Previous IPE

SOLVED PAPERS

MARCH -2020 (TS)

PREVIOUS PAPERS

IPE: MARCH-2020(TS)

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

SECTION-A

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

1. What are cathode rays?
2. State Heisenberg's Uncertainty Principle.
3. Which gates are called Universal Gates?
4. Which type of communication is employed in mobile phones?
5. What is the magnetic moment associated with a solenoid?
6. A concave mirror produces an image of a long vertical pin, placed 40 cm from the mirror, at the position of the object. Find the focal length of the mirror.
7. Define magnetic declination
8. Distinguish between ammeter and voltmeter.
9. A power transmission line feeds input power at 2300V to a stepdown transformer with its primary windings having 4000turns. What should be the number of turns in the secondary in order to get output power at 230V?
10. What are the applications of microwaves?

SECTION-B

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

11. Explain the formation of a rainbow.
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 equatorial plane of an electric dipole.
14. Derive an expression for the capacitance of a parallel plate capacitor.
15. State and explain Biot-Savart Law.
16. Obtain an expression for the magnetic energy stored in a solenoid in terms of magnetic field B, area A and length L of the solenoid.
17. What are the limitations of Bohr's theory of hydrogen atom?
18. Distinguish between half-wave and full-wave rectifiers.

SECTION-C

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

19. Explain the formation of stationary waves in an air column enclosed in open pipe. Derive the equations for the frequencies of the harmonics produced.
    A open organ pipe 85cm long is sounded. If the velocity of sound is 330m/s, what is the fundamental frequency of vibration of the air column?
20. State the working principle of potentiometer. Explain with the help of circuit diagram how the potentiometer is used to determine the internal resistance of the given primary cell.
    In a potentiometer arrangement, a cell of emf 1.25V gives a balance point at 35.0cm length of the wire. If the cell is replaced by another cell and the balance point shifts to 63.0cm, what is the emf of the second cell?
21. Explain the principle and working of a nuclear reactor with the help of a labelled diagram.

IPE TS MARCH-2020

SOLUTIONS

SECTION-A

1. What are cathode rays?

A: 1) Cathode Rays: The rays emitted from cathode of a discharge tube, when the gas in it is subjected to low pressure (0.001 mm of Hg) and strong electric field, are called cathode rays.

2) The cathode rays are streams of electrons.

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2. 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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3. Which gates are called universal gates?

A : 1) Universal Gates: NAND and NOR gates are called universal gates.

2) Because any logic gate can be constructed by using NAND gate or NOR gate.

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4. Which type of communication is employed in Mobile Phones ?

A : 'Space wave communication' is employed in Mobile Phones.

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5. What is the magnetic moment associated with a solenoid ?

A : Magnetic Moment of a Solenoid: The magnetic moment associated with a solenoid is given by $\bar{M} = Ni\bar{A}$ where N is the number of turns, i is the current passing through it and $\vec{A}$ is the area of cross section.

6. A concave mirror produces an image of a long vertical pin, placed 40 cm from the mirror, at the position of the object. Find the focal length of the mirror.

Sol: v = –40 cm, u = –40 cm, f = ?

Mirror Formula : $\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{-40}+\frac{1}{-40}=\frac{1}{f} \Rightarrow f=-\frac{40}{2}=-20$ cm

Focal length of the mirror is –20 cm.

(–) sign indicates that it is concave mirror. ie, focal length of concave mirror is **20 cm.**

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7. Define magnetic declination.

A : **Magnetic Declination :** At a given place, the angle between the 'geographical meridian' and the 'magnetic meridian' is called Magnetic declination.

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8. Distinguish between ammeter and voltmeter.

A :

Ammeter	Voltmeter
1) It is a device used to measure current.	1) It is a device used to measure voltage.
2) It is connected in series to a circuit.	2) It is connected in parallel to a circuit.
3) It is prepared by connecting a very **small resistance** called shunt (r_s) in parallel to a galvanometer (G).	3) It is prepared by connecting a **high resistance**(R) in series to a galvanometer.

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9. A power transmission line feeds input power at 2300V to a stepdown transformer with its primary windings having 4000turns. What should be the number of turns in the secondary in order to get output power at 230V?

Sol: Given that Primary Voltage V_P=2300V

N_P=4000 turns Secondary VoltageV_S=230V

Formula: $\frac{V_S}{V_P}=\frac{N_S}{N_P} \Rightarrow \frac{230}{2300}=\frac{N_S}{4000} \Rightarrow N_S=400$

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10. What are applications of microwaves?

