Previous IPE

SOLVED PAPERS

MARCH -2023 (TS)

PREVIOUS PAPERS

IPE: MARCH-2023(TS)

Time : 3 Hours **SR.PHYSICS** Max.Marks : 60

SECTION-A

I. Answer all questions : **10 × 2 = 20**

1. What is the principle of a moving coil galvanometer ?
2. Define magnetic inclination or angle of dip.
3. A small angled prism of 4° deviates a ray through 2.48°. Find the refractive index of the prism.
4. Classify the following materials with regard to magnetism. Manganese, Cobalt, Nickel, Bismuth, Oxygen, Copper .
5. What important fact did Millikan's experiment establish ?
6. A transformer converts 200 V AC into 2000 V AC. Calculate the number of turns in the secondary if the primary has 10 turns.
7. If the wavelength of electromagnetic radiation is doubled, what happens to the energy of photon?
8. Give examples of photosensitive substances. Why are they called so?
9. What is sky wave propagation ?
10. Write the truth table of NAND gate. How does it differ from AND gate ?

SECTION-B

II. Answer any six of the following Questions. **6 × 4 = 24**

11. Distinguish between half-wave and full wave rectifiers.
12. Describe the ways in which Eddy currents are used to advantage.
13. Write a short note on deBroglie's explanation of Bohr's second postulate of quantization.
14. Derive an expression for the magnetic dipole moment of a revolving electron.
15. Define critical angle. Explain total internal reflection using a neat diagram.
16. Explain Doppler effcet in light. Distinguish between red shift adn blue shift.
17. Derive an expression for the capacitance of a parallel plate capacitor.
18. State Gauss' law in electrostatics and explain its importance.

SECTION-C

III. Answer any two of the following Questions. **2 × 8 = 16**

19. How are stationary waves formed in closed pipes ? Explain the various modes of vibration and obtain relations for their frequencies.
    A closed organ pipe 70cm long is sounded. If the velocity of sound is 331m/s, what is the fundamental frequency of vibration of the air column?
20. (a) What is radioactivity ? State the law of radioactive decay. Show that radioactive decay is exponential in nature.
    (b) The half life of radium is 1600 years. How much time does 1 g of radium take to reduce to 0.125 g.
21. State Kirchoff's law for an electrical network. Using these laws deduce the condition for balance in a Wheatstone bridge.

IPE TS MARCH-2023
SOLUTIONS

SECTION-A

1. What is the principle of a moving coil galvanometer ?

A: 1) Principle of Moving Coil Galvanometer: When a current carrying coil is placed in a uniform magnetic field, it experiences a torque.

2) Here, Current in the coil (i) $\propto$ deflecting angle (θ)

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2. Define magnetic inclination or angle of dip.

A : Magnetic Inclination : At a given place, the angle between 'total Earth's field' and it's 'horizontal line in magnetic meridian' is called Magnetic inclination.

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3. 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, $D_m = (n_{21} - 1)A$

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

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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. What important fact did Millikan's experiment establish ?

A : 1) Millikan's experiment established the fact that electric charge is quantised.

2) Millikan found the value of charge of electron is $e = 1.602 \times 10^{-19}$ C.

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

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

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

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7. If the wavelength of electromagnetic radiation is doubled, what happens to the energy of photon ?

A : We have $\lambda_1 = \lambda$ and $\lambda_2 = 2\lambda$. Also $E_1 = E$

Let E_1, E_2 are respective Energies

Energy of photon is inversely proportional to wavelength 'λ'. $E \propto \frac{1}{\lambda}$

$$\therefore \frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1} \Rightarrow \frac{E_1}{E_2} = \frac{2\lambda}{\lambda} = 2 \Rightarrow E_2 = \frac{E_1}{2}$$

Thus, if wavelength of electromagnetic radiation is doubled, the energy of photon is **halved**.

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8. Give examples of <u>photosensitive substances</u>. Why are they called so?

A : 1) **Photosensitive substances:** Alkali metals like lithium, sodium, potassium, caesium and rubidium.

2) These alkali metals emit electrons when they are illuminated by light.

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9. What is sky wave propagation ?

A : **Sky Wave Propagation:** The communication between two long distance points on the earth achieved by the reflection of radio waves (3 MHz to 30 MHz) from the ionosphere is called sky wave propagation. Radios work on sky wave propagation.

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10. Write the truth table of <u>NAND gate</u>. How does it <u>differ from AND gate</u> ?

A:

NAND gate-Truth Table

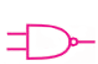
Input		Output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

AND gate-Truth Table

Input		Output
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

1) In NAND gate, the output becomes zero only when both the inputs are 1.
2) In AND gate, the output becomes 1 only when both the inputs are 1.

