Semiconductor Devices and Logic Gates

Question1

Which of the following statements is correct for an n-type semiconductor?

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Options:

A. The donor energy level lies closely above the top of the valance band

B. The donor energy level lies at the half way mark of forbidden energy gap

C. The donor energy level does not exist

D. The donor energy level lies just the bottom of the conduction band

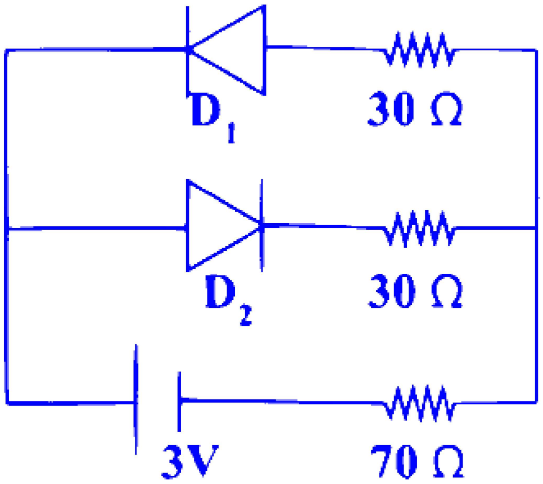
Answer: D

Solution:

In an n-type semiconductor, donor impurities contribute electron energy levels high in the semiconductor band gap, allowing electrons to be easivy excited into the conduction b and. This donar level is located closed to, and just below, the bottom of the conduction band.

Question2

The circuit shown in figure contains two ideal diodes D_1 and D_2. If a cell of emf $3V$ and negligible internal resistance is connected as shown, then the current through 70Ω resistance, (in ampere) is



KCET 2025

Options:

A. 0.01

B. 0.02

C. 0.03

D. 0

Answer: C

Solution:

$D_1 \Rightarrow$ revere biased, $\Rightarrow$ act as open circuit

$D_2 \Rightarrow$ Forward biased

$R_{eq} = 30 + 70 = 100\Omega$

$I \Rightarrow \frac{V}{R_{eq}} = \frac{3}{100} = 0.03 \text{ A}$

Question3

Depletion region in an unbiased semiconductor diode is a region consisting of only free electrons only holes

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Options:

A. both free electrons and holes

B. neither free electrons nor holes

C. only free electrons

D. only holes

Answer: B

Solution:

Depletion region in an unbiased semiconductor diode is a region consisting of immobile ions only. i.e. In depletion region, neither free elements nor holes exist.

Question4

The upper level of valence band and lower level of conduction band overlap in the case of

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Options:

A. silicon

B. copper

C. carbon

D. germanium

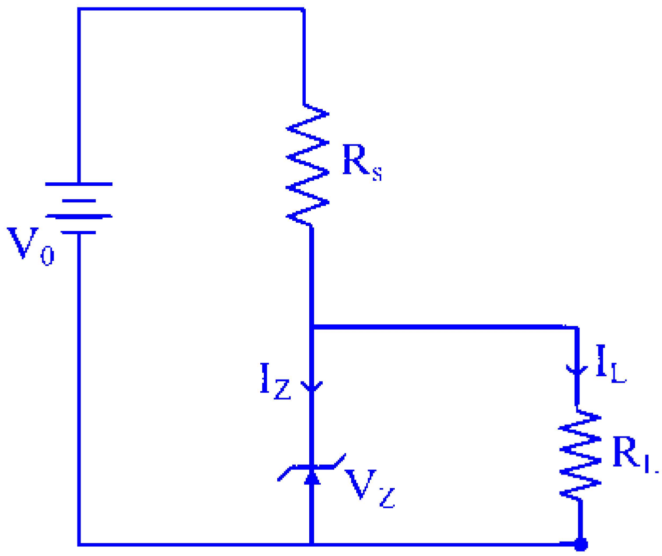
Answer: B

Solution:

There is no forbidden energy gap between conduction bond and valence band for a conductor (copper). Hence, in copper, valence band and conduction band are overlapped.

