Semiconductor Electronics JEE Main PYQ - 2

Total Time: 1 Hour **Total Marks:** 100

Instructions

Instructions

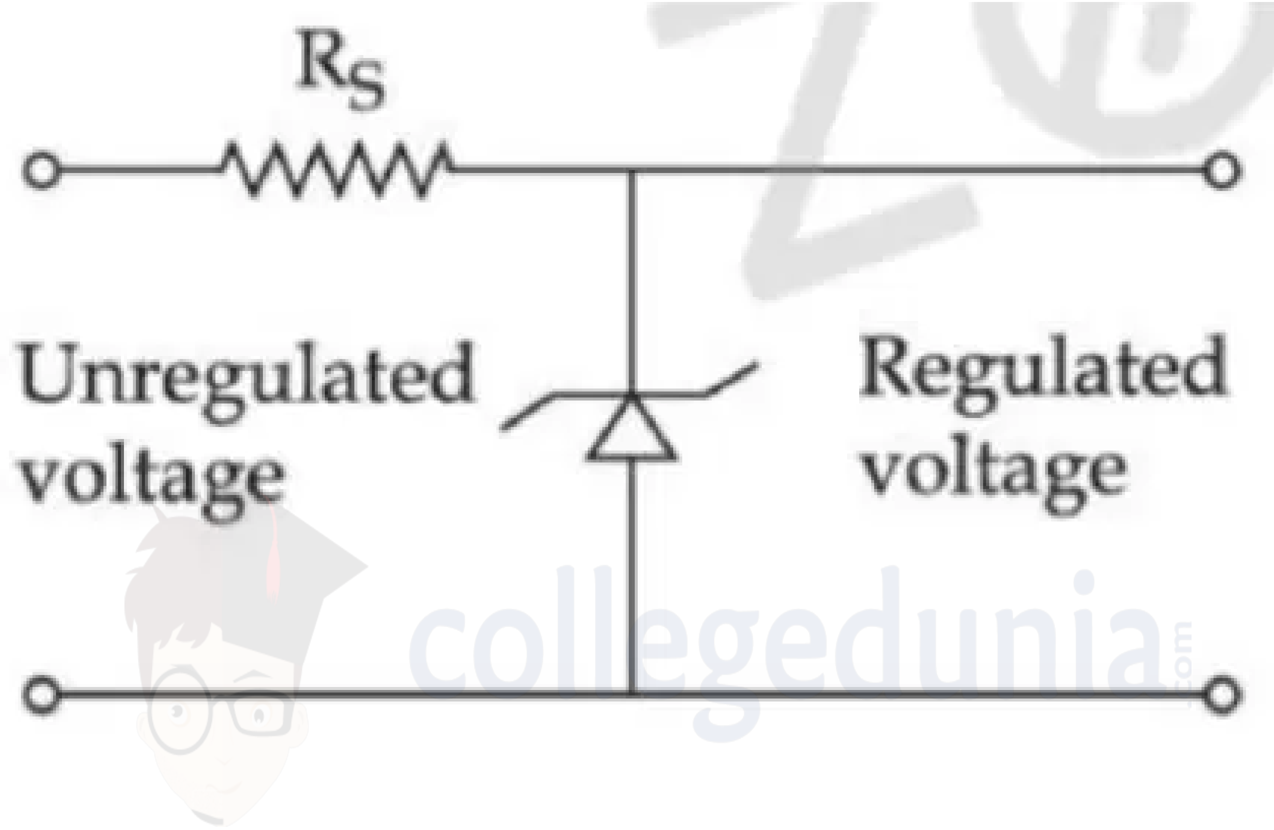
1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Semiconductor Electronics

1. A zener diode of power rating 2 W is to be used as a voltage regulator. If the zener diode has a breakdown of 10 V and it has to regulate voltage fluctuated between 6 V and 14 V, the value of R_S for safe operation should be __________ Ω. (+4, -1)



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2. For a transistor α and β are given as $\alpha = \frac{I_C}{I_E}$ and $\beta = \frac{I_C}{I_B}$. Then the correct relation between α and β will be : (+4, -1)

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

b. $\alpha\beta = 1$

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

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

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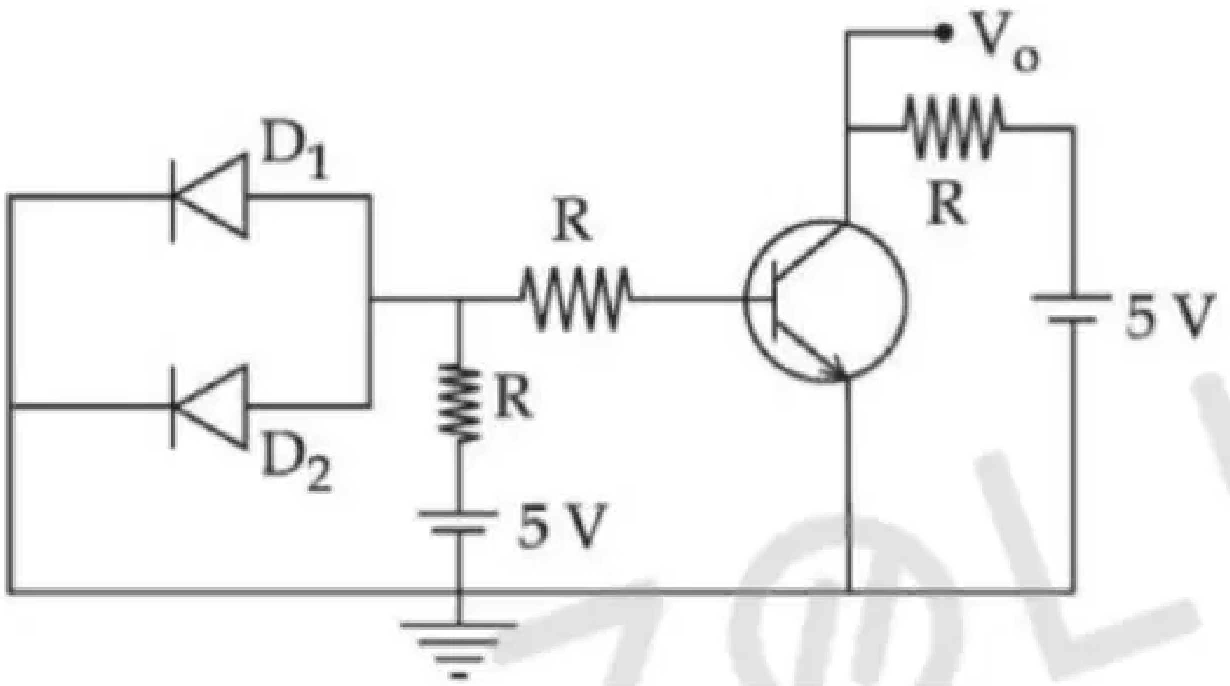
3. A circuit is arranged as shown in figure. The output voltage V_o is equal to ________ V. (+4, -1)



4. **For a transistor in CE mode to be used as an amplifier, it must be operated in :** **(+4, -1)**

a. Cut-off region only

b. Saturation region only

c. Both cut-off and Saturation

d. The active region only

5. **Statement I : By doping silicon semiconductor with pentavalent material, the electrons density increases.** **(+4, -1)**
Statement II : The n-type semiconductor has net negative charge.
In the light of the above statements, choose the most appropriate answer from the options given below :

a. Both Statement I and Statement II are true.

b. Both Statement I and Statement II are false.

c. Statement I is true but Statement II is false.

d. Statement I is false but Statement II is true.

