Semiconductor Electronics: Materials, Devices and Simple Circuits

Class 12 Physics · 24 NEET MCQs with answers & explanations

Semiconductor Electronics covers intrinsic and extrinsic semiconductors, p-n junction diode, LED, photodiode, solar cell, Zener diode, transistor (npn, pnp) and logic gates. NEET tests p-n junction behaviour (forward/reverse bias), transistor as amplifier/switch, logic gate truth tables and semiconductor band theory.

Key Semiconductor Concepts

Concept	Key Fact
n-type semiconductor	Doped with pentavalent (P, As); majority carriers = electrons
p-type semiconductor	Doped with trivalent (B, Al); majority carriers = holes
p-n junction	Forward bias: current flows (low resistance); Reverse bias: no current (high resistance, only leakage)
Zener diode	Reverse bias breakdown at fixed voltage; used as voltage regulator
Transistor	npn/pnp; CE config: current gain β = I_C/I_B; used as amplifier and switch
Logic gates	AND: A·B; OR: A+B; NOT: Ā; NAND: universal gate; NOR: universal gate

Questions

Q1. In an intrinsic semiconductor at absolute zero temperature (0 K), which of the following correctly describes its electrical behaviour?

(A) It behaves as a perfect insulator because no electrons exist in the conduction band
(B) It behaves as a conductor because electrons are free to move
(C) It behaves as a p-type semiconductor due to hole dominance
(D) It behaves as an n-type semiconductor due to excess electrons

Q2. Which energy band contains the energy levels occupied by the valence electrons of a solid?

(A) Conduction band
(B) Valence band
(C) Forbidden band
(D) Donor band

Q3. In a common-emitter NPN amplifier, the input signal is applied between the base and emitter. The output signal at the collector is:

(A) In phase with the input
(B) 180° out of phase with the input
(C) 90° out of phase with the input
(D) 270° out of phase with the input

Q4. Choose the INCORRECT statement regarding conductors, semiconductors and insulators.

(A) In conductors, the valence and conduction bands may overlap
(B) Substances with energy gap of about 5 to 10 eV are generally insulators
(C) The resistivity of a semiconductor increases when temperature is increased
(D) The conductivity of a semiconductor increases when temperature is increased

Q5. In an intrinsic semiconductor at a given temperature, the number of free electrons is:

(A) Greater than the number of holes
(B) Equal to the number of holes
(C) Less than the number of holes
(D) Always zero

Q6. When a p-type and n-type semiconductor are joined, the initial movement of majority carriers across the junction occurs mainly because of:

(A) Attraction by an external battery
(B) Magnetic force on charge carriers
(C) Difference in carrier concentration across the junction
(D) Gravitational force on charge carriers

Q7. A p-n junction diode is said to be forward biased when:

(A) p-side is connected to the negative terminal and n-side to the positive terminal
(B) p-side is connected to the positive terminal and n-side to the negative terminal
(C) Both sides are connected to positive terminals of the same battery
(D) No external battery is connected to the junction

Q8. In a full-wave rectifier operating from a 50 Hz AC supply, the fundamental frequency of the rectified output is:

(A) 100 Hz
(B) 50 Hz
(C) 25 Hz
(D) 70.7 Hz

Q9. A transistor is used as a switch in common-emitter configuration. Which two regions of operation correspond to the OFF and ON states respectively?

(A) Cut-off and active
(B) Cut-off and saturation
(C) Active and saturation
(D) Active and cut-off

Q10. A Boolean circuit has output Y = (A+B)-bar. Which pair of gates directly implements this function?

(A) AND followed by NOT
(B) NOR followed by NOT
(C) OR followed by NOT
(D) NAND followed by NOT

Q11. As the temperature increases, the electrical resistance of a semiconductor generally:

(A) Increases
(B) Decreases
(C) Remains constant
(D) First increases and then decreases

Q12. In an n-p-n transistor operating in the active region, the collector is at a higher potential than the base and emitter. Which bias condition does this satisfy?

(A) Emitter-base junction reverse biased and collector-base junction forward biased
(B) Emitter-base junction forward biased and collector-base junction reverse biased
(C) Both junctions forward biased
(D) Both junctions reverse biased

Q13. A two-input NAND gate has inputs A = 1 and B = 1. Its output is:

(A) 1
(B) Depends on frequency
(C) Depends on supply voltage
(D) 0

Q14. A Zener diode is specifically designed to operate in which region when used as a voltage regulator?

