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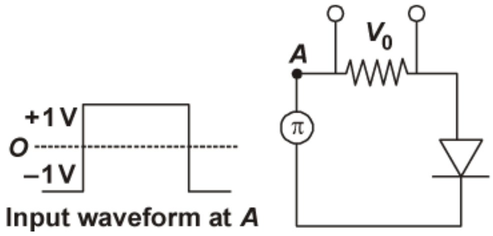
Q1. The amplifiers *X*, *Y* and *Z* are connected in series. If the voltage gains of *X*, *Y* and *Z* are 10, 20 and 30, respectively and the input signal is 1 mV peak value, then what is the output signal voltage (peak value)

(a) if D.C. supply voltage is 10 V? (b) if D.C. supply voltage is 5 V?

Q2. Can the potential barrier across a *p-n* junction be measured by simply connecting a voltmeter across the junction?

Q3. Draw the output waveform across the resistor (see figure).

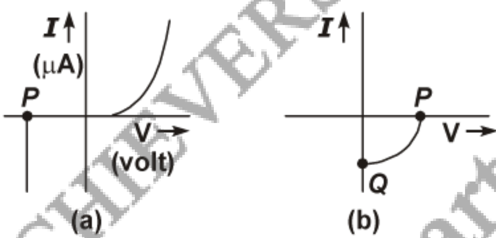


Q4. Sn, C, and Si, Ge are all group XIV elements. Yet, Sn is a conductor, C is an insulator while Si and Ge are semiconductors. Why?

Q5. Why are elemental dopants for Silicon or Germanium usually chosen from group XIII or group XV?

Q6. In a *CE* transistor amplifier there is a current and voltage gain associated with the circuit. In other words there is a power gain. Considering power a measure of energy, does the circuit violate conservation of energy?

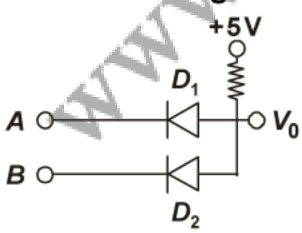
Q7. (a) Name the type of a diode whose characteristics are shown in figure (a) and figure (b).



(b) What does the point *P* in figure (a) represent?

(c) What does the points *P* and *Q* in figure (b) represent?

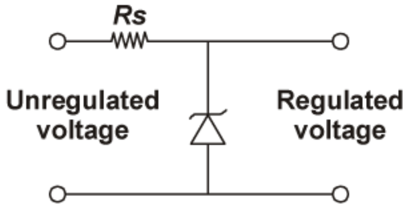
Q8. Write the truth table for the circuit shown in figure. Name the gate that the circuit resembles.



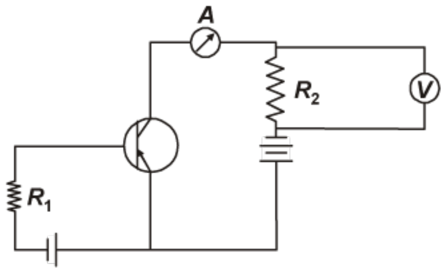
Q9. Explain why elemental semiconductor cannot be used to make visible LEDs.

Q10. Three photo diodes D_1, D_2 and D_3 are made of semiconductors having band gaps of 2.5 eV, 2 eV and 3 eV, respectively. Which ones will be able to detect light of wavelength 6000 Å?

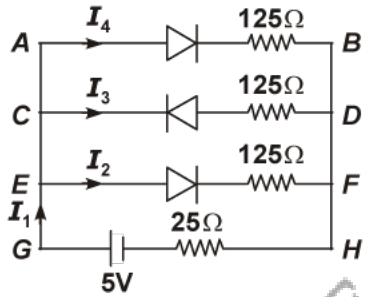
Q11. A Zener of power rating 1 W is to be used as a voltage regulator. If zener has a breakdown of 5 V and it has to regulate voltage which fluctuated between 3 V and 7 V, what should be the value of *Rs* for safe operation (see figure)?



Q12. If the resistance R_1 is increased (see figure), how will the readings of the ammeter and voltmeter change?



Q13. If each diode in as shown in figure, has a forward bias resistance of 25 Ω and infinite resistance in reverse bias, what will be the values of the current I_1, I_2, I_3 and I_4?