Question5

In the diagram shown, the Zener diode has a reverse breakdown voltage of V_Z. The current through the load resistance R_L is I_L. The current through the Zener diode is



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Options:

A. $\frac{V_0 - V_Z}{R_S}$

B. $\frac{V_0 - V_Z}{R_L}$

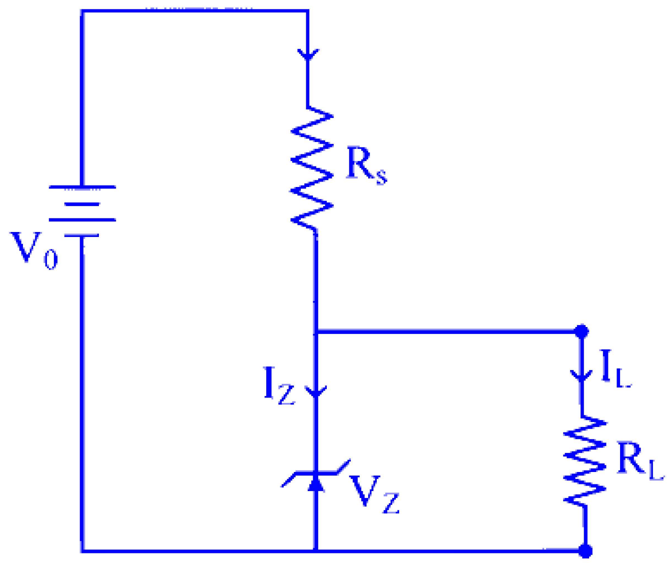
C. $\frac{V_Z}{R_L}$

D. $\left(\frac{V_0 - V_Z}{R_S}\right) - I_L$

Answer: D

Solution:

From the diagram,



$I = I_Z + I_L$

$$\Rightarrow \quad I_Z = I - I_L = \frac{V_O - V_Z}{R_S} - I_L$$

Question6

A $p-n$ junction diode is connected to a battery of emf 5.7 V in series with a resistant $5 \mathrm{k} \Omega$ such that it is forward biased. If the barrier potential of the diode is 0.7 V , neglecting the diode resistance, the current in the circuit is

KCET 2024

Options:

A. 1.14 mA

B. 1 mA

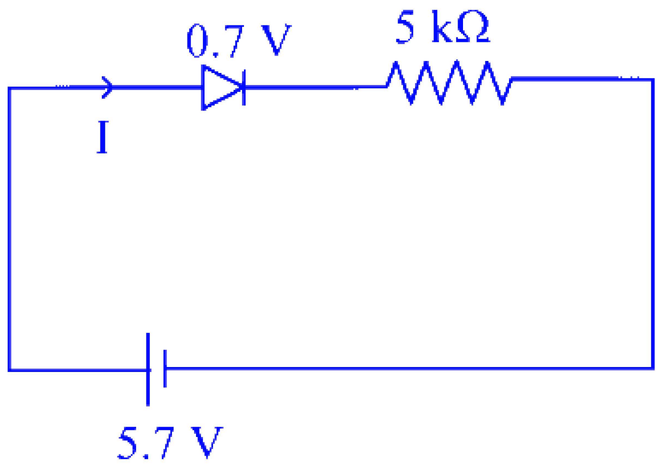
C. 1 A

D. 1.14 A

Answer: B

Solution:

Given, barrier potential, $V_B = 0.7V$



Series resistance,

$$R_S = 5\text{k}\Omega = 5 \times 10^3 \Omega$$

$$\therefore \quad I = \frac{V - V_B}{R_S} = \frac{5.7 - 0.7}{5 \times 10^3} = 1 \times 10^{-3}\text{ A} = 1\text{ mA}$$

Question7

When a p-n junction diode is in forward bias, which type of charge carriers flows in the connecting wire?

KCET 2023

Options:

A. Free electrons

B. Ions

C. Protons

D. Holes

Answer: A

Solution:

When p-n junction diode is forward biased, then free electrons flow in the connecting wire.

Question8

A full-wave rectifier with diodes D_1 and D_2 is used to rectify 50 Hz alternating voltage. The diode D_1 conducts .... times in one second.

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Options:

A. 100

B. 25

C. 75

D. 50

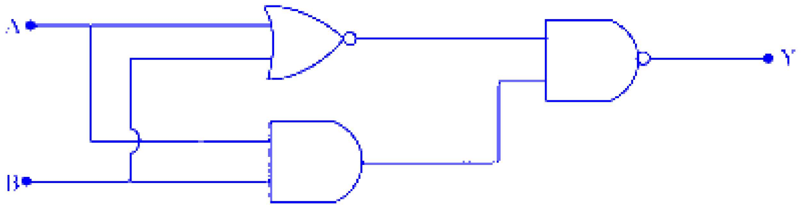
Answer: D

Solution:

In full wave rectifier, one diode works for positive half cycle and another diode works for negative half cycle of alternating voltage. Thus, each diode works one time in one complete cycle of input AC signal. Hence, for 50 Hz AC supply, diode D_1 conducts 50 times in 1s.

