SHORT QUESTIONS

18.1 How does the motion of an electron in a n-type substance differ from the motion of holes in a p-type substance?

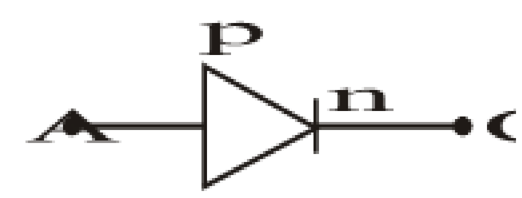
Ans. As we know that the majority charge carriers in N-type substances are free electron and majority charge carriers in P-type substances are holes. Both electrons and holes are moving in opposite direction. The motion of electrons in N-type substances is much faster than the motion of holes in P-type substances.

18.2 What is the net charge on a n-type or a p-type substance?

Ans. P-type and N-type substances are neutral. Since they are made as a result of combination of atoms of intrinsic semi-conductors and atoms of impurity. Atom as whole is neutral therefore there is no net charge on P-type or N-type substance.

18.3 The anode of a diode is 0.2 V positive with respect to its cathode. Is it forward-biased?

Ans. If the anode of the diode (P-type substance) is at higher potential 0.2 volt (positive) with respect to cathode (N-type substance), so P-n junction is forward biased.



18.4 Why charge carriers are not present in the depletion region?

Ans. In p-n-junction, n-region contains free electrons and p-region contain holes. As electrons in the n-region due to their random motion diffuse into the p-region. As a result of their diffusion, the recombination of electrons and holes take place within depletion region since the charge carriers are removed so chargeless region is formed in which charge carriers are not present so depletion region has no charge carriers.

18.5 What is the effect of forward and reverse biasing of a diode on the width of depletion region?

Ans. When a diode is forward biased, the width of depletion region decreases while when a diode is reversed biased, the width of depletion region is increased.

18.6 Why ordinary silicon diodes do not emit light?

Ans. There are two reasons for ordinary silicon diode do not emit light.

(i) Opaque nature of silicon.

(ii) In forward biased condition when electrons recombine with holes energy will release in the form of photons whose wavelength will lies in invisible region because their wavelength will be greater than visible region.

18.7 Why a photo diode is operated in reverse biased state?

Ans. Photodiode is basically the device used for the detection of light. In the absence of light, current is negligible due to reverse biased state. As light falls on it, then electron-hole pair is created due to which reverse current increases and hence light can be detected.

18.8 Why is the base current in a transistor very small?

Ans. As base is very thin of the order of 10^{-6} m then emitter and collector and also impurity ratio in base is very small as compared to emitter and collector. Secondary the voltage between collector to base is very large as compared to voltage between base to emitter. That is why, the base current in a transistor is very small.

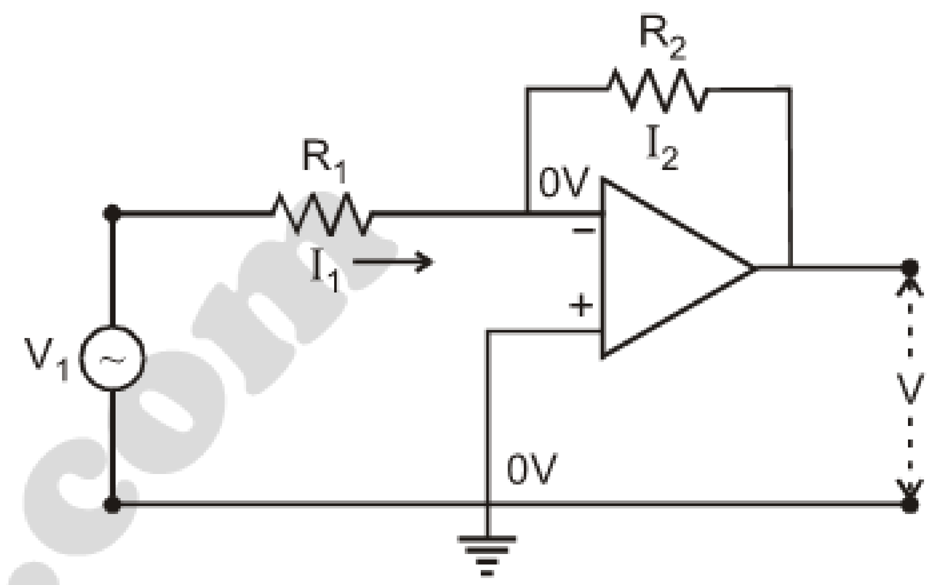
18.9 What is the biasing requirement of the junctions of a transistor for its normal operation? Explain how these requirements are met in a common emitter amplifier?

