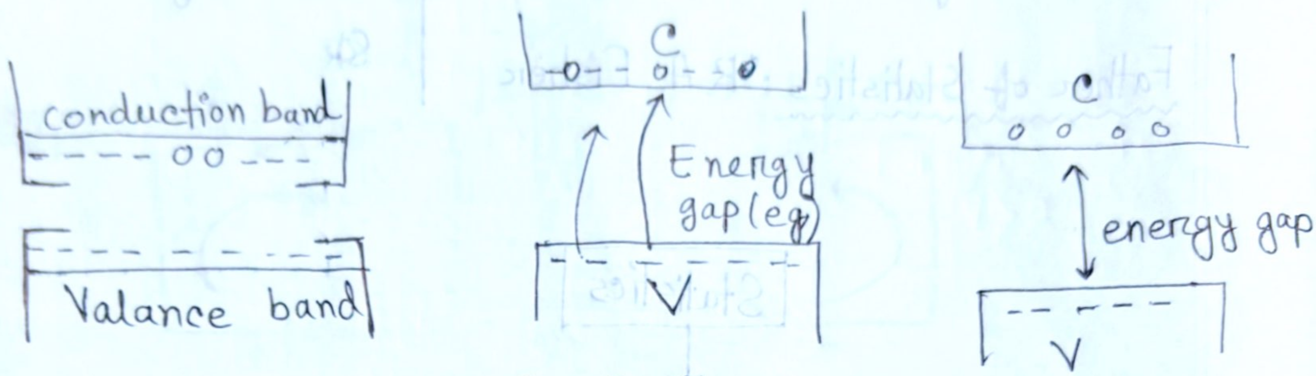
C.W 22/10/2024

# CSE251

## Diode

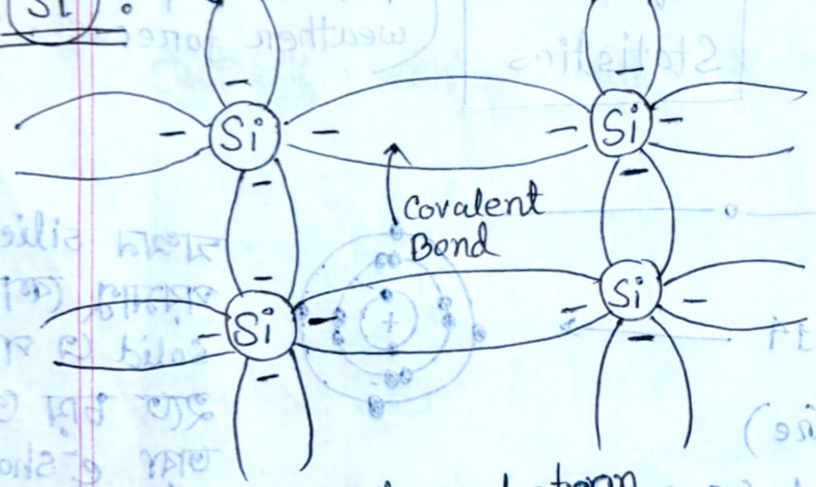
Conductor | Semi-Conductor | Insulator




Ge → 0.67ev

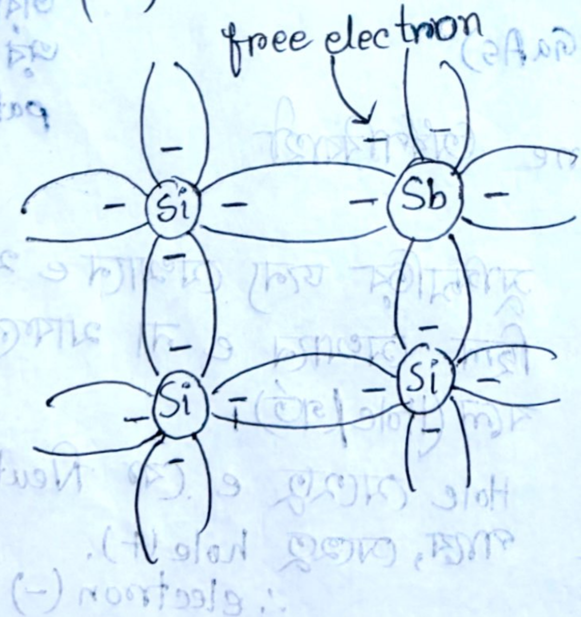
Si → 1.1ev

Si : crystal




Intrinsic material : No impurity or pure (all silicone)

Dope :




