Semiconductors **Marks: 50**

ANSWER KEY

Physics

Q.1 B	Q.2 D	Q.3 D	Q.4 D	Q.5 C	Q.6 D	Q.7 C	Q.8 A
Q.9 B	Q.10 B	Q.11 A	Q.12 D	Q.13 C	Q.14 C	Q.15 C	Q.16 D
Q.17 B	Q.18 A	Q.19 B	Q.20 A	Q.21 B	Q.22 D	Q.23 D	Q.24 A
Q.25 C	Q.26 C	Q.27 B	Q.28 A	Q.29 B	Q.30 D	Q.31 D	Q.32 D
Q.33 B	Q.34 C	Q.35 A	Q.36 D	Q.37 C	Q.38 C	Q.39 C	Q.40 D
Q.41 C	Q.42 B	Q.43 D	Q.44 D	Q.45 B	Q.46 D	Q.47 D	Q.48 B
Q.49 C	Q.50 A						

SOLUTION

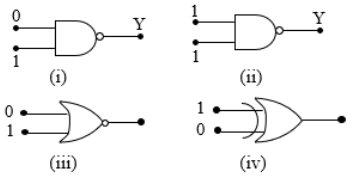
Physics

Q.1 In a p-n junction, there is no appreciable current if

Correct option: (B)

The correct answer is (B) a potential difference is applied across junction making p-section negative and n-section positive, because this configuration represents reverse bias, where the potential barrier is increased, and thus, no appreciable current flows through the junction under normal conditions.

Q.2 Identify the logic gates from the following, which will have an output of '1' for the given inputs.



Correct option: (D)

Gate (i) is a NAND gate. Output of NAND gate is 1 when either of input is 1 and other is 0. Also, Gate (iv) is an Ex-OR gate. Output of Ex-OR gate is 1 when either of input is 1 and other is 0. Hence, correct option is (D).

Q.3 The depletion layer in the p-n junction diode is caused by

Correct option: (D)

Q.4 In a good conductor the energy gap between the conduction band and the valence band is

Correct option: (D)

The conduction and valence bands in the conductors merge into each other.

Q.5 In a common emitter transistor amplifier circuit, the input resistance is 1.8 kΩ and output is obtained across a load resistance of 9 kΩ. The alternating current gain is 70. Corresponding to an a.c. input voltage of 6 mV, the output voltage will be

Correct option: (C)

AC input Current :

$I_{in} = \frac{V_{in}}{R_{in}} = \frac{6 \times 10^{-3}}{1800} = 3.33 \times 10^{-6}$A

A·C output Current :

$I_{out} = \beta_{ac} \cdot I_{in}$ (β_{ac} = A·C· Current gain)

$= 70 \times 3.33 \times 10^{-6}$

$= 2.33 \times 10^{-4}$ A

A·C Output Voltage :

$V_{out} = I_{out} \cdot R_L$

$= 2.33 \times 10^{-4} \times 9000$

$= 2.097$

$\approx 2{\cdot}1$ V

Q.6 When forward bias is applied to a p–n junction, then the potential barrier and the width of the depletion region respectively.

Correct option: (D)

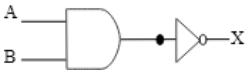
When a p–n junction diode is forward biased, the external voltage applied across the junction opposes the built-in potential barrier of the diode. As a result, the height of the potential barrier decreases. This allows more majority carriers to cross the junction, leading to the narrowing of depletion region.

Q.7 In p-type semiconductor, the holes created in the valence band by impurity atoms occupy energy levels in

Correct option: (C)

Q.8

What is the Boolean expression for the gate circuit shown in the figure?



Correct option: (A)

The given circuit represents a NAND gate. The output of a NAND gate is 1 only when both of its inputs are 0. Otherwise, the output is 0. The Boolean expression for the circuit is therefore, $\overline{A \cdot B} = X$. This means that the output X is equal to the NOT of the AND operation of A and B.

Q.9 If p-n junction diode is forward biased, then

Correct option: (B)

Q.10 Solar cell produces photo voltage when incident light has energy

Correct option: (B)

For a solar cell to produce photovoltage, the incident light's energy must be sufficient to excite electrons from the valence band to the conduction band of the semiconductor material. This minimum energy required for excitation is known as the band gap energy (E_g). If the incident photon's energy (E) is

less than

E_g, it cannot generate electron-hole pairs, and thus no photovoltage is produced. While photons with energy

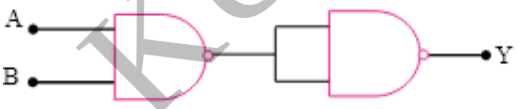
equal to

E_g can excite electrons, for robust and efficient generation of charge carriers contributing to a measurable photovoltage, the energy of the incident light must be

greater than

the band gap energy ($E > E_g$). This ensures the creation of free charge carriers that contribute to the electrical current and voltage.