Ans. For normal operations of transistors, batteries V_{BB} and V_{CC} are connected in such a way that its emitter-base junction is forward biased and its collector-base junction is reverse biased. V_{CC} is of much higher value than V_{BB}.

For common emitter amplifier V_{BB} forward biases, the base-emitter junction and V_{CC} reverse biases the collector base junction.

18.10 What is the principle of virtual ground? Apply it to find the gain of an inverting amplifier.

Ans. Figure shows operational amplifier as an inverting amplifier.



As $$A_{OL} = \frac{V_o}{V_+ - V_-}$$

$$V_+ - V_- = \frac{V_o}{A_{OL}}$$

Since $$A_{OL} = 10^5$$

$\therefore$ $$V_+ - V_- = \frac{V_o}{10^5}$$

$$V_+ - V_- \simeq 0$$

$$V_+ \simeq V_-$$

Since V_+ is at ground so V_- is virtually at ground potential i.e., $V_- \simeq 0$. This is known as virtual ground principle.

18.11 The inputs of a gate are 1 and 0. Identify the gate if its output is (a) 0, (b) 1.

Ans. The inputs of a gate are 1 and 0. Identify the gate if its input is (a) 0 and (b) 1.

(a) AND gate (b) OR gate

18.12 Tick (✓) the correct answer

(i) A diode characteristic curve is a plot between

(a) current and time

(b) voltage and time

(c) voltage and current

(d) forward voltage and reverse voltage

(ii) The colour of light emitted by a LED depends on

(a) its forward bias

(b) its reverse bias

(c) the amount of forward current

(d) the type of semi-conductor material used

(iii) In a half-wave rectifier the diode conducts during

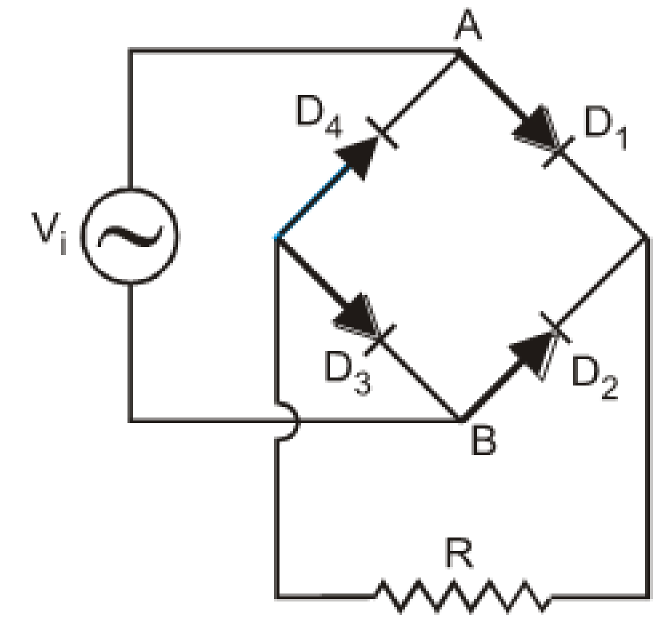
(a) both halves of the input cycle

(b) a portion of the positive half of the input cycle

(c) a portion of the negative half of the input cycle

(d) one half of the input cycle

(iv) **In a bridge rectifier of Fig. Q. when V_i is positive at point B with respect to point A, which diodes are ON**



(a) D_2 and D_4
(b) D_1 and D_3
(a) D_2 and D_3
(b) D_1 and D_4

(v) **The common emitter current amplification factor β is given by**

(a) $\frac{I_C}{I_E}$ (b) $\frac{I_C}{I_B}$
(c) $\frac{I_E}{I_B}$ (d) $\frac{I_B}{I_E}$

