Previous IPE

SOLVED PAPERS

MARCH -2019 (AP)

PREVIOUS PAPERS

IPE: MARCH-2019(AP)

SR.PHYSICS

Time : 3 Hours Max.Marks : 60

SECTION-A

I. Answer ALL questions : $10 \times 2 = 20$

1. A small angled prism of 4° deviates a ray through 2.48°. Find the refractive index of the prism.
2. How do you convert a moving coil galvanometer into an ammeter ?
3. Magnetic lines form continuous closed loop. Why?
4. Classify the following materials with regard to magnetism :
   Bismuth, Cobalt, Oxygen, Copper
5. A transformer converts 200 V ac into 2000 V ac. Calculate the number of turns in the secondary, if the primary has 10 turns.
6. Give two uses of infrared rays.
7. State Heisenberg's uncertainty principle.
8. What is 'Work function' ?
9. Draw the circuit symbols for *p-n-p* and *n-p-n* transistors.
10. Mention the basic methods of modulation

SECTION-B

II. Answer any SIX of the following Questions. $6 \times 4 = 24$

11. Define focal length of a concave mirror. Prove that the radius of curvature of a concave mirror is double its focal length.
12. How do you determine the resolving power of your eye?
13. Derive an expression for the intensity of the electric field at a point on the axial line of an electric dipole.
14. Explain the behaviour of dielectrics in an external field
15. A 100 turn closely wound circular coil of radius 10 cm carries a current of 3.2 A.
    a) What is the field at the centre of the coil ?
    b) What is the magnetic moment of this coil ?
16. Describe the ways in which Eddy currents are used to advantage.
17. Explain the different types of spectral series.
18. Distinguish between half - wave and full - wave rectifiers.

SECTION-C

III. Answer any TWO of the following Questions. $2 \times 8 = 16$

19. a) Explain the formation of stationary waves in stretched strings and hence deduce the laws of transverse waves in stretched strings
    (b) A steel wire 0.72 m long has an mass 5.0×10^{-3} kg. If the wire is under a tension of 60 N, what is the speed of transverse waves on the wire?
20. (a) State Kirchhoff's laws for an electrical network. Using these laws deduce the conditions for balance in a Wheatstone bridge.
    (b) A wire of resistance 4R is bent in the form of a circle. What is the effective resistance between the ends of the diameter?
21. Explain the principle and working of a nuclear reactor with the help of a labelled diagram.

IPE AP MARCH-2019

SOLUTIONS

SECTION-A

1. A small angled prism of 4^0 deviates a ray through 2.48^0. Find the refractive index of the prism.

Sol: $A = 4^0$, $D_m = 2.48^0$, $n_{21} = ?$

Formula: For a thin angled prism, $D_m = (n_{21} - 1)A$

$\Rightarrow 2.48 = (n_{21} - 1)4 \Rightarrow n_{21} = $ **1.62**

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2. How do you convert a moving coil galvanometer into an ammeter?

A: A galvanometer (G) can be converted into an ammeter (A) by connecting a very **small shunt resistance** (r_s) in **parallel** to it.

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3. Magnetic lines form continuous closed loops. Why ?

A: The magnetic field lines of a magnet or a solenoid form continuous closed loops, because the **magnetic poles N and S always exist together in pairs**.

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4. Classify the following materials with regard to Magnetism. Manganese, Cobalt, Nickel, Bismuth, Oxygen, Copper

A:
1) **Para magnetic :** Manganese and Oxygen
2) **Dia magnetic :** Bismuth and Copper
3) **Ferro magnetic :** Cobalt and Nickel

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5. A transformer converts 200 V AC into 2000 V AC. Calculate the number of turns in the secondary if the primary has 10 turns.

A: Given that $V_p = 200$ V, $V_s = 2000$ V, $N_p = 10$, $N_s = ?$

Transformer formula : $\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow N_s = \frac{V_s}{V_p} N_p = \frac{2000}{200} \times 10 = $ **100**

6. Give two uses of infrared rays.

A : Infrared rays are used in

1)remote control systems of TV etc.

2) the treatment of skin diseases.

3) taking photographs where there is no visible light.

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7. State Heisenberg's Uncertainty Principle.