3) Thus NAND gate is just opposite to AND gate.

4) The symbol of NAND gate: 

5) The symbol of AND gate : 

SECTION-B

11. 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 %.

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12. 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.

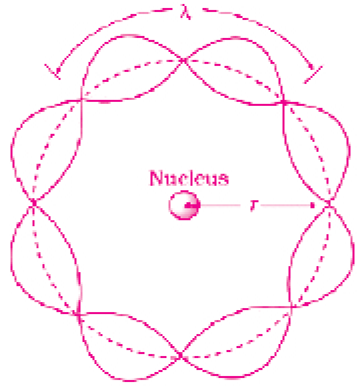
iv) Electric power meters: The shiny **metal disc** in the 'electric power meter' **rotates** due to eddy currents.

13. Write a short note on deBroglie's explanation of Bohr's second postulate of quantization.

A : Bohr's second postulate: The angular momentum of electron in a stationary orbit is quantised.

Thus, $m\, v_n\, r_n = \frac{nh}{2\pi}$ ....(1)

de Broglie's explanation: de Broglie explained that the electron in the stationary orbit acts like a particle wave. So it forms stationary waves in the orbit. .



The distance travelled by the particle wave along circumference is an integral multiple of wavelength.Thus, $2\pi\, r_n = n\lambda$ ....(2)

where n = 1, 2, 3 . . .

From de Broglie hypothesis, we have

$$\lambda = \frac{h}{p} = \frac{h}{mv_n}$$

Now, from (2) $2\pi\, r_n = n\frac{h}{mv_n}$ $\Rightarrow m\, v_n\, r_n = \frac{nh}{2\pi}$ ....(3)

Thus, from (1) & (3) we concluded that de Broglie's explanation coincides with the second postulate of Bohr model of atom.

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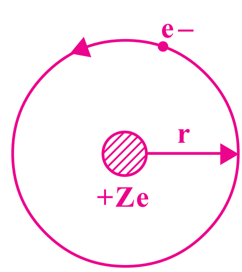
14. Derive an expression for the magnetic dipole moment of a revolving electron.

A: Magnetic Dipole Moment due to Revolving Electron:

Let us suppose that an electron is revolving in a circular orbit of radius r with a speed v and time period T.



Formula: $v = \frac{2\pi r}{T} \Rightarrow T = \frac{2\pi r}{v}$

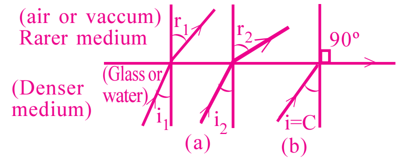
Current $i = \frac{e}{T} \Rightarrow i = \frac{ve}{2\pi r}$

Magnetic dipole moment $M = iA = \frac{ve(\pi r^2)}{2\pi r}$

Magnetic dipole moment due to revolving electron is $\boxed{M = \frac{evr}{2}}$

15. Define critical angle. Explain Total internal reflection using a neat diagram.

A: 1) Critical Angle: When a light ray is passing from denser medium to rarer medium, the angle of incidence in denser medium for which the angle of refraction becomes 90º in rarer medium is called critical angle (i_C).

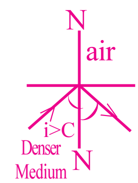


Critical Angle

Equation for critical angle is $n_{21} = \frac{1}{\sin i_C}$

where n_{21} = refractive index of the denser medium w.r.to rarer medium.

2) Total Internal Reflection(TIR): When a light ray is passing from denser medium to rarer medium if the angle of incidence is greater than its critical angle ($i > i_C$), it gets reflected into the same denser medium without any refraction. This phenomenon is called Total Internal Reflection.



TIR

An **optical fibre** works on the principle of Total Internal Reflection.

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16. Explain Doppler effect in light. Distinguish between red shift and blue shift.

A : 1) Doppler effect in Light: To an observer on the earth the light from a star moving towards him appears with high frequency or less wave length. Similarly, the apparent wave length is high in the case of star moving away from him. This change in apparent frequency or wavelength of light due to relative motion of the source is called Doppler effect in light.

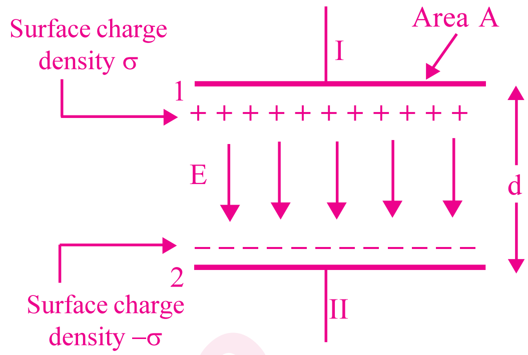
2) Red Shift : According to Doppler effect, when a star goes away from the observer on the earth, its light appears to him with higher wavelength. As a result, the wavelength in the middle of the visible region of the spectrum (VIBGYOR) moves towards the red end of the spectrum. This is called red shift.