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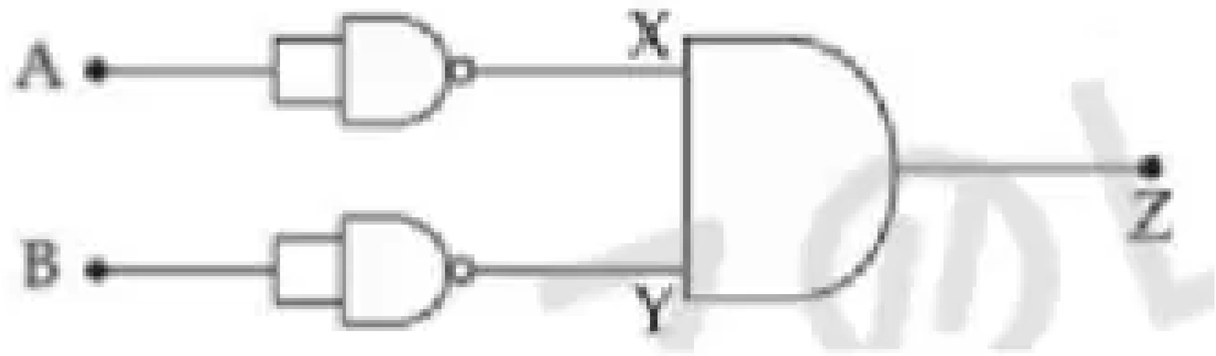
6. Identify the logic operation carried out by the given circuit : (+4, -1)



a. AND

b. OR

c. NAND

d. NOR

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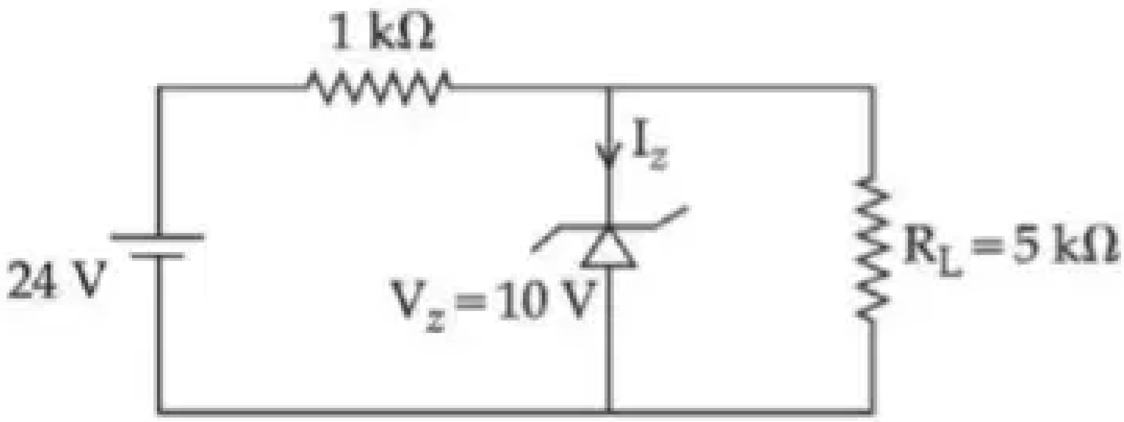
7. For the given circuit, the power across zener diode is __________ mW. (+4, -1)



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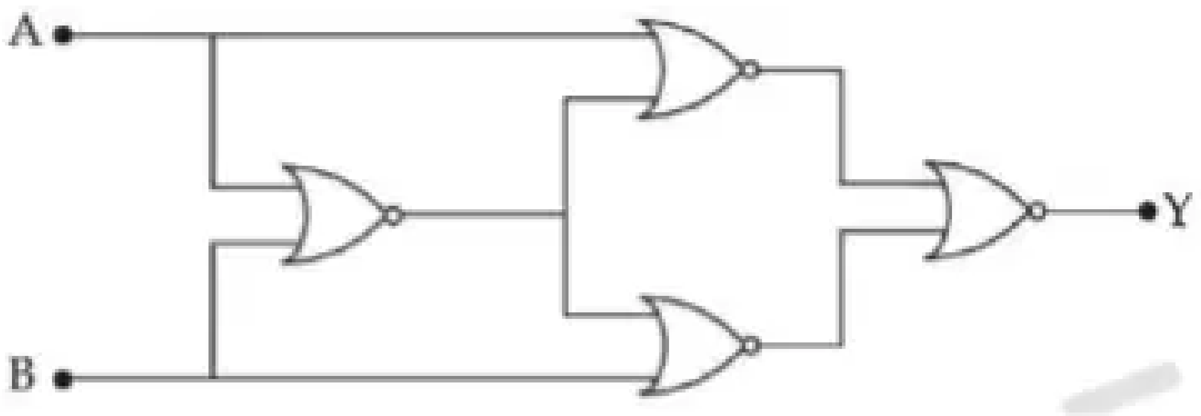
8. Four NOR gates are connected as shown in figure. The truth table for the given figure is : (+4, -1)


A
B
Y

(A)

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

(B)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

(C)

A	B	Y
0	0	1
0	1	0
1	0	1
1	1	0

(D)

A	B	Y
0	0	0
0	1	1
1	0	0
1	1	1

a. A

b. B

c. C

d. D

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9. **Consider a n-type semiconductor in which n_e and n_h are the number of electrons and holes, respectively.** **(+4, -1)**

a. Holes are minority carriers

b. The dopant is a pentavalent atom

c. $n_e n_h = n_i^2$ for intrinsic semiconductor

d. $n_e \gg n_h$ for extrinsic semiconductor The correct answer from the options given below is:

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10. **Given below are two statements: Statement-I: The equivalent emf of two nonideal batteries connected in parallel is smaller than either of the two emfs. Statement-II: The equivalent internal resistance of two nonideal batteries connected in parallel is smaller than the internal resistance of either of the two batteries. In light of the above statements, choose the correct answer from the options given below.** **(+4, -1)**

a. Statement-I is true but Statement-II is false

b. Both Statement-I and Statement-II are false

c. Both Statement-I and Statement-II are true

d. Statement-I is false but Statement-II is true

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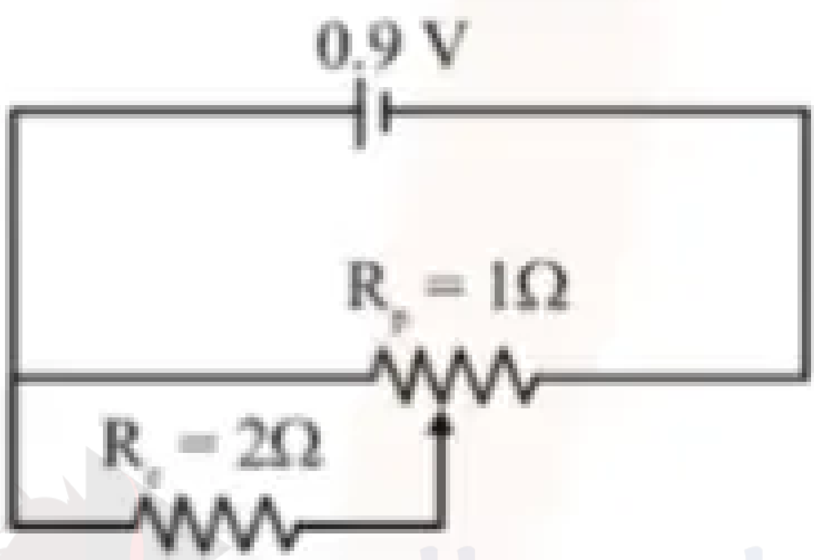
11. Sliding contact of a potentiometer is in the middle of the potentiometer wire having resistance $R_p = 1\,\Omega$ as shown in the figure. An external resistance of $R_e = 2\,\Omega$ is connected via the sliding contact. (+4, -1)

The current i is :



a. 0.3 A

b. 1.35 A

c. 1.0 A

d. 0.9 A

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12. Conductivity of a photodiode starts changing only if the wavelength of incident light is less than 660 nm. The band gap of the photodiode is found to be (+4, -1)

$$\frac{X}{8}\,\mathrm{eV}.$$

The value of X is:\text{(Given, $h = 6.6 \times 10^{-34}\,\mathrm{Js}$, $e = 1.6 \times 10^{-19}\,\mathrm{C}$)}