Question9

A truth table for the given circuit is



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Options:

A.

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

B.

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

C.

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

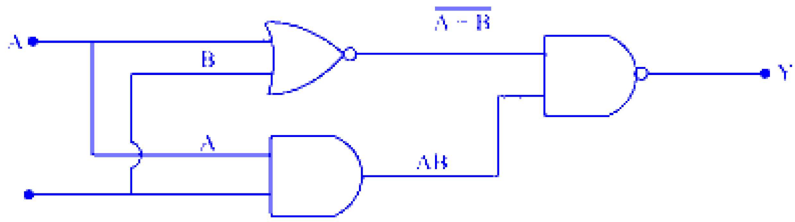
D.

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

Answer: C

Solution:

The given logic circuit diagram is



Output of the logic gate is

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

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

$=(A+\bar{A})+(B+\bar{B}) \quad [\because x+\bar{x}=1]$

$=1+1=1$

Thus output is always 1 for all value of inputs A and B. Hence, option (c) is correct.

Question10

The resistivity of a semiconductor at room temperature is in between

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Options:

A. 10^{-3} to $10^{6} \Omega-\mathrm{cm}$

B. 10^{6} tol $0^{8} \Omega-\mathrm{cm}$

C. 10^{10} to $10^{12} \Omega-\mathrm{cm}$

D. 10^{-2} to $10^{-5} \Omega-\mathrm{cm}$

Answer: A

Solution:

The resistivity of a material is a measure of how strongly the material resists the flow of electric current. Semiconductors have resistivity values that are between those of good conductors (like metals) and good insulators (like ceramics).

Option A states that the resistivity range is from 10^{-3} to $10^{6}\Omega - \text{cm}$.

Option B suggests a range from 10^{6} to $10^{8}\Omega - \text{cm}$.

Option C offers a range from 10^{10} to $10^{12}\Omega - \text{cm}$.

Option D proposes a range from 10^{-2} to $10^{-5}\Omega - \text{cm}$.

The correct resistivity range for semiconductors at room temperature is typically closer to Option A: 10^{-3} to $10^{6}\Omega - \text{cm}$. This range is wide because it can be affected by several factors, including the type of semiconductor material, the presence of impurities (doping), and the temperature of the material.

Question11

The forbidden energy gap for Ge crystal at 0K is

KCET 2022

Options:

A. 0.71 eV

B. 2.57 eV

C. 6.57 eV

D. 0.071 eV

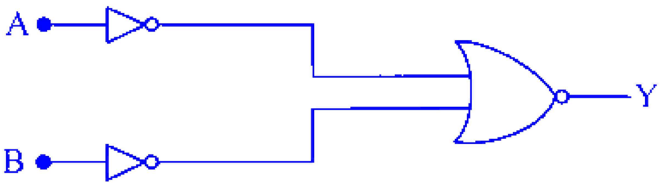
Answer: C

Solution:

Ge is a semiconductor material which behaves as an insulator at 0 K. We know that, forbidden energy gap of an insulator is more than 3 eV. Hence, among the given options, option (c) is correct.

Question12

Which logic gate is represented by the following combination of logic gates?



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Options:

A. NAND

B. AND

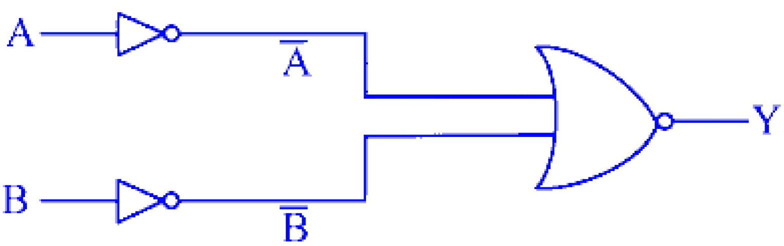
C. NOR

D. OR

Answer: B

Solution:

The given logic gate is represented as



Output of logic gate is written as

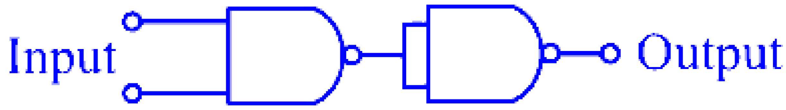
$y = \overline{\bar{A} + \bar{B}} = \bar{\bar{A}} \cdot \bar{\bar{B}}$

[According to Demorgan's law $\overline{x + y} = \bar{x} \cdot \bar{y}$]

$= A \cdot B =$ Output of AND gate

Question13

The circuit given represents which of the logic operations?



