Physics

Time: 3hours **Max.Marks:70**

General Instructions

1. Candidates are allowed additional 15 minutes for only reading the paper. They must not start writing during this time.
2. All questions are compulsory. This question paper is divided into A, B, C, and D as follows.
   Section A Question number 1 is of twelve marks. All parts of this question are compulsory.
   Section B Question numbers 2 to 12 carry 2 marks each with two question having internal choice.
   Section C Question numbers 13 to 19 carry 3 marks each with two question having internal choice.
   Section D Question numbers 20 to 22 are long answer type question and carry 5 marks each.
3. All working including rough work should be done on the same sheet and adjacent to the right of the answer.
4. The intended marks for questions or parts of question are given in brackets [ ]
5. A list of useful physical constants is given at the end of this paper

SECTION A

1. **A. Choose the correct alternative (a), (b), (c) and (d) for each of the question given below: [5x1].**

   (i) A closed surface in vacuum enclose charges –q and +3q. The total electric flux emerging out of the surface is

   (a) Zero

   (b) $\frac{2q}{\varepsilon_0}$

   (c) $\frac{3q}{\varepsilon_0}$

   (d) $\frac{4q}{\varepsilon_0}$

   Sol: b

   We know that the total electric flux through the closed surface,

$$\phi = \frac{1}{\varepsilon_0}\left[-q+3q\right]$$

$$\Rightarrow \phi = \frac{2q}{\varepsilon_0}$$

(ii) **What is the angle of dip at a place where the horizontal component B_H and the vertical component B_V of the earth's magnetic field are equal to**

(a) 130^0

(b) 60^0

(c) 45^0

(d) 90^0

Sol: c

Since, the angle of dip is

$$\tan\theta = \frac{B_Y}{B_H}$$

$$\Rightarrow \tan\theta = 1$$

$$\Rightarrow \tan\theta = \tan 45^0$$

$$\Rightarrow \theta = 45^0$$

(iii) **A beam of light is incident at the polarizing angle of** 35^0 **on a certain glass plate. The refractive index of the glass plate is**

(a) $\sin 35^0$

(b) $\tan 35^0$

(c) $\sin 55^0$

(d) $\tan 55^0$

Sol: b

We know that the refractive index of glass plate is $n = \tan i$

$n = \tan 35^0$

(iv) **In a gamma ray emission from nucleus**

(a) Only the number of proton change

(b) The number of proton and neutron both changes

(c) There is no change in the number of protons and the number of neutrons

(d) Only the number of neutrons changes

Sol: c

There is no change in the number of protons and the number of neutrons

(v) **The energy associated with light of which of the following colors in minimum?**

(a) Violet
(b) Red
(c) Green
(d) Yellow

Sol: b

We know that the wavelength of the red light is maximum. Therefore, the energy of light for red color will be minimum

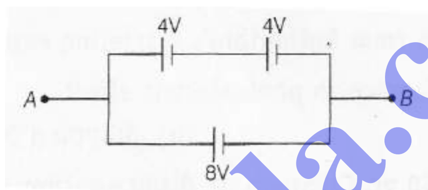
B. Answer the following questions briefly and to the point.

(i) Define equipotential surface

Sol:

Equipotential surface is defined as any surfaces which has same electrostatic potential at every pint on it

(ii) Calculate the net emf across A and B shown in the figure below



Sol:

Here, we saw that

4V and 4V cells are connected in series so their combined emf,

$E = 4 + 4 = 8V$. Now, E_1 and 8V cells are in parallel so the combined emf of the battery is 8V.

(iii) Why are the pole pieces of a horseshoe magnet in moving coil galvanometer made cylindrical in shape?

Sol:

The pole pieces of a horseshoe magnet in moving coil galvanometer made cylindrical in shape to increase the strength of the magnetic field.

(iv) What is the value of power factor for pure resistor connected to an alternating current sources?

Sol:

We know that the phase difference between alternating current and alternating voltage is $\phi = \theta$ for pure resistor.

Therefore, power factor $= \cos\phi = \cos 0^0 = 1$.

(v) What should be the path difference between two waves reaching a point for obtaining constructive interference in Young's double slit experiment?

Sol:

Let x be the path difference between the interfering waves,

So,

$$x = \frac{\lambda}{2\pi}\phi$$

Therefore, for the maximum intensity $\phi = 2m\pi$

$$x = \frac{\lambda}{2\pi}(2m\pi)$$
$$\Rightarrow x = m\lambda$$

(vi) Define the critical angle for the given medium.