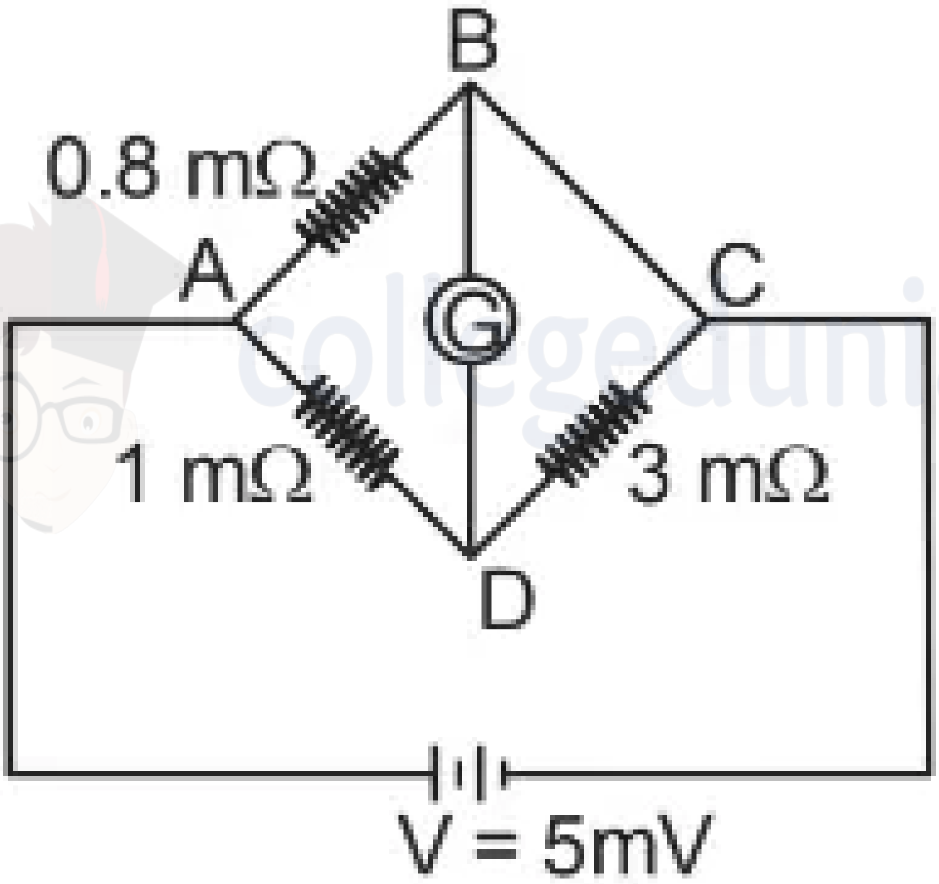
a. 15

b. 11

c. 13

d. 21

13. To measure the temperature coefficient of resistivity α of a semiconductor, an electrical arrangement shown in the figure is prepared. The arm BC is made up of the semiconductor. The experiment is being conducted at $25°\mathrm{C}$ and the resistance of the semiconductor arm is $3\,\mathrm{m\Omega}$. Arm BC is cooled at a constant rate of $2°\mathrm{C/s}$. If the galvanometer G shows no deflection after 10 s, then α is: **(+4, -1)**



a. $-2 \times 10^{-2}\ ^\circ\mathrm{C}^{-1}$

b. $-1.5 \times 10^{-2}\ ^\circ\mathrm{C}^{-1}$

c. $-1 \times 10^{-2}\ ^\circ\mathrm{C}^{-1}$

d. $-2.5 \times 10^{-2}\ ^\circ\mathrm{C}^{-1}$

14. The acceptor level of a p-type semiconductor is 6eV. The maximum wavelength of light which can create a hole would be : Given hc = 1242 eV nm. **(+4, -1)**

a. 407 nm

b. 414 nm

c. 207 nm

d. 103.5 nm

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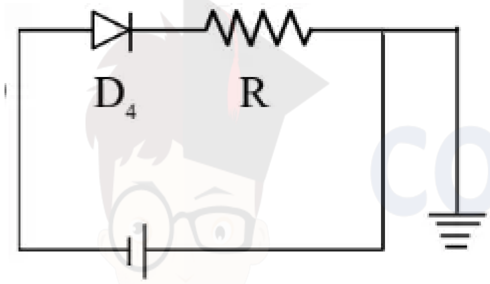
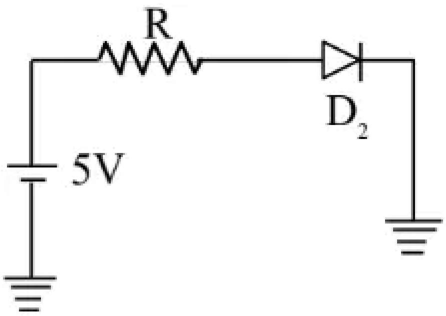
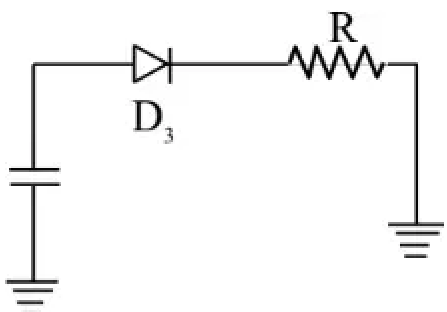
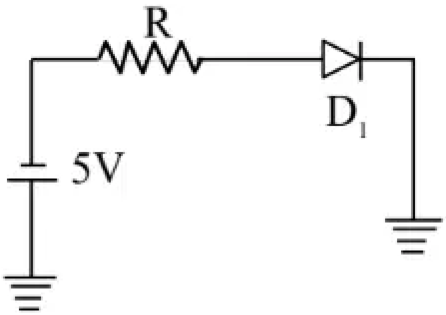
15. Which of the diode circuit shows correct biasing used for the measurement of dynamic resistance of p-n junction diode : **(+4, -1)**

a. 

b. 

c. 

d. 

16. A light emitting diode (LED) is fabricated using GaAs semiconducting material whose band gap is 1.42 eV. The wavelength of light emitted from the LED is: (+4, -1)

a. 650 nm

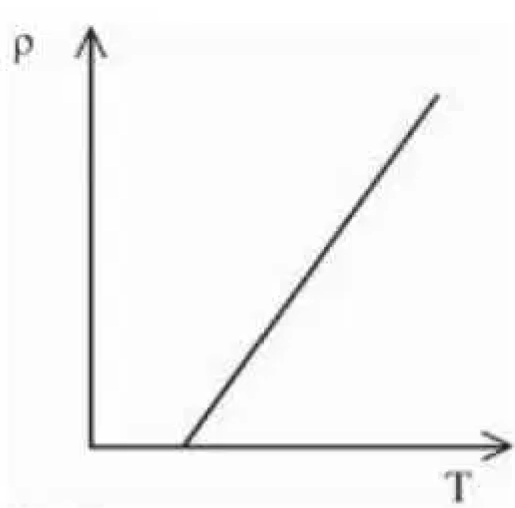
b. 1243 nm

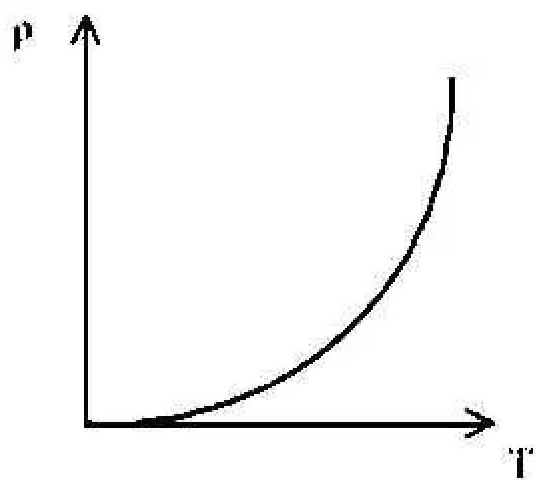
c. 875 nm

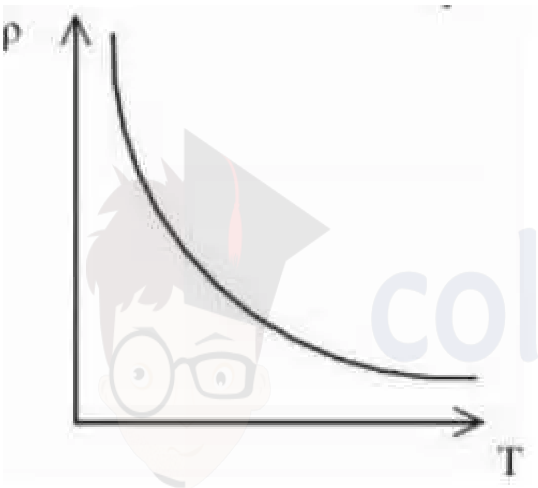
d. 1400 nm

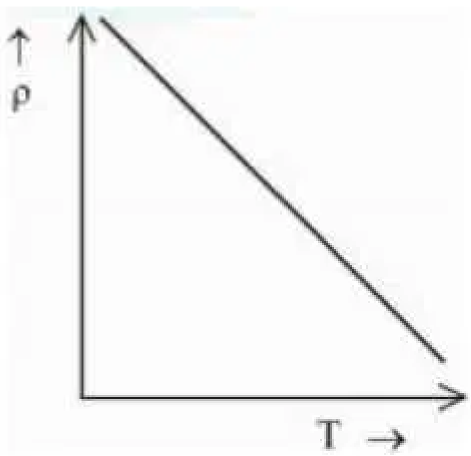
17. The current flowing through a conductor connected across a source is 2A and 1.2 A at 0°C and 100°C respectively. The current flowing through the conductor at 50°C will be ______x10^2 mA. (+4, -1)

18. The resistivity (ρ) of semiconductor varies with temperature. Which of the following curve represents the correct behavior (+4, -1)

a. 

b. 

c. 

d. 

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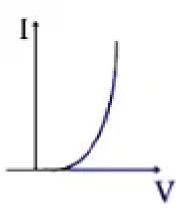
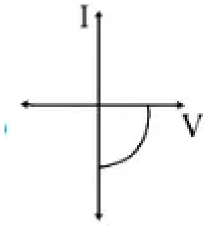
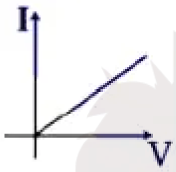
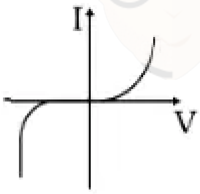
19. Identify the solar cell characteristics from the following options : **(+4, -1)**

a. 

b. 

c. 

d. 