A : 1) Heisenberg's Uncertainty Principle: It is not possible to measure both the position and momentum of an electron (or any other particle) at the same time exactly.

2) If the uncertainty in position is Δx and uncertainty in momentum is Δp, the product of Δx and Δp is of the order of $\hbar$. Thus $\Delta x\, \Delta p = \hbar$ (where $\hbar = h/2\pi$)

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8. What is work function ?

A: Work Function: The minimum energy required by an electron to escape from the surface of a metal is called work function (ϕ_0) of the metal.

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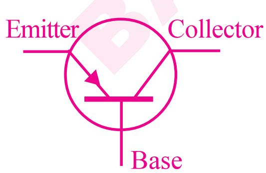
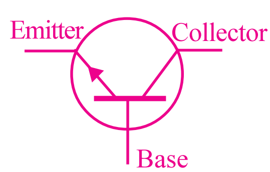
9. Draw the circuit symbols for *p-n-p* and *n-p-n* transistors.

A:



p-n-p transistor



n-p-n transistor

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10. Mention the basic methods of modulation.

A : Basic Methods of Modulation:

1) Amplitude Modulation (AM)

2) Frequency Modulation (FM)

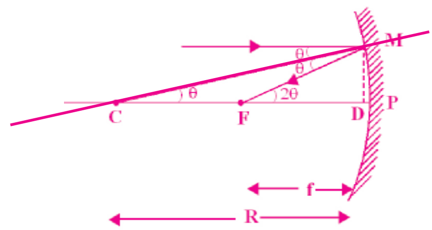
3) Phase Modulation (PM).

SECTION-B

11. Define focal length of a concave mirror. Prove that the radius of curvature of a concave mirror is double its focal length.

A : Focal Length(f): The distance between the focus F and the pole P of the concave mirror is called focal length (f) of the concave mirror.

To show that R = 2f for Concave Mirror



Consider a concave mirror of pole P, focus F and centre of curvature C. When a light ray parallel to its principal axis is incident at M, the reflected ray passes through its focus F. The line joining M and C is normal to the mirror at M.

If the angle of incidence is θ, the angle of reflection ∠ FMC will also be θ as per law of reflection. In figure, ∠ MCP = θ and ∠ MFP = 2θ

The perpendicular drawn from M on to principal axis is MD.

Then, in triangle CMD, $\tan\theta = \frac{MD}{CD}$ and in triangle FMD, $\tan 2\theta = \frac{MD}{FD}$

As θ is very small, tan θ = θ and tan 2θ = 2θ.

Then, $\theta = \frac{MD}{CD}$ and $2\theta = \frac{MD}{FD} \Rightarrow \frac{\cancel{MD}}{FD} = 2\frac{\cancel{MD}}{CD} \Rightarrow CD = 2FD.$

As the mirror is very thin, D almost coincides with P.

DC = PC = R = Radius of curvature and DF = PF = f = Focal length.

∴ Radius of curvature = 2 (Focal length). R = 2f

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12. How do you determine the resolving power of your eye ?

A: 1) Resolving Power of Eye: It is the ability to see the fine details in the viewed objects .

2) We can estimate the resolving power of our eye with a simple experiment.

3) Let us take a pattern of black stripes of equal width (each 5 mm) separated by white stripes of increasing width (0.5mm, 1mm,1.5 mm....)

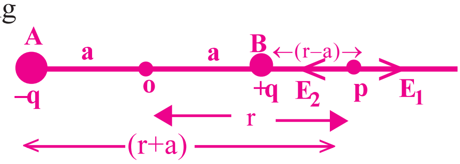
from left to right as shown in the figure and paste it on a wall of the room.

4) Now, let us watch the pattern with one eye. By moving our eye away or closer to the wall, we have to find the white stripe where we can just see some two black stripes as separate stripes. All the black stripes to the left of white stripe would merge into one another and would not be distinguishable.

5) On the other hand, the black stripes on the right of the white stripe would be more and more clearly visible. If d is the width of the white stripe which separates the two regions and D is the distance between the eye and the wall, the resolving power of the eye is given by d/D.

