

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

**10-Years
Solved FBISE Papers
Federal Board**

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

FBI SE PAPER # (2008)

PHYSICS HSSC-II (2008)

SECTION-A (Marks 17)

Time: 25 Minutes

Marks: 17

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 25 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q.1 Insert the correct option i.e. A/B /C/ D in the empty box provided opposite each part. Each part carries one mark.

(i) Viewed from above, the current in a solenoid is anti-clockwise. What magnetic pole would the top end of the solenoid be?

- A. North pole
B. South pole
C. May be North or South
D. Insufficient data

(ii) If the distance between two charged bodies is halved, what will the force between them become?

- A. Double
B. Half
C. Four times
D. One half

(iii) The ratio of collector current to the base current is nearly equal and is known as:

- A. Reverse bias current
B. Forward bias current
C. Emitter current
D. Current gain

(iv) 1×10^7 electrons pass through a wire in $1\mu\text{s}$. The current through the wire will be:

- A. $1.6 \times 10^{-6} \text{ A}$ B. $2.6 \times 10^{-6} \text{ A}$
C. $3.6 \times 10^{-6} \text{ A}$ D. $4.6 \times 10^{-6} \text{ A}$

(v) What is the barrier potential of silicon diode at room temperature?

- A. 0.3 V B. 0.7 V C. 1V D. 2mV

(vi) Which of the following bands may be either completely filled or partially filled by electrons but can never be empty?

- A. Conduction band
B. Valance band
C. Forbidden band
D. None of these

(vii) By increasing the frequency of an alternating current the value of inductive reactance.

- A. Increases
B. Decreases
C. Does not change
D. None of these

(viii) What is the % elongation when one m long copper wire is stretched by 20 cm due to a stress?

- A. 10 B. 20 C. 30 D. 0.2

(ix) What will be the output value of an OR operational gate when both the switches (input A and input B) are open?

- A. 0 B. 1 C. Both 0 and 1 D. None of these

(x) What should be done to increase the sensitivity of a Galvanometer?

- A. Increase the number of turns

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

- Physics 12th
- B. Increase the area of its coil
C. Place its coil in a stronger field
D. All of these
- (xi) **A dynamo converts?**
A. Mechanical energy into electrical energy
B. Electrical energy into mechanical energy
C. Magnetic energy into mechanical energy
D. Magnetic energy into electrical energy
- (xii) **What are the minority charge carriers in an N-type substance?**
A. Protons
B. Positron
C. Holes
D. Electrons
- (xiii) **Which of the following cannot be accelerated by an electric or magnetic field?**
A. Electrons
B. Protons
C. Neutrons
D. Alpha particles
- (xiv) **What does larger capacitance in A.C circuit results at the same frequency?**
A. More reactance
B. The same reactance
C. Less reactance
D. Less reactance if voltage decreases
- (xv) **What effect do two parallel wires carrying currents in the opposite directions have on each other?**
A. Repel
B. Attract
C. Have no effect
D. They cancel out their individual magnetic fields
- (xvi) **The amount of energy needed to remove electron from the metal surface depends upon:**
A. Work
B. Work function
C. Power
D. Power function
- (xvii) **Electron in hydrogen atom jumps from any higher orbit to 1st orbit. What is the set of lines emitted called?**
A. Lyman series
B. Paschen series
C. Pfund series
D. Bracket series

PHYSICS HSSC-II

Time allowed: 2:35 Hours

Total Marks = 68

Note: Sections 'B' and 'C' are to be answered on the separately provided answer book. Answer any fourteen the questions from section 'B' and attempt any two questions from section 'C' Use supplementary answer sheet i.e., sheet B if required. Write your answers neatly and legibly.

SECTION-B (Marks 42)

- Q. 2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines. (14×3 = 42)
- (i) Two conducting spheres having charges $3Q$ and $5Q$ attract each other with a force of 10JV. They are then touched with each other and then separated to the same distance again. Calculate the magnitude and nature of force now.

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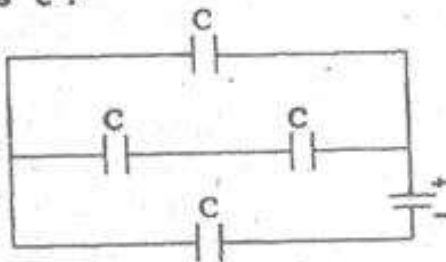
340

Physics 12th

- (ii) A conducting wire of resistance " R " is cut into three equal parts and then these three parts are joined in parallel. Calculate the equivalent resistance.
- (iii) At what speed of an observer the length of an object will appear as 70% of its proper length?
- (iv) What happens to light intensity of lamps in a series circuit when more lamps are added in the circuit?
- (v) Discuss the situation when:-
 a. Electric intensity at a point is zero but electric potential is not zero.
 b. Electric potential at a point is zero but electric intensity is not zero.
- (vi) A balloon is negatively charged by rubbing and then set free. It first clings to a wall but eventually falls down. Why?
- (vii) When we hold a live wire standing barefoot we get an electric shock while wearing plastic or rubber shoes we don't. Explain the reason.
- (viii) In a Hydrogen atom there are two attractions between electron and proton. Name them. Also find their magnitudes if the radius of Hydrogen atom is 0.053 nm .
- (ix) Write down three differences between Coulomb's electrostatic force and gravitational force.
- (x) What will be the instantaneous value of alternating voltage at time " $T/6$ " where " T " is the time period of the alternating voltage?
- (xi) What factors make a fusion reaction difficult to achieve?
- (xii) How can radioactivity help in the treatment of cancer?
- (xiii) The decay constant for ^{90}Sr is $1.99 \times 10^{-5} \text{ s}^{-1}$. Calculate its half life.
- (xiv) A capacitor is connected across a battery:
 a. Why does each plate receive charge of exactly the same magnitude?
 b. Is this true even if the plates are of different sizes?
 c. Will there be any current flowing through the circuit?
- (xv) Find the equivalent resistance for the combination shown in the figure (Between A and B). Resistance of each resistor is " R ".



- (xi) Find the equivalent capacitance of the circuit if the capacitance of each capacitor is " C ":-



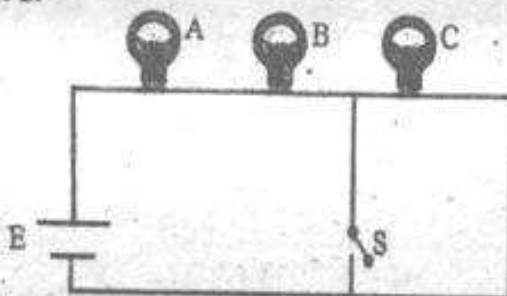
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341

Physics 12^a

(xvii) A series circuit of three identical lamps is connected to a battery as shown in figure.



When switch "S" is closed what effect will it have on the following:-

- Brightness of A and B.
- Brightness of lamp "C".
- Current in the circuit.

(xviii) The resistance of a conductor decreases with the increase in cross sectional area of the conductor. Why?

(xix) Why do we choose a potentiometer to measure potential difference accurately, rather than a voltmeter?

SECTION - C (Marks 26)

Note: Attempt any TWO questions.

(2×13 = 26)

Q. 3 a. What is mutual induction? Explain how induced emf is produced in the secondary coil. What factors does mutual induction depend upon?

1 + 4 + 2

b. Name the unit of mutual induction and define it.

02

c. An emf of 5.6 V is induced in a coil while the current in a nearby coil is decreased from 100 A to 20 A in 0.02 s. What is the mutual inductance of the two coils? If the secondary coil has 200 turns, find the change in the flux during this interval.

04

Q. 4 a. What is Compton Effect? Prove that the wave-length of the photon increases after collision with the electron.

2 + 5

b. A 50 KeV photon is Compton scattered by quasi-free electron. If the scattered photon comes off at 45°, what is its wavelength?

04

c. Explain why bright light ejects more electrons from a metal surface than dimmer light of the same colour?

02

Q. 5 a. State the basic postulates of Bohr's atomic model of the hydrogen atom. Also derive expressions for radii of quantized orbits of electron.

07

b. What is meant by half life of a radioactive element? How can it be determined from the decay constant of radioactive element?

04

c. Compute the shortest wave length radiation in the Balmer series. What value of "n" must be used? And why?

02

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

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342

Physics 12th

SOLUTION OF FBISE PAPER # (2008)

SECTION- A (MCQs)

i. A	ii. C	iii. D	iv. A	v. B	vi. A
vii. B	viii. B	ix. B	x. D	xi. A	xii. C
xiii. C	xiv. B	xv. A	xvi. B	xvii.	

SECTION- B

- (i) Two conducting spheres having charges $3Q$ and $5Q$ attract each other with a force of 10 N . They are then touched with each other and then separated to the same distance again. Calculate the magnitude and nature of force now.

Ans: $q_1 = 3Q$, $q_2 = 5Q$, $F = 10\text{ N}$
 We know that

$$F = k \frac{q_1 q_2}{r^2} \Rightarrow r^2 = k \frac{q_1 q_2}{F}$$

Taking square root on b/s, we get

$$r = \sqrt{k \frac{q_1 q_2}{F}} \Rightarrow r = \sqrt{9 \times 10^9 \frac{3 \times 5}{10}}$$

$$r = \sqrt{9 \times 10^9 \frac{3 \times 5}{10}} \Rightarrow r = 2.01 \times 10^5$$

- (ii) A conducting wire of resistance " R " is cut into three equal parts and then these three parts are joined in parallel. Calculate the equivalent resistance.

Ans: $\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
 $\frac{1}{R_e} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} = \frac{1+1+1}{R} = \frac{3}{R}$
 $R_e = \frac{R}{3} = \frac{1}{3} R$

- (iii) At what speed of an observer the length of an object will appear as 70% of its proper length?

Ans: Given that:

$$l = 70\% \text{ of } l_o$$

To find:

$$V = ?$$

We know that:

$$l = l_o \sqrt{1 - \frac{v^2}{c^2}} \Rightarrow 70\% l_o = l_o \sqrt{1 - \frac{v^2}{c^2}} \Rightarrow 0.70 = \sqrt{1 - \frac{v^2}{c^2}}$$

Taking square on both sides, we get

$$0.49 = 1 - \frac{v^2}{c^2} \Rightarrow \frac{v^2}{c^2} = 1 - 0.49 \Rightarrow \frac{v^2}{c^2} = 1 - 0.49$$

$$\frac{v^2}{c^2} = 0.51 \Rightarrow v^2 = 0.51 c^2$$

Taking square root on both sides we get

$$v = 0.71 c$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

343

Physics 12^a

(iv) What happens to light intensity of lamps in a series circuit when more lamps are added in the circuit?

Ans: As in the series circuit current will be same. So addition of more lamps in a series circuit will have no effect on the intensity of lamp because intensity of lamp does not depend on whether the lamps are in series or parallel circuit.

(v) Discuss the situation when:-

a. Electric intensity at a point is zero but electric potential is not zero.

Ans: Electric intensity is zero because electric field intensity is a vector quantity and it has only one direction along a given point.

When equilibrium is established the electrostatic force becomes zero and hence by formula Electric intensity becomes zero.

$$E = \frac{F}{q}$$

But Electric potential is not zero because it is a source to run the charges.

b. Electric potential at a point is zero but electric intensity is not zero.

Ans: If we have two charges, one is positive and other is negative of the same magnitude by a small distance then the electric potential due to positive and negative charges is given by

$$V^+ = \frac{q}{4\pi\epsilon_0 d} \quad \text{and} \quad V^- = -\frac{q}{4\pi\epsilon_0 d}$$

Where d is the distance midway between them so

$$V = V^+ + V^-$$

Electric field intensity due to positive and negative charges is given by

$$E = \frac{q}{4\pi\epsilon_0 d^2} \quad \text{and} \quad E = \frac{q}{4\pi\epsilon_0 d^2}$$

So the electric field intensity exists.

(vi) A balloon is negatively charged by rubbing and then set free. It first clings to a wall but eventually falls down. Why?

Ans: Because the wall is positively charged due to difference in charges the balloon clings to wall but after some time the balloon becomes neutral due to electrostatic induction and due to no same charge (repulsion) it falls down.

(vii) When we hold a live wire standing barefoot we get an electric shock while wearing plastic or rubber shoes we don't. Explain the reason.

Ans: When we hold wire standing barefoot we get an electric shock because our foot touches the ground which is a pure conductor of electricity, forms a circuit and current flows from it but the plastic and rubber shoes are bad conductors of electricity they do not carry electricity (potential difference becomes zero) and no current flows from it that's why we do not get electric shock from it.

(viii) In a Hydrogen atom there are two attractions between electron and proton. Name them. Also find their magnitudes if the radius of Hydrogen atom is 0.053 nm.

Ans: Coulomb's force as reaction force and Centripetal force as an action force. Magnitude of two forces are as:

$$F_c = \frac{mv_n^2}{r_n}$$

and

$$F_e = \frac{ke^2}{r_n^2}$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

344

Physics 12*

- (ix) Write down three differences between Coulomb's electrostatic force and gravitational force.

Ans: a. The value of gravitational constant G is very small as compared to electrical constant $\frac{1}{4\pi\epsilon_0}$. It is because of this fact that the gravitational force is a very weak force as compared to electrostatic force.

b. As regards their qualitative aspect, the electrostatic force could be attractive or repulsive while, on the other hand, gravitational force is only attractive.

c. Another difference to be noted is that the electrostatic force is medium dependant and can be shielded while gravitational force lacks this property.

- (x) What will be the instantaneous value of alternating voltage at time " $T/6$ " where " T " is the time period of the alternating voltage?

Ans:

$$v = v_o \sin \omega t$$

$$v = v_o \sin \frac{2\pi}{T} \times \frac{T}{6}$$

$$v = v_o \sin 2\pi \times \frac{1}{6} = v_o \sin \frac{\pi}{3} = v_o \sin(60^\circ)$$

$$v = 0.866 v_o$$

- (xi) What factors make a fusion reaction difficult to achieve?

Ans: Difficulties to achieve nuclear fusion reaction:

We know that for fusion of two light nuclei the work has to be done to overcome the repulsive force which exists between them. For this the two nuclei are hurled towards one another at a very high speed. One method to do so is to give these nuclei a very large velocity with the help of an accelerator. This method has been used in the research study of nuclear fusion of ${}^2_1H$ and ${}^3_1H$. But this method of nuclear fusion for getting energy cannot be used on a large scale.

- (xii) How can radioactivity help in the treatment of cancer?

Ans: Young and rapidly growing cells are particularly susceptible; hence X-rays are useful for selective destruction of cancer cells. On the other hand a cell may be damaged by radiation but survive, continue dividing and produce generation of defective cells. Thus X-rays can cause cancer.

- (xiii) The decay constant for Sr is $1.99 \times 10^{-5} s^{-1}$. Calculate its half life.

Ans: We know that

$$\lambda T_{1/2} = 0.693$$

$$1.99 \times 10^{-5} T_{1/2} = 0.693$$

$$T_{1/2} = \frac{0.693}{1.99 \times 10^{-5}} = 34824.12$$

- (xiv) A capacitor is connected across a battery:

a. Why does each plate receive charge of exactly the same magnitude?

b. Is this true even if the plates are of different sizes?

c. Will there be any current flowing through the circuit?

Ans: a. Because each plate is connected in series.

b. Yes it is true plates receive current even they are of different sizes.

c. Yes the current will flow through the circuit.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

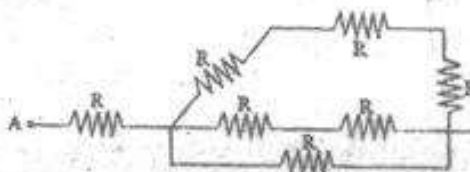
345

Physics 12th

(xv) Find the equivalent resistance for the combination shown in the figure (Between A and B). Resistance of each resistor is "R".

Ans: For Parallel:

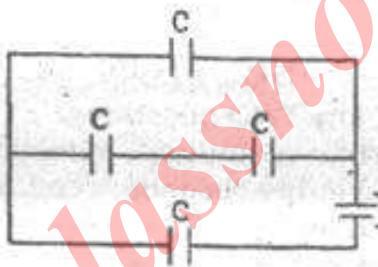
$$\frac{1}{R_e} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R} \Rightarrow R_e = \frac{R}{2}$$



Now all the resistances are in series:

$$R_E = R + R + R + R + R + \frac{R}{2} = \frac{2R + 2R + 2R + 2R + 2R + R}{2} = \frac{11R}{2}$$

(xi) Find the equivalent capacitance of the circuit if the capacitance of each capacitor is "C":-



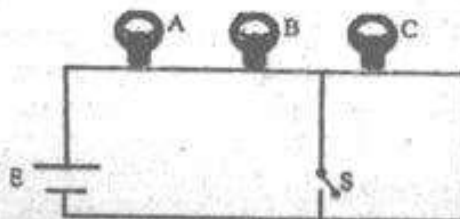
Ans: For series Combination:

$$\frac{1}{C_e} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C} \Rightarrow C_e = \frac{C}{2}$$

For parallel combination:

$$C_e = C + \frac{C}{2} + C \Rightarrow C_e = \frac{5C}{2}$$

(xvii) A series circuit of three identical lamps is connected to a battery as shown in figure.



When switch "S" is closed what effect will it have on the following:-

- Brightness of A and B.
- Brightness of lamp "C".
- Current in the circuit.

Ans: a. Brightness of A and B enhanced.
 b. Brightness of lamp C is same as A and B.
 c. Current will remain same due to series combination.

(xviii) The resistance of a conductor decreases with the increase in cross sectional area of the conductor. Why?

Ans: We know that

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

346

Physics 12th

$$R = \rho \frac{L}{A}$$

From the given formula resistance is inversely proportional to the cross sectional area if area increase the resistance will be decreased.

(xix) Why do we choose a potentiometer to measure potential difference accurately, rather than a voltmeter?

Ans: Because the voltmeter is connected across the two points in a circuit between which potential difference is to be measured. It is necessary that the resistance of the voltmeter be large compared to the circuit resistance across which the voltmeter is connected. Otherwise an appreciable current will flow through the voltmeter which will alter the circuit current and the potential difference to be measured. Thus the voltmeter can read the correct potential difference only when it does not draw any current from the circuit across which it is connected. Where the potentiometer measure the potential difference accurately and it does not draw any current from the circuit.

SECTION - C (Marks 26)

Note: Attempt any **TWO** questions.

(2×13 = 26)

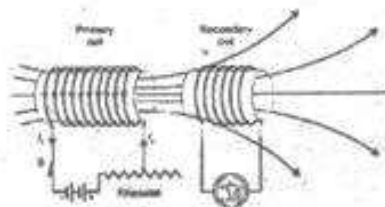
Q.3 a. What is mutual induction? Explain how induced emf is produced in the secondary coil. What factors does mutual induction depend upon?

Ans: Mutual induction:

The phenomenon in which a changing current in one coil induces an emf in another coil is called the mutual induction.

Derivation of mutual induction:

i. Consider two coils placed close to each other. One coil connected with a battery through a switch and a rheostat is called the "primary" and the other one connected to the galvanometer is called the "secondary".



ii. If the current in the primary is changed by varying the resistance of the rheostat, the magnetic flux in the surrounding region changes. Since the secondary coil is in the magnetic field of the primary, the changing flux also links with the secondary. This causes an induced emf in the secondary.

iii. According to Faraday's law, the emf induced in the secondary coil is proportional to the rate of change of flux $\frac{\Delta \phi_s}{\Delta t}$ passing through it, i.e.,

$$\mathcal{E}_s = - N_s \frac{\Delta \phi_s}{\Delta t}$$

Where N_s is the number of turns in the secondary coil.

iv. Mutual inductance:

Let the flux passing through one loop of the secondary coil be ϕ_s . Net flux passing through the coil of N_s loops is $N_s \phi_s$. As this flux is proportional to the magnetic field produced by the current I_p in the primary and the magnetic field itself is proportional to I_p , therefore

$$\begin{aligned} N_s \phi_s &\propto I_p \\ N_s \phi_s &= M I_p \quad \dots\dots\dots (1) \end{aligned}$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

347

Physics 12th

Where $M = \frac{N_s \phi_s}{I_p}$ is proportionality constant called the mutual inductance of the two coils. It depends upon the number of turns of the coils, their area of cross - section, their closeness together and the nature of the core material upon which the two coils are wound.

v. By Faraday's law the emf induced in the secondary coil is given by the rate of change of flux through the secondary.

$$\mathcal{E}_s = -N_s \frac{\Delta \phi_s}{\Delta t} = - \frac{\Delta N_s \phi_s}{\Delta t}$$

Putting $N_s \phi_s = MI_p$ from Eq.1

$$\mathcal{E}_s = - \frac{\Delta(MI_p)}{\Delta t}$$

$$\mathcal{E}_s = - M \frac{\Delta I_p}{\Delta t} \dots \dots \dots (2)$$

The Eq.2 shows that the emf induced in the secondary is proportional to the time rate of change of current in the primary.

Note: The negative sign in Eq.2 indicates the fact that the induced emf is in such a direction that it opposes the change of current in the primary coil. While finding out the value of M from Eq.2, negative sign is ignored. Thus M may be defined as the ratio of average emf induced in the secondary to the time rate of change of current in the primary.

$$M = \frac{\mathcal{E}_s}{\frac{\Delta I_p}{\Delta t}}$$

b. **Name the unit of mutual induction and define it.**

Ans: Unit of mutual induction:

The SI unit for the mutual inductance M is Vs A⁻¹, which is called as henry (H) after Joseph Henry.

Henry:

"One henry is the mutual inductance of the pair of coils in which the rate of change of current of one ampere per second in the primary causes an induced emf of one volt in the secondary."

c. **An emf of 5.6 V is induced in a coil while the current in a nearby coil is decreased from 100 A to 20 A in 0.02 s. What is the mutual inductance of the two coils? If the secondary coil has 200 turns, find the change in the flux during this interval.**

Ans: Solution:

emf induced in the secondary coil = $\mathcal{E}_s = 5.6\text{V}$

Change in current in primary coil = $\Delta I_p = 100\text{ A} - 20\text{A}$

Change in current in primary coil = $\Delta I_p = 80\text{A}$

Time interval for the change = $\Delta t = 0.02\text{s}$

Number of turns in the secondary coil = $N_s = 200$

Mutual inductance = $M = ?$

Change in flux = $\Delta \phi = ?$

Using the relation for mutual inductance

$$\mathcal{E}_s = M \frac{\Delta I_p}{\Delta t}$$

$$5.6 = M \times \frac{80}{0.02}$$

$$M = \frac{5.6 \times 0.02}{80} = 1.4 \times 10^{-3} \text{ Vs A}^{-1} \text{ Ans.}$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

348

Physics 12th

According to Faraday's law

$$\varepsilon_s = N_s \frac{\Delta\phi}{\Delta t}$$

$$\varepsilon_s \Delta t = N_s \Delta\phi$$

$$\Delta\phi = \frac{\varepsilon_s \Delta t}{N_s} = \frac{5.6 \times 0.02}{200} = 5.6 \times 10^{-4} \text{ Wb Ans.}$$

Q. 4 a. What is Compton Effect? Prove that the wave-length of the photon increases after collision with the electron.

Ans: Compton effect:

When X-rays are scattered by loosely bound electrons from a graphite target, it is known as Compton effect.

Explanation:

i. Arthur Holly Compton at Washington University in 1923 studied the scattering of X-rays by loosely bound electrons from a graphite target.

ii. He measured the wavelength of X-rays scattered at an angle θ with the original direction. He found that wavelength λ_s of the scattered X-rays is larger than the wavelength λ_i of the incident X-rays. This is known as Compton effect.

iii. The increase in wavelength of scattered X-rays could not be explained on the basis of classical wave theory. Compton suggested that X-rays consist of photons and in the process of scattering the photons suffer collision with electrons like billiard balls. In this collision, a part of incident photon energy and momentum is transferred to an electron.

iv. Compton shift ($\Delta\lambda$):

Applying energy and momentum conservation laws to the process, he derived an expression for the change in wavelength $\Delta\lambda$ known as Compton shift for scattering angle θ as

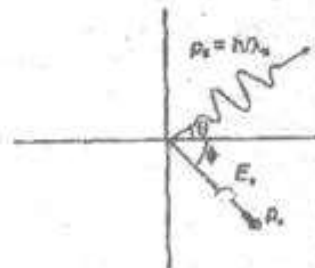
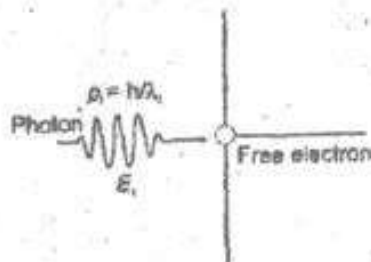
$$\Delta\lambda = \frac{h}{m_0 c} (1 - \cos\theta) \dots \dots \dots (1)$$

where m_0 is the rest mass of the electron.

v. Compton wavelength ($\frac{h}{m_0 c}$):

The factor $\frac{h}{m_0 c}$ has dimensions of length and is called Compton wavelength and has the numerical value

$$\frac{h}{m_0 c} = \frac{6.6 \times 10^{-34} \text{ Js}}{9.1 \times 10^{-31} \text{ kg} \times 3 \times 10^8 \text{ ms}^{-1}} = 2.43 \times 10^{-12} \text{ m}$$



vi. If the scattered X-ray photons are observed at $\theta = 90^\circ$, the Compton shift $\Delta\lambda$ equals the Compton wavelength.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Physics 12th

Note: The Eq.1 was found to be in complete agreement with Compton's experimental result, which again is a striking confirmation of particle like interaction of electromagnetic waves with matter.

Arthur Holly Compton was awarded Nobel Prize in physics in 1927 for his discovery of the effect named after him.

- b. **A 50KeV photon is Compton scattered by quasi-free electron. If the scattered photon comes off at 45°, what is its wavelength?**

Ans: Solution:

$$\text{Energy of photon} = E = 50 \text{ k eV} = 50 \times 10^3 \times 1.6 \times 10^{-19} \text{ J} = 80 \times 10^{-16} \text{ J}$$

$$\text{Angle} = \theta = 45^\circ$$

$$\text{Wavelength of scattered photon} = \lambda = ?$$

Wavelength of incident photon can be calculated by using the relation

$$E = hf$$

$$\text{or } E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E}$$

$$\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{80 \times 10^{-16}} = \frac{19.89 \times 10^{-26}}{80 \times 10^{-16}} = 0.0248 \text{ nm}$$

Now, the relation for change in wavelength is

$$\Delta \lambda = \lambda' - \lambda = \frac{h}{m_0 c} (1 - \cos \theta)$$

$$\lambda' - \lambda = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 3 \times 10^8} \times (1 - \cos 45^\circ) = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{27.3 \times 10^{-23}} \times (1 - 0.707)$$

$$\lambda' - \lambda = 0.2429 \times 10^{-11} \times 0.293 = 0.0007 \text{ nm}$$

$$\lambda = \lambda + 0.0007 = 0.0248 + 0.0007 = 0.0255 \text{ nm Ans.}$$

- c. **Explain why bright light ejects more electrons from a metal surface than dimmer light of the same colour?**

Ans: As in photoelectric effect the number of photoelectrons emitted is directly proportional to intensity of light used, so the bright light reject more electrons as compared to dimmer light.

- Q. 5 a. **State the basic postulates of Bohr's atomic model of the hydrogen atom. Also derive expressions for radii of quantized orbits of electron.**

Ans: Bohr's model of the hydrogen atom:

In order to explain the empirical results obtained by Rydberg, Neils Bohr, in 1913, formulated a model of hydrogen atom utilizing classical physics and Planck's quantum theory. This semi classical theory is based on the following three postulates:

Postulate I:

An electron, bound to the nucleus in an atom, can move around the nucleus in certain circular orbits without radiating. These orbits are called the discrete stationary states of the atom.

Postulate II:

Only those stationary orbits are allowed for which orbital angular momentum is equal to an integral multiple of $\frac{h}{2\pi}$ i.e.,

$$mvr = \frac{nh}{2\pi} \quad (1)$$

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where $n = 1, 2, 3, \dots$ and n is called the principal quantum number, m and v are the mass and velocity of the orbiting electron respectively, and h is Planck's constant.

Postulate III:

Whenever an electron makes a transition, that is, jumps from high energy state E_n to a lower energy state E_p , a photon of energy hf is emitted so that

$$hf = E_n - E_p \quad (2)$$

where $f = c/\lambda$ is the frequency of the radiation emitted.

Quantized radii:

Consider a hydrogen atom in which electron moving with velocity v_n is in stationary circular orbit of radius r_n . From Eq.

$$mvr = \frac{nh}{2\pi} \quad (1)$$

$$v_n = \frac{nh}{2\pi m r_n} \quad (1)$$

As electron to stay in the circular orbit, shown in Fig., the centripetal force, $F_c = \frac{mv_n^2}{r_n}$ is provided by the Coulomb's force $F_e = \frac{ke^2}{r_n^2}$, where 'e' is the magnitude of charge on electron as well as on the hydrogen nucleus consisting of a single proton. Thus,

$$\frac{mv_n^2}{r_n} = \frac{ke^2}{r_n^2} \quad (2)$$

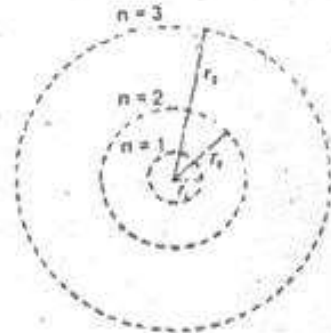
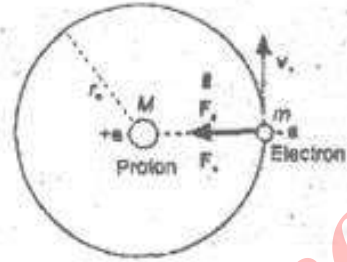
where constant k is equal to $\frac{1}{4\pi\epsilon_0}$.

After substituting for v_n from Eq. 1, we have

$$r_n = \frac{n^2 h^2}{4\pi^2 k m e^2} = n^2 r_1 \quad (3)$$

where $r_1 = \frac{h^2}{4\pi^2 k m e^2} = 0.053 \text{ nm}$

This agrees with the experimentally measured values and is called the first Bohr orbit radius of the hydrogen atom.



Note: Thus according to Bohr's theory, the radii of different stationary orbits of the electrons in the hydrogen atom are given by $r_n = r_1, 4r_1, 9r_1, 16r_1, \dots$

The first Bohr orbit in the hydrogen atom has a radius $r_1 = 5.3 \times 10^{-11} \text{ m}$.

The second and third Bohr orbits have radii $r_2 = 4r_1$ and $r_3 = 9r_1$ respectively.

b. What is meant by half life of a radioactive element? How can it be determined from the decay constant of radioactive element?

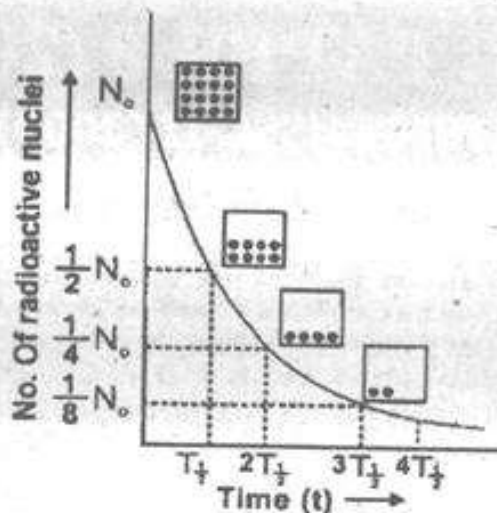
Ans: Half life: It is the period in which half of the radioactive element atoms decay. An element completely decayed after an infinite time.

If at any particular time the number of radioactive atoms be N , then in an interval Δt , the number of decaying atom, ΔN is proportional to the time interval Δt and the number of atoms N , i.e.,

$$\Delta N \propto -N \Delta t$$

$$\Delta N = -\lambda N \Delta t \quad (1)$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)



where λ is the constant of proportionality and is called decay constant.

- c. **Compute the shortest wave length radiation in the Balmer series.**
What value of "n" must be used? And why?