3) Blue Shift : According to Doppler effect, when a star moves towards the observer on the earth, its light appears to him with less wavelength. As a result, the wavelength in the middle of the visible region of the spectrum (VIBGYOR) moves towards the violet (or blue which is more sensitive to eye) end of the spectrum. This is called blue shift.

17. Derive an expression for the capacitance of a parallel plate capacitor.

A : Capacitance of a parallel plate capacitor :

Consider a parallel plate capacitor consisting of two parallel plates of area A, separated by a small distance 'd'.



Let 'V' be the potential difference between two plates.

The charges of the plates are Q and –Q.

The plate 1 has uniform surface charge density σ = Q/A and the plate 2 has uniform charge density –σ.

The electric field due to plate 1 is $\frac{\sigma}{2\varepsilon_0}$. The electric field due to plate 2 is $-\frac{\sigma}{2\varepsilon_0}$.

Electric field between two charged plates is

$$E = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = 2\frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$$

But $\sigma = Q/A$

$\therefore$ The field inside the capacitor is $E = \frac{Q}{\varepsilon_0 A}$ ....(1)

$$\Rightarrow \frac{V}{d} = \frac{Q}{\varepsilon_0 A} \left[\because E = \frac{V}{d}\right]$$

$$\Rightarrow \frac{V}{d} = \frac{CV}{\varepsilon_0 A} \quad [\because Q = CV]$$

$$\Rightarrow C = \frac{\varepsilon_0 A}{d}$$

$\therefore$ Capacitance of the parallel plate capacitor is given by $C = \frac{\varepsilon_0 A}{d}$

18. State Gauss' law in electrostatics and explain its importance.

A : 1) Gauss' Law: The total electric flux (ϕ) through any closed surface is equal to $\frac{1}{\varepsilon_0}$ times the net charge (q) enclosed by the closed surface. Thus $\phi = \frac{1}{\varepsilon_0}(q)$

2) Importance of Gauss' Law:

i)Gauss' law is true for any closed surface (of any shape and any size).

ii)Gauss law gives the relation between the electric field and the charge.

iii)Gauss' law is valid for stationary charges as well as for rapidly moving charge.

iv)Gauss' law is based on Coulomb's law. Gauss' law is valid as long as Coulomb's law is valid.

SECTION-C

19. How are stationary waves formed in closed pipes ? Explain the various modes of vibration and obtain relations for their frequencies.

A: **1) Closed pipe:** A pipe closed at one end is called closed pipe.

2) Formation of Stationary waves : When a sound wave is sent to a closed pipe, the wave reflects back at the closed end of the pipe. These incident wave and reflected wave travelling in opposite directions super impose each other to produce Stationary waves.

3) A node (N) is formed at the closed end and an antinode (A) is formed at open end .

4) Notation: l= length of air column,

V= Velocity of sound in air, $\lambda_1, \lambda_3, \lambda_5$ are the wave lengths of waves in respective harmonics.

5) First Harmonic: Here, 1 node and 1 antinode is formed.

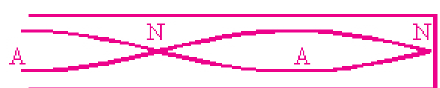
Length of the air column $l = \frac{\lambda_1}{4} \Rightarrow \lambda_1 = 4l$

$\therefore$ Frequency of first harmonic $n_1 = \frac{V}{\lambda_1}$

$$\therefore \ n_1 = \frac{V}{4l} \quad ....(i)$$

6) Third Harmonic: Here, 2 nodes and 2 antinodes are formed.

Length of air column $l = \frac{\lambda_3}{4} + \frac{\lambda_3}{4} + \frac{\lambda_3}{4} = \frac{3\lambda_3}{4}$



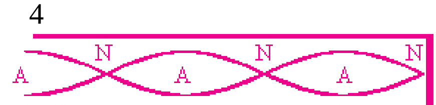
$\therefore l = \frac{3\lambda_3}{4} \Rightarrow \lambda_3 = \frac{4l}{3}$

$\therefore$ Frequency of third harmonic $n_3 = \frac{V}{\lambda_3} = V\left(\frac{3}{4l}\right) = 3\left(\frac{V}{4l}\right) = 3n_1$ ....(ii)

7) Fifth Harmonic: Here, 3 nodes and 3 antinodes are formed.