Sol:

Critical angle is defined for two media is the angle of incidence in the denser medium for which the angle of refraction in the rarer medium is 90^0.

(vii) Name the series in the atomic spectra of the hydrogen atom that falls in the ultraviolet region.

Sol:

Lyman series.

SECTION B

2. In a potentiometer experiment, the balancing length with a resistance of 2Ω is found to be 100cm, while that of unknown resistance is 500cm. calculate the value of the unknown resistance.

Sol:

Let l_1 and l_2 are the balancing length corresponding to resistance R and X respectively.

$$\frac{X}{R} = \frac{l_2}{l_1}$$

And the unknown resistance,

$X = \frac{l_2}{l_1} R$

$= \frac{500}{100} \times 2$

$= 10\Omega$

Hence, the value of the unknown resistance is 10Ω.

3. A rectangular loop of area $5m^2$, has 50 turns and carries a current of 1A. It is held in a uniform magnetic field of 0.1T, at an angle of 30^0. Calculate the torque experienced by the coil.

Sol:

We have area of rectangular loop, $A = 5m^2$

Number of turns, $B = 50$,

Current $I = 1A$

Magnetic Field, $B = 0.1T$

Angle, $\theta = 30^0$

Therefore, the torque experienced by the coil is

$\tau = NIAB\sin(90 - \theta)$

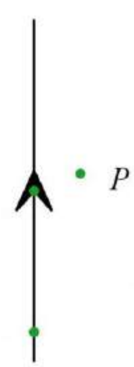
$= 50 \times 1 \times 5 \times 0.1 \times \sin(90^0 - 30^0)$

$= 50 \times 1 \times 5 \times 0.1 \times \sin 60^0$

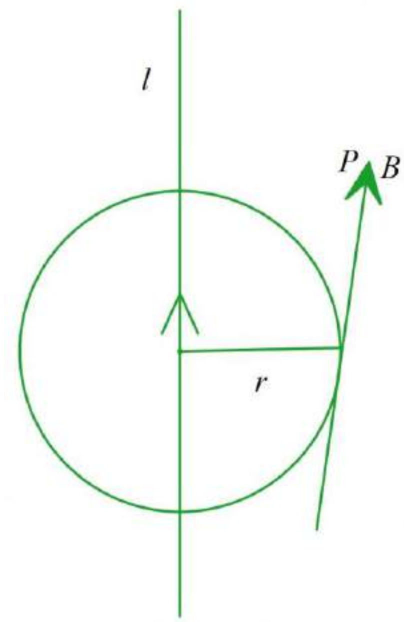
$= \frac{25\sqrt{3}}{2}$

$= 12.5\sqrt{3} N - m$

4. An electric current I flows through an infinitely long conductor as shown in the figure given below. Write an expression and direction for the magnetic field at point P.



Sol:



So, the magnitude of magnetic field at a point P is

$$B = \frac{\mu_0 l}{2\pi r}$$

Since, its direction at P along the tangent to a circle of radius r centered on the conductor.

5. A transformer is used to step up an alternating emf of $200V$ *to* $440V$. **if the primary coil has 1000turns, calculate the number of turns in secondary coil.**

Sol:

We have

$N_P = 1000, V_P = 200, V_S = 440V$

$$N_P = 1000, V_P = 200, V_S = 440V$$

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

Therefore, $\Rightarrow \frac{440}{200} = \frac{N_S}{1000}$

$$\Rightarrow N_S = \frac{440 \times 1000}{200}$$

$$= 2200$$

Hence, the number of turns in secondary coil is 2200.

6. State any two properties of microwaves.

Sol:

The two properties of microwaves are as follows:

(i) Reflection
(ii) Polarization

7. Write any one use for each of the following mirrors.

(i) Convex
(ii) Concave

Sol:

(i) Convex- It is used in sunglasses.
(ii) Concave- It is used in Ophthalmoscope.

(i)

8. The deviation produced for violet, yellow and lights for crown glass are $3.75^0, 3.25^0$ **and** 2.86^0 **respectively. Calculate the dispersive power of the crown glass.**

Sol:

We know that the dispersive power of the prism material is

$$\omega = \frac{\delta_v - \delta_R}{\delta_Y}$$
$$= \frac{3.75^0 - 2.86^0}{3.25^0}$$
$$= \frac{0.89^0}{3.25^0}$$
$$= 0.274^0$$

Hence, the dispersive power of the crown glass is 0.274^0.