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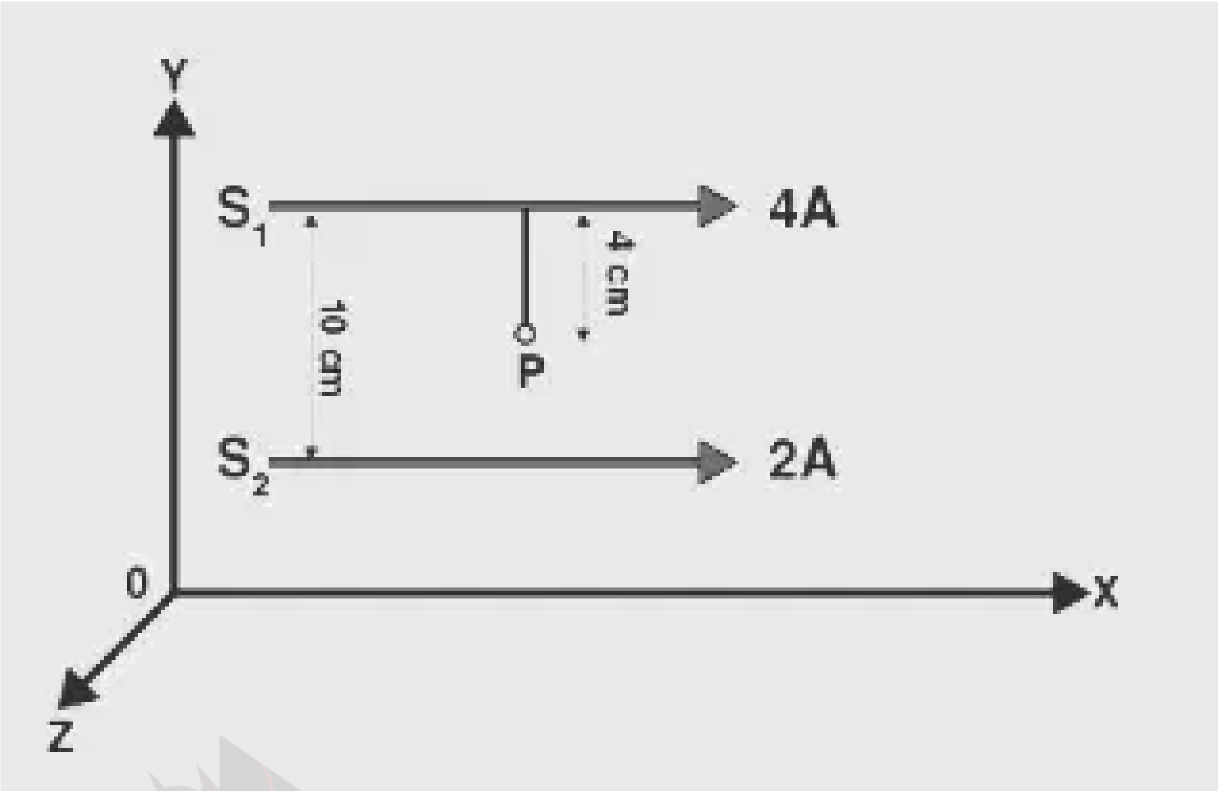
20. Two long parallel conductors S_1 and S_2 are separated by a distance 10 cm and carrying currents of 4 A and 2 A respectively. The conductors are placed along x-axis in X–Y plane. There is a point P located between the conductors (as shown in figure). A charge particle of 3π coulomb is passing through the point P with velocity $\vec{v} = (2\hat{i} + 3\hat{j})$ m/s; where $\hat{i}$ and $\hat{j}$ represents unit vector along x & y axis respectively. The force acting on the charge particle is $4\pi \times 10^{-5}(-x\hat{i} + 2\hat{j})N$. The value of x is: **(+4, -1)**



a. 2

b. 1

c. 3

d. -3

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21. A potential barrier of 0.4 V exists across a p-n junction. An electron enters the junction from the n-side with a speed of 6.0×10^5 ms^{-1}. The speed with which electrons enters the p side will be **(+4, -1)**

$\frac{x}{3} \times 10^5$ ms^{-1}

the value of x is __________.

(Give mass of electron = 9×10^{-31} kg, charge on electron = 1.6×10^{-19} C)

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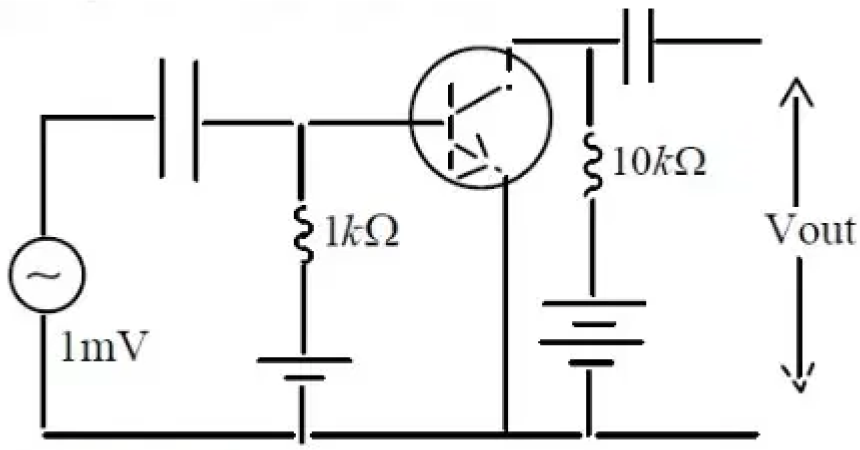
22. An npn transistor with current gain $\beta = 100$ in common emitter configuration is shown in the figure. The output voltage of the amplifier will be **(+4, -1)**



a. 0.1 V

b. 1.0 V

c. 10 V

d. 100 V

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23. Given below are two statements: One is labelled as Assertion A and the other is labelled as Reason R. **(+4, -1)**

Assertion A :n-p-n transistor permits more current than a p-n-p transistor.
Reason R: Electrons have greater mobility as a charge carrier.

Choose the correct answer from the options given below:

a. Both A and Rare true, and R is correct explanation of A.

b. Both A and R are true but R is NOT the correct explanation of A.

c. A is true but R is false.

d. A is false but R is true.

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24. For using a multimeter to identify diode from electrical components, choose the correct statement out of the following about the diode: **(+4, -1)**

a. It is two terminal device which conducts current in both directions.

b. It is two terminal device which conducts current in one direction only.

c. It does not conduct current gives an initial deflection which decays to zero.

d. It is three terminal device which conducts current in one direction only between central terminal and either of the remaining two terminals.

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25. In the following circuit, the correct relation between output (Y) and inputs A and B will be: **(+4, -1)**

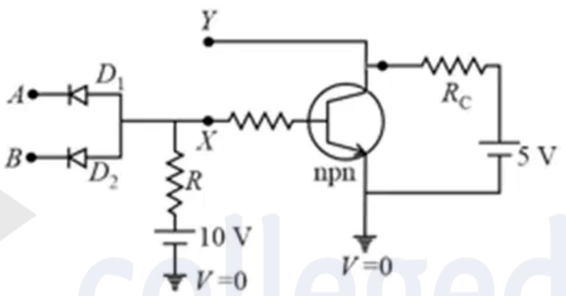

Fig. Circuit

a. $Y = AB$

b. $Y = A + B$

c. $Y = \overline{AB}$

d. $Y = \overline{A + B}$

Answers

1. **Answer: 20 - 20**

Explanation:

Step 1: Understanding the Question:
We need to find the value of the series resistance R_S required for the safe operation of a Zener diode regulator. "Safe operation" implies that the power dissipated by the Zener diode does not exceed its maximum power rating.
Step 2: Key Formula or Approach:
1. The Zener diode maintains a constant voltage V_Z across it.
2. The maximum current the Zener can safely handle is $I_{Z,max} = \frac{P_Z}{V_Z}$.
3. The current through the series resistor is $I_S = \frac{V_{in} - V_Z}{R_S}$.
4. The total current I_S splits into the Zener current I_Z and the load current I_L: $I_S = I_Z + I_L$.
5. The worst-case condition for the Zener (maximum power dissipation) occurs when the input voltage is maximum and the load current is minimum (or zero if no load is specified).
Step 3: Detailed Explanation:
Given values:
- Power rating of Zener diode, $P_Z = 2$ W.
- Zener breakdown voltage, $V_Z = 10$ V.
- Input voltage range, $V_{in} = 6$ V to 14 V.
First, note that the Zener diode will only regulate when $V_{in} \geq V_Z$. So, the operational input range is actually from 10 V to 14 V. The 6 V value is below the breakdown voltage.
Calculate the maximum safe Zener current:

$$I_{Z,max} = \frac{P_Z}{V_Z} = \frac{2\,\text{W}}{10\,\text{V}} = 0.2\,\text{A}$$

The Zener current I_Z will be maximum when the input voltage V_{in} is maximum and the load current I_L is minimum. Since no load is specified in the problem, we assume the worst-case scenario where there is no load connected, i.e., $I_L = 0$.
In this case, all the current from the source resistor passes through the Zener diode: $I_S = I_Z$.
This maximum current occurs at the maximum input voltage, $V_{in,max} = 14$ V. To ensure safe operation, we must limit this current to be no more than $I_{Z,max}$.

$$I_S \leq I_{Z,max}$$

$$\frac{V_{in,max} - V_Z}{R_S} \leq I_{Z,max}$$

To find the minimum resistance R_S that guarantees safety, we use the equality:

$$R_S = \frac{V_{in,max} - V_Z}{I_{Z,max}}$$

$$R_S = \frac{14\,\text{V} - 10\,\text{V}}{0.2\,\text{A}} = \frac{4\,\text{V}}{0.2\,\text{A}} = 20\,\Omega$$

A resistance of 20 Ω will ensure that even under the worst conditions (14 V input, no load), the current through the Zener will not exceed its safe limit.