Dope Intrinsic material

↓

Extrinsic material

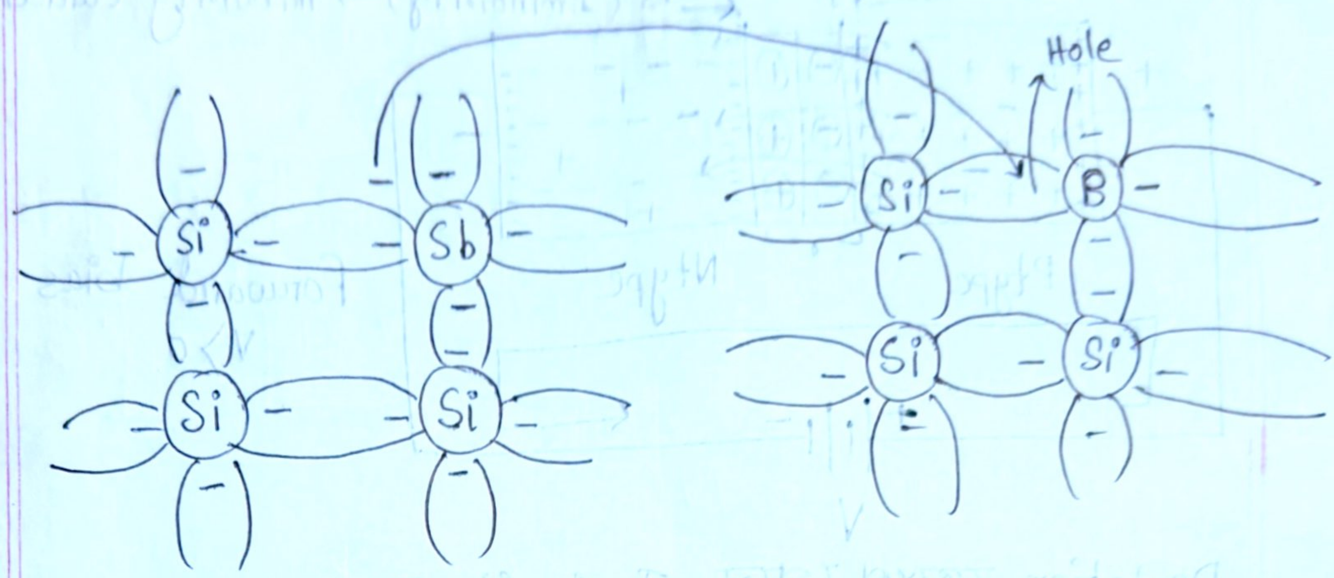
↓

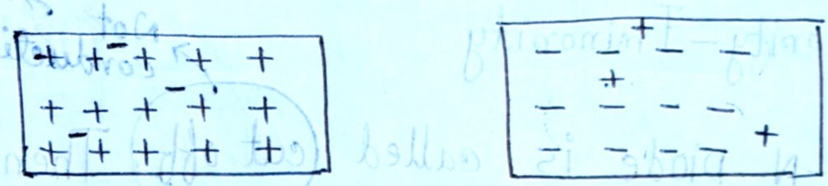
impure

↓

n type (5 টা)

p type → Al, B, Ga (+3)

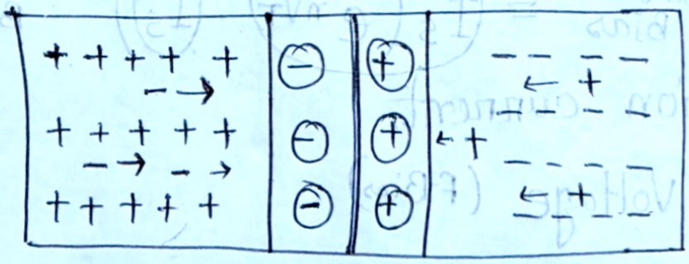


P type ↓ N-type ↓

| | |
|---|---|
| Hole → +ve → Majority career | Electron → -ve → Majority career |
| electron → -ve → Minority career | Hole → +ve → Minority " |

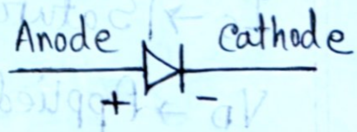
**P-N Diode :**



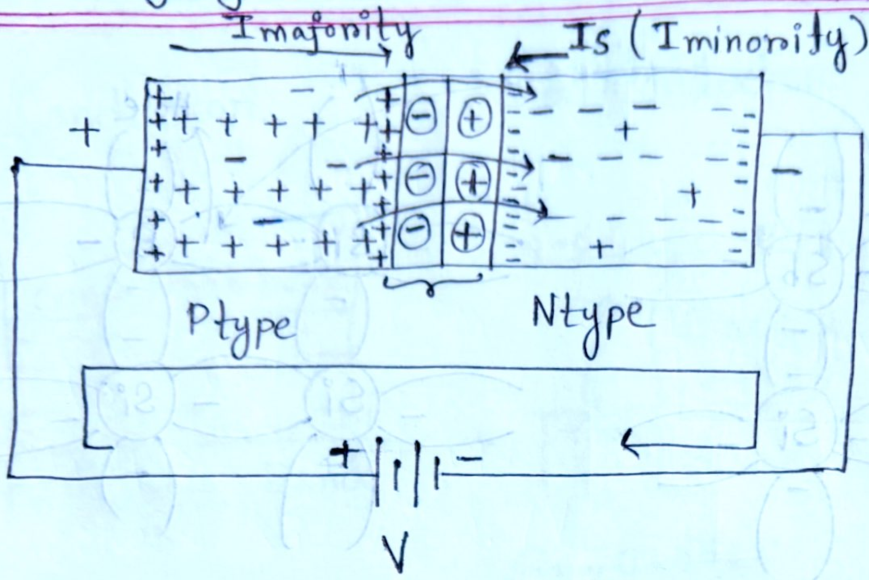
Ptype (Junction) Ntype

Depletion region (W)

P-N → Diode



## Applying V on P-N Diode :




Forward bias
$V > 0$

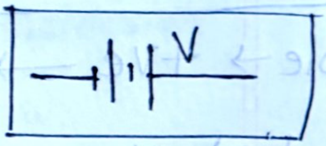
Depletion ভেঙে গেলে I minority হয়।

$I_D = I_{majority} - I_{minority}$

* if $V = 0$, P-N Diode is called cut off. Then, Depletion region will be reformed.