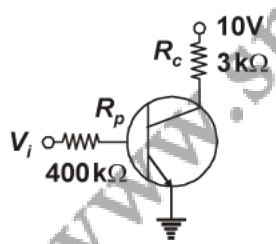


Q14. Suppose a '*n*'-type wafer is created by doping Si crystal having 5×10^{28} atoms/m^3 with 1 ppm concentration of As. On the surface 200 ppm Boron is added to create '*P*' region in this wafer. Considering $n_i = 1.5 \times 10^{16}\ m^{-3}$,

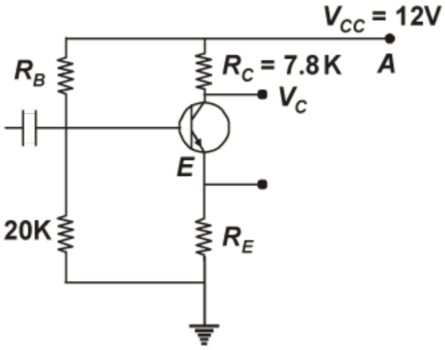
(a) Calculate the densities of the charge carriers in the *n* & *p* regions.

(b) Comment which charge carriers would contribute largely for the reverse saturation current when diode is reverse biased.

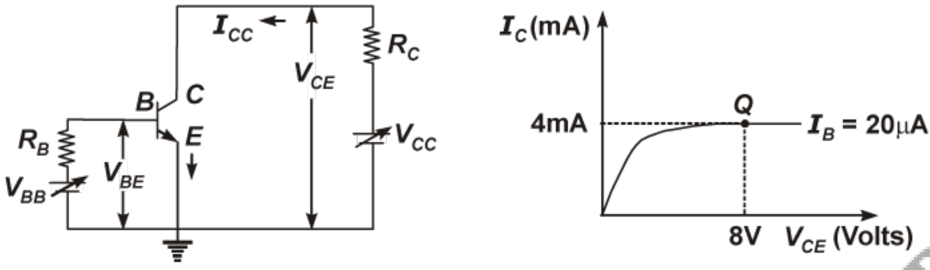
Q15. In the circuit shown in figure, when the input voltage of the base resistance is 10 V, V_{be} is zero and V_{ce} is also zero. Find the values of I_b, I_c and β.



Q16. For the transistor circuit shown in figure, evaluate V_E, R_B, R_E given I_C = 1 mA, V_{CE} = 3 V, V_{BE} = 0.5 V and V_{CC} = 12 V, β = 100.



Q17. Consider the circuit arrangement shown in figure (a) for studying input and output characteristics of npn transistor in *CE* configuration.

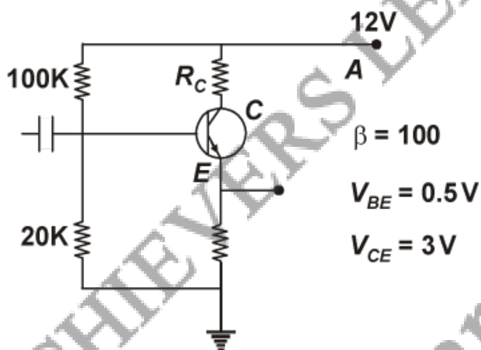


(a) (b)

Select the values of R_B and R_C for a transistor whose V_{BE} = 0.7 V, so that the transistor is operating at point *Q* as shown in the characteristics shown in figure (b).

Given that the input impedance of the transistor is very small and V_{CC} = V_{BB} = 16 V, also find the voltage gain and power gain of circuit making appropriate assumptions.

Q18. In the circuit shown in figure, find the value of R_C.



Q19. An X-OR gate has following truth table:

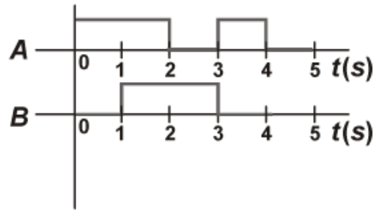
A	*B*	*Y*
0	0	0
0	1	1
1	0	1
1	1	0

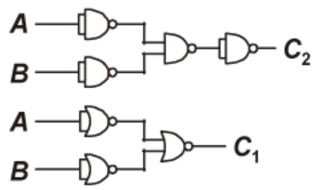
It is represented by following logic relation

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

Build this gate using AND, OR and NOT gates.

Q20. Draw the output signals C_1 and C_2 in the given combination of gates (see figure).





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S1. Given,

$$Av_x = 10, \quad Av_y = 20, \quad Av_z = 30,$$
$$\Delta V_i = 1\,\text{mV} = 10^{-3}\,\text{V}$$

Now,
$$\frac{\text{Output Singnal Voltage } (\Delta V_0)}{\text{Input Signal Voltage } (\Delta V_i)} = \text{Total voltage amplification}$$
$$= Av_x \times Av_y \times Av_z$$

$\Rightarrow$
$$\Delta V_0 = Av_x \times Av_y \times Av_z \times AV_i$$
$$= 10 \times 20 \times 30 \times 10^{-3} = 6\,\text{V}$$

(a) If D.C. supply voltage is 10 V, then output is 6 V, since theoretical gain is equal to practical gain, *i.e.*, output can never be greater than 6 V.

(b) If D.C. supply voltage is 5 V, *i.e.*, $V_{cc} = 5$ V. Then output peak will not exceed 5 V. Hence, $V_0 = 5$ V.