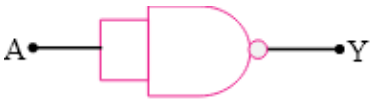
Q.11 The output (Y) of the combination of gates is



Correct option: (A)

Smart tip:

If both inputs of NAND gates are shorted, then it becomes NOT gate (similar is applicable for NOR gate).



NOT gate

The output of the given combination is,

$\therefore$ Y = $\overline{\overline{A} \cdot \overline{B}}$ = A·B

Q.12 In common emitter amplifier, a change of 0.2 mA in the base current causes a change of 5 mA in the collector current. If input resistance is 2 kΩ and voltage gain is 75, the load resistance used in the circuit is

Correct option: (D)

Given: $A_v = 75, R_i = 2k\Omega$

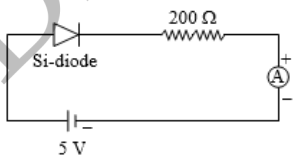
For a CE amplifier,

$$\beta = \frac{\Delta I_c}{\Delta I_b} = \frac{5}{0.2} = 25$$

Voltage gain $A_v = \beta \frac{R_L}{R_i}$

$$\therefore \quad R_L = \frac{A_v R_i}{\beta} = \frac{75 \times 2}{25} = 6k\Omega$$

Q.13 In the following circuit, the reading in the ammeter is



Correct option: (C)

Reading of ammeter shows the current in the circuit.

Current is given by, I = V/R

$$\text{I} = \frac{V - V_{diode}}{R}$$

For silicon diode, V_{diode} = 0.7 V

$$\therefore \quad \text{I} = \frac{5 - 0.7}{200} = \frac{4.3}{200} = 21.5 \text{ mA}$$

Q.14 Electrical conductivity of a silicon is _____ approximately.

Correct option: (C)

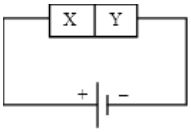
The electrical conductivity of silicon is approximately *1.56 x 10^{-3} S/m*. This value is a measure of how easily an electric current can flow through the material. Silicon is a semiconductor, which means its conductivity lies between that of a conductor and an insulator. It is a good electrical conductor but not as good as metals.

Q.15 In extrinsic semiconductors,

Correct option: (C) the gap between conduction band and valence band is near about 1 eV.

Self Explanatory

Q.16 A semiconductor X is made by doping a germanium crystal with arsenic (Z = 33). A second semiconductor Y is made by doping germanium with indium (Z = 49). The two are joined end to end and connected to a battery as shown in figure. Which of the following statements is correct?



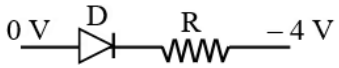
Correct option: (D)

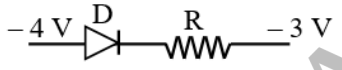
Germanium is a group IV element. When doped with arsenic (Z = 33), it has 5 valence electrons. Arsenic acts as a donor and creates an *n-type* semiconductor. When doped with indium (Z = 49), it has 3 valence electrons. Indium acts as an acceptor and creates a *p-type* semiconductor. Thus, N(i.e. X) is connected to the positive terminal of battery and P (i.e. Y) is connected to negative terminal of battery so P-N junction is reverse biased.

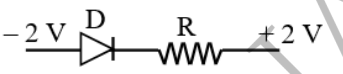
Q.17 In insulators

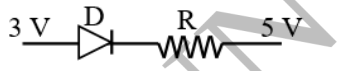
Correct option: (B)

Q.18 Which of the following figure represents forward bias diode?

a. 

b. 

c. 

d. 

Correct option: (A)

Thinking Hatke

This question can be solved using the 'odd one out' method. Only in figure (a) is the voltage on the left side higher than the voltage on the right side. In all the other figures, the voltage on the left side is lower than the voltage on the right side.