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Options:

A. OR

B. AND

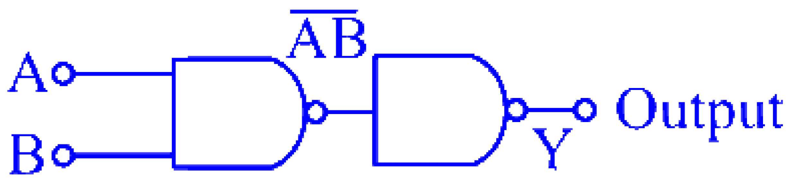
C. NOT

D. NOR

Answer: B

Solution:

This diagram can be shown as



$$\begin{aligned} Y &= \overline{\overline{AB}} \\ &= AB \end{aligned}$$

$\therefore$ Output represents logic operations of AND gate.

Question14

Identify the incorrect statement.

KCET 2021

Options:

A. When a p-n junction diode is forward biased, then the width of the depletion region decreases.

B. When a p-n junction diode is reverse biased, the barrier potential increases.

C. A photodiode is operated in the reverse bias.

D. An LED is a lightly doped p-n junction diode which emits spontaneous radiation of forward biasing.

Answer: D

Solution:

The LED is a heavily doped p-n junction with forward biasing. It is a specially designed forward biased p-n junction diode that emits light spontaneously when energised.

Question15

Three photodiodes D_1, D_2 and D_3 are made of semiconductors having band gaps of $2.5 \mathrm{~eV}, 2 \mathrm{~eV}$ and $3 \mathrm{~eV}$, respectively. Which one will be able to detect light of wavelength $600 \mathrm{~nm}$?

KCET 2021

Options:

A. D_1 only

B. Both D_1 and D_3

C. D_2 only

D. All of these

Answer: C

Solution:

Given, $E_1=2.5 \mathrm{~eV}, E_2=2 \mathrm{~eV}, E_3=3 \mathrm{~eV}$ and $\lambda=600 \mathrm{~nm}$

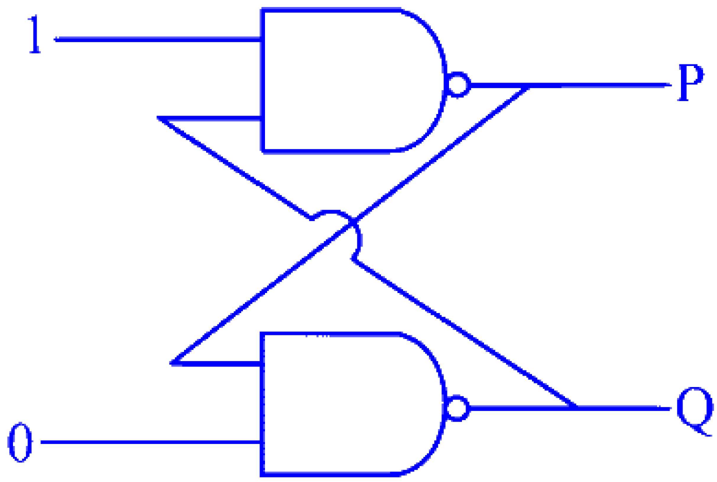
As we know,

$$E=\frac{1242}{\lambda}=\frac{1242}{600}$$
$$=2.07 \text{ eV}$$

Since, E_1 and E_3 is greater than E. So, only D_2 will able to detect the given light of wavelength 600 nm.

