Tribhuvan University

Institute of Science and Technology

2077

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Bachelor Level / First Year/ First Semester/ Science

Computer Science and Information Technology (PHY. 113)

(Physics)

(New Course)

Full Marks: 60

Pass Marks: 24

Time: 3 hours.

Candidates are required to give their answers in their own words as for as practicable.

The questions are of equal value.

Group A

Long Answer Questions:

Attempt any TWO questions **(2x10=20)**

1. Explain RTL and TTL gates. How memory and clock circuits can be made by using these gates? Explain how they work?

2. Set up differential equation for an oscillation of a spring using Hooke's and Newton's second law. Find the general solution of this equation and hence the expressions for period, velocity and acceleration of oscillation.

3. Describe Frank-Hertz experiment. Interpret how the results of this experiment advocate atomic model proposed by Bohr?

Group B

Short Answer Questions: **(8x5=40)**

Attempt any EIGHT questions:

4. Discuss magnetic dipole moment. What is its effect on atom? and on molecules? Explain.

5. Describe the following process of IC production: (a) Oxidation, (b) Pattern definition, and (c) Doping.

6. Explain the construction and working of bipolar junction transistor (BJT).

7. A roulette wheel with moment of inertia $I = 0.5$ kg m^2 rotating initially at 2 rev/sec coasts to a stop from the constant friction torque of the bearing. If the torque is 0.4 Nm, how long does it take to stop?

8. Two large parallel plates are separated by a distance of 5 cm. The plates have equaled but opposite charges that create an electric field in the region between the plates. An α particle (q=3.2 x 10^{-19} C, m= 6.68 x 10^{-27} kg) is released from the positively charged plate, and it strikes

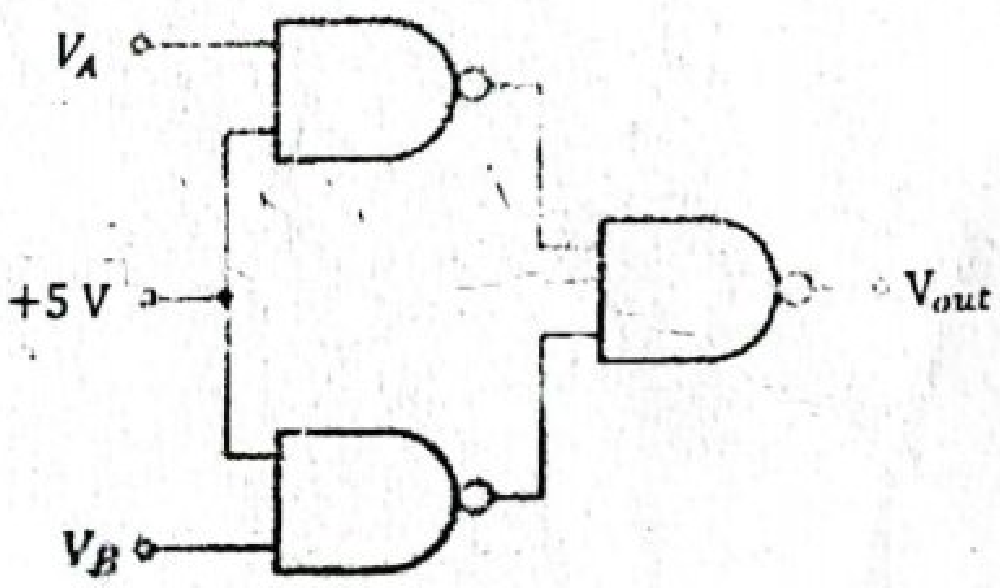
the negatively charged plate 2×10^{-6} sec. later. Assuming that the electric field between the plates is uniform and perpendicular to the plates, what is the strength of the electric field?

9. In neutron spectroscopy a beam of monoenergetic neutrons is obtained by reflecting reactor neutrons from a beryllium crystal. If the separation between the atomic planes of the beryllium crystal is 0.732 Å, what is the angle between the incident neuton beam and the atomic planes that will yield a monochromatic beam of neutrons of wavelength 0.1 Å?

10. What is the probability of finding a particle in a well of width a at a position $a/4$ from the wall if $n = 1$, if $n = 2$, if $n = 3$. Use the normalized wavefunction $\psi(x,t) = \left(\frac{2}{a}\right)^{\frac{1}{2}} \sin\left(\frac{n\pi x}{a}\right) e^{-\frac{iEt}{\hbar}}$.

11. The energy gap in silicon is 1.1 eV, whereas in diamond it is 6 eV. What conclusion can you draw about the transparency of the two materials to visible light (4000 Å to 7000 Å)?

12. Find the truth table for the circuit shown in the figure. What logic function will the circuit perform if the constant + 5 V input to the first two gates is changed to ground potential?



7. A roulette wheel with moment of inertia $I = 0.5\,kgm^2$ rotating initially at 2 rev/sec coasts to a stop from the constant friction torque of the bearing. If the torque is 0.4 Nm, how long does it take to stop?

Sol. Given,

Moment of Inertia $(I) = 0.5\,kgm^2$

frequency $(f) = 2$ rev/sec

Torque $(\tau) = 0.4\,Nm$

Time $(t) = ?$

we know,

$$\tau = I\alpha$$

$$\tau = I \cdot \frac{\omega}{t} \quad \left(\alpha = \frac{\omega}{t} \right)$$

$$\tau = I \times \frac{2\pi f}{t} \quad (\omega = 2\pi f)$$

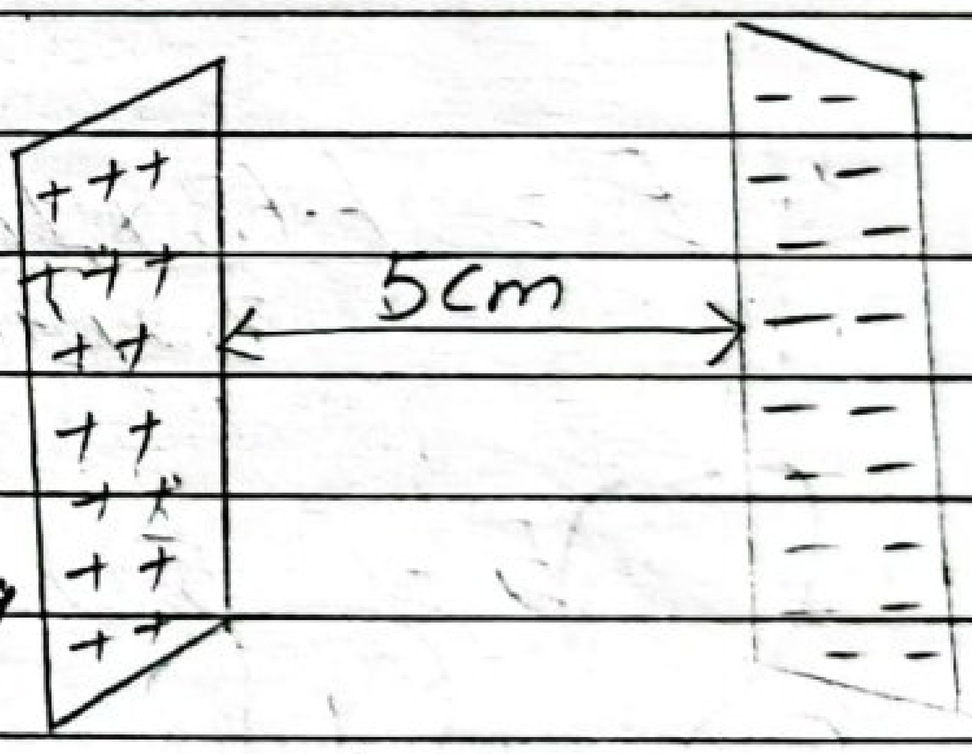
$$t = \frac{0.5 \times 2\pi \times 2}{0.4}$$

$$\therefore t = 15.7 \text{ seconds.}$$

$\therefore$ It take 15.7 seconds to stop.

8. Two large parallel plates are separated by a distance of 5cm. The plates have equaled but opposite charges that create an electric field in the region between the plates. An α particle ($q = 3.2 \times 10^{-19}$ C, $m = 6.68 \times 10^{-27}$ kg) is released from the positively charged plate and it strikes the negatively charged plate 2×10^{-6} sec later. Assuming that the electric field between the plates is uniform and perpendicular to the plates, What is the strength of the electric field?