13. Derive an expression for the intensity of the electric field at a point on the axial line of an electric dipole.

A : **1) Electric Dipole:** Consider an electric dipole consisting of two equal and opposite charges –q & q located at A and B.
These are separated by a distance **2a**.
Let P be a point on the axial line of a dipole at a distance r from its centre.
Then distance of P from B is (r – a) and from A is (r+a).



Axial line of Dipole

2) Intensity:
Intensity of electric field at P due to +q is $E_1 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}$ ....(1)

Intensity of electric field at P due to –q is $E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}$ ....(2)

3) Resultant intensity of electric field due to the dipole at point P is E = $E_1 - E_2$

$$\Rightarrow E = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{(r-a)^2} - \frac{q}{(r+a)^2}\right) = \frac{q}{4\pi\varepsilon_0}\left(\frac{(r+a)^2-(r-a)^2}{(r^2-a^2)^2}\right) = \frac{q}{4\pi\varepsilon_0}\left[\frac{4ar}{(r^2-a^2)^2}\right] = \frac{1}{4\pi\varepsilon_0}\left[\frac{2[q(2a)]r}{(r^2-a^2)^2}\right]$$

$$\Rightarrow E = \frac{1}{4\pi\varepsilon_0}\left[\frac{2Pr}{(r^2-a^2)^2}\right] \text{.............(3)} \quad [\because \text{Dipolemoment } P = q(2a)]$$

$$\Rightarrow E = \frac{1}{4\pi\varepsilon_0}\frac{2Pr}{r^4}$$ [At larger distances (r>>a), the a^2 term can be neglected]

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14. Explain the behaviour of dielectrics in an external field.

A : 1) Dielectrics are non-conducting substances. The molecules of a dielectric may be polar or non-polar.

2) Polarization: When a dielectric with non-polar molecules is placed in an external electric field, the positive and negative charges of a non-polar molecules are displaced in opposite directions. Thus induced dipole moments are developed in the dielectric by the external field. Hence the dielectric is said to be polarised by the external field. All the induced dipole moments of the non-polar molecules add up to give a net dipole moment to the dielectric.

3) In dielectric with polar molecules, in the absence of external electric field, the different permanent dipoles are oriented randomly due to thermal agitation. Hence, the total dipole moment becomes zero. When an external electrical field is applied, the individual dipole moments tend to align with the field. As a result, a net dipole moment comes to the dielectric in the direction of external field. Hence the dielectric is polarised.

4) Thus in either case, whether polar or non-polar, a dielectric develops a net dipole moment in the presence of an external field. The dipole moment per unit volume is called polarisation (P).

5) For linear isotropic dielectrics, $P = \chi_e E$ where χ_e is electric susceptibility and E is intensity of external field.

15. A 100 turn closely wound circular coil of radius 10 cm carries a current of 3.2 A.

a) What is the field at the centre of the coil ?

b) What is the magnetic moment of this coil ?

Sol: Given $N=100$, $r=10=10\times10^{-2}=0.1m$

$I= 3.2A$

a) $B_{centre} = \frac{\mu_0 NI}{2r} = \frac{2\pi\times10^{-7}\times100\times3.2}{0.1} = 20.096\times10^{-4}T$

b) $M=NIA = 100(3.2)\pi(0.1)^2 = 10.048Am^2$

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16. Describe the ways in which Eddy currents are used to advantage.

A: **1) Eddy Currents :** When large pieces of conductors are subjected to changing magnetic fluxes, induced currents are produced in them. Such induced currents are called eddy currents

2) Advantages of Eddy Currents :

i) **Magnetic Brakes to Trains:** When the strong electromagnets are activated, the eddy currents induced in the rails oppose the motion of the train. As a result, **smooth braking effect** comes into play.

ii) **Electromagnetic Damping:** In galvanometers, electromagnetic damping brings the coil to rest quickly. This happens due to eddy currents produced in the core.

iii) **Induction Furnace :** A high frequency alternating current is passed through a coil which surrounds the metals to be melted. Then the eddy currents generated in the metals produce high temperatures.

iv) **Electric power meters:** The shiny **metal disc** in the 'electric power meter' **rotates** due to eddy currents.

17. Explain the different types of spectral series of hydrogen atom

A : Hydrogen atom consists of five spectral series. They are

1) Lyman series 2) Balmer series 3) Paschen series 4) Brackett series 5) Pfund series.