Not conducting → less than 0.7 for Si

- Reverse bias condition when, $V < 0$




- Diode current, $I_D = I_S\left(e^{\frac{V_D}{nV_T}} - 1\right)$

$$\underset{\text{Forward Bias}}{} = I_S\left(e^{\frac{V_D}{nV_T}}\right) - (I_S) \quad \text{Reverse Bias}$$

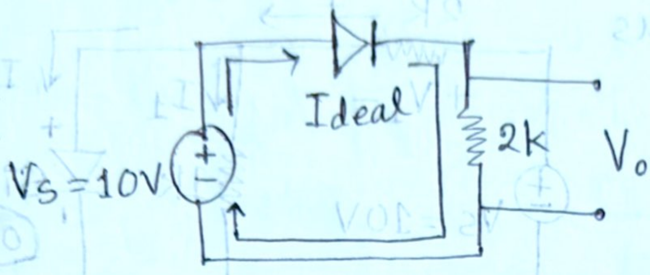
$I_S \rightarrow$ Reverse Saturation current

$V_D \rightarrow$ Applied Voltage (F-Bias)

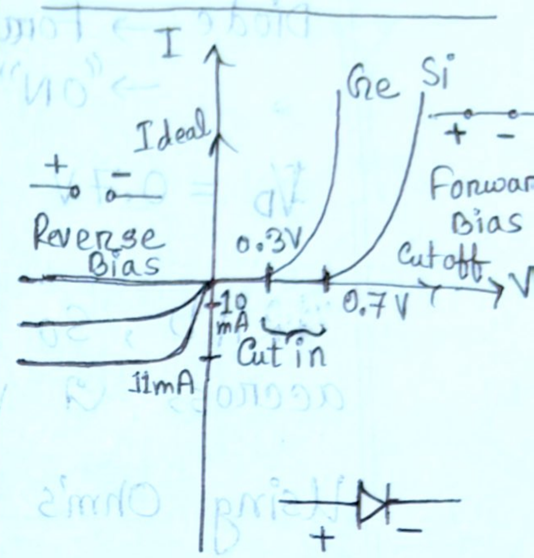
$V_T \rightarrow$ Thermal Voltage

$\eta \rightarrow$ Identity factor (1 or 2) depends on construction $\left.\right\}$ $\eta \rightarrow 1$ : Ge, $\eta \rightarrow 2$ : Si

# Determine the voltage $V_o$




I-V characteristic curve




**Soln:** Diode → forward bias → "ON"

Ideal Diode, $V_D = 0\,V$

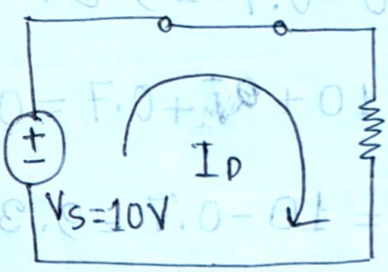
$$I_D = \frac{V_S}{2k} = \frac{10}{2k} \text{ [Ohm's law]}$$

$$= 5\,mA$$

$$V_o = 2K \times I_D$$

$$= 2k \times 5\,mA$$

$$= 10\,V$$

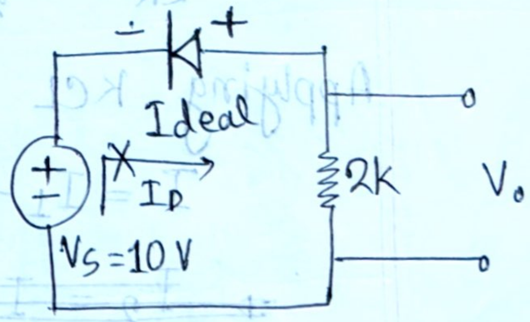



Reverse Diode এর ক্ষেত্রে,

Diode → Reverse bias → "OFF"

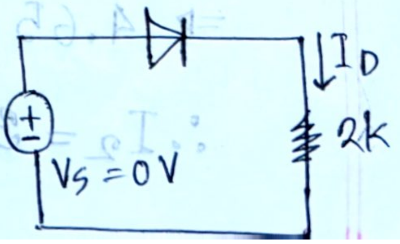
$I_D = 0A$

$V_o = 0V$



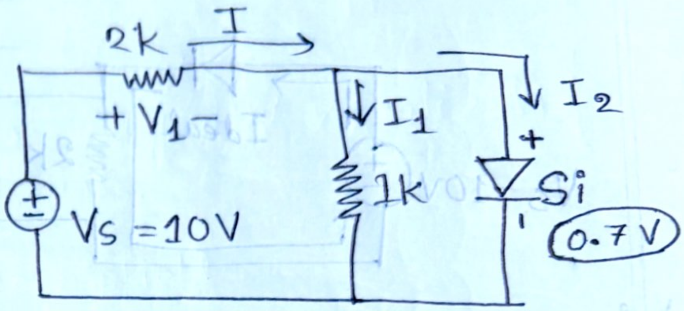

Diode → cut off

$I_D = 0A$



# Determine $I, I_1, I_2$ & $V_1$

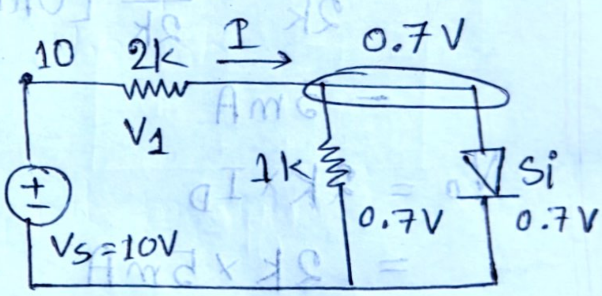
Diode → Forward bias
→ "ON"