Question16

In the following circuit what are P and Q



KCET 2020

Options:

A. $P=1, Q=0$

B. $P=0, Q=1$

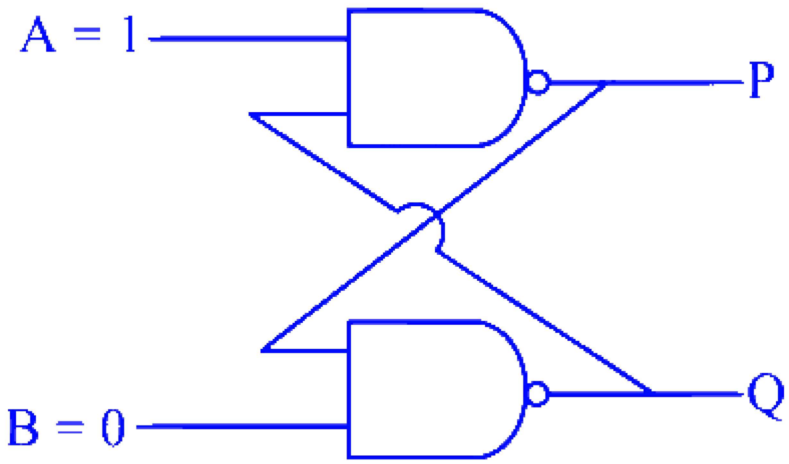
C. $P=0, Q=0$

D. $P=1, Q=1$

Answer: B

Solution:

The given circuit is as shown



The truth table for P can be shown as

A	Q	$P = \overline{A \cdot Q}$
1	0	1
1	1	0

The truth table for Q can be shown as

B	P	$Q = \overline{B \cdot P}$
0	0	1
0	1	1

Thus, Q is 1 for any value of P. So, the values satisfying given condition are,

$P = 0, Q = 1$

Question17

A positive hole in a semiconductor is

KCET 2020

Options:

A. an anti-particle of electron

B. a vacancy created when an electron leaves a covalent bond

C. absence of free electrons

D. an artificially created particle

Answer: B

Solution:

At room temperature, some of the valence electrons acquire thermal energy greater than E_g (energy gap between conduction and valence band) and some of the valence electrons becomes free. Thus, we can say that a valence electron is shifted to conduction band leaving a vacancy of electron in valence.

This vacancy is known as hole and carries a positive charge.

Question18

The conductivity of semiconductor increases with increase in temperature because

KCET 2019

Options:

A. number density of charge carriers increases

B. relaxation time increases

C. both number density of charge carriers and relaxation time increases

D. number density of current carriers increases, relaxation time decreases but effect of decrease in relaxation time is much less than increase in number density

Answer: D

Solution:

When temperature of semiconductor material increases, then more number of charge carriers increases due to breaking of covalent bonds. Hence conductivity of semiconductor material increases with increases in temperature due to increase in number density.

When temperature of semiconductor material increases, then relaxation time also decreases but decrease in relaxation time is much less than increase in number density.

Question19

For a transistor amplifier, the voltage gain

KCET 2019

Options:

A. remains constant for all frequencies

B. is high at high and low frequencies and constant in the middle frequency range

C. is low at high and low frequencies and constant at mid frequencies

D. constant at high frequencies and low at low frequencies

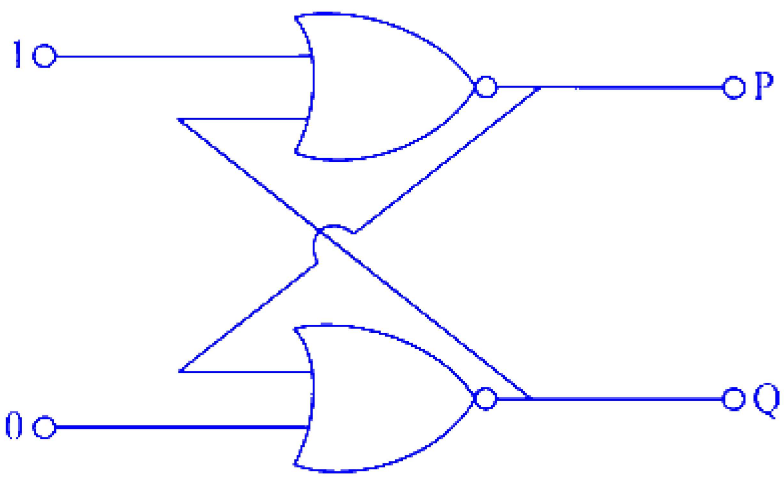
Answer: C

Solution:

For a transistor amplifier, the voltage gain is low at high frequency because of negligible influence of input capacitor and at low frequency gain is low because of low gain of coubled capacitor. At the middle frequencies range, voltage gain is constant for transistor amplifier.