Solution: For Balmer series

$$P = 2$$

$$n = \infty \quad (\text{infinity only for shortest wavelength})$$

$$R_H = 1.0974 \times 10^7 \text{ m}^{-1}$$

$$\lambda_{\min} = ?$$

The general formula to find wavelength in hydrogen spectrum:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{p^2} - \frac{1}{n^2} \right)$$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{(2)^2} - \frac{1}{(\infty)^2} \right) = 1.097 \times 10^7 \times \frac{1}{4} \quad (\because \frac{1}{\infty} = 0)$$

$$\lambda = \frac{4}{1.097 \times 10^7} = 364.5 \times 10^{-9} = 364.5 \text{ nm Ans.}$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

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334

Page No.

FBISE PAPER # (2009)

PHYSICS HSSC-II (2009)

SECTION-A (Marks 17)

Time: 25 Minutes

Marks: 17

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 25 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q.1 Insert the correct option i.e. A / B / C / D in the empty box provided opposite each part. Each part carries one mark.

(i) The copying process is called:

A. Xerography

B. Topography

C. Neurography

D. Spectroscopy

(ii) When air is used as dielectric between the plates of a parallel plate capacitor then its capacitance is:

A. $\frac{A\epsilon_0}{d}$

B. $\frac{Q}{A\epsilon_0}$

C. $\frac{Qd}{A\epsilon_0}$

D. $\frac{Q}{A\epsilon_0 d}$

(iii) The terminal potential difference of a cell is given by:

A. $V_1 = \frac{E}{R+r}$

B. $V_1 = E - IR$

C. $V_1 = \frac{E}{IR}$

D. None of these

(iv) In SI unit the value of μ_0 is:

A. $4\pi \times 100^7 \text{ WbA}^{-1}\text{m}^{-1}$

B. $4\pi \times 100^7 \text{ WbA}^{-1}\text{m}$

C. $4\pi \times 100^7 \text{ WbAm}^{-1}$

D. $4\pi \times 10^{-7} \text{ WbA}^{-1}\text{m}^{-1}$

(v) The e/m of an electron moving with the speed along a circular path in a magnetic field is given as:

A. $\frac{e}{m} = \frac{B^2 R}{E}$

B. $\frac{e}{m} = \frac{E}{B^2 R}$

C. $\frac{e}{m} = \frac{E^2}{B^2 R}$

D. $\frac{e}{m} = \frac{ER}{B^2}$

(vi) The principle of electric generator depends upon:

A. Lenz's law

B. Faraday's law

C. Coulomb's law

D. Ohm's law

(vii) The current passing through a choke coil of 5H is decreased at the rate of 2/s, the induced e.m.f in the coil is:

A. 2.5 V

B. -2.5 V

C. 10 V

D. -10 V

(viii) When $X_L = X_C$ this condition is called:

A. Balanced

B. Equality

C. Resonance

D. All of these

(ix) The process of combining low frequency signal with a high frequency radio wave is called:

A. Demodulation

B. Modulation

C. Resonance

D. Impedance

(x) The substances in which magnetic fields produced by orbital and spin molecules of the electron add up to zero are called:

A. Ferromagnetic

B. Diamagnetic

C. Paramagnetic

D. None of these

(xi) A trivalent impurity is usually called:

A. Acceptor

B. Donor

C. Rectifier

D. Transistor

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Physics 12th

- (xii) Which of the following is NOT basic operation of Boolean variables?
A. YES operation B. NOT operation
C. AND operation D. OR operation
- (xiii) A forward biased p-n junction practically offers:
A. Zero resistance B. Very low resistance
C. Very high resistance D. None of these
- (xiv) The existence of positron was discovered in the:
A. Thermal radiation B. Cosmic radiation
C. Electromagnetic radiation D. Non-electromagnetic radiation
- (xv) When x-rays are passed through successive aluminum sheets, their hardness:
A. Decreases B. Increases C. Remains same D. None of these
- (xvi) The energy equivalent to one atomic mass unit is:
A. $1.6 \times 10^{-19} \text{ J}$ B. $6 \times 10^{23} \text{ J}$ C. 931 MeV D. 9.31 MeV
- (xvii) The solar energy is mainly due to:
A. Fission B. Fusion C. Pair production D. All of these

PHYSICS HSSC-II
SECTION - B (Marks 42)

- Q.2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines. (14×3 = 42)
- (i) The potential is constant throughout a given region of space. Is the electrical field zero or non-zero in this region? Explain.
- (ii) Is it true that Gauss's law states that the total number of lines of forces crossing any closed surface in the outward direction is proportional to the net positive charge enclosed within surface?
- (iii) A potential difference is applied across the ends of a copper wire. What is the effect on the drift velocity of free electron by:
a. Increasing the potential difference.
b. Decreasing the length and the temperature of the wire.
- (iv) Is the filament resistance lower or higher in 500 W, 220 V light bulb than in a 100 W 220 V bulb?
- (v) A plane conducting loop is located in a uniform magnetic field that is directed along the x-axis. For what orientation of the loop is the flux a maximum? For what orientation is the flux a minimum?
- (vi) If a charged particle moves in a straight line through some region of space, can you say that the magnetic field in the region is zero.
- (vii) Show that ϵ and $\frac{\Delta\phi}{\Delta t}$ have the same units.
- (viii) When the primary coil of a transformer is connected to A.C mains the current in it:
a. Is very small if the secondary circuit is open, but
b. Increases when the secondary circuit is closed. Explain these facts.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

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354

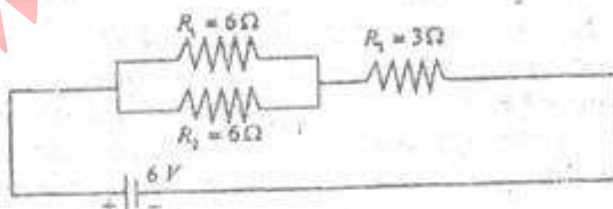
- (ix) Name the device that will (a) permit flow of direct current but oppose the flow of alternating current (b) permit flow of alternating current but not the direct current.
- (x) What is meant by A.M and F.M?
- (xi) What is meant by hysteresis loss? How is it used in the construction of a transformer?
- (xii) What is the effect of forward and reverse biasing of a diode on the width of depletion region?
- (xiii) Which photon, red, green or blue carries the most energy and momentum?
- (xiv) If measurements show a precise position for an electron, can those measurements show precise momentum also? Explain.
- (xv) What are the advantages of laser over ordinary light?
- (xvi) The radioactive element ${}^{226}_{88}\text{Ra}$ has a half-life of 1.6×10^3 years. Since the earth is about 5 billion years old, how can you explain that we still can find this element in nature.
- (xvii) Why a photo diode is operated in reverse biased state?
- (xviii) Name different groups of sub-atomic particles. Also differentiate between hadrons and leptons.
- (xix) Complete the following equations:
 a. ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Ra} + \text{---}$
 b. $\text{---} \rightarrow {}^1_1\text{H} + {}^0_{-1}\text{e}$

SECTION - C (Marks 26)

Note:- Attempt any TWO questions.

(2×13 = 26)

- Q.3 a. State and explain ohms law. Calculate the equivalent resistance when a number of resistances are connected in (i) series and (ii) in parallel. 1+2+2+2
- b. Differentiate between resistivity and conductivity.
- c. Find the equivalent resistance of the circuit, total current drawn from source and the current through each resistance. 04



- Q.4 a. Define Transistors. How can we use transistor as an amplifier? 2+5
- b. What is voltage gain of an amplifier? 02
- c. The current flowing into the base of a transistor is $100\mu\text{A}$. Find its collector current I_c emitter current I_e and the ratio I_c/I_e if the value of current gain β is 100. 04
- Q.5 a. Define Photoelectric effect. Explain the same on the bases of quantum theory and derive Einstein photoelectric equation. 2+5

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355

Physics 12th

- b. How can the spectrum of hydrogen contain so many lines when hydrogen contains only one electron? 02
 c. Sodium surface is illuminated with light of wave length 300nm. The work function for sodium metal is 2.46eV. 04
 (i) Find the maximum K.E of ejected electron.
 (ii) Determine the cutoff wavelength for sodium.

SOLUTION OF FBISE PAPER # (2009)

SECTION- A (MCQs)

i. A	ii. A	iii. D	iv. D	v. B	vi. B
vii. D	viii. C	ix. A	x. A	xi. B	xii. B
xiii. B	xiv. B	xv. B	xvi. C	xvii. D	

- (i) The potential is constant throughout a given region of space. Is the electrical field zero or no-zero in this region? Explain.

Ans: Since $E = K \frac{q}{r^2}$

If we move a unit positive charge from one point to other at infinity, no work will be done, i.e., all the points at infinity will be at the same potential. Electric field intensity being inversely proportional to the square of distance is zero at infinity ($\because \frac{1}{\infty} = 0$).

- (ii) Is it true that Gauss's law states that the total number of lines of forces crossing any closed surface in the outward direction is proportional to the net positive charge enclosed within surface?

Ans: Yes it is true. Electric flux measures the number of electric field lines passing through a certain area. Also electric flux is directly proportional to charge enclosed. Hence the total number of lines of force crossing any closed surface in the outward direction is proportional to the net positive charge enclosed within surface.

- (iii) A potential difference is applied across the ends of a copper wire. What is the effect on the drift velocity of free electron by:

- a. Increasing the potential difference.
 b. Decreasing the length and the temperature of the wire.

Ans: Drift velocity: The average directed velocity along the conductor in the presence of applied electric field is called drift velocity and is given by

$$v_d = \frac{eE\tau}{m}$$

Where τ is relaxation time, E is electric field strength and m is mass of the electron.

- (a) The drift velocity of free electrons increases with increases of potential difference because by increasing potential difference electric field increases.

$$v_d \propto V \quad \text{or} \quad v_d \propto E$$

- (b) Decreasing resistance and temperature of the wire it increases electric current (rate of flow of charges) which demands increase in drift velocity because

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Maryam Key Series

356

Physics 12th

$$V_d \propto \frac{1}{R}$$

and

$$V_d \propto \frac{1}{L}$$

- (iv) Is the filament resistance lower or higher in 500 W, 220 V light bulb than in a 100W 220V bulb?

Ans: Since $R = \frac{V^2}{P}$

Now $R_1 = \frac{(220)^2}{500} = 96.8 \Omega$

Also $R_2 = \frac{(220)^2}{100} = 484 \Omega$

Clearly, R_1 is less than R_2 .

Hence, 500 W, 220 V bulb has lower filament resistance than 100 W, 220 V bulb.

- (v) A plane conducting loop is located in a uniform magnetic field that is directed along the x-axis. For what orientation of the loop is the flux a maximum? For what orientation is the flux a minimum?

Ans: The flux will be the maximum when the plane of the loop will be perpendicular to the magnetic field (perpendicular to x-axis). The flux will be the minimum when the plane of the loop will be parallel to the magnetic field (parallel to x-axis).

Since $\phi_B = B A \cos \theta$

Case 1: In Fig. the field is directed along the normal to the area, so θ is zero and the flux is maximum, equal to BA .

Case 2: When the field is parallel to the plane of the area, the angle between the field and normal to area is 90° i.e., $\theta = 90^\circ$, so the flux through the area in this position is zero.

- (vi) If a charged particle moves in a straight line through some region of space, can you say that the magnetic field in the region is zero.

Ans: Since according to Ampere's law

$$B = \mu_0 n I \Rightarrow B \propto I$$

When a charged particle moves in a straight line in a certain region of space it will produce current hence there will be a magnetic field around the current carrying conductor. Therefore magnetic field in the region is not zero.

- (vii) Show that ϵ and $\frac{\Delta \phi}{\Delta t}$ have the same units.

Ans: We know that, $\epsilon = \frac{W}{q}$

$$\text{Unit of } \epsilon = \frac{\text{Joule}}{\text{Coulomb}} = \text{Volt}$$

$$\text{Now } \frac{\Delta \phi}{\Delta t} = \frac{B \Delta A}{\Delta t} = \frac{N A^{-1} m^{-1} \times m^2}{s} = \frac{Nm}{s \times A} = \frac{\text{Joule}}{\text{Coulomb}} = \text{Volt}$$

Hence ϵ and $\frac{\Delta \phi}{\Delta t}$ have the same units.

- (viii) When the primary coil of a transformer is connected to A.C mains the current in it:

- Is very small if the secondary circuit is open, but
- Increases when the secondary circuit is closed. Explain these facts.

Ans: (a) When the secondary circuit is open then there is no load to consume electric power or output power used is zero.

$$\text{Output power} = V_s I_s = 0$$

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357

Physics 12th

Since output power of a transformer is smaller than input power. Hence the primary coil of the transformer draws a very small current from a.c.

(b) When the secondary circuit is closed then output power increases

$$\text{input power} = \text{output power}$$

$$I_p V_p = I_s V_s$$

The transformer will draw large current from the a.c mains to increase the primary power because greater current is needed in primary coil to equalize power in the secondary coil.

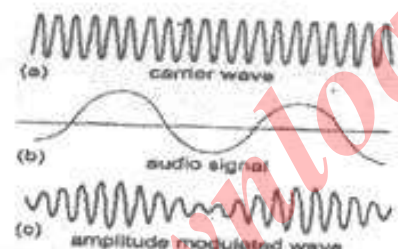
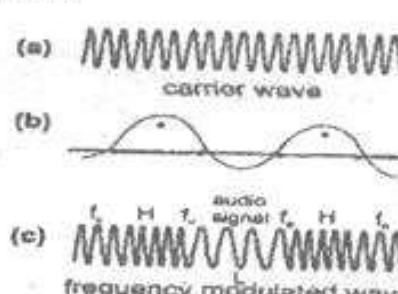
(ix) Name the device that will (a) permit flow of direct current but oppose the flow of alternating current (b) permit flow of alternating current but not the direct current.

Ans: (a) An inductor (choke) will oppose A.C. due its inductive reactance.

(b) Capacitor will oppose the flow of direct current but allows the flow of alternating current.

(x) What is meant by A.M and F.M?

Ans:

Amplitude modulation (A.M)	Frequency modulation (F.M)
In this type of modulation the amplitude of the carrier wave is increased or diminished as the amplitude of the superposing modulating signal increases and decreases.  Fig. (a) represents a high frequency carrier wave of constant amplitude and frequency. Fig. (b) represents a low or audio frequency signal of a sine waveform. Fig. (c) shows the result obtained by modulating the carrier waves with the modulating wave.	In this type of modulation the frequency of the carrier wave is increased or diminished as the modulating signal, amplitude increases or decreases but the carrier wave amplitude remains constant.  Fig. shows frequency modulation. The frequency of the modulated carrier wave is highest (point H) when the signal amplitude is at its maximum positive value and is at its lowest frequency (point L) when signal amplitude has maximum negative. When the signal amplitude is zero, the carrier frequency is at its normal frequency f_0.
The A.M. transmission frequencies range from 540 kHz to 1600 kHz.	The F.M. transmission frequencies range from 88 MHz to 108 MHz.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

358

Physics 12th

(xi) What is meant by hysteresis loss? How is it used in the construction of a transformer?

Ans: Hysteresis loss:

The area of the loop is a measure of the energy needed to magnetize and demagnetize the specimen during each cycle of the magnetizing current. This is the energy required to do work against internal friction of the domains. This work, like all work that is done against friction, is dissipated as heat. It is called **hysteresis loss**.

Use in the construction of transformer:

Hard magnetic materials like steel cannot be easily magnetized or demagnetized, so they have large loop area as compared to soft magnetic material such as iron which can easily be magnetized. The energy dissipated per cycle, thus, for iron is less than for steel. That is why soft iron used in transformers.

(xii) What is the effect of forward and reverse biasing of a diode on the width of depletion region?

Ans: When a diode is forward biased, the width of the depletion region is decreased. It is mainly due to a large value of diffusion current and a small value of drift current. On the other hand the width of depletion region increases when the diode is reversed biased.

(xiii) Which photon, red, green or blue carries the most energy and momentum?

Ans: The photon with highest frequency or smaller wavelength will have the most energy and momentum.

As frequency of blue light is greater than the frequency of green and red light. Therefore photon of blue light have most energy ($E = hf = \frac{hc}{\lambda}$) and most momentum

$$(P = \frac{h}{\lambda}).$$

(xiv) If measurements show a precise position for an electron, can those measurements show precise momentum also? Explain.

Ans: Position and momentum of a particle cannot both be measured simultaneously with perfect accuracy. There is always a fundamental uncertainty associated with any measurement. It is a consequence of the wave particle duality of matter and radiation. It is known as Heisenberg uncertainty principle.

$$\Delta x \cdot \Delta p \approx \lambda \left(\frac{h}{\lambda} \right) \approx h \dots\dots\dots (1)$$

The equation 1 is the mathematical form of uncertainty principle.

It is not possible to measure position and momentum at the same time. If one quantity is precise then other becomes uncertain because it will violate Heisenberg's uncertainty principle.

(xv) What are the advantages of laser over ordinary light?

Ans: Lasers are used for producing an intense, monochromatic, and unidirectional coherent beam of visible light. It is more intense, monochromatic, unidirectional and coherent, whereas, ordinary light does not have such properties. Therefore a laser beam is much more power full than an ordinary light beam. Energy of laser can be focused at a point to get energy for welding and surgical purpose while ordinary light cannot do so.

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359

Physics 12th

(xvi) The radioactive element $^{226}_{88}\text{Ra}$ has a half-life of 1.6×10^3 years. Since the earth is about 5 billion years old, how can you explain that we still can find this element in nature.

Ans: Half life: It is the period in which half of the radioactive element atoms decay. An element completely decayed after an infinite time.

Thus with the passage of every half life the number of atoms remaining behind becomes half of the number of atoms already present. In this way an infinite time is required for all atoms to decay. As the earth five billion years old (not infinite time) so we can still find $^{226}_{88}\text{Ra}$ element in nature.

(xvii) Why a photo diode is operated in reverse biased state?

Ans: When no light is incident on the junction, the reverse current is almost zero. When light is incident on p-n junction (i.e. diode), reverse current begins to flow. Reverse current increases with the intensity of light. As this light produces electron hole pair and are separated by reverse biased which conduct the electric current. Hence reverse biased state is used in Photo-diode.

(xviii) Name different groups of sub-atomic particles. Also differentiate between hadrons and leptons.

Ans: Subatomic particles are divided into three groups.

1. Photons
2. Leptons
3. Hadrons

Leptons	Hadrons
Hadrons are particles that experience the strong nuclear force. In addition to protons, neutrons and mesons are hadrons.	Leptons are particles that do not experience strong nuclear force. Electron, muons and neutrinos are leptons.

(xix) Complete the following equations:



SECTION - C (Marks 26)

Note:-Attempt any TWO questions.

Q.3 a. State and explain ohms law. Calculate the equivalent resistance when a number of resistances are connected in.

- (i) series and (ii) in parallel.

Ans: Ohm's law:

"The current flowing through a conductor is directly proportional to the potential difference across its ends provided the physical state such as temperature etc. of the conductor remains constant".

Mathematical form of ohm's law:

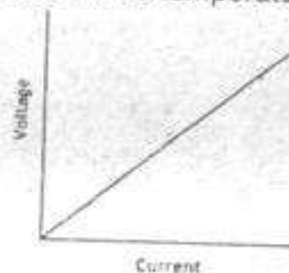
Symbolically Ohm's law can be written as

$$V \propto I$$

It implies that

$$V = RI$$

where R, the constant of proportionality is called the resistance of the conductor. The value of the resistance depends upon the nature, dimensions and the physical state of the conductor.



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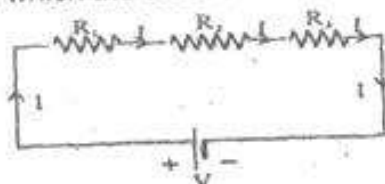
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360

Physics 12th

Series combination of Resistances:

- 1- There is one path in which the electrons can flow in the circuit.



- 2- The current flow is the same throughout a series circuit.
 $I = I_1 = I_2 = I_3$

- 3- Sum of the potential difference across individual components in a series circuit is equal to the potential difference across the whole circuit.
 $V = V_1 + V_2 + V_3$

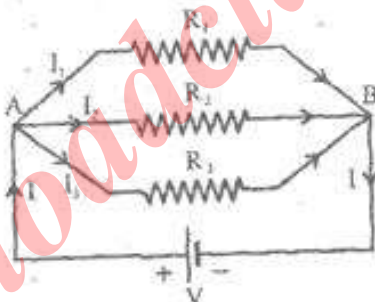
- 4- The total resistance R_e of the resistors connected in series circuit is equal to the sum of the separate resistors.
 $R_e = R_1 + R_2 + R_3$

- 5- For n resistances

$$R_e = R_1 + R_2 + R_3 + \dots + R_n$$

Parallel combination of Resistances:

- 1- There are more than one paths for the flow of electrons in the circuit.



- 2- The current flow in the main circuit is the sum of the currents in the separate branches.
 $I = I_1 + I_2 + I_3$

- 3- Each component connected in parallel has the same potential difference across it.
 $V = V_1 = V_2 = V_3$

- 4- The reciprocal of equivalent resistance $\frac{1}{R_e}$ of the equivalent resistance of the combination is the sum of the reciprocals of the individual resistances.

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

- 5- For n resistances

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}$$

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Maryam Key Series

361

Physics 12th

b. Differentiate between resistivity and conductivity.

Ans:

Resistivity	Conductivity
The resistance of a metre cube of a material is called resistivity denoted by ρ .	Likewise conductivity, σ is the reciprocal of resistivity i.e., $\sigma = \frac{1}{\rho}$
The SI unit of resistivity is ohm-metre ($\Omega \text{ m}$).	The SI unit of conductivity is ohm ⁻¹ m ⁻¹ or mh m ⁻¹ .

c. Find the equivalent resistance of the circuit, total current drawn from source and the current through each resistance. 04

Solution:

$$R_1 = 6 \Omega, \quad R_2 = 6 \Omega, \quad R_3 = 3 \Omega$$

$$V = 6V$$

$$\text{Equivalent Resistance} = R_{eq} = ? \quad \text{Total current} = I = ?$$

$$\text{Current through } R_1 = I_1 = ?$$

$$\text{Current through } R_2 = I_2 = ?$$

$$\text{Current through } R_3 = I_3 = ?$$

In order to solve this numerical first of all we label the figure as follows:

For the parallel combination of R_1 and R_2 :

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow \frac{1}{R} = \frac{1}{6} + \frac{1}{6} \Rightarrow \frac{1}{R} = \frac{1+1}{6} = \frac{2}{6}$$

$$R = 3 \Omega$$

This resistance R will be in series with R_3

$$R_{eq} = R + R_3 = 3 + 3 = 6 \Omega \text{ Ans.}$$

$$\text{According to Ohm's law, } I = \frac{V}{R_{eq}} = \frac{6}{6} = 1 \text{ A Ans.}$$

$$\text{Using values we get, } I = \frac{6}{6} = 1 \text{ A Ans.}$$

$$\text{Again using Ohm's law, } V_{BC} = IR_3$$

$$V_{BC} = 1 \times 3 = 3 \text{ volts}$$

It is clear that,

$$V_{AB} + V_{BC} = 6V \Rightarrow V_{AB} = 6V - V_{BC} = 6V - 3V = 3V$$

$$\text{Now, } I = \frac{V_{AB}}{R_1} = \frac{3}{6} = 0.5 \text{ A Ans.}$$

$$\text{And, } I_2 = \frac{V_{AB}}{R_2} = \frac{3}{6} = 0.5 \text{ A Ans.}$$

$$\text{From figure it is clear that, } I_1 = I = 1 \text{ A Ans.}$$

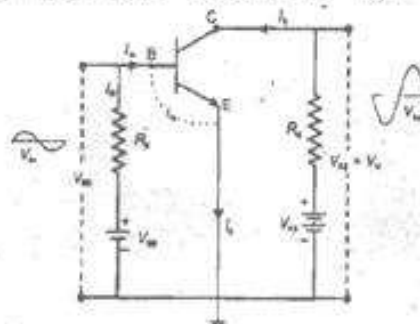
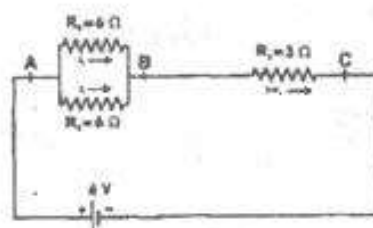
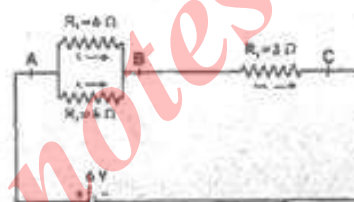
Q. 4 a. Define Transistors. How can we use transistor as an amplifier?

Ans: Transistor:

Transistor is a semiconductor device consisting of three electrodes, namely emitter, base and collector. For normal operation, the base-emitter junction is forward biased whereas the collector-base junction is reverse biased.

Transistors as an amplifier:

In majority of electronic circuits, transistors are basically used as amplifiers. An amplifier is thus



PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

362

Physics 12th

the building block of every complex electronic circuit. It is for this reason that study of transistor amplifier is important.

Transistor voltage amplifier:

The circuit in Fig. is a transistor voltage amplifier. The battery V_{BE} forward biases the base-emitter junction and V_{CC} reverse biases the collector-base junction. V_{BE} and V_{CE} are the input and output voltages respectively. The base current is $I_B = V_{BE}/r_{ie}$ where r_{ie} is base emitter resistance of the transistor. The transistor amplifies it β times. So

$$I_C = \beta I_B = \beta V_{BE}/r_{ie}$$

Output voltage:

The output voltage $V_0 = V_{CE}$ is determined by applying KVL equation in the output loop which gives

$$V_{CC} = I_C R_C + V_{CE} \quad \text{or} \quad V_{CE} = V_{CC} - I_C R_C$$

Substituting the value of I_C and replacing V_{CE} by V_0

$$V_0 = V_{CC} - \beta V_{BE} R_C / r_{ie} \quad \dots \dots (1)$$

Application of small signal voltage:

When small signal voltage ΔV_{in} is applied at the input terminal B, the input voltage changes from V_{BE} to $V_{BE} + \Delta V_{in}$. This causes a little change in base current from I_B to $(I_B + \Delta I_B)$ due to which the collector current changes from I_C to $(I_C + \Delta I_C)$. As the collector current changes, the voltage drop across R_C i.e. $(I_C R_C)$ also changes due to which the output voltage V_0 changes by ΔV_0 . Substituting the changed values in Eq. 1

$$V_0 + \Delta V_0 = V_{CC} - \beta (V_{BE} + \Delta V_{in}) R_C / r_{ie} \quad \dots \dots (2)$$

Subtracting Eq. 1 from Eq. 2

$$\Delta V_0 = -\beta \Delta V_{in} R_C / r_{ie}$$

Note: The value of the factor R_C/r_{ie} is of the order of hundreds, so the input voltage is amplified. The negative sign shows that there is a phase shift of 180° between the input and the output signals.

b. What is voltage gain of an amplifier?

Ans: Gain of amplifier:

Therefore the gain of the amplifier $A = \Delta V_0 / \Delta V_{in} = \beta R_C / r_{ie}$.

c. The current flowing into the base of a transistor is $100 \mu A$. Find its collector current I_C , emitter current I_E and the ratio I_C / I_E if the value of current gain β is 100.

Solution:

Base Current $= I_B = 100 \mu A = 100 \times 10^{-6} A$

Current Gain $= \beta = 100$

Collector Current $= I_C = ?$

Emitter Current $= I_E = ?$

The ratio $= \frac{I_C}{I_E} = ?$

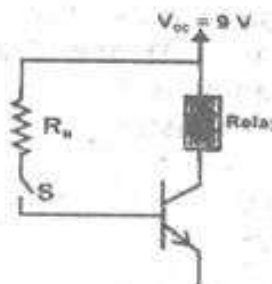
Current gain $= \beta = \frac{I_C}{I_B} \Rightarrow I_C = \beta \times I_B$

$I_C = 100 \times 100 \times 10^{-6} = 10 \times 10^{-3} A = 10 \text{ mA}$ **Ans.**

The equation of transistor is given by, $I_E = I_B + I_C$

$I_E = 100 \times 10^{-6} + 10 \times 10^{-3} = 100 \times 10^{-6} + 10 \times 10^{-3} \times 10^{-3} \times 10^{-3}$

$I_E = 100 \times 10^{-6} + 10,000 \times 10^{-6} = (100 + 10,000) \times 10^{-6}$



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Maryam Key Series

363

Physics 12th

$$I_E = 10,100 \times 10^{-6} = 10,100 \mu A = 10.1 \times 10^{-3} A = 10.1 \text{ mA Ans.}$$

The ratio of I_C and I_E is given by,

$$\frac{I_C}{I_E} = \frac{10 \times 10^{-3}}{10.10 \times 10^{-3}} = 0.99 \text{ Ans.}$$

Q. 5 a. Define Photoelectric effect. Explain the same on the bases of quantum theory and derive Einstein photoelectric equation.

Ans: Photoelectric effect:

The emission of electrons from a metal surface when exposed to ultraviolet light of suitable frequency is called the photoelectric effect.

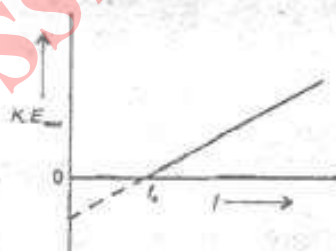
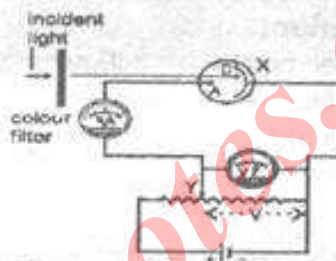
i. Einstein extended the idea of quantization of energy proposed by Max Planck that light is emitted or absorbed in quanta, known as photons. The energy of each photon of frequency f as given by quantum theory is

$$E = hf \dots\dots (1)$$

A photon could be absorbed by a single electron in the metal surface.

ii. **Work function ' ϕ ':**

The electron needs a certain minimum energy called the work function ' ϕ ' to escape from the metal surface. If the energy of incident photon is sufficient, the electron is ejected instantaneously from the metal surface. A part of the photon energy (work function) is used by the electron to break away from the metal and the rest appears as the kinetic energy of the electron. That is,



A graph of the maximum kinetic energy of photoelectrons vs. light frequency. Below a certain frequency, f_0 , no photoemission occurs.

Incident photon energy - Work function = Max. K.E. of photoelectron

$$\text{or } hf - \phi = \frac{1}{2} mv_{\max}^2 \dots\dots (2)$$

Note: This is known as Einstein's photoelectric equation.

iii. When $K.E._{\max}$ of the photoelectron is zero, the frequency f is equal to threshold frequency f_0 , hence the Eq. 2 becomes

$$hf_0 - \phi = 0 \text{ or } \phi = hf_0 \dots\dots (3)$$

Hence, we can also write Einstein's photoelectric equation as

$$K.E._{\max} = hf - hf_0 \dots\dots (4)$$

Albert Einstein was awarded Nobel Prize in physics in 1921 for his explanation of photoelectric effect.

b. How can the spectrum of hydrogen contain so many lines when hydrogen contains only one electron?

Ans: Hydrogen atom contains one electron. It will emit one spectral line, if it jumps direct from higher energy state to the ground state.

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364

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The electron does not necessarily return to the ground state in the single jump, but may return by several jumps. That is why hydrogen spectrum contains many lines.

c. Sodium surface is illuminated with light of wave length 300nm. The work function for sodium metal is 2.46eV.

- (i) Find the maximum K.E of ejected electron,
 (ii) Determine the cutoff wavelength for sodium.

Solution:

Wavelength = $\lambda = 300 \text{ nm} = 300 \times 10^{-9} \text{ m}$, Work function = $\phi = 2.46 \text{ eV}$

(a) Max. K.E. of electron = $E = ?$ (b) Cut off wavelength = $\lambda_0 = ?$

(a) Find the maximum K.E. of the ejected electron.

We have,

$$E = hf \Rightarrow E = \frac{hc}{\lambda} \quad (\because f = \frac{c}{\lambda})$$

$$E = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{300 \times 10^{-9}} = \frac{19.89 \times 10^{-26}}{300 \times 10^{-9}} = 6.63 \times 10^{-19} \text{ J}$$

$$E = \frac{6.63 \times 10^{-19}}{1.6 \times 10^{-19}} \quad (\because 1\text{eV} = 1.6 \times 10^{-19} \text{ J})$$

$$E = 4.14 \text{ eV}$$

According to Einstein's equation for Photoelectric effect:

$$K.E_{\text{max}} = E - \phi$$

$$K.E_{\text{max}} = 4.14 - 2.46 = 1.68 \text{ eV Ans.}$$

(b) Determine the cut off wavelength of sodium.