Length of air column $l = \frac{\lambda_5}{4} + \frac{\lambda_5}{4} + \frac{\lambda_5}{4} + \frac{\lambda_5}{4} + \frac{\lambda_5}{4} = \frac{5\lambda_5}{4}$

$\therefore l = \frac{5\lambda_5}{4} \Rightarrow \lambda_5 = \frac{4l}{5}$



$\therefore$ Frequency of fifth harmonic $n_5 = \frac{V}{\lambda_5} = V\left(\frac{5}{4l}\right) = 5\left(\frac{V}{4l}\right) = 5n_1$ ....(iii)

8) From (i), (ii) & (iii) we have $n_1 : n_3 : n_5 : ...... = n_1 : 3n_1 : 5n_1 : ...... = 1 : 3 : 5 : ......$

b) A closed organ pipe 70cm long is sounded. If the velocity of sound is 331m/s, what is the fundamental frequency of vibration of the air column?

Sol: Given length of closed pipe l=70 cm = 0.7 m , V = 331 m/s, n=?

Fundamental frequency $n = \frac{V}{4l} = \frac{331}{4 \times 0.7} = 118.2$ Hz

20. What is radioactivity ? State the law of radioactive decay. Show that radioactive decay is exponential in nature.

A : **1) Natural Radioactivity**: The phenomenon in which an unstable nucleus like uranium undergoes a decay is called radioactivity.

2) Law of Radioactive Decay: The rate of disintegration is directly proportional to number of nuclei present at that instant.

3) $\therefore \frac{dN}{dt} \propto N$

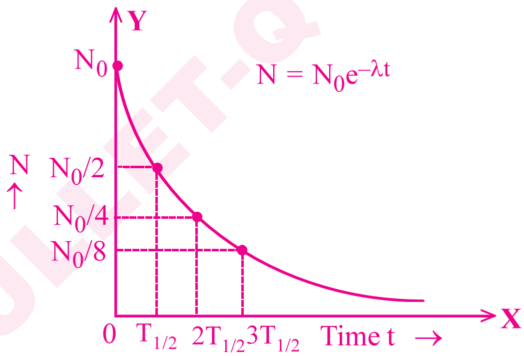
$\Rightarrow \frac{dN}{dt} = -\lambda N$ - - - - (i)where λ is called decay constant.

$\Rightarrow \frac{dN}{N} = -\lambda\, dt$

4) On integrating both sides,

we get $\int_{N_0}^{N} \frac{dN}{N} = -\lambda \int_0^t dt$

$\Rightarrow \log_e N - \log_e N_0 = -\lambda t$ ......(ii)



5) Here, N_0 = number of nuclei at t= 0

N = number of nuclei at time t.

6) $\therefore \log_e \frac{N}{N_0} = -\lambda t$

$\Rightarrow \frac{N}{N_0} = e^{-\lambda t}$

7) $\therefore N = N_0 e^{-\lambda t}$ ....(iii)

8) Thus the radioactive decay is exponential in nature.

b) The half life of radium is 1600 years. How much time does 1 g of radium take to reduce to 0.125 g.

Sol: In every 1600 yrs it reduces to half.

If 1g of Radium is at present,

after 1600 yrs, half of 1 g ie, 0.5 g remains.

After 3200 yrs, half of 0.5 g = 0.25 g remains.

After 4800 yrs, half of 0.25= 0.125 g remains.

Thus it takes **4800 yrs** to reduce to 0.125 g.

21. 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.

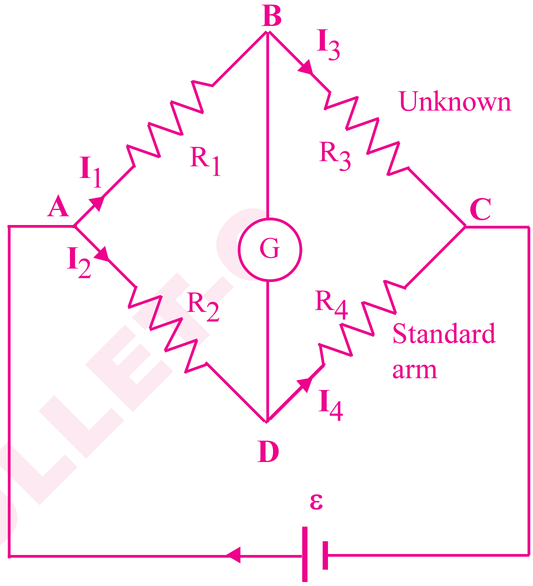
2) Kirchoff's Second Law : The algebraic sum of changes in potential around any closed loop involving resistors and cells in the loop is zero.

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 $I_1 R_1 + 0 - I_2 R_2 = 0$

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

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 $I_4 = I_2$

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

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 $I_g = 0$.