S2. No, because the voltmeter must have a resistance very high compared to the junction resistance, the latter being nearly infinite.

S3. As we know that the diode only works in forward biased, so the output is obtained only when positive input is given, so the output wave form is

S4. A material is a conductor if in its energy band diagram, there is no energy gap between conduction band and valence band. For insulator, the energy gap is large and for semiconductor the energy gap is moderate.

The energy gap for Sn is 0 eV, for C is 5.4 eV, for Si is 1.1 eV and for Ge is 0.7 eV, related to their atomic size. Therefore, Sn is a conductor, C is an insulator and Ge and Si are semiconductors.

S5. The size of dopant atoms should be such as not to distort the pure semiconductor lattice structure and yet easily contribute a charge carrier on forming co-valent bonds with Si or Ge.

S6. In *CE* transistor amplifier, the power gain is very high.

In this circuit, the extra power required for amplified output is obtained from D.C. source. Thus the circuit used does not violet the law of conservation.

S7. (a) The characteristic curve (a) is of Zener diode and curve (b) is of solar cell.

(b) The point *P* in figure (a) represents Zener break down voltage.

(c) In figure (b), the point *Q* represents zero voltage and negative current. It means light falling on solar cell with atleast minimum threshold frequency gives the current in opposite direction to that due to a battery connected to solar cell. But for the point *Q*, the battery is short circuited. Hence represents the short circuit current.

In figure (b), the point P represents some positive voltage on solar cell with zero current through solar cell.

It means, there is a battery connected to a solar cell which gives rise to the equal and opposite current to that in solar cell by virtue of light falling on it.

As current is zero for point P, hence we say P represents open circuit voltage.

S8. Truth table

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

AND Gate.

S9. Elemental semiconductor's band-gap is such that emissions are in infrared region.

S10. Energy of incident light photon

$$h\nu = \frac{6.6\times 10^{-34}\times 3\times 10^{8}}{6\times 10^{-7}\times 1.6\times 10^{-19}} = 2.06\,\text{eV}$$

For the incident radiation to be detected by the photodiode, energy of incident radiation photon should be greater than the band gap. This is true only for D_2. Therefore, only D_2 will detect this radiation.

S11. Given,

Power = 1 W

Zener breakdown $V_z = 5\,\text{V}$

Minimum voltage $V_{\text{min}} = 3\,\text{V}$

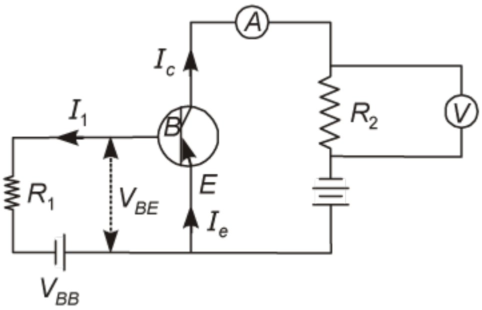
Maximum voltage $V_{\text{max}} = 7\,\text{V}$

$$I_{Z\,\text{max}} = \frac{P}{V_Z} = 0.2\,\text{A} = 200\,\text{mA}$$

The value R_z for safe operation

$$R_S = \frac{V_{\text{max}} - V_Z}{I_{Z\,\text{max}}} = \frac{2}{0.2} = 10\,\Omega.$$

S12. Consider the circuit in fig (b) to find the change in reading



As we know the formula for base current,

$$I_B = \frac{V_{BB} - V_{BE}}{R_i}$$

As R_i is increased, I_B is decreased.

Now, the current in ammeter is collector current I_C.

$I_C = \beta I_B$ as I_B decreased I_C also decreased and the reading of voltmeter and ammeter also decreased.

S13. Given, Forward biased resistance = 25 Ω

Reverse biased resistance = ∞

As the diode in branch *CD* is in reverse biased having resistance infinite.

I_3 is zero as the diode in that branch is reverse biased. Resistance in the branch *AB* and *EF* are each (125 + 25) Ω = 150 Ω.

As *AB* and *EF* are identical parallel branches, their effective resistance is $\frac{150}{2}$ = 75 Ω

∴ Net resistance in the circuit = (75 + 25) Ω = 100 Ω.

$$\therefore \quad \text{Current } I_1 = \frac{5}{100} = 0.05\,\text{A}.$$

As resistances of *AB* and *EF* are equal, and $I_1 = I_2 + I_3 + I_4$, $I_3 = 0$

Here, the resistances R_1 and R_2 is same.