Since $\phi = hf_0 = \frac{hf}{\lambda_0}$

$$\lambda_0 = \frac{hc}{\phi}$$

Here $\phi = 2.46 \text{ eV} = 3.94 \times 10^{-19} \text{ J} \quad (\because 1\text{eV} = 1.6 \times 10^{-19} \text{ J})$

$$\lambda_0 = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{3.94 \times 10^{-19}} = 5.05 \times 10^{-7} \text{ m} = 505 \text{ nm Ans.}$$

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FBISE PAPER # (2010)

PHYSICS HSSC-II (2010)

SECTION-A (Marks 17)

Time: 25 Minutes

Marks: 17

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 20 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q. 1 Circle the correct option i.e. A / B / C / D. Each part carries one mark.

(i) A closed surface contains two equal and opposite charges. The net electric flux from the surface will be _____.

- A. Negative B. Positive C. Infinite D. Zero

(ii) What will be the current in the circuit shown?

- A. $\frac{1}{45} A$ B. $\frac{1}{10} A$ C. $\frac{1}{5} A$ D. $5 A$



(iii) Watt-hour measures _____.

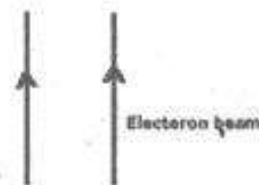
- A. Current B. Electric energy C. Power D. Voltage

(iv) According to Faraday's Law, emf induced in a circuit depends on _____.

- A. Maximum magnetic flux B. Rate of change of magnetic flux
C. Change in magnetic flux D. Initial magnetic flux

(v) An electron beam is moving parallel- The nature of force between them is _____.

- A. Attractive
B. Repulsive
C. Attractive or repulsive depends on the magnitude of velocity
D. None of these



(vi) In Compton scattering, the change in wavelength is maximum if _____.

- A. Angle of scattering is 90° B. Angle of scattering is 60°
C. Angle of scattering is 180° D. Angle of scattering is Zero

(vii) Temperature coefficient of thermister is _____.

- A. Always negative
B. Always positive
C. Changing from positive to negative and vice versa
D. May be positive or may be negative

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300

Physics 12th

- (viii) If capacitance of LC circuit is made four times, then frequency of the circuit becomes _____.
A. Twice B. One half C. Four times D. None of these
- (ix) A transformer steps down the voltage of 220V to 20V with the help of 20 turns on the secondary coil. What is the number of turns on the primary?
A. 200 B. 220 C. 20 D. 22
- (x) The colour of light emitted by a LED depends on _____.
A. Its forward bias B. Its reverse bias
C. The amount of forward current
D. The type of semi conductor material used
- (xi) The output of a two inputs OR gate is 0 only when it's _____.
A. Both inputs are 0 B. Either input is 1
C. Both inputs are 1 D. Either input is 0
- (xii) A 100 ohm resistor, a $0.1\mu\text{F}$ capacitor and a 0.1 Henry inductor are connected in parallel to a 100V supply. The resonant frequency is _____.
A. 1392Hz B. 1492Hz C. 1592Hz D. None of these
- (xiii) An electric force can deflect _____.
A. Neutrons B. γ -rays C. Both A and B D. None of these
- (xiv) As per Bohr's atomic model, a minimum energy (in eV) required to remove an electron from the ground state of doubly ionized Li atom is _____.
A. 1.51 eV B. 13.6 eV C. 40.8 eV D. 122.4 eV
- (xv) When the motor is at its maximum speed, the back emf will be _____.
A. Maximum B. Zero
C. Intermediate values D. No back emf
- (xvi) As mass number increases, which of the following does not change?
A. Mass B. Volume
C. Density D. Binding energy
- (xvii) In Ge (Germanium) sample traces of Ga (Gallium) are added as impurity. The resulting sample would behave like _____.
A. A conductor B. A P-type semiconductor
C. An N-type semiconductor D. An insulator

PHYSICS HSSC-II

Time allowed: 2:40 Hours

Total Marks = 68

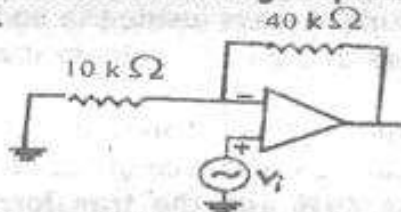
Note: Sections 'B' and 'C' are to be answered on the separately provided answer book. Answer eleven the questions from section 'B' and attempt any two questions from section 'C' Use supplementary answer sheet i.e., sheet B if required. Write your answers neatly and legibly.

SECTION - B (Marks 42)

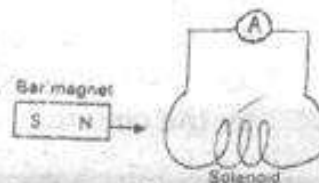
- Q.2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines. (14 × 3 = 42)

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

- (i) Calculate the gain of non-inverting amplifier shown in figure.



- (ii) Draw the symbolic circuit diagram for exclusive NOR (XNOR) gate.
 (iii) Write down the heating effect of current.
 (iv) State Ohm's law.
 (v) A parallel plate capacitor of capacitance C is charged using a battery of emf V_0 . After the capacitor is charged, the battery is removed and the distance between the capacitors is doubled. Find the new energy stored,
 (vi) Show graphically the phase relationship between the current and the voltage across an inductor,
 (vii) You are given a number of $2\mu F$ capacitors, each with a maximum working potential difference of $10 V$. How would you construct capacitors of:
 a. $1\mu F$ capacitance, suitable for use upto $20 V$.
 b. $2\mu F$ capacitance, suitable for use upto $20 V$.
 (viii) A source of light is placed at a distance of $0.1m$ from a photocell and cut-off potential (stopping potential) is found to be V_0 . If the lamp is now placed at a distance of $2m$, what will be the cut-off potential,
 (ix) Define Elastic limit.
 (x) What is a photon?
 (xi) Why ordinary silicon diodes do not emit light?
 (xii) When a magnet is pushed into the solenoid, the ammeter records a small current:
 a. Explain why a current is produced.
 b. State what is observed:
 1. When the magnet is pulled out of the solenoid.
 2. When the magnet is stationary inside the solenoid.
 (xiii) Verify that an ohm times farad is equivalent to second
 (xiv) A dry battery can deliver $3000J$ of energy to a small $2W$ electric motor before the battery is exhausted. For how many minutes does the motor run?
 (xv) When base current is changed from $30\mu A$ to $80\mu A$, the collector current changes from $1mA$ to $3.5 mA$. Find the current gain in CE configuration.
 (xvi) The effects of radiation on the human body depend on the properties of the radiation. Explain why a source emitting



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- α - particles inside the body is more dangerous than a source of the same activity emitting γ - rays inside the body.
- (xvii) What do you understand by an equipotential surface in an electric field?
- (xviii) A lamp is connected to the secondary coil of the transformer by long leads which have a resistance of 2.5 ohms. The power input to the primary coil is 40 W and the transformer is 100% efficient. Calculate the potential drop across the resistance of the leads.
- (xix) By assuming that a hydrogen atom consists of an electron of charge e^- orbiting a proton of charge e^+ . Calculate the ratio of the electric force between the electron and proton to the gravitational force between them.
- (Mass of electron $m_e = 9.1 \times 10^{-31}$ kg mass of proton $m_p = 1.67 \times 10^{-27}$ kg)

SECTION - C (Marks 26)

- Note:- Attempt any TWO questions. (2×13 = 26)
- Q. 3 a. Derive an expression for torque acting on a current carrying rectangular coil placed in a uniform magnetic field. 07
- b. A coil of 0.1m × 0.1m and of 200 turns carrying a current 1.0mA is placed in a uniform magnetic field of 0.1T. Calculate the maximum torque that acts on the coil. 06
- Q. 4 a. What are isotopes? Explain mass spectrograph to demonstrate the existence of isotopes. 2+6
- b. Find the mass defect and the binding energy for tritium, if the atomic mass of tritium is 3.016049u. 05
- Q. 5 a. Define Impedance. 02
- b. What do you understand by R-C and R-L series circuit? Calculate the impedance of both the circuits by drawing their impedance diagram. 07
- c. A circuit has an inductance of $\frac{1}{\pi}$ H and resistant of 2000Ω. A 50 Hz A.C is supplied to it. Calculate the reactance and impedance offered by the circuit. 04

SOLUTION OF FBISE PAPER # (2010)

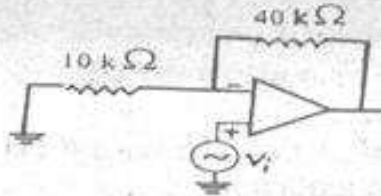
SECTION- A (MCQs)

i. D	ii. A	iii. C	iv. B	v. A	vi. A
vii. D	viii. B	ix. B	x. D	xi. A	xii. C
xiii. D	xiv. B	xv. A	xvi. D	xvii. B	

SECTION- B

- (i) Calculate the gain of non-inverting amplifier shown in figure.

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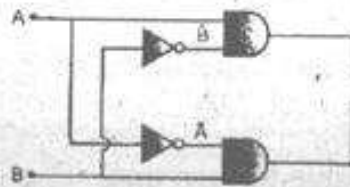


Ans: The formula for the gain of a non-inverting OP-AMP is

$$G = 1 + \frac{R_2}{R_1} = 1 + \frac{40}{10} = 1 + 4 = 5$$

(ii) Draw the symbolic circuit diagram for exclusive NOR (XNOR) gate.

Ans:



(iii) Write down the heating effect of current.

Ans: a. Current flows through a metallic wire due to motion of free electrons. During the course of their motion, they collide frequently with the atoms of the metal. At each collision, they lose some of their kinetic energy and give it to atoms with which they collide. Thus as the current flows through the wire, it increases the kinetic energy of the vibrations of the metal atoms, i.e., it generates heat in the wire.

b. It is found that the heat H produced by a current I in the wire of resistance R during a time interval t is given by

$$H = I^2 R t$$

(iv) State Ohm's law.

Ans: Ohm's law:

"The current flowing through a conductor is directly proportional to the potential difference across its ends provided the physical state such as temperature etc. of the conductor remains constant".

Mathematical form of ohm's law:

Symbolically Ohm's law can be written as

$$V \propto I$$

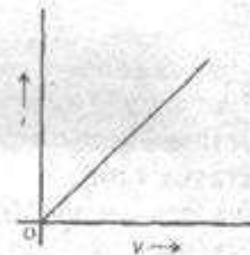
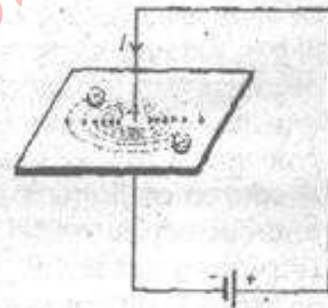
$$V = RI$$

It implies that

where R , the constant of proportionality is called the resistance of the conductor. The value of the resistance depends upon the nature, dimensions and the physical state of the conductor.

(v) A parallel plate capacitor of capacitance C is charged using a battery of emf V_0 . After the capacitor is charged, the battery is removed and the distance between the capacitors is doubled. Find the new energy stored.

Ans: The formula of:



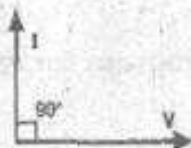
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Energy stored in a capacitor= $E = \frac{1}{2} CV^2$

If the distance is doubled there is no effect in the stored energy because it is not depend upon distance.

- (vi) **Show graphically the phase relationship between the current and the voltage across an inductor.**

Ans:



- (vii) You are given a number of $2\mu F$ capacitors, each with a maximum working potential difference of 10V. How would you construct capacitors of:

- $1\mu F$ capacitance, suitable for use upto 20 V
- $2\mu F$ capacitance, suitable for use upto 20 V.

Ans: By using formula of capacitance.

$$C = \frac{Q}{V}$$

By increasing voltage capacitance will be decreased.

- If the voltage is increase from 10V to 20V by formula capacitance will decrease from $2\mu F$ to $10\mu F$.
- Whether capacitance of capacitor remains same, Therefore Q is directly proportional to V for this we increase the charges.

- (viii) A source of light is placed at a distance of 0.1m from a photocell and cut-off potential (stopping potential) is found to be V_0 . If the lamp is now placed at a distance of 2m, what will be the cut-off potential?

Ans: According to formula of working potential.

$$\frac{1}{2}mv_{max}^2 = eV_0$$

It is independent of distance so increase in distance do not effect the cut off potential and it remains same.

- (ix) **Define Elastic limit.**

Ans: **Elastic limit:**

The limit beyond which the sample becomes permanently deformed.

The value of stress at B is also known as elastic limit σ_e .

- (x) **What is a photon?**

Ans: **Photon:**

Einstein extended his idea and postulated that packets or tiny bundles of energy are integral part of all electromagnetic radiation and that they could not be subdivided. These indivisible tiny bundles of energy he called photons.

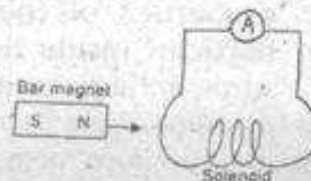
- (xi) **Why ordinary silicon diodes do not emit light?**

Ans: In ordinary silicon diode the potential barrier between p and n sides is of several mega ohms. Due to this reason silicon diodes do not emit light.

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(xii) When a magnet is pushed into the solenoid, the ammeter records a small current:

- a. Explain why a current is produced.
- b. State what is observed:



1. When the magnet is pulled out of the solenoid.
2. When the magnet is stationary inside the solenoid.

Ans: a. When the magnet is pushed into the solenoid, the magnetic flux through the coil changes and this changing flux produces the induced current in the coil.

- b. 1. When the magnet is pulled out of the solenoid, a current is again induced but now in opposite direction.
2. When the magnet is stationary inside the solenoid no flux change occurs and there will be no current.

(xiii) Verify that an ohm times farad is equivalent to second.

Ans: By Ohm's law

$$V = IR$$

Also,

$$I = \frac{q}{t}$$

$$V = \frac{q}{t} R$$

$$R = \frac{Vt}{q} \quad \dots (i)$$

We know that

$$q = CV$$

Or

$$C = \frac{q}{V} \quad \dots (ii)$$

Multiplying Eqs (i) and (ii), we have

$$RC = \frac{Vt}{q} \times \frac{q}{V} = t$$

$\Rightarrow$

$$RC = t$$

Since $1 \text{ ohm} \times 1 \text{ farad} = 1 \text{ second}$

Hence proved.

(xiv) A dry battery can deliver 3000J of energy to a small 2W electric motor before the battery is exhausted. For how many minutes does the motor run?

$$\begin{aligned} \text{Ans: } P &= \frac{W}{t} & \Rightarrow & t = \frac{W}{P} \\ t &= \frac{3000}{2} & \Rightarrow & t = 1500 \text{ Sec} \\ t &= \frac{1500}{60} & \Rightarrow & t = 25 \text{ minutes} \end{aligned}$$

(xv) When base current is changed from $30 \mu\text{A}$ to $80 \mu\text{A}$, the collector current changes from 1mA to 3.5 mA . Find the current gain in CE configuration.

Ans: Given that:

$$\Delta I_B = 80 \mu\text{A} - 30 \mu\text{A} = 50 \mu\text{A} = 50 \times 10^{-6} \text{ A}$$

$$\Delta I_C = 3.5 \text{ mA} - 1 \text{ mA} = 2.5 \text{ mA} = 2.5 \times 10^{-3} \text{ A}$$

We know that:

$$\beta = \frac{I_C}{I_B} = \frac{50 \times 10^{-6}}{2.5 \times 10^{-3}} = 20 \times 10^{-3} \text{ A}$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

312

- (xvi) The effects of radiation on the human body depend on the properties of the radiation. Explain why a source emitting α - particles inside the body is more dangerous than a source of the same activity emitting γ - rays inside the body.

Ans: α -source could be more dangerous. As, due to its extremely high ionizing power, it will produce more disorder in body cells than a β -source. It should also be noted that RBE for alpha is much greater than beta.

- (xvii) What do you understand by an equipotential surface in an electric field?

Ans: In electric field where the current remains throughout the surface remains same is called equipotential surface.

- (xviii) A lamp is connected to the secondary coil of the transformer by long leads which have a resistance of 2.5 ohms. The power input to the primary coil is 40W and the transformer is 100% efficient. Calculate the potential drop across the resistance of the leads.

Ans: Since it is an ideal transformer. (Efficiency = 100 %)

$$R = 2.5 \text{ ohms}$$

$$V_p I_p = 40 \text{ w}$$

Potential drop = ?

$$\text{Efficiency} = E = \frac{\text{output power}}{\text{input power}} \times 100$$

$$100 = \frac{\text{output power}}{40} \times 100$$

$$\text{Output power} = 40 \text{ W}$$

$$\text{Since } P = I^2 R \Rightarrow I^2 = \frac{P}{R} \Rightarrow I^2 = \frac{40}{2.5} \Rightarrow I^2 = 16$$

$$I_s = 4 \text{ A}$$

$$\text{Since } V_s = I_s R = 4 \times 2.5 = 10 \text{ V}$$

- (xix) By assuming that a hydrogen atom consists of an electron of charge e^- orbiting a proton of charge e^+ . Calculate the ratio of the electric force between the electron and proton to the gravitational force between them.

(Mass of electron $m_e = 9.1 \times 10^{-31} \text{ kg}$ mass of proton $m_p = 1.67 \times 10^{-27} \text{ kg}$)

Ans: Mass of electron $m_e = 9.1 \times 10^{-31} \text{ kg}$

Mass of proton $m_p = 1.67 \times 10^{-27} \text{ kg}$

Charge $= q = 1.6 \times 10^{-19} \text{ C}$

$$G = 6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$$

$$K = 9 \times 10^{10} \text{ Nm}^2 \text{ C}^{-2}$$

$$\frac{F_e}{F_g} = ?$$

The formula for the electric force in case of identical charges is,

$$F_e = \frac{1}{4\pi\epsilon_0} \frac{q^2}{r^2} \dots\dots\dots (1)$$

The formula for the gravitational force in case of identical masses is,

$$F_g = G \frac{m_e \times m_p}{r^2} \dots\dots\dots (2)$$

Dividing equation (1) by (2) we get,

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

373

Physics 12th

$$\frac{F_e}{F_g} = K \frac{q^2}{r^2} \times \frac{r^2}{G \times m_e \times m_p} = \frac{Kq^2}{G \times m_e \times m_p} \dots\dots\dots (3)$$

Using values in equation (3) we get,

$$\frac{F_e}{F_g} = \frac{9 \times 10^9 \times (1.6 \times 10^{-19})^2}{6.67 \times 10^{-11} \times 9.1 \times 10^{-31} \times 1.67 \times 10^{-27}} = \frac{9 \times 10^9 \times 2.56 \times 10^{-38}}{101.36 \times 10^{-65}} = \frac{23.04 \times 10^{9-38+65}}{101.36}$$

$$\frac{F_e}{F_g} = \frac{23.04 \times 10^{36}}{101.36} = 0.227 \times 10^{36} = 2.27 \times 10^{35} \text{ Ans.}$$

SECTION - C (Marks 26)

Note:- Attempt any TWO questions. (2×13 = 26)

Q. 3 a. Derive an expression for torque acting on a current carrying rectangular coil placed in a uniform magnetic field.

Ans: Torque on a current carrying coil:

i. Consider a rectangular coil carrying a current I . The coil is capable of rotation about an axis. Suppose it is placed in uniform magnetic field B with its plane along the field.

ii. We know that a current carrying conductor of length L when placed in a magnetic field experiences a force $F = ILB \sin \theta$ where θ is the angle between conductor and the field.

iii. In case of sides AB and CD of the coil, the angle θ is zero or 180° , so the force on these sides will be zero.

iv. In case of sides DA and BC, the angle θ is 90° and the force on these sides will be

$$F_1 = F_2 = ILB$$

Where L is the length of these sides, F_1 is the force on the side DA and F_2 on BC.

v. The direction of the force is given by the vector $I \times L \times B$. It can be seen that F_1 is directed out of the plane of paper and F_2 into the plane of paper. Therefore, the forces F_1 and F_2 being equal and opposite form a couple which tends to rotate it about the axis.

vi. The torque of this couple is given by $\tau = \text{Force} \times \text{Moment arm} = ILB \times a$. Where 'a' is the moment arm of the couple and is equal to the length of the side AB or CD. La is the area A of the coil, $\tau = IBA \dots\dots\dots (1)$

Note that the Eq. 1 gives the value of torque when the field B is in the plane of the coil. However if the field makes an angle α with the plane of the coil, as shown in Fig., the moment arm now becomes $a \cos \alpha$. So

$$\tau = ILB \times a \cos \alpha = IBA \cos \alpha \dots\dots\dots (2)$$

b. A coil of $0.1m \times 0.1m$ and of 200 turns carrying a current $1.0mA$ is placed in a uniform magnetic field of $0.1T$. Calculate the maximum torque that acts on the coil.

Solution:

$$A = 0.1m \times 0.1m = 0.01 m^2$$

$$I = 1 mA = 1 \times 10^{-3} A$$

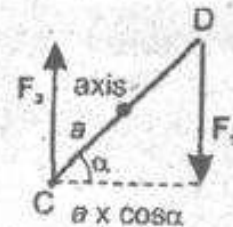
$$N = 200 \text{ turns}$$

$$B = 0.1 T$$

$$\tau_{\max} = ?$$

$$\tau_{\max} = BIAN \cos \alpha$$

For maximum torque $\alpha = 0^\circ$



PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

374

Physics 12th

$$\tau_{\max} = 0.1 \times 1 \times 10^{-3} \times 0.01 \times 200 \times \cos 0^\circ = 2 \times 10^{-4} \text{ Nm Ans.}$$

Q. 4 a. What are isotopes? Explain mass spectrograph to demonstrate the existence of isotopes.

Ans: Isotopes:

Isotopes are such nuclei of an element that have the same charge number Z, but have different mass number

Mass spectrograph:

A device with the help of which not only the isotopes of any element can be separated from one another but their masses can also be determined quite accurately is called mass spectrograph.

Construction and working of mass spectrograph:

i. The atoms or molecules of the element under investigation, in vapour form, are ionized in the ions source S. As a result of ionization, one electron is removed from the particle, leaving with a net positive charge +e

ii. The positive ions, escaping the slit S₁, are accelerated through a potential difference V applied between the two slits S₁ and S₂.

iii. **The K.E. of singly charged ion at the slit S₂:**

The ions pass through the slit S₂ in the form of a narrow beam. The K.E. of singly charged ion at the slit S₂ will be given by

$$\frac{1}{2} mv^2 = Ve \quad \dots\dots\dots (1)$$

iv. **Application of magnetic field (B):**

The ions are then subjected to a perpendicular and uniform magnetic field B in a vacuum chamber, where they are deflected in semicircular paths towards a detector. The detector records the number of ions arriving per second. The centripetal force applied by the magnetic field is given by

$$Bev = \frac{mv^2}{r} \quad \dots\dots\dots (2)$$

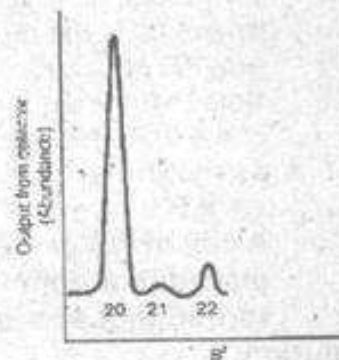
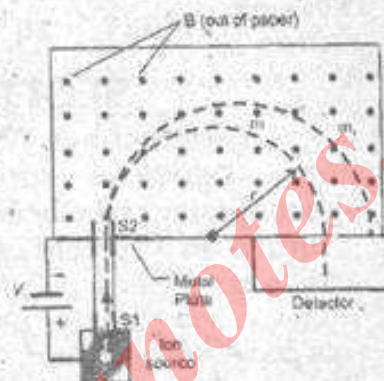
$$m = \frac{Ber}{v}$$

Substituting the values of v from Eq. 1, we get

$$m = \left(\frac{er^2}{2V} \right) B^2 \quad \dots\dots\dots (3)$$

The above equation shows that the mass of each ion reaching the detector is proportional to B² i.e.

$$m \propto B^2$$



v. **Graph of the detector output as a function of B²:**

By adjusting the value of B and keeping the term in the parentheses constant, ions of different masses are allowed to enter the detector. A graph of the

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

375

Physics 12th

detector output as a function of B^2 then gives an indication of what masses are present and the abundance of each mass.

Detection of most abundant isotope:

Fig. shows a record obtained for naturally occurring neon gas showing three isotopes whose atomic mass numbers are 20, 21, and 22. The larger is the peak, the more abundant is the isotope. Thus most abundant isotope of neon is neon-20.

b. Find the mass defect and the binding energy for tritium, if the atomic mass of tritium is 3.016049μ .

Solution:

Mass of tritium = $m = 3.016094\text{ u}$

Mass defect of tritium = $\Delta m = ?$

Binding energy of tritium = $B.E = ?$

Mass defect = $\Delta m = Z \times m_p + (A - Z) m_n - m$

Where m_p = mass of proton = 1.0059 u

m_n = mass of neutron = 1.008665 u

$\Delta m = \{1 \times 1.007276 + (3 - 1) 1.008665 - 3.016049\} = 8.5566 \times 10^{-3}\text{ u} = 0.00857\text{ u Ans.}$

Now Binding energy = $B.E = \Delta m \times c^2$

$B.E = 0.0085 \times 1.66 \times 10^{-27} \times 9 \times 10^{16} = 0.126990 \times 10^{-11}\text{ J}$

$B.E = \frac{0.126990 \times 10^{-11}}{1.6 \times 10^{-19}} = 0.0793687 \times 10^8 = 7.93687 \times 10^6\text{ eV} = 7.97\text{ MeV Ans.}$

Q. 5 a. Define Impedance.

Ans: Impedance:

An A.C. circuit may consist of a resistance R , an inductance L , a capacitance C or a combination of these elements. The combined effect of resistance and reactances in such a circuit is known as impedance and is denoted by Z .

It is measured by the ratio of the rms value of the applied voltage to the rms value of resulting A.C.

Thus $Z = \frac{V_{rms}}{I_{rms}}$

b. What do you understand by R-C and R-L series circuit? Calculate the impedance of both the circuits by drawing their impedance diagram.

Ans: R-C series circuits:

A circuit in which resistance R and capacitance C are connected in series with the source of alternating voltage is known as R-C series circuit.

Impedance of R-C series Circuit:

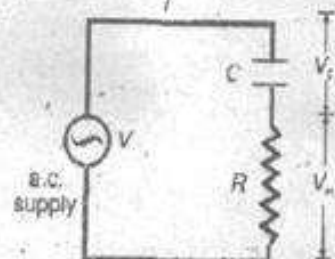
The applied voltage V_{rms} that will send the current I in the circuit is obtained by the resultant of the vectors $I_{rms}R$ and $\frac{I_{rms}}{\omega C}$ i.e.,

$$V = \sqrt{(V_R)^2 + (V_C)^2}$$

$$V_{rms} = \sqrt{(I_{rms}R)^2 + \left(\frac{I_{rms}}{\omega C}\right)^2}$$

$$V_{rms} = I_{rms} \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$$

$$\frac{V}{I} = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$$



PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

376

Physics 12th

$$\text{Impedance} = Z = \frac{V_{rms}}{I_{rms}} = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2} \dots\dots\dots (1)$$

It can be seen in Fig. that the current and the applied voltage are not in phase. The current leads the applied voltage by an angle θ such that

$$\theta = \tan^{-1}\left(\frac{1}{\omega CR}\right) \dots\dots\dots (2)$$

R-L series circuit:

A circuit in which resistance R and inductance L are connected in series with the source of alternating voltage is known as R-L series circuit.

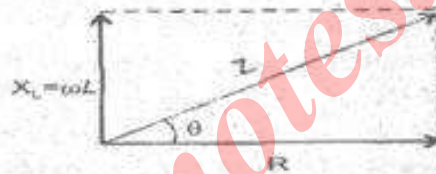
Impedance of R-L series circuit:

The impedance Z of the circuit is obtained by the vector sum of R and ωL lines.

Thus
$$Z = \sqrt{R^2 + (\omega L)^2}$$

The angle $\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$ which Z makes with

R line gives the R phase difference between the applied voltage and current. In this case the voltage leads the current by θ° .



- c. A circuit has an inductance of $\frac{1}{\pi}$ H and resistant of 2000Ω . A 50 Hz A.C is supplied to it. Calculate the reactance and impedance offered by the circuit.

Solution:

$L = \frac{1}{\pi}$ H $V = 220$ V $f = 50$ Hz $R = 2000 \Omega$

$X_L = ?$ $Z = ?$

We know that,

$X_L = 2\pi fL$

$X_L = 2 \times \pi \times 50 \times \frac{1}{\pi} = 100 \Omega$ Ans.

Also $Z = \sqrt{(X_L)^2 + R^2} \Rightarrow Z = \sqrt{(100)^2 + (2000)^2} = 2002.5 \Omega$ Ans.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

377

Physics 12th

FBISE PAPER # (2011)

PHYSICS HSSC-II (2011)

SECTION-A (Marks 17)

Time: 25 Minutes

Marks: 17

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 20 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q.1. Circle the correct option i.e. A / B / C / D. Each part carries one mark.

(i) What is S.I unit of electric flux?

- A. NmC^{-1} B. $\text{Nm}^{-1}\text{C}^{-1}$ C. Nm^2C^{-1} D. Nm^3C^{-2}

(ii) What is the quantity $\frac{\Delta V}{\Delta r}$ called?

- A. Electric potential B. Electric energy
C. Potential barrier D. Potential gradient

(iii) In carbon resistors, what is the value of violet colour?

- A. 6 B. 7 C. 8 D. 9

(iv) Which equation represents the maximum output power?

- A. $P = \frac{E^2}{4R}$ B. $P = \frac{E^2}{4r}$ C. $P = \frac{E^2}{4R^2}$ D. $P = \frac{E^2}{4r^2}$

(v) What is the unit of magnetic flux?

- A. $\text{Nm}^{-1}\text{A}^{-1}$ B. NmA^{-1} C. Nm^{-1}A D. Wb.m^{-2}

(vi) On what principle does a transformer work?

- A. Electrostatic induction B. Electromagnetism
C. Ohm's law D. Mutual induction

(vii) "Eddy Currents" are set up in a direction

- A. Parallel to the flux B. Anti parallel to the flux
C. At an angle of 45° to the flux D. Perpendicular to the flux

(viii) The r.m.s value of current is given by

- A. $\frac{I_0}{\sqrt{2}}$ B. $\sqrt{2} I_0$ C. $2\sqrt{2} I_0$ D. $\frac{I_0}{2\sqrt{2}}$

(ix) At what frequency will an inductor of 1.0 H have a reactance of 500Ω ?

- A. 50 Hz B. 80 Hz C. 500 Hz D. 1000 Hz

(x) What are the substances called which undergo plastic deformation until they break?

- A. Brittle substances B. Ductile substances
C. Amorphous solids D. Polymeric solids

(xi) The common emitter current amplification factor β is given by

- A. $\frac{I_C}{I_E}$ B. $\frac{I_C}{I_B}$ C. $\frac{I_E}{I_B}$ D. $\frac{I_B}{I_E}$

(xii) In which type of logic gate, the output is one when both inputs are zero?

- A. OR gate B. AND gate C. NOT gate D. NOR gate

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

- Maryam Key Series 378 Physics 12th
- (xiii) $1 \mu =$ _____ Mev
A. 1.6×10^{-19} B. 3.36 C. 1.66×10^{-27} D. 931
- (xiv) At what speed would the mass of an electron become double of its rest mass?
A. 0.5 c B. 0.707 c C. 0.866 c D. 0.99 c
- (xv) In which region of electromagnetic spectrum of Hydrogen, the balmer series lies?
A. Infrared B. Visible C. Ultraviolet D. Far ultraviolet
- (xvi) The half-life of $^{91}_{38}\text{Sr}$ is 9.70 hours. What is its decay constant?
A. $1.98 \times 10^{-5} \text{ s}^{-1}$ B. $1.6 \times 10^{-4} \text{ s}^{-1}$ C. $2.5 \times 10^{-5} \text{ s}^{-1}$ D. None of these
- (xvii) Leptons are particles that do not experience _____
A. Weak nuclear force B. Strong nuclear force
C. Electric force D. Magnetic force

PHYSICS HSSC-II

Time allowed: 2:40 Hours

Total Marks = 68

Note: Sections 'B' and 'C' are to be answered on the separately provided answer book. Answer eleven the questions from section 'B' and attempt any two questions from section 'C' Use supplementary answer sheet i.e., sheet B if required. Write your answers neatly and legibly.