9. (i) What is the meant by the mass defect?

(ii) What conclusion is drawn from Rutherford's scattering experiment of $\alpha - particles$?

Sol:

(i) The difference between the actual mass and the sum of masses of protons and neutrons forming a nucleus.

(ii) Rutherford got that the nucleus was positively charged because the alpha particles was positively charged so the like charges repel. And he found that the atom has lot of empty space and practically the entire mass of the atom was confined to an extremely small central core from 10^{-15} m. And the distance of electron from nucleus is $10^4 to 10^5$ times the size of nucleus itself. If the velocity vector of the particle was far away from the central line of the nucleus then it makes the lesser angle of scattering.

10. Define the following with reference to photoelectric effect.

(i) Threshold frequency f_0

(ii) Stopping potential V_s

Sol:

(i) It is the lowest frequency of light which can emit photoelectrons from the material.

(ii) It is the negative potential where the photoelectric current becomes zero.

11. The half-life of radium is 1550yr. calculate its disintegration constant λ .

Sol:

We know that the Disintegration constant,

$$\lambda = \frac{0.6931}{T}$$
$$= \frac{0.6931}{1550}$$
$$= \frac{0.6931}{1550 \times 3.15 \times 10^{7}} s^{-1}$$
$$= 1.42 \times 10^{-11} s^{-1}$$

12. Define frequency modulation and state any one advantage of frequency modulation (FM) over amplitude modulation (AM).

Sol:

Frequency modulation defined as when the frequency of the carrier wave is changed in accordance with the amplitude of the modulating wave (signal), it is called frequency.

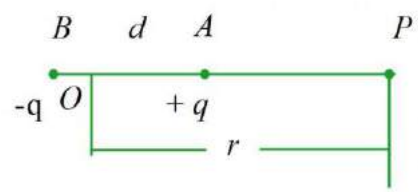
Since the amplitude of FM wave is constant. Whatever be the modulation index.

SECTION C

13. Obtain an expression for electric potential V at the point in an end-on position, axial position of an electric dipole.

Sol:

Let us suppose that the electric dipole AB is placed in a medium of K dielectric constant. The electric dipole has +q and –q charges separated by the distance d



Now, the electric potential at point p situated at distance r from the center of the electric dipole.

The distance from +q is $\left(r-\frac{d}{2}\right)$ and from –q is $\left(r+\frac{d}{2}\right)$

Therefore, the potential due to +q charge at point P is

$$V_1=\frac{1}{4\pi\varepsilon_0 k}\left[\frac{q}{r-\frac{d}{2}}\right]..............(i)$$

And the potential due to –q

$$V_2=\frac{1}{4\pi\varepsilon_0 k}\left[\frac{-q}{r+\frac{d}{2}}\right]..............(ii)$$

Since, the resultant potential at point P, V_1+V_2

$$=\frac{1}{4\pi\varepsilon_0 k}\left[\frac{q}{r-\frac{d}{2}}\right]+\frac{1}{4\pi\varepsilon_0 k}\left[\frac{-q}{r+\frac{d}{2}}\right]$$

$$=\frac{1}{4\pi\varepsilon_0 k}\left[\frac{q\times d}{r^2-\left(\frac{d}{2}\right)^2}\right]$$

If the dipole moment is P then $q\times d$

$$V=\frac{1}{4\pi\varepsilon_0 k}\left[\frac{q\times d}{r^2-\left(\frac{d}{2}\right)^2}\right]$$

If $\frac{d}{2} << r$, then neglecting $\left(\frac{d}{2}\right)^2$ in comparison to r^2

$$V = \frac{1}{4\pi\varepsilon_0 k}\left(\frac{p}{r^2}\right)$$

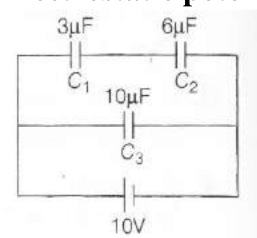
If the electric dipole is situated in air then.

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{p}{r^2}\right)$$

14. Three capacitors o capacitance $C_1 = 3\mu F, C_2 = 6\mu F$ and $C_3 = 10\mu F$ are connected to a 10v battery as shown in the figure given below.

(i) Equivalent

(ii) Electrostatic potential energy stored in the system.



Sol:

(i) Here, we get that $C_1 and\ C_2$ are in series combination, Then equivalent capacitance

$$C' = \frac{3\times 6}{3+6}$$
$$= 2\mu F$$

Now, $C' and\ C_3$ are in parallel combination.