Step 4: Final Answer:

The value of R_S for safe operation should be 20 Ω.

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2. **Answer: c**

Explanation:

Step 1: Understanding the Question:

We are given the definitions of the current gain in common-base configuration (α) and common-emitter configuration (β) for a transistor. We need to find the mathematical relationship between them.

Step 2: Key Formula or Approach:

The fundamental relationship between the three transistor currents (emitter current I_E, base current I_B, and collector current I_C) is:

$$I_E = I_B + I_C$$

We will use this equation along with the definitions of α and β to derive the relationship.

Step 3: Detailed Explanation:

Start with the fundamental current equation:

$$I_E = I_B + I_C$$

We want to find a relationship between $\alpha = \frac{I_C}{I_E}$ and $\beta = \frac{I_C}{I_B}$. Let's try to express β in terms of α.

To do this, we need to eliminate I_E and I_B and have only I_C and the gains.

Divide the fundamental equation by I_C:

$$\frac{I_E}{I_C} = \frac{I_B}{I_C} + \frac{I_C}{I_C}$$

From the definitions, we know:
- $\frac{I_E}{I_C} = \frac{1}{\alpha}$
- $\frac{I_B}{I_C} = \frac{1}{\beta}$

Substitute these into the divided equation:

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

Now, we just need to rearrange this equation to match one of the options. Let's solve for β.

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

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

Taking the reciprocal of both sides:

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

This matches option (C).
Step 4: Final Answer:
The correct relation between α and β is $\beta = \frac{\alpha}{1-\alpha}$.

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3. Answer: 5 - 5

Explanation:

Step 1: Understanding the Question:
We are given a circuit containing diodes and a transistor and asked to find the output voltage V_o. We need to determine the operating state of the transistor (cut-off, active, or saturation).
Step 2: Key Formula or Approach:
1. Analyze the input diode section to find the voltage at the node connected to the transistor's base. 2. Use this base voltage to determine if the transistor's base-emitter junction is forward-biased. 3. The transistor is in cut-off if the base-emitter voltage

V_{BE} is less than the cut-in voltage (typically $\sim$0.7 V for silicon). 4. If the transistor is in cut-off, it acts as an open circuit, and no collector current flows. The output voltage will be the collector supply voltage.

Step 3: Detailed Explanation:

Let's analyze the circuit. The input to diode D1 is 0 V, and the input to diode D2 is +5 V. Let's assume the diodes are ideal for simplicity.

- Diode D2 has +5 V at its anode. - Diode D1 has 0 V at its anode. - Since the anode of D2 is at a higher potential, D2 will be forward biased (ON), and D1 will be reverse biased (OFF). - Therefore, the junction point P (where the diodes meet the first resistor) will be at +5 V.

Now, consider the base of the NPN transistor. The base is connected to a voltage divider formed by two equal resistors R. One resistor is connected to point P (+5 V), and the other is connected to -5 V.

The voltage at the base, V_B, can be calculated using the voltage divider rule:

$$V_B = \frac{(-5\text{ V}) \cdot R + (+5\text{ V}) \cdot R}{R + R} = \frac{-5R + 5R}{2R} = \frac{0}{2R} = 0\text{ V}$$

So, the potential at the base of the transistor is 0 V.

The emitter of the transistor is connected directly to the ground, so its potential is $V_E = 0$ V.

The base-emitter voltage is $V_{BE} = V_B - V_E = 0\text{ V} - 0\text{ V} = 0$ V.

For an NPN transistor to turn on and conduct, the base-emitter voltage V_{BE} must be positive and greater than its cut-in voltage (around 0.6 V to 0.7 V). Since $V_{BE} = 0$ V, the transistor is in the **cut-off region**.

When the transistor is in cut-off, it acts like an open switch between its collector and emitter. No current flows through the collector ($I_C = 0$).

The output voltage V_o is the voltage at the collector. Since no current flows through the collector resistor R, there is no voltage drop across it. Therefore, the output voltage V_o is equal to the collector supply voltage.

$$V_o = 5\text{ V}$$

Step 4: Final Answer:

The output voltage V_o is equal to 5 V.

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4. Answer: d

Explanation:

Step 1: Understanding the Question:
The question asks about the required operating region for a transistor when it is used as an amplifier in the Common Emitter (CE) configuration.
Step 2: Key Formula or Approach:
This is a conceptual question based on the operating principles of a Bipolar Junction Transistor (BJT). We need to understand the characteristics of the different operating regions.
Step 3: Detailed Explanation:
A transistor has three main operating regions, defined by the biasing of its two junctions (Emitter-Base and Collector-Base):
1. **Active Region:** The emitter-base (EB) junction is forward-biased, and the collector-base (CB) junction is reverse-biased. In this region, the collector current (I_C) is approximately proportional to the base current (I_B), with a large amplification factor beta (β), i.e., $I_C = \beta I_B$. This linear relationship allows a small input signal at the base to be amplified into a larger output signal at the collector. This is the region required for amplification.
2. **Cut-off Region:** Both the EB and CB junctions are reverse-biased. The transistor acts like an open switch, and ideally, no current flows ($I_C \approx 0$).
3. **Saturation Region:** Both the EB and CB junctions are forward-biased. The transistor acts like a closed switch. The collector current reaches its maximum possible value, determined by the external circuit, and is no longer controlled by the base current.
For amplification, we need the output current to be a magnified but faithful reproduction of the input current. This linear control is only possible in the active region. The cut-off and saturation regions are used for digital logic and switching applications, where the transistor is either fully OFF or fully ON.
Step 4: Final Answer:
For a transistor to function as an amplifier, it must be operated in the active region.

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5. Answer: c

Explanation:

Step 1: Understanding the Concept:
Intrinsic semiconductors are doped with impurities to change their conductivity. Doping modifies the carrier concentration but must respect overall charge neutrality.
Step 2: Detailed Explanation:
1. **Statement I:** Silicon is tetravalent (4 valence electrons). Pentavalent dopants (like

Phosphorus) have 5 valence electrons. Four electrons bond with Silicon, leaving one free electron. Thus, electron density increases. This statement is **True**.
2. **Statement II:** Although n-type semiconductors have more free electrons, they are formed by adding neutral dopant atoms to neutral Silicon atoms. For every free electron released, there remains a positive ion (the dopant nucleus) in the lattice. Therefore, the material as a whole remains electrically **neutral**. This statement is **False**.
Step 3: Final Answer:
Statement I is true but Statement II is false.

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6. Answer: a

Explanation:

Step 1: Understanding the Concept:
A NAND gate with shorted inputs acts as a NOT gate. We can simplify the logical expressions for each stage of the circuit to determine the overall operation.
Step 2: Detailed Explanation:
1. The first part consists of two NAND gates where inputs are shorted.
For input A, the output is $X = \overline{A \cdot A} = \bar{A}$.
For input B, the output is $Y = \overline{B \cdot B} = \bar{B}$.
2. These outputs X and Y are fed into a NOR gate.
3. The final output Z is:

$$Z = \overline{X + Y}$$

Substitute $X = \bar{A}$ and $Y = \bar{B}$:

$$Z = \overline{\bar{A} + \bar{B}}$$

4. According to De Morgan's Law ($\overline{P + Q} = \bar{P} \cdot \bar{Q}$):

$$Z = \bar{\bar{A}} \cdot \bar{\bar{B}} = A \cdot B$$

The expression $Z = A \cdot B$ represents the AND operation.
Step 4: Final Answer:
The logical operation performed by the circuit is AND.