A : Microwaves are used in

1) microwave ovens to raise the temperature of food.
2) radar systems for air-craft navigation.
3) speed guns to measure the speed of fast moving balls, automobiles etc.

SECTION-B

11. Explain the formation of a rainbow.

A : 1) Rainbow :

i) The multicoloured arc that appears in the sky, opposite to sun on a rainy day is called rainbow.

ii) Rainbow is the combined effect of dispersion, refraction and total internal reflection of sunlight

iii) This happens due to spherical water droplets of rain in atmosphere.

iv) The water drops in atmosphere act as small prisms and cause dispersion and total internal reflection of sunlight to form rainbow.

2) Primary rainbow:

i) Sunlight is first refracted as it enters a rain drop, which causes different colours.

ii) These refracted rays strike the inner surface of the drop and get reflected internally.

iii) These internally reflected rays again get refracted at the opposite surface and come out.

iv) As red is less deviated, it comes straight to observer and appears on top.

v) As violet is deviated more, it comes from lower level drops and appears at bottom.

3) Secondary rainbow: It is formed due to double internal reflection of sunlight in the rain drop

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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.

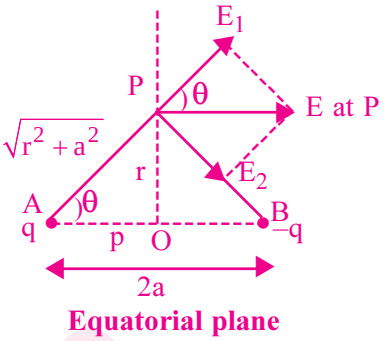
3) Let us take a pattern of black stripes of equal width (each 5 mm) separated by white stripes of increasing width (0.5mm, 1mm,1.5 mm....) from left to right as shown in the figure and paste it on a wall of the room.

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 equatorial plane 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 equatorial plane of a dipole at a distance r from its centre.

The magnitude of electric field at P due to +q is

$$E_1 = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r^2+a^2}\right) \quad .....(1)$$

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

From the figure, it is clear that the y-components of E_1 and E_2 are equal and opposite. Hence they cancel each other.

But the sum of x-components gives the resultant field E at P.

2) Intensity of resultant electric field is $E = E_1\cos\theta + E_2\cos\theta$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r^2+a^2}\right)\cos\theta + \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r^2+a^2}\right)\cos\theta = 2\frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r^2+a^2}\right)\cos\theta$$

From Δ PAO, $\cos\theta = \frac{a}{\sqrt{r^2+a^2}}$

$$\therefore E = 2\frac{1}{4\pi\varepsilon_0}\left(\frac{q}{r^2+a^2}\right)\frac{a}{\sqrt{r^2+a^2}} = \frac{q(2a)}{4\pi\varepsilon_0(r^2+a^2)^{3/2}}$$. But dipole moment P= q(2a)

$$\Rightarrow \text{Intensity of electric field } E = \frac{1}{4\pi\varepsilon_0}\frac{P}{(r^2+a^2)^{3/2}} \quad .....(3)$$

$$\therefore E = \frac{1}{4\pi\varepsilon_0}\frac{P}{r^3}$$ [$\because$ At larger distances (r>>a), the a^2 term can be neglected]

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

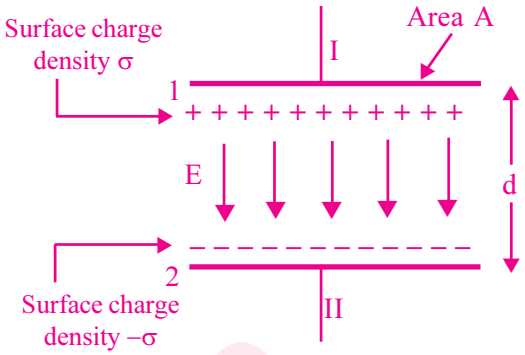
A : Capacitance of a parallel plate capacitor :

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 $\sigma = Q/A$ and the plate 2 has uniform charge density $-\sigma$.



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

he 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)

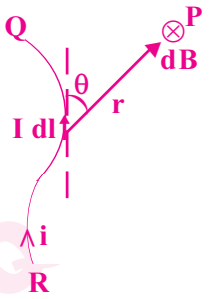
$$\Rightarrow \frac{V}{d} = \frac{Q}{\varepsilon_0 A} \left[\because E = \frac{V}{d}\right]$$

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

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

15. State and explain Biot-Savart law.

A: 1) Biot-Savart Law: The magnitude of magnetic field induction due to small element of current carrying conductor is directly proportional to the strength of the current, length of the element, sine of the angle between position vector and the element; and inversely proportional to the square of the distance of the point from the element.