Q.19 The collector supply voltage is 6 V and the voltage drop across a resistor of 600 Ω in the collector circuit is 0.6 V in a transistor connected in common emitter mode. If the current gain is 20, the base current is

Correct option: (B)

The collector current is given by,

$$I_C = \frac{V_C}{R_C} = \frac{0.6\,V}{600\,\Omega} = 1 \times 10^{-3}\ \text{A} = 1\ \text{mA}$$

$$\beta = \frac{I_C}{I_B} \Rightarrow I_B = \frac{I_C}{\beta} = \frac{1\,mA}{20} = 0.05\ \text{mA}$$

Q.20 A Ge specimen is doped with Al. The concentration of acceptor atoms is $\sim 10^{21}$ atoms/m^3. Given that the intrinsic concentration of electron-hole pairs is $\sim 10^{19}/m^3$, the concentration of electrons in the specimen is

Correct option: (A) $10^{17}/m^3$

The intrinsic concentration of electron-hole pairs is given by,

$n_i^2 = n_e n_h$

$\therefore n_e = \frac{n_i^2}{n_h} = \frac{(10^{19})^2}{10^{21}} = 10^{17}/m^3$

Q.21 If an alternating voltage is applied across a p-n junction diode in series with a load then

Correct option: (B)

A p-n junction diode conducts current primarily in one direction, allowing current to flow when it is forward-biased (positive voltage applied to the anode relative to the cathode) and blocking current when reverse-biased (negative voltage applied to the anode), except for negligible leakage current. Since a p-n junction diode only allows current to flow during the positive half-cycles of the AC input, the output voltage across the load will not be a constant DC voltage but rather a pulsating one. The voltage is zero during the negative half-cycles of the AC input and pulsates during the positive half-cycles.

Q.22 For a transistor $\frac{1}{\alpha_{dc}} - \frac{1}{\beta_{dc}}$ is (α_{dc} and β_{dc} are current gains)

Correct option: (D)

We know

$$\alpha_{dc} = \frac{I_c}{I_e} \text{ and } \beta_{dc} = \frac{I_c}{I_b}$$

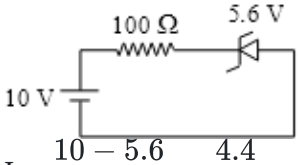
$$\therefore \quad \frac{1}{\alpha_{dc}} - \frac{1}{\beta_{dc}} = \frac{I_e}{I_c} - \frac{I_b}{I_c}$$

$$= \frac{I_e - I_b}{I_c}$$

$$= \frac{I_c}{I_c} = 1 \quad \ldots.(\because\ I_c = I_e - I_b)$$

Q.23 A Zener diode having break-down voltage 5.6 V is connected in reverse bias with a battery of emf 10 V and a resistance of 100 Ω in series. The current flowing through the Zener is

Correct option: (D)



$I = \frac{10 - 5.6}{100} = \frac{4.4}{100}$

$= 0.04 = 44 \times 10^{-3}$ A

= 44 mA

Q.24 What is the Boolean expression for the gate circuit shown in the figure? [BCECE 2015]

Correct option: (A) $\overline{A \cdot B}$**= X**

Self Explanatory

Q.25 If the temperature of a semiconductor is increased, then the forbidden gap will

Correct option: (C)

The forbidden gap in a semiconductor is the energy difference between the valence band and the conduction band. As the temperature increases, the atoms in the semiconductor vibrate more strongly, which leads to an increase in the energy of the electrons in the valence band. This means that electrons can more easily jump from the valence band to the conduction band, resulting in a decrease in the forbidden gap.

Q.26 The process of adding impurities to the pure semiconductor is called

Correct option: (C) doping

Self Explanatory

Q.27 The density of an electron-hole pair in a pure germanium is 3×10^{16} m^{-3} at room temperature. On doping with aluminium, the hole density increases to 4.5×10^{22} m^{-3}. Now the electron density (in m^{-3}) in doped germanium will be

Correct option: (B)

Smart tip :

In a doped semiconductor, the density of electrons and holes is not equal. It can be shown that $n_e\, n_h = n_i^2$.

$n_i^2 = n_h n_e \Rightarrow n_e =$

$$\frac{(3 \times 10^{16})^2}{4.5 \times 10^{22}} = \frac{9 \times 10^{32}}{4.5 \times 10^{22}}$$

$= 2 \times 10^{10}\ \text{m}^{-3}$

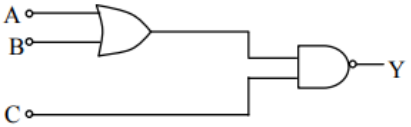
Q.28 A pure silicon crystal at temperature of 300 K has electron and hole concentration ($n_e = n_h$) 1.5×10^{16} m^{-3} each. Doping by indium increases n_h to 4.5×10^{22} m^{-3}. The value of 'n_e' for doped silicon crystal will be

Correct option: (A)

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

$\therefore\ n_e = 5 \times 10^9 m^{-3}$

Q.29 To get an output $Y = 1$ in the given logic circuit, the correct choice for the input is



Correct option: (B)

Output from first gate is,

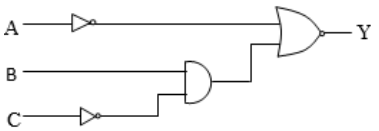
Y_1 = A + B (OR GATE)

The input to the second gate is Y_1 and C.

