PHYSICS

BOOKS - VIKRAM PUBLICATION (ANDHRA PUBLICATION)

SEMICONDUCTOR ELECTRONICS : MATERIALS , DEVICES , AND SIMPLE CIRCUITS

Textual Examples

1. C,Si and Ge have same lattice structure.Why is C insulator while Si and Ge instinsic semiconductors?

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2. Suppose a pure Si crystal has 5×10^{28} atoms m^{-3} . It is droped by 1 ppm concentration of pentavalent As. Calculate the number of electrons and holes. Given that $n_i = 1.5 \times 10^{16} m^{-3}$.

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3. Can we take one slab of p-type semiconductor and physically join it to another n-type semiconductor to get p-n junction ?

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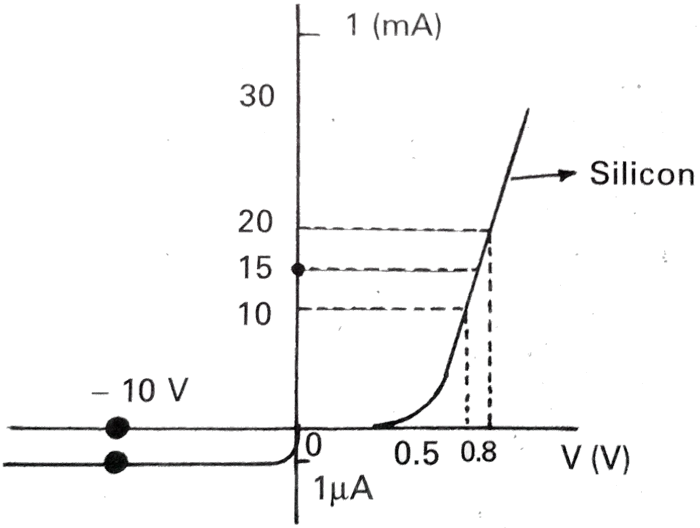
4. The V-I characteristics of a silicon diode are shown in the Figure. Calculate the resistance of the diode at (a) $I_D = 15mA$ and (b)

$V_D = -10V$



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5. In a Zener regulated power supply a Zener diode with $V_z = 6.0V$ is used forregulation. The load current is to be 4.0 mA and the

unregulated input is 10.0 V. What should be the value of series resistor R_s ?

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6. The current in the forward bias is known to be more $(\sim mA)$ than the current in the reverse bias $(\sim \mu A)$ .What is the reason then to operate the photodiodes in reverse bias ?

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7. Why are Si and GaAs are preferred materials for solar cells ?

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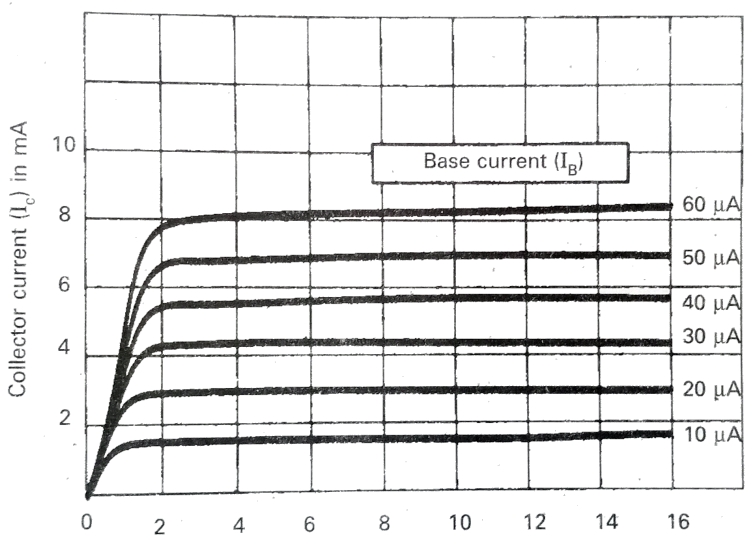
8. From the output characteristis shown in figure.Calculate the values of β_{ac} and β_{dc} of the transistor when V_{CE} is 10V and

$I_C = 4.0mA.$



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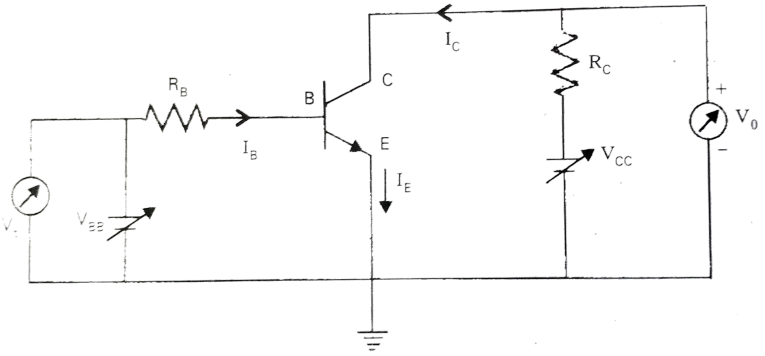
9. In Figure the V_{BB} supply can be varied from OV to 5.0 V . The Si transistor has $\beta_{dc} = 250$ and $R_B = 100k\Omega, R_C = 1K\Omega, V_{CC} = 5.0V.$

