SOLVED NCERT QUESTIONS

1. In an *n*-type silicon, which of the following statement is true:

(a) Electrons are majority carriers and trivalent atoms are the dopants.
(b) Electrons are minority carriers and pentavalent atoms are the dopants.
(c) Holes are minority carriers and pentavalent atoms are the dopants.
(d) Holes are majority carriers and trivalent atoms are the dopants.

Sol. (c)

2. Which of the statements given in question no. 1 is true for *p*-type semi-conductors?

Sol. (d)

3. Carbon, silicon and germanium have four valence electrons each. These are characterised by valence and conduction bands separated by energy band gap respectively equal to $(E_g)_C$, $(E_g)_{Si}$ and $(E_g)_{Ge}$. Which of the following statements is true?

(a) $(E_g)_{Si} < (E_g)_{Ge} < (E_g)_C$
(b) $(E_g)_C < (E_g)_{Ge} < (E_g)_{Si}$
(c) $(E_g)_C > (E_g)_{Si} > (E_g)_{Ge}$
(d) $(E_g)_C = (E_g)_{Si} = (E_g)_{Ge}$

Sol. (c)

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4. In an unbiased *p*-*n* junction, holes diffuse from the *p*-region to *n*-region because

(a) free electrons in the *n*-region attract them.
(b) they move across the junction by the potential difference.
(c) hole concentration in *p*-region is more as compared to *n*-region.
(d) all the above.

Sol. (c)

5. When a forward bias is applied to a *p*-*n* junction, it

(a) raises the potential barrier.
(b) reduces the majority carrier current to zero.
(c) lowers the potential barrier.
(d) none of the above.

Sol. (c)

6. For transistor action, which of the following statements are correct:

(a) Base, emitter and collector regions should have similar size and doping concentrations.
(b) The base region must be very thin and lightly doped.
(c) The emitter junction is forward biased and collector junction is reverse biased.

(d) Both the emitter junction as well as the collector junction are forward biased.

Sol. (b) and (c)

7. For a transistor amplifier, the voltage gain

(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) none of the above.

Sol. (c)

8. In half-wave rectification, what is the output frequency if the input frequency is 50 Hz. What is the output frequency of a full-wave rectifier for the same input frequency.

Sol. In half-wave rectification, output frequency remains same as input (i.e. 50 Hz). In full wave rectification, output shows two positive pulses for each input pulse hence frequency doubles (i.e.100 Hz).

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9. For a CE-transistor amplifier, the audio signal voltage across the collected resistance of 2 kΩ is 2V. Suppose the current amplification factor of the transistor is 100, find the input signal voltage and base current, if the base resistance is 1 kΩ.

Sol. Now, voltage gain $A_V = \dfrac{\Delta V_0}{\Delta V_i} = \beta_{dc}\,\dfrac{R_0}{R_i}$

$$\Rightarrow \qquad \Delta V_i = \frac{\Delta V_0 \times R_i}{\beta \times R_0} = \frac{2\times 1\times 10^3}{100\times 2\times 10^3} = 0.01 \text{ V}$$

Also, $\Delta I_b = \dfrac{\Delta V_i}{\Delta R_i}$ (Since in CE configuration base current is input current)

$$= \frac{0.01}{1000} = 10^{-5}\text{ A} = 10\ \mu\text{A}$$

10. Two amplifiers are connected one after the other in series (cascaded). The first amplifier has a voltage gain of 10 and the second has a voltage gain of 20. If the input signal is 0.01 volt, calculate the output ac signal.

Sol. Total voltage gain, $A_V = \dfrac{\Delta V_0}{\Delta V_i} = A_{V_1} \times A_{V_2}$ or $\Delta V_0 = \Delta V_i \times A_{V1} \times A_{V2}$

$$= 0.01 \times 10 \times 20 = 2 \text{ V.}$$

11. A *p-n* photodiode is fabricated from a semi-conductor with band gap of 2.8 eV. Can it detect a wavelength of 6000 nm?

Sol. In a photo-diode, incident photon gives its energy to the electron which jumps the energy gap to conduct current. Thus incident photon must have energy $\geq E_g$.

For a photon of $\lambda = 6000$ nm

$$E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{6000 \times 10^{-9}} = 3.3 \times 10^{-20}\ \text{J}$$

$$= \frac{3.3 \times 10^{-20}}{1.6 \times 10^{-19}}\ \text{eV} \cong 2 \times 10^{-1}\ \text{eV} = 0.2\ \text{eV}$$

Since energy of photon is less, hence it would not be detected.

12. The number of silicon atoms per m^3 is 5×10^{28}. This is doped simultaneously with 5×10^{22} atoms per m^3 of Arsenic and 5×10^{20} per m^3 atoms of Indium. Calculate the number of electrons and holes. Given that $n_i = 1.5 \times 10^{16}\ \text{m}^{-3}$. Is the material *n*-type or *p*-type?

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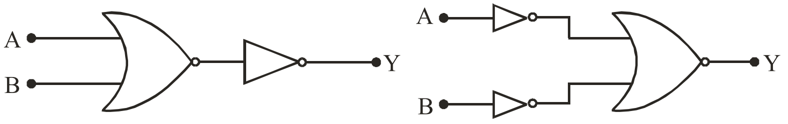
Sol. $n_e = 5 \times 10^{22} - 5 \times 10^{20} = (5 - 0.05) \times 10^{22} = 4.95 \times 10^{22}/\text{m}^3$;

$$n_h = \frac{n_i^2}{n_e} = \frac{(1.5 \times 10^{16})^2}{4.95 \times 10^{22}} = 4.54 \times 10^{9}/\text{m}^3.$$

As $n_e >> n_h$ $\quad\therefore$ *n*-type semi-conductor.