2) Explanation: Suppose RQ is a conductor carrying a current i. dl is a small length of element on the conductor. The distance between dl and P is 'r'. Let θ be the angle between $\overline{dl}$ and radius vector $\overline{r}$. The magnetic induction due to dl is dB

Here according to Biotsavart law

(i) $dB \propto i$ (ii) $dB \propto dl$ (iii) $dB \propto \sin\theta$ (iv) $dB \propto \frac{1}{r^2}$

Thus, $dB \propto \frac{idl\sin\theta}{r^2}$ (or) $dB = \frac{\mu_0}{4\pi}\frac{idl\sin\theta}{r^2}$

Here $\frac{\mu_0}{4\pi} = 10^{-7}\ Hm^{-1}$

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16. Obtain an expression for the magnetic energy stored in a solenoid in terms of the magnetic field, area and length of the solenoid.

A: Magnetic Energy stored in a Solenoid:

1) The energy required to build up the current in a solenoid is given by $W = \frac{1}{2}Li^2$ .....(i) where L is the self inductance of the solenoid.

2) Self inductance of a solenoid is given by $L = \mu_0 n^2 A l$ ..... (ii) where n is number of turns per unit length, A is area of cross section, l is length of the solenoid.

3) Substituting equ (ii) in equ (i), we get $W = \frac{1}{2}(\mu_0 n^2 A l)I^2$..... (iii)

4) Magnetic induction inside a solenoid is $B = \mu_0 n i \Rightarrow i = B/\mu_0 n$ ..... (iv)

5) Putting this in equ (ii), we get $W = \frac{1}{2}(\mu_0 n^2 A l)\frac{B^2}{\mu_0^2 n^2} \Rightarrow W = \frac{1}{2\mu_0}B^2 Al$

This is the expression for magnetic energy stored in a solenoid.

17. What are the limitations of Bohr's theory of hydrogen atom ?

A : Limitations of Bohr's theory of Hydrogen atom :

1) It could not explain the **fine structure of spectral lines** in hydrogen atom.
2) It could not explain the **elliptical orbits** because Bohr assumed the circular orbits.
3) It could not explain the **wave properties** of electron.
4) It could not explain the **splitting of spectra** under **electric and magnetic field.**

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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 an air column enclosed in open pipe. Derive the equations for the frequencies of the harmonics produced.

A: **1) Open pipe:** A pipe open at 'both the ends' is called 'open pipe'.

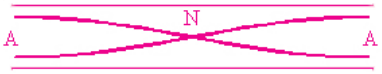
2) Formation of Stationary wave : When a sound wave is sent to an open pipe, the wave reflects back at the other end of the pipe. The incident wave and reflected wave 'travelling in opposite directions' **super impose each other** to produce Stationary waves.

3) Antinodes (A) are formed at the open ends.

4) Notation: l= length of air column, V= Velocity of sound in air, $\lambda_1, \lambda_2, \lambda_3$ are the wave lengths of waves in respective harmonics.

5) First Harmonic: Here, 1 node and 2 antinodes are formed.

Length of the air column = Half of the wavelength



$\Rightarrow l = \frac{\lambda_1}{2} \quad \Rightarrow \lambda_1 = 2l$

$\therefore$ Frequency of first harmonic $n_1 = \frac{V}{\lambda_1} = \frac{V}{2l} \qquad \therefore n_1 = \frac{V}{2l}$ .....(i)

6) Second Harmonic: Here, 2 nodes and 3 antinodes are formed.

Length of the air column $l = \frac{\lambda_2}{2} + \frac{\lambda_2}{2} = \lambda_2 \Rightarrow \lambda_2 = l$

$\therefore$ Frequency of the second harmonic $n_2 = \frac{V}{\lambda_2} = \frac{V}{l} = 2\left(\frac{V}{2l}\right) = 2n_1$ .....(ii)

7) Third Harmonic: Here, 3 nodes and 4 antinodes are formed.

The length of the air column $l = \frac{3\lambda_3}{2} \Rightarrow \lambda_3 = \frac{2l}{3}$

$\therefore$ Frequency of the third harmonic $n_3 = \frac{V}{\lambda_3} = V\left(\frac{3}{2l}\right) = 3n_1$ .....(iii)

8) From (i), (ii) & (iii) we have $n_1 : n_2 : n_3 : \ldots\ldots = \cancel{n_1} : 2\cancel{n_1} : 3\cancel{n_1} \ldots\ldots = 1:2:3:\ldots\ldots$

b) A open organ pipe 85cm long is sounded. If the velocity of sound is 340m/s, what is the fundamental frequency of vibration of the air column?

