle
d) Boltzmann law

Solution : -

According to the Pauli's exclusion principle, the electronic configuration of number of subshells existing in a shell and number of electrons entering each subshell is found. Hence, on the basis of the Pauli' s exclusion principle, manifestation of band structure in solids can be explained

37. If the energy of a photon of sodium light (λ = 589 nm) equals the band gap of semiconductor, the minimum energy required to create hole electron pair

a) 1.1eV **b) 2.1eV** c) 3.2eV d) 1.5eV

Solution : -

$$Using, \quad E = E_g = \frac{hc}{\lambda}$$

$$= \frac{6.6\times10^{-34}\times3\times10^{8}}{589\times10^{-9}} J$$

$$= \frac{6.6\times10^{-34}\times3\times10^{8}}{589\times10^{-9}\times1.6\times10^{-19}} eV = 2.1eV$$

38. Find the wavelength of light that may excite an electron in the valence band of diamond to the conduction band. The energy gap is 5.50 eV.

a) 226 nm b) 312 nm c) 432 nm d) 550 nm

Solution : -

Energy gap, $E_g = \frac{hc}{\lambda}; \lambda = \frac{hc}{E_g}$

Here, energy gap = 5.50 eV

Take hc = 1240 eV nm

$$\therefore \lambda = \frac{1240 \quad eV \quad nm}{5.5eV} = 226 \quad nm$$

39. The maximum wavelength of electromagnetic radiation, which can create a hole-electron pair in germanium. (Given that forbidden energy gap in germanium is 0.72 eV)

a) 1.7 x 10^{-6} m b) 1.5 x 10^{-5} m c) 1.3 x 10^{-4} m d) 1.9 x 10^{-5} m

Solution : -

Here, E_g = 0.72 eV = 0.72 x 1.6 x 10^{-19} J If λ is the maximum wavelength of electromagnetic radiation which can create a hole-electron pair in germanium, then $E_g = \frac{hc}{\lambda}$

$$or \quad \lambda = \frac{hc}{E_g} = \frac{6.62\times10^{-34}\times3\times10^{8}}{0.72\times1.6\times10^{-19}} = 1.7\times10^{-6} m$$

40. The probability of electrons to be found in the conduction band of an intrinsic semiconductor of finite temperature

a) increases exponentially with increasing band gap.

b) decreases exponentially with increasing band gap. c) decreases with increasing temperature.

d) is independent of the temperature and band gap.

41. Which of the following equations correctly represents the temperature variation of energy gap between the conduction and valence bands for Si?

a) E_g(T) = 0.70 - 2.23 x 10^{-4}T eV b) E_g(T) = 0.70 + 2.23 x 10^{-4}T eV **c) E_g(T) = 1.10 - 3.60 x 10^{-4}T eV**

d) E_g(T) = 1.10 + 3.60 x 10^{-4}T eV

Solution : -

The energy gap E_g depends on the temperature.

For silicon, E_g(T)= 1.10 - 3.60 x 10^{-4}T eV

For germanium, E_g(T)= 0.70 - 2.23 x 10^{-4}T eV

42. An intrinsic semiconductor has a resistivity of 0.50 Ω m at room temperature. Find the intrinsic carrier concentration if the mobilities of electrons and holes are 0.39 $m^2 V^{-1} S^{-1}$ and 0.11 $m^2 V^{-1} S^{-1}$ respectively:

a) 1.2 x 10^{18} m^{-3} **b) 2.5 x 10^{19} m^{-3}** c) 1.9 x 10^{20} m^{-3} d) 3.1 x 10^{21} m^{-3}

Solution : -

$Here, \quad \rho = 0.50\Omega m$

$\mu_c = 0.39 \quad m^2V^{-1}s^{-1}$

$\mu_h = 0.11 \quad m^2V^{-1}s^{-1}$

The resistivity of intrinsic semiconductor is

$\frac{1}{\rho} = e(n_i\mu_e + n_i\mu_h)$

where n_i is the intrinsic carrier concentration

$\therefore n_i = \frac{1}{\rho e(\mu_e+\mu_h)}$

Substituting the given values, we get

$n_i = \frac{1}{(0.5)(1.6\times1-^{-19})(0.39+0.11)} = 2.5\times10^{19}m^{-3}$

43. In pure semiconductor, the number of conduction electrons is 6 x 10^{18} per cubic metre. How many holes are there in a sample of size 1 cm x 1 cm x 1 mm?