Assume that when the transistor is saturated , $V_{CE} = 0V$ and $V_{BE0=0.8V}$. Calculate (a) the minimum base current, forwhcih the transistor will reach saturation.Hence, (b) determine V_1 for when the transistor is 'switched on'. (c) find the ranges of V_1 for which the transistor is 'switched of and switched on'.



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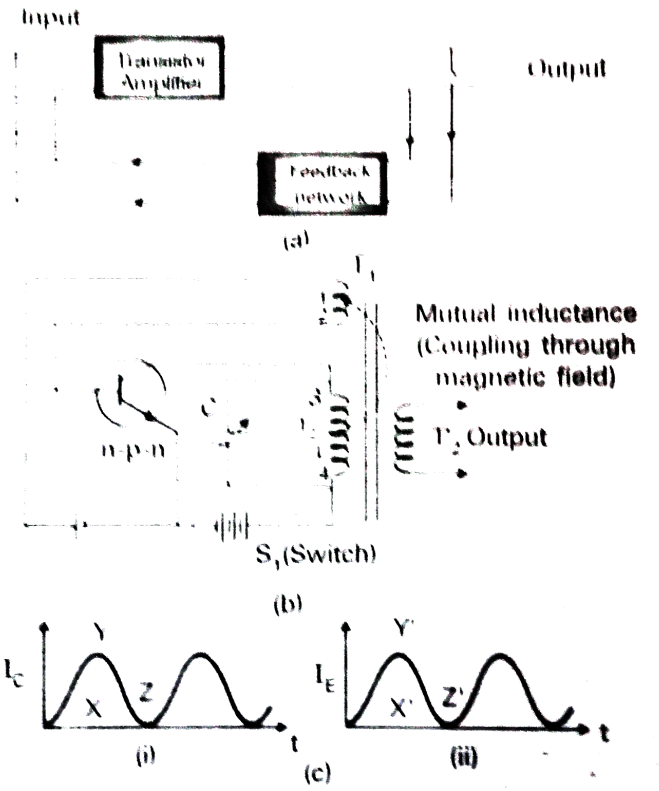
10. For a CE transistor amplifier, the aurdio signal voltage across the collector resistance of$2.0k\Omega$ is 2.0 V.Suppose the current amplification factor of the transistor is 100, what should be the value ofR_B in series with V_{BB} supply of 2.0 V if the dc base current has to be 10 times the signal current. Also calculate the dc drop across the collector

resistance (Refer to Figure).



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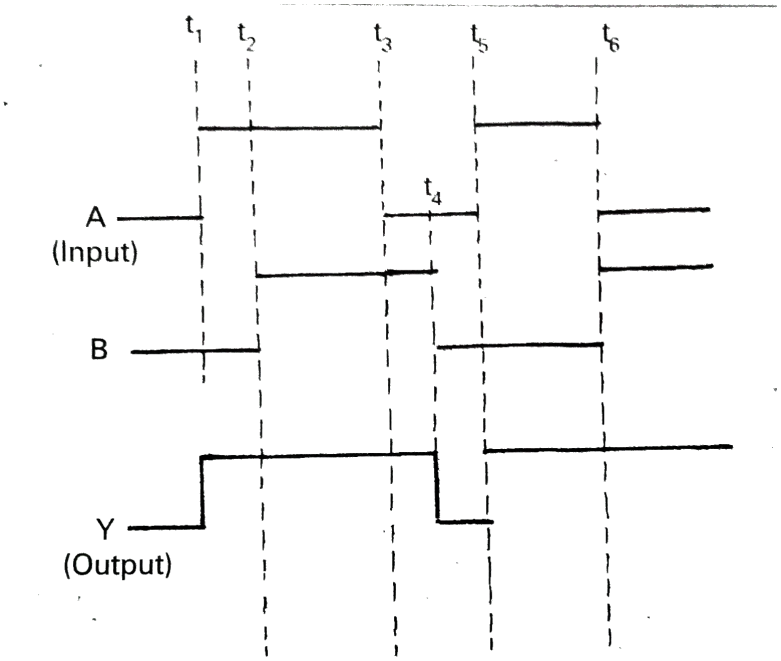
11. Justify the output waveform(Y) of the OR gate for the following inputs A and B given in figure.