Sol^n Given,



distance $(s) = 5cm = 5 \times 10^{-2}$ m

charge of α-particle $(q) = 3.2 \times 10^{-19}$ C

Mass of α-particle $(m) = 6.68 \times 10^{-27}$ kg

Time $(t) = 2 \times 10^{-6}$ sec

Strength of Electric field $(E) = ?$

Using eq^n of motion

$$s = ut + \frac{1}{2}at^2 \quad (u = 0)$$

$$s = \frac{at^2}{2}$$

$$a = \frac{2s}{at^2} \quad --- (1)$$

From Newton's law

$$F = ma$$

$$F = m \times \frac{2s}{t^2} \quad \text{---} \; (ii)$$

Again,

electrostatic force

$$F = qE \quad \text{---} \; (iii)$$

Using eqⁿ (ii) and (iii)

$$qE = \frac{m \times 2s}{t^2}$$

$$E = \frac{m \times 2s}{q \times t^2}$$

$$E = \frac{6.68 \times 10^{-27} \times 2 \times 5 \times 10^{-2}}{3.2 \times 10^{-19} \times (2 \times 10^{-6})^2}$$

$E = 522$ N/C Ans

∴ The strength of Electric field is 522 N/C Ans

9. In neutron spectroscopy a beam of monoenergetic neutrons is obtained by reflecting reactor neutrons from a beryllium crystal. If the separation between the atomic planes of the beryllium crystal is 0.732A°, What is the angle between the incident neutron beam and the atomic planes that will yield a monochromatic beam of neutrons of wavelength 0.1A°?

Sol: Given,

separation between the atomic planes (d) = 0.732A° = 0.732×10^{-10} m

Wavelength (λ) = 0.1A° = 0.1×10^{-10} m

Angle (θ) = ?

we know,

$$2d\sin\theta = n\lambda$$

or, $$\sin\theta = \frac{n\lambda}{2d}$$

or, $$\theta = \sin^{-1}\left(\frac{n\lambda}{2d}\right)$$

or, $$\theta = \sin^{-1}\left(\frac{1 \times 0.1 \times 10^{-10}}{2 \times 0.732 \times 10^{-10}}\right)$$

$\therefore$ $\theta = 3.92°$ Ans

$\therefore$ The angle between the incident neutron beam and the atomic planes is 3.92° Ans

CamScanner

10. What is the probability of finding a particle in a well of width α at a position $\alpha/4$ from the wall if $n=1$, if $n=2$, if $n=3$. Use the normalized wave function $\psi(x,t) = \left(\frac{2}{a}\right)^{1/2} \sin\left(\frac{n\pi x}{a}\right) e^{\frac{-iEt}{\hbar}}$

Sol: Given,

width of wall $(l) = \alpha$

Position $(x) = \frac{\alpha}{4}$

Normalised wave function

$$\psi(x,t) = \sqrt{\frac{2}{\alpha}} \sin\left(\frac{n\pi x}{\alpha}\right) e^{\frac{-iEt}{\hbar}}$$

Probability of finding the particle $P = \cancel{\psi^* \psi}\ \psi^* \cdot \psi$

$$P = \left(\sqrt{\frac{2}{\alpha}} \sin \frac{n\pi}{\alpha} \cdot \frac{\alpha}{4}\ e^{\frac{+iEt}{\hbar}}\right)\left(\sqrt{\frac{2}{\alpha}} \sin \frac{n\pi}{\alpha} \cdot \frac{\alpha}{4}\ e^{\frac{-iEt}{\hbar}}\right)$$

$$P = \frac{2}{\alpha} \sin^2 \frac{n\pi}{4} \quad \text{----} \; (1)$$

For $n=1$ then eq^n (1) becomes

$$P_1 = \frac{2}{\alpha} \sin^2\left(\frac{\pi}{4}\right) = \frac{2}{\alpha} \times \left(\frac{1}{\sqrt{2}}\right)^2 = \frac{1}{\alpha}$$

For $n=2$, then eq^n ① becomes

$$P_2 = \frac{2}{\alpha}\sin^2\left(\frac{2\pi}{4}\right) = \frac{2}{\alpha}$$

For $n=3$, then eq^n ① becomes.

$$P_3 = \frac{2}{\alpha}\sin^2\left(\frac{3\pi}{4}\right) = \frac{2}{\alpha}\times\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{1}{\alpha}$$

Hence, the probability of finding the particle in a well of width of position $x=\frac{\alpha}{4}$ from the wall for $n=1$, $n=2$ and $n=3$ are $\frac{1}{\alpha}$, $\frac{2}{\alpha}$ and $\frac{1}{\alpha}$ respectively.

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11. The energy gap in silicon is 1.1 ev, whereas in diamond it is 6 ev. What conclusion can you draw about the transparency of the two materials to visible light (4000 A° to 7000 A°)?

Sol: Given,

energy gap in silicon ($E_{silicon}$) = 1.1 ev.
$= 1.1 \times 1.6 \times 10^{-19}$

Energy gap in diamond ($E_{diamond}$) = 6 ev
$= 6 \times 1.6 \times 10^{-19}$

we have, For silion,

$$E_{silicon} = \frac{hc}{\lambda_{silicon}}$$

$$\lambda_{silicon} = \frac{hc}{E_{silicon}}$$

$$= \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{1.1 \times 1.6 \times 10^{-19}}$$

$$\lambda_{silicon} = 11290\ A^{\circ}$$

Hence, all visible light are absorbed since $\lambda_{silion} > \lambda_{visible}$

For diamond,

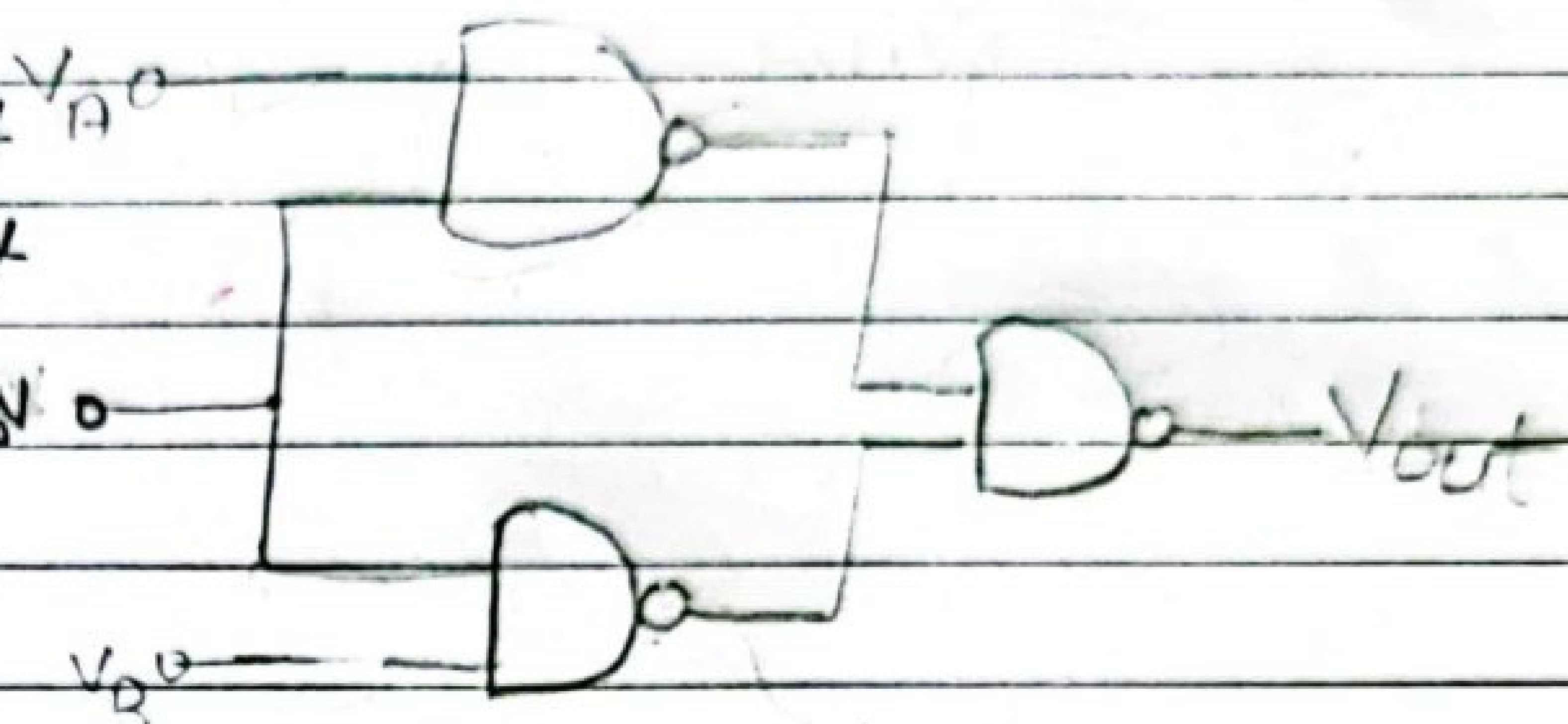
$$\lambda_{diamond} = \frac{hc}{E_{diamond}}$$

$$= \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{6 \times 1.6 \times 10^{-19}}$$

$$= 2066 A^{\circ}$$

Hence, $(\lambda_{diamond} < \lambda_{vissible})$ so all vissible light are transmitted diamond appers transparent.