a) 3 x 10^{10} **b) 6 x 10^{11}** c) 3 X 10^{11} d) 6 x 10^{10}

Solution : -

Here,n_e=6x$10^{18}$$m^{-3}$

Volume of the sample = 1 cm x 1 cm x 1 mm = 10^{-7} m^3

Number of holes in the sample = Number of electrons in the sample

= n_e x V = 6 X10^{18}X 10^{-7} = 6 X 10^{11}

44. Mobilities of electrons and holes in a sample of intrinsic germanium at room temperature are 0.54 $m^2 V^{-1} s^{-1}$ and 0.18 $m^2 V^{-1} s^{-1}$ respectively. If the electron and hole densities are equal to 3.6 x 10^{19} m^{-3} the germanium conductivity is

a) 4.14 Sm^{-1} b) 2.12 Sm^{-1} c) 1.13 Sm^{-1} d) 5.6 Sm^{-1}

Solution : -

$As \quad \sigma = e(n_e\mu_c + n_n\mu_n)$

$= en_i(\mu_c + \mu_n)$

= 1.6 X 10^{-19} x 3.6 x 10^{19}(0.54 + 0.18) = 4.147 S m^{-1}

45. A block of pure silicon at 300 K has a length of 10 cm and an area of 1.0 cm^2. A battery of emf 2 V is connected across it. The mobility of electrons is 0.14 $m^2 V^{-1} S^{-1}$and their number density is 1.5 x $10^{16}$$m^{-3}$ • The electron current is

a) 6.72 x 10^{-4}A b) 6.72 x 10^{-5} A c) 6.72 X 10^{-6}A **d) 6.72 x 10^{-7} A**

Solution : -

$As \quad E = \frac{V}{l} = \frac{2V}{0.1m} = 20 \quad Vm^{-1}$

$A = 1.0 \quad cm^2 = 1.0\times10^{-4}m^2$

$v_e = \mu_e E = 0.14\times20 = 2.8 \quad ms^{-1}$

The electron current is

$I_e = n_eAev_e$

= (1.5 x 10^{16}) x (1.0 x 10^{-4}) x (1.6 x 10^{-19}) x 2.8

= 6.72 x 10^{-7} A

46. In n-type semiconductor when all donor states are filled, then the net charge density in the donor states becomes

a) 1 **b) >1** c) <1, but not zero d) zero

Solution : -

If all the donor states in n-type semiconductor are filled, the number of electrons in donor states will increase. Due to it, the charge density in donor states will become more than one.

47. A pure Si crystal has 5 x 10^{22}atoms m^{-3}.It is doped by 1 ppm concentration of pentavalent As. The number of holes is ($n_i^2 = n_pn_e$) (Take n_i = 1.5 x $10^{16}$$m^{-3}$

a) 4.5 x 10^9m^{-3} b) 4.5 x 10^6m^{-3} c) 2.5 x 10^9m^{-3} d) 2.5 x 10^6m^{-3}

Solution : -

The electron and holes concentration semiconductor in thermal equilibrium is

$$n_e n_h = n_i^2$$

$$or \quad n_h = \frac{n_i^2}{n_e}$$

$$Here, \quad n_i = 1.5 \times 10^{16} m^{-3}, n_e = 5 \times 10^{23} m^{-3}$$

$$\therefore n_h = \frac{(1.5 \times 10^{16})^2}{(5 \times 10^{22})} = \frac{2.5 \times 10^{32}}{5 \times 10^{22}} = 4.5 \times 10^9 m^{-3}$$

48. A semiconductor has equal electron and hole concentration of 6 x 10^8 per m^3 . On doping with certain impurity, electron concentration increases to 9 x 10^{12}per m^3. The new hole concentration is

a) 2x10^4per m^3 b) 2x10^2per m^3 **c) 4 x 10^4per m^3** d) 4 x 10^2per m^3

Solution : -

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

$$Here, \quad n_i = 6 \times 10^8 \quad per \quad m^3 and \quad n_e = 9 \times 10^{12} per \quad m^3$$

$$\therefore n_h = \frac{(6 \times 10^8)^2}{(9 \times 10^{12})} = 4 \times 10^4 per \quad m^3$$

49. Region without free electrons and holes in a p-n junction is

a) n-region b) p-region **c) depletion region** d) none of these

Solution : -

The depletion region created at the junction is devoid of free charge carriers.

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

a) 10 x 10^9 m^{-3} **b) 8.89 x 10^9 m^{-3}** c) 11 x 10^9 m^{-3} d) 16.78 x 10^9 m^{-3}

Solution : -

$$Using, \quad n_e = n_i^2$$

$$Here, \quad n_i = 2 \times 10^{16} m^{-3}, \rho = 4.5 \times 10^{22} m^{-3}$$

$$\therefore n = \frac{n_i^2}{\rho} = \frac{(2 \times 10^{16})^2}{4.5 \times 10^{22}} = 8.89 \times 10^9 m^{-3}$$