SECTION - B (Marks 42)

- Q.2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines. (14 × 3 = 42)
- (i) Compare Electric and Gravitational forces.
- (ii) Prove that the electric intensity at any point inside a hollow charged sphere is zero.
- (iii) What are the difficulties in testing whether the filament of a lighted bulb obeys ohm's law?
- (iv) Describe briefly, how Potentiometer is used to compare the e.m.f's of two cells.
- (v) Give three uses of Cathode Ray Oscilloscope(CRO).
- (vi) By using formula, describe the change in the magnetic field inside a solenoid carrying a steady current I if (a) the length of the solenoid is doubled but the number of turns remains the same and (b) the number of turns is doubled but the length remains the same.
- (vii) Does the induced e.m.f in a circuit depend on the resistance of the circuit? Does the induced current: depend on the resistance of the circuit?
- (viii) When the primary of a transformer is connected to A.C mains the current in it (a) is very small if the secondary circuit is open but (b) increases when the secondary circuit is closed. Explain these facts.
- (ix) What are Electrical oscillators? How do they play their part in metal detectors?
- (x) Compare F.M and A.M radio waves.
- (xi) What are Superconductors? Why are they preferred? Give names of the two devices where superconductors are applied.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

379

Physics 12th

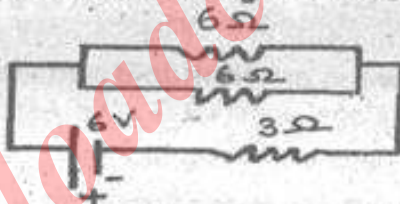
- (xii) What is meant by Hysteresis loss? How is it used in construction of a transformer?
- (xiii) What is Photodiode? Why is it operated in reverse biased state?
- (xiv) We often see that during day time when it is cloudy, street lights turn ON, automatically. Why does it so happen?
- (xv) How have the results of special theory of relativity been applied to NAVSTAR navigation system?
- (xvi) Photon A has twice the energy of photon B. What is the ratio of the momentum of A to that of B?
- (xvii) How can the spectrum of hydrogen contain so many lines when hydrogen contains one electron?
- (xviii) What factors make a fusion reaction difficult to achieve?
- (xix) What do you understand by "background radiation"? State two sources of this radiation.

SECTION - C (Marks 26)

Note:- Attempt any TWO questions.

(2×13 = 26)

- Q. 3 a. What is Capacitor and its Capacitance? Discuss the factors upon which capacitance of a capacitor depends. Obtain the expression for dielectric constant. 08
- b. Find equivalent resistance of the circuit, total current drawn from the source and the current through each resistor. 05



- Q. 4 a. What is Current generator? Give the principle and construction of an A.C generator. Derive formula to calculate the e.m.f induced in the loop. 08
- b. A circuit consists of a capacitor of $2\mu F$ and a resistance of 1000Ω connected in series. An alternating voltage of 12 volts and frequency $50Hz$ is applied. Find : 04
- (i) The current in the circuit
 - (ii) The average power supplied
- c. How many times per second will an incandescent lamp reach maximum brilliance when connected to a $50Hz$ source? 01
- Q.5 a. How are the X-rays Produced? Explain the production of: 08
- (i) Characteristic X-ray
 - (ii) Continuous X-ray
- b. What is the de-Broglie wavelength of an electron whose kinetic energy is $120 eV$? 04
- c. What does LASER stand for? 01

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

380

Physics 12th

SOLUTION OF FBISE PAPER # (2011)

SECTION- A (MCQs)

i. C	ii. D	iii. B	iv. A	v. A	vi. D
vii. D	viii. A	ix. B	x. C	xi. B	xii. D
xiii. D	xiv. C	xv. B	xvi. A	xvii. B	

SECTION- B

(i) Compare Electric and Gravitational forces.

Ans: Electric and gravitational forces (a comparison):

i. **Gravitational force:**

Gravitational force is a conservative force, that is, work done in such a field is independent of path.

ii. **Electric force:**

Coulomb's electrostatic force is also conservative force. The electric force between two charges $F = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}$, is similar in form to the gravitational force

between the two point masses, $F = G \frac{m_1 m_2}{r^2}$.

iii. **Similarity between gravitational and electric force:**

Both forces vary inversely with the square of the distance between the two charges or the two masses.

iv. **Dissimilarity between gravitational and electric force:**

a. The value of gravitational constant G is very small as compared to electrical constant $\frac{1}{4\pi\epsilon_0}$. It is because of this fact that the gravitational force is a very weak force as compared to electrostatic force.

b. As regards their qualitative aspect, the electrostatic force could be attractive or repulsive while, on the other hand, gravitational force is only attractive.

c. Another difference to be noted is that the electrostatic force is medium dependant and can be shielded while gravitational force lacks this property.

(ii) **Prove that the electric intensity at any point inside a hollow charged sphere is zero.**

Ans: **Intensity of field inside a hollow charged sphere:**

i. Suppose that a hollow conducting sphere of radius R is given a positive charge q .

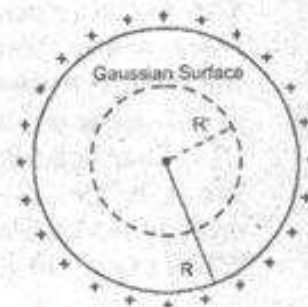
ii. Now imagine a sphere of radius $R' < R$ to be inscribed within the hollow charged sphere. The surface of this sphere is the Gaussian surface.

Applying Gaussian law, we have

$$\phi_e = \frac{q}{\epsilon_0} = 0$$

Since $\phi_e = E \cdot A = 0$ as $A \neq 0$,
therefore, $E = 0$

Note: i. The interior of a hollow charged metal sphere is a field free region.



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ii. As a consequence, any apparatus placed within a metal enclosure is "shielded" from electric fields.

(iii) **What are the difficulties in testing whether the filament of a lighted bulb obeys ohm's law?**

Ans: When the current in an electric bulb rises to a maximum then its temperature and resistance increases. To apply Ohm's law we must have resistance and temperature constant. In bulb it doesn't happen, and its V-I graph is not a straight line. Showing that bulb is non Ohmic.

(iv) **Describe briefly, how Potentiometer is used to compare the e.m.fs of two cells.**

Ans: The emfs E_1 and E_2 of two cells. The balancing lengths, l_1 and l_2 are found separately for the two cells. Then, $E_1 = E \frac{l_1}{L}$ and $E_2 = E \frac{l_2}{L}$

Dividing these two equations, we get $\frac{E_1}{E_2} = \frac{l_1}{l_2}$

(v) **Give three uses of Cathode Ray Oscilloscope(CRO).**

Ans: i. The CRO is used for displaying the waveform of a given voltage. Once the waveform is displayed, we can measure the voltage, its frequency and phase. For example, Fig. shows the waveform of an alternating voltage. As the y-axis is calibrated in volts and the x-axis in time, we can easily find the instantaneous value and peak value of the voltage.

ii. The time period can also be determined by using the time calibration of x-axis.

iii. Information about the phase difference between two voltages can be obtained by simultaneously displaying their waveforms. For example, the waveforms of two voltages are shown in Fig. These waveforms show that when the voltage of I is increasing, that of II is decreasing and vice versa. Thus the phase difference between these voltages is 180° .

(vi) **By using formula, describe the change in the magnetic field inside a solenoid carrying a steady current I if (a) the length of the solenoid is doubled but the number of turns remains the same and (b) the number of turns is doubled but the length remains the same.**

Ans: Magnetic field inside a solenoid is

$$B = \frac{\mu_0 N I}{L} \Rightarrow B \propto \frac{1}{L} \quad \text{and} \quad B \propto N$$

Therefore, it is clear that

(a) By doubling length L the magnetic field will be halved. $B \propto \frac{1}{L}$

(b) By doubling number of turns N , the magnetic field will be doubled. $B \propto N$

(vii) **Does the induced e.m.f in a circuit depend on the resistance of the circuit? Does the induced current depend on the resistance of the circuit?**

Ans: According to Faraday's law induced emf is $\epsilon = -N \frac{\Delta\phi}{\Delta t}$. This relation shows that induced emf does not depend upon the resistance of the circuit.

According to Ohm's law $I = \frac{\epsilon}{R}$. This relation shows that induced current does depend upon the resistance of the circuit.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

382

Physics 12

- (viii) When the primary of a transformer is connected to A.C mains the current in it (a) is very small if the secondary circuit is open but (b) increases when the secondary circuit is closed. Explain these facts.

Ans: (a) When the secondary circuit is open then there is no load to consume electric power or output power used is zero.

$$\text{Output power} = V_s I_s = 0$$

Since output power of a transformer is smaller than input power. Hence the primary coil of the transformer draws a very small current from a.c.

- (b) When the secondary circuit is closed then output power increases
 input power = output power

$$I_p V_p = I_s V_s$$

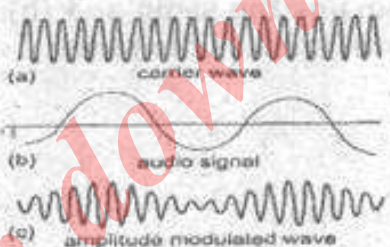
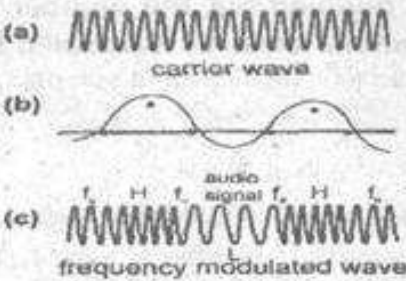
The transformer will draw large current from the a.c mains to increase the primary power because greater current is needed in primary coil to equalize power in the secondary coil.

- (ix) What are Electrical oscillators? How do they play their part in metal detectors?

Ans: An L-C circuit behaves just like an oscillating mass-spring system. In this case energy oscillates between a capacitor and an inductor. The circuit is called an electrical oscillator. Two such oscillators A and B are used in the operation of a common type of metal detector.

- (x) Compare F.M and A.M radio waves.

Ans:

Amplitude modulation (A.M)	Frequency modulation (F.M)
In this type of modulation the amplitude of the carrier wave is increased or diminished as the amplitude of the superposing modulating signal increases and decreases.	In this type of modulation the frequency of the carrier wave is increased or diminished as the modulating signal, amplitude increases or decreases but the carrier wave amplitude remains constant.
 (a) carrier wave (b) audio signal (c) amplitude modulated wave	 (a) carrier wave (b) audio signal (c) frequency modulated wave
Fig. (a) represents a high frequency carrier wave of constant amplitude and frequency. Fig. (b) represents a low or audio frequency signal of a sine waveform. Fig. (c) shows the result obtained by modulating the carrier waves with the modulating wave.	Fig. shows frequency modulation. The frequency of the modulated carrier wave is highest (point H) when the signal amplitude is at its maximum positive value and is at its lowest frequency (point L) when signal amplitude has maximum negative. When the signal amplitude is zero, the

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Physics 12 ^o	
	carrier frequency is at its normal frequency f_0 .
The A.M. transmission frequencies range from 540 kHz to 1600 kHz.	The F.M. transmission frequencies range from 88 MHz to 108 MHz.

(xi) **What are Superconductors? Why are they preferred? Give names of the two devices where superconductors are applied.**

Ans: Superconductors:

Superconductors are alloys that, at certain temperatures, conduct electricity with no resistance.

They are preferred because:

- Superconductors offer no resistance to electric current and are, therefore, perfect conductors.
- Once the resistance of a material drops to zero, no energy is dissipated and the current, once established, continues to exist indefinitely without the source of an emf.

Superconductors have many technological applications such as in magnetic resonance imaging (MRI), magnetic levitation trains, powerful but small electric motors and faster computer chips.

(xii) **What is meant by Hysteresis loss? How is it used in construction of a transformer?**

Ans: Hysteresis loss:

The area of the loop is a measure of the energy needed to magnetize and demagnetize the specimen during each cycle of the magnetizing current. This is the energy required to do work against internal friction of the domains. This work, like all work that is done against friction, is dissipated as heat. It is called **hysteresis loss**.

Use in the construction of transformer:

Hard magnetic materials like steel cannot be easily magnetized or demagnetized, so they have large loop area as compared to soft magnetic material such as iron which can easily be magnetized. The energy dissipated per cycle, thus, for iron is less than for steel. That is why soft iron used in transformers.

(xiii) **What is Photodiode? Why is it operated in reverse biased state?**

Ans: A photo diode is a semi-conductor diode made from silicon. It converts light energy directly into electrical energy

When no light is incident on the junction, the reverse current is almost zero. When light is incident on p-n junction (i.e. diode), reverse current begins to flow. Reverse current increases with the intensity of light. As this light produces electron

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

hole pair and are separated by reverse biased which conduct the electric current. Hence reverse biased state is used in Photo-diode.

(xiv) We often see that during day time when it is cloudy, street lights turn ON, automatically. Why does it so happen?

Ans: As it gets darker, R_L becomes larger and V decreases. When V becomes just less than V_R , the output of op-amp switches to $+V_{CC}$ which energizes the relay system and the street lights are turned ON.

(xv) How have the results of special theory of relativity been applied to NAVSTAR navigation system?

Ans: The results of special theory of relativity are put to practical use even in everyday life by a modern system of navigation satellites called NAVSTAR.

(xvi) Photon A has twice the energy of photon B. What is the ratio of the momentum of A to that of B?

Ans: Since energy of photon $= E = \frac{hc}{\lambda}$ or $E = pc$

Let energy of photon A $= E_1$

Let energy of photon B $= E_2$

Let momentum of photon A $= P_1$

Let momentum of photon B $= P_2$

Therefore $E_1 = P_1 c$ (1) and $E_2 = P_2 c$ (2)

Given that $E_1 = 2 E_2$

Put in Eq. 1 $2E_2 = P_1 c$ (3)

Dividing Eq. 3 by Eq. 2

$$\frac{2E_2}{E_2} = \frac{P_1 c}{P_2 c}$$

$$\frac{P_1}{P_2} = 2$$

Hence momentum of photon A is 2 times the momentum of photon B.

(xvii) How can the spectrum of hydrogen contain so many lines when hydrogen contains one electron?

Ans: Hydrogen atom contains one electron. It will emit one spectral line, if it jumps direct from higher energy state to the ground state.

The electron does not necessarily return to the ground state in the single jump, but may return by several jumps. That is why hydrogen spectrum contains many lines.

(xviii) What factors make a fusion reaction difficult to achieve?

Ans: We know that for fusion of two light nuclei the work has to be done to overcome the repulsive force which exists between them. For this the two nuclei are hurled towards one another at a very high speed. One method to do so is to give these nuclei a very large velocity with the help of an accelerator. This method has been used in the research study of nuclear fusion of ^2_1H and ^3_1H . But this method of nuclear fusion for getting energy cannot be used on a large scale.

(xix) What do you understand by "background radiation"? State two sources of this radiation.

Ans: When a Geiger tube is used in any experiment, it records radiation even when a radioactive source is nowhere near it. This is caused by radiation called background radiation. It is partly due to cosmic radiation which comes to us from

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

outer space and partly from naturally occurring radioactive substance in the Earth's crust. The main sources are: distant stars, galaxies and cosmic rays.

SECTION - C (Marks 26)

Q. 3 a. What is Capacitor and its Capacitance? Discuss the factors upon which capacitance of a capacitor depends. Obtain the expression for dielectric constant.

Ans: Capacitor: A capacitor is a device that can store charge.

Capacitance:

It is a measure of the ability of capacitor to store charge.

The capacitance of a capacitor can be defined as the amount of charge on one plate necessary to raise the potential of that plate by one volt with respect to the other. It is found that

$$Q \propto V \quad \text{or} \quad Q = CV \quad \text{or} \quad C = \frac{Q}{V} \dots (1)$$

The proportionality constant C is called the capacitance of the capacitor.

Factors affecting capacitance of a capacitor:

Capacitance depends upon the geometry of the plates and the medium between them.

Expression for dielectric constant:

capacitance of a parallel plate capacitor:

i. Consider a parallel plate capacitor consisting of two plane metal plates, each of area A , separated by a distance d as shown in Fig.

ii. The distance d is small so that the electric field E between the plates is uniform and confined almost entirely in the region between the plates.

iii. Let initially the medium between the plates be air or vacuum. Then

$$C_{vac} = \frac{Q}{V} \dots (1)$$

Where Q is the charge on the capacitor and V is the potential difference between the parallel plates.

iv. The magnitude E of electric intensity is related with the distance d by Eq. as

$$E = \frac{V}{d} \dots (2)$$

v. As Q is the charge on either of the plates of area A , the surface density of charge on the plates is as

$$\sigma = \frac{Q}{A}$$

vi. The electric intensity between two oppositely charged plates is given by $E = \frac{\sigma}{\epsilon_0}$. Substituting the value of σ , we

have $E = \frac{Q}{A\epsilon_0} \dots (3)$

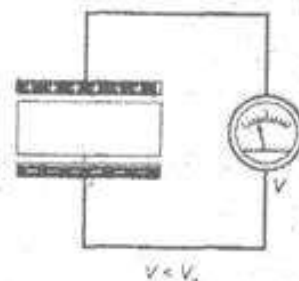
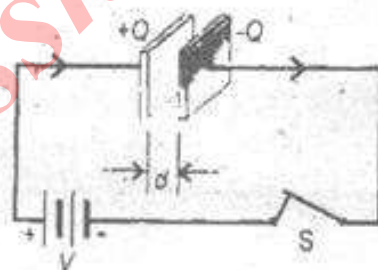
By comparing Eq. 2 and 3 we get,

$$\frac{V}{d} = \frac{Q}{A\epsilon_0} \dots (4)$$

$$\frac{Q}{V} = \frac{A\epsilon_0}{d}$$

By using Eq. 1

$$C_{vac} = \frac{A\epsilon_0}{d} \dots (5)$$



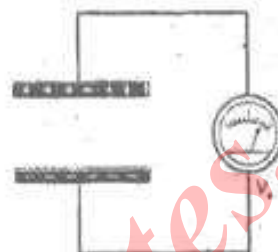
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Dielectric constant (ϵ_r):

If an insulating material, called dielectric, of relative permittivity ϵ_r , is introduced between the plates, the capacitance of capacitor is enhanced by the factor ϵ_r . Capacitors commonly have some dielectric medium, thereby ϵ_r , is also called as dielectric constant.

Effect of insertion of dielectric between the plates of a capacitor:

Consider a charged capacitor whose plates are connected to a voltmeter. The deflection of the meter is a measure of the potential difference between the plates. When a dielectric material is inserted between the plates, reading drops indicating a decrease in the potential difference between the plates.



From the definition, $C = Q/V$, since V decreases while Q remains constant, the value of C increases. Then

$$C_{\text{med}} = \frac{A\epsilon_0\epsilon_r}{d} \quad (6)$$

Eq. 5 shows the dependence of a capacitor upon the area of plates, the separation between the plates and medium between them.

Expression for dielectric constant (ϵ_r):

Dividing Eq. 6 by Eq. 5 we get expression for dielectric constant as,

$$\epsilon_r = \frac{C_{\text{med}}}{C_{\text{vac}}} \quad (7)$$

Dielectric co-efficient or dielectric constant (ϵ_r):

Dielectric co-efficient or dielectric constant is defined as "The ratio of the capacitance of a parallel plate capacitor with an insulating substance as medium between the plates to its capacitance with vacuum (or air) as medium between them."

- b. Find equivalent resistance of the circuit, total current drawn from the source and the current through each resistor.

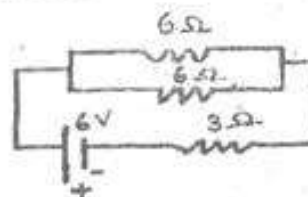
Solution: $R_1 = 6\ \Omega$, $R_2 = 6\ \Omega$
 $R_3 = 3\ \Omega$, $V = 6V$

Equivalent Resistance = $R_{\text{eq}} = ?$ Total current = $I = ?$

Current through $R_1 = I_1 = ?$

Current through $R_2 = I_2 = ?$

Current through $R_3 = I_3 = ?$



In order to solve this numerical first of all we label the figure as follows:

For the parallel combination of R_1 and R_2 :

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow \frac{1}{R} = \frac{1}{6} + \frac{1}{6} \Rightarrow \frac{1}{R} = \frac{1+1}{6} = \frac{1}{3}$$

$$R = 3\ \Omega$$

This resistance R will be in series with R_3

$$R_{\text{eq}} = R + R_3 = 3 + 3 = 6\ \Omega \text{ Ans.}$$

According to Ohm's law,

$$I = \frac{V}{R_{\text{eq}}}$$

Using values we get,

$$I = \frac{6}{6} = 1\ \text{A Ans.}$$

Again using Ohm's law,

$$V_{\text{BC}} = IR_3$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Physics 12th

It is clear that, $V_{AB} + V_{BC} = 6V$ $V_{BC} = 1 \times 3 = 3$ volts $\Rightarrow V_{AB} = 6V - V_{BC} = 6V - 3V = 3V$

Now, $I = \frac{V_{AB}}{R_1} = \frac{3}{6} = 0.5$ A Ans.

And, $I_2 = \frac{V_{AB}}{R_2} = \frac{3}{6} = 0.5$ A Ans.

From figure it is clear that, $I_1 = I = 1$ A Ans.

Q. 4 a. What is Current generator? Give the principle and construction of an A.C generator. Derive formula to calculate the e.m.f induced in the loop.

Ans: Alternating current generator (A.C. generator):

A current generator is a device that converts mechanical energy into electrical energy."

Principle of A.C. generator:

The principle of an electric generator is based on Faraday's law of electromagnetic induction.

Working of A.C. generator:

When a coil is rotated in a magnetic field by some mechanical means, magnetic flux through the coil changes, and consequently an emf is induced in the coil.

If the generator is connected to an external circuit, an electric current is the output of the generator.



Construction of A.C. generator:

Rectangular loop of wire:

Let a rectangular loop of wire of area A be placed in a uniform magnetic field B. The loop is rotated about z-axis through its centre at constant angular velocity ω .

Slip rings:

One end of the loop is attached to a metal ring R and the other end to the ring R'. These rings, called the slip rings are concentric with the axis of the loop and rotate with it.

Carbon brushes:

Rings R R' slide against stationary carbon brushes to which external circuit is connected.

Calculation of induced emf in the loop:

i. To calculate the induced emf in the loop, consider its position while it is rotating anticlockwise. The figure shows the top view of the coil.

ii. The vertical side ab of the loop is moving with velocity v in the magnetic field B. If the angle between v and B be θ , the motional emf induced in the side ab has the magnitude, $\mathcal{E}_{ab} = vBL \sin \theta$

The direction of induced current in the wire ab is the same as that of force F experienced by the charges in the wire, i.e., from top to the bottom.

iii. The same amount of emf is induced in the side cd but the direction of current is from bottom to the top. Therefore $\mathcal{E}_{cd} = vBL \sin \theta$

iv. The net contribution to emf by sides bc and da is zero because the force acting on the charges inside bc and da is not along the wire. Thus

$$\mathcal{E}_{bc} = \mathcal{E}_{da} = 0$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

388

PHYSICS 1.4

- v. Since both the emfs in the sides ab and cd drive current in the same direction around the loop, the total emf in the loop is $\mathcal{E} = \mathcal{E}_{ab} + \mathcal{E}_{cd}$

$$\mathcal{E} = vBL \sin\theta + vBL \sin\theta = 2vBL \sin\theta$$

- vi. If the loop is replaced by a coil of N turns, the total emf in the coil will be,
 $\mathcal{E} = 2 NvBL \sin\theta \dots\dots\dots (1)$

- vii. The linear speed v of the vertical wire is related to the angular speed ω by the relation

$$v = \omega r$$

where r is the distance of the vertical wires from the centre of the coil.
 Substituting ωr for v in Eq. (1), We get

$$\mathcal{E} = 2N (\omega r) BL \sin\theta$$

$$\mathcal{E} = N\omega (2rL) B \sin\theta$$

$$\mathcal{E} = N\omega AB \sin\theta \dots\dots\dots (2)$$

where $A = 2 rL$ = area of the coil

As the angular displacement $\theta = \omega t$, so the Eq. 2 becomes

$$\mathcal{E} = N\omega AB \sin(\omega t) \dots\dots\dots (3)$$

- viii. **Maximum value of emf ($\mathcal{E}_0$):**

Eq.3 shows that the induced emf varies sinusoidally with time.
 It has the maximum value $\mathcal{E}_0$ when $\sin(\omega t)$ is equal to 1. Thus

$$\mathcal{E}_0 = N \omega AB \dots\dots\dots (4)$$

The Eq. 3 can be written as,

$$\mathcal{E} = \mathcal{E}_0 \sin(\omega t) \dots\dots\dots (5)$$

- b. A circuit consists of a capacitor of $2\mu F$ and a resistance of 1000Ω connected in series. An alternating voltage of 12 volts and frequency 50Hz is applied. Find :

- (i) The current in the circuit
 (ii) The average power supplied

Solution:

Capacitance = $C = 2 \mu F = 2 \times 10^{-6} F$

Resistance = $R = 1000 \Omega$

Alternating Voltage = $V = 12 V$

Frequency = $f = 50 Hz$

(i) Current = $I_{rms} = ?$

(ii) Average power = $P = ?$

Since

$$X_c = \frac{1}{2\pi fC}$$

$$X_c = \frac{1}{2 \times 3.14 \times 50 \times 2 \times 10^{-6}} = 1592 \Omega$$

Also

$$Z = \sqrt{R^2 + (X_c)^2}$$

$$Z = \sqrt{(1000)^2 + (1592)^2} = 1880 \Omega$$

Now

$$I_{rms} = \frac{V_{rms}}{Z}$$

$$I_{rms} = \frac{12}{1880} = 0.0064 A = 6.4 \times 10^{-3} A = 6.4 mA \text{ Ans.}$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

389

Physics 12th

Phase difference = $\theta = \tan^{-1} \left(\frac{X_C}{R} \right)$

$$\theta = \tan^{-1} \left(\frac{1592}{1000} \right) = \tan^{-1} (1.592) = 57.87^\circ$$

Average power = $P_{av} = V_{rms} I_{rms} \cos \theta$

$$P_{av} = 12 \times 0.0064 \text{ A} \times \cos 57.87^\circ$$

$$P_{av} = 12 \text{ V} \times 0.0064 \text{ A} \times 0.532 = 0.04 \text{ W Ans.}$$

c. How many times per second will an incandescent lamp reach maximum brilliance when connected to a 50Hz source?

Ans: Since in each cycle, alternating voltage reaches its maximum value two times (once for positive peak value and one for negative peak value). Therefore lamp will show maximum brilliance twice the frequency of A.C.

$$\text{Brilliance of lamp} = 2 \times f = 2 \times 50 = 100 \text{ times}$$

Q. 5 a. How are the X-rays Produced? Explain the production of:
 (i) Characteristic X-ray (ii) Continuous X-ray

Ans: X-rays production unit:

i. X-ray tube:

It consists of a high vacuum tube called X-ray tube.

ii. Function of filament:

When the cathode is heated by the filament F, it emits electrons which are accelerated towards the anode T.

ii. Kinetic energy of electron:

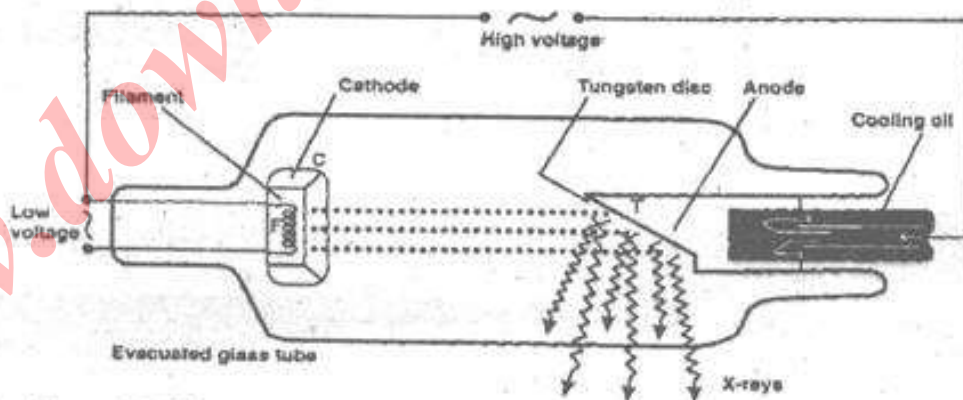
If V is the potential difference between C and T the kinetic energy K.E. with which the electron strike the target is given by

$$\text{K.E.} = Ve \quad \dots (1)$$

Production of K_α X-ray:

Suppose that one of the electrons in the K shell is removed, thereby producing a vacancy or hole in that shell. The electron from the L shell jumps to occupy the hole in the K shell, thereby emitting a photon of energy $hf_{K\alpha}$ called the K_α X-ray given by

$$hf_{K\alpha} = E_L - E_K \quad \dots (2)$$



Production of K_β X-ray:

It is also possible that the electron from the M shell might also jump to occupy the hole in the K shell. The photons emitted are K_β X-ray with energies

$$hf_{K\beta} = E_M - E_K \quad \dots (3)$$

These photons give rise to K_β X-ray and so on.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

390

Physics 12th

Characteristic X-rays:

The photons emitted in such transitions i.e., inner shell transitions are called characteristic X-rays, because their energies depend upon the type of target material.

Creation of holes:

The holes created in the L and M shells are occupied by transitions of electrons from higher states creating more X-rays. The characteristic X-rays appear as discrete lines on a continuous spectrum.

The continuous X-ray spectrum:

The continuous spectrum is due to an effect known as **bremsstrahlung** or **braking radiation**.

- i. When the fast moving electrons bombard the target, they are suddenly slowed down on impact with the target. We know that an accelerating charge emits electromagnetic radiation. Hence, these impacting electrons emit radiation as they are strongly decelerated by the target.
- ii. Since the rate of deceleration is so large, the emitted radiation corresponds to short wavelength and so the bremsstrahlung is in the X-ray region. In the case when the electrons lose all their kinetic energy in the first collision, the entire kinetic energy appears as a X-ray photon of energy $hf_{\max}$ i.e.,

$$K.E. = hf_{\max}$$
- iii. The wavelength $\lambda_{\min}$ in Fig. corresponds to frequency $f_{\max}$. Other electrons do not lose all their energy in the first collision. They may suffer a number of collisions before coming to rest. This will give rise to photons of smaller energy or X-rays of longer wavelength. Thus the continuous spectrum is obtained due to deceleration of impacting electrons.

- b. **What is the de-Broglie wavelength of an electron whose kinetic energy is 120 eV?**

Solution:

$$m = 9.11 \times 10^{-31} \text{ Kg}$$

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$K.E = 120 \text{ keV} = 120 \times 10^3 = 120 \times 10^3 \times 1.6 \times 10^{-19}$$

$$K.E = 192 \times 10^{-16} \text{ J}$$

$$V = ?$$

Since,

$$\frac{1}{2}mv^2 = K.E$$

$$v^2 = \frac{2 \times K.E}{m}$$

$$v = \sqrt{\frac{2 \times K.E}{m}}$$

$$v = \frac{\sqrt{2 \times 192 \times 10^{-16}}}{\sqrt{9.11 \times 10^{-31}}} = \sqrt{4.219 \times 10^{13}} = 6.5 \times 10^6 \text{ ms}^{-1}$$

De-Broglie wavelength is,

$$\lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 6.5 \times 10^6} = 0.112 \times 10^{-9} = 1.12 \times 10^{-10} \text{ m Ans.}$$

- c. **What does LASER stand for?**

Ans: Laser stands for Light Amplification by Stimulated emission of Radiation.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

391

Physics 12*

FBISE PAPER # (2012)
PHYSICS HSSC-II (2012)

SECTION-A (Marks 17)

Time allowed: 25 Minutes

Marks: 17

NOTE:- Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 25 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q. 1 Circle the correct option i.e. A/B/C/D. Each part carries one mark.