12. Find the truth table for the circuit shown in the figure. What logic function will be circuit perform if the constant +5V input to the first two gates is changed to ground potential?



Sol: Here,
Truth table for the given circuit of logic function

$$Y = \overline{\overline{(5V \cdot V_A)} \cdot \overline{(V_B \cdot 5V)}}$$ using De-Morgan's theorem

$\overline{A+B} = \bar{A} \cdot \bar{B}$ and $\overline{AB} = \bar{A} + \bar{B}$

$$Y = V_A + V_B$$

Y = OR - operation

Input			Intermediate (V)					Output
V_A	V_B	5V	$5V \cdot V_A$	$5V \cdot V_B$	$\overline{5V \cdot V_A}$	$\overline{5V \cdot V_B}$	$(\overline{5V \cdot V_A}) \cdot (\overline{5V \cdot V_B})$	$\overline{(\overline{5V \cdot V_A})\,(\overline{5V \cdot V_B})}$
0	0	+5	0	0	5	5	5	0
0	5	+5	0	5	5	0	0	5
5	0	+5	5	0	0	5	0	5
5	5	+5	5	5	0	0	0	5

Logic Family, RTL and TTL Gates Q.N;1

In digital designs, a circuit configuration or arrangement of the circuit elements in a special manner will result in a particular logic family. Electrical characteristics of the IC will be indentical. In other words, different parameter like Noise margin, Fan In, Fan out etc. will be identical.

Different IC's belonging to the same logic families will be compatible with each other.

Digital IC gates are classified not only by their logic operation, but also by the specific logic circuit family to which it belongs. Each logic family has its own basic electronic circuit upon which more complex digital circuits and function are developed.

Different Types of Logic Gate Families

RTL : Resistor transistor logic gate family

DCTL : Direct coupled transistor logic gate family

RCTL : Resistor capacitor transistor logic gate family

DTL : Diode transistor logic gate family

TTL : Transistor transistor logic gate family

IIL : Integrated injection gate family

Resistor transistor logic (RTL) gate family is often found in an IC. In which all the logic are implemented using resistor and transistors.

An example of RTL gate is shown in figure, which implements the NOR function.

The circuit consists of two inverters wired in parallel with V_{out} and the collector R_C common to both. V_A and V_B are two inputs and each affects the output of their respective transistor.

Suppose $V_A = 5V$ and $V_B = 0V$, transistor A will conduct, that is, I_{B_1} will be high and therefore I_C will be high. Consequently, the collector of A will be at approximately 0V with respect to ground ($V_{CE} \approx 0V$) and V_{out} will be 0V.

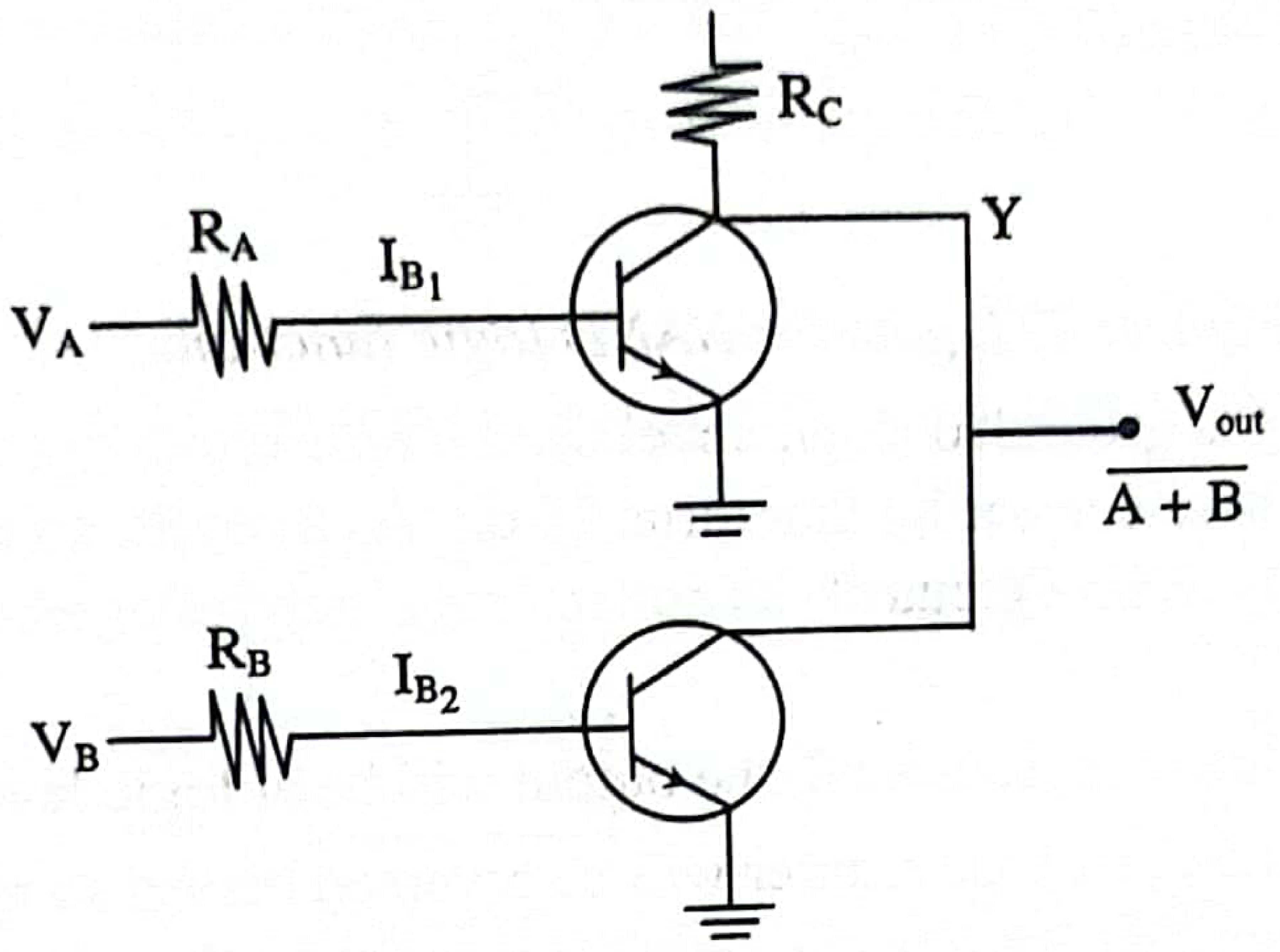


Figure: RTL circuit for NOR logic function.

A similar output will be obtained if $V_A = 0V$ and $V_B = 5V$ or if both $V_A = V_B = 5V$.

Thus, if either or both inputs are logic level 1, the output will be at logic level 0.

If $V_A = V_B = 0V$, then neither of the two transistor will conduct ($I_C = 0$) and both collectors will be at 5V with respect to their emitters, which are grounded; $V_{out} = 5V$.

Thus the circuit implements the NOR logic function.

The primary advantage of RTL technology was that it used a minimum number of transistors. The disadvantage of RTL is its high power dissipation, limited fan in, and has a low noise immunity.

TTL gates have many advantages over RTL and DTL gates with some simple modifications the fan out of the TTL gate can be as great as 15 (For RTL gates it is typically 5 and for DTL gates it is 8). The propagation delay for a TTL gate is about 10 nsec as compared with 25 nsec for the DTL and RTL gates. The noise immunity is also better for the TTL gates.

An example of TTL gate is shown in figure, which implements a NAND function.

The input transistor Q_1 is an npn transistor with several emitters. Transistor with 8 or more input emitters are not unusual nor difficult to manufacture in IC form.