7. **Answer: 120 - 120**

Explanation:

Step 1: Understanding the Question:
We are given a voltage regulator circuit using a Zener diode. We need to calculate the power dissipated by the Zener diode.
Step 2: Key Formula or Approach:
1. A Zener diode, when operating in the breakdown region, maintains a constant voltage across it, which is the Zener voltage V_Z.
2. The voltage across the load resistor R_L will be equal to V_Z since they are in parallel.
3. Calculate the current through the load resistor (I_L) and the total current (I) flowing through the series resistor.
4. The current through the Zener diode (I_Z) is the difference between the total current and the load current ($I = I_Z + I_L$).
5. The power dissipated by the Zener diode is $P_Z = V_Z \times I_Z$.
Step 3: Detailed Explanation:
Given values:
Input Voltage, V_{in} = 24 V
Series Resistance, R_s = 1 kΩ = 1000 Ω
Zener Voltage, V_Z = 10 V
Load Resistance, R_L = 5 kΩ = 5000 Ω
Since the input voltage (24 V) is greater than the Zener voltage (10 V), the Zener diode is in its breakdown region and will regulate the voltage. The voltage across the load resistor is $V_L = V_Z$ = 10 V.
Calculate the current through the load resistor, I_L:

$$I_L = \frac{V_L}{R_L} = \frac{10 \text{ V}}{5000\,\Omega} = 0.002 \text{ A} = 2 \text{ mA}$$

The voltage drop across the series resistor R_s is:

$$V_s = V_{in} - V_Z = 24 \text{ V} - 10 \text{ V} = 14 \text{ V}$$

Calculate the total current I flowing from the source:

$$I = \frac{V_s}{R_s} = \frac{14 \text{ V}}{1000\,\Omega} = 0.014 \text{ A} = 14 \text{ mA}$$

This total current splits between the Zener diode and the load resistor. By Kirchhoff's current law:

$$I = I_Z + I_L$$

$$I_Z = I - I_L = 14\text{ mA} - 2\text{ mA} = 12\text{ mA}$$

Finally, calculate the power dissipated by the Zener diode:

$$P_Z = V_Z \times I_Z = 10\text{ V} \times 12\text{ mA} = 10\text{ V} \times (12 \times 10^{-3}\text{ A}) = 120 \times 10^{-3}\text{ W} = 120\text{ mW}$$

Step 4: Final Answer:
The power across the Zener diode is 120 mW.

---

8. Answer: a

Explanation:

Step 1: Understanding the Question:
We are given a logic circuit made of four NOR gates and two inputs, A and B. We need to find the truth table for the final output Y.
Step 2: Key Formula or Approach:
We will trace the logic signals through the circuit for each possible input combination (00, 01, 10, 11). The Boolean expression for a NOR gate with inputs X and Z is $\overline{X+Z}$.
Step 3: Detailed Explanation:
Let's label the intermediate outputs.
- The output of the top-left NOR gate (inputs A, B) be Y_1.

$$Y_1 = \overline{A+B}$$

- The output of the middle NOR gate (inputs A, Y_1) be Y_2.

$$Y_2 = \overline{A+Y_1} = \overline{A+\overline{A+B}}$$

- The output of the bottom NOR gate (inputs B, Y_1) be Y_3.

$$Y_3 = \overline{B+Y_1} = \overline{B+\overline{A+B}}$$

- The output of the final NOR gate (inputs Y_2, Y_3) is Y.

$$Y = \overline{Y_2+Y_3} = \overline{(\overline{A+\overline{A+B}}) + (\overline{B+\overline{A+B}})}$$

Let's simplify this using Boolean algebra:

First, simplify Y_2 and Y_3. Using De Morgan's theorem ($\overline{X+Z} = \bar{X} \cdot \bar{Z}$):

$$Y_2 = \overline{A + \overline{A+B}} = \bar{A} \cdot (\overline{\overline{A+B}}) = \bar{A} \cdot (A+B) = \bar{A}A + \bar{A}B = 0 + \bar{A}B = \bar{A}B$$

$$Y_3 = \overline{B + \overline{A+B}} = \bar{B} \cdot (\overline{\overline{A+B}}) = \bar{B} \cdot (A+B) = A\bar{B} + \bar{B}B = A\bar{B} + 0 = A\bar{B}$$

Now, substitute these into the expression for Y:

$$Y = \overline{Y_2 + Y_3} = \overline{\bar{A}B + A\bar{B}}$$

The expression $\bar{A}B + A\bar{B}$ is the definition of the XOR operation ($A \oplus B$).
Therefore, $Y = \overline{A \oplus B}$, which is the XNOR operation.
Let's construct the truth table for Y = XNOR(A, B):
- If A=0, B=0: $Y = \overline{0 \oplus 0} = \bar{0} = 1$
- If A=0, B=1: $Y = \overline{0 \oplus 1} = \bar{1} = 0$
- If A=1, B=0: $Y = \overline{1 \oplus 0} = \bar{1} = 0$
- If A=1, B=1: $Y = \overline{1 \oplus 1} = \bar{0} = 1$

Step 4: Final Answer:
The resulting truth table is:
This matches the truth table in option (A).

---

9. **Answer: c**

Explanation:

To understand the correct answer, let's evaluate each statement given in the options with respect to an n-type semiconductor:

1. **Holes are minority carriers:** In an n-type semiconductor, electrons are the majority charge carriers because they are supplied by the pentavalent dopant atoms, typically Phosphorus or Arsenic. Consequently, the number of electrons n_e is much larger than the number of holes n_h. Therefore, holes indeed are minority carriers. However, this option is incorrect as per the given correct answer.
2. **The dopant is a pentavalent atom:** In n-type semiconductors, the dopants are typically pentavalent, meaning they have five valence electrons. Examples include Phosphorus, Arsenic, or Antimony. This statement is true for n-type semiconductors, but this is not the correct answer as per the problem.

3. $n_e n_h = n_i^2$ **for intrinsic semiconductor:** This formula represents the mass action law in semiconductors. Here, n_i is the intrinsic carrier concentration. This equation is valid for any semiconductor condition, regardless of doping. In an intrinsic semiconductor, $n_e = n_h = n_i$. Hence, this statement is always true and matches the given correct answer.
4. $n_e \gg n_h$ **for extrinsic semiconductor:** In an n-type semiconductor, which is an example of an extrinsic semiconductor, the electron concentration n_e is indeed much greater than the hole concentration n_h, due to additional electrons from dopant atoms. Although this statement holds true in practice, this is not the correct option as per the problem statement.

Based on this analysis, the correct answer is indeed: $n_e n_h = n_i^2$ **for intrinsic semiconductor**. This statement is based on the fundamental principle of semiconductor physics and holds true under equilibrium conditions for any type of semiconductor, whether intrinsic (pure) or extrinsic (doped).

---

10. Answer: d

Explanation:

To understand why the correct choice is **"Statement-I is false but Statement-II is true"**, we need to examine each statement individually.

Statement-I: "The equivalent emf of two nonideal batteries connected in parallel is smaller than either of the two emfs."

When two nonideal batteries are connected in parallel, the equivalent emf (E_{eq}) is not simply smaller than either emf but rather an average based on their internal resistances. The formula for the equivalent emf is:

$$E_{eq} = (E_1 R_2 + E_2 R_1)/(R_1 + R_2)$$

Here, E_1 and E_2 are the emfs of the two batteries, while R_1 and R_2 are their internal resistances. The E_{eq} is essentially a weighted average and can be greater than or equal to the smaller emf and smaller than or equal to the larger emf. Therefore, Statement-I is **false**.

Statement-II: "The equivalent internal resistance of two nonideal batteries connected in parallel is smaller than the internal resistance of either of the two batteries."

When internal resistances are combined in parallel, the equivalent resistance (R_{eq}) is smaller than either of the individual resistances. The formula for the equivalent internal resistance is:

$$1/R_{eq} = 1/R_1 + 1/R_2$$

As a result, R_{eq} is indeed smaller than either R_1 or R_2. Therefore, Statement-II is **true**.

Thus, the correct answer is: **Statement-I is false but Statement-II is true.**

---

11. Answer: c

Explanation:

The circuit can be considered as:

$$R_{\text{eq}} = 0.5 + \frac{0.5 \times 2}{2 + 0.5} = \frac{5}{10} + \frac{10}{25}\,\Omega = 0.9\,\Omega$$

Now, the current is:

$$i = \frac{0.9}{0.9} = 1\,\text{A}$$

Thus, the current is $\boxed{1.0\,\text{A}}$.

---

12. Answer: a

Explanation:

To determine the value of X, we need to calculate the band gap energy of the photodiode, given that it starts changing its conductivity when illuminated with light whose wavelength is less than 660 nm.

The energy E of a photon is related to its wavelength λ by the formula:

$E = \frac{hc}{\lambda}$

where:

- $h = 6.6 \times 10^{-34}\,\text{Js}$ is Planck's constant.
- $c = 3 \times 10^{8}\,\text{m/s}$ is the speed of light in a vacuum.
- $\lambda = 660 \times 10^{-9}\,\text{m}$ is the wavelength of the incident light.

