

Semiconductor Electronics: Materials, Devices and Simple Circuits — NEET Physics PYQ (2005-2021)

Class 12 Physics · 24 real NEET & AIPMT questions, year-tagged · answers checked by RankUp

NEET 2021

1. The electron concentration in an n-type semiconductor is the same as hole concentration in a p-type semiconductor. An external field (electric) is applied across each of them. Compare the currents in them.

- (A) current in n-type = current in p-type.
- (B) current in p-type > current in n-type.
- (C) current in n-type > current in p-type.
- (D) No current will flow in p-type, current will only flow in n-type.

NEET 2020 · Q153

2. The increase in the width of the depletion region in a p-n junction diode is due to :

- (A) forward bias only
- (B) reverse bias only
- (C) both forward bias and reverse bias
- (D) increase in forward current

NEET 2019 · Q18

3. For a p-type semiconductor, which of the following statements is true?

- (A) Electrons are the majority carriers and trivalent atoms are the dopants.
- (B) Holes are the majority carriers and trivalent atoms are the dopants.
- (C) Holes are the majority carriers and pentavalent atoms are the dopants.
- (D) Electrons are the majority carriers and pentavalent atoms are the dopants.

NEET 2018 · Q16

4. 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

NEET 2017 · Q174

5. In a common emitter transistor amplifier the audio signal voltage across the collector is 3 V. The resistance of collector is 3 k Ω . If current gain is 100 and the base resistance is 2 k Ω , 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

AIPMT 2014

6. The barrier potential of a p-n junction depends on: (a) type of semi conductor material (b) amount of doping (c) temperature. Which one of the following is correct?

- (A) (b) only
- (B) (b) and (c) only
- (C) (a), (b) and (c)
- (D) (a) and (b) only

NEET 2013

7. In an n-type semiconductor, which of the following statements is true?

- (A) Electrons are majority carriers and trivalent atoms are dopants
- (B) Electrons are minority carriers and pentavalent atoms are dopants
- (C) Holes are minority carriers and pentavalent atoms are dopants
- (D) Holes are majority carriers and trivalent atoms are dopants

AIPMT 2012 Mains

8. The input resistance of a silicon transistor is $100\ \Omega$. Base current is changed by $40\ \mu\text{A}$ which results in a change in collector current by $2\ \text{mA}$. This transistor is used as a common emitter amplifier with a load resistance of $4\ \text{k}\Omega$. The voltage gain of the amplifier is

- (A) 2000
- (B) 3000
- (C) 4000
- (D) 1000

AIPMT 2012 Prelims

9. In a CE transistor amplifier, the audio signal voltage across the collector resistance of $2\ \text{k}\Omega$ is $2\ \text{V}$. If the base resistance is $1\ \text{k}\Omega$ and the current amplification of the transistor is 100, the input signal voltage is

- (A) $10\ \text{mV}$
- (B) $0.1\ \text{V}$
- (C) $1.0\ \text{V}$
- (D) $1\ \text{mV}$

AIPMT 2012 Prelims

10. C and Si both have same lattice structure, having 4 bonding electrons in each. However, C is insulator where as Si is intrinsic semiconductor. This is because

- (A) The four bonding electrons in the case of C lie in the third orbit, whereas for Si they lie in the fourth orbit
- (B) In case of C the valance band is not completely filled at absolute zero temperature
- (C) In case of C the conduction band is partly filled even at absolute zero temperature
- (D) The four bonding electrons in the case of C lie in the second orbit, whereas in the case of Si they lie in the third

AIPMT 2011 Mains

11. Pure Si at $500\ \text{K}$ has equal number of electron (n_e) and hole (n_h) concentrations of $1.5 \times 10^{16}\ \text{m}^{-3}$. Doping by indium increases n_h to $4.5 \times 10^{22}\ \text{m}^{-3}$. The doped semiconductor is of

- (A) n-type with electron concentration $n_e = 2.5 \times 10^{23}\ \text{m}^{-3}$
- (B) p-type having electron concentration $n_e = 5 \times 10^9\ \text{m}^{-3}$
- (C) n-type with electron concentration $n_e = 2.5 \times 10^{22}\ \text{m}^{-3}$
- (D) p-type with electron concentration $n_e = 2.5 \times 10^{10}\ \text{m}^{-3}$

AIPMT 2011 Prelims

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

- (A) Its resistance is increased
- (B) It becomes a p-type semiconductor
- (C) The antimony becomes an acceptor atom
- (D) There will be more free electrons than holes in the semiconductor

AIPMT 2011 Prelims

13. 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 thin
- (B) The positive terminal of the battery is connected to p-side and the depletion region becomes thick
- (C) The positive terminal of the battery is connected to n-side and the depletion region becomes thin
- (D) The positive terminal of the battery is connected to n-side and the depletion region becomes thick

14. For transistor action

- (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-base junction is forward biased and base-collector junction is reverse biased.
- (d) Both the emitter-base junction as well as the base collector junction are forward biased.

Which one of the following pairs of statements is correct?