1) **Lyman series:** When an electron jumps from any outer orbits to the first orbit, we get Lyman series. It is observed in the **UV** region. Here n_1=1 and n_2=2,3,4,5....

$$\therefore \nu = R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right] = R\left[\frac{1}{1^2}-\frac{1}{n_2^2}\right]$$

2) **Balmer Series:** When an electron jumps from any outer orbits to the second orbit, we get Balmer series. It is observed in the **Visible** region. Here n_1=2 and n_2=3,4,5....

$$\therefore \nu = R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right] = R\left[\frac{1}{2^2}-\frac{1}{n_2^2}\right]$$

3) **Paschen Series :** When an electron jumps from any outer orbits to the third orbit, we get Paschen series. It is observed in the **near infrared** region. Here n_1=3 and n_2=4,5,6,........

$$\therefore \nu = R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right] = R\left[\frac{1}{3^2}-\frac{1}{n_2^2}\right]$$

4) **Brackett Series :** When an electron jumps from any outer orbits to the fourth orbit, we get Brackett series. It is observed in the **infrared** region. Here n_1=4 and n_2=5,6,7,..........

$$\therefore \nu = R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right] = R\left[\frac{1}{4^2}-\frac{1}{n_2^2}\right]$$

5) **Pfund Series :** When an electron jumps from any outer orbits to the fifth orbit, we get Pfund series. It is observed in the **far infrared** region. Here n_1=5 and n_2=6,7,8,..........

$$\therefore \nu = R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right] = R\left[\frac{1}{5^2}-\frac{1}{n_2^2}\right]$$

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

A :

Half wave rectifier	Full wave rectifier
1) A **single diode** is used in half wave rectifier.	1) **Two diodes** are used in full wave rectifier.
2) A **transformer without centre tap** is used in it.	2) A **transformer with centre tap** is used in it.
3) Half wave rectifier converts only one half of AC into DC.	3) Full wave rectifier converts both the half cycles of AC into DC.
4) Its maximum efficiency is 40.6%.	4) Its maximum efficiency is 81.2 %.

SECTION-C

19. Explain the formation of stationary waves in stretched strings and hence deduce the laws of transverse waves in stretched strings.

A: 1) **Stretched String:** When a stretched string is plucked and released at the middle, transverse waves are generated. They reflect back at its ends.

2) **Formation of Stationary Waves :** When two reflected waves travelling in opposite directions along the string super impose each other to produce stationary waves.

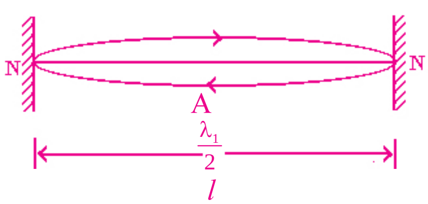
3) Nodes(N) are formed at the ends.

4) **Notation:** l= length of the string, T= Tension in the string, μ = Linear density of the string and V= Velocity of the transverse wave.

$\lambda_1, \lambda_2, \lambda_3$ are the wave lengths of waves in respective harmonics.

Modes of vibration in a stretched string:

5) **First harmonic :** Here, the string vibrates in a single loop



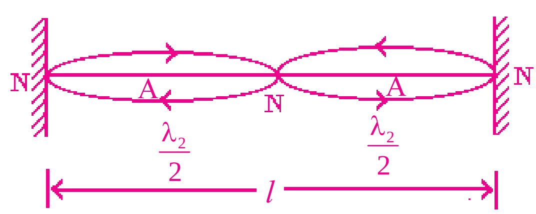
From the fig., $l = \frac{\lambda_1}{2} \Rightarrow \lambda_1 = 2l$. Here , $n_1 = \frac{V}{\lambda_1} = \frac{V}{2l}$

We know, velocity of transverse wave is $V = \sqrt{\frac{T}{\mu}}$

From the above two equations, we get $n_1 = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

This frequency is called First harmonic (or Fundamental frequency).