$V_D = 0.7V$

$1k \parallel D$, So 1k এর accross এ $V = 0.7V$

Using Ohm's law, $I_1 = \frac{0.7}{1k} = 0.7mA$




$V_1 = 10 - 0.7 = 9.3V$

OR, KVL, $-10 + V_1 + 0.7 = 0$

$\Rightarrow V_1 = 10 - 0.7 = 9.3V$

$I = \frac{V_1}{2k} = \frac{9.3}{2} = 4.65mA$

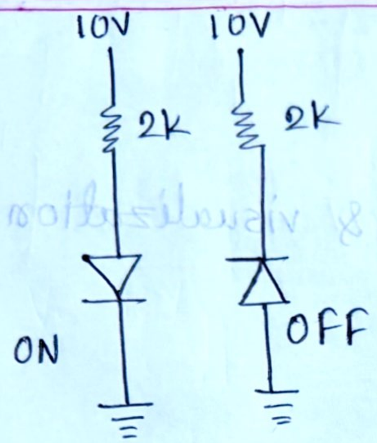
Applying KCL at node A,

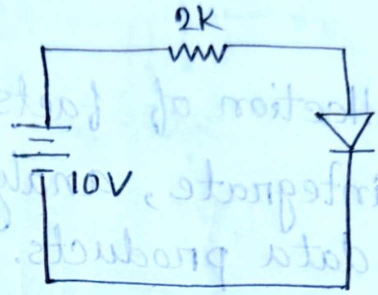
$I = I_1 + I_2$

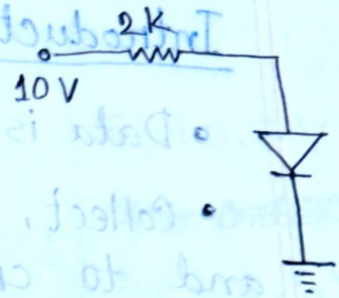
~~$\Rightarrow I_2 = I - I_1$~~

$\Rightarrow 4.65 = 0.7 + I_2$

$\therefore I_2 = 3.9mA$ (Ans)

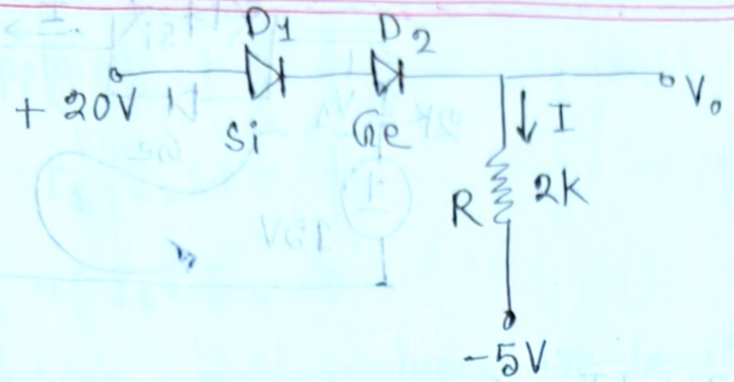

10V
2K
ON
10V
2K
OFF


2K
10V


2K
10 V

C.W 27/10/2024

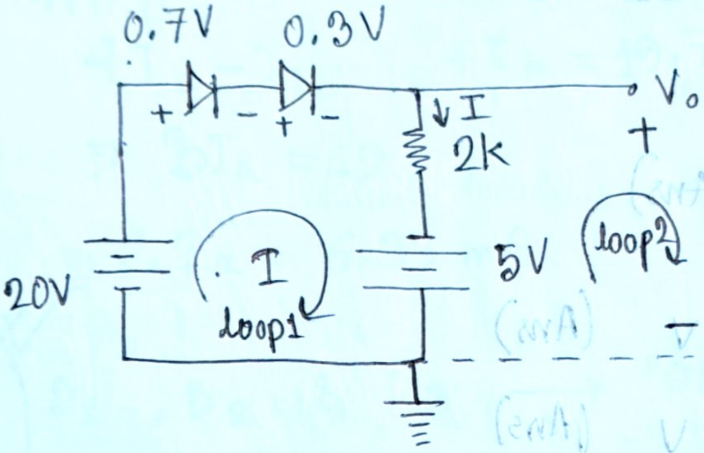
# Determine the current I & the voltage $V_o$




$Si = 0.7V$

~~Ge = 0.3V~~

$Ge = 0.3V$




Forward Bias

$\therefore D_1$ & $D_2 \longrightarrow$ "ON"

KVL,

$$-20 + 0.7 + 0.3 + 2I - 5 = 0$$

$$\Rightarrow 2I = 24$$

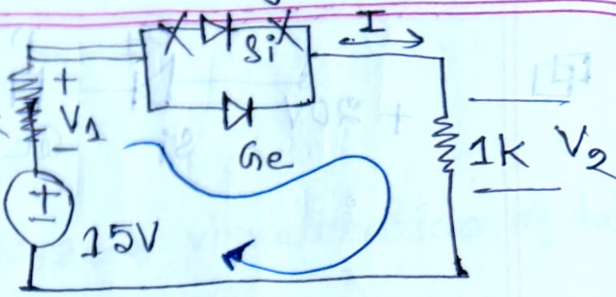
$$\Rightarrow I = 12 \text{ mA} \quad \text{(Ans)}$$