(i) The fact that Electric Field exists in space around an electrical charge is _____.

- A. Electrical property
B. Gravitational Field
C. Intrinsic property of nature
D. All of these

(ii) One coulomb charge is carried by _____.

- A. 6.25×10^{18}
B. One electron
C. 1.6×10^{-19}
D. None of these

(iii) Power of an electric generator of voltage (V) and driving current (I) through an appliance is _____.

- A. $P = VI$
B. $P = I^2R$
C. $P = \frac{V^2}{R}$
D. All of these

(iv) Electric field and potential difference inside a hollow charge conducting sphere are:

- A. 0, 0
B. $\frac{1}{4\pi\epsilon_0} \frac{q}{r}, 0$
C. 0, $\frac{1}{4\pi\epsilon_0} \frac{q}{r}$
D. None of these

(v) Dimensional representation of Planck's constant is the same as _____.

- A. Gravitational Constant
B. Torque
C. Momentum
D. Angular Momentum

(vi) The deflecting couple in a galvanometer is given by _____.

- A. $\frac{NI}{AB}$
B. NIBA
C. $\frac{AB}{N}$
D. None of these

(vii) An Inductor may store energy in its _____.

- A. Coil
B. Electric Field
C. Magnetic Field
D. Both B and C

(viii) In CRO, the time base generator circuit is connected to the _____.

- A. X-Plate
B. Y-Plate
C. Electron Gun
D. Accelerating Electrodes

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

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- (ix) In ac Circuit at resonance, the phase difference between current and voltage is _____.
A. 90° B. 180° C. 0° D. 360°
- (x) Once the resistance of material drops to zero, the _____.
A. Energy is dissipated
B. Current is dissipated
C. Energy and current both are dissipated
D. Energy and current both are not dissipated
- (xi) Radius of 3rd Bohr orbit in hydrogen atom is greater than radius of 1st orbit by _____.
A. 2 B. 3 C. 4 D. 9
- (xii) Component in generator which consumes energy is called _____.
A. Commutator B. Split rings
C. Capacitor D. Load
- (xiii) Solid state detector is basically _____.
A. NPN Transistor B. PNP Transistor
C. PN Junction D. LED
- (xiv) Half Life of $^{91}_{38}\text{Sr}$ is 9.70 hrs. Its decay constant is _____.
A. $1.99 \times 10^{-5} \text{ s}$ B. $1.99 \times 10^{-7} \text{ s}$
C. $1.99 \times 10^5 \text{ s}$ D. 1.99 hrs
- (xv) The circuit which changes input signal at output with phase difference of 180° is called:-
A. Amplifier B. Inverter
C. Non-Inverter D. Switch
- (xvi) Electromagnetic waves do not transport _____.
A. Energy B. Momentum
C. Charge D. Information
- (xvii) One Tesla is _____.
A. N A m B. $\text{N A}^{-1} \text{ m}^{-1}$
C. 10 Nam D. None of these

PHYSICS HSSC-II

Time allowed: 2:35 Hours

Total Marks Sections B and C: 68

NOTE:- Answer any fourteen parts from Section 'B' and any two questions From Section 'C' on the separately provided answer book. Use supplementary answer sheet i.e. Sheet-B if required. Write your answers neatly and legibly.

SECTION - B (Marks 42)

- Q.2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines. (14 × 3 = 42)
- (i) Define Electric Flux and give its unit.
- (ii) What is the difference between electrical potential energy and electric potential at any point of an electric field?
- (iii) Define electric power. Obtain the maximum power equation.
- (iv) Why does the resistance of a conductor rise with temperature?
- (v) How can you use a magnetic field to separate isotopes of chemical element?

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393

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- (vi) Does the Induced emf in a circuit depend on the resistance of the circuit? Does the induced current depend on the resistance of the circuit?
- (vii) What is stable or dead beat Galvanometer?
- (viii) In a transformer, there is no transfer of charge from the primary to the secondary. How is, then the power transferred?
- (ix) What is a Parallel Resonance circuit? Write down its properties.
- (x) Explain the existence of magnetic domains in Ferromagnetic material.
- (xi) Why do not we observe Compton effect with visible light?
- (xii) If the speed of light were infinite, what would the equations of special theory of Relativity reduce to?
- (xiii) Why are charge carriers not present in the depletion region?
- (xiv) Find the mass m of a moving object with speed $0.8c$.
- (xv) How can the spectrum of hydrogen contain so many lines, when hydrogen contains only one electron?
- (xvi) What is the effect of forward biasing of a diode on the width of depletion region?
- (xvii) What do we mean by the term Critical mass?
- (xviii) What factors make a fusion reaction difficult to achieve?
- (xix) An A.C Voltmeter reads 250 V. What is its peak and instantaneous values if the frequency of alternating voltage is 50 Hz?

SECTION - C (Marks 26)

Note: Attempt any TWO questions.

(2 × 13 = 26)

- Q. 3 a. Define Mutual Induction. 02
 b. Derive an expression for energy stored in an Inductor. Also express the energy in term of magnetic field. 06
 c. A permanent magnet DC motor is run by a battery of 24 volts. The coil of the motor has a resistance of 2 ohms. It develops a back e.m.f of 22.5 volts when driving the load at normal speed. What is the current when motor just starts up? Also find the current when motor is running at normal speed? 05
- Q. 4 a. What is a Transistor? Describe the construction and operation of a transistor. Also find an expression for its gain. 1+2+2+4
 b. The current flowing into the base of a transistor is $100\mu A$. Find its collector current I_c , its emitter current I_e and the ratio I_c/I_e , if the value of current gain β is 100. 04
- Q. 5 a. How are X-rays produced? What are the important properties of X-rays? 5+4
 b. Calculate the longest wavelength of radiation for the Paschen series. 04

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SOLUTION OF FBISE PAPER # (2012)

SECTION- A (MCQs)

i. C	ii. A	iii. D	iv. A	v. D	vi. B
vii. C	viii. A	ix. C	x. D	xi. D	xii. D
xiii. C	xiv. A	xv. B	xvi. C	xvii. B	

SECTION- B

(i) Define Electric Flux and give its unit.

Ans: Electric flux:

The number of the field lines passing through a certain element of area is known as electric flux through that area. It is usually denoted by Greek letter ϕ .

$$\phi_e = EA \cos \theta$$

Unit of electric flux (ϕ):

Electric flux, being a scalar product, is a scalar quantity. Its SI unit is Nm^2C^{-1} .

(ii) What is the difference between electrical potential energy and electric potential at any point of an electric field?

Ans: Electrical potential energy:

The electrostatic potential energy, U_E , of one point charge q in the presence of an electric field E is defined as the negative of the work W done by the electrostatic force to bring it from the reference position r_{ref} to some position r .

Units: The SI unit of electric potential energy is the joule.

The electrostatic potential energy, U_E , of one point charge q in the presence of an electric field E due to a point charge Q , taking an infinite separation between the charges as the reference position, is:

$$U_E = \frac{1}{4\pi\epsilon_0} \frac{qQ}{r}$$

where $\frac{1}{4\pi\epsilon_0}$ is Coulomb's constant, and r is the distance between the point charges q and Q .

Electric potential:

In classical electromagnetism, the electric potential (a scalar quantity denoted by ϕ , ϕ_E or V and also called the electric field potential or the electrostatic potential) at a point is the amount of electric potential energy that a unitary point charge at that location would have.

The electric potential at a point is equal to the electric potential energy (measured in joules) of any charged particle at that location divided by the charge (measured in coulombs) of the particle. Since the charge of the test particle has been divided out, the electric potential is a "property" related only to the electric field itself and not the test particle. The electric potential has the units of joules per coulomb, or volts.

(iii) Define electric power. Obtain the maximum power equation.

Ans: Electrical power:

The rate at which the battery is supplying electrical energy is the power output or electrical power of the battery. Using the definition of power we have

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$$\text{Electrical Power} = \frac{\text{Energy supplied}}{\text{time taken}} = V \frac{\Delta Q}{\Delta t}$$

Since $I = \frac{\Delta Q}{\Delta t}$, so Electrical power = $V \times I$ (2)

Maximum power equation:

- i. In the circuit of Fig. as the current I flow through the resistance R , the charges flow from a point of higher potential to a point of lower potential and as such, they lose potential energy.
- ii. If V is the potential difference across R , the loss of potential energy per second is VI . This loss of energy per second appears in other forms of energy and is known as power delivered to R by current I .

$$\therefore \text{Power delivered to } R = P_{\text{out}} = VI \dots \dots \dots (1)$$

$$P_{\text{out}} = I^2 R \dots \dots \dots (2)$$

$$(\therefore V = IR)$$

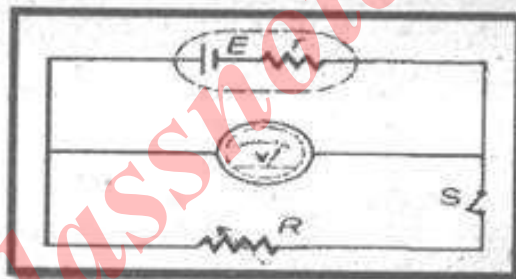
As

$$I = \frac{E}{R+r}$$

From Eq. 2

$$P_{\text{out}} = \frac{E^2 R}{(R+r)^2}$$

$$P_{\text{out}} = \frac{E^2 R}{(R+r)^2} = \frac{E^2 R}{(R-r)^2 + 4Rr} \dots \dots \dots (3)$$



Note:

- i. When $R = r$, the denominator of the expression of P_{out} is least and so P_{out} is then a maximum.
- ii. Thus we see that maximum power is delivered to a resistance (load), when the internal resistance of the source equals the load resistance.
- iii. The value of maximum output power as given by Eq. 3 is $\frac{E^2}{4R}$.

(iv) Why does the resistance of a conductor rise with temperature?

Ans: Effect of Temperature upon Resistance:

When the temperature of the conductor rises, average speed of the random motion of the free electrons increases which enhances the rate of collision of electrons and the atoms. This causes an increase in the resistance of the conductor. The increase in resistance is directly proportional to the increase of temperature. i.e. $T \propto R$.

(v) How can you use a magnetic field to separate isotopes of chemical element?

Ans: $r = \frac{mv}{qB} \Rightarrow r \propto m$

If isotopes in the ions form are projected into the field, they will be deflected due to the magnetic field in circular paths whose radii will depend on their masses (radii being directly proportional to the masses). Hence, they will be separated easily.

(vi) Does the Induced emf in a circuit depend on the resistance of the circuit? Does the induced current depend on the resistance of the circuit?

Ans: According to Faraday's law induced emf is $\varepsilon = -N \frac{\Delta \phi}{\Delta t}$. This relation shows that induced emf does not depend upon the resistance of the circuit. According to

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396

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Ohm's law $I = \frac{E}{R}$. This relation shows that induced current depend upon the resistance of the circuit.

(vii) What is stable or dead beat Galvanometer?

Ans: Stable or dead beat galvanometer:

- i. When the current passing through the galvanometer is discontinued, the coil will not come to rest as soon as the current flowing through the coil is stopped. It keeps on oscillating about its mean position before coming to rest.
- ii. In the same way if the current is established suddenly in a galvanometer, the coil will shoot beyond its final equilibrium position and will oscillate several times before coming to rest at its equilibrium position.
- iii. As it is annoying and time consuming to wait for the coil to come to rest, artificial ways are employed to make the coil come to rest quickly. Such galvanometer, in which the coil comes to rest quickly after the current passed through it or the current is stopped from flowing through it, is called **stable or a dead beat galvanometer**.

(viii) In a transformer, there is no transfer of charge from the primary to the secondary. How is, then the power transferred?

Ans: In a transformer, power is transferred from its primary coil to its secondary coil by changing magnetic flux passing from the primary towards the secondary coil. It should be noted that there is no electrical connection between the two coils but they are magnetically linked.

Suppose that an alternating emf is applied to the primary. If at some instant (the flux in the primary is changing at the rate of $\frac{\Delta\phi}{\Delta t}$ then there will be back emf induced in the primary which will oppose the applied voltage. Due to this process power is transferred.

(ix) What is a Parallel Resonance circuit? Write down its properties.

Ans: Parallel resonance circuit:

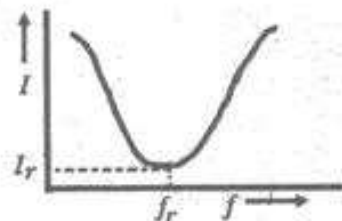
A condition of resonance will be experienced in a tank circuit when the reactances of the capacitor and inductor are equal to each other. Because inductive reactance increases with increasing frequency and capacitive reactance decreases with increasing frequency, there will only be one frequency where these two reactances will be equal.

The circuit resonates at a frequency $\omega = \omega_r$ which makes $X_L = X_C$, so that the two branch currents are equal but opposite Hence, they cancel out with the result that the current drawn from the supply is zero In actual practice, the current is not zero but has a minimum value due to small resistance r of the coil.

Properties of parallel resonant circuits:

Properties of parallel resonant circuits are

- (i) Resonance frequency is $f_r = \frac{1}{2\pi\sqrt{LC}}$
- (ii) At the resonance frequency, the circuit impedance is maximum. It is resistive.
- (iii) At the resonance the current is minimum and it is in phase with the applied voltage. So the power factor is one. The variation of current with the frequency of the source is shown in Fig.



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- (iv) At resonance, the branch currents I_L and I_C may each be larger than the source current I_r .

- (x) Explain the existence of magnetic domains in Ferromagnetic material.

Ans: Ferromagnetic substances:

There are some solid substances e.g., Fe, Co, Ni, Chromium dioxide, and Alnico (an iron aluminium-nickel-cobalt alloy) in which the atoms co-operate with each other in such a way so as to exhibit a strong magnetic effect. They are called ferromagnetic substances.

Domains:

There exists in ferromagnetic substance small regions called 'domains'. The domains are of macroscopic size of the order of millimetres or less but large enough to contain 10^{12} to 10^{16} atoms.

Saturation and un-saturation of domains:

Within each domain the magnetic fields of all the spinning electrons are parallel to one another i.e., each domain is magnetized to saturation.

Each domain behaves as a small magnet with its own north and south poles.

In unmagnetised iron the domains are oriented in a disorderly fashion, so that the net magnetic effect of a sizeable specimen is zero.

Electro magnet:

When the specimen is placed in an external magnetic field as that of a solenoid, the domains line up parallel to lines of external magnetic field and the entire specimen becomes saturated.

The combination of a solenoid and a specimen of iron inside it thus make a powerful magnet and are called an electromagnet.



Domains in iron:

Iron is a soft magnetic material. Its domains are easily oriented on applying an external field and also readily return to random positions when the field is removed. This is, desirable in an electromagnet and also in transformers.

- (xi) Why do not we observe Compton effect with visible light?

Ans: During interaction with matter the photon of visible light is completely absorbed showing photoelectric effect because in Compton effect $hf \gg \phi$. For Compton Effect energy of the particle has to be high enough so that during interaction only a part of its energy is absorbed and the rest is use for scattered.

- (xii) If the speed of light were infinite, what would the equations of special theory of Relativity reduce to?

Ans: There will be no relativistic effect.

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Since $c = \infty$ therefore $v^2/c^2 = 0 \dots\dots\dots (1)$

i. Since $t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

From Eq. 1 $t = \frac{t_0}{\sqrt{1 - 0}} \Rightarrow t = t_0$

ii. Since $l = l_0 \sqrt{1 - \frac{v^2}{c^2}}$

From Eq. 1 $l = \frac{l_0}{\sqrt{1 - 0}} \Rightarrow l = l_0$

iii. Since $m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

From Eq. 1 $m = \frac{m_0}{\sqrt{1 - 0}} \Rightarrow m = m_0$

Therefore the relativistic equations become:

$t = t_0$, $l = l_0$, and $m = m_0$.

(xiii) **Why are charge carriers not present in the depletion region?**

Ans: In depletion region potential difference stops diffusion of electrons into p-region. Due to the recombination of electrons and holes which leaves no free, undiffused electrons or holes. Hence there are, no charge carriers (free electrons - e) present in depletion region.

(xiv) **Find the mass m of a moving object with speed 0.8 c.**

Solution: Speed of mass $= v = 0.8 c$
 Mass of moving object $= m = ?$
 Mass variation $= m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

$$m = \frac{m_0}{\sqrt{1 - \frac{(0.8c)^2}{c^2}}} = \frac{m_0}{\sqrt{1 - (0.8)^2}} = \frac{m_0}{\sqrt{1 - 0.64}} = \frac{m_0}{\sqrt{0.36}} = 1.67 m_0$$

(xv) **How can the spectrum of hydrogen contain so many lines, when hydrogen contains only one electron?**

Ans: Hydrogen atom contains one electron. It will emit one spectral line, if it jumps direct from higher energy state to the ground state. The electron does not necessarily return to the ground state in the single jump, but may return by several jumps. That is why hydrogen spectrum contains many lines.

(xvi) **What is the effect of forward biasing of a diode on the width of depletion region?**

Ans: When a diode is forward biased, the width of the depletion region is decreased. It is mainly due to a large value of diffusion current and a small value of drift current. On the other hand the width of depletion region increases when the diode is reversed biased.

(xvii) **What do we mean by the term Critical mass?**

Ans: Critical mass:
 Such a mass of uranium in which one neutron, out of all the neutrons produced in one fission reaction, produces further fission is called critical mass. The volume of this mass of uranium is called critical volume.

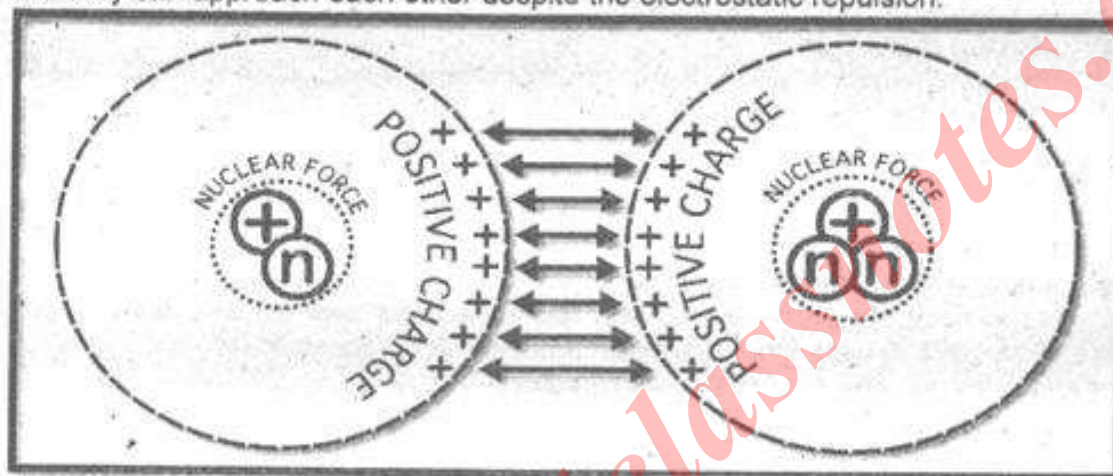
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If the mass of uranium is much greater than the critical mass, then the chain reaction proceeds at a rapid speed and a huge explosion is produced. Atom bomb works at this principle.

If the mass of uranium is less than the critical mass, the chain reaction does not proceed.

(xviii) What factors make a fusion reaction difficult to achieve?

Ans: The electrostatic force between the positively charged nuclei is repulsive, but when the separation is small enough, the attractive nuclear force is stronger. Therefore the prerequisite for fusion is that the nuclei have enough kinetic energy that they can approach each other despite the electrostatic repulsion.



The situation is similar if two nuclei are brought together. As they approach each other, all the protons in one nucleus repel all the protons in the other. Not until the two nuclei actually come in contact can the strong nuclear force take over. Consequently, even when the final energy state is lower, there is a large energy barrier that must first be overcome. It is called the Coulomb barrier.

Fusion reaction by thermo-nuclear reaction:

To start a fusion reaction the temperature at which the required speed of the light nuclei can be obtained is about 10 million degrees Celsius. At such extraordinarily high temperature the reaction that takes place is called thermo-nuclear reaction. Ordinarily such a high temperature cannot be achieved. However during the explosion of an atom bomb this temperature can be had for a very short time.

(xix) An A.C Voltmeter reads 250 V. What is its peak and instantaneous values if the frequency of alternating voltage is 50 Hz?

Solution:

rms values of alternating voltage	=	V_{rms}	=	250 V
Frequency of alternating voltage	=	f	=	50 Hz
Peak value of alternating voltage	=	V_0	=	?
Instantaneous voltage	=	V	=	?

Peak value V_0 of alternating voltage:

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$V_0 = \sqrt{2} V_{rms}$$

$$V_0 = \sqrt{2} \times 250 = 1.414 \times 250 \quad (\because \sqrt{2} = 1.414)$$

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$$V_0 = 353.5 \text{ V}$$

Since Angular frequency $= \omega = 2\pi f$
 $\omega = 2 \times \pi \times 50 = 100 \pi \text{ Hz}$

Instantaneous value of alternating voltage:

$$V = V_0 \sin \omega t$$

$$V = 353.5 \sin (100 \pi t) \text{ V}$$

SECTION- C

Note: Attempt any TWO questions.

(2 × 13 = 26)

Q. 3 a. Define Mutual Induction.

02

Ans: Mutual induction:

"The phenomenon in which a changing current in one coil induces an emf in another coil is called the mutual induction."

$$\mathcal{E}_s = -N_s \frac{\Delta \phi_s}{\Delta t}$$

b. Derive an expression for energy stored in an Inductor. Also express the energy in term of magnetic field.

06

Ans: Energy stored in an inductor:

As in case of a capacitor, energy is stored in the electric field between the plates, likewise, in an inductor, energy is stored in the magnetic field.

Derivation of energy stored in an inductor:

i. Consider a coil connected to a battery and a switch in series. When the switch is turned on voltage V is applied across the ends of the coil and current through it raises from zero to its maximum value I .

ii. Due to change of current, an emf is induced, which is opposite to that of battery. Work is done by the battery to move charges against the induced emf.

iii. Work done by the battery in moving a small charge Δq is

$$W = \Delta q \mathcal{E}_L \quad (1)$$

where $\mathcal{E}_L$ is the magnitude of induced emf, given by

$$\mathcal{E}_L = L \frac{\Delta I}{\Delta t}$$

Putting the value of $\mathcal{E}_L$ in Eq.1 we get

$$W = \Delta q \cdot L \frac{\Delta I}{\Delta t} = \frac{\Delta q}{\Delta t} \cdot L \Delta I \quad (2)$$

iv. Total work done in establishing the current from 0 to I is found by inserting for $\frac{\Delta q}{\Delta t}$, the average current, and the value of ΔI .

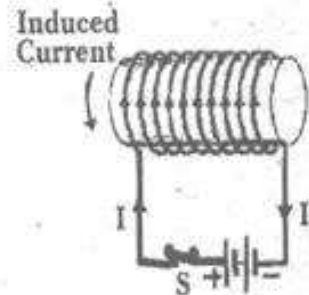
$$\text{Average current} = \frac{\Delta q}{\Delta t} = \frac{0+I}{2} = \frac{1}{2} I$$

$$\text{Change in current} = \Delta I = I - 0 = I$$

$$\text{Total work} = W = \left(\frac{1}{2} I\right) L I = \frac{1}{2} I^2$$

This work is stored as potential energy in the inductor. Hence the energy stored in an inductor is

$$U_m = \frac{1}{2} L I^2 \quad (3)$$



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Energy stored in an inductor (U_m) and magnetic field (B):

Therefore, Eq. 3 can be expressed in terms of the magnetic field B of a solenoid which has n turns per unit length and area of cross section A. The magnetic field strength inside it is $B = \mu_0 n I$. Since flux through the coil is:-

$$\phi = BA$$

$$\phi = \mu_0 n I \dots \dots \dots (4)$$

Substituting the value of ϕ in Eq.

$$N \phi = L I \quad \text{or} \quad L = \frac{N \phi}{I}$$

we have

$$L = N \frac{\mu_0 n I A}{I} = N \mu_0 n A$$

If ℓ is the length of solenoid, then putting $N = n \ell$ in above Eq. we get the self inductance of the solenoid as

$$L = (n \ell) \mu_0 n A$$

$$L = \mu_0 n^2 A \ell \dots \dots \dots (5)$$

Substituting for L, the Eq.3 becomes,

$$U_m = \frac{1}{2} (\mu_0 n^2 A \ell) I^2 \dots \dots \dots (6)$$

Since B for a solenoid is given by

$$B = \mu_0 n I \quad \text{or} \quad I = \frac{B}{\mu_0 n}$$

Substituting for I, Eq.6 becomes

$$U_m = \frac{1}{2} (\mu_0 n^2 A \ell) \left(\frac{B}{\mu_0 n} \right)^2$$

$$U_m = \frac{1}{2 \mu_0} B^2 (A \ell) \dots \dots \dots (7)$$

Energy density:

Energy density can be defined as the energy stored per unit volume inside the solenoid, so dividing Eq.7 by the volume ($A \ell$), we get energy density,

$$u_m = \frac{1}{2 \mu_0} B^2$$

- c. **A permanent magnet DC motor is run by a battery of 24 volts. The coil of the motor has a resistance of 2 ohms. It develops a back e.m.f of 22.5 volts when driving the load at normal speed. What is the current when motor just starts up? Also find the current when motor is running at normal speed?** **05**

Solution:

Operated voltage	= $V = 24 \text{ V}$
Resistance of the coil	= $R = 2 \Omega$
Back emf	= $\varepsilon = 22.5 \text{ V}$
Current	= $I = ?$

When motor just starts up, the back emf $\varepsilon = 0$

Using the relation, $V = \varepsilon + IR$

$$24 = 0 + I \times 2$$

$$I = \frac{24}{2} = 12 \text{ V } \Omega^{-1} = 12 \text{ A Ans.}$$

When motor runs at normal speed, the back emf $\varepsilon = 22.5 \text{ V}$ Again using the relation

$$V = \varepsilon + IR$$

$$24 = 22.5 + I \times 2$$

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$$I = \frac{24 - 22.5}{2} = 0.75 \text{ V } \Omega^{-1} = 0.75 \text{ A Ans.}$$

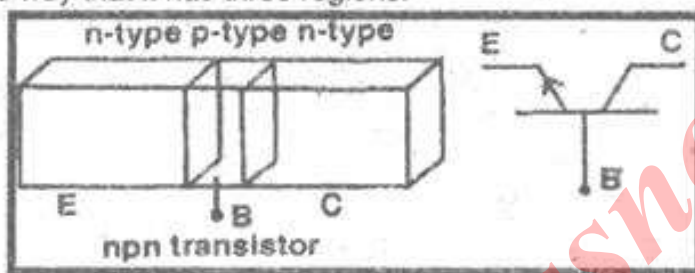
Q. 4 a. What is a Transistor? Describe the construction and operation of a transistor. Also find an expression for its gain. 1+2+2+4

Ans: Transistors:

Transistor is a semiconductor device consisting of three electrodes, namely emitter, base and collector. For normal operation, the base-emitter junction is forward biased whereas the collector-base junction is reverse biased.

Construction of transistor:

A transistor consists of a single crystal of germanium or silicon which is grown in such a way that it has three regions.



Types of transistors:

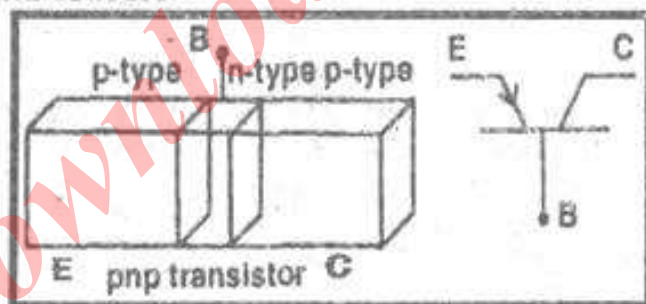
n-p-n transistor:

If the central region is p type which is sandwiched between two n type regions. It is known as n-p-n transistor.

p-n-p transistor:

If the n type central region is sandwiched between two p type regions. It forms a p-n-p transistor.

Base, emitter and collector:



The central region is known as base and the other two regions are called emitter and collector. Usually the base is very thin, of the order of 10^{-6} m. The emitter and collector have greater concentration of impurity. The collector is comparatively larger than the emitter. The emitter has greater concentration of impurity as compared to the collector.

It can be seen in Figs., that a transistor is a combination of two back to back p-n junctions: emitter-base junction and collector-base junction.

Operation of the transistor:

For normal operation of the transistor, batteries V_{BB} and V_{CC} are connected in such a way that its emitter-base junction is forward biased and its collector base junction is reverse biased. V_{CC} is of much higher value than V_{BB} .

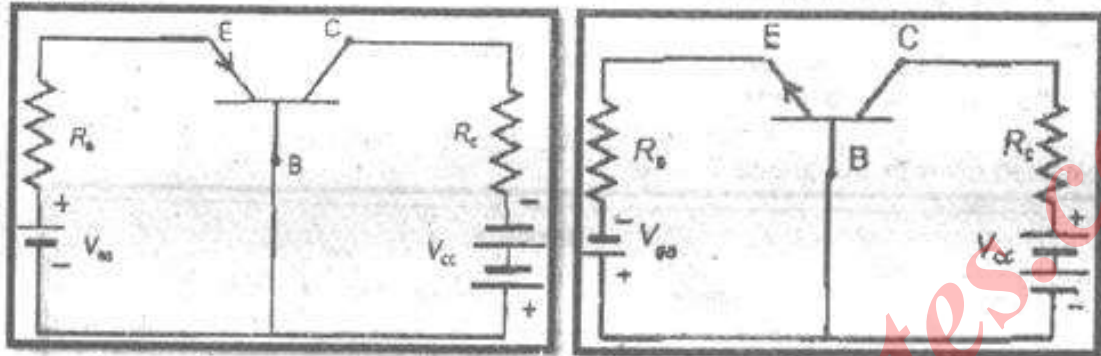
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Fig. shows the biasing arrangement for n-p-n transistor when the transistor has been represented by its symbolic form. Fig. shows the same for a p-n-p transistor.



It may be noted that polarities of the biasing batteries V_{BB} and V_{CC} are opposite in the two types of the transistors. In actual practice, it is the n-p-n transistor that is generally used.

Current gain of transistor (β):

It is also found that for a given transistor the ratio of collector current I_C to base current I_B is nearly constant i.e.

$$\beta = \frac{I_C}{I_B}$$

The ratio β is called current gain of transistor. Its value is quite large of the order of hundreds.