$$\therefore \quad I_2 = I_4$$

$$\therefore \quad I_1 = 2I_2$$

$$I_2 = \frac{0.05}{2} = 0.025\,\text{A}$$

$$I_4 = 0.025\,\text{A}..$$

S14. (a) In '*n*' region; number of e^- is due to As:

$$n_e = N_D = 1 \times 10^{-6} \times 5 \times 10^{28} \text{ atoms/m}^3$$ [n_e = No. of electrons and n_h = No. of holes]

$$n_e = 5 \times 10^{22}/\text{m}^3$$

The minority carriers (hole) is

$$n_h = \frac{n_i^2}{n_e} = \frac{(1.5 \times 10^{16})^2}{5 \times 10^{22}} = \frac{2.25 \times 10^{32}}{5 \times 10^{22}}$$

$$n_h = 0.45 \times 10/\text{m}^3$$

Similarly, when Boron is implanted a '*p*' type is created with holes

$$n_h = N_A = 200 \times 10^{-6} \times 5 \times 10^{28}$$
$$= 1 \times 10^{25}/\text{m}^3$$

This is far greater than e^- that existed in '*n*' type wafer on which Boron was diffused.

Therefore, minority carriers in created '*p*' region

$$n_e = \frac{n_i^2}{n_h} = \frac{2.25 \times 10^{32}}{1 \times 10^{25}}$$
$$= 2.25 \times 10^7/\text{m}^3$$

(b) Thus, when reverse biased $0.45 \times 10^{10}/m^3$, holes of '*n*' region would contribute more to the reverse saturation current than $2.25 \times 10^7/m^3$ minority e^- of *p* type region.

S15. As $V_{be} = 0$, potential drop across R_b is 10 V.

$$\therefore \qquad I_b = \frac{10}{400 \times 10^3} = 25\,\mu A$$

Since $V_{ce} = 0$, potential drop across R_c, *i.e.*, $I_c R_c$ is 10 V.

$$\therefore \qquad I_c = \frac{10}{3 \times 10^3} = 3.33 \times 10^{-3} = 3.33 \text{ mA}.$$

$$\therefore \qquad \beta = \frac{I_c}{I_b} = \frac{3.33 \times 10^{-3}}{25 \times 10^6} = 1.33 \times 10^{-2} = 133.$$

S16.

$$I_C \approx I_E \qquad \therefore \quad I_C(R_C + R_E) + V_{CE} = 12\,V$$

$$R_E = 9 - R_C = 1.2\,K\Omega$$

$$\therefore \qquad V_E = 1.2\,V$$

$$V_B = V_E + V_{BE} = 1.7\,V$$

$$I = \frac{V_B}{20K} = 0.085\,mA$$

$$R_B = \frac{12 - 1.7}{I_C/\beta + 0.085} = \frac{10.3}{0.01 + 1.085} = 108\,K.$$

S17. From the output characteristics at point *Q*, $V_{CE} = 8V$ & $I_C = 4\,mA$

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

$$R_C = \frac{V_{CC} - V_{CE}}{I_C}$$

$$R_C = \frac{16 - 8}{4 \times 10^{-3}} = 3\,K\Omega$$

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

$$R_B = \frac{16 - 0.7}{30 \times 10^{-6}} = 510\,K\Omega$$

Now, $$\beta = \frac{I_C}{I_B} = \frac{4 \times 10^{-3}}{30 \times 10^{-6}} = 133$$

$$\text{Voltage gain} = A_v = -\beta\frac{R_C}{R_B} \qquad [A_v = \text{Current gain} \times \text{resistance gain}]$$

$$= -133 \times \frac{2\times 10^3}{510\times 10^3} = 0.52$$

$$\text{Power Gain} = A_p = \beta \times A_v$$

$$= -\beta^2\frac{R_C}{R_B}$$

$$= (133)^2 \times \frac{2\times 10^3}{510\times 10^3} = 69.$$

S18. $I_E = I_C + I_B \qquad I_C = \beta I_B$ (i)

$I_C R_C + V_{CE} + I_E R_E = V_{CC}$ (ii)

$RI_B + V_{BE} + I_E R_E = V_{CC}$ (iii)

From (iii), $I_e \approx I_C = \beta I_B$

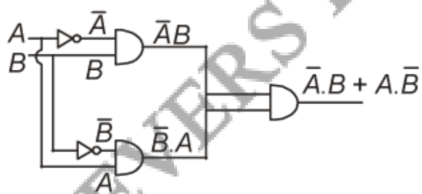
$(R + \beta R_E) = V_{CC} - V_{BE},$

$$I_B = \frac{V_{CC} - V_{BE}}{R + \beta I_E} = \frac{11.5}{200}\,\text{mA}$$

From (ii) $$R_C + R_E = \frac{V_{CC} - V_{CE}}{I_C} = \frac{V_{CC} - V_{CE}}{\beta I_B} = \frac{2}{11.5}(12-3)\text{K}\Omega = 1.56\,\text{K}\Omega$$

$$R_C = 1.56 - 1 = 0.56\,\text{K}\Omega.$$

S19.



S20.