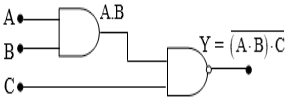
Therefore, Y = $\left(\overline{A + B}\right) \cdot C$ ...(NAND gate)

$\therefore$ Only the condition A = 1, B = 1, C = 0 will give Y = 1.

Q.30 The output Y of the following logic circuit is



Correct option: (D)



Output of AND Gate = $B\overline{C}$

Output of NOR gate = $\overline{\overline{A} + B\overline{C}}$

Q.31 For an ideal diode, in forward and reverse biased condition the resistance is respectively

Correct option: (D)

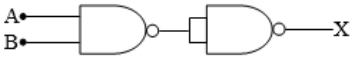
Q.32 In a transistor, in common emitter configuration, the ratio of power gain to voltage gain is

Correct option: (D)

Power gain = Voltage gain × Current gain

$\therefore \quad \frac{Power\ Gain}{Voltage\ Gain}$ = Current gain = β

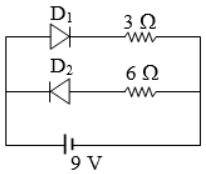
Q.33 The output (X) of the logic circuit shown below will be



Correct option: (B)

The first gate is a NAND gate. Its output is $\overline{A \cdot B}$. The second gate is a shorted NAND gate. A shorted NAND gate acts as a NOT gate. Therefore, the find output will be X = $\overline{\overline{A \cdot B}}$

Q.34 In the given circuit, the current flowing through 3 Ω and 6 Ω resistance respectively will be



Correct option: (C)

Diode D_2 is in reverse bias and will not conduct.

Current through D_1, $I_1 = \frac{V}{R} = \frac{9}{3} = 3$ A

Q.35 For the following combination of logic gates, when all the three inputs are first high and then low, the output 'Y' will respectively be

Correct option: (A)

In the first case, the output of the AND gate will be high; hence, both inputs of the NAND gate are high. As a result, the output will be low. In the second case, the output of the AND gate will be low; hence, both inputs of the NAND gate will be low. Hence, the output will be high.

Q.36 In an n-p-n transistor circuit, the collector current is 10 mA. If 90% of the electrons emitted reach the collector, the emitter current (I_e) and base current (I_b) are given by

Correct option: (D)

Given I_c = 10 mA

also, I_c = 90% I_c

⇒ 10 mA = 9 × I_e

$\therefore \quad I_e$ = 11 mA

From $I_b + I_c = I_e$

⇒ $I_b = I_e - I_c$ = 11 – 10 = 1 mA

Q.37 C and Si both have same lattice structure, having 4 bonding electrons in each. However, C is insulator whereas Si is intrinsic semiconductor. This is because [CBSE PMT (Prelims) 2012]

Correct option: (C) 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.

The electronic configuration of C and Si are:

$^6C = 1S^2, 2S^2\ 2P^2$ and $^{14}Si = 1S^2, 2S^2\ 2P^6, 3S^2\ 3P^2$

Thus, the electrons in the outer most shell of carbon atoms are more tightly bound to the nucleus unlike for silicon and are not available for conduction. Hence it acts as an insulator.

Q.38 Thermistor is a temperature sensitive _____ device.

Correct option: (C)

Thermistors are temperature-sensitive semiconductor devices because their resistance varies significantly with changes in temperature. The behaviour (decreasing or increasing resistance) depends on whether the thermistor is an NTC or PTC type.

Q.39 Suitable impurities are added to a semiconductor depending on its use. This is done to

Correct option: (C)

Adding impurities to a semiconductor is a process called *doping*. Doping is done to control the electrical conductivity of the semiconductor. Impurities with more valence electrons than the semiconductor's atoms are called *donors*, while impurities with fewer valence electrons are called *acceptors*.