- b. The current flowing into the base of a transistor is $100 \mu A$. Find its collector current I_C , its emitter current I_E and the ratio I_C/I_E , if the value of current gain β is 100.**

04

Solution:

$$\text{Base Current} = I_B = 100 \mu A = 100 \times 10^{-6} A$$

$$\text{Current Gain} = \beta = 100$$

$$\text{Collector Current} = I_C = ?$$

$$\text{Emitter Current} = I_E = ?$$

$$\text{The ratio} = \frac{I_C}{I_E} = ?$$

$$\text{Current gain} = \beta = \frac{I_C}{I_B}$$

$$\Rightarrow I_C = \beta \times I_B$$

$$I_C = 100 \times 100 \times 10^{-6} = 10 \times 10^{-3} A$$

$$I_C = 10 \text{ mA}$$

The equation of transistor is given by,

$$I_E = I_B + I_C$$

$$I_E = 100 \times 10^{-6} + 10 \times 10^{-3} = 100 \times 10^{-6} + 10 \times 10^3 \times 10^{-3} \times 10^{-3}$$

$$I_E = 100 \times 10^{-6} + 10,000 \times 10^{-6} = (100 + 10,000) \times 10^{-6}$$

$$I_E = 10,100 \times 10^{-6} = 10,100 \mu A = 10.1 \times 10^{-3} A = 10.1 \text{ mA}$$

The ratio of I_C and I_E is given by,

$$\frac{I_C}{I_E} = \frac{10 \times 10^{-3}}{10.10 \times 10^{-3}} = 0.99$$

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Q. 5 a. How are X-rays produced? What are the important properties of X-rays?
 5+4

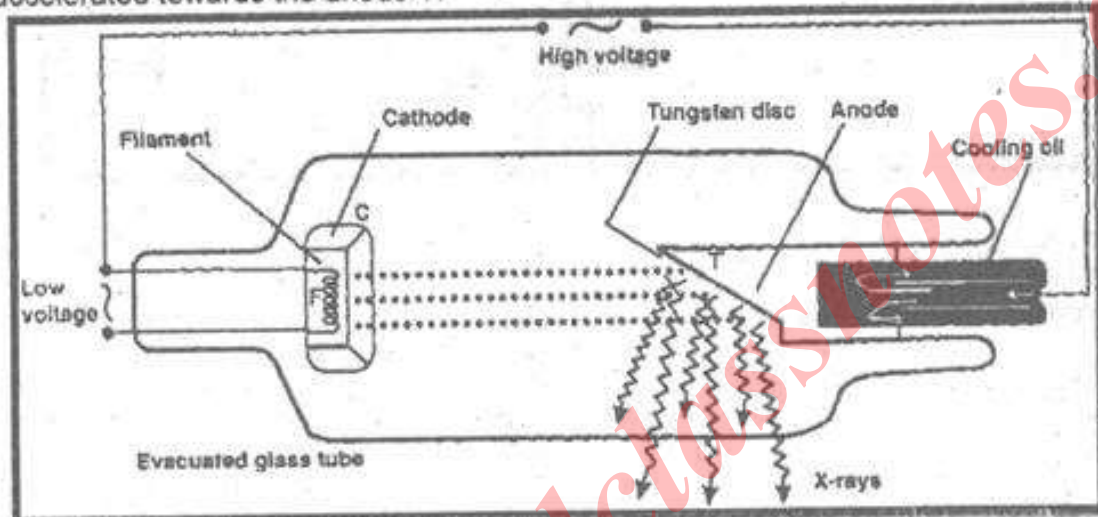
Ans: X-rays production unit:

i. **X-ray tube:**

It consists of a high vacuum tube called X-ray tube.

ii. **Function of filament:**

When the cathode is heated by the filament F, it emits electrons which are accelerated towards the anode T.



ii. **Kinetic energy of electron:**

If V is the potential difference between C and T the kinetic energy K.E. with which the electron strike the target is given by

$$K.E. = Ve \quad \dots\dots\dots (1)$$

Production of K_{α} X-ray:

Suppose that one of the electrons in the K shell is removed, thereby producing a vacancy or hole in that shell. The electron from the L shell jumps to occupy the hole in the K shell, thereby emitting a photon of energy $hf_{k\alpha}$ called the K_{α} X-ray given by

$$hf_{k\alpha} = E_L - E_K \quad \dots\dots\dots (2)$$

Production of K_{β} X-ray:

It is also possible that the electron from the M shell might also jump to occupy the hole in the K shell. The photons emitted are K_{β} X-ray with energies

$$hf_{k\beta} = E_M - E_K \quad \dots\dots\dots (3)$$

These photons give rise to K_{β} X-ray and so on.

Characteristic X-rays:

The photons emitted in such transitions i.e., inner shell transitions are called characteristic X-rays, because their energies depend upon the type of target material.

Creation of holes:

The holes created in the L and M shells are occupied by transitions of electrons from higher states creating more X-rays. The characteristic X-rays appear as discrete lines on a continuous spectrum.

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Maryam Key Series

405

Physics 12th

Properties and uses of X-rays:

X-rays have many practical applications in medicine and industry.

- i. X-rays can penetrate several centimeters into a solid matter, so they can be used to visualize the interiors of the materials opaque to ordinary light, such as fractured bones or defects in structural steel.

ii. **Procedure to detect fracture by X-rays:**

The object to be visualized is placed between an X-ray source and a large sheet of photographic film; the darkening of the film is proportional to the radiation exposure. A crack or air bubble allows greater amount of X-rays to pass. This appears as a dark area on the photographic film. Shadow of bones appears lighter than the surrounding flesh. It is due to the fact that bones contain greater proportions of elements with high atomic number and so they absorb greater amount of incident X-rays than flesh. In flesh, light elements like carbon, hydrogen and oxygen predominate. These elements allow greater amount of incident X-rays to pass through them.

- b. **Calculate the longest wavelength of radiation for the Paschen series.**

04

Solution: For longest wavelength in Paschen series

$$p = 3$$

$$n = 4$$

$$R_H = 1.0974 \times 10^7 \text{ m}^{-1}$$

$$\lambda_{\max} = ?$$

The general formula to find wavelength in hydrogen spectrum:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{p^2} - \frac{1}{n^2} \right)$$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{9} - \frac{1}{16} \right) = 1.097 \times 10^7 \left(\frac{7}{9 \times 16} \right) = \frac{16 \times 9}{7 \times 1.097 \times 10^7}$$

$$\lambda = 18.75 \times 10^{-7} = 1875 \times 10^{-9} \text{ m} = 1875 \text{ nm}$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

406

Physics 12th

FBISE PAPER # (2013)

PHYSICS HSSC-II (2013)

SECTION-A (Marks 17)

Time: 25 Minutes

Marks: 17

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 20 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q. 1 Circle the correct option i.e. A / B / C / D. Each part carries one mark.

(i) The Electric intensity near an infinite plate of positive charge will be _____.

- A. $\frac{q}{\epsilon_0}$ B. $\frac{\sigma}{2\epsilon_0}$ C. $\frac{q}{A}$ D. None of these

(ii) One Electron Volt is equal to _____.

- A. 6.25×10^{18} Joule B. 6.25×10^{-18} Joule
C. 1.6×10^{-19} Joule D. 1.6×10^{19} Joule

(iii) Ceramic materials exhibit super-conductivity at _____.

- A. 0°C B. 125 K C. 60 K D. 30 K

(iv) Which electric bulb has the least resistance?

- A. 60 watts B. 100 watts
C. 200 watts D. 500 watts

(v) The grid in CRO _____.

- A. Controls the number of electrons accelerated by anodes
B. Controls the brightness of the spot fall on the screen
C. Both A and B
D. Deflects the beam of electrons

(vi) The frequency of A.C. used in Pakistan is _____.

- A. 60CPS B. 50CPS
C. 100 CPS D. 120 CPS

(vii) Potentiometer can be used as _____.

- A. Ohm meter B. Ammeter
C. Galvanometer D. Potential Divider

(viii) To convert a Weston-Type galvanometer into voltmeter, the series resistance is given by _____.

- A. $R_h = \frac{V}{I_g} + R_g$ B. $R_h = \frac{V}{I_g} - R_g$
C. $R_h = \frac{V}{R_g} - I_g$ D. $R_h = \frac{V}{R_g} + I_g$

(ix) N-Type germanium is obtained by doping intrinsic germanium with _____.

- A. Tetravalent impurity atom B. Trivalent impurity atom
C. Pentavalent impurity atom D. Hexavalent impurity atom

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- Maryam Key Series 407 Physics 12^a
- (x) Emission of electron by metals on heating is called _____.
- A. Secondary Emission B. Field effect
 C. Photoelectric Emission D. Thermionic Emission
- (xi) Which of the following is NOT basic operation of Boolean variables?
- A. YES operation B. NOT operation
 C. AND operation D. OR operation
- (xii) When X-rays are passed through successive aluminum sheets, their hardness _____.
- A. Decreases B. Increases
 C. Remains the same D. None of these
- (xiii) If the ionization energy of hydrogen atom is 13.6 eV, its ionization potential will be _____.
- A. 13.6 V B. 136.0 V
 C. 3.4 V D. None of these
- (xiv) One amu is equal to _____.
- A. 931 MeV B. 9.31 MeV
 C. 93.1 MeV D. 0.931 MeV
- (xv) Cobalt 60 emits γ - rays of energy _____.
- A. 117 MeV B. 11.7 MeV
 C. 1.17 MeV D. 1.17 BeV
- (xvi) Which of the following statements is CORRECT?
- A. Moderators slow down the neutrons.
 B. Moderators bring the neutrons to rest.
 C. Moderators absorb the neutrons.
 D. Moderators reflect the neutrons.
- (xvii) The half life Of radioactive element is _____.
- A. $T_{\frac{1}{2}} = \frac{0.693}{\lambda}$ B. $T_{\frac{1}{2}} = 1.43\lambda$
 C. $T_{\frac{1}{2}} = 0.693\lambda$ D. None of these

PHYSICS HSSC-II

Time allowed: 2:40 Hours

Total Marks = 68

Note: Sections 'B' and 'C' are to be answered on the separately provided answer book. Answer eleven the questions from section 'B' and attempt any two questions from section 'C' Use supplementary answer sheet i.e., sheet B if required. Write your answers neatly and legibly.

SECTION - B (Marks 42)

- Q.2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines. (14 × 3 = 42)
- (i) How can you identify that which plate of a capacitor is positively charged?
- (iii) if a point charge q of mass m is released in a non-uniform electric field with field lines pointing in the same direction, will it make a rectilinear motion?
- (iii) Why does the resistance of a conductor rise with temperature?
- (iv) What is Wheatstone Bridge? How can it be used to determine an unknown resistance?

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

408

Physics 12th

- (v) Is it possible to orient a current loop in a uniform magnetic field such that the loop will not tend to rotate? Explain.
- (vi) You are asked to design a solenoid that will give a magnetic field of 0.10 T, yet the current must not exceed 10.0 A. Find the number of turns per unit length that the solenoid should have.
- (vii) Does the induced emf always act to decrease the magnetic flux through a circuit?
- (viii) A metal rod of length 25 cm is moving at a speed of 0.5 ms^{-1} in a direction perpendicular to a 0.25 T magnetic field. Find the emf produced in the rod.
- (ix) A circuit contains an iron-cored inductor, a switch and D.C. source arranged in series. The switch is closed and after an interval reopened. Explain why a spark jumps across the switch contacts.
- (x) At what frequency will an inductor of 1.0 H have a reactance of 500Ω ?
- (xi) What is meant by Hysteresis loss? How is it used in the construction of a transformer?
- (xii) What is the effect of forward and reverse biasing of a diode on the width of depletion region?
- (xiii) In a certain circuit, the transistor has a collector current of 10 mA and a base current of $40 \mu\text{A}$. What is the current gain of the transistor?
- (xiv) A beam of red light and a beam of blue light have exactly the same energy. Which beam contains the greater number of photons?
- (xv) If an electron and a proton have the same de Broglie wavelength, which particle has greater speed?
- (xvi) Find the speed of the electron in the first Bohr orbit.
- (xvii) A tungsten target is struck by electrons that have been accelerated from rest through 40 kV potential difference. Find the shortest wavelength of the bremsstrahlung radiation emitted?
- (xviii) The radioactive element $^{226}_{88}\text{Ra}$ has a half-life of 1.6×10^3 years. Since the Earth is about 5 billion years old, how can you explain why we still can find this element in nature?
- (xix) Why are heavy nuclei unstable?

SECTION - C (Marks 26)

Note: Attempt any TWO questions.

($2 \times 13 = 26$)

- Q. 3 a. What is temperature co-efficient of Resistance and Resistivity? Derive the equations. (06)
- b. The resistance of an iron wire at 0°C is $1 \times 10^4\Omega$. What is the resistance at 500°C if the temperature co-efficient of iron is 5.2×10^{-3} ? 05
- c. Define electron Volt and find its relation with joule. 02
- Q. 4 a. Describe RLC series circuit. Derive relation for resonance frequency. Also give any four properties of series resonance. 07

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409

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- b. What is the resonant frequency of a circuit which includes a coil of inductance 2.5 H and capacitance of $40\mu F$? 03
- c. Write a short note on three phase AC Supply. 03
- Q. 5 a. What do you know about the Biological effect of radiation? Write in detail. 05
- b. A 75 kg person receives a whole body radiation dose of 24 m-rad, delivered by α particles for which RBE factor is 12. Calculate: 05
- (i) The absorbed energy in joules
- (ii) The equivalent dose in rem.
- c. Write a short note on basic forces of nature. 03

SOLUTION OF FBISE PAPER # (2013)

SECTION- A (MCQs)

i. B	ii. C	iii. B	iv. D	v. C	vi. B
vii. D	viii. D	ix. C	x. C	xi. A	xii. C
xiii. A	xiv. A	xv. C	xvi. A	xvii. A	

SECTION-B

- (i) How can you identify that which plate of a capacitor is positively charged?

Ans: Case 1.

Bring a positively charged object close to the plate if it is repelled the plate is positive otherwise not.

Case 2.

Bring the plate close to a positively charged electroscope if the leaves further diverge due to electrostatic induction it has positive charge otherwise not.

- (ii) if a point charge q of mass m is released in a non-uniform electric field with field lines pointing in the same direction, will it make a rectilinear motion?

Ans: If the field is due to an isolated charge then charge will make a rectilinear motion. If the field is due to the combination of charges then the point charge will move along a curved path.

- (iii) Why does the resistance of a conductor rise with temperature?

Ans: Effect of Temperature upon Resistance:

When the temperature of the conductor rises, average speed of the random motion of the free electrons increases which enhances the rate of collision of electrons and the atoms. This causes an increase in the resistance of the conductor. The increase in resistance is directly proportional to the increase of temperature. i.e. $T \propto R$.

- (iv) What is Wheatstone bridge? How can it be used to determine an unknown resistance?

Ans: Wheatstone bridge:

Wheatstone bridge is an electric circuit that is used to measure the value of an unknown resistance accurately.

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410

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Determination of an unknown resistance:

If we connect three resistances R_1 , R_2 and R_3 of known adjustable values and a fourth resistance R_4 of unknown value and the resistances R_1 , R_2 and R_3 are so adjusted that the galvanometer shows no deflection then, from the known resistances R_1 , R_2 and R_3 the unknown resistance R_4 can be determined by using Eq.

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

- (v) Is it possible to orient a current loop in a uniform magnetic field such that the loop will not tend to rotate? Explain.

Ans: Yes, it is possible when we place it in the magnetic field such that the plane of the loop is perpendicular to the magnetic field. We know that, $\tau = BNIA \cos \alpha$, in this case, $\alpha = 90^\circ$ and $\cos 90^\circ = 0$, hence torque on the loop will be zero and loop will not rotate.

- (vi) You are asked to design a solenoid that will give a magnetic field of 0.10 T, yet the current must not exceed 10.0 A. Find the number of turns per unit length that the solenoid should have.

Solution: $B = 0.10 \text{ T}$
 $I = 10 \text{ A}$

Permeability of free space $= \mu_0 = 4\pi \times 10^{-7} \text{ Wb A}^{-1} \text{ m}^{-1}$

$n = ?$

Since $B = \mu_0 n I \Rightarrow n = \frac{B}{\mu_0 I}$

$n = \frac{0.10}{4\pi \times 10^{-7} \times 10} = 7.9567 \times 10^3 \text{ turns/meter}$

- (vii) Does the induced emf always act to decrease the magnetic flux through a circuit?

Ans: No. According to Lenz's law, it always acts to maintain the flux by opposing any change in it. If the flux increases, it will tend to decrease it and vice versa.

- (viii) A metal rod of length 25 cm is moving at a speed of 0.5 ms^{-1} in a direction perpendicular to a 0.25 T magnetic field. Find the emf produced in the rod.

Solution: Speed of rod $= v = 0.5 \text{ ms}^{-1}$

Length of rod $= L = 25 \text{ cm} = 0.25 \text{ m}$

Magnetic flux density $= B = 0.25 \text{ T} = 0.25 \text{ N A}^{-1} \text{ W}^{-1}$

Induced emf $= \varepsilon = ?$

Since $\varepsilon = v B L \sin \theta$

$\varepsilon = 0.5 \times 0.25 \times 0.25 \times \sin 90^\circ = 3.13 \times 10^{-2} \times 1 \text{ JC}^{-1} \quad (\because \text{JC}^{-1} = \text{V})$

$\varepsilon = 3.13 \times 10^{-2} \text{ V}$

- (ix) A circuit contains an iron-cored inductor, a switch and D.C. source arranged in series. The switch is closed and after an interval reopened. Explain why a spark jumps across the switch contacts.

Ans: When a current flows through the inductor energy is stored in the inductor in the form of magnetic field. When the switch is closed current grows from zero to maximum and when the switch is opened it creases from maximum to zero. Hence at the instant we reopen the switch the current through it is maximum which causes the spark jumps.

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411

Physics 12th

(x) At what frequency will an inductor of 1.0 H have a reactance of 500Ω?

Solution: Inductance of inductor = $L = 1.0 \text{ H}$
 Reactance of inductor = $X_L = 500 \Omega$
 Frequency = $f = ?$

Reactance of the inductor:

$$X_L = \omega L \Rightarrow X_L = 2\pi fL \quad (\because \omega = 2\pi f)$$

$$f = \frac{X_L}{2\pi L} \Rightarrow f = \frac{500}{2 \times 3.14 \times 1.0} = 80 \text{ Hz}$$

(xi) What is meant by Hysteresis loss? How is it used in the construction of a transformer?

Ans: Hysteresis loss:

The area of the loop is a measure of the energy needed to magnetize and demagnetize the specimen during each cycle of the magnetizing current. This is the energy required to do work against internal friction of the domains. This work, like all work that is done against friction, is dissipated as heat. It is called **hysteresis loss**.

Use in the construction of transformer:

Hard magnetic materials like steel cannot be easily magnetized or demagnetized, so they have large loop area as compared to soft magnetic material such as iron which can easily be magnetized. The energy dissipated per cycle, thus, for iron is less than for steel. That is why soft iron used in transformers.

(xii) What is the effect of forward and reverse biasing-of a diode on the width of depletion region?

Ans: When a diode is forward biased, the width of the depletion region is decreased. It is mainly due to a large value of diffusion current and a small value of drift current. On the other hand the width of depletion region increases when the diode is reversed biased.

(xiii) In a certain circuit, the transistor has a collector current of 10 mA and a base current of 40 μA. What is the current gain of the transistor?

Solution: Collector current = $I_c = 10 \text{ mA} = 10 \times 10^{-3} \text{ A}$
 Base Current = $I_B = 40 \mu\text{A} = 40 \times 10^{-6} \text{ A}$
 Current gain = $\beta = ?$

$$\text{Since } \beta = \frac{I_c}{I_B} \Rightarrow \beta = \frac{10 \times 10^{-3}}{40 \times 10^{-6}} = \frac{10}{40} \times 10^{-3} \times 10^6 = \frac{1}{4} \times 10^3 = \frac{1000}{4} = 250$$

(xiv) A beam of red light and a beam of blue light have exactly the same energy. Which beam contains the greater number of photons?

Solution: Energy for single photon = $E = hf$
 Energy for 'n' photons = $E = n hf$ (1)
 Since $c = f\lambda \Rightarrow f = \frac{c}{\lambda}$ put in Eq. 1

$$E = n h \times \frac{c}{\lambda}$$

$$n = \frac{E\lambda}{hc} \Rightarrow n \propto \lambda$$

Therefore longer wavelengths will have greater number of photons. The wave length of red colour is greater than blue colour. Therefore red beam contains greater number of photons.

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412

Physics 12th

- (xv) $\lambda_{red} > \lambda_{blue}$
 If an electron and a proton have the same de Broglie wavelength, which particle has greater speed?

Ans: According to de-Broglie Equation $\lambda = \frac{h}{mv}$

$$v = \frac{h}{m\lambda} \Rightarrow v \propto \frac{1}{m}$$

Hence for same wavelength the smaller mass has greater velocity. Therefore electron will have greater speed because the mass of electron is smaller than that of protons.

- (xvi) Find the speed of the electron in the first Bohr orbit.

Solution: $n = 1 \Rightarrow h = 6.63 \times 10^{-34} \text{ J s}$

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$k = 9 \times 10^9 \text{ Nm}^2 \text{ C}^{-2} \Rightarrow v_1 = ?$$

According to Bohr Theory:

$$v_n = \frac{2\pi k e^2}{n h}$$

$$v_1 = \frac{2 \times 3.14 \times 9 \times 10^9 \times (1.6 \times 10^{-19})^2}{1 \times 6.63 \times 10^{-34}} = \frac{2 \times 3.14 \times 9 \times 10^9 \times 2.56 \times 10^{-38}}{6.63 \times 10^{-34}} = 2.19 \times 10^6 \text{ ms}^{-1}$$

- (xvii) A tungsten target is struck by electrons that have been accelerated from rest through 40 kV potential difference. Find the shortest wavelength of the bremsstrahlung radiation emitted?

Solution: $V = 40 \text{ kV} \Rightarrow V = 40 \times 1000 \text{ Volts} \Rightarrow e = 1.6 \times 10^{-19} \text{ C}$
 $\lambda_{min} = ?$

The energy of a photon is given by

$$E = \frac{hc}{\lambda} \quad \dots\dots (1)$$

The electric potential energy is given by

$$U = eV \quad \dots\dots (2)$$

By equating above two energies we get,

$$eV = \frac{hc}{\lambda_{min}}$$

$$\lambda_{min} = \frac{hc}{eV}$$

$$\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19} \times 4000} = 3.10 \times 10^{-11} = 0.31 \times 10^{-10} \text{ m}$$

- (xviii) The radioactive element ${}^{226}_{88}\text{Ra}$ has a half-life of 1.6×10^3 years. Since the Earth is about 5 billion years old, how can you explain why we still can find this element in nature?

Ans: Half life:

It is the period in which half of the radioactive element atoms decay. An element completely decayed after an infinite time.

Thus with the passage of every half life the number of atoms remaining behind becomes half of the number of atoms already present. In this way an infinite time is required for all atoms to decay. As the earth five billion years old (not infinite time) so we can still find ${}^{226}_{88}\text{Ra}$ element in nature.

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413

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(xix) **Why are heavy nuclei unstable?**

Ans: Heavy nuclei are unstable because of their low binding energy per nucleon and due to repulsive electromagnetic forces which become more and more dominant as the size of the nucleus increases. Hence a heavy nucleus is less stable.

SECTION - C (Marks 26)

Q. 3 a. What is temperature co-efficient of Resistance and Resistivity?

Derive the equations.

06

Ans: Experimentally the change in resistance of a metallic conductor with temperature is found to be nearly linear over a considerable range of temperature above and below 0°C.

Temperature coefficient of resistance:

The fractional change in resistance per kelvin is known as the temperature coefficient of resistance i.e.,

$$\alpha = \frac{R_t - R_0}{R_0 t} \quad (1)$$

where R_0 and R_t are resistances at temperature 0°C and t°C. As resistivity ρ depends upon the temperature, Eq. 1 gives

$$R_t = \rho_t \frac{L}{A} \quad \text{and} \quad R_0 = \rho_0 \frac{L}{A}$$

Substituting the values of R_t and R_0 in Eq. 1, we get as $\alpha = \frac{\rho_t - \rho_0}{\rho_0 t} \quad (2)$

where ρ_0 is the resistivity of a conductor at 0°C and ρ_t is the resistivity at t°C.

Negative temperature coefficients:

There are some substances like germanium, silicon etc., whose resistance decreases with increase in temperature, i.e., these substances have negative temperature coefficients.

b. The resistance of an iron wire at 0 °C is $1 \times 10^4 \Omega$. What is the resistance at 500° C if the temperature coefficient of resistance of iron is $5.2 \times 10^{-3} \text{ K}^{-1}$?

05

Solution:

Lower Temperature = $T_0 = 0^\circ\text{C} = 0 + 273 = 273 \text{ K}$
 Higher Temperature = $T = 500^\circ\text{C} = 500 + 273 = 773 \text{ K}$
 Temperature Difference = $\Delta T = T - T_0 = 773 - 273 = 500 \text{ K}$
 Resistance at T_0 = $R_0 = 1 \times 10^4 \Omega$
 Temperature co-efficient = $\alpha = 5.2 \times 10^{-3} \text{ K}^{-1}$
 Resistance at T = $R_t = ?$

Since $R_t = R_0 (1 + \alpha \Delta T)$

$$R_t = 1 \times 10^4 \times 1 + 5.2 \times 10^{-3} \times 500$$

$$R_t = (1 + 2600 \times 10^{-3}) \times 10^4 = (1 + 2.6) \times 10^4$$

$$R_t = 3.6 \times 10^4 \Omega$$

c. Define electron Volt and find its relation with joule.

02

Ans: Electron volt:

The amount of energy equal to $1.6 \times 10^{-19} \text{ J}$ is called one electron-volt and is denoted by 1eV. It is defined as "the amount of energy acquired or lost by an electron as it traverses a potential difference of one volt". Thus,

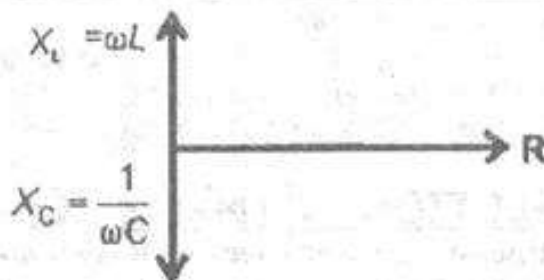
$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J} \quad (1)$$

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414

Physics 12th



Derivation: Suppose charge carried by the particle is $q = e = 1.6 \times 10^{-19} \text{ C}$.

Thus, in this case, the energy acquired by the charge will be

$$\Delta K.E = q \Delta V = e \Delta V = (1.6 \times 10^{-19} \text{ C}) (\Delta V)$$

Moreover, assume that $\Delta V = 1 \text{ volt}$, hence

$$\Delta K.E = q \Delta V = (1.6 \times 10^{-19} \text{ C}) \times (1 \text{ volt})$$

$$\Delta K.E = (1.6 \times 10^{-19}) \times (\text{C} \times \text{V}) = 1.6 \times 10^{-19} \text{ J}$$

Thus,

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J} \quad \dots \text{Proved}$$

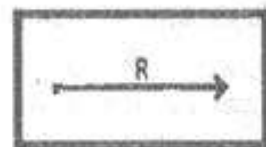
Q. 4 a. Describe RLC series circuit. Derive relation for resonance frequency. Also give any four properties of series resonance. 07

Ans: RLC series circuit:

When resistor, capacitor and inductor are connected in series and energized with alternating voltage is called RLC series circuit or series resonance circuit.

Series resonance circuit:

i. Consider an R-L-C series circuit which is excited by an alternating voltage source whose frequency could be varied.



ii. The impedance diagram of the circuit is shown in Fig.

iii. The inductive reactance $X_L = \omega L$ and capacitor reactance $X_C = \frac{1}{\omega C}$ are directed opposite to each other.

iv. When the frequency of A.C. source is very small $X_C = \frac{1}{\omega C}$ is much greater than $X_L = \omega L$. So the capacitance dominates at low frequencies and the circuit behaves like an R - C circuit.

v. At high frequencies $X_L = \omega L$, is much greater than $X_C = \frac{1}{\omega C}$. In this case the inductance dominates and the circuit behaves like R-L circuit.

vi. **Resonance:**

In between these frequencies there will be a frequency ω_r at which $X_L = X_C$. This condition is called resonance. Thus at resonance the inductive reactance being equal and opposite to capacitor reactance, cancel each other and the impedance diagram assumes the form as in Fig.

vii. The value of the resonance frequency can be obtained by putting

$$\omega_r = \frac{1}{\omega_r C}$$

$$\text{Or } \omega_r^2 = \frac{1}{LC} \quad \text{or } \omega_r = \frac{1}{\sqrt{LC}}$$

$$\text{Or } f_r = \frac{1}{2\pi\sqrt{LC}} \quad \dots \dots \dots (1)$$

Properties of the series resonance circuit:

The following are the properties of the series resonance.

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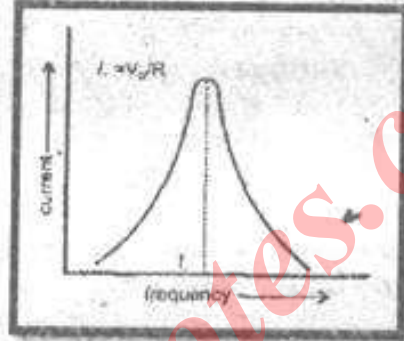
415

Physics 12th

- (i) The resonance frequency is given by

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$
- (ii) The impedance of the circuit at resonance is resistive so the current and voltage are in phase. The power factor is 1.

$$\cos\theta = \frac{P}{I_{rms} \times V_{rms}} = 1$$
- (iii) The impedance of the circuit is minimum at this frequency and it is equal to R.
- (iv) If the amplitude of the source voltage V_0 is constant, the current is a maximum at the resonance frequency and its value is V_0/R . The variation of current with the frequency is shown in Fig.
- (v) At resonance V_L , the voltage drop across inductance and V_C the voltage drop across capacitance may be much larger than the source voltage.



- b. What is the resonant frequency of a circuit which includes a coil of inductance 2.5 H and capacitance of $40\mu F$? 03

Solution: $L = 2.5 \text{ H}$, $C = 40 \mu F = 40 \times 10^{-6} \text{ F}$
 $f_r = ?$

Resonance frequency is given by

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{10^3}{2 \times 3.14 \sqrt{2.5 \times 40 \times 10^{-6}}} = \frac{1000}{62.8} = 15.9 \text{ Hz}$$

- c. Write a short note on three phase AC Supply. 03

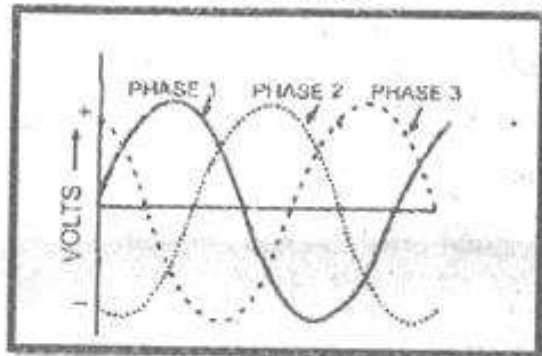
Ans: Three phase A.C. supply:

- In a three phase A.C. generator, instead of one coil, there are three coils inclined at 120° to each other, each connected to its own pair of slip rings.
- When this combination of three coils rotate in the magnetic field, each coil generates an alternating voltage across its own pair of slip rings. Thus, three alternating voltages are generated. The phase difference between these voltages is 120° . Such a voltage is called three phase supply.

Explanation:

- i. Pair of slip rings:

When voltage across the first pair of slip rings is zero, having a phase of 0° , the voltage across the second pair of slip rings would not be zero but it will have a phase of 120° . Similarly at this instant the voltage generated across the third pair will have a phase 240° . This is shown in Fig.



- ii. Terminals:

The machine, instead of having six terminals, two for each pair of slip rings, has only four terminals because the starting point of all the three coils has a

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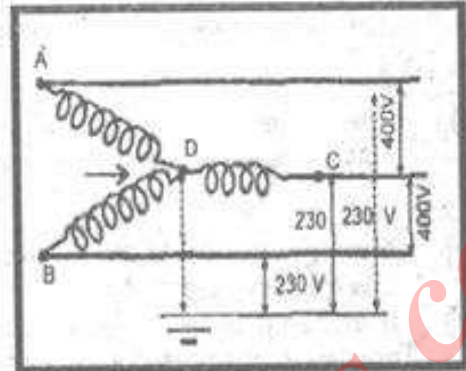
416

Physics 12th

common junction which is often earthed to the shaft of the generator and the other three ends of the coils are connected to three separate terminals on the machine. These four terminals along with the lines and coils connected to them are shown in Fig.

iii. Voltage:

The voltage across each of lines connected to terminals A, B, C and the neutral line is 230 V. Because of 120° phase shift, the voltage across any two lines is about 400 V.



Advantages of three phase A.C. supply (three phase supply is better than single phase supply):

- The main advantage of having a three phase supply is that the total load of the house or a factory is divided in three parts, so that none of the line is over loaded.
- If heavy load consisting of a number of air conditioners and motors etc., is supplied power from a single phase supply, its voltage is likely to drop at full load.
- Moreover, the three phase supply also provides 400 V which can be used to operate some special appliances requiring 400 V for their operation.

Q. 5 a. What do you know about the Biological effect of radiation? Write in detail. **05**

Ans: Units of radiation:

The strength of the radiation source is indicated by its activity measured in Becquerel (Bq).

Becquerel (Bq): One Becquerel is one disintegration per second.

Curie (Ci):

A larger unit is curie (Ci) which equals 3.7×10^{10} disintegrations per second.