(vi) **Truth table of logic function**

(a) summarizes its output values
(b) tabulates all its input conditions only
(c) display all its input/output possibilities
(d) is not based on logic algebra

(vii) **The output of a two inputs OR gate is 0 only when its**

(a) both inputs are 0 (b) either input is 1
(c) both inputs are 1 (d) either input is 0

(viii) **A two inputs NAND gate with inputs A and B has an output 0 if**

(a) A is 0 (b) B is 0
(c) both A and B are zero (d) both A and B are 1

(ix) **The truth table shown below is for ________ gate**

A	B	X
0	0	1
0	1	0
1	0	0
1	1	1

(a) XNOR
(b) OR
(c) AND
(d) NAND

Ans. **(i)** (c) **(ii)** (d) **(iii)** (d) **(iv)** (a) **(v)** (b)
(vi) (c) **(vii)** (a) **(viii)** (d) **(ix)** (a)

PROBLEMS WITH SOLUTIONS

PROBLEM 18.1

The current flowing into the base of a transistor is 100 μA. Find its collector current I_C, its emitter current I_E and the ratio I_C/I_E, if the value of current gain β is 100.

Data

Base current $= I_B = 100\ \mu A$

$= 100 \times 10^{-6}$ A

Value of current gain $= \beta = 100$

To Find

Collector current $= I_C = ?$

Emitter current $= I_E = ?$

Ratio $= \dfrac{I_C}{I_E} = ?$

SOLUTION

By formula

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

$$I_C = \beta \times I_B$$
$$= 100 \times 10^{-6} \times 100$$
$$I_C = 10 \times 10^{-3} \text{ A}$$
$$I_C = 10 \text{ m A}$$

For emitter current

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

$$= 10 \times 10^{-3} + 100 \times 10^{-6}$$
$$= 10^{-3}(10 + 100 \times 10^{-3})$$
$$= 10^{-3}(10 + 0.1)$$
$$= 10.1 \times 10^{-3} \text{ A}$$
$$I_E = 10.1 \text{ m A}$$

For ratio

$$\frac{I_C}{I_E} = \frac{10 \times 10^{-3}}{10.1 \times 10^{-3}}$$
$$= 0.99$$

Result

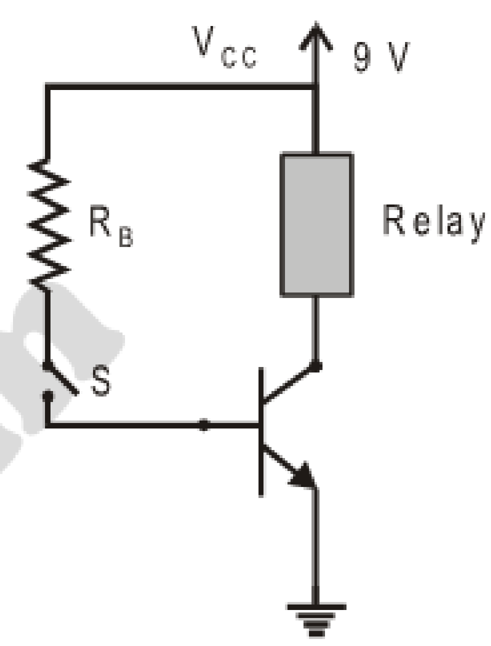
Collector current $= I_C = 10\text{ m A}$

Emitter current $= I_E = 10.1\text{ m A}$

$$\frac{I_C}{I_E} = 0.99$$

PROBLEM 18.2

Figure shows a transistor which operates a relay as the switch S is closed. The relay is energized by a current of 10 mA. Calculate the value R_B which will just make the relay operate. The current gain β of the transistor is 200. When the transistor conducts, its V_{BE} can be assumed to be 0.6V.