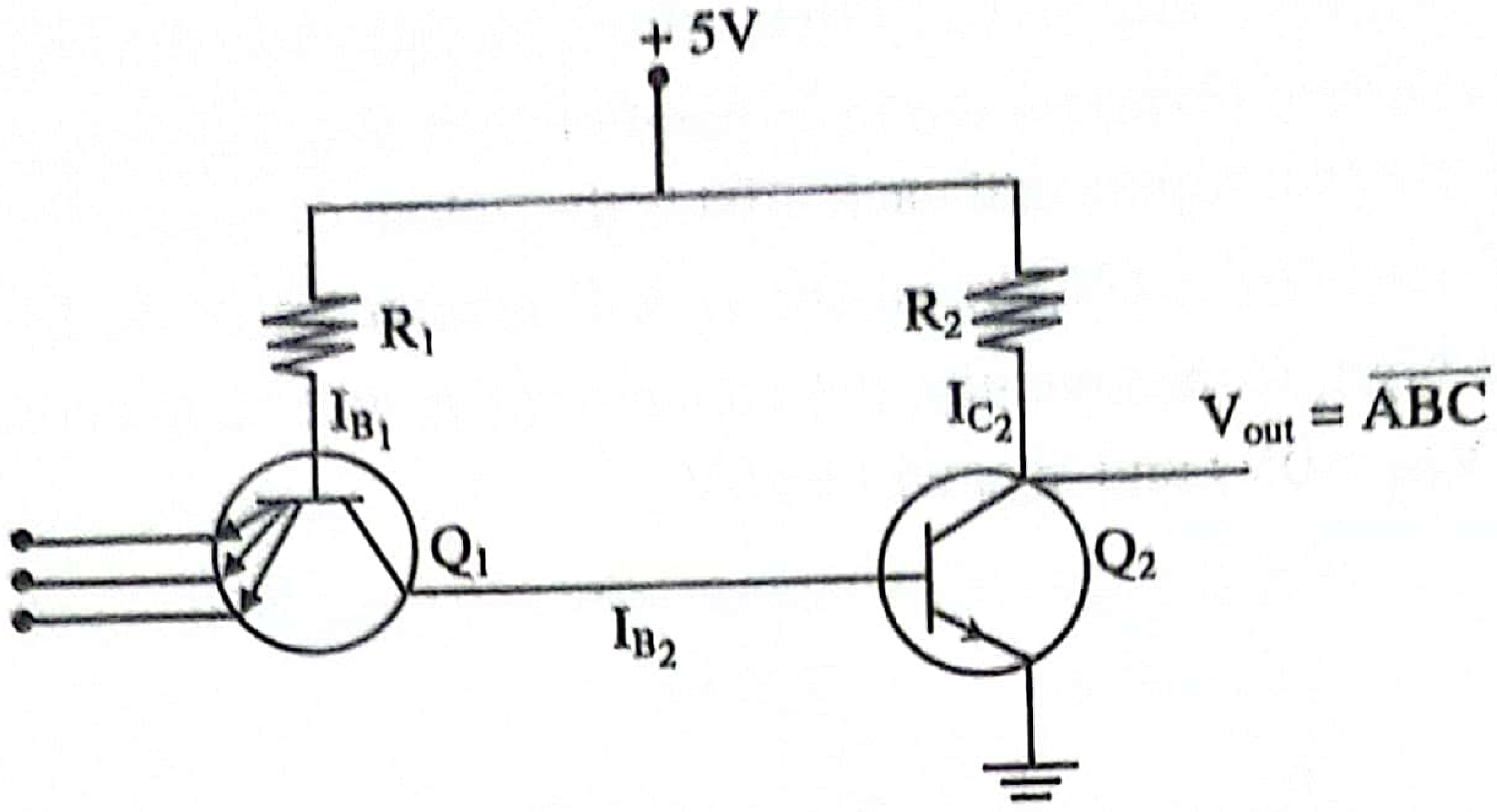


Figure: TTL gate for NAND logic function.

If any one the inputs of Q_1 is grounded (logic level 0), the base emitter junction of Q_1 will be forward based, so a large base current I_{B1} that turns Q_1 on. As a result, no current flows in the emitter base junction of Q_2. With Q_2 cutoff, its collector emitter voltage becomes 5V, that is, $V_{out} = 5V$.

Thus, if any of the inputs are at logic level 0, the output will be at logic level 1.

If all the input of Q_1 are at 5V, its base emitter will be reversed biased so no current can flow from the base of Q_1 to its emitter, current can flow through R and through the forward biased base collector of Q_1. This will turn Q_2 on and make its collector emitter voltage 0V therefore $V_{out} = 0V$.

Thus, when all inputs are at logic level 1, the output will be a logic level 0.

This is logically a NAND gate.

Fanout: It is the maximum number of inputs that can be driven by a logic gate. A fanout 10 means 10 unit loads can be driven by the gate still maintaining the output logic level.

Propagation delay: The time required for the output of a digital circuit to change states after a change at one or more of its inputs.

Noise immunity: It is the ability of a gate to stay in a given logic state in the presence of fluctuations (noise) in the input signal. A large noise immunity means output logic level will not change in the presence of large fluctuations in the input logic level.

Set of Differential equation of the oscillation of horizontal spring by application of Hook's Law and Newton's Law. Write its solution. Also find acceleration, time period and velocity.

⇒

Q.N;2

Fig:- motion of horizontal spring along x-axis

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Let m be the mass of the particle which is attached by horizontal spring. At first it is rest ($a=0$) after application of force it stretched then Force $F = kx$ --- (I)
which is given by Hook's Law, where x is the stretching length. When we apply Force in one direction then there is reaction Force in another direction with the help of Newton's third Law of motion so Force becomes:

$$F = -kx \quad --- (II)$$

where k is Force constant or spring constant

$$F = ma$$

$$F = m\frac{d^2x}{dt^2} \; - (III)$$ (double derivative of velocity)

From eq^n (II) and (III)

$$m\frac{d^2x}{dt^2} = -kx$$

$$\boxed{m\frac{d^2x}{dt^2} + kx = 0} \quad --- (IV)$$

which is the eq^n of horizontal spring. This eq^n is same as the eq^n of S.H.M so, it is oscillatory motion.

Solution of this equation is

$$x = A\sin(\omega t + \phi)$$

wher ϕ is the phase angle, $(\omega t + \phi)$ is phase Factor and A is Amplitude.

using relation,

$$ma = -kx$$

$$a = \frac{-k}{m}x$$

$$\therefore \boxed{\text{acceleration}(a) = \frac{-k}{m} \times x}$$

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Again, From acceleration of oscillatory motion

$$a = -\omega^2 x$$

$$\cancel{-}\frac{K}{m} \times \cancel{x} = \cancel{-}\omega^2 \cancel{x}$$

$$\omega = \sqrt{\frac{K}{m}}$$

$\therefore$ $\boxed{\text{angular velocity } (\omega) = \sqrt{\frac{K}{m}}}$

$\boxed{\text{velocity} = \sqrt{\frac{K}{m}} \times x}$ $(v = \omega r)$

Time period,

$$T = \frac{2\pi}{\omega}$$

The time taken by particle to complete a cycle of oscillation is called time period 'T'.

or, $$T = \frac{2\pi}{\sqrt{\frac{K}{m}}}$$

$\therefore$ $\boxed{T = 2\pi\sqrt{\frac{m}{K}}}$

Frequency,

$$F = \frac{1}{T}$$

The number of complete oscillations made by an ocillating particle in one second is called frequency. It is given by $F = \frac{1}{T}$