Question20

In the following circuit, what are P and Q?



KCET 2019

Options:

A. $P=0, Q=0$

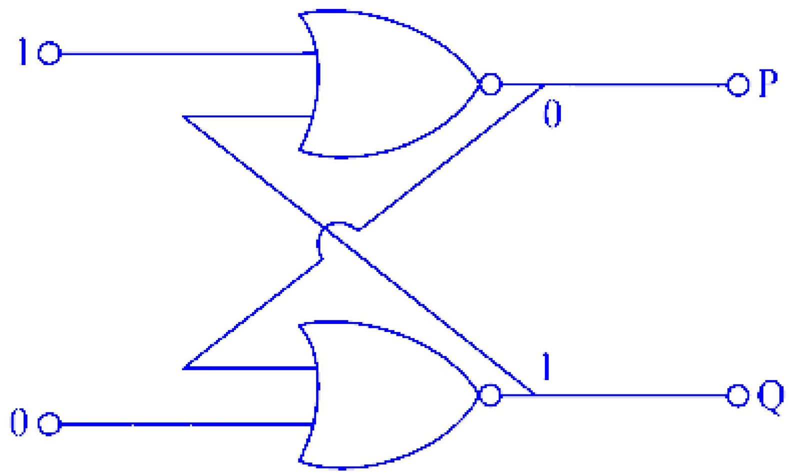
B. $P=1, Q=0$

C. $P=0, Q=1$

D. $P=1, Q=1$

Answer: C

Solution:



When, $P=0$ and $Q=1$, then above logic circuit holds.

Question21

In a CE amplifier, the input AC signal to be amplified is applied across

KCET 2018

Options:

A. forward biased emitter-base junction

B. reverse biased collector-base junction

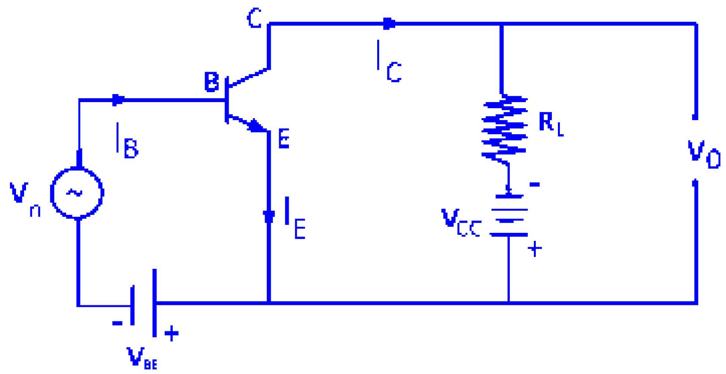
C. reverse biased emitter-base junction

D. forward biased collector-base junction

Answer: A

Solution:

The circuit diagram for CE amplifier is given belowInput signal is applied across base-emitter junction



Question22

If $A = 1$ and $B = 0$, then in terms of Boolean algebra, $A + \bar{B} =$

KCET 2018

Options:

A. B

B. $\bar{B}$

C. A

D. $\bar{A}$

Answer: C

Solution:

Let's evaluate the expression step by step:

Since $B = 0$, its Boolean complement is:

$\bar{B} = \bar{0} = 1.$

The expression given is:

$A + \bar{B}.$

With $A = 1$ and $\bar{B} = 1$, it becomes:

$1 + 1.$

In Boolean algebra, the OR operation (denoted by $+$) follows the rule:

$1 + 1 = 1.$

Since $A = 1$, the expression $A + \bar{B}$ simplifies to A.

Thus, the correct answer is:

Option C: A.

Question23

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

KCET 2018

Options:

A. 1×10^{10}

B. 2×10^{10}

C. 0.5×10^{10}

D. 4×10^{10}

Answer: B

Solution:

When germanium is pure (intrinsic), the electron density n_i and the hole density p_i are equal and given as:

$n_i = p_i = 3 \times 10^{16}\ \mathrm{m}^{-3}.$

After doping with aluminium (which is an acceptor impurity), the hole density increases to:

$p = 4.5 \times 10^{22}\,\mathrm{m}^{-3}$.

In a semiconductor, the law of mass action holds, which states that:

$n \times p = n_i^2$,

where n is the electron density in the doped semiconductor.