KVL in loop 2, $+5 - 2I + V_o = 0$

$$\Rightarrow 5 - 24 + V_o = 0$$

$$\Rightarrow V_o = 19 \quad \text{(Ans)}$$

# Determine the current I & the voltage $V_1$ & $V_2$




$D_1 \rightarrow$ "OFF"

$D_2 \rightarrow$ "ON"

Applying KVL,

$-15 + 2I + 0.3 + 1I = 0$

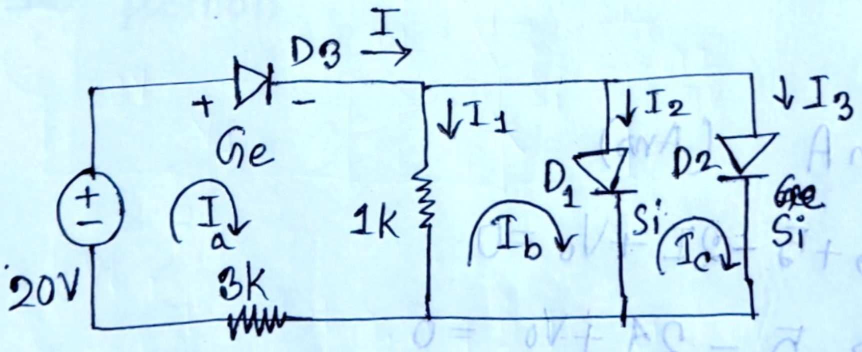
$\Rightarrow 3I = 14.7$

$\Rightarrow I \approx 5\,mA$ (Ans)

$\therefore V_1 = 2 \times 5 = 10\,V$ (Ans)

$\therefore V_2 = 1 \times 5 = 5\,V$ (Ans)

# Determine the voltage $V_1$ & the currents $I_1, I_2, I_3$




Applying mesh analysis in loop 1,

$-20 + 0.3 + I_a - I_b + 3I_a = 0$

$\Rightarrow 4I_a - \cancel{+3}I_b = 19.7$

Applying mesh analysis in loop 2,

$I_b - I_a + 0.7 = 0$

$\Rightarrow I_a - I_b = 0.7$

~~Applying mesh analysis in loop 3,~~

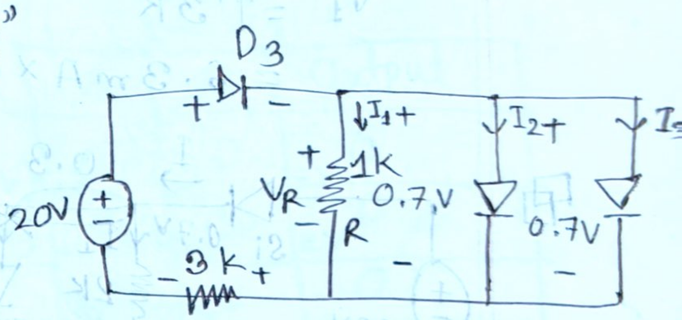
$4I_a - I_b - I_a + I_b = 19.7 - 0.7$

$\Rightarrow 3I_a = 19$

$\therefore I_a = 6.33\ mA$

Wrong Answer

Soln: $D_1$, $D_2$ & $D_3 \longrightarrow$ "ON"




$V_{D_3} = 0.3V$

$V_{D_1} = V_{D_2} = 0.7V$

Since, $R \parallel D_1 \parallel D_2$

$V_R = V_{D_1} = V_{D_2} = 0.7V$

Applying KVL, $-20 + V_{D_3} + V_R + V_1 = 0$

$\Rightarrow -20 + 0.3 + 0.7 + I' 3K = 0$

$\therefore I' = 6.3\ mA = I$

(Ans)

Applying KCL,

$$I = I_1 + I_2 + I_3$$

$$\Rightarrow I_2 + I_3 = I - I_1$$
$$= 6.3mA - 0.7mA$$
$$= 5.6mA$$

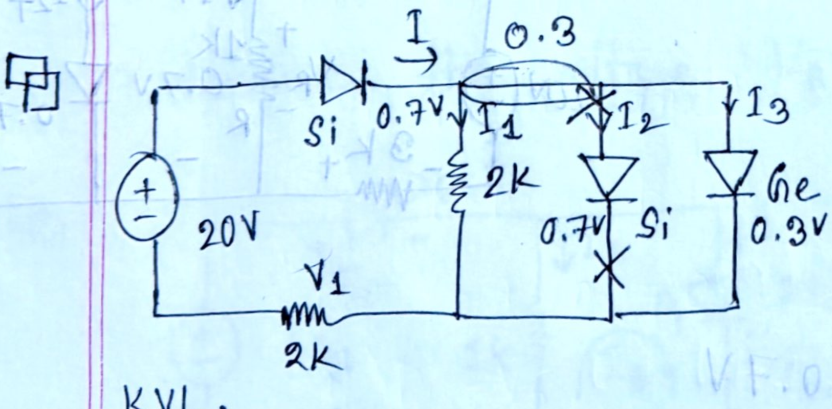
$$I_2 = I_3 = \frac{5.6}{2} mA = 2.8mA \text{ (Ans)}$$