Dose (D):

The effect of radiation on a body absorbing it relates to a quantity called absorbed dose D defined as the energy E absorbed from ionizing radiation per unit mass m of the absorbing body.

$$D = \frac{E}{m} \quad \dots \dots \dots (1)$$

SI unit of radiation gray (Gy):

Its SI unit is gray (Gy) defined as one joule per kilogram.

$$1 \text{ Gy} = 1 \text{ Jkg}^{-1}$$

Old unit rad: An old unit is rad, an acronym for radiation absorbed dose.

$$1 \text{ rad} = 0.01 \text{ Gy}$$

Biological effectiveness or RBE:

The absorbed dose is multiplied by a quality factor known as relative biological effectiveness or RBE.

Equivalent dose D_e :

The equivalent dose D_e of any absorbed radiation is defined as the product of absorbed dose and RBE of the kind of radiation being absorbed.

$$D_e = D \times \text{RBE} \quad \dots \dots \dots (2)$$

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417

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SI unit of equivalent dose is sievert (Sv):

The SI unit of equivalent dose is sievert (Sv).

$$1 \text{ Sv} = 1 \text{ Gy} \times \text{RBE}$$

Rem: An old unit, the rem is equal to 0.01 Sv.

$$1 \text{ rem} = 0.01 \text{ Sv}$$

Biological effects of radiation:

- i. Equal doses of different radiations do not produce same biological effect.
- ii. For the same absorbed dose, α -particles are 20 times more damaging than X-rays.
- iii. The effect also depends on the part of the body absorbing the radiation. For example, neutrons are particularly more damaging to eyes than other parts of the body.
- iv. The background radiation to which we are exposed, on the average, is 2 mSv per year. Doses of 3 Sv will cause radiation burns to the skin.
- v. For workers in the nuclear facilities or mines, a weekly dose of 1 mSv is normally considered safe.
- vi. The damage from α -particles is small unless the source enters the body, α and β -particles can cause redness and sores on the skin.

vii. Low level radiation effects:

Some other low level radiation effects are loss of hair, ulceration, stiffening of the lungs, and a drop in the white blood cells which is followed by a sickness pattern of diarrhea, vomiting and fever known as radiation sickness.

viii. High level radiation effects:

High levels of radiation may disrupt the blood cells seriously leading to diseases such as anaemia and leukaemia.

Chromosome abnormalities or mutation may cause delayed genetic effects such as cancer, eye cataracts and abnormalities in the future generations. These may develop many years after exposure to harmful radiation.

b. A 75 kg person receives a whole body radiation dose of 24 m-rad, delivered by α particles for which RBE factor is 12. Calculate: 05

(i) The absorbed energy in joules

(ii) The equivalent dose in rem.

Solution:

Mass	=	m	=	75 Kg	$\Rightarrow$	RBE factor	=	12
Radiation dose	=	D	=	24 m-rad	=	$24 \times 10^{-3} \text{ rad}$		
(a)	E (in J)	=	?	(b)	D_e (in rem)	=	?	

(a) Since $D = \frac{E}{m}$

$$E = m \times D$$

$$E = 75 \times 24 \times 10^{-5} = 1800 \times 10^{-5} = 18 \times 10^{-3} \text{ J} = 18 \text{ mJ}$$

(b) For equivalent dose in terms of absorbed dose is:

$$D_e = \text{RBE} \times D \quad \dots\dots\dots (1)$$

Since $D = 24 \times 10^{-3} \text{ rad}$

But $1 \text{ rad} = 0.01 \text{ Gy} \Rightarrow D = 24 \times 10^{-3} \times 0.01 = 24 \times 10^{-5} \text{ Gy}$

By using the values of D and RBE in equation (1) we get,

$$D_e = 12 \times 24 \times 10^{-5} = 12 \times 24 \times 10^{-5} \text{ sv} \quad (\because 1 \text{ sv} = \text{RBE} \times 1 \text{ Gy})$$

$$D_e = 288 \times 10^{-5} = 0.288 \times 10^{-2} \text{ sv}$$

$$D_e = 0.29 \text{ rem}$$

$$(\because 1 \text{ rem} = 10^{-2} \text{ sv})$$

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418

Physics 12th

c. Write a short note on basic forces of nature. **03**

Ans: Basic forces of nature:

The basic forces are:

- | | |
|-------------------------|-----------------------|
| 1. Gravitational force | 2. Magnetic force |
| 3. Electric force | 4. Weak nuclear force |
| 5. Strong nuclear force | |

Explanation:

i. The electric and magnetic forces were unified to get an electromagnetic force by Faraday and Maxwell, who were able to prove that a current is induced in a coil whenever the magnetic flux passing through the coil is changed; leaving behind four fundamental forces, the strong nuclear force, the electromagnetic force, the weak nuclear force and the gravitational force. These four fundamental forces of nature have seemed for some time quite different from one another.

ii. **Strong nuclear force:**

Despite its different effective strength, the strong nuclear force is effective only within sub-nuclear distances and therefore, confines the neutrons and protons within the nucleus.

iii. **Electromagnetic force:**

The electromagnetic force is long-range and causes all chemical reactions. It binds together atoms, molecules, crystals, trees, buildings and you. This force acting on a microscopic level is responsible for a variety of apparently different macroscopic forces such as friction, cohesion and adhesion.

iv. **Weak nuclear force:**

The weak nuclear force is short range, like the strong nuclear force, and is responsible for spontaneous breaking up of the radioactive elements. It is a sort of repulsive force of very short range (10^{-17} m). It is usually masked by the effect of the strong and electromagnetic forces inside the nuclei.

v. **Gravitational force:**

The gravitational force, like the electromagnetic force, is again long range, extending upto and beyond the remotest stars and galaxies. It keeps you, the atmosphere and the seas fixed to the surface of the planet. It gives rise to the ocean tides and keeps the planets moving in their orbits around the Sun.

Unification of electromagnetic and weak forces:

One hundred years after the unification of electric and magnetic forces into electromagnetic force, in 1979, the physics Nobel prize was conferred on Glashow, Weinberg and Abdus Salam for the unification of electromagnetic and weak forces.

Grand unified electro-nuclear force:

It is further expected that a strong nuclear force will eventually unite with electroweak force to make up a single entity resulting in the grand unified electro-nuclear force.

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419

Physics 12th

FBISE PAPER # (2014)

PHYSICS HSSC-II (2014)

SECTION-A (Marks 17)

Time: 25 Minutes

Marks: 17

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 25 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q. 1 Circle the correct option i.e. A / B / C / D. Each part carries one mark.

(i) It is required to suspend a proton of charge 'q' and mass 'm' in an Electric Field. The strength of field must be _____.

A. $E = \frac{mg}{qv}$

B. $E = \frac{q}{mg}$

C. $E = \frac{mg}{q}$

D. $E = \frac{q \sin \theta}{q}$

(ii) Two current carrying conductors are placed parallel to each other then _____.

A. They attract each other for the same direction of currents

B. They attract each other for the opposite direction of currents

C. They repel each other for the same direction of currents

D. No force is present between them

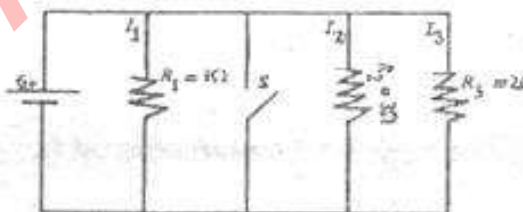
(iii) In the given circuit when switch 'S' is closed, the current through all the branches are _____.

A. $\begin{cases} I_1 = 6A \\ I_2 = 2A \\ I_3 = 3A \end{cases}$

B. $\begin{cases} I_1 = 0A \\ I_2 = 2A \\ I_3 = 6A \end{cases}$

C. $\begin{cases} I_1 = 3A \\ I_2 = 0A \\ I_3 = 0A \end{cases}$

D. $\begin{cases} I_1 = 0A \\ I_2 = 0A \\ I_3 = 0A \end{cases}$



(iv) The energy stored per unit volume in the electric field between the plates of charged capacitor with dielectric is _____.

A. $U = \frac{1}{2} \frac{\epsilon_0}{\epsilon_r} E^2$

B. $U = \frac{1}{2} \frac{\epsilon_r}{\epsilon_0} E^2$

C. $U = \frac{1}{2} \epsilon_0 \epsilon_r E^2$

D. $U = \frac{1}{2} \frac{E^2}{\epsilon_0 \epsilon_r}$

(v) A coil has an inductance 5.0 H. If current through it changes at the rate of 5 A s^{-1} , the emf induced in the coil will be _____.

A. 2.5 V

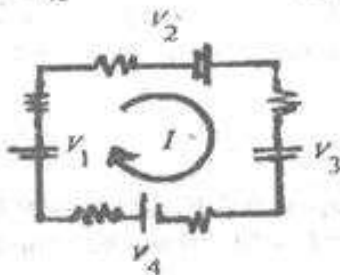
B. 25 V

C. 1.0 V

D. $\frac{1}{25} \text{ V}$

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- (vi) The energy equivalent of 1μ mass is _____.
 A. 931 J B. 9.31 J C. 931 MeV D. 9.31 MeV
- (vii) A charge 'q' is placed stationary in a region where both the electric and magnetic fields are present. The charge will experience _____.
 A. Both electric and magnetic forces B. Electric force
 C. Magnetic force D. No force at all
- (viii) The mathematical relation for NOR operation is _____.
 A. $X = \overline{A \cdot B}$ B. $X = \overline{A + B}$
 C. $X = \overline{A} \cdot \overline{B}$ D. $X = \overline{A} \cdot B$
- (ix) The voltage gain of an inverting OP-Amplifier is _____.
 A. $G = 1 - \frac{R_2}{R_1}$ B. $G = 1 - \frac{-R_1}{R_2}$
 C. $G = 1 + \frac{R_2}{R_1}$ D. None of these
- (x) The Compton shift " $\Delta\lambda$ " is equal to the Compton wavelength, if the scattered X-ray is observed at an angle θ for _____.
 A. $\theta = 90^\circ$ B. $\theta = 180^\circ$
 C. $\theta = 45^\circ$ D. None of these
- (xi) If number of atoms in metastable state (E_2) is " N_2 " and in ground state (E_1) is " N_1 " the population inversion means _____.
 A. $N_2 = N_1$ B. $N_2 < N_1$
 C. $N_2 > N_1$ D. $\frac{N_1}{N_2} = \frac{E_2}{E_1}$
- (xii) Which phenomenon proves the particle nature of electromagnetic waves?
 A. Diffraction B. Polarization
 C. Interference D. Photoelectric effect
- (xiii) The emission of α -particle from ${}^{226}_{88}\text{Ra}$ results into the formation of new element ${}_Z^AY$ in a reaction $[{}^{226}_{88}\text{Ra} \rightarrow {}_Z^AY + \alpha]$, where ${}_Z^AY$ stands for _____.
 A. ${}^{230}_{88}\text{Y}$ B. ${}^{224}_{84}\text{Y}$ C. ${}^{222}_{86}\text{Y}$ D. ${}^{226}_{84}\text{Y}$
- (xiv) The total applied voltage in the given circuit is _____.
 A. $[V_1 + V_2 - V_3 + V_4]$ B. $[V_1 + V_2 + V_3 + V_4]$
 C. $[V_1 - V_2 - V_3 - V_4]$ D. $[-V_1 - V_2 + V_3 + V_4]$



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421

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(xv) Which phase diagram is true for RC-series circuit?



(xvi) The process of combining the low frequency signal with high frequency carrier waves is called _____.

- A. Wave transmission
 B. Modulation
 C. Resonance
 D. Beats

(xvii) Photon 'A' has twice the energy to that of photon 'B'. The ratio of momentum of 'A' to that of 'B' is _____.

- A. $\frac{P_A}{P_B} = 1$
 B. $\frac{P_A}{P_B} = \frac{1}{2}$
 C. $\frac{P_A}{P_B} = 2$
 D. $\frac{P_A}{P_B} = 4$

PHYSICS HSSC-II

Time allowed: 2:40 Hours

Total Marks = 68

Note: Sections 'B' and 'C' are to be answered on the separately provided answer book. Answer eleven the questions from section 'B' and attempt any two questions from section 'C'. Use supplementary answer sheet i.e., sheet B if required. Write your answers neatly and legibly.

SECTION - B (Marks 42)

Q. 2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines. (14 × 3 = 42)

- (i) Does there exist any electric field inside a hollow charged shell? Prove your answer. How can a metal body act as electrostatic shielding for electronic devices?
- (ii) What is the maximum power output theorem? Derive its formula.
- (iii) A wire having total resistance of 32Ω , is cut into 4-equal lengths. Three of them are connected in parallel and one in series to them. Find total resistance of the combination.
- (iv) What is one electron volt energy? Derive its formula.
- (v) There exists a magnetic field of 0.30 T in space along +X-axis. What will be the magnetic force on a proton of $q = 1.6 \times 10^{-9} \text{ C}$, when it is moving with velocity $3 \times 10^4 \text{ ms}^{-1}$ at an angle of 30° to the field.
- (vi) What is current sensitivity of a suspended moving coil galvanometer? How does it depend upon different factors? Describe by mathematical formula.
- (vii) When the primary of a transformer is connected to a.c mains, the current in it:
 - a. is very low if the secondary circuit is open, but

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422

Physics 12th

- b. increases when the secondary circuit is closed. Explain these facts.
- (viii) In a certain region, the earth's magnetic field points vertically down $\vec{B} = -B_z \hat{k}$. When a plane flies due north with velocity $\vec{V} = V_y \hat{j}$, which wing of the plane is positively charged and why?
- (ix) What is Reactance? Prove that the capacitive reactance $[X_c = \frac{1}{\omega C}]$ and inductive reactance $[X_L = \omega L]$ have the same units equal to that of resistance 'R' i.e. ohm.
- (x) How is depletion region formed in PN-junction diode? What is the effect on the width of depletion region when:
 a. Diode is forward biased b. Diode is reverse biased
- (xi) What will be the impedance of the R_c -series circuit when frequency of applied voltage is
 a. $f = 0 \text{ Hz}$. b. $f = \infty \text{ Hz}$
- (xii) An electron and a proton moving with velocities v_1 and v_2 respectively have equal de.Broglies wavelengths. Find the ratio of their velocities. Which will be moving faster?
- (xiii) How does an operational amplifier work as a comparator? Draw its circuit diagram and write down its two working conditions.
- (xiv) An electron is to be confined in a box of the size of nucleus ($1.0 \times 10^{-14} \text{ m}$). What would be the speed of the electron if it were so confined?
- (xv) If the speed of light were infinite, what would the equations of special theory of relativity reduce to?
- (xvi) Differentiate between Spontaneous emission and Stimulated emission with the help of energy level diagram.
- (xvii) Write the names and define three distinct ways of interaction of radiation with matter. Also give their energy range.
- (xviii) Draw the circuit diagram of Wheatstone Bridge and derive its balanced condition to find the un-known resistance R_x .
- (xix) If mass of proton $m_p = 1.6726 \times 10^{-27} \text{ kg}$ and mass of neutron $m_n = 1.6749 \times 10^{-27} \text{ kg}$, the experimental mass of deuteron $m_D = 3.3435 \times 10^{-27} \text{ kg}$, find the Binding energy of deuteron nucleus.

SECTION - C (Marks 26)

Note:- Attempt any TWO questions.

(2×13 = 26)

Q. 3 a. What are the main parts of AC. generator? Describe its principle and working. Also derive the equation of emf induced in its coils.

(07)

b. It is desired to make an a.c. generator that can produce emf of maximum value 5.0 kV with 50 Hz frequency. A coil of area 1 m^2 and having 200 turns is used as armature. What should be the magnitude of magnetic field in which the coil rotates?

(04)

c. Why is the core of transformer laminated?

(02)

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423

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- Q. 4 a. What is Electric Potential? Derive an expression of electric potential at a point due to a point charge. (06)
- b. Using zero reference at infinity, determine the amount by which a point charge of $4.0 \times 10^{-8} \text{C}$ alters the electric potential at a point 12m away when (a) Charge is positive (b) Charge is negative. (05)
- c. Write two similarities and two differences between Electric and Gravitational forces. (02)
- Q. 5 a. Applying Bohr's Theory of Hydrogen Atom, derive: (08)
- (i) Formula of Quantized Radii
- (ii) Formula of Quantized Energies
- b. An electron jumps from a level $E_i = -3.5 \times 10^{-19} \text{J}$ to $E_f = -1.20 \times 10^{-18} \text{J}$. What is the wavelength of the emitted light? (05)

SOLUTION OF EBISE PAPER # (2014)

SECTION- A (MCQs)

i. C	ii. D	iii. A	iv. C	v. B	vi. C
vii. A	viii. B	ix. C	x. A	xi. C	xii. D
xiii. C	xiv. A	xv. D	xvi. B	xvii. C	

SECTION - B (Marks 42)

- Q. 2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines. (14 × 3 = 42)

- (i) Does there exist any electric field inside a hollow charged shell? Prove your answer. How can a metal body act as electrostatic shielding for electronic devices?

Ans: Inside a hollow conducting sphere, (Gaussian surface) charges spread themselves out. So, forces pulling or pushing at the center of the sphere cancel out, and the net force is zero. $E = F/q$, and if F is zero, then E is zero, no matter the charge q .

As a consequence, any apparatus placed within a metal enclosure is "shielded" from electric fields.

To determine stray electric field interference, circuits of sensitive electronics devices such as T.V and computers are often enclosed within metal boxes to shield from electric fields.

(Gauss Law)

- (ii) What is the maximum power output theorem? Derive its formula.

Ans: Maximum power output theorem:

In electrical engineering, the maximum power transfer theorem states that, to obtain maximum external power from a source with a finite internal resistance, the resistance of the load must be equal to the resistance of the source as viewing from the output terminals.

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424

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- i. In the circuit of Fig. as the current I flow through the resistance R , the charges flow from a point of higher potential to a point of lower potential and as such, they loose potential energy.
- ii. If V is the potential difference across R , the loss of potential energy per second is VI . This loss of energy per second appears in other forms of energy and is known as power delivered to R by current I .
- ∴ Power delivered to $R = P_{out} = VI$ (1)

$$P_{out} = I^2 R \text{ (2)}$$

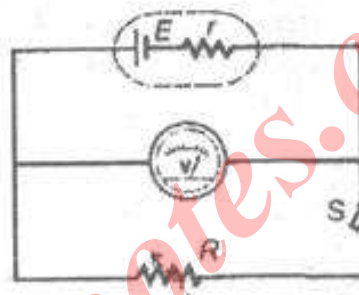
$$(\because V = IR)$$

$$I = \frac{E}{R+r}$$

$$P_{out} = \frac{E^2 R}{(R+r)^2}$$

From Eq. 2

$$P_{out} = \frac{E^2 R}{(R+r)^2} = \frac{E^2 R}{(R-r)^2 + 4Rr} \text{ (3)}$$



Note:

- i. When $R = r$, the denominator of the expression of P_{out} is least and so P_{out} is then a maximum.
- ii. Thus we see that maximum power is delivered to a resistance (load), when the internal resistance of the source equals the load resistance.
- iii. The value of maximum output power as given by Eq. 3 is $\frac{E^2}{4R}$.
- (iii) A wire having total resistance of 32Ω , is cut into 4-equal lengths. Three of them are connected in parallel and one in series to them. Find total resistance of the combination.

Solution: Total Resistance = 32Ω

Wire is cut into 4 equal lengths each having 8Ω resistance.

R_e For Parallel Resistance:

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_e} = \frac{1}{8} + \frac{1}{8} + \frac{1}{8} = \frac{1+1+1}{8} = \frac{3}{8} \Omega$$

$$R_e = \frac{8}{3}$$

R_e For Series Resistance:

$$R_{e\text{total}} = R_e + R_4$$

$$R_{e\text{total}} = \frac{8}{3} + 8 = \frac{8+24}{3} = \frac{32}{3} \Omega$$

(iv) What is one electron volt energy? Derive its formula.

Ans: Electron volt:

The amount of energy equal to $1.6 \times 10^{-19} \text{ J}$ is called one electron-volt and is denoted by 1eV . It is defined as "the amount of energy acquired or lost by an electron as it traverses a potential difference of one volt". Thus,

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J} \text{ (1)}$$

Derivation:

Suppose charge carried by the particle is $q = e = 1.6 \times 10^{-19} \text{ C}$.

Thus, in this case, the energy acquired by the charge will be

$$\Delta K.E = q \Delta V = e \Delta V = (1.6 \times 10^{-19} \text{ C}) (\Delta V)$$

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425

Physics 12th

Moreover, assume that $\Delta V = 1$ volt, hence

$$\Delta K.E = q \Delta V = (1.6 \times 10^{-19} \text{C}) \times (1 \text{ volt})$$

$$\Delta K.E = (1.6 \times 10^{-19}) \times (C \times V) = 1.6 \times 10^{-19} \text{J}$$

Thus $1 \text{ eV} = 1.6 \times 10^{-19} \text{J}$ Proved

- (v) There exists a magnetic field of 0.30 T in space along $+X$ -axis. What will be the magnetic force on a proton of $q = 1.6 \times 10^{-19} \text{C}$, when it is moving with velocity $3 \times 10^4 \text{ms}^{-1}$ at an angle of 30° to the field.

Solution: Speed of proton = $v = 3 \times 10^4 \text{ms}^{-1}$ Angle = $\theta = 30^\circ$

Magnetic field = $B = 0.30 \text{ T}$

Charge on a proton = $q = 1.6 \times 10^{-19} \text{C}$

Magnetic force = $F = ?$

Since $F = qvB \sin \theta$

$$F = 1.6 \times 10^{-19} \times 3 \times 10^4 \times \sin 30^\circ$$

$$F = 4.8 \times 10^{-15} \times 0.5 = 2.4 \times 10^{-15} \text{N}$$

- (vi) What is current sensitivity of a suspended moving coil galvanometer? How does it depend upon different factors? Describe by mathematical formula.

Ans: Sensitivity of a galvanometer:

The amount of angular twist for a unit (1A) current is called the current sensitivity of the galvanometer.

Consider a coil of N turns and cross-sectional area A , carrying a current I in a field of flux density B . The torque due to the magnetic field is given by:

$$\tau = N I B A \cos \alpha$$

for a radial field, and the opposing torque due to the twist of the suspension is $c\theta$ where c is the torsion constant for the wire and θ is the angle of deflection.

In equilibrium $c\theta = BAN I$

The angular twist per unit current (θ/I) is called the current sensitivity of the meter and is defined by the formula:

$$\text{Current sensitivity} = \frac{\theta}{I} = \frac{BAN}{c}$$

$$I = \frac{c}{BAN} \theta \quad \dots \dots \dots (1)$$

Thus $I \propto \theta$ since $\frac{c}{BAN} = \text{constant}$

Thus the current passing through the coil is directly proportional to the angle of deflection.

To increase this (that is, to make the meter more sensitive) we require:

- large magnetic flux density (B), that is, the gap between the poles as small as possible,
- a coil with a large area (A),
- a large number of turns (N), and
- a small value of c (the torsion constant) that is, a very thin wire or one with a very low rigidity.

- (vii) When the primary of a transformer is connected to a.c mains, the current in it:

- is very low if the secondary circuit is open, but
- increases when the secondary circuit is closed. Explain these facts.

Ans: (a) When the secondary circuit is open then there is no load to consume electric power or output power used is zero.

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Maryam Key Series

426

Physics 12th

$$\text{Output power} = V_s I_s = 0$$

Since output power of a transformer is smaller than input power. Hence the primary coil of the transformer draws a very small current from a.c.

- (b) When the secondary circuit is closed then output power increases
 input power = output power

$$I_p V_p = I_s V_s$$

The transformer will draw large current from the a.c mains to increase the primary power because greater current is needed in primary coil to equalize power in the secondary coil.

- (viii) In a certain region, the earth's magnetic field points vertically down $\vec{B} = -B_z \hat{k}$. When a plane flies due north with velocity $\vec{V} = V_y \hat{j}$, which wing of the plane is positively charged and why?

Ans: When a plane flies through the magnetic field of earth along north, the electrons in the wing experience a magnetic force, $\vec{F} = -e(\vec{V} \times \vec{B})$, from right to left wing. Thus the west wing of the plane is positively charged.

- (ix) What is Reactance? Prove that the capacitive reactance $[X_c = \frac{1}{\omega C}]$ and inductive reactance $[X_L = \omega L]$ have the same units equal to that of resistance 'R' i.e. ohm.

Ans: Reactance:

Reactance of a capacitor is a measure of the opposition offered by the capacitor to the flow of A.C. It is usually represented by X_c . Its value is given by

$$X_c = \frac{V_{rms}}{I_{rms}} \quad \dots \dots \dots (2)$$

Where V_{rms} is the rms value of the alternating voltage across the capacitor and I_{rms} is the rms value of current passing through the capacitor.

Unit of reactance: The unit of reactance is ohm.

Capacitive reactance $[X_c = \frac{1}{\omega C}]$:

Here C = Capacitance expressed in farad (F), and ω = angular frequency

$$X_c = \frac{1}{\omega C} = \frac{1}{s^{-1} F} = \frac{1}{s^{-1} (C/V)} = \frac{V}{Cs^{-1}} = \frac{V}{A} = \Omega$$

Inductive reactance $[X_L = \omega L]$:

Here L = Inductance expressed in henry (H), and ω = angular frequency

$$X_L = \omega L = s^{-1} (VsA^{-1}) = \frac{V}{A} = \Omega$$

- (x) How is depletion region formed in PN-junction diode? What is the effect on the width of depletion region when:

- a. Diode is forward biased b. Diode is reverse biased

Ans: Depletion region:

Just after the formation of the junction, the free electrons in the n-region, because of their random motion, diffuse into the p-region. As a result of this diffusion, a region is formed around the junction in which charge carriers are not present. This region is known as depletion region.

When a diode is forward biased, the width of the depletion region is decreased. It is mainly due to a large value of diffusion current and a small value of drift current. On

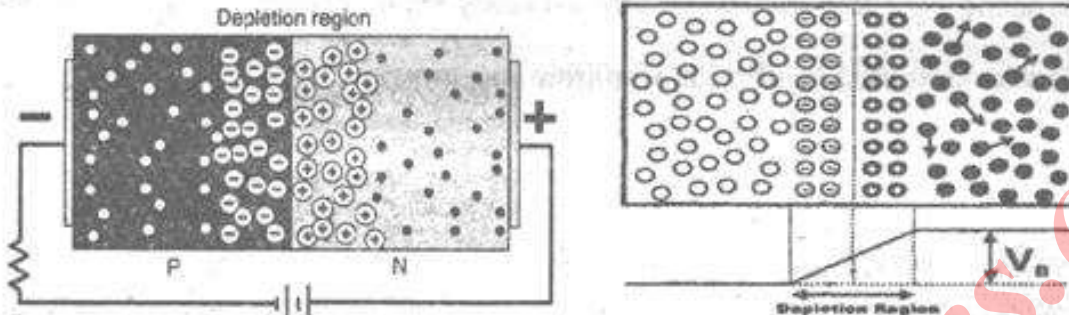
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Maryam Key Series

427

Physics 12th

the other hand the width of depletion region increases when the diode is reversed biased.



- (xi) What will be the impedance of the R_C -series circuit when frequency of applied voltage is: - a. $f = 0 \text{ Hz}$. b. $f = \infty \text{ Hz}$

Solution: Case (i) Here, $X_C = \frac{1}{2\pi fC}$

$$\text{Impedance} = Z = \sqrt{R^2 + (X_C)^2}$$

$$Z = \sqrt{R^2 + \left(\frac{1}{2\pi fC}\right)^2} = \sqrt{R^2 + \left(\frac{1}{0}\right)^2} = \sqrt{R^2 + \left(\frac{1}{\infty}\right)^2}$$

$$Z = R$$

Case (ii) Impedance = $Z = \sqrt{R^2 + (X_C)^2}$

$$Z = \sqrt{R^2 + \left(\frac{1}{\infty}\right)^2} = \sqrt{R^2 + \frac{1}{0}} = \sqrt{R^2 + \infty} = \infty$$

- (xii) An electron and a proton moving with velocities v_1 and v_2 respectively have equal de-Broglie wavelengths. Find the ratio of their velocities. Which will be moving faster?

Ans: According to de-Broglie Equation $\lambda = \frac{h}{mv}$

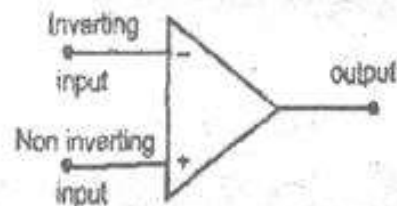
$$v = \frac{h}{m\lambda} \Rightarrow v \propto \frac{1}{m}$$

Hence for same wavelength the smaller mass has greater velocity. Therefore electron will have greater speed because the mass of electron is smaller than that of protons.

- (xiii) How does an operational amplifier work as a comparator? Draw its circuit diagram and write down its two working conditions.

Ans: Operational amplifier (op-amp):

Instead of making amplifier circuit by discrete components, the whole amplifier is integrated on a small silicon chip and enclosed in a capsule. Pins connected with working terminals such as inputs, outputs and power supply project outside the capsule. Such an integrated amplifier is known as operational amplifier.



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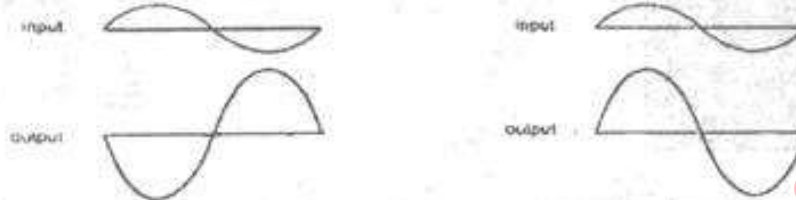
428

Physics 12th

Use of op-amp:

Operational amplifier (op-amp), sometimes used to perform mathematical operations electronically. The op-amp is usually represented by its symbol shown in Fig.

Construction of Operational amplifier (op-amp):



It has two input terminals. One is known as inverting input (-) and the other non-inverting input (+).

Working of Operational amplifier (op-amp):

A signal that is applied at the inverting (-) input appears after amplification, at the output terminal with a phase shift of 180°.

It can be seen that the signal is inverted as it appears at the output. This is why this terminal is known as inverting. If the signal is applied at non-inverting input (+), it is amplified at the output without any change of phase.

(xiv) An electron is to be confined in a box of the size of nucleus ($1.0 \times 10^{-14} \text{ m}$). What would be the speed of the electron if it were so confined?

Solution: Maximum uncertainty in the location of electron equals the size of the nucleus of the box itself that is $\Delta x = 1.0 \times 10^{-14} \text{ m}$. The minimum uncertainty in the velocity of electron is found from Heisenberg uncertainty principle.

$$\Delta p \approx \frac{h}{\Delta x}$$

$$m\Delta v \approx \frac{h}{\Delta x}$$

$$\Delta v = \frac{h}{m\Delta x} = \frac{1.05 \times 10^{-34}}{9.1 \times 10^{-31} \times 1.0 \times 10^{-14}} = 1.15 \times 10^{10} \text{ ms}^{-1}$$

(xv) If the speed of light were infinite, what would the equations of special theory of relativity reduce to?

Ans: There will be no relativistic effect.

Since $c = \infty$ therefore

$$v^2/c^2 = 0 \dots\dots\dots (1)$$

i. Since $t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

From Eq. 1 $t = \frac{t_0}{\sqrt{1 - 0}} \Rightarrow t = t_0$

ii. Since $\ell = \ell_0 \sqrt{1 - \frac{v^2}{c^2}}$

From Eq. 1 $\ell = \frac{\ell_0}{\sqrt{1 - 0}} \Rightarrow \ell = \ell_0$

iii. Since $m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

From Eq. 1 $m = \frac{m_0}{\sqrt{1 - 0}} \Rightarrow m = m_0$

Therefore the relativistic equations become:

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Maryam Key Series

429

Physics 12th

$$t = t_0, \quad l = l_0, \quad \text{and} \quad m = m_0.$$

(xvi) Differentiate between Spontaneous emission and Stimulated emission with the help of energy level diagram.

Ans: Spontaneous or induced emission:

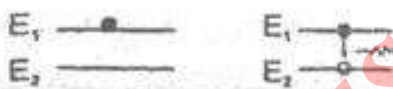
Spontaneous or induced emission is that in which the atom emits a photon of energy $hf = E_2 - E_1$ in any arbitrary direction.