To find n (the electron density in doped germanium), follow these steps:

Calculate the square of the intrinsic carrier concentration:

$n_i^2 = (3 \times 10^{16})^2 = 9 \times 10^{32}\,\mathrm{m}^{-6}$.

Use the mass action law to solve for n:

$n = \frac{n_i^2}{p} = \frac{9 \times 10^{32}}{4.5 \times 10^{22}}$.

Perform the division:

$n = 2 \times 10^{10}\,\mathrm{m}^{-3}$.

Thus, the electron density in the doped germanium is $2 \times 10^{10}\,\mathrm{m}^{-3}$, which corresponds to Option B.

Question24

The DC common emitter current gain of an $n-p-n$ transistor is 50 . The potential difference applied across the collector and emitter of a transistor used in CE configuration is, $V_{CE} = 2$ V. If the collector resistance $R_C = 4\mathrm{k}\Omega$, the base current (I_B) and the collector current (I_C) are

KCET 2018

Options:

A. $I_B = 10\mu$ A, $I_C = 0.5$ mA

B. $I_B = 0.5\mu$ A, $I_C = 10$ mA

C. $I_B = 5\mu$ A, $I_C = 1$ mA

D. $I_B = 1\mu$ A, $I_C = 0.5$ mA

Answer: A

Solution:

Let's analyze the problem step by step.

We are given the DC current gain of the common emitter (CE) configuration:

$\beta = \frac{I_C}{I_B} = 50.$

This means that the collector current is 50 times the base current:

$I_C = 50\, I_B.$

The circuit has a collector resistor:

$R_C = 4\,\text{k}\Omega,$

and the voltage applied across the collector and emitter is:

$V_{CE} = 2\,\text{V}.$

In a common emitter configuration, the supply voltage (say, V_{CC}) is shared between the collector resistor and the transistor. That is,

$V_{CC} = I_C R_C + V_{CE}.$

Although V_{CC} is not given explicitly, we can use the available values to find a consistent solution.

Suppose the voltage drop across R_C is equal to:

$V_{R_C} = I_C R_C.$

For a consistent operating point, one possible scenario is that:

$V_{R_C} = 2\,\text{V}.$

Then,

$I_C R_C = 2\,\text{V} \quad \Longrightarrow \quad I_C = \frac{2\,\text{V}}{4\,\text{k}\Omega} = 0.5\,\text{mA}.$

Now, using the relation

$I_B = \frac{I_C}{\beta},$

we get:

$I_B = \frac{0.5\,\text{mA}}{50} = 0.01\,\text{mA} = 10\,\mu\text{A}.$

Thus, we have:

Base Current, $I_B = 10\,\mu\text{A}$

Collector Current, $I_C = 0.5\,\text{mA}$

These results correspond to Option A.

Question25

In the three parts of a transistor, 'Emitter' is of

KCET 2017

Options:

A. larger size and lightly doped

B. moderate size and heavily doped

C. thin size and heavily doped

D. large size and moderately doped

Answer: B

Solution:

The emitter of a transistor is of moderate size and heavily doped. Its primary role is to provide a substantial amount of majority charge carriers, which facilitates the current flow through the transistor.

Question26

The energy gap in case of which of the following is less than 3 eV ?

KCET 2017

Options:

A. Germanium

B. Iron

C. Copper

D. Aluminium

Answer: A

Solution:

The energy gap (or band gap) is the energy difference between the valence band and the conduction band in a

Semiconductors have a finite band gap that allows electrons to jump from the valence band to the conduction band with the absorption of energy. Typically, the band gap in semiconductors is less than 3 eV. For example, Germanium has a band gap of around 0.66 eV.

Metals, on the other hand, have overlapping conduction and valence bands, meaning they do not have a meaningful band gap (effectively, the gap is 0 eV).

Given the options:

Option A: Germanium (a semiconductor with $\sim$ 0.66 eV band gap, which is less than 3 eV)

Options B (Iron), C (Copper), and D (Aluminium) are metals and do not exhibit a band gap in the context of semiconductor physics.