$$V_1 = I'3K$$
$$= 6.3mA \times 3 = 18.9V \text{ (Ans)}$$

Using Ohm's law,

$$I_1 = \frac{0.7}{1K} = 0.7mA$$

# $V_1, I_1, I_2$ & $I_3$




KVL,

$$-20 + 0.7 + 0.3 + 2I = 0$$
$$\Rightarrow 2I = 19$$
$$\therefore I = 9.5 mA$$

As $D_2$ = "OFF", $I_2 = 0 mA$

~~KVL in loop,~~ CDR, $I_1 = \frac{0.3}{2} = 0.15\,mA$

Applying KCL, $I = I_1 + I_3$

$\Rightarrow I_3 = I - I_1$

$\therefore I_3 = 9.5 - 0.15 = 9.35\,mA$

$\therefore V_1 = 2 \times I = 2 \times 9.5 = 19\,V$

Slide-11

# AND Gate

| A | B | Output |
|---|---|---|
| 0 (0V) | 0 (0V) | 0 (0V) |
| 0 (0V) | 1 (5V) | 1 (5V) |
| 1 (5V) | 0 (0V) | 1 (5V) |
| 1 (5V) | 1 (5V) | 1 (5V) |

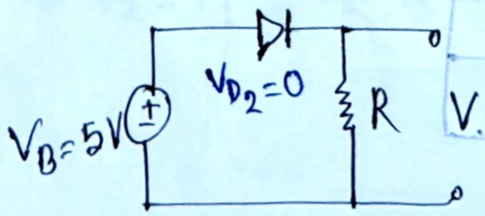
{ logic"0" → 0V
logic"1" → 5V }

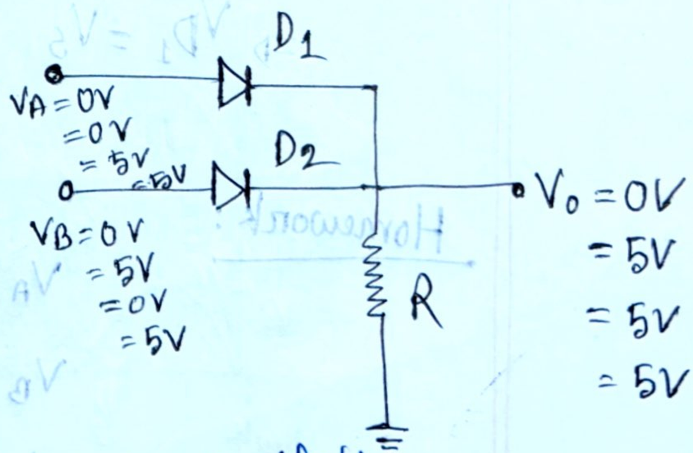
# OR Gate

| A | B | Output |
|---|---|---|
| 0 (0V) | 0 (0V) | 0 (0V) |
| 0 (0V) | 1 (5V) | 0 (0V) |
| 1 (5V) | 0 (0V) | 0 (0V) |
| 1 (5V) | 1 (5V) | 1 (5V) |

# $D_1$ & $D_2$ → Ideal diode

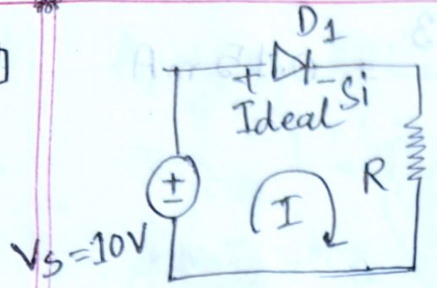
$V_{D1}$ & $V_{D2} \rightarrow 0V$



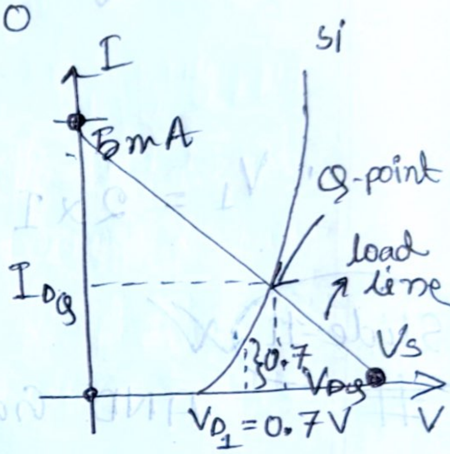

This circuit is representing → OR gate

# Determine the load line for the following circuit and determine the Q point.




Soln: Applying KVL, $-10 + 0.7 + 2I = 0$

$\Rightarrow I = 4.65\ mA$




Let $V_{D_1} = 0V$

$-V_S + V_R = 0$

$\Rightarrow V_R = V_S$

$\Rightarrow IR = V_S$

$\Rightarrow I = \frac{V_S}{R}$

$= \frac{10}{2} = 5mA$

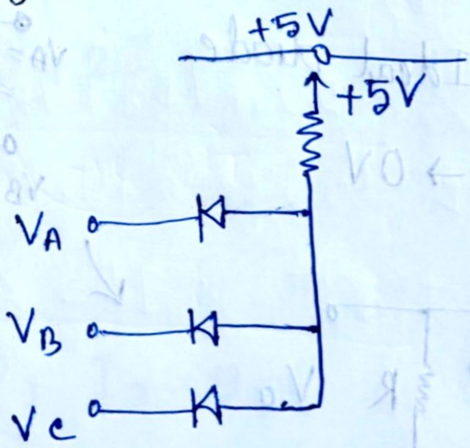
Let, $I = 0A$, From eqn (1)

