CLASS – 12

WORKSHEET- SEMICONDUCTOR DEVICES AND DIGITAL CIRCUITS

A. SEMICONDUCTOR MATERIAL

(1 Mark Questions)

1. Give the ratio of holes and the number of conduction electrons in an intrinsic semiconductor.

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2. How does the forbidden energy gap of an intrinsic semiconductor vary with increase in temperature?

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3. How does the energy gap in an intrinsic semiconductor vary, when doped with a pentavalent impurity?

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4. Is the ratio of number of holes and number of conduction electrons in a p-type semiconductor more than, less than or equal to 1?

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5. Draw the energy band diagram of p-type semiconductor.

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6. Draw the energy band diagram of n-type semiconductor.

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7. What are 'holes'?

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8. 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 (Eg)c, (Eg)si and (Eg)Ge-
Which of the following statements is true ?

(a) (Eg)Si < (Eg)Ge < (Eg)c
(b)(E)c<(Eg)Ge>(Eg)si
(c) (Eg)c > (Eg)si > (Eg)Ge
(d) (Eg)c = (Eg)si = (Eg)Ge

9. The conductivity of a semiconductor increases with increase in temperature because
(a) number density of free current carriers increases.
(b) relaxation time increases.
(c) both number density of carriers and relaxation time increase.
(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

(2 Marks Questions)

10. What is meant by the terms, doping of an intrinsic semiconductor? How does it affect the conductivity of a semiconductor?

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11. Explain with the help of graph, the variation of conductivity with temperature for a metallic conductor.

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12. Distinguish between metals, insulators and semiconductors on the basis of their energy bands.

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13. A semiconductor has equal electron and hole concentration 6×10^{8} m^{-3}. On doping with certain impurity, electron concentration increases to 8×10^{12} m^{-3}. Identify the type of semiconductor doping.

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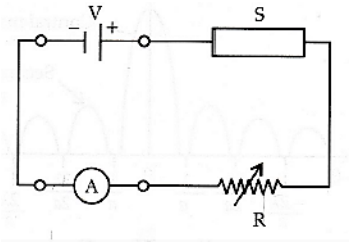
14. A semiconductor has equal electron and hole concentration of $6\times10^{8}/m^{3}$. On doping with certain impurity, electron concentration increases to $9\times10^{12}/m^{3}$.
(i) Identify the new semiconductor obtained after doping.
(ii) Calculate the new hole concentration.

15. Distinguish between an intrinsic semiconductor and P-type semiconductor.
Given reason, why, a P-type semiconductor crystal is electrically neutral, although $n_h >> n_e$?

16. How is a p-type semiconductor formed? Name the major charge carriers in it. Draw the energy band diagram of a p-type semiconductor.

(3 Marks Questions)

17. The diagram shows a piece of pure semiconductor, S in series with a variable resistor R, and a source of constant voltage V. Would you increase or decrease the value of R to keep the reading of ammeter (A) constant, when semiconductor S is heated? Give reason.



18. A semiconductor has equal electron and hole concentrations of $2\times10^{8}/m^{3}$. On doping with a certain impurity, the hole concentration increases to $4\times10^{10}/m^{3}$.
(i) What type of semiconductor is obtained on doping?
(ii) Calculate the new electron concentration of the semiconductor.
(iii) How does the energy gap vary with doping?

19. Explain the formation of energy band in solids. Draw energy band diagram for (i) a conductor, (ii) an intrinsic semiconductor.

20. What is an intrinsic semiconductor? How can this material be converted into (i) p-type (ii) n-type extrinsic semiconductor? Explain with the help of energy band diagrams.

21. Deduce an expression for the conductivity of p-type semiconductor.

(5 Marks Questions)

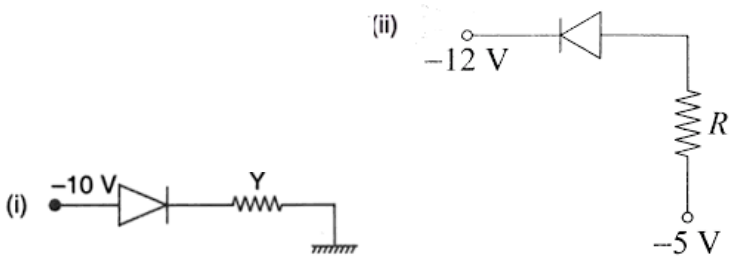
22. On the basis of the energy band diagrams, distinguish between (a) a metal, (b) an insulator and (iii) a semiconductor.