Data

Collector current $= I_C = 10\text{ m A}$

$= 10 \times 10^{-3}\text{ A}$

Current gain of transistor $= \beta = 200$

Base – Emitter voltage $= V_{BE} = 0.6\text{ volt}$

Common – Collector voltage $= V_{CC} = 9\text{ volt}$

To Find

Base resistance $= R_B = ?$

SOLUTION

As we know that

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

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

$$I_B = \frac{10 \times 10^{-3}}{200} = \frac{1}{20} \times 10^{-3}$$

$$= 0.05 \times 10^{-3}\text{ A}$$

$$= 0.05\text{ mA}$$

Applying Kirchhoff's voltage rule on input loop

$$V_{CC} = I_B R_B + V_{BE}$$

$$\boxed{I_B R_B = V_{CC} - V_{BE}}$$

$$= 9 - 0.6$$

$$I_B R_B = 8.4$$

$$R_B = \frac{8.4}{I_B}$$

$$= \frac{8.4}{0.05 \times 10^{-3}}$$

$$= 168 \times 10^{3}\ \Omega$$

$$R_B = 168\ \text{K}\Omega$$

Result

Base resistance = R_B = $168\ \text{K}\Omega$

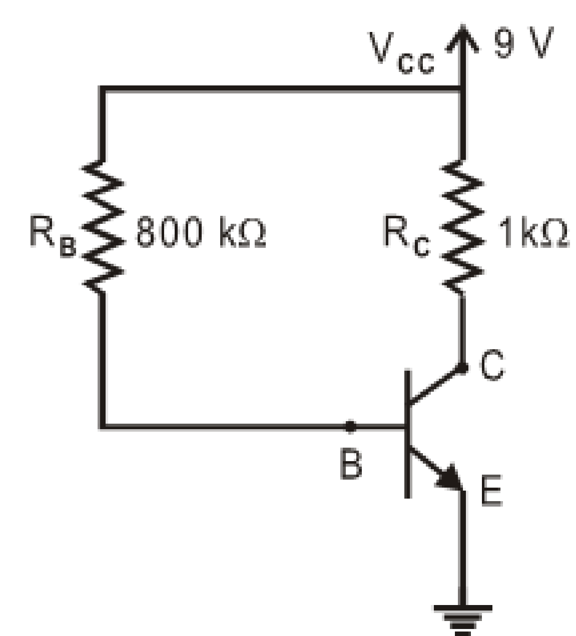
PROBLEM 18.3

In circuit shown in figure, there is negligible potential drop between B and E where β is 100, calculate

(i) base current **(ii) collector current**

(iii) potential drop across R_C **(iv) V_{CE}**

Data



Current grin = β = 100

Collector – biasing voltage = V_{CC} = 9 volt

Collector resistance = R_C = $1\ \text{K}\Omega$

= $1000\ \Omega$

Base resistance = R_B = $800\ \text{K}\Omega$

= 800×1000

= $8 \times 10^{5}\ \Omega$

V_{BE} = 0

To Find

(i) Base current = I_B = ?

(ii) Collector current = I_C = ?

(iii) Potential drop across = R_C = ?

(iv) V_{CE} = ?

SOLUTION

(i) Applying Kirchhoff's voltage rule on input loop

Since, $V_{CC} = I_B R_B + V_{BE}$

$$9 = I_B R_B + 0$$

$$I_B = \frac{9}{R_B} = \frac{9}{800 \times 10^{3}}$$

$$I_B = 1.125 \times 10^{-5}$$
$$= 11.25 \times 10^{-6} A$$
$$= 11.25 \mu A$$

(ii) For collector current

$$\beta = \frac{I_C}{I_B}$$
$$I_C = \beta \times I_B$$
$$= 100 \times 11.25 \times 10^{-6}$$
$$= 11.25 \times 10^{-4}$$
$$= 1.125 \times 10^{-3} A$$
$$I_C = 1.125 \text{ mA}$$

(iii) For potential drop across R_C is

$$V_C = I_C R_C$$
$$= 1.125 \times 10^{-3} \times 1000$$
$$= 1.125 \text{ volt}$$

(iv) Applying Kirchhoff's voltage rule on output loop

$$V_{CC} = V_C + V_{CE}$$
$$V_{CE} = V_{CC} - V_C$$
$$= 9 - 1.125$$
$$= 7.875 \text{ volt}$$

Result

(i) Base current = I_B = 11.25 μ Amp

(ii) Collector current = I_C = 1.125 mA

(iii) Potential drop across R_C = V_C = 1.125 volt

(iv) V_{CE} = 7.875 volt

PROBLEM 18.4

Calculate the output of the op-amp circuit shown in figure.