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

15. A common emitter amplifier has a voltage gain of 50, an input impedance of 100 Ω and an output impedance of 200 Ω . The power gain of the amplifier is

- (A) 50
- (B) 500
- (C) 1000
- (D) 1250

16. 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) Covalent bonding
- (B) Metallic bonding
- (C) van der Waal's bonding
- (D) Ionic bonding

17. The device that can act as a complete electronic circuit is

- (A) Zener diode
- (B) Junction diode
- (C) Integrated circuit
- (D) Junction transistor

18. Which of the following statements is false?

- (A) The resistance of intrinsic semiconductor decreases with increase of temperature
- (B) Pure Si doped with trivalent impurities gives a p-type semiconductor
- (C) Majority carriers in an n-type semiconductor are holes
- (D) Minority carriers in a p-type semiconductor are electrons

19. 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 $\text{\AA}$
- (D) 6000 $\text{\AA}$

20. A transistor is operated in common-emitter configuration at $V_c = 2\text{ V}$ such that a change in the base current from $100\text{ }\mu\text{A}$ to $200\text{ }\mu\text{A}$ produces a change in the collector current from 5 mA to 10 mA . The current gain is:

- (A) 100
- (B) 150
- (C) 50
- (D) 75

21. A p-n photodiode is made of a material with a band gap of 2.0 eV . The minimum frequency of the radiation that can be absorbed by the material is nearly

- (A) $20 \times 10^{14}\text{ Hz}$
- (B) $10 \times 10^{14}\text{ Hz}$
- (C) $5 \times 10^{14}\text{ Hz}$
- (D) $1 \times 10^{14}\text{ Hz}$

22. With which one of the following elements silicon should be doped so as to give p-type of semiconductor?

- (A) Boron
- (B) Germanium
- (C) Arsenic
- (D) Selenium

23. Carbon, silicon and germanium atoms have four valence electrons each. Their valence and conduction bands are separated by energy band gaps represented by $(E_g)_C$, $(E_g)_{Si}$ and $(E_g)_{Ge}$ respectively. Which one of the following relationships is true in their case ?

- (A) $(E_g)_C > (E_g)_{Si}$
- (B) $(E_g)_C = (E_g)_{Si}$
- (C) $(E_g)_C < (E_g)_{Ge}$
- (D) $(E_g)_C < (E_g)_{Si}$

24. Choose the only false statement from the following :

- (A) Substances with energy gap of the order of 10 eV are insulators
- (B) The conductivity of a semiconductor increases with increases in temperature
- (C) In conductors the valence and conduction bands may overlap
- (D) The resistivity of a semiconductor increases with increase in temperature

Answer key and explanations

1. Answer: (C) current in n-type > current in p-type.

Current density $J = ne\mu E$; with equal carrier concentration and the same field, the current depends on mobility. Electrons have higher mobility than holes, so the n-type sample carries more current. Holes do conduct, so p-type current is not zero.

2. Answer: (B) reverse bias only

A reverse bias adds to the barrier potential and pulls majority carriers away from the junction, so the depletion region widens. Forward bias opposes the barrier and narrows the depletion layer, which is also why forward current rises.

3. Answer: (B) Holes are the majority carriers and trivalent atoms are the dopants.

A p-type semiconductor is made by doping with trivalent (acceptor) atoms, which create holes; holes are therefore the majority carriers. Pentavalent dopants produce n-type material with electrons as majority carriers.

4. Answer: (D) affects the overall V - I characteristics of p-n junction

Heating generates more electron-hole pairs, which changes the reverse saturation current, the barrier potential and the forward current. Hence both forward and reverse behaviour, i.e. the whole V-I characteristic, change; it is not limited to one bias direction.

5. Answer: (C) 150 and 15000

Voltage gain $A_V = \beta \times R_C/R_B = 100 \times 3/2 = 150$, and power gain $= \beta \times A_V = 100 \times 150 = 15000$. The 3 V signal value is not needed.

6. Answer: (C) (a), (b) and (c)

The barrier potential depends on the semiconductor (about 0.7 V for Si, 0.3 V for Ge), increases with doping, and falls as temperature rises. So all three factors matter.

7. Answer: (C) Holes are minority carriers and pentavalent atoms are dopants

An n-type semiconductor is made by doping with pentavalent atoms (e.g. P, As), which donate electrons. Electrons become the majority carriers and holes the minority carriers. Trivalent dopants would give p-type material.

8. Answer: (A) 2000

Current gain $\beta = \Delta I_C/\Delta I_B = 2 \text{ mA}/40 \text{ } \mu\text{A} = 50$. Voltage gain $= \beta \times R_L/R_{in} = 50 \times 4000/100 = 2000$.

9. Answer: (A) 10 mV

Voltage gain of a CE amplifier $= \beta(R_C/R_B) = 100 \times (2 \text{ k}\Omega/1 \text{ k}\Omega) = 200$. Input voltage $= \text{output}/\text{gain} = 2 \text{ V}/200 = 0.01 \text{ V} = 10 \text{ mV}$. Taking 0.1 V comes from using only the resistance ratio or only β instead of their product.