Then equivalent capacitance is

$$C = C' + C_3$$
$$= 2 + 10 = 12\mu F$$

(ii) Total charge ,

$$Q = CV = 12\times 10$$
$$= 120\mu C$$

Therefore, the potential energy stored in the system is:

$$U = \frac{1}{2}QV$$

$$= \frac{1}{2}120 \times 10^{-6} \times 10$$

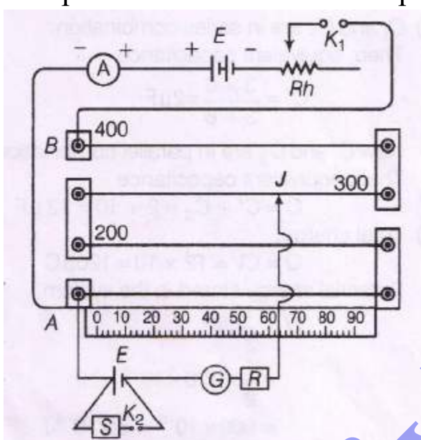
$$= 600 \times 10^{-6}$$

$$= 6 \times 10^{-4} J$$

15. Draw a labelled circuit diagram of a potentiometer to measure the internal resistance r of a cell. Write the working formula (deviation is not required).

Sol:

Let us consider E’ be the emf of the battery, and a constant current *I* is maintained through the potentiometer with the help of rheostat



For the determining the resistance of cell in which the plug K_2 is kept out and the jockey J is moved on the potentiometer

Let us suppose l_1 be the balancing length of the potentiometer wire between point A and jockey J. And x be the resistance of the wire

$$E = xl_1 i......(i)$$

Let us introduce some resistance S from the resistance box and then put in the plug K_2. So the potential difference is

$$V = xl_2 i......(ii)$$

By dividing the eq (i) from eq (ii) then, we get

$$\frac{E}{V} = \frac{xl_1 i}{xl_2 i}$$

$$= \frac{l_1}{l_2}$$

Now, thee internal resistance of the cell is given by

$$r = \left(\frac{E}{V} - 1\right)S$$

$$= \left(\frac{l_1}{l_2} - 1\right)S$$

16. A ray of light is incident on a prism whose refraction index is 1.52 at an angle of 40^0 **. If the angle of emergence is** 60^0**, calculation the angle of the prism.**

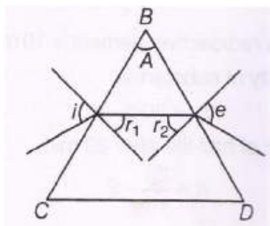
Sol:

We have,

$n = 1.52,$

$i = 40^0$

$e = 60^0$



Where, n is the refractive index, i and e angle of incidence and emergence,

So,

For face BC,

$$n = \frac{\sin i}{\sin r_1}$$

$$\Rightarrow 1.52 = \frac{\sin 40^0}{\sin r_1}$$

$$\Rightarrow \sin r_1 = \frac{0.642}{1.52}$$

$$= 0.4223$$

$$\Rightarrow r_1 = \sin^{-1}(0.4223) = 24.98^0$$

And, for face BD

$$\frac{\sin r_2}{\text{sine}} = \frac{1}{n}$$

$$\Rightarrow \frac{\sin r_2}{\sin 60^0} = \frac{1}{1.52}$$

$$\Rightarrow \sin r_2 = \frac{\frac{\sqrt{3}}{2}}{1.52}$$

$$= \frac{0.8660}{1.52}$$

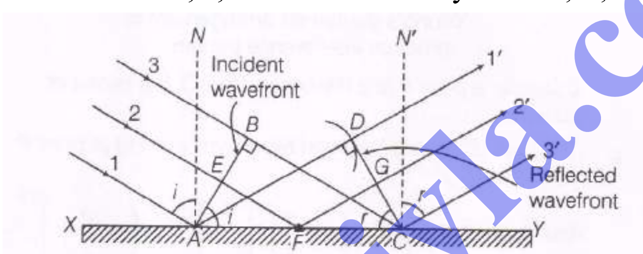
$$= 0.569$$

$$\Rightarrow r_2 = \sin^{-1}(0.569) = 34.68^0$$

Therefore, the angle of prism is, $A = r_1 + r_2 = 24.98^0 + 34.68^0 \approx 60^0$

17. Derive the law of reflection using Huygens's wave theory.

Sol: Let us consider $1, 2, 3$ is he incident rays and $1', 2', 3'$ is the reflected rays.