(A) Reverse breakdown region
(B) Forward-bias region
(C) Zero-current region
(D) Ordinary reverse-bias region without breakdown

Q15. A transistor has a common-base current gain $\alpha = 0.96$. The common-emitter current gain β is:

(A) 6
(B) 12
(C) 24
(D) 48

Q16. When a pure semiconductor is doped with a pentavalent impurity, the resulting semiconductor is:

(A) intrinsic
(B) insulating
(C) n-type
(D) p-type

Q17. In a p-n junction diode, an increase in temperature due to heating affects:

(A) Only the forward resistance of the diode
(B) Only the reverse resistance of the diode
(C) Neither the forward nor the reverse characteristic
(D) The overall V-I characteristic of the p-n junction

Q18. On the basis of electrical conductivity, which material has the smallest resistivity?

(A) Germanium
(B) Glass
(C) Silver
(D) Silicon

Q19. A semiconductor is best described as a material whose electrical conductivity at ordinary conditions is:

(A) Equal to that of an ideal conductor
(B) Always zero
(C) Intermediate between a good conductor and an insulator
(D) Higher than that of every metal

Q20. Which statement correctly distinguishes a semiconductor from an ordinary metallic conductor?

(A) Heating generally decreases semiconductor resistance but increases metallic resistance
(B) Heating increases the resistance of both materials in the same manner
(C) Semiconductor resistance is independent of temperature
(D) Metallic resistance decreases with temperature while semiconductor resistance increases

Q21. In an intrinsic semiconductor, as temperature is raised from room temperature, which of the following correctly describes the change in mobile carriers and conductivity?

(A) Both the number of mobile carriers and conductivity increase
(B) Both the number of mobile carriers and conductivity decrease
(C) Number of mobile carriers increases but conductivity decreases
(D) Number of mobile carriers decreases but conductivity increases

Q22. Which statement correctly compares the resistivity of a semiconductor with that of silver at room temperature?

(A) Semiconductor resistivity is much higher than that of silver
(B) Semiconductor resistivity is lower than that of silver
(C) Semiconductor and silver have equal resistivity at all temperatures
(D) Semiconductor resistivity is independent of temperature

Q23. Consider the following statements about semiconductors: I. Conductivity generally increases with temperature. II. Resistance generally decreases with temperature. III. Conductivity is always greater than metallic conductivity. IV. Silicon is a commonly used semiconductor. How many of the above statements are correct?

(A) Only 1
(B) Only 2
(C) Only 3
(D) All 4

Q24. Which of the following statements about semiconductor resistivity is correct?

(A) It is always lower than the resistivity of metals
(B) It is independent of temperature
(C) It generally decreases as temperature increases
(D) It becomes exactly zero when temperature is sufficiently increased

Answer key

1-A	2-B	3-B	4-C	5-B	6-C	7-B	8-A
9-B	10-C	11-B	12-B	13-D	14-A	15-C	16-C
17-D	18-C	19-C	20-A	21-A	22-A	23-C	24-C

Answers with explanations

Q1 — Answer: (A) It behaves as a perfect insulator because no electrons exist in the conduction band
At 0 K, all electrons are tightly bound in the valence band and the conduction band is completely empty, making the material a perfect insulator. Options C and D are wrong because intrinsic semiconductors have no dopants to create n-type or p-type behaviour.

Q2 — Answer: (B) Valence band
The valence band contains the energy levels of valence electrons. The conduction band lies above it and contains electrons free for conduction. The forbidden band has no allowed states.

Q3 — Answer: (B) 180° out of phase with the input
When IB increases, IC increases, voltage drop ICRC increases, and VC=VCC-ICRC decreases. So output is inverted — 180° out of phase. This is the defining CE amplifier phase property.

Q4 — Answer: (C) The resistivity of a semiconductor increases when temperature is increased
Statement C is false. Increasing temperature generates more electron-hole pairs in a semiconductor, raising conductivity and lowering resistivity. Statement D (conductivity increases) is the correct counterpart.

Q5 — Answer: (B) Equal to the number of holes
In an intrinsic semiconductor, electron-hole pairs are generated thermally in pairs. Each excited electron leaves exactly one hole. Therefore ne = nh = ni at all temperatures above 0 K.

Q6 — Answer: (C) Difference in carrier concentration across the junction
Hole concentration is high on p-side, electron concentration high on n-side. This gradient drives diffusion — holes to n-side, electrons to p-side. No external agency is needed; concentration gradient alone initiates carrier movement.