B. SEMICONDUCTOR DEVICE

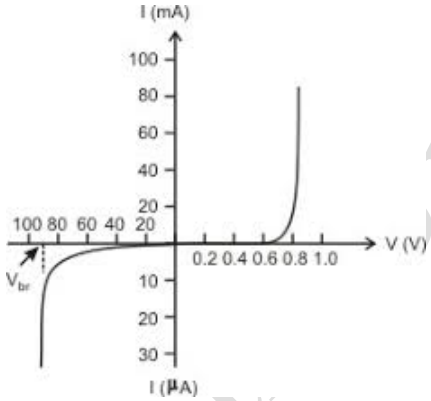
(1 Mark Questions)

1. How does the width of the depletion region of pn junction vary, if the reverse bias applied to it increases?

2. In the following diagrams, write which of the diodes are forward biased and which are reverse biased.



3. The figure below shows the V-I characteristic of a semiconductor diode.



(i) Identify the semiconductor diode used.

(ii) Draw the circuit diagram to obtain the given characteristic of this device.

(iii) Briefly explain how this diode can be used as a voltage regulator.

4. Draw the voltage current characteristic of a Zener diode.

5. Why should a photodiode be operated at reverse bias?

6. State the reason, why GaAs is most commonly used in making of a solar cell.

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7. 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 doplants.
(d) Holes are majority carriers and trivalent atoms are the dopants.

8. Which of the statements given in previous Question is true for p-type semiconductors?

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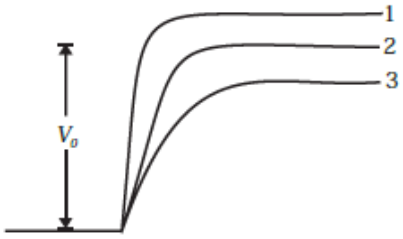
9. In an unbiased p-n junction, holes diffuse from the p-region to n-region because
(a) free electrons in the n-region attract them.
(b) they move across the junction by the potential difference.
(c) hole concentration in p-region is more as compared to n-region.
(d) All the above.

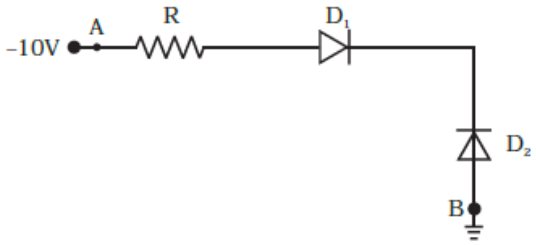
10. When a forward bias is applied to a p-n junction, it
(a) raises the potential barrier
(b) reduces the majority carrier current to zero
(c) lowers the potential barrier
(d) none of the above.

11. In Figure, V_0 is the potential barrier across a p-n junction, when no battery is connected across the junction



(a) 1 and 3 both correspond to forward bias of junction
(b) 3 corresponds to forward bias of junction and 1 corresponds to reverse bias of junction
(c) 1 corresponds to forward bias and 3 corresponds to reverse bias of junction.
(d) 3 and 1 both correspond to reverse bias of junction

12. In Figure, assuming the diodes to be ideal,



(a) D_1 is forward biased and D_2 is reverse biased and hence current flows from A to B
(b) D_2 is forward biased and D_1 is reverse biased and hence no current flows from B to A and vice versa.
(c) D_1 and D_2 are both forward biased and hence current flows from A to B.
(d) D_1 and D_2 are both reverse biased and hence no current flows from A to B and vice versa.

13. The output of the given circuit in Figure.

(a) would be zero at all times.
(b) would be like a half wave rectifier with positive cycles in output.
(c) would be like a half wave rectifier with negative cycles in output.
(d) would be like that of a full wave rectifier

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

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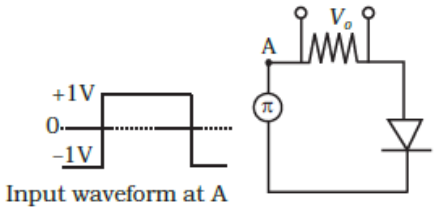
15. Draw the output waveform across the resistor (Figure).