Laws of reflection by Huygens' principle

Let us suppose c is the speed of light, t is the time taken by the light to go from B to C or A to D or E to Go through F, then

$$t = \frac{EF}{c} + \frac{FG}{c}$$

$$In\ \Delta AEF, \sin i = \frac{EF}{AF}$$

$$In\ \Delta FGC, \sin r = \frac{FG}{FC}$$

In

$$\Rightarrow t = \frac{AF \sin i}{c} + \frac{FC \sin r}{c}$$

$$\Rightarrow t = \frac{AC \sin r + AF(\sin i - \sin r)}{c}$$

And for the rays of light for the different parts on the incident wave front, the values of AF are different.

Therefore, t should not depend upon AF

$\sin i - \sin r = 0$

$\sin i = \sin r$

$\angle i = \angle r$

Which is the first law of reflection

18. State any two Bohr's postulates and write the energy value of the ground state of the hydrogen atom.

Sol:

1. Electrons can revolve only in those orbits in which angular momentum of electron is integral multiple of $\frac{h}{2\pi}$ i.e. $\text{mvr} = \frac{\text{nh}}{2\pi}$ $n = +ve$ n integral no. , h is the Planck's $= 6.63\times10^{-34}\,Js$ constant.

Thus, the angular momentum (L) of the orbiting electron is quantized,

$$L = \frac{nh}{2\pi}$$

So, for any permitted orbit

$$mvr = \frac{nh}{2\pi}$$

Where, n is the positive number 1, 2, 3.

2. He also state that in an atom could revolve in certain stable orbits without the emission of radiant energy.

The ground value of the ground state of the hydrogen atom, $E = -13.6eV$

19. With reference to semiconductor answer the following.

(i) What is the change in the resistance of the semiconductor with increase in temperature?

(ii) Name the majority charge carries in n-type semiconductor.

(iii) What is meant by doping?

Sol:

(i) The resistance of semiconductor decreases with rise in temperature.

(ii) Electrons are the majority carriers and holes are the minority carriers in n-type. Semiconductor.

(iii) The process of adding impurities to the pure form of semiconductor.

SECTION D

20. (i) An alternating emf of 200V, 50Hz is applied to an L-R circuit, having a resistance R of 10Ω and an inductance L of 0.o5H connected in series. Calculate.

(a) Impedance

(b) Current flowing in the circuit.

Sol:

We have

$V_{rms} = 200, L = 0.05H, R = 10\Omega, f = 50Hz$

Angular frequency

$$\omega = 2\pi l$$
$$= 2\pi \times 50$$
$$= 100\pi rad / s$$

Inductive resistance,

$$X_L = \omega KL$$
$$= 100\pi \times 0.05$$
$$= 5\pi\Omega$$

$$Z = \sqrt{R^2 \times X_L^2}$$

(a) Impedance, $= \sqrt{(10)^2 + (5\pi)^2}$

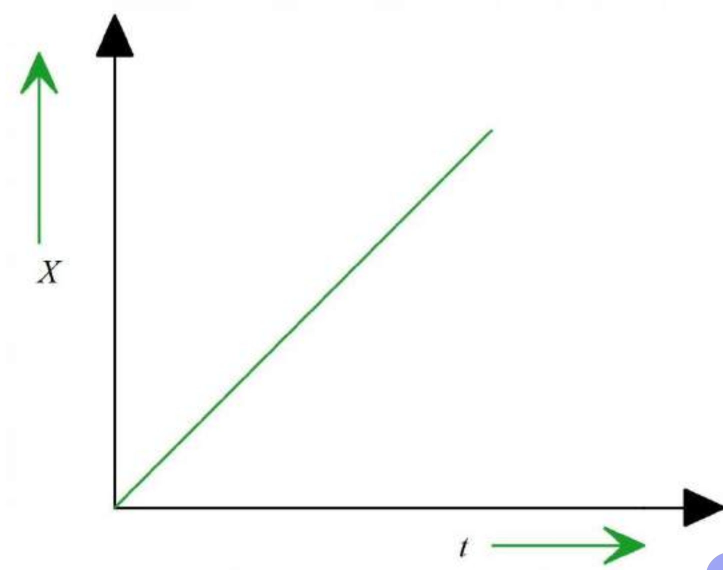
$$= \sqrt{346.74}$$
$$= 18.614\Omega$$

(b) Current flowing in the circuit,

$$I = \frac{V_{rms}}{Z}$$
$$= \frac{200}{18.614}$$
$$= 10.744A$$

(ii)Draw a labelled graph showing the variation of inductive reactance X_L versus **frequency f.**

Sol: Graph showing the radiation of inductive reactance X_L versus frequency.