$-V_S + V_{D_1} + IR = 0$

$\Rightarrow -V_S + V_{D1} = 0 \quad [IR = 0]$

$\Rightarrow V_{D_1} = V_S$

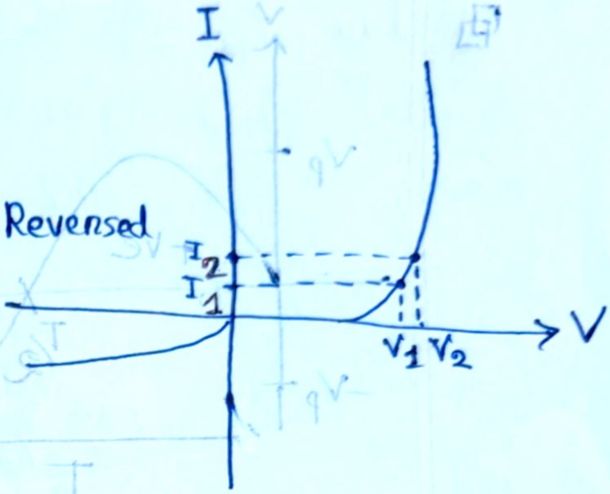
Homework:



29/10/24

$$I = I_s\left(e^{\frac{V_D}{nV_T}} - 1\right)$$

$$= \underbrace{I_s e^{\frac{V_D}{nV_T}}}_{\text{Forward Bias}} - \underbrace{I_s}_{\text{Reverse Bias}}$$




$V_T$ = Thermal Voltage

$$\therefore V_T = \frac{KT}{q} = 25.5 \approx 26\,mV$$

# Let, $n = 1$

$$\therefore I_1 = I_s e^{\frac{V_1}{V_T}}, \quad I_2 = I_s e^{\frac{V_2}{V_T}}$$

$$\therefore \frac{I_2}{I_1} = \frac{I_s e^{V_2/V_T}}{I_s e^{V_1/V_T}} = \frac{e^{V_2/V_T}}{e^{V_1/V_T}}$$

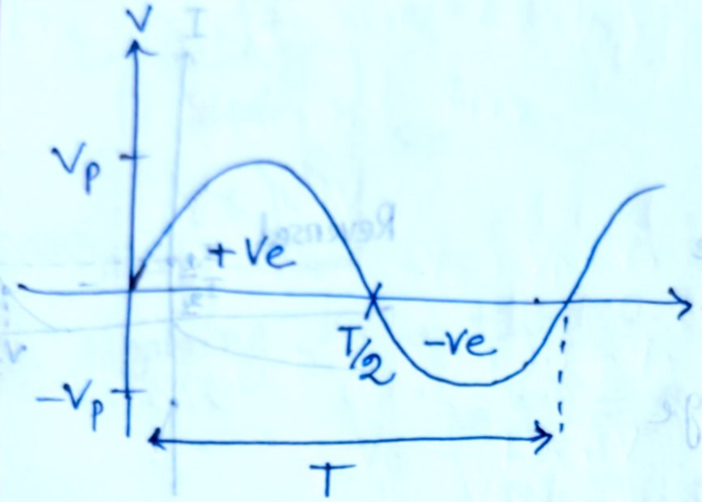
$$\Rightarrow \frac{I_2}{I_1} = \frac{e^{V_2/V_T}}{e^{V_1/V_T}}$$

$$\Rightarrow \frac{I_2}{I_1} = e^{(V_2 - V_1)/V_T}$$

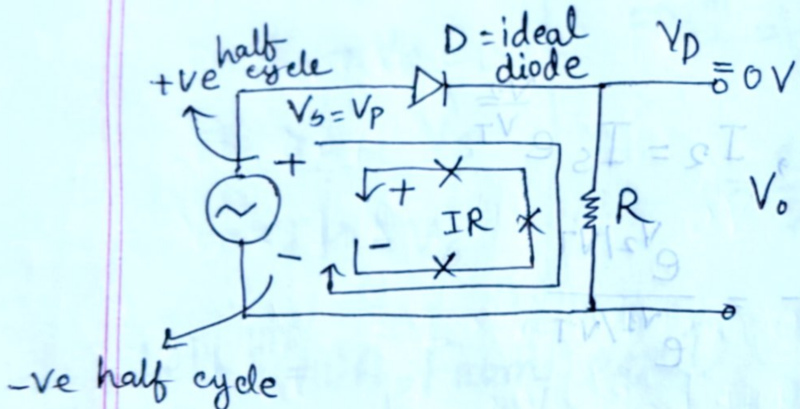
$$\Rightarrow V_2 - V_1 = V_T \ln\left(\frac{I_2}{I_1}\right)$$