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12. Take A and B input waveforms similar to that in Example .Sketch the output waveform obtained from AND gate.

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13. Sketch the output Y from a NAND gate having inputs A and B given below :

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Problems

1. In a half wave rectifier, a p-n junction diode with internal resistance 20 ohm is used. If the load resistance of 2 ohm is used in the circuit, then find the efficiency of this half wave rectifier.

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2. A full wave p-n junction diode rectifier uses a load resistance of 1300ohm. The internal

resistance of each diode is 9 ohm. Find the efficiency of this full wave rectifier.

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3. Calculate the current amplification factor β(beta) when change in collector current is 1mA and change in base current is $20\Omega A$.

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4. For a transistor amplifier, the collecor load resistance $R_L = 2k$ ohm and the input resistance $R_i = 1k$ohm . If the current gain is 50, calculate voltage gain of the amplifier.

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Very Short Answer Questions

1. What is an n-type semiconductor ? What are the majority and minority charge carriers in it?

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2. What are intrisic and extrinsic semiconductors ?

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3. What is a p-type semiconductor ? What are the majority and minority and minority charge carriers in it ?

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4. What is p-n junction diode ? Define depletion layer.

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5. How is a battery connected to a junction dioide in (i) forward and (ii) reverse bias ?

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6. What is the maximum percentage of rectification in half wave and full wave rectifiers?

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7. What is Zener voltage (V_2) and how will a Zener diode be connected in circuits generally ?

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8. Write the expressions for the efficiency of a full wave rectifier and a half wave rectifier.

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9. What happens to the width of depletion layer of a p-n junction when it is (i) forward biased, (ii) reverse biased?

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10. Draw the circuit symbols for p-n-p and n-p-n transistors

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11. Define amplifier and amplification factor.

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12. In which bias can be a Zener diode be used as voltage regulator ?

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13. Which gates are called universal gates?

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14. Write the truth table of NAND gate. How does it differ from AND gate?

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Short Answer Questions

1. What are n-type and p-type semiconducts ? How is a semiconductor junction formed ?

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2. Discuss the behaviour of p-n junction. How does a potential barrier develop at the junction ?

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3. Draw and explain the current -voltage (I-V) characteristic curves of a junction diode in forward and reverse bias.

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4. Describe how a semiconductor diode isused as a half wave rectifier.

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5. What is rectification ? Explain the working of a full wave rectifier.

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6. Distinguish between half-wave and full-wave rectifiers.

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7. Distinguish between zener breakdown and avalanche breakdown.

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8. Explain hole conduction in intrinsic semiconductors.

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9. What is a photodiode ? Explain its working with a circuit diagram and draw its I-V characteristics.

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10. Explain the working of LED and what are its advantages over conventional in can descent low power lamps.

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11. Explain the working of a solar cell and draw its I-V characteristics .

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12. Explain the different transistor configuration with diagrams.

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13. Explain how transistor can be used as a switch ?

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14. Explain how transistor can be used as an oscillator ?

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15. Define NAND and NOR gates. Give their truth tables.

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16. Explain the operation of a NOT gate and give its truth table.

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Long Answer Questions

1. What is a junction diode ? Explain the formation of depletion region at the junction. Explain the variation of depletion region in forward and reverse-biased condition.

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2. Distinguish between half-wave and full-wave rectifiers.

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3. What is a Zener diode ? Explain how it is used as a voltage regulator .

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4. Describe a transistor and explain its working.

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5. What is amplification ? Explain the working of a common emitter amplifier with necessary

diagram.

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6. Draw an OR gate using two diode and explain its operation. Write the truth table and logic symbol of OR gate.

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7. Sketch a basic AND circuit with two diodes and explain its operation.Explain how doping

increases the conductivity in semiconductors ?

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Textual Exercises

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

(a) Electrons are majority carriers are 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.

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2. (a) Electrons are majority carriers are 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.

Which of the statements given in Exercise is true for p-type semiconductors ?

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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) $(E_g)_C = (E_g)_{Si} = (E_g)_{Ge}$

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

(a) free electron 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.

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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.

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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 reverser biased.

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

7. For a transistor amplifier, the voltage gain

(a) remains constant for all frequencies

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

(c) is low frequencies and constant at mid frequencies.

(d) None of the above.

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

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9. For a CE-transistor amplifier,the aurdio signal across the collectoed resistance of 2 $k\Omega$ is 2V. Suppose the current amplification factor of the transistoris 100, find the input signal voltage and base current, if the base resistance is $1k\Omega$.

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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.