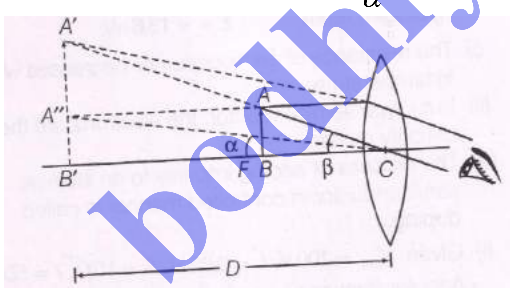


21. Draw a neat labelled ray diagram showing the formation of an image at the least distance of distinct vision D by a simple microscope. When the final image is at D, derive an expansions for its magnifying power at D.

Sol:

The angular magnification of a simple microscope is defined as the ratio of the angle β subtended at the eye by image at the near point and the angle α subtended at the unaided eye by the object at the near point.

Therefore, magnifying power, $m = \frac{\beta}{\alpha}$...........1



$In \triangle A'B'C, \quad \tan\beta = \frac{A'B'}{D}$

$In \triangle A''B''C, \quad \tan\alpha = \frac{A''B''}{D}$

Since, the Angles are small, then

$\tan\alpha \approx \alpha \ and \tan\beta = \beta$

$\therefore \beta = \frac{A'B'}{D}$ And $\alpha = \frac{AB}{D}$

From eq(i), we have

$$m = \frac{A'B'}{D} \times \frac{D}{AB}$$

$$= \frac{A'B'}{AB}$$

It gives the liner magnification produced by the lens.

$$\frac{A'B'}{AB} = \frac{v}{u}$$

Since, we know that

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

By multiplying both sides by v, we have

$$\frac{v}{v} - \frac{v}{u} = \frac{v}{f}$$

$$\Rightarrow 1 - m = \frac{v}{f}$$

$$\Rightarrow m = 1 - \frac{v}{f}$$

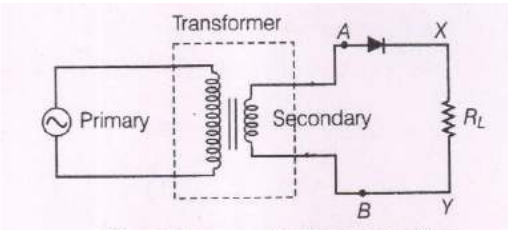
$$\therefore m = 1 + \frac{D}{f}$$

22. (I) Draw a labelled circuit diagram of a half-wave rectifier and give its output waveform.

Sol:

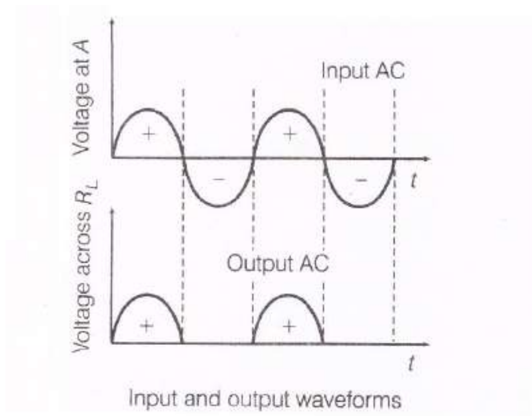
Here, the AC voltage to be rectified is connected to the primary coil of step- down transformer and secondary coil is connected to the diode through resistors.

During negative half cycle of the input AC, the p-n junction is reverse biased. Therefore, the resistance of p-n- junction is too much high and diode does not work.



Circuit diagram of half-wave rectifier

Now, the working, during half cycle of the input AC, then the p-n junction is forward biased. And the resistance in p-n junction becomes very low and diode works, therefore, current flows.

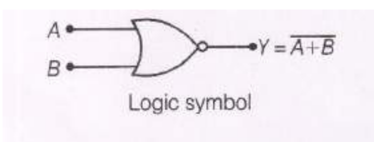


Input and output waveforms

(II) Draw a symbol for NOR gate and write its truth table.

Sol:

This is the symbol of NOR gate



Logic symbol

And the truth table is

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