

Semiconductor Electronics — Assignment 2

Class 12 Physics · Higher-difficulty challenge set + integrated problems · Answer key included · Narayan Gurukul Academy

Instructions: (1) Attempt all questions; start with the topic-wise challenge set, then attempt the integrated (multi-topic) problems.
(2) Give all answers with correct SI units. $g = 10 \text{ m/s}^2$ unless stated.
(3) A final answer key is provided at the end — try the full set before checking it.

Part A — Topic-wise challenge questions

Energy Bands and Doping

1. Distinguish between intrinsic and extrinsic semiconductors.
2. Explain how doping with a pentavalent impurity produces an n-type semiconductor.
3. Draw the energy band diagrams of conductors, insulators and semiconductors.

P-N Junction and Diode

1. Explain the formation of a depletion region and a potential barrier in a p-n junction.
2. Draw the I-V characteristics of a p-n junction diode in forward and reverse bias.
3. Why does a p-n junction diode not conduct in reverse bias?

Rectifiers, LED, Photodiode and Solar Cell

1. Explain the working of a half-wave rectifier.
2. Explain the working of a full-wave bridge rectifier.
3. Describe the working of a photodiode and a solar cell.

Transistors and Amplification

1. Explain the working of an n-p-n transistor as an amplifier.
2. Define the current gain and voltage gain of a common-emitter amplifier.
3. Describe the biasing of the junctions of a transistor for normal operation.

Logic Gates

1. Draw the symbols and write the truth tables of the AND, OR and NOT gates.
2. Write the truth tables of the NAND and NOR gates and explain why they are universal gates.
3. Give one application of logic gates.

Part B — Integrated problems (multi-topic)

1. In a common-emitter amplifier, the base current is $100 \mu\text{A}$ and the collector current is 10 mA . Find the current gain β and the emitter current.
2. The current gain of a common-emitter amplifier is 100. If the base current changes by $40 \mu\text{A}$, find the change in the collector current.
3. Draw the output waveform of a half-wave rectifier for a sinusoidal input and explain the result.

4. A silicon diode has a forward voltage drop of 0.7 V. If it is connected in series with a 1 k Ω resistor and a 5 V battery, find the current through the diode.

5. Write the truth table of a two-input NAND gate and state the output when both inputs are high.

Answer Key

Energy Bands and Doping

Intrinsic: pure semiconductor, equal electrons and holes. Extrinsic: doped. Pentavalent doping gives free electrons, so an n-type semiconductor. Band diagrams: negligible, small (≈ 1 eV) and large gap for conductors, semiconductors and insulators.

P-N Junction and Diode

Diffusion of carriers across the junction forms a depletion region with immobile ions and a potential barrier. Forward bias reduces the barrier (conducts); reverse bias increases it (no conduction).

Rectifiers, LED, Photodiode and Solar Cell

Half-wave: one diode, output is a pulsating DC for half of each cycle. Full-wave bridge: four diodes, output for both halves. LED converts electrical energy to light; a photodiode in reverse bias responds to light; a solar cell converts light to electricity.

Transistors and Amplification

Emitter heavily doped, base lightly doped and thin, collector moderately doped; emitter-base forward biased, collector-base reverse biased. Current gain $\beta = I_C/I_B$.

Logic Gates

AND: high only when all inputs high. OR: high when any input high. NOT: inverter. NAND and NOR are universal gates.

Integrated problems

1: $\beta = 10 \text{ mA} / 100 \text{ } \mu\text{A} = 100$; $I_E = I_B + I_C = 10.1 \text{ mA}$. 2: $\Delta I_C = \beta \Delta I_B = 100 \times 40 \text{ } \mu\text{A} = 4 \text{ mA}$. 3: Positive half cycles appear across the load; negative halves are blocked. 4: $I = (5 - 0.7)/1000 = 4.3 \text{ mA}$. 5: NAND truth table; output is LOW (0) when both inputs are high.