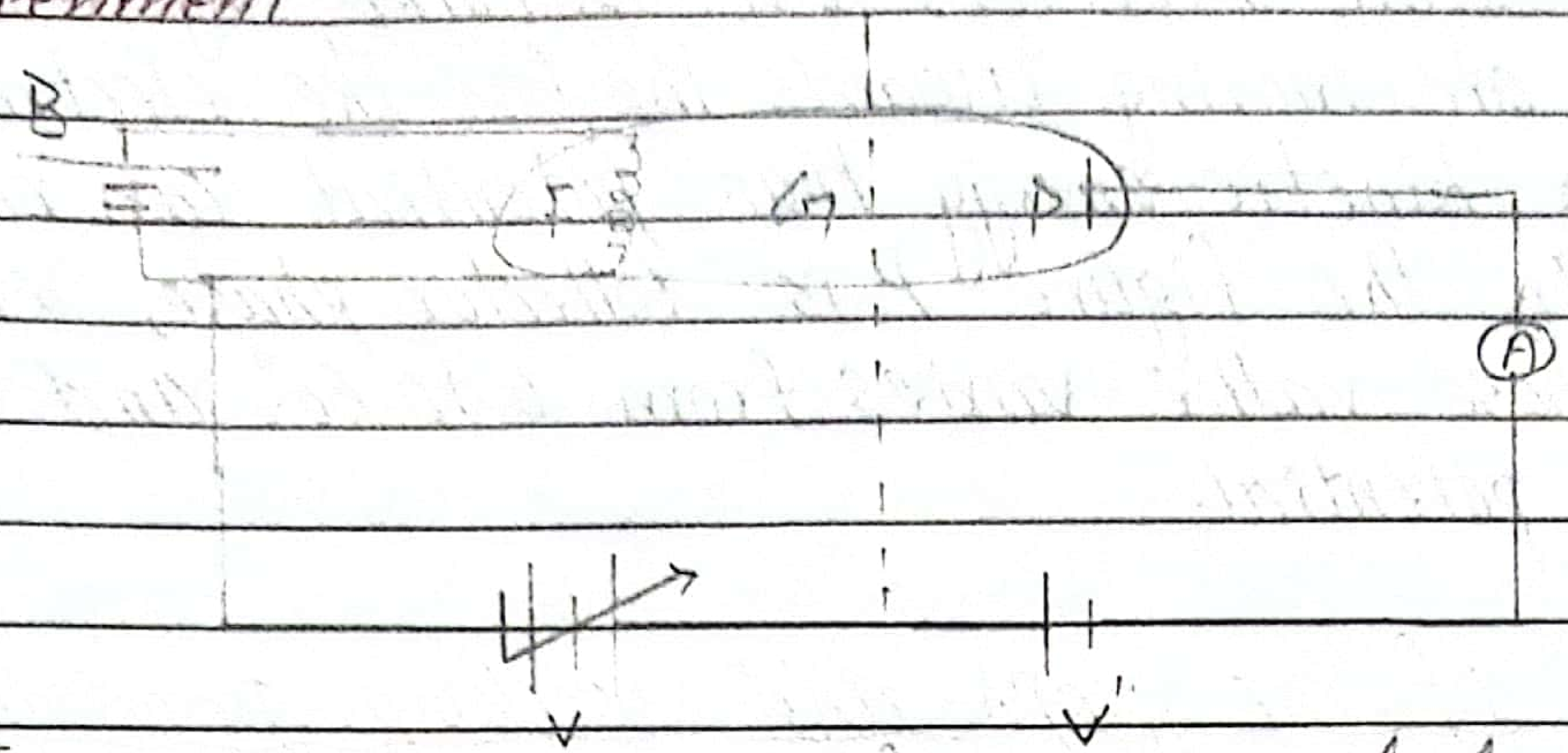
or, $$F = \frac{1}{2\pi\sqrt{\frac{m}{K}}}$$

$\therefore$ $\boxed{F = \frac{1}{2\pi}\sqrt{\frac{K}{m}}}$

Franck-Hertz Experiment Q.N;3

Q.N State Franck-Hertz Experiment and Explain his experiment.

=>



Fig(I):- Experimental arrangement of franck-Hertz experim...

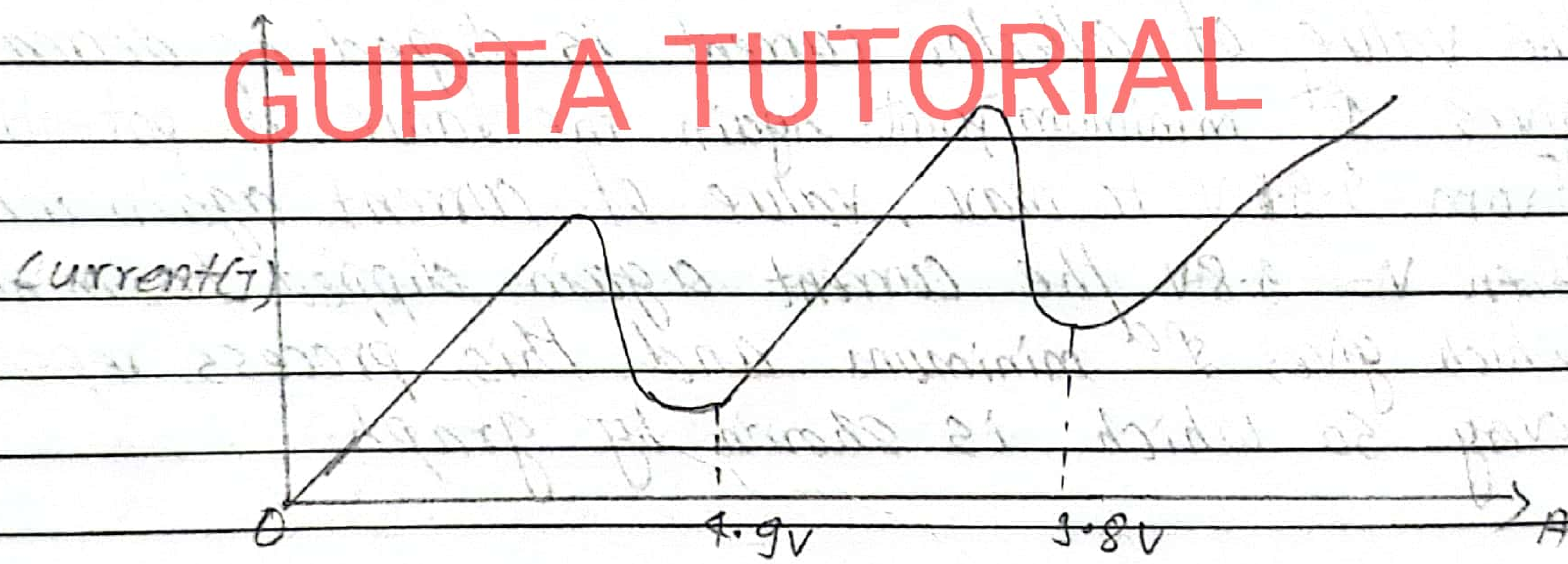


fig:(II) Accelerating potential V

GUPTA TUTORIAL

Statement:-

He proved that the existence of discrete energy state is as atom and studied the Ionization and excitation of mercury, Helium and Neon atom. He found that the discrete energy states of atoms are quantised in nature

Explaination

The experiment arrangement of franck-Hertz Experiment is as shown in above figure①. Gas is filled in the mercury Table. Electrons are produced by a filament F which are moving towards the G_1. The electrons which have greater kinetic energy than potential can reach from G_1 to P. In the figure P is collector phase, V is variable potential whose value varies from 0 to 60° and V' is the fixed potential.

Explaination of the graph and working principle.

When the value of potential increases from 0 to other value, ~~the~~ value of current also increase. At V = 4.9V the value of collector current is dipped or decreases. It gives 1st minimum point. Again the value of potential increase from 4.9 V to max, value of current again increases. When V = 9.8V the current again dipped to minimum which gives 2nd minimum and this process repeated every so which is shown by graph.