Substituting these values into the formula, we get:

$E = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{660 \times 10^{-9}}$

Calculating the above expression gives:

$E = \frac{6.6 \times 3}{660} \times 10^{-34+8+9}\,\text{eV}$

Simplifying gives:

$E = \frac{6.6 \times 3}{660} \times 10^{-17}\,\text{eV}$

$E = \frac{19.8}{660} \times 10^{-17}\,\text{eV}$

$E \approx 3.0 \times 10^{-19}\,\text{J}$

To convert energy from joules to electron volts, use the conversion factor $1\,\text{eV} = 1.6 \times 10^{-19}\,\text{J}$:

$E = \frac{3.0 \times 10^{-19}}{1.6 \times 10^{-19}}\,\text{eV}$

$E \approx 1.875\,\text{eV}$

The band gap E_g is given as $\frac{X}{8}\,\text{eV}$, so we equate and solve for X:

$\frac{X}{8} = 1.875$

Therefore,

$X = 1.875 \times 8 = 15$

Hence, the value of X is 15. Thus, the correct answer is **15**.

---

13. Answer: c

Explanation:

To solve this problem, we'll start by understanding the setup and conditions given:

The Wheatstone bridge is balanced initially, with arm BC, made of semiconductor, having an initial resistance $R_0 = 3\,\text{m}\Omega$ at $25°\text{C}$. This arm is cooled at $2°\text{C/s}$. If the galvanometer shows no deflection after 10 seconds, the bridge remains balanced, and the resistance change condition can be expressed as follows:

The temperature change in 10 seconds is:

$\Delta T = \text{rate of cooling} \times \text{time} = 2°\text{C/s} \times 10\,\text{s} = 20°\text{C}$

Let α be the temperature coefficient of resistivity. The change in resistance will be:

$\Delta R = R_0 \times \alpha \times \Delta T$

For the bridge to remain balanced:

The initial configuration has resistance $R_{DA} = 1\,\text{m}\Omega$ and $R_{AB} = 0.8\,\text{m}\Omega$. In the balanced condition:

$\frac{R_{AB}}{R_{BC}} = \frac{R_{DA}}{R_{CD}}$

The change in resistance ΔR should satisfy:

$R_0 + \Delta R = R_{BC} + \Delta R_{BC} = R_{CD}$

Initially, $R_{BC} = 3\,\text{m}\Omega$ and $R_{CDC} = 3\,\text{m}\Omega$ after 10s.

Let's substitute the known values:

$0.8\,\text{m}\Omega/(3\,\text{m}\Omega + \alpha \times 3\,\text{m}\Omega \times 20°\text{C}) = 1\,\text{m}\Omega/3\,\text{m}\Omega$

Re-arranging gives:

$0.8\,\text{m}\Omega \times 3\,\text{m}\Omega = 3\,\text{m}\Omega \times (3\,\text{m}\Omega + \alpha \times 3\,\text{m}\Omega \times 20°\text{C})$

This simplifies to:

$0.8 = 1 + 60 \times \alpha$

$60 \times \alpha = -0.2$

$\alpha = -\frac{0.2}{60} = -\frac{1}{300}\,\text{C}^{-1} = -1 \times 10^{-2}\,\text{C}^{-1}$

Therefore, the temperature coefficient of resistivity α is:

$\alpha = -1 \times 10^{-2}\,^{\circ}\mathrm{C}^{-1}$, which matches option C.

---

14. **Answer: c**

Explanation:

To solve this problem, we need to determine the maximum wavelength of light that can create a hole in a p-type semiconductor with an acceptor level of 6 eV. This involves using the relationship between energy, wavelength, and the quantum nature of light.

The energy E of a photon is related to its wavelength λ via the equation:

$E = \frac{hc}{\lambda}$

where:

- h is Planck's constant.
- c is the speed of light.
- λ is the wavelength.

Given that $hc = 1242\,\mathrm{eV\ nm}$ and the acceptor level energy $E = 6\,\mathrm{eV}$, we need to find the maximum wavelength λ that can induce transitions corresponding to this energy level.

Re-arranging the formula for wavelength, we get:

$\lambda = \frac{hc}{E}$

Substituting the provided values:

$\lambda = \frac{1242\,\mathrm{eV\ nm}}{6\,\mathrm{eV}}$

Calculating this gives:

$\lambda = 207\,\mathrm{nm}$

Thus, the maximum wavelength of light that can create a hole in this semiconductor is **207 nm**.

Let's justify this answer:

- **Option: 407 nm** — This option would imply a lower energy than required.
- **Option: 414 nm** — This option also implies a lower energy than required.
- **Option: 207 nm** — Correct, as calculated.
- **Option: 103.5 nm** — This implies higher energy, which isn't needed to create the hole.

Therefore, the correct answer is **207 nm**.

---

15. **Answer: b**

Explanation:

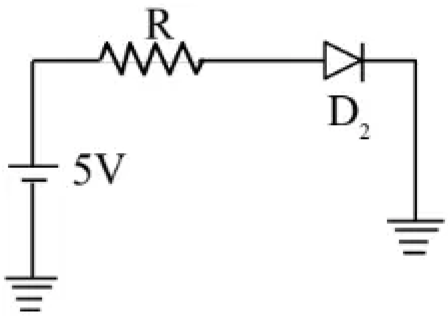
To determine the correct diode circuit used for measuring the dynamic resistance of a p-n junction diode, we need to understand the concept of biasing in diodes.

Concept Explanation:

- The measurement of dynamic resistance is typically done under forward bias conditions, where a small AC signal is superimposed on the DC biasing voltage across the diode. Under this condition, the diode is forward biased and the dynamic resistance is defined as the reciprocal of the slope of the diode's I-V characteristic curve at a particular operating point.
- The dynamic resistance r_d is given by the formula: $r_d = \frac{\Delta V}{\Delta I}$ where ΔV is the small change in voltage and ΔI is the small change in current.
- The correct circuit for measuring dynamic resistance should have a DC forward bias, with a means to measure small changes in current and voltage.

Analysis of Options:

1. Option 1: Incorrect biasing for measuring dynamic resistance.
2. Option 2:



This circuit shows a correctly forward-biased diode for measuring dynamic resistance. A small AC input can be applied across the diode in this configuration to measure the changes in current and voltage, hence calculating the dynamic resistance.

3. Option 3: Incorrect biasing for measuring dynamic resistance.
4. Option 4: Incorrect biasing for measuring dynamic resistance.

Conclusion:

The correct answer is Option 2, which shows the correct forward biasing configuration necessary for measuring the dynamic resistance of a p-n junction diode. In this circuit, the diode is forward biased, allowing for the measurement of voltage change and current change as required for dynamic resistance calculation.

---

16. Answer: c

Explanation:

To determine the wavelength of light emitted from the LED, we need to understand the relationship between the energy of a photon and its wavelength. The energy of a photon is given by the equation:

$E = \frac{hc}{\lambda}$

Where:

- E is the energy of the photon, measured in electron volts (eV).
- h is Planck's constant, approximately $4.1357 \times 10^{-15}\,\mathrm{eV \cdot s}$.
- c is the speed of light in vacuum, approximately $3 \times 10^{8}\,\mathrm{m/s}$.
- λ is the wavelength of the emitted light, measured in meters.

The band gap energy of GaAs (Gallium Arsenide) is given as $1.42\,\mathrm{eV}$. This energy corresponds to the energy of the photons emitted from the LED.

We will rearrange the equation to solve for wavelength λ:

$\lambda = \frac{hc}{E}$

Substitute the known values into the equation:

$\lambda = \frac{4.1357 \times 10^{-15}\,\text{eV}\cdot\text{s} \times 3 \times 10^{8}\,\text{m/s}}{1.42\,\text{eV}}$

Calculate the wavelength:

$\lambda = \frac{12.4071 \times 10^{-7}\,\text{m eV/s}}{1.42\,\text{eV}} \approx 8.7408 \times 10^{-7}\,\text{m}$

Convert meters to nanometers (1 m = 10^9 nm):

$\lambda \approx 874.08\,\text{nm}$

The wavelength of the light emitted from the LED is approximately $875\,\text{nm}$.

This calculation matches the correct answer, which is $875\,\text{nm}$.

Therefore, the correct answer is 875 nm.