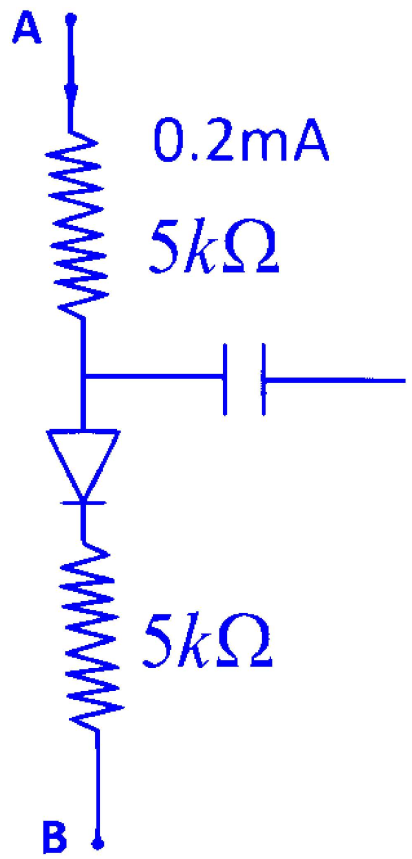
Thus, the correct answer is:

Option A

Germanium

Question27

In the figure shown, if the diode forward voltage drop is 0.2 V , the voltage difference between A and B is



KCET 2017

Options:

A. 2.2 V

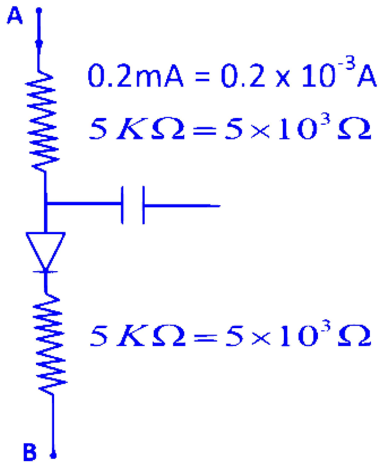
B. 1.3 V

C. 0

D. 0.5 V

Answer: A

Solution:



The voltage drop across 5kΩ resistance is given by

$V = 02 \times 10^{-3} \times 5 \times 10^{3}$
$V = 1.0 \text{ V}$

Applying the KVL (Kirchoff's Voltage Law)

$V_{AB} = 1 + 02 + 1$

$[\because$ Voltage drop acros diode $= 02 \text{ V}]$

$V_{AB} = 22 \text{ V}$

Question28

Which of the following semi-conducting device is used as voltage regulator?

KCET 2017

Options:

A. LASER diode

B. Zener diode

C. Solar cell

D. Photo diode

Answer: B

Solution:

The correct answer is Option B: Zener diode.

Here's why:

A voltage regulator maintains a constant voltage level regardless of changes in the load current or supply voltage.

A Zener diode, when reverse-biased, enters a breakdown region at its specified Zener voltage. In this region, it maintains approximately that voltage across its terminals even if the current varies.

This characteristic makes the Zener diode ideal for use in simple voltage regulation circuits.

The other options do not serve this function:

A laser diode is primarily used for emitting focused light in optical applications.

A solar cell converts light energy into electrical energy.

A photodiode detects light and converts it into a current but does not regulate voltage.

Thus, the Zener diode is the semiconductor device used as a voltage regulator.

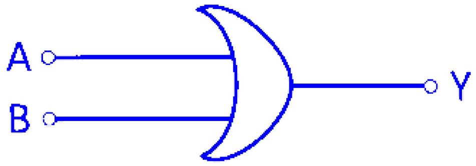
Question29

Which of the following logic gate is universal gate

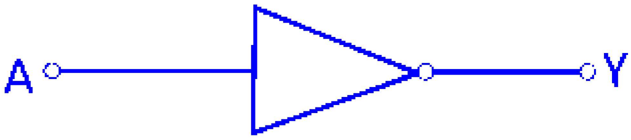
KCET 2017

Options:

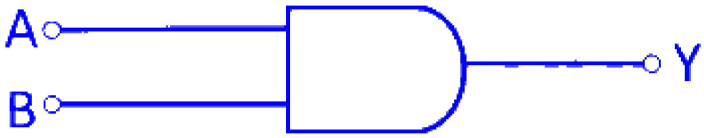
A.



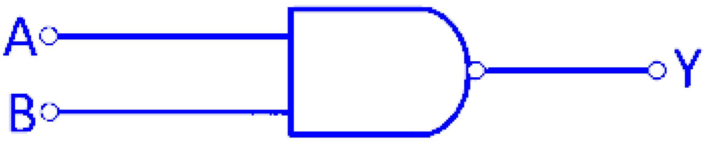
B.



C.



D.



Answer: D

Solution:

NAND gate is an universal gate.