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

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Additional Exercises

1. 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 ˆ (3) atoms of Indium. Calculate the number of electron and holes. Given that $n_i = 1.5 \times 10^{16} m^{-3}$. Is the material n-type or p-type ?

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2. In an intrinsic semiconductor the energy gapE_g is1.2 eV. Its hole mobility is much

smaller than electron and independent of temperature. What is the ratio between conductivity at 600 K and that at 300 K? Assume that the temperature dependence of intrinsic carrier concentration n_i is given by $n_i = n_o \exp\left(-\frac{E_g}{2K_BT}T\right)$ where n_0 is a constant .

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3. In a p-n junction diode, the currentI can be expressed as $I = I_0 \exp\left(\frac{eV}{2K_BT} - 1\right)$ where

$I_0$is called the reverse saturation current,V is the voltage across the diode andis positive for forward bias and negative for reverse biase,and I is the current through the diode, k_B is the Boltzmann constant $\left(8.6 \times 10^{-5} eV/K\right)$ and T is the absolute temperature . If fora given diode $I_0 = 5 \times 10^{-12} A$ and $T = 300K$, then

(i) What will be the forward current at a forward voltage of 0.6V?

(b) What will be the increase in the current if the voltage across the diode is increased to 0.7 V ?

(c) What is the dynamic resistance ?

(d) What will be the current if reverse biase voltage changes from 1V to 2V ?

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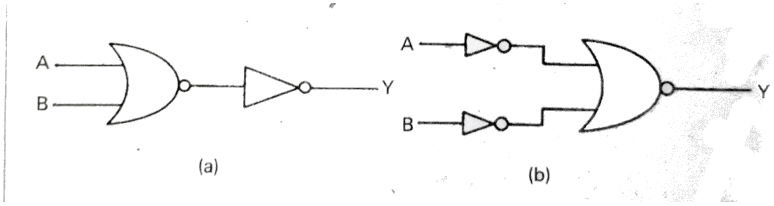
4. You are given the two circuit as shown in figure, show that the circuit (a) acts as OR gate while the circuit (b) acts as AND gets



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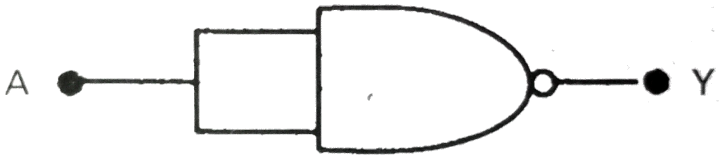
5. Write the truth table for a NAND gate connected as given in figure.



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

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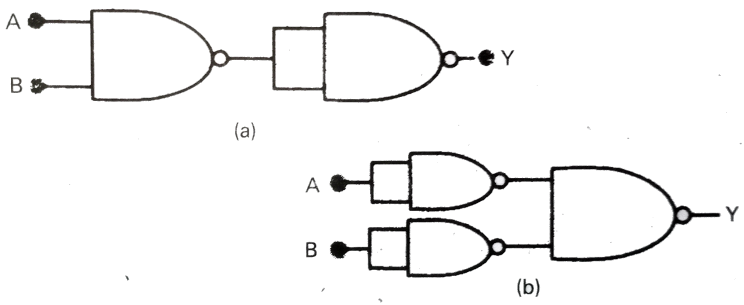
6. You are given two circuits as shown in figure, which consists of NAND gates. Identify the logic operation carried out by the two circuits.



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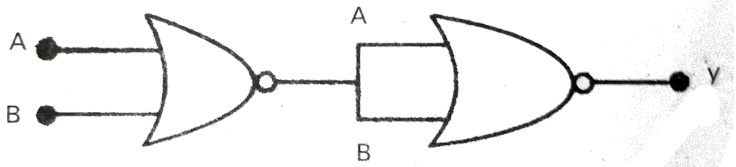
7. Write the truth table for circuit given in figure, below consisting of NOR gates and identify the logic operation(OR,AND,NOT) which this circuit is performing.



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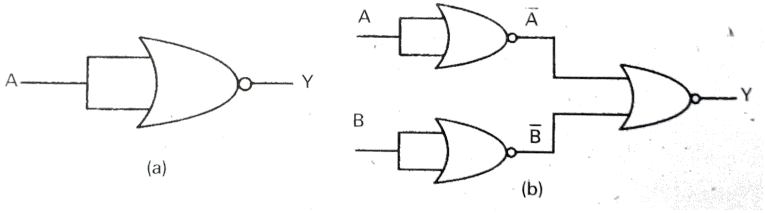
8. Write the truth table for the circuits given in figure, consisting of NOR gates only. Identify

the logic operation (OR, AND, NOT) performed by the two circuits.



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