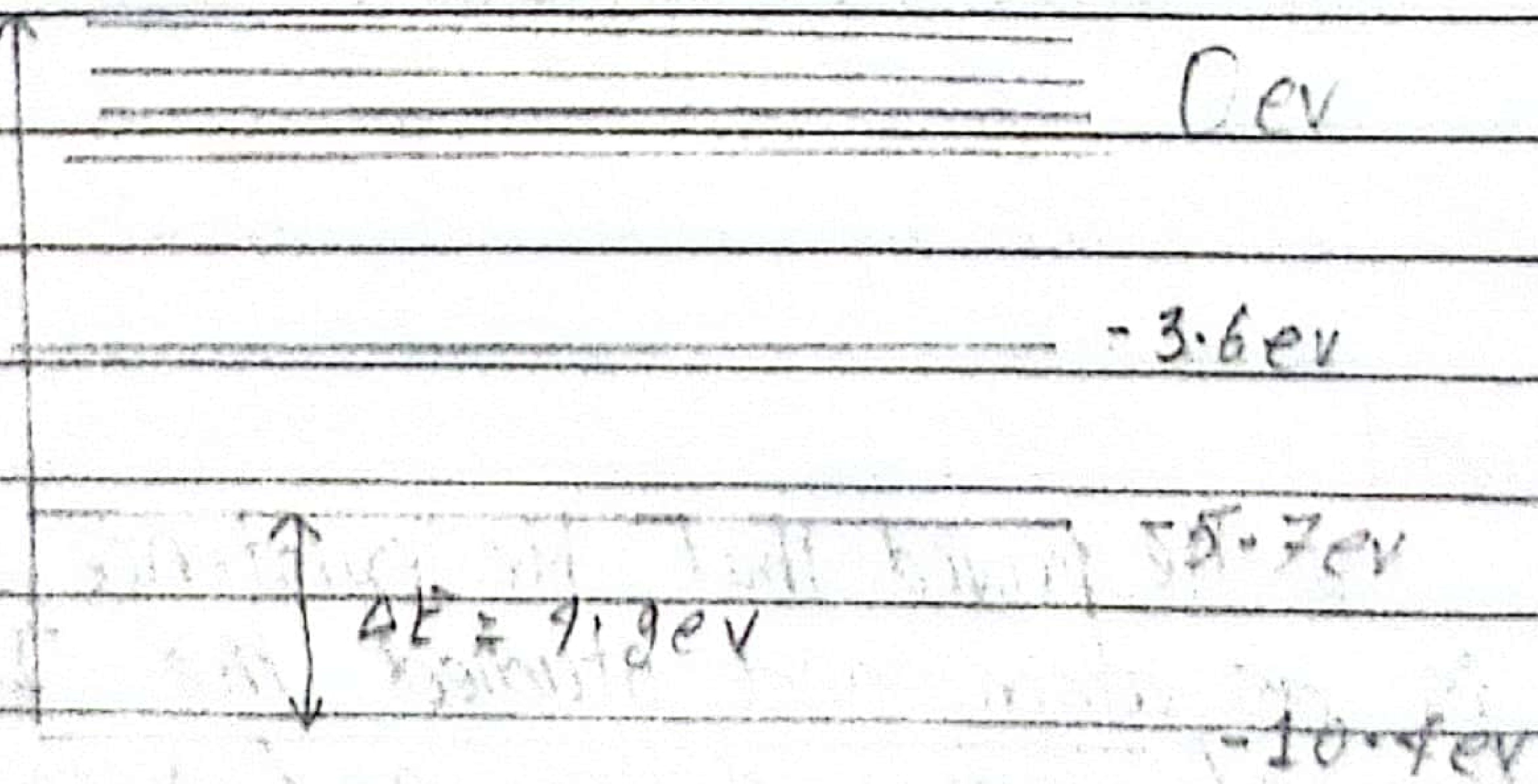


Fig. ③ Atomic energy levels of mercury atom

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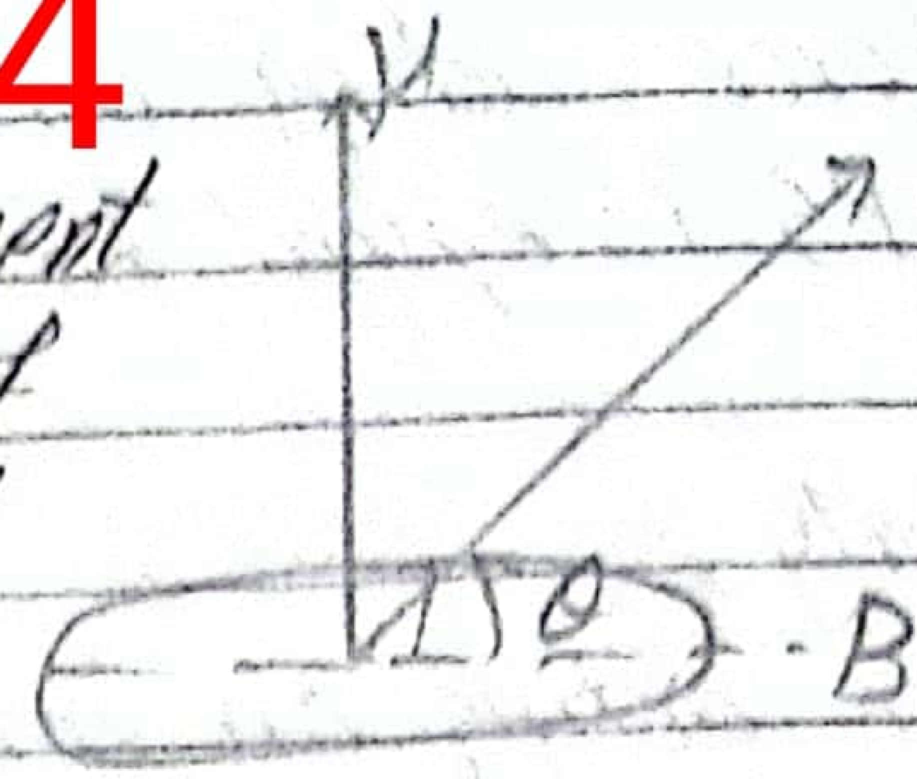
Let electrons are going from G to P. At that time electrons gets energy. At V=4.9V, the electrons acquires 4.9ev energy. It looses this energy when strike with mercury atom with inelastic collision. At that the current decreases and give minimum value. This suggest that the current is not becomes 0 which means some electrons can reache the plate P without loss of energy. After this minimum point the electron again moves and starts to reach to the plate. The value of potential increases and value of current also increase. The value of potential V=9.8V the current dipped and gives 2nd minimum point the electron again strike with the mercury atom of Inelastic collision. At that situation, the atom gets energy 4.9ev and emit photon in energy collision. The wavelength of the photon coming from the tube is 2536 A° which is found by Franck Hertz on his experiment. Hence we can find the energy of Photon.

$$E = \frac{hc}{\lambda} = \frac{(6.67 \times 10^{-34} \times 3 \times 10^{8})}{(2536 \times 10^{-10})} = 4.9ev$$

The leaving energy of electron when strike with mercury atom is same as the energy of photon found by the experiment. This shows that the existance of discrete energy states is as atom is proved.

Magnetic dipole moment Q.N;4



The magnetic dipole moment (μ) is defined as the product of the current through the loop and area of the loop which is given by

$$\mu = IA$$

The torque acting on the loop due to magnetic field intensity (B) is

$$\tau = BIA\sin\theta$$

$$\tau = \mu B\sin\theta \quad (\mu = IA)$$

The energy of the dipole is defined as the work done in changing its orientation from $90°$ to $\theta°$ is

$$E = \int_{90}^{\theta} \tau\, d\theta$$

$$E = \int_{90}^{\theta} \mu B\sin\theta\, d\theta$$

$$E = -\mu B\,[\cos\theta]_{90°}^{\theta}$$

$$\boxed{E = -\mu B\cos\theta}$$

$$\boxed{E = -\vec{\mu}\cdot\vec{B}}$$ in vector form

... pass through it.)

2. Doping

An integrated circuit has informal name chip. The formation of circuit components in a chip is achieved by the selective introduction of donor and acceptor impurities into the Si wafer to create localized n-type and p-type regions. The two most commonly used techniques for doping are diffusion and ion implantation.

Q.N;5

a. Diffusion

When Si is heated to temperatures in the range of 1000°C, some of the semiconductor atoms move out of their lattice sites, leaving behind empty lattice sites that can migrate through the sample. If the heating is done in an atmosphere of either acceptors or donors, these impurity atoms move into the vacant lattice sites formed at high temperature. The diffusion of the dopant impurities can be stopped by cooling down the wafer. Because the diffusion of impurities is time and temperature dependent, the depth of the diffusion layer can be controlled by varying these two parameters. The SiO_2 pattern, formed by photolithography acts as a mask that permits the diffusion of the impurities only in specific regions of the wafer.

The open furnace tube system using solid, liquid and gaseous dopant sources is the most common diffusion technology used in IC fabrication. The wafers are loaded vertically into a quartz boat and put into the furnace where the wafers are heated to high temperature. In general, diffusion systems are similar to oxidation furnace.

(i) **Solid Source:** In this system, the dopant source is in solid form as shown in figure (1). The carrier gases N_2 or O_2 picks up the vapour from the dopant source and transport it to the furnace tube, where the dopant atoms are deposited on the surface of wafer.