10. Answer: (D) The four bonding electrons in the case of C lie in the second orbit, whereas in the case of Si they lie in the third

Carbon's four bonding electrons are in the second shell ($n = 2$) and silicon's in the third ($n = 3$). The more tightly bound carbon electrons give a much larger band gap (about 5.5 eV vs 1.1 eV), so diamond is an insulator. A partly filled band at absolute zero would make carbon a conductor, not an insulator.

11. Answer: (B) p-type having electron concentration $n_e = 5 \times 10^9 \text{ m}^{-3}$

Indium is trivalent, so the doped crystal is p-type. By the mass-action law $n_e = n_i^2/n_h = (1.5 \times 10^{16})^2/(4.5 \times 10^{22}) = 2.25 \times 10^{32}/4.5 \times 10^{22} = 5 \times 10^9 \text{ m}^{-3}$. The n-type choices are wrong because an acceptor dopant was added.

12. Answer: (D) There will be more free electrons than holes in the semiconductor

Antimony is pentavalent; in germanium it donates an extra electron, making an n-type semiconductor with free electrons as majority carriers. It is a donor, not an acceptor, and doping lowers the resistance rather than increasing it.

13. Answer: (A) The positive terminal of the battery is connected to p-side and the depletion region becomes thin

In forward bias, the p-side is connected to the positive terminal; this opposes the built-in field and narrows the depletion region, letting current flow. Connecting the positive terminal to the n-side is reverse bias, which widens the depletion layer.

14. Answer: (C) (b), (c)

A transistor works because the base is very thin and lightly doped, and in active mode the emitter-base junction is forward biased while the collector-base junction is reverse biased. The regions are deliberately unequal in size and doping, and forward-biasing both junctions puts the transistor in saturation, not normal transistor action.

15. Answer: (D) 1250

Voltage gain $A_V = \beta \times (R_{out}/R_{in})$, so $\beta = 50 \times 100/200 = 25$. Power gain $= A_V \times \beta = 50 \times 25 = 1250$. Taking the power gain equal to the voltage gain (50) ignores the current gain.

16. Answer: (B) Metallic bonding

Metallic solids reflect visible light (lustre), have high melting points and their conductivity falls as temperature rises because lattice vibrations scatter the free electrons. Covalent and ionic solids are poor conductors whose conductivity, if any, increases with temperature.

17. Answer: (C) Integrated circuit

An integrated circuit contains many transistors, diodes, resistors and capacitors on one chip, so it can work as a complete circuit. A diode or a single transistor is just one component.

18. Answer: (C) Majority carriers in an n-type semiconductor are holes

In n-type semiconductors the majority carriers are electrons, not holes, so that statement is false. Intrinsic resistance does fall with temperature, trivalent doping does give p-type, and electrons are minority carriers in p-type.

19. Answer: (C) 4000 Å

The longest detectable wavelength is $\lambda = hc/E_g = 1240 \text{ eV nm}/2.5 \text{ eV} \approx 496 \text{ nm} \approx 5000 \text{ Å}$. Only photons of shorter wavelength have enough energy, so 4000 Å (400 nm) is detected. 6000 Å and the nm values of 4000 and 6000 are all longer than the cut-off.

20. Answer: (C) 50

Current gain $\beta = \Delta I_c / \Delta I_b = (10 - 5) \text{ mA} / (200 - 100) \mu\text{A} = 5 \times 10^{-3} \text{ A} / 10^{-4} \text{ A} = 50$. A value of 100 or more comes from mishandling the milli and micro prefixes.

21. Answer: (C) $5 \times 10^{14} \text{ Hz}$

The photon must at least bridge the band gap: $\nu = E_g/h = (2.0 \times 1.6 \times 10^{-19}) / (6.63 \times 10^{-34}) \approx 4.8 \times 10^{14} \text{ Hz} \approx 5 \times 10^{14} \text{ Hz}$. $10 \times 10^{14} \text{ Hz}$ would correspond to a 4 eV gap.

22. Answer: (A) Boron

A trivalent dopant such as boron has one electron too few to complete the four bonds with silicon, which creates holes, the majority carriers in a p-type semiconductor. Arsenic is pentavalent and gives n-type, while germanium is tetravalent like silicon and creates no extra carriers.

23. Answer: (A) $(E_g)_C > (E_g)_{Si}$

Band gaps fall down group 14: carbon (diamond) $\approx 5.5 \text{ eV}$, Si $\approx 1.1 \text{ eV}$, Ge $\approx 0.7 \text{ eV}$. So $(E_g)_C > (E_g)_{Si}$; diamond is an insulator, not a material with a smaller gap.

24. Answer: (D) The resistivity of a semiconductor increases with increase in temperature

In a semiconductor more electrons cross the band gap as temperature rises, so conductivity increases and resistivity decreases. The statement that resistivity increases with temperature is therefore the false one; the other three are true.

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