Stimulated or induced emission:

Stimulated or induced emission is that in which the incident photon of energy $hf = E_2 - E_1$ induces the atom to decay by emitting a photon that travels in the direction of the incident photon. For each incident photon, we will have two photons going in the same direction giving rise to an amplified as well as a unidirectional coherent beam. Such a beam is called laser.



(a) Induced Absorption



(b) Spontaneous Emission



(c) Induced Emission

(xvii) Write the names and define three distinct ways of interaction of radiation with matter. Also give their energy range.

Ans: Interaction of radiation with matter:

a. Interaction of α -particles with matter:

An α -particle travels a well defined distance in a medium before coming to rest. This distance is called the range of the particle.

Ionization is the main interaction with matter to detect the particle or to measure its energy. The range depends on the

- i. charge, mass and energy of the particle and
- ii. The density of the medium and ionization potentials of the atoms of the medium.

b. Interaction of β -particles with matter:

β -particles also lose energy by producing ionization. However, its ionizing ability is about 100 times less than that of α -particles. As a result its range is about 100 times more than α -particles. β -particles are more easily deflected by collisions than heavy α -particles. The range of β -particles is measured by the effective depth of penetration into the medium not by the length of erratic path. The more dense the material through which the particle moves, the shorter its range will be.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

430

Physics 12^a

c. Interaction of γ -particles with matter:

Photons of γ -rays, being uncharged, cause very little ionization. Photons are removed from a beam by either scattering or absorption in the medium. They interact with matter in three distinct ways, depending mainly on their energy.

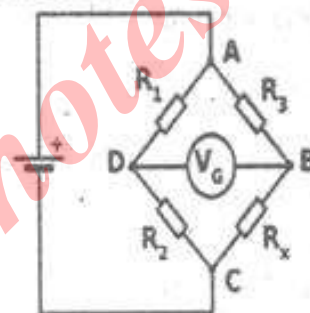
- (i) At low energies (less than about 0.5 MeV), the dominant process that removes photons from a beam is the photoelectric effect.
- (ii) At intermediate energies, the dominant process is Compton scattering.
- (iii) At higher energies (more than 1.02 MeV), the dominant process is pair production.

(xviii) Draw the circuit diagram of Wheatstone Bridge and derive its balanced condition to find the un-known resistance R_x .

Ans: Wheatstone Bridge Measurement:

Balanced Condition:

As shown in the circuit diagram, there are four resistances connected as a bridge circuit. The three resistors R_1 , R_2 and R_3 will have known values. The value of the resistance R_x will be unknown and has to be calculated. The value of resistance R_2 is adjustable. A galvanometer has to be set between the points B and D.



The condition to be satisfied at the point of balance is given below.

If $\frac{R_2}{R_1} = \frac{R_x}{R_3}$, then $V_{BD} = 0$ and current through $V_G = 0$. To reach this condition, the adjustable resistor is varied. The direction of the current can be known from the value of the resistor R_2 .

As soon as the balance condition is obtained the value of the resistance R_x is obtained.

$$\text{Thus, } R_x = \left[\frac{R_2}{R_1} \right] \times R_3$$

This method is very accurate as the other values of resistors are of high precision.

- (xix) If mass of proton $m_p = 1.6726 \times 10^{-27} \text{ kg}$ and mass of neutron $m_n = 1.6749 \times 10^{-27} \text{ kg}$, the experimental mass of dedutron $m_D = 3.3435 \times 10^{-27} \text{ kg}$, find the Binding energy of deutron nucleus.**

Solution: Mass of deutron = $m_D = 3.3435 \times 10^{-27} \text{ kg}$

Mass of proton = $m_p = 1.6730 \times 10^{-27} \text{ kg}$

Mass of neutron = $m_n = 1.6750 \times 10^{-27} \text{ kg}$

Mass defect = $\Delta m = ?$

Binding energy = B.E. = ?

Mass defect = $\Delta m = m_p + m_n - m_D$

$$\Delta m = 1.673 \times 10^{-27} + 1.675 \times 10^{-27} - 3.3435 \times 10^{-27}$$

$$\Delta m = 3.348 \times 10^{-27} - 3.3435 \times 10^{-27}$$

$$\Delta m = 4.0 \times 10^{-30} \text{ kg}$$

$$\text{Binding energy} = \text{B.E.} = mc^2$$

$$\text{B.E.} = 4.0 \times 10^{-30} \times (3.0 \times 10^8)^2$$

$$\text{B.E.} = 3.6 \times 10^{-13} \text{ J}$$

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431

Physics 12th

$$\text{B.E.} = \frac{3.6 \times 10^{-13}}{1.6 \times 10^{-19}} = 2250000 = 2.25 \times 10^6 \text{ eV}$$

SECTION - C (Marks 26)

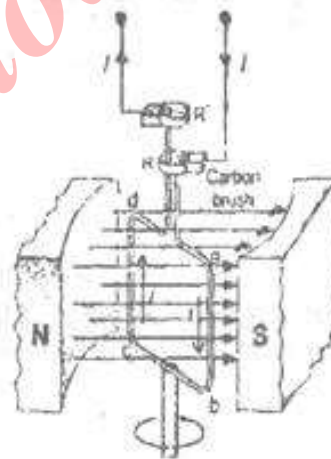
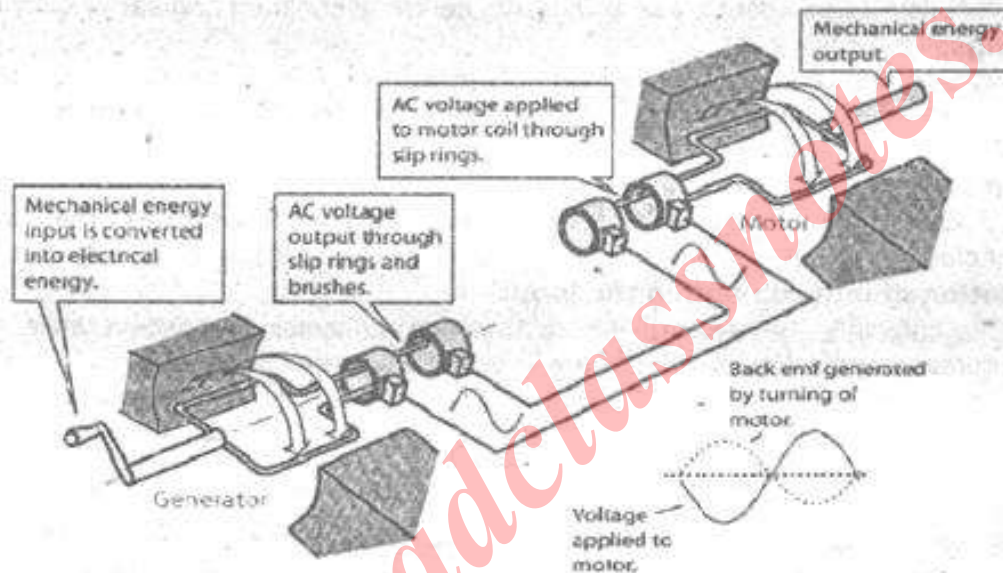
Note:- Attempt any TWO questions.

(2×13 = 26)

Q. 3 a. What are the main parts of AC generator? Describe its principle and working. Also derive the equation of emf induced in its coils. (07)

Ans: Alternating current generator (A.C. generator):

"A current generator is a device that converts mechanical energy into electrical energy."



(Front view)

Principle of A.C. generator:

The principle of an electric generator is based on Faraday's law of electromagnetic induction.

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Maryam Key Series

432

Physics 12^a

Working of A.C. generator:

When a coil is rotated in a magnetic field by some mechanical means, magnetic flux through the coil changes, and consequently an emf is induced in the coil.

If the generator is connected to an external circuit, an electric current is the output of the generator.

Construction of A.C. generator:

Rectangular loop of wire:

Let a rectangular loop of wire of area A be placed in a uniform magnetic field B . The loop is rotated about z -axis through its centre at constant angular velocity ω .

Slip rings:

One end of the loop is attached to a metal ring R and the other end to the ring R' . These rings, called the slip rings are concentric with the axis of the loop and rotate with it.

Carbon brushes:

Rings R R' slide against stationary carbon brushes to which external circuit is connected.

Calculation of induced emf in the loop:

- i. To calculate the induced emf in the loop, consider its position while it is rotating anticlockwise. The figure shows the top view of the coil.
- ii. The vertical side ab of the loop is moving with velocity v in the magnetic field B . If the angle between v and B be θ , the motional emf induced in the side ab has the magnitude,

$$\mathcal{E}_{ab} = vBL \sin\theta$$

The direction of induced current in the wire ab is the same as that of force F experienced by the charges in the wire, i.e., from top to the bottom.

- iii. The same amount of emf is induced in the side cd but the direction of current is from bottom to the top. Therefore,

$$\mathcal{E}_{cd} = vBL \sin\theta$$

- iv. The net contribution to emf by sides bc and da is zero because the force acting on the charges inside bc and da is not along the wire. Thus,

$$\mathcal{E}_{bc} = \mathcal{E}_{da} = 0$$

- v. Since both the emfs in the sides ab and cd drive current in the same direction around the loop, the total emf in the loop is $\mathcal{E} = \mathcal{E}_{ab} + \mathcal{E}_{cd}$

$$\mathcal{E} = vBL \sin\theta + vBL \sin\theta = 2vBL \sin\theta$$

- vi. If the loop is replaced by a coil of N turns, the total emf in the coil will be,

$$\mathcal{E} = 2NvBL \sin\theta \quad \text{..... (1)}$$

- vii. The linear speed v of the vertical wire is related to the angular speed ω by the relation

$$v = \omega r$$

where r is the distance of the vertical wires from the centre of the coil. Substituting ωr for v in Equation. (1), We get

$$\mathcal{E} = 2N(\omega r)BL \sin\theta$$

$$\mathcal{E} = N\omega(2rL)B \sin\theta$$

$$\mathcal{E} = N\omega AB \sin\theta \quad \text{..... (2)}$$

where $A = 2rL = \text{area of the coil}$

As the angular displacement $\theta = \omega t$, so the Eq. 2 becomes

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Mariam Key Series

433

Physics 12*

$$\mathcal{E} = N\omega AB \sin(\omega t) \dots\dots\dots (3)$$

viii. Maximum value of emf ($\mathcal{E}_0$):

Eq.3 shows that the induced emf varies sinusoidally with time. It has the maximum value $\mathcal{E}_0$ when $\sin(\omega t)$ is equal to 1. Thus

$$\mathcal{E}_0 = N \omega AB \dots\dots\dots (4)$$

The Eq. 3 can be written as,

$$\mathcal{E} = \mathcal{E}_0 \sin(\omega t) \dots\dots\dots (5)$$

ix. Induced current:

If R is the resistance of the coil, then by Ohm's law, induced current in the coil will be

$$I = \frac{\mathcal{E}}{R} = \frac{\mathcal{E}_0 \sin(\omega t)}{R} = \frac{\mathcal{E}_0}{R} \sin(\omega t)$$

or

$$I = I_0 \sin(\omega t) \dots\dots\dots (6)$$

where I_0 is maximum current.

x. Relation of induced emf and induced current with frequency:

Angular speed ω of the coil is related to its frequency of rotation f as, $\omega = 2\pi f$

The Eqs. 5 and 6 can be written as

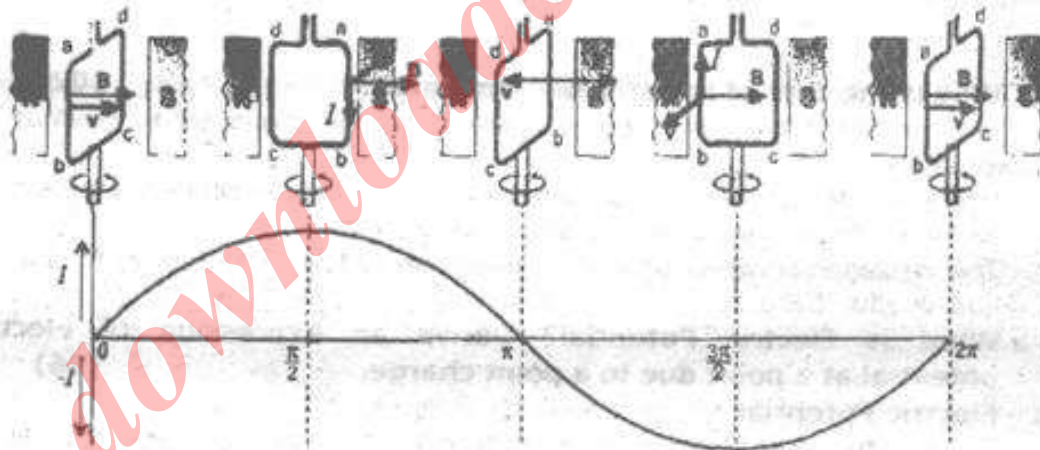
$$\mathcal{E} = \mathcal{E}_0 \sin(2\pi f t) \dots\dots\dots (7)$$

$$I = I_0 \sin(2\pi f t) \dots\dots\dots (8)$$

Eq. 8 indicates the variation of current as a function of $\theta = 2\pi f t$.

Graphical representation for the current and different positions of coil during one loop:

Fig. shows the graph for the current corresponding to different positions of one loop of the coil.



Case 1:

When the angle between $\mathbf{v}$ & $\mathbf{B}$ is $\theta = 0^\circ$, the plane of the loop is perpendicular to $\mathbf{B}$, current is zero.

Case 2:

As θ increases, current also increases and at $\theta = 90^\circ = \pi/2$ rad, the loop is parallel to $\mathbf{B}$, current is maximum, directed along $abcd$.

Case 3:

On further increase in θ current decreases, and at $\theta = 180^\circ = \pi$ rad the current becomes zero as the loop is again perpendicular to $\mathbf{B}$.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

434

Physics 12th

Case 4:

For $180^\circ < \theta < 270^\circ$ current increases but reverses its direction as is clear from the figure. Current is now directed along dcba. At $\theta = 270^\circ = 3\pi/2$ rad, current is maximum in the reverse direction as the loop is parallel to B.

Case 5:

At $\theta = 360^\circ = 2\pi$ rad, one rotation is completed, the loop is perpendicular to B and the current decreases to zero. After one rotation the cycle repeats itself.

Note: The current alternates in direction once in one cycle. Therefore, such a current is called the alternating current. It reverses its direction f times per second.

- b. It is desired to make an a.c. generator that can produce emf of maximum value 5.0 kV with 50 Hz frequency. A coil of area 1m^2 and having 200 turns is used as armature. What should be the magnitude of magnetic field in which the coil rotates? (04)

Solution: $\varepsilon_0 = 5\text{ kV} = 5000\text{ V}$
 $f = 50\text{ Hz}$
 $A = 1\text{ m}^2$

Number of turns = $N = 200$ turns

$B = ?$

For maximum induced emf in a generator:

$$B = \frac{\varepsilon_0}{N\omega A} = \frac{\varepsilon_0}{N \times 2\pi f \times A} \quad (\because \omega = 2\pi f)$$

$$B = \frac{5000}{200 \times 1 \times 2 \times 3.14 \times 50} = 0.0795 = 0.08\text{ T}$$

- c. Why is the core of transformer laminated? (02)

Ans: In order to improve the efficiency, care should be exercised, to minimize all the power losses.

For example core should be assembled from the laminated sheets of a material whose hysteresis loop area is very small.

The insulation between lamination sheets should be perfect so as to stop the flow of eddy currents.

- Q. 4 a. What is Electric Potential? Derive an expression of electric potential at a point due to a point charge. (06)

Ans: Electric Potential

The electric potential (or simply potential) at a point in an electric field is defined as the work done in moving a unit positive charge from infinity to that point. The electric potential at infinity is assumed to be zero. Force and potential energy are directly related.

Electrical potential at a point due to a point charge:

Case I:

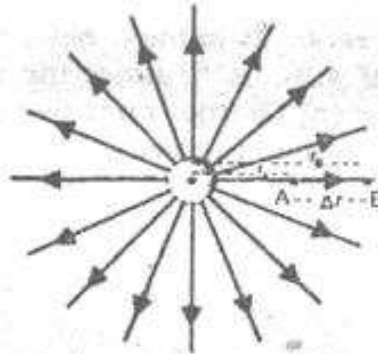
- Let us take two points A and B, infinitesimally close to each other, so that E remains almost constant between them.
- The distance of points A and B from q are r_A and r_B respectively and distance of midpoint of space interval between A and B is r from q . Then according to Fig.

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Mariam Key Series

433

Physics 12th



$$r_B = r_A + \Delta r \quad \dots\dots\dots (1)$$

$$\Delta r = r_B - r_A \quad \dots\dots\dots (2)$$

- iii. As 'r' represents midpoint of interval between A and B so

$$r = \frac{r_A + r_B}{2} \quad \dots\dots\dots (3)$$

- iv. The magnitude of electric intensity at this point is,

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \quad \dots\dots\dots (4)$$

- v. As the points A and B are very close then, as a first approximation, we can take the arithmetic mean to be equal to geometric mean which gives

$$\frac{r}{r_A} = \frac{r_B}{r}$$

$$\left\{ r_A, r, r_B \text{ are in G. M., where common ratio} = \frac{\text{2nd term}}{\text{1st term}} \right\}$$

$$r^2 = r_A r_B \quad \dots\dots\dots (5)$$

Thus, Eq. 4 can be written as

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r_A r_B} \quad \dots\dots\dots (6)$$

Case II:

- vi. Now, if a unit positive charge is moved from B to A, the work done is equal to the potential difference between A and B,

$$V_A - V_B = -E (r_A - r_B)$$

$$V_A - V_B = E (r_B - r_A)$$

Substituting value of E from Eq. 6,

$$V_A - V_B = \frac{q}{4\pi\epsilon_0} \left(\frac{r_B - r_A}{r_A r_B} \right)$$

$$V_A - V_B = \frac{q}{4\pi\epsilon_0} \left(\frac{1}{r_A} - \frac{1}{r_B} \right)$$

To calculate absolute potential or potential at A, point B assumed to be infinity point so that $V_B = 0$ and hence

$$\frac{1}{r_B} = \frac{1}{r_{\infty}} = \frac{1}{\infty} = 0$$

This gives,

$$V_A = \frac{1}{4\pi\epsilon_0} \frac{q}{r_A}$$

- vii. The general expression for electric potential V_r at a distant r from q is,

$$V_r = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

436

Physics 12th

- b. Using zero reference at infinity, determine the amount by which a point charge of $4.0 \times 10^{-8} \text{ C}$ alters the electric potential at a point 12m away when (a) Charge is positive (b) Charge is negative. (05)

Solution: (a) Charge is positive

$$\begin{aligned} q &= 4.0 \times 10^{-8} \text{ C} \\ r &= 12 \text{ m} \\ k &= 9 \times 10^9 \text{ Nm}^2 \text{ C}^{-2} \end{aligned}$$

As the proton will

$$\Delta V = k \frac{q}{r}$$

$$\Delta V = 9 \times 10^9 \times \frac{4.0 \times 10^{-8}}{12} = 300 \text{ volts}$$

$$\Delta V = +3.0 \times 10^2 \text{ volts}$$

- (b) Charge is negative

$$\begin{aligned} q &= -4.0 \times 10^{-8} \text{ C} \\ r &= 12 \text{ m} \\ k &= 9 \times 10^9 \text{ Nm}^2 \text{ C}^{-2} \end{aligned}$$

$$\Delta V = k \frac{q}{r}$$

$$\Delta V = 9 \times 10^9 \times \frac{-4.0 \times 10^{-8}}{12} = -300 \text{ volts}$$

$$\Delta V = -3.0 \times 10^2 \text{ volts}$$

- c. Write two similarities and two differences between Electric and Gravitational forces. (02)

Ans: Electric and gravitational forces (a comparison):

- i. Gravitational force:

Gravitational force is a conservative force, that is, work done in such a field is independent of path.

- ii. Electric force:

Coulomb's electrostatic force is also conservative force. The electric force between two charges

$F = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}$ is similar in form to the gravitational force between the two point masses, $F = G \frac{m_1 m_2}{r^2}$.

- iii. Similarity between gravitational and electric force:

Both forces vary inversely with the square of the distance between the two charges or the two masses.

- iv. Dissimilarity between gravitational and electric force:

- a. The value of gravitational constant G is very small as compared to electrical constant $\frac{1}{4\pi\epsilon_0}$. It is because of this fact that the gravitational force is a very weak force as compared to electrostatic force.

- b. As regards their qualitative aspect, the electrostatic force could be attractive or repulsive while, on the other hand, gravitational force is only attractive.

- c. Another difference to be noted is that the electrostatic force is medium dependant and can be shielded while gravitational force lacks this property.

AKA

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

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437

Physics 12th

Q.5a. Applying Bohr's Theory of Hydrogen Atom, derive: (08)

- (i) Formula of Quantized Radii
- (ii) Formula of Quantized Energies

Ans: Quantized radii:

Consider a hydrogen atom in which electron moving with velocity v_n is in stationary circular orbit of radius r_n . From Eq.

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

$$v_n = \frac{nh}{2\pi m r_n} \quad \dots\dots\dots (1)$$

As electron to stay in the circular orbit, shown in Fig., the centripetal force

$F_c = \frac{mv_n^2}{r_n}$ is provided by the Coulomb's force

$F_e = \frac{ke^2}{r_n^2}$, where 'e' is the magnitude of charge on electron as well as on the hydrogen nucleus consisting of a single proton. Thus,

$$\frac{mv_n^2}{r_n} = \frac{ke^2}{r_n^2} \quad \dots\dots\dots (2)$$

where constant k is equal to $\frac{1}{4\pi\epsilon_0}$

After substituting for v_n from Eq. 1, we have

$$r_n = \frac{n^2 h^2}{4\pi^2 k m e^2} = n^2 r_1 \quad \dots\dots\dots (3)$$

where $r_1 = \frac{h^2}{4\pi^2 k m e^2} = 0.053 \text{ nm}$

This agrees with the experimentally measured values and is called the first Bohr orbit radius of the hydrogen atom.

Note: Thus according to Bohr's theory, the radii of different stationary orbits of the electrons in the hydrogen atom are given by

$$r_n = r_1, 4r_1, 9r_1, 16r_1, \dots\dots\dots$$

The first Bohr orbit in the hydrogen atom has a radius $r_1 = 5.3 \times 10^{-11} \text{ m}$. The second and third Bohr orbits have radii $r_2 = 4r_1$ and $r_3 = 9r_1$ respectively

Speed of electron in nth orbit:

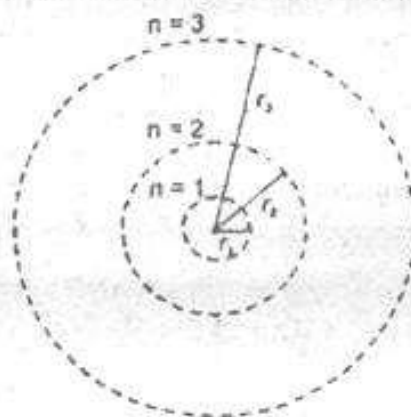
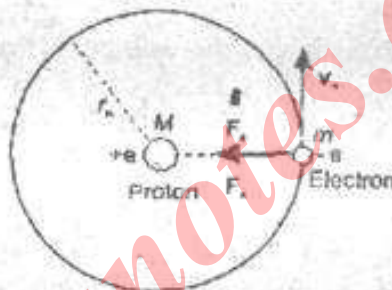
Substituting the value of r_n from Eq. 3 in Eq. 1, the speed of electron in the nth orbit is

$$v_n = \frac{2\pi k e^2}{nh} \quad \dots\dots\dots (4)$$

Quantized energies:

Let us now calculate the total energy E_n of the electron in the Bohr orbit; E_n is the sum of the kinetic energy K.E. and the potential energy U. i.e.,

$$E_n = \text{K.E.} + U = \frac{1}{2} m v_n^2 + \left(\frac{-ke^2}{r_n} \right) \quad \dots\dots\dots (1)$$



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Maryam Key Series

438

Physics 12^a

Since $\frac{mv_n^2}{r_n} = \frac{ke^2}{r_n^2}$ (2)

By rearranging Eq. 2, we get

$$\frac{1}{2}mv_n^2 = \frac{ke^2}{2r_n} \text{ (3)}$$

then put in Eq. 1 $E_n = \frac{ke^2}{2r_n} - \frac{ke^2}{r_n} = -\frac{ke^2}{r_n}$ (4)

Since $r_n = \frac{n^2 h^2}{4\pi^2 k m e^2}$ (5)

By substituting the value of r_n from Eq., we have

$$E_n = -\frac{1}{n^2} \left(\frac{2\pi^2 m e^4}{h^2} \right) = -\frac{E_0}{n^2} \text{ (6)}$$

where $E_0 = \frac{2\pi^2 k^2 m e^4}{h^2} = \text{constant} = 13.6 \text{ eV}$

which is the energy required to completely remove an electron from the first Bohr orbit. This is called ionization energy. The ionization energy may be provided to the electron by collision with an external electron.

Ionization potential:

The minimum potential through which this external electron should be accelerated so that it can supply the requisite ionization energy is known as ionization potential. Thus for $n = 1, 2, 3 \dots$ we get the allowed energy levels of a hydrogen atom to be

$$E_n = -E_0, -\frac{E_0}{4}, -\frac{E_0}{9}, -\frac{E_0}{16}, \dots$$

The experimentally measured value of the binding energy of the electron in the hydrogen atom is in perfect agreement with the value predicted by Bohr theory.

Excitation potential:

The potential through which an electron should be accelerated so that, on collision it can lift the electron in the atom from its ground state to some higher state, is known as excitation potential.

b. An electron jumps from a level $E_i = -3.5 \times 10^{-19} \text{ J}$ to $E_f = -1.20 \times 10^{-18} \text{ J}$.

What is the wavelength of the emitted light? (05)

Solution: $E_i = -3.5 \times 10^{-19} \text{ J}$

$$E_f = -1.2 \times 10^{-18} \text{ J}$$

$$\Delta E = E_i - E_f$$

$$\Delta E = -3.5 \times 10^{-19} - (-1.2 \times 10^{-18}) = -3.5 \times 10^{-19} + 12 \times 10^{-19}$$

$$\Delta E = 8.5 \times 10^{-19} \text{ J}$$

$$\lambda = ?$$

Since $\lambda = \frac{hc}{\Delta E}$

$$\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{8.5 \times 10^{-19}} = 234 \times 10^{-9} \text{ m} = 234 \text{ nm}$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)**Physics 12^a****FBISE PAPER # (2015)**

PHYSICS HSSC-II (2015)

SECTION-A (Marks 17)

Time: 25 Minutes

Marks: 17

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 25 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q. 1 Circle the correct option i.e. A / B / C / D. Each part carries one mark.

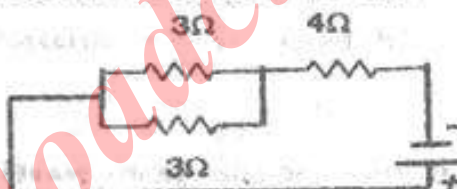
- (i) The work done in moving a positive charge on an equipotential surface is:

- A. Finite and Positive
B. Infinite
C. Finite and Negative
D. Zero

- (ii) If the temperature of a conductor is increased, the product of resistivity and conductivity:

- A. Increases
B. Decreases
C. Remains constant
D. May increase or decrease

- (iii) If the current flowing through the 3Ω resistor is 0.8A , the potential which drops across the 4Ω resistor will be:



- A. 6.4 volts B. 4.5 volts C. 8.8 volts D. None of these

- (iv) An Inductor may store energy in:

- A. Its Magnetic field
B. Its electric field
C. Its coil
D. Battery

- (v) When a particle of charge " q " and mass " m " enters a region of constant magnetic induction " B ", traveling with the velocity " v " perpendicular to the direction of the field, it describes a circular orbit of radius:

- A. $R = mq / vB$ B. $R = mqv / B$
C. $R = mv / Bq$ D. $R = Bq / mv$

- (vi) When the current in a coil changes from 0 to 10 A in 0.025s, an average emf induced in a neighboring coil is 600V, the Mutual inductance for two coils is:

- A. 1.5 Henry B. 12.5 Henry C. 6 Henry D. 10 Henry

- (vii) A mutually occurring disintegration involving the emission of high energy electrons is called:

- A. Positron Decay B. Beta Decay
C. Gamma Decay D. Alpha Decay

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440

Physics 12th

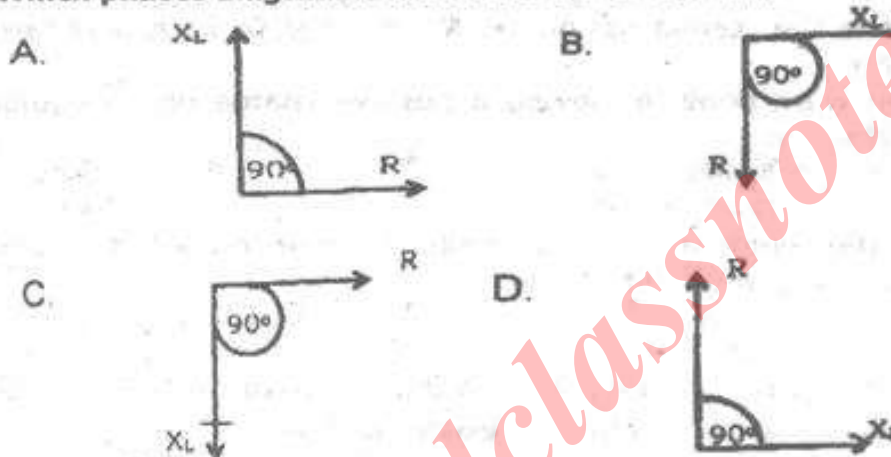
(viii) The Truth Table of logic function:

- A. Summarizes its output values
- B. Tabulates all its input conditions only
- C. Display all its input/output possibilities
- D. Is not based on logic gates

(ix) In a common base amplifier, the phase difference between the input signal voltage and output signal voltage is:

- A. $\frac{\pi}{4}$
- B. π
- C. 0
- D. $\frac{\pi}{2}$

(x) Which phases diagram is true of RL-Series circuit?



(xi) If $^{233}_{92}\text{U}$ is decayed twice by α - emission, then the resulting isotope is:

- A. $^{229}_{92}\text{Y}$
- B. $^{223}_{88}\text{Y}$
- C. $^{223}_{92}\text{Y}$
- D. $^{225}_{88}\text{Y}$

(xii) In Compton scattering, the change in wavelength is maximum if:

- A. $\theta = 90^\circ$
- B. $\theta = 180^\circ$
- C. $\theta = 0^\circ$
- D. $\theta = 45^\circ$

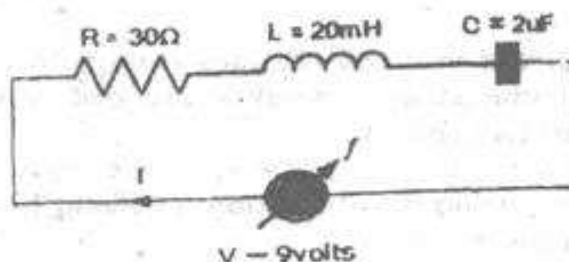
(xiii) Joule/Ampere is the unit of:

- A. Magnetic Induction
- B. Magnetic Flux density
- C. Magnetic Flux
- D. Potential Gradient

(xiv) The Lenz's law refers to:

- A. Induced Current
- B. Induced Potential
- C. Motional emf
- D. All of these

(xv) Calculate the Resonance frequency with the help of the given RLC Series circuit:



- A. 900 Hertz
- B. 796 Hertz
- C. 245 Hertz
- D. None of these

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

441

Physics 12^a

(xvi) The rest mass of photon is:

- A. Infinity
C. 1

- B. Zero
D. $9.1 \times 10^{-31} \text{ kg}$

(xvii) The Absorption Power of a perfect black body is always:

- A. Zero B. -1 C. 1 D. 100

Physics HSSC-II

Time allowed: 2:35 Hours

Total Marks = 68

Note: Sections 'B' and 'C' are to be answered on the separately provided answer book.
Answer eleven the questions from section 'B' and attempt any two questions from section 'C'.