---

17. Answer: 15 - 15

Explanation:

Solution:
Using the formula for the current through the conductor, which relates the current at different temperatures:

$$i_0 R_0 = i_{100} R_{100} \quad \text{[For the same source]}$$

This gives:

$$2R_0 = 1.2R_0[1 + 100\alpha] \quad \Rightarrow \quad 1 + 100\alpha = \frac{5}{3} \quad \Rightarrow \quad 100\alpha = \frac{2}{3}$$

Now, calculate α:

$$50\alpha = \frac{1}{3}$$

Thus, the current at 50°C will be:

$$i_{50} R_{50} = i_0 R_0$$

Substituting values:

$$i_{50} = \frac{i_0 R_0}{R_{50}} = \frac{2R_0}{R_0(1+50\alpha)} = \frac{2}{1+\frac{1}{3}} = \frac{2}{\frac{4}{3}} = 1.5\,\text{A}$$

Thus, the current at 50°C is $1.5\,\text{A} = 1500\,\text{mA}$. Therefore, the correct answer is $\boxed{1500}\,\text{mA}$.

---

18. **Answer: c**

Explanation:

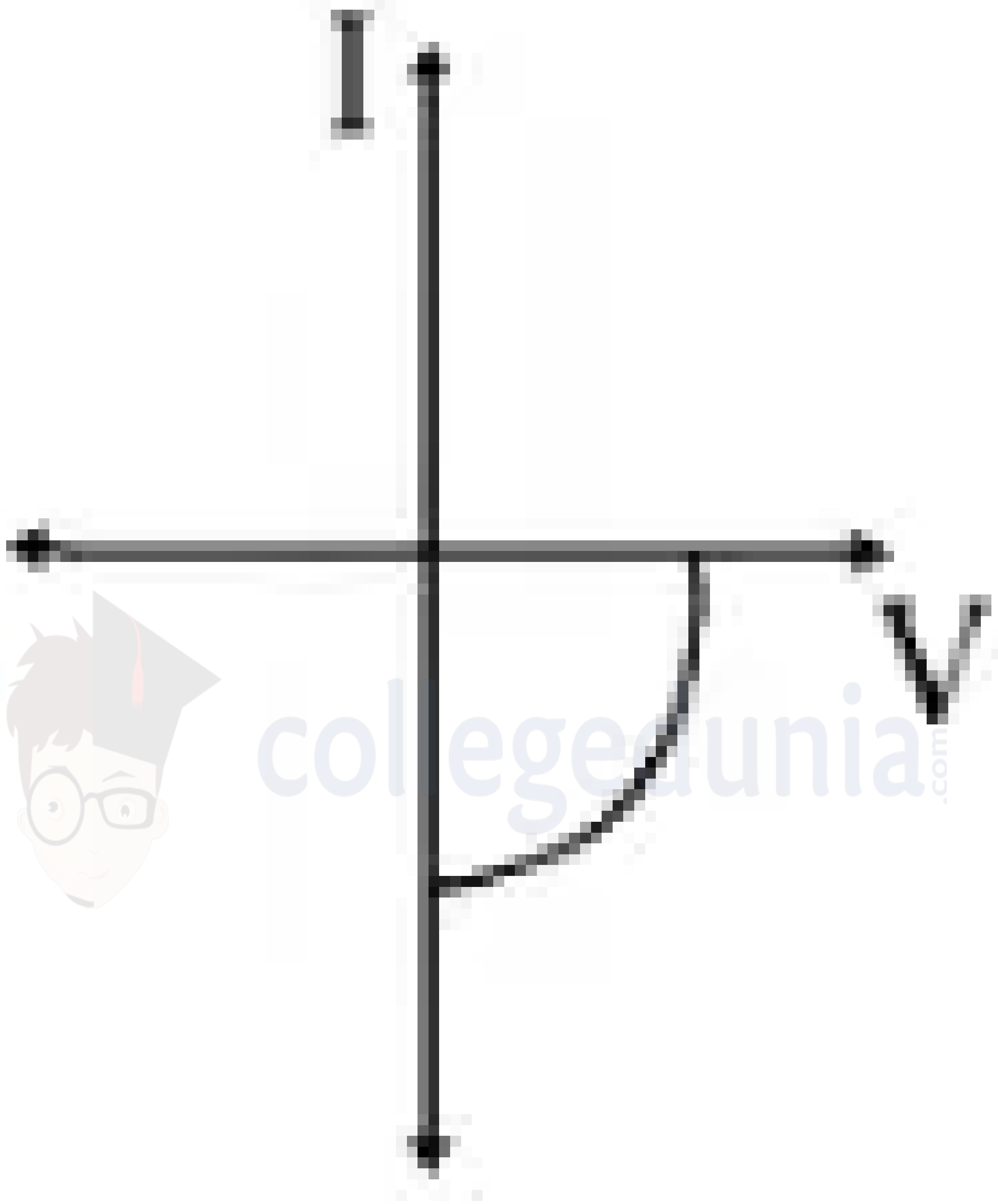
A semiconductor starts conduction more as the temperature increases. It means resistance decreases with increase in temperature. So, if temperature increases, its resistivity decreases. Also, ρ = m /$ne^2\tau$ As Temperature increase, τ decreases but n increases and n is dominant over τ.

---

19. **Answer: b**

Explanation:

The correct answer is



Concepts:

1. Semiconductors:

Semiconductors are a crystalline solid materials, whose electrical conductivity lies between a conductor and an insulator. Semiconductors are mainly used in the manufacturing of electronic devices like capacitors, transistors, diodes, Integrated circuits, etc.

Properties of Semiconductor:

1. Semiconductor acts like an insulator at Zero Kelvin. On increasing the temperature, it works as a conductor.
2. Due to their exceptional electrical properties, semiconductors can be modified by doping to make semiconductor devices suitable for energy conversion, switches, and amplifiers.
3. Lesser power losses.

Uses of Semiconductor:

1. Semiconductors are widely used in manufacturing electronics devices like transistors, diodes, sensors, integrated circuits.
2. Semiconductors are widely used in all electronic devices, like mobile phones, digital cameras, communication devices, trains, ATMs, etc.

---

20. Answer: c

Explanation:

Field at P is

$$= \left(\frac{\mu_0 \times i_1}{2\pi r_1} - \frac{\mu_0 i_2}{2\pi r_2}\right)\left(-\hat{k}\right)$$

$$= -\left(\frac{\mu_0 4}{2\pi \times 0.04} - \frac{\mu_0 \times 2}{2\pi \times 0.06}\right)\hat{k} = -\frac{\mu_0 \times 200}{6\pi}\hat{k}$$

Therefore, the force

$$\vec{F} = q\vec{v} \times \vec{B}$$

$$= 3\pi(2\hat{i} + 3\hat{j}) \times \left(-\left(\frac{\mu_0 \times 200}{6\pi}\right)\hat{k}\right)$$

$$= 3\pi\left(\frac{200\mu_0}{3\pi\hat{j}} - \frac{100\mu_0}{\pi}\hat{i}\right)$$

$$= 200\mu_0\hat{j} - 300\mu_0\hat{i}$$

= $4\pi \times 10^{-5}(2\hat{j} – 3\hat{i})$

$Hence, \ \ x \ = 3$

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21. Answer: 14 - 14

Explanation:

The correct answer is 14
Conserving energy,
$\frac{1}{2}mv^2 = \frac{1}{2}m(6 \ \times 10^5)^2 - 0.4eV$
$\Rightarrow v = \sqrt{(6 \ \times \ 10^5)^2 - \frac{2 \times 1.6 \times 10^{-19} \times 0.4}{9 \times 10^{-31}}}$

$= \sqrt{36 \times 10^{10} - \frac{1.28}{9} \times 10^{12}}$

$\Rightarrow v = \frac{14}{3} \times 10^5 m/s$

⇒ x = 14

There , the speed will be 14 m/s

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22. Answer: b

Explanation:

$A_V = \beta \frac{R_L}{R_i} = \frac{V_{out}}{V_{in}}$

$100 \times \frac{10\times10^3}{1\times10^3} = \frac{V_{out}}{1\times10^{-3}}$

$\Rightarrow V_{out} = 1V$

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23. Answer: a

Explanation:

The correct answer is (A) : Both A and Rare true, and R is correct explanation of A.
(A) is true as n-p-n transistor permits more current than p-n-p transistor as electrons which are majority charge carriers in n-p-n have higher mobility than holes which are majority carriers in
p-n-p transistor

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24. Answer: b

Explanation:

The correct answer is (B) : It is two terminal device which conducts current in one direction only.
A diode is a two terminal device which conducts current in forward bias only.

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25. Answer: c

Explanation:

The correct answer is (C) : $Y = \overline{AB}$

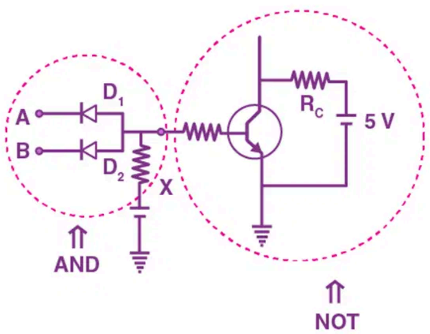

Fig. Circuit

The shown circuit is a combination of AND gate and a NOT gate.
$\Rightarrow Y \ = \overline{AB}$

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