6) **Second harmonic:** Here, the string vibrates in two loops:



From the fig., $l = \frac{\lambda_2}{2} + \frac{\lambda_2}{2} = \lambda_2 \Rightarrow \lambda_2 = l$

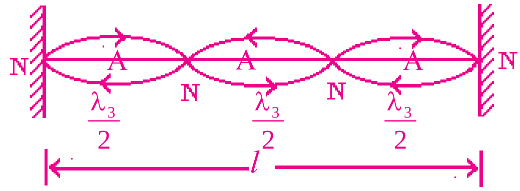
Here $n_2 = \frac{V}{\lambda_2} = \frac{V}{l}$. But $V = \sqrt{\frac{T}{\mu}}$

$\therefore \quad n_2 = \frac{1}{l}\sqrt{\frac{T}{\mu}} = 2 \times \frac{1}{2l}\sqrt{\frac{T}{\mu}} = 2n_1$

This frequency is called second harmonic (or first overtone).

7) Third harmonic: Here, the string vibrates in three loops:

From the fig, $l = \frac{\lambda_3}{2} + \frac{\lambda_3}{2} + \frac{\lambda_3}{2} = \frac{3\lambda_3}{2} \Rightarrow \lambda_3 = \frac{2l}{3}$



Here $V = n_3\lambda_3$ $\Rightarrow n_3 = \frac{V}{\lambda_3} = \frac{V}{\left(\frac{2l}{3}\right)} = \frac{3V}{2l}$

$\therefore n_3 = \frac{3}{2l}\sqrt{\frac{T}{\mu}} = 3n_1$ $\left[\because V = \sqrt{\frac{T}{\mu}}\right]$

This frequency is called Third harmonic (or Second overtone).

8) Deduction of Laws of transverse waves:

The fundamental frequency is given by $n_1 = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

i) First law: The fundamental frequency(first harmonic) of a vibrating string is inversely proportional to its length (l) when tension(T) and linear density(μ) are kept constants.

Thus, $n \propto \frac{1}{l}$ ($\because$ T,μ are constants)

ii) Second law: The fundamental frequency of a vibrating string is directly proportional to square root of its tension (T) when length(l) and linear density(μ) are kept constants.

Thus, $n \propto \sqrt{T}$ ($\because l,\mu$ are constants)

iii) Third law: The fundamental frequency of vibrating string is inversely proportional to square root of its linear density (μ) when length(l) and tension (T) are kept constants.

Thus, $n \propto \frac{1}{\sqrt{\mu}}$ ($\because l$,T are constants)

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b) A steel wire 0.72 m long has a mass of 5.0×10^{-3} kg. If the wire is under a tension of 60 N, what is the speed of transverse waves on the wire ?

Sol: Linear density = Mass per unit length of the wire, $\mu = \frac{M}{l} = \frac{5.0\times10^{-3}}{0.72} = 6.9\times10^{-3}$ kg m^{-1}

Given Tension, T = 60 N

The speed of wave on the wire is given by $V = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{60}{6.9\times10^{-3}}}$ = **93 m s^{-1}**

20. State Kirchoff's law for an electrical network. Using these laws deduce the condition for balance in a Wheatstone bridge.

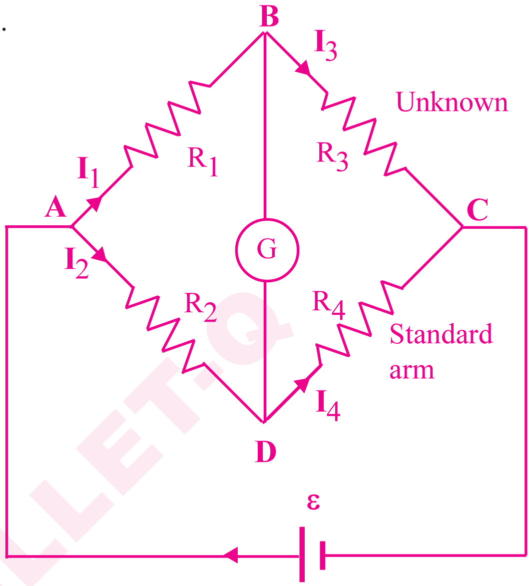
A : **1) Kirchoff's First Law :** At any junction in an electric circuit, the sum of currents entering the junction is equal to the sum of currents leaving the junction.

2) Kirchoff's Second Law : The algebraic sum of changes in potential around any closed loop involving resistors and cells in the loop is zero.