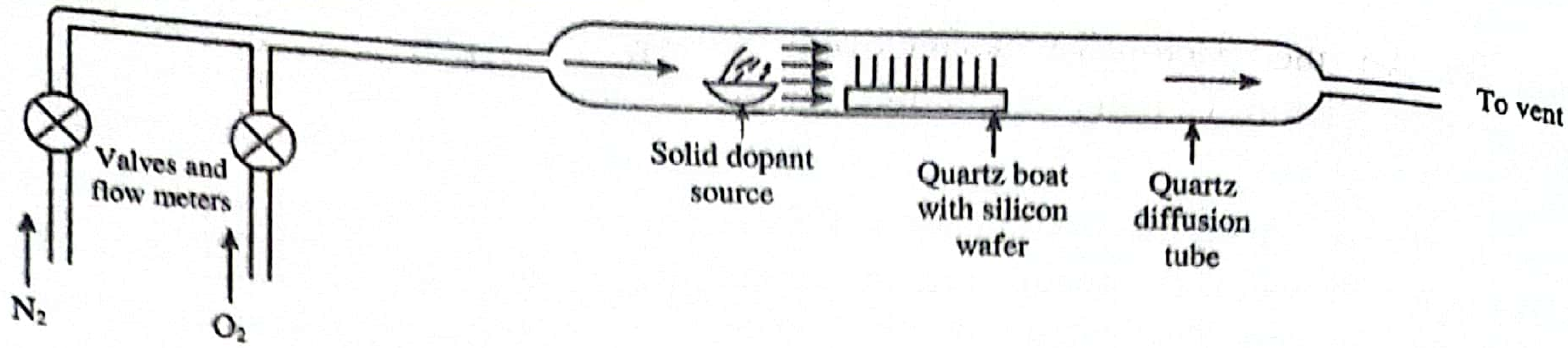


Figure (1): Open furnace tube diffusion system: Solid impurity source

The common solid source of Boron is Trimethyl Borate (TMB)

$$2\,(CH_3O)_3\,B + 9O_2 \xrightarrow{900^0 C} B_2O_3 + 6CO_2 + 9\,(H_2O)$$

$$2\,B_2O_3 + 3Si \leftrightarrow 4B + 3\,SiO_2$$

The common solid source of Phosphorous is Phosphorous Pentaoxide.

$$2P_2O_5 + 5\,Si \leftrightarrow 4P + 5\,Si\,O_2$$

(ii) Liquid Source

In this system the dopant source is in liquid form as shown in figure (2). The carrier gas passes through a bubbler where it picks up the vapour of the liquid source. The carrier gas carries the vapour into the furnace tube where it reacts with the surface of the silicon wafer.

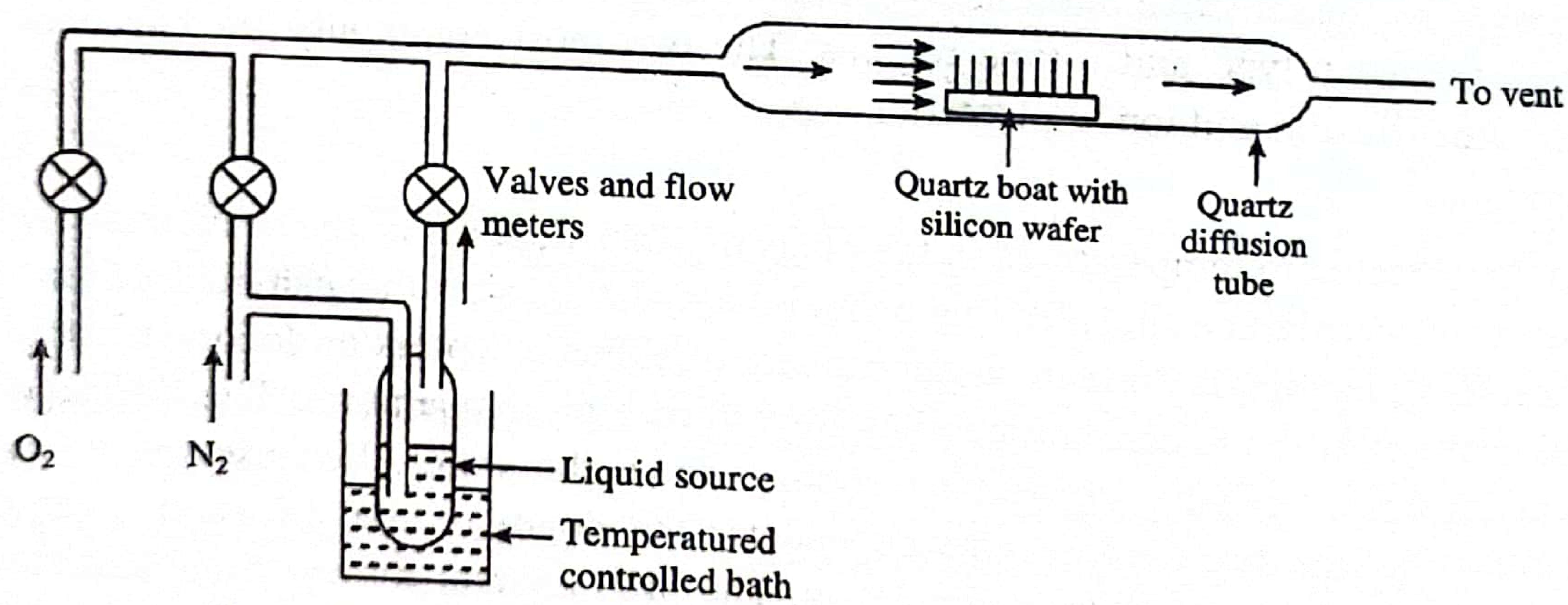


Figure (2): Open furnace tube diffusion system: Liquid impurity source

The most common liquid source of Boron is Boron Tribromide.

The reaction is

$$4\,BBr_3 + 3O_2 \rightarrow 2B_2\,O_3 + 6\,Br_2$$

$$2\,B_2O_3 + 3Si \leftrightarrow 4B + 3\,SiO_2$$

The common liquid source of 'P' is Phosphorous Oxychloride.

$$4\,P\,O\,Cl_3 + 3\,O_2 \rightarrow 2P_2O_5 + 6Cl_2$$

$$2\,P_2O_5 + 5Si \leftrightarrow 4P + 5SiO_2$$

Bipolar Junction Transistor "BJT" Q.N;6

⇒ A P-N junction ~~affects~~ offers a low resistance under Forward bias and high resistance offered under reverse bias. A single crystal having two close P-N Junction may be prepared one Junction being Forward bias and other Junction being reversed bias. Then one Junction will offer Low resistance and other will offer high resistance. A small ~~sing~~ signal is applied across forward bias, it ~~is~~ will apper high resistance Junction in reversed bias with high power gain. Such a device is called transistor. The point transistor have number of Limitations to solve these difficulties Junction transistor is inverted. The transistor is a electronic device formed by the combination of two P-N Junction in a specific manner