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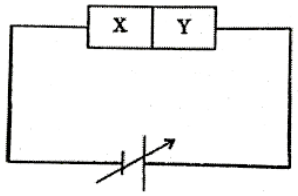
(2 Marks Questions)

16. Explain how the width of depletion layer in a pn junction diode changes when the junction is (i) forward biased (ii) reverse biased.

17. Two semiconductor materials X and Y shown in the given figure, are made by doping germanium crystal with indium and arsenic respectively. The two are joined end to end and connected to a battery as shown.



(i) Will the junction be forward biased or reverse biased?
(ii) Sketch a V-I graph for this arrangement.

18. Draw the circuit diagram fop n junction diode in forward bias. Sketch the voltage current graph.

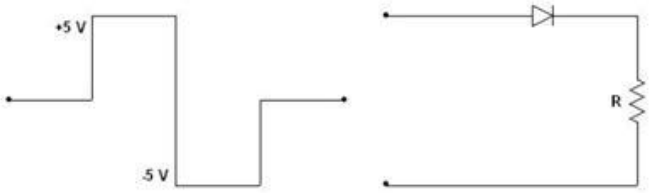
19. Explain the use of pn diode as rectifier.

20. Draw the circuit diagram for use of pn junction as a half wave rectifier.

21. What is a pn junction diode? Define the term dynamic resistance for the junction diode.

22. With the help of a diagram, show the biasing of a light emitting diode (LED). Give its two advantages over conventional incandescent lamps.

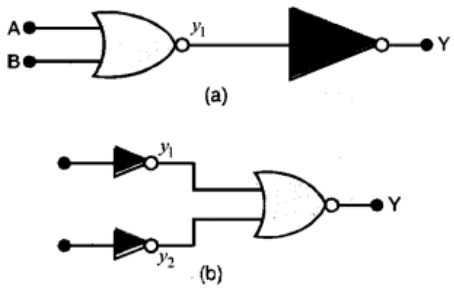
23. Draw and explain the output waveform across the load resistor R, if the input waveform is as shown in the given figure.



24. 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.

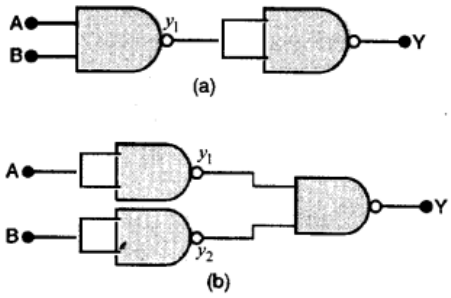
25. A p-n photodiode is fabricated from a semiconductor with band gap of 2.8 eV. Can it detect a wavelength of 6000 nm?

26. 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.

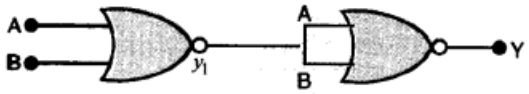


27. Write the truth table for a NAND gate connected as given in Fig. Hence identify the exact logic operation carried out by these circuits.

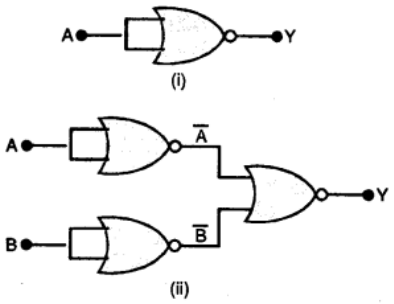
28. You are given two circuits as shown in Fig., which consist of NAND gates. Identify the logic operation carried out by the two circuits.



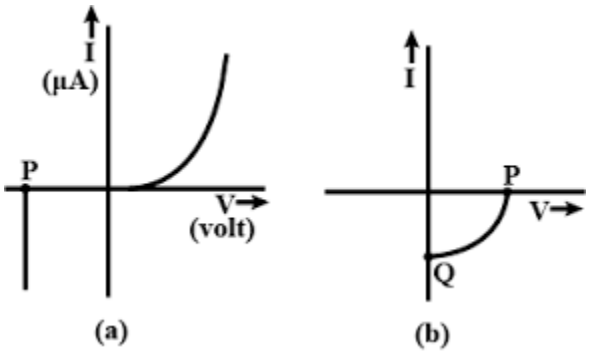
29. Write the truth table for circuit given in the Fig. below consisting of NOR gates and identify the logic operation (OR, AND, NOT) which this circuit is performing.



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



31. (i) Name the type of a diode whose characteristics are shown in Fig. (a) and Fig. (b). (ii) What does the point P in Fig. (a) represent? (iii) What does the points P and Q in Fig. (b) represent?