Q7 — Answer: (B) p-side is connected to the positive terminal and n-side to the negative terminal
In forward bias, p-side connects to the positive terminal and n-side to the negative terminal. The applied field opposes the built-in junction field, reducing depletion width and allowing majority-carrier diffusion across the junction.

Q8 — Answer: (A) 100 Hz
FWR produces pulses in both half-cycles so f_out = 2f = 2x50 = 100 Hz. Option B is the input frequency, a common confusion. Option D is f/√2, which has no physical basis here.

Q9 — Answer: (B) Cut-off and saturation
Cut-off gives I_C ≈ 0 and acts as an open switch (OFF). Saturation drives both junctions forward biased, giving strong conduction (ON). The active region is used for amplification, not ideal switching.

Q10 — Answer: (C) OR followed by NOT
Y = (A+B)-bar requires first computing A+B via OR, then inverting via NOT. Option B gives ((A+B)-bar)-bar = A+B, which is OR — double inversion cancels the complement, giving the wrong function.

Q11 — Answer: (B) Decreases
Increasing temperature generates more thermally excited electron-hole pairs. Higher carrier concentration raises conductivity, so resistance decreases. Option D describes a metal near a phase transition, not a semiconductor.

Q12 — Answer: (B) Emitter-base junction forward biased and collector-base junction reverse biased
In active mode, the emitter-base junction is forward biased (permits carrier injection) and the collector-base junction is reverse biased (sweeps injected carriers to the collector). Option A exactly reverses the two bias conditions — the most common error.

Q13 — Answer: (D) 0
NAND gives Y = (AB)-bar. For A=B=1, AB=1, so Y = 1-bar = 0. Output is LOW only for this all-HIGH input combination. Option A is the most common error — students confuse NAND with AND for the 11 input.

Q14 — Answer: (A) Reverse breakdown region
A Zener diode is heavily doped and designed to operate in the reverse breakdown region, where its voltage remains nearly constant over the useful current range, enabling voltage regulation.

Q15 — Answer: (C) 24
$\beta = \alpha/(1-\alpha) = 0.96/0.04 = 24$. Trap: option A ($\beta=6$) arises from wrongly computing 0.96/0.16, confusing $(1-\alpha)$ with $(1-\alpha^2)$. Memorise $\beta = \alpha/(1-\alpha)$.

Q16 — Answer: (C) n-type
A pentavalent impurity donates its fifth valence electron after four participate in covalent bonds. This raises electron concentration above hole concentration, forming an n-type semiconductor.

Q17 — Answer: (D) The overall V-I characteristic of the p-n junction
Heating increases thermally generated electron-hole pairs, reduces the potential barrier, and shifts the diode characteristic. The entire V-I curve is affected — not just one type of resistance. Options A and B incorrectly limit the effect to one bias direction.

Q18 — Answer: (C) Silver
Silver is a metallic conductor with resistivity $\sim 10^{-8}$ Ω m, the lowest among the options. Germanium and silicon are semiconductors; glass is an insulator with far higher resistivity.

Q19 — Answer: (C) Intermediate between a good conductor and an insulator
Semiconductors have conductivity between conductors ($\sim 10^{7}$ S/m) and insulators ($\sim 10^{-11}$ S/m). Option D is false — metals have far greater conductivity. Option B describes behaviour only at 0 K.

Q20 — Answer: (A) Heating generally decreases semiconductor resistance but increases metallic resistance
Semiconductors have a negative temperature coefficient — resistance decreases on heating due to increased carriers. Metals have a positive temperature coefficient — resistance increases on heating. Option D reverses both signs, a classic student error.

Q21 — Answer: (A) Both the number of mobile carriers and conductivity increase
Thermal energy excites valence electrons across the forbidden gap, generating electron-hole pairs. More carriers directly increase conductivity — both rise together. Options C and D are internally inconsistent with semiconductor physics.

Q22 — Answer: (A) Semiconductor resistivity is much higher than that of silver
Metals such as silver have resistivity $\sim 10^{-8}$ Ω m; silicon has resistivity $\sim 10^{2}$ Ω m — roughly 10 orders of magnitude higher. Option D is false — semiconductor resistivity is strongly temperature dependent.

Q23 — Answer: (C) Only 3
Statements I, II and IV are correct. III is false — metals have conductivity many orders of magnitude higher than semiconductors at room temperature. Students confuse higher conductivity with higher carrier sensitivity.

Q24 — Answer: (C) It generally decreases as temperature increases
Semiconductor resistivity decreases with increasing temperature due to more thermally generated carriers. It never reaches zero — it asymptotically decreases. Option D is the most common trap: students confuse this with superconductivity.

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