$$\Rightarrow V_2 - V_1 = 2.3\, V_T \log\left(\frac{I_2}{I_1}\right)$$

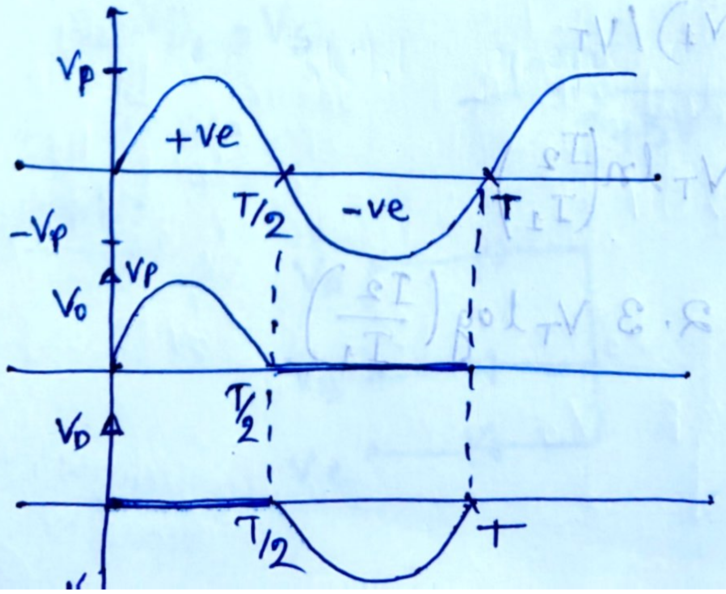
(ω = angular frequency)




* For +ve half cycle
  D ⇒ Forward bias
* For -ve half cycle
  D ⇒ Reverse bias




## Halfwave Rectifier:




halfwave Rectifier Circuit

For, +ve half cycle, Applying KVL,

$$-V_P + V_D + V_o = 0$$

$$\Rightarrow V_o = V_P - \cancel{V_D}^{\,0}$$

$$\therefore V_o = V_P$$

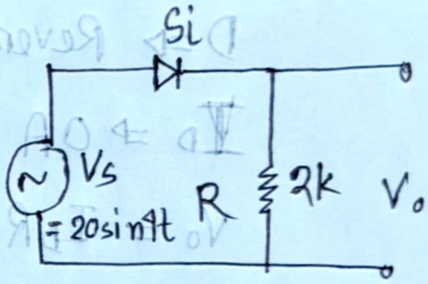
For, negative (-ve) half cycle, Applying KVL,

$$V_S + V_D + V_o = 0$$

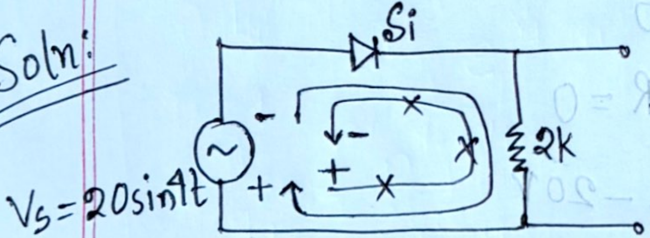
$$\Rightarrow V_D = -V_S = -V_P$$

Here, $I_R = 0$, $V_o = I$

\# Determine the output voltage $V_o$ and sketch the wave forms accross the output resistance and diode

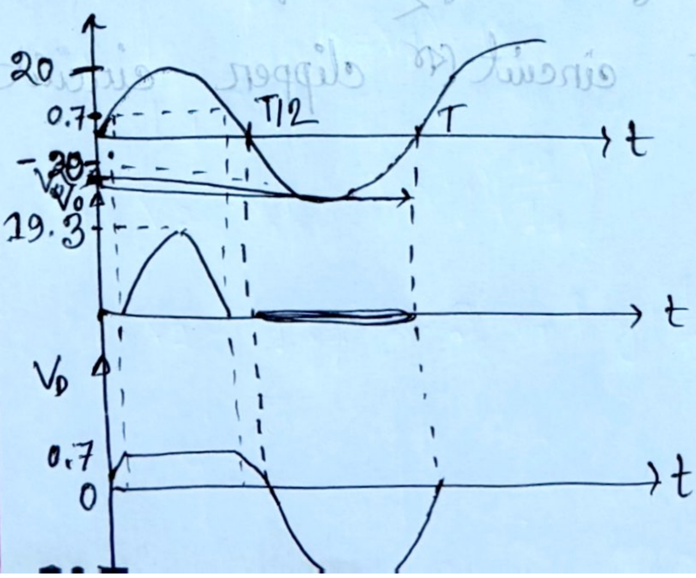



Soln:




Here, $V_S = 20\angle 0^{\circ}$

$\omega = 4$ rad/sec




Reverse bias fixed voltage drop থাকে না, তাই maximum voltage থাকে কারণ Reverse bias এ open circuit

For +ve half cycle $(0-T/2)$

$D \Rightarrow$ Forward bias

$V_D = 0.7V$

$\therefore$ Applying KVL, $-V_S + V_D + V_0 = 0$

$\Rightarrow -20 + 0.7 + V_0 = 0$

$\therefore V_0 = 19.3V$

For (-ve) half cycle $(T/2 - T)$

$D \Rightarrow$ Reverse bias

$I_D \Rightarrow 0A$

$V_0 = I_D R = 0 \times 2K = 0V$

$\therefore$ Applying KVL, $V_S + V_D + V_0 = 0$

$\Rightarrow V_S + V_D + I_D R = 0$

$\Rightarrow V_D = -V_S = -20V$

* Diode একটি অংশ কেটে যাচ্ছে আর একটা অংশ থেকে যাচ্ছে এই ধরনের circuit কে clipper circuit বলে।