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

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(3 Marks Questions)

33. Explain how the depletion layer and barrier potential are formed in a pn junction diode.

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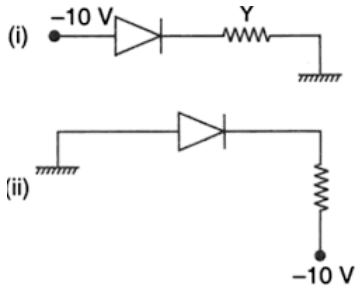
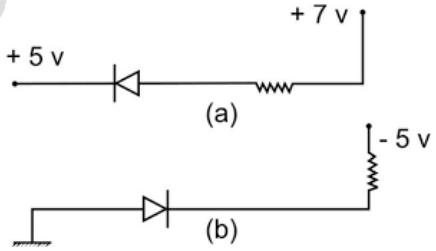
34. Explain with the help of a circuit diagram, how the thickness of depletion layer in a p-n junction diode changes when it is forward biased. In the following circuits which one of the two diodes is forward biased and which is reverse biased?



35. Explain (i) forward biasing, (ii) reverse biasing of a p-n junction diode. With the help of a circuit diagram explain the use of this device as a half wave rectifier.

36. Explain with the help of a circuit diagram, how the thickness of depletion layer in a p-n junction diode changes when it is forward biased. In the following circuits which one of the two diodes is forward biased and which is reverse biased?



37. Explain briefly with the help of circuit diagram, how V-I characteristics of a pn junction diode are obtained in (i) forward bias and (ii) reverse bias. Draw the shape of curves obtained.

38. Explain with the help of a schematic diagram, the principle and wording of a Light Emitting Diode. What criteria is kept in mind while choosing the semiconductor material for such a device? Write any two advantages of Light Emitting Diode over conventional incandescent lamps.

39. What is Zener diode? How is it symbolically represented? With the help of a circuit diagram, explain the use of Zener diode as a voltage stabilizer.

40. Why are photodiodes used preferably in reverse bias condition? A photodiode is fabricated from a semiconductor with band gap of 2.8eV. Can it detect a wavelength of 6000nm? Justify.

(5 Marks Questions)

41. Draw the circuit diagram of a full wave rectifier and explain its working. Draw the input and output waveforms.

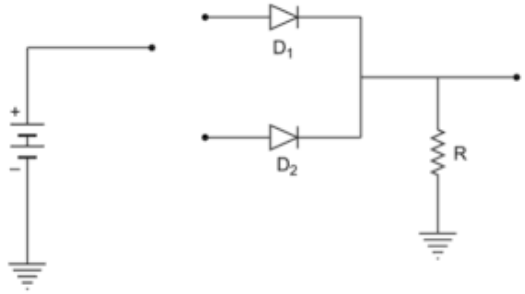
42. State the principle of working of p-n diode as rectifier. Explain, with the help of circuit diagram, the use of p-n diode as fill wave rectifier. Draw a sketch of the input and output waveforms.

C. LOGIC GATES

(1 Mark Questions)

1. Write the truth table of OR gate.

2. Name the logic gate realized using p-n junction diodes in the given diagram. Give its logic symbol.

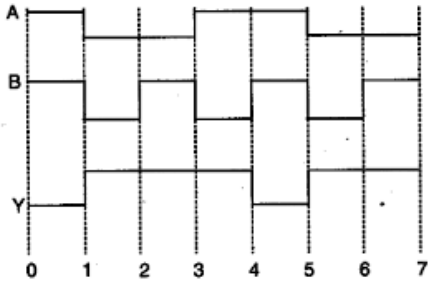


3. Draw the logic symbol of an AND gate.

4. Draw the truth table of an AND gate.

(2 Marks Questions)

5. Draw the output wave form for input wave forms A and B for OR gate.



6. The following truth table gives the output of a 2-input logic gate:

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0

If the output of this gate is fed as input to a NOT gate, name the new logic gate so formed.

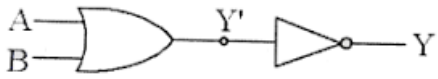
7. Draw the input and output wave forms of the signal in a common emitter amplifier using an n-p-n transistor. Write the expression for its voltage gain.