Sol: l=85 cm = 0.85 m , v = 340 m/s, ν=?

Formula for open pipe: $\nu = \frac{v}{2l}$

$\Rightarrow \nu = \frac{340}{2 \times 0.85} = 200$ Hz

20. State the working principle of potentiometer. Explain with the help of circuit diagram how the potentiometer is used to determine the internal resistance of the given primary cell.

A : 1) Potentiometer : Potentiometer is a device used to measure emf of a cell without drawing any current from it.

2) Construction: Potentiometer consists of a wooden board on which a uniform manganin wire of length 4 m is fixed in parallel rows between two binding screws A and C, by the side of a metre scale. A jockey is provided to make a contact at any point of the wire.

3) Principle: The potential difference (E) between any 2 points of the wire is directly proportional to the length l of the wire between the two points. $\varepsilon \propto l \Rightarrow \varepsilon = \phi l$

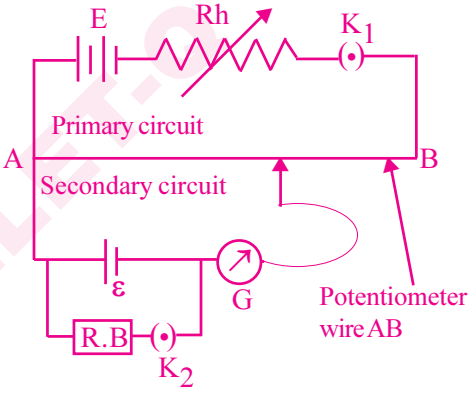
Here, ϕ is potential drop per unit length of the wire.

4) Determining Internal Resistance of a Cell:

The cell of emf ε, whose internal resistance r is to be determined is connected across a resistance box through a key K_2.

First the key K_1 is closed. Then keeping K_2 open, the position of the jockey is adjusted until the galvanometer shows 'null deflection'.

Its balancing length l_1 of the wire is noted.



In the first case, the cell is in the circuit ,

$\therefore$ Emf of the cell $\varepsilon = \phi\, l_1$ .....(1)

where ϕ is potential drop per unit length of the potentiometer wire.

Now the key K_2 is closed to include R in the circuit.

Again the position of the jockey is adjusted for null deflection of the galvanometer.

Balancing length of the wire l_2 is noted.

In this second case, R is in parallel to the cell.

The terminal voltage is given by $V = \phi\, l_2$ .....(2)

Dividing equation (1) by equation (2) we get, $\frac{\varepsilon}{V} = \frac{l_1}{l_2}$ .....(3)

But $\varepsilon = I(R + r)$ and $V = IR \Rightarrow \frac{\varepsilon}{V} = \frac{R+r}{R}$ ..... (4)

From (3) and (4), we get $\frac{R+r}{R} = \frac{l_1}{l_2} \Rightarrow 1 + \frac{r}{R} = \frac{l_1}{l_2} \Rightarrow \frac{r}{R} = \left(\frac{l_1}{l_2} - 1\right) \Rightarrow r = R\left(\frac{l_1}{l_2} - 1\right)$

Using this formula, Internal resistance r of the cell can be calculated.

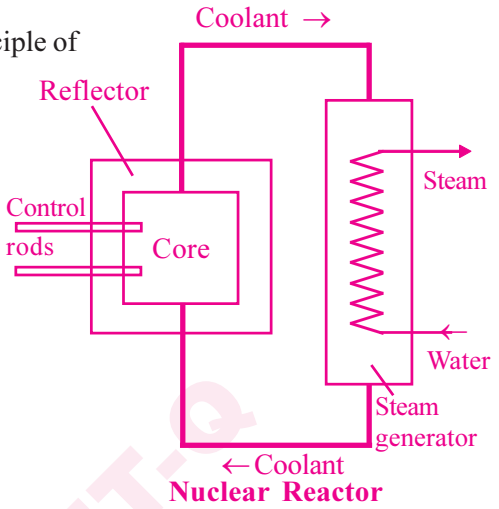
b) In a potentiometer arrangement, a cell of emf 1.25V gives a balance point at 35.0cm length of the wire. If the cell is replaced by another cell and the balance point shifts to 63.0cm, what is the emf of the second cell?

Sol: Given that $\varepsilon_1 = 1.25V$, $l_1 = 35.0cm$, $l_2 = 63.0cm$, $\varepsilon_2 = ?$

Formula: $\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2} \Rightarrow \varepsilon_2 = \frac{\varepsilon_1 \times l_2}{l_1} = \frac{1.25 \times 63}{35} = 2.25V$

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

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.