Q.40 The transformer is used in rectifier circuit,

Correct option: (D)

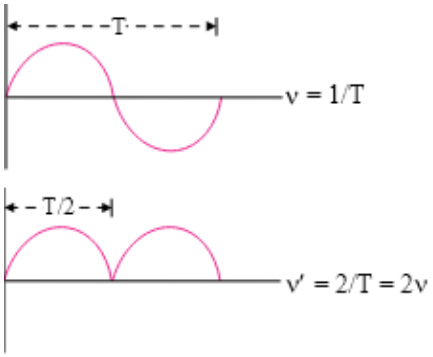
The transformer is an essential component in a rectifier circuit due to several reasons:

1. It provides *electrical isolation* between the AC mains supply and the rectifier circuit. This is a critical safety feature, preventing direct connection to high voltage and significantly reducing the risk of electric shock.
2. It facilitates *voltage transformation*. Depending on the requirement, the transformer can either step up or step down the input AC voltage to the desired level needed by the rectifier and the subsequent DC load. For example, it can reduce a 230V AC input to a lower, safer voltage like 12V AC for rectification.
3. Although not its sole purpose, by ensuring the voltage supplied to the rectifier is at an appropriate level, the transformer indirectly *protects the diodes* within the circuit from experiencing excessive voltage. This helps in keeping the diodes operating within their safe limits and prevents damage due to overvoltage.

Considering these functionalities, all the given options correctly describe the roles of a transformer in a rectifier circuit.

Q.41 In a full wave rectifier, input A.C. current has a frequency 'ν'. The output frequency of current is

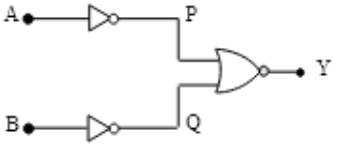
Correct option: (C)



Q.42 The schematic symbol of light emitting diode is (LED)

Correct option: (B)

Q.43 In the following circuit, Y = 1 for the inputs A and B respectively equal to



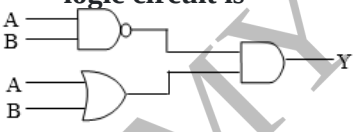
Correct option: (D)

$P = \bar{A}$ and Q = $\bar{B}$

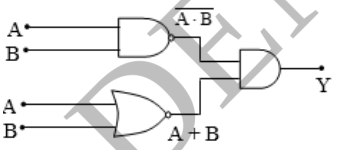
Now Y = 1 ⇒ both P and Q are 0

P = 0 ⇒ A = 1 amd Q = 0 ⇒ B = 1

Q.44 The logic gate represented by following logic circuit is



Correct option: (D)



$\therefore$ Y = $\overline{A \cdot B} \cdot (A + B)$

$\therefore$ Y = $\left(\overline{A} + \overline{B}\right) \cdot (A + B)$ ....

$\left(\because \overline{A \cdot B} = \overline{A} + \overline{B}\right)$

$\therefore$ Y = $\overline{A} \cdot B + \overline{B} \cdot A$

$\therefore$ Y = $A \cdot \overline{B} + B \cdot \overline{A}$

This represents XOR gate.

Q.45 Zener breakdown takes place if

Correct option: (B)

In lightly doped diodes, the necessary voltage is higher and avalanche breakdown is then the chief process involved.

Q.46 Photocurrent in a photodiode depends upon

Correct option: (D) intensity of incident radiation.

Self Explanatory

Q.47 On doping germanium metal with a little amount of indium, one gets

Correct option: (D)

Indium has three valence electrons, while germanium has four. When indium is added to germanium, it creates a ***p***-type semiconductor. This

is because indium atoms replace germanium atoms in the crystal lattice, leaving a "hole" in the covalent bond. This "hole" acts as a positive charge carrier, leading to a p-type semiconductor.

Q.48 In the working of photodiode, the reverse current depends on
Correct option: (B)

Q.49 Which of the following statements is TRUE for n-type semiconductor?
Correct option: (C)

Creating n-type semiconductors involves adding pentavalent atoms, such as phosphorus, to a pure semiconductor crystal (e.g., silicon or germanium). These atoms introduce extra electrons, which become the majority charge carriers, while positively charged holes are the minority charge carriers.

Q.50 In a semiconductor diode, the barrier potential offers opposition to only
Correct option: (A)

In a semiconductor diode, the barrier potential is formed due to the diffusion of majority carriers from both the n-type and p-type regions across the junction. This diffusion creates a depletion region with a potential barrier that opposes further diffusion of majority carriers, while allowing minority carriers to flow across the junction. Therefore, the barrier potential offers opposition to majority carriers in both regions.