Data

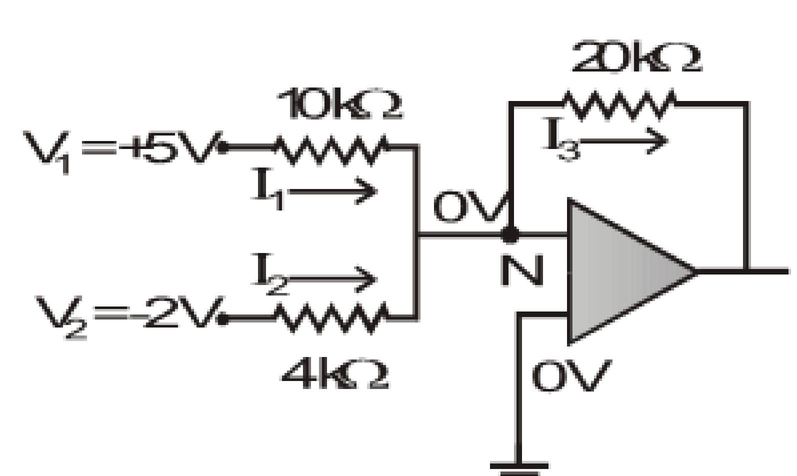
Resistance = R_1 = 10 kΩ

Resistance = R_2 = 4 kΩ

Resistance = R_3 = 20 kΩ

Potential = V_1 = 5 V

Potential = V_2 = –2 V



To Find

Output voltage $= V_0 = ?$

SOLUTION

By using Kirchhoff's current rule

$$I_1 + I_2 = I_3$$

As $V = IR$

$$\therefore \quad I = \frac{V}{R}$$

$$\left(\frac{V-0}{R_1}\right) + \left(\frac{-V-0}{R_2}\right) = \frac{0-V_o}{R_3}$$

$$\left(\frac{5-0}{10\text{ k}\Omega}\right) + \left(\frac{-2-0}{4\text{ k}\Omega}\right) = \frac{0-V_o}{20\text{ k}\Omega}$$

$$\frac{1}{2\text{ k}\Omega} - \frac{1}{2\text{ k}\Omega} = -\frac{V_o}{20\text{ k}\Omega}$$

$$0 = -\frac{V_o}{20\text{ k}\Omega}$$

$$\therefore \quad V_o = 0\text{ V}$$

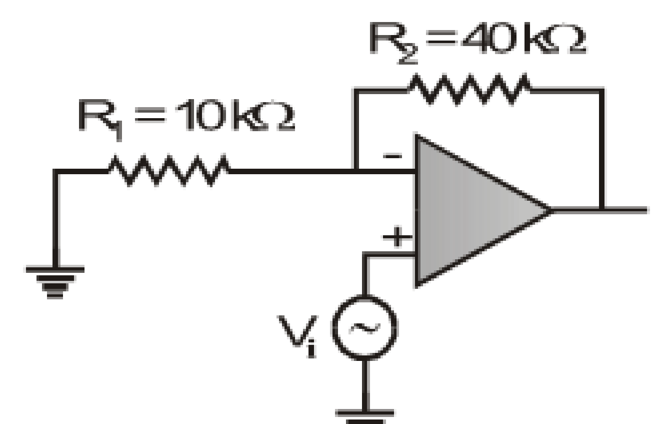
Result

Output voltage $= V_0 = 0$ volt

PROBLEM 18.5

Calculate the gain of non-inverting amplifier shown in figure.

Data



Resistance $= R_1 = 10\text{ k}\Omega = 10 \times 1000$

$= 10^4\ \Omega$

Resistance $= R_2 = 40\text{ k}\Omega = 40 \times 1000$

$= 4 \times 10^4\ \Omega$

To Find

Gain of non-inverting amplifier $= G = ?$

SOLUTION

By formula for the gain of non-inverting amplifier

$$\boxed{G = 1 + \frac{R_2}{R_1}}$$

Therefore

$$G = 1 + \frac{4 \times 10^4}{10^4}$$

$$G = 1 + 4$$

$$G = 5$$

Result

Gain of non-inverting amplifier $= G = 5$