8. Draw a circuit diagram for a two input OR gate and explain its working with the help of input, output waveforms.

9. The output of an OR gate is connected to both the inputs of a NAND gate. Draw the logic circuit of this combination of gates and write its truth table.

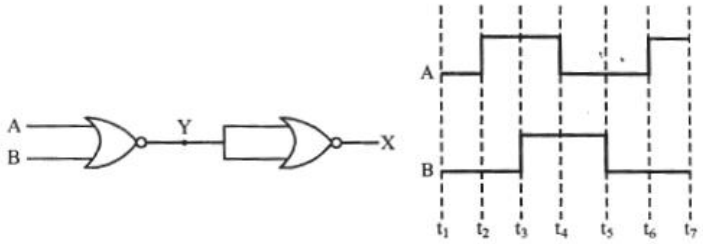
10. Draw the logic symbol of 2 input NAND gate. Write down its truth table.

11. Name the gate obtained from the combination of gate shown in the figure. Draw its logic symbol. Write the truth table of the combination.



12. Draw the logic symbol of 2 input NOR gate. Write down its truth table.

13. Draw the output wave form at X, using the given inputs A and B for the logic circuit shown below. Also identify the gate.



14. If the output of a 2 input NOR gate is fed as both inputs A and B to another NOR gate, write down a truth table to find the final output, for all combinations of A, B.

15. If the output of a 2 input NAND gate is fed as the input to a NOT gate (i) name the new logic gate obtained and (ii) write down its truth table.

16. The output of a 2-input AND gate is fed to a NOT gate. Draw the logic circuit of this combination.

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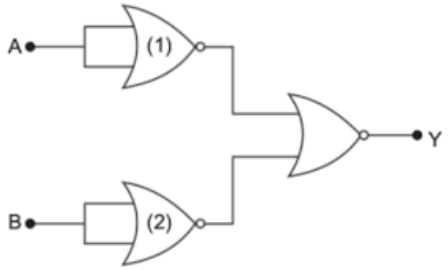
17. The inputs of A and B are inverted by using two NOT gates and their outputs are fed to the NOR gate as shown below:



Analyse the action of the gates (1) and (2) and identify the logic gate of the complete circuit so obtained. Give its symbol and the truth table.

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18. If the output of a 2-input NOR gate is fed as the input to a NOT game, (i) name the new logic gate obtained and (ii) write down its truth table.

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19. Identify the logic gates marked X, y. Write down the output as Z, when A = 1, B = 1 and A = 0, B = 0.

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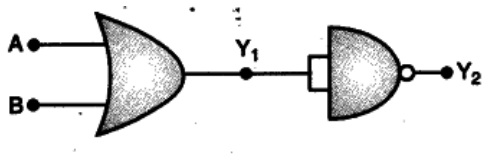
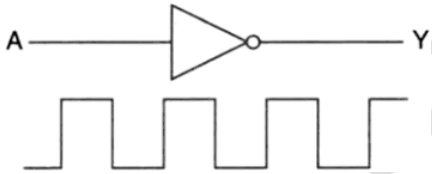
20. For the given circuit given, write truth table showing the outputs Y_1:Y_2 for all possible inputs at A and B.



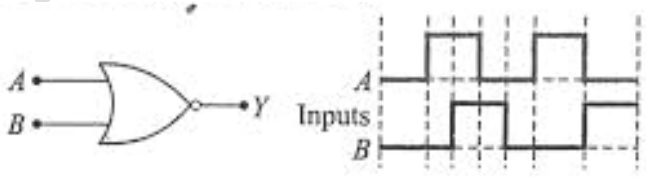
(3 Marks Questions)

21. In the figure given below, circuit symbol of a logic gate and input wave form is shown.



(i) Name the logic gate, (ii) write its truth table and (iii) give the output wave form.

22. In the figure, the circuit symbol of logic gate and input wave forms are given. Name the logic gate. Write its truth table and give the output wave form.



D. CHALLENGING PROBLEMS

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

2. In an intrinsic semiconductor the energy gap E_g is 1.2 eV. Its hole mobility is much smaller than electron mobility 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

$$n_i = n_0 \exp\left(-\frac{E_g}{2k_B T}\right),$$

where n_0 is constant.

3. In a P-n junction diode, the current I can be expressed as

$$I = I_0(e^{ev/2K_B T} - 1)$$

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

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

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

(c) What is the dynamic resistance?

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

SPACE FOR ROUGH WORK

SPACE FOR NOTES