There are two types of transistor
(1) P-N-P (2) N-P-N

(i) P-N-P Transistor (ii) N-P-N Transistor

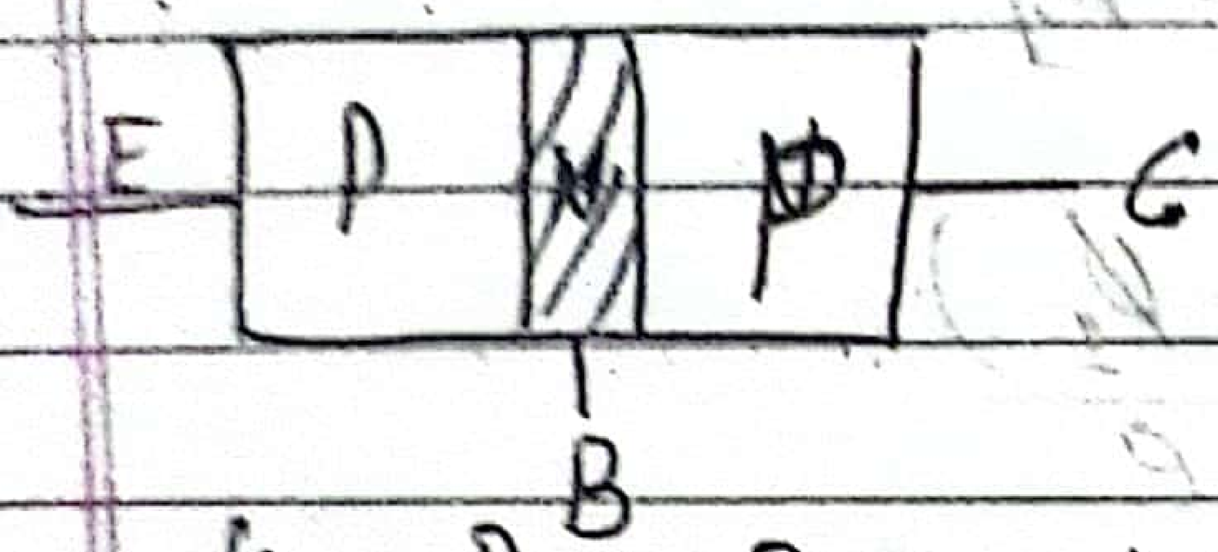


fig:- P-N-P Transistor

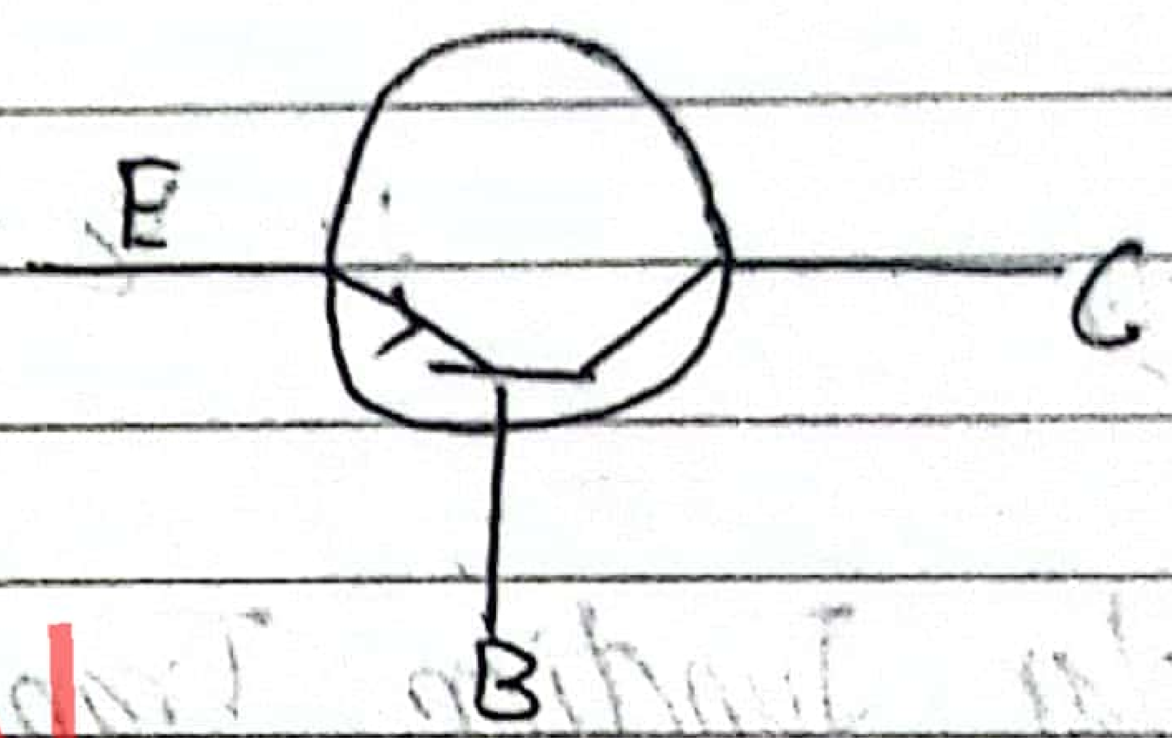
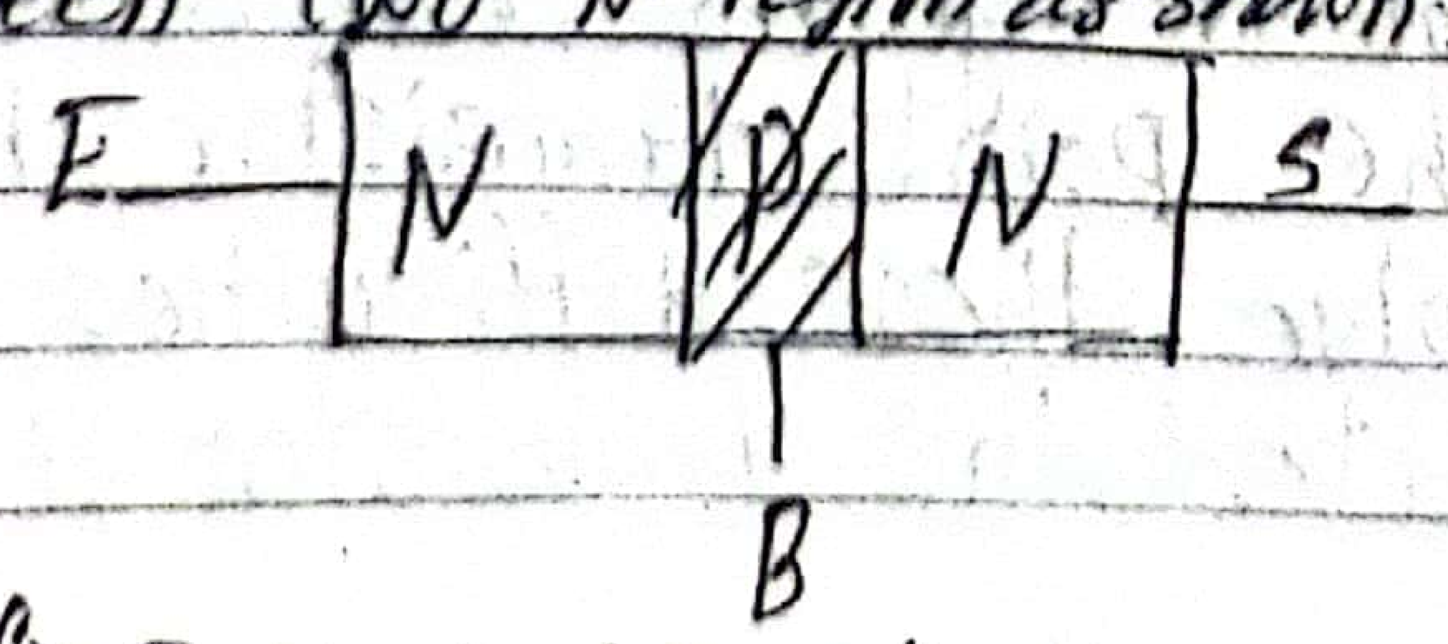


fig:- symbol of N-P-N Transistor

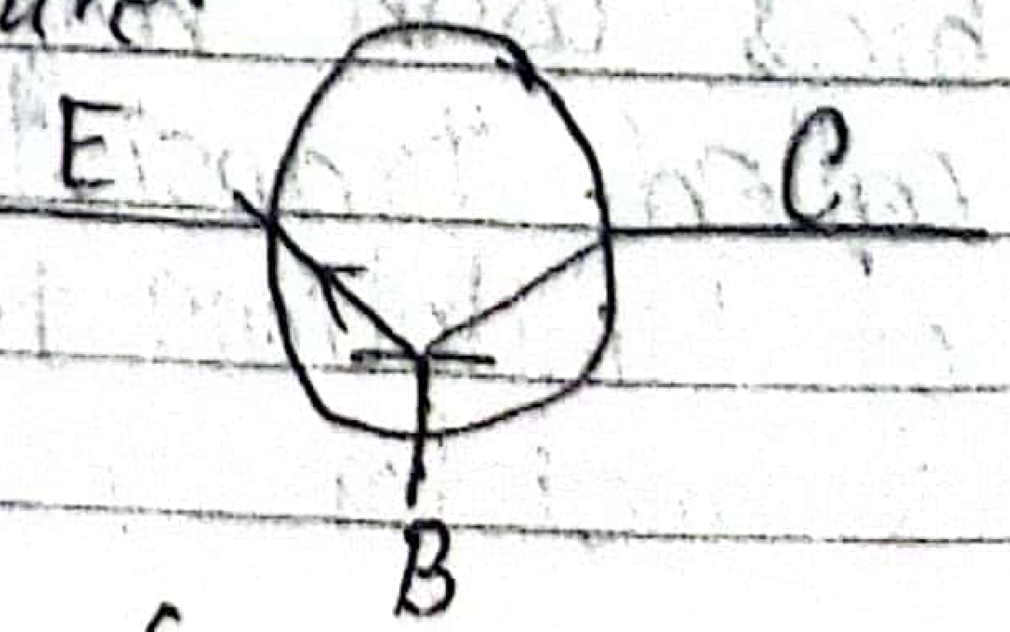
It consists of silicon or Germanium crystal in which thin Layer of N region is in between two P-region. Arrow is symbol of P-N-P transistor from emitter to base

(2) N-P-N Transistor

It consists of silicon or Germanium crystal inwhich a thin layer of P-region is in between two N-region as shown in figure.



fig(a) N-P-N Junction



fig(b) N-P-N Transistor