3) Wheatstone's Bridge :

The circuit shown in the figure is called Wheatstone's bridge. It has four resistors R_1, R_2, R_3 and R_4. AC is battery arm, BD is galvanometer arm.

The galvanometer G detects the current. If the resistors are adjusted such that the galvanometer current $I_g = 0$, the bridge is said to be balanced.



Wheatstone bridge

Applying Kirchoff's junction rule at B, we get $I_1 = I_3$ ....(1)

Applying Kirchoff's junction rule at D, we get $I_2 = I_4$ ....(2)

Applying Kirchoff's loop rule to closed loop ABDA, we get $I_1 R_1 + 0 - I_2 R_2 = 0$

$\Rightarrow I_1 R_1 = I_2 R_2 \Rightarrow \frac{I_1}{I_2} = \frac{R_2}{R_1}$ ....(3)

Applying Kirchoff's loop rule to closed loop CBDC, we get $I_4 R_4 + 0 + -I_3 R_3 = 0$

$\Rightarrow I_3 R_3 = I_4 R_4$ From (1) & (2) $I_3 = I_1$ and $I_4 = I_2$

$\therefore I_1 R_3 = I_2 R_4 \Rightarrow \frac{I_1}{I_2} = \frac{R_4}{R_3}$ ....(4)

Equating the RHS of equ (3) and equ (4), we get $\frac{R_2}{R_1} = \frac{R_4}{R_3} \Rightarrow \frac{R_1}{R_2} = \frac{R_3}{R4}$

This is the **balance condition of Wheatstone's bridge** to make $I_g = 0$.

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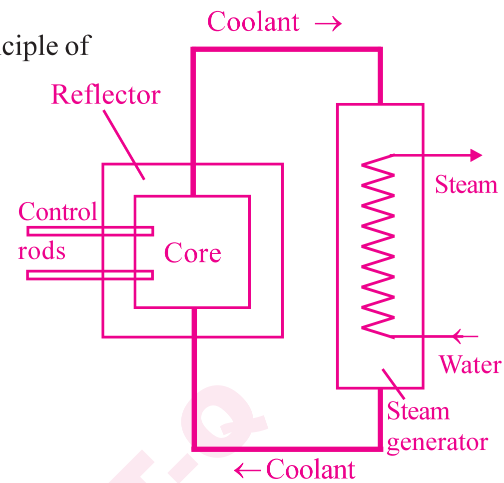
b) A wire of resistance 4R is bent in the form of a circle. What is the effective resistance between the ends of the diameter?

Sol: A wire of 4RΩ bent into a circle = a parallel combination of two resistors of 2RΩ.

$\therefore$ Equivalent resistance $R_p = \frac{R_1 R_2}{R_1 + R_2} = \frac{2R\Omega \times 2R\Omega}{2R\Omega + 2R\Omega} = \frac{4R\Omega}{4R\Omega} = 1\Omega$

21. Explain the principle and working of a nuclear reactor with the help of a labelled diagram.

A: **1) Principle:** Nuclear reactor works on the principle of **controlled chain reaction.**



Nuclear Reactor

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Be Clear with Nuclear

2) Main parts of Nuclear reactor:

(i) Fuel
(ii) Moderator
(iii) Control rods
(iv) Protective Sheilding
(v) Coolant

3) Fuel: The material which undergoes fission is called fuel. **Ex:** U^{235} .

4) Moderator: The material which slows down the fast moving neutrons is called moderator. **Ex:** D_2O, Graphite

5) Control rods: The rods which absorb neutrons to control the chain reaction are called control rods.

Ex: Cd, B

6) Protective Shielding: The construction with cement and lead(Pb) around the reactor which protects from harmful radiations is called protective shielding.

7) Coolant: The liquid which removes the heat generated by the reactor is called circulating coolant. **Ex:** Water at high pressure, molten sodium.

8) Working:

i) Uranium fuel rods are arranged in the A*l* cylinders.

ii) The graphite moderator is placed in between the fuel cylinders.

iii) When U^{235} undergo fission, fast neutrons are released.

iv) These neutrons pass through the surrounding graphite moderator and loose their energy.

v) The heat generated here is used to produce steam.

vi) This steam is used to rotate steam turbine then electric power is produced.