13. You are given the two circuits as shown in figure. Show that circuit (a) acts as OR gate while the circuit (b) acts as AND gate.



(a) (b)

Sol. (a) Output of NOR = $\overline{A+B}$ Output of NOT = $\overline{\overline{A+B}} = A+B$

Truth Table:			
A	B	$\overline{A+B}$	$\overline{\overline{A+B}} = Y = A+B$
0	0	1	0
0	1	0	1
1	0	0	1
1	1	0	1

∴ Circuit acts as OR gate.

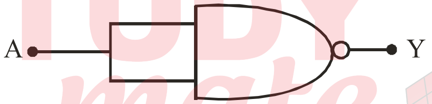
(b) Output of 1st NOT gate = $\overline{A}$ Output of 2nd NOT gate = $\overline{B}$

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

Truth Table:					
A	B	$\overline{A}$	$\overline{B}$	$\overline{A}+\overline{B}$	$\overline{\overline{A}+\overline{B}}$ = A. B = Y
0	0	1	1	1	0
0	1	1	0	1	0
1	0	0	1	1	0
1	1	0	0	0	1

∴ Circuit acts as AND gate.

14. Write the truth table for a NAND gate connected as given in figure



Hence identify the exact logic operation carried out by this circuit.

Sol. Input is repeated for NAND gate.

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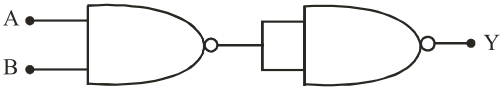
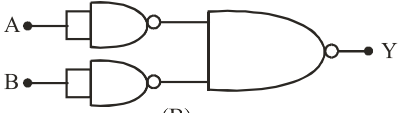
∴ **Truth Table**		**Operation**
A	A	Y (NAND gate)
0	0	1
1	1	0

The logic operation carried out by this circuit is the same as of a NOT gate.

15. You are given two circuits as shown in figure, which consist of NAND gates. Identify the logic operation carried out by the two circuits.



(A)



(B)

Sol. (a) Output of 1st NAND gate = $\overline{A.B}$

Output of 2nd NAND gate = $\overline{\overline{A.B}}$ = A . B

Truth Table			
A	B	$\overline{A.B}$	$\overline{\overline{A.B}} = A.B = Y$
0	1	1	0
1	0	1	0
1	1	0	1

This acts as AND gate.

(b) Output of 1st NAND gate = $\overline{A.A}$

Output of 2nd NAND gate = $\overline{B.B}$

Output of 3rd NAND gate = Y = $\overline{\overline{A.A}.\overline{B.B}} = A + B$

Truth Table:				
A	B	$\overline{A.A}$	$\overline{B.B}$	$\overline{\overline{A.A}.\overline{B.B}} = A + B = Y$
0	0	1	1	0
0	1	1	0	1
1	0	0	1	1
1	1	0	0	1

This acts as OR gate

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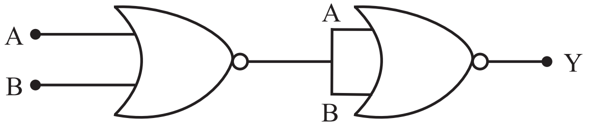
16. Write the truth table for circuit given in figure below consisting of NOR gates and identify the logic operation (OR, AND, NOT) which this circuit is performing.



(**Hint:** A = 0, B = 1 then A and B inputs of second NOR gate will be 0 and hence Y = 1. Similarly work out the values of Y for other combinations of A and B. Compare with the truth table of OR, AND, NOT gates and find the correct one.)

Sol. Output of 1st NOR gate $\overline{A+B}$

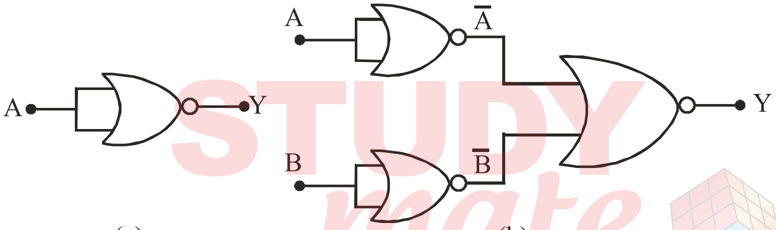
Output of 2nd NOR gate = $\overline{\overline{A+B}} = A + B$

Truth Table:

A	B	$\overline{A+B}$	$\overline{\overline{A+B}} = A + B = Y$
0	0	1	0
0	1	0	1
1	0	0	1
1	1	0	1

This acts as OR gate.

17. Write the truth table for the circuits given in figure consisting of NOR gates only. Identify the logic operations (OR, AND, NOT) performed by the two circuits.



(a) (b)

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Sol. (a) Same input to NOR gate. ∴ Output = $\overline{A+A}$ = Y

A	A + A	$\overline{A+A}$ = Y
0	0	1
1	1	0

∴ It acts as NOT gate.

(b) Same input to 1st NOR gate. ∴ Output = $\overline{A+A}$

Same input to 2nd NOR gate. ∴ Output = $\overline{B+B}$

Output of 3rd NOR gate = $\overline{\bar{A}+\bar{B}}$ = A . B = Y

Truth Table:

A	B	$\overline{A+A} = \bar{A}$	$\overline{B+B} = \bar{B}$	$\overline{\bar{A}+\bar{B}} = A.B = Y$
0	0	1	1	0
0	1	1	0	0
1	0	0	1	0
1	1	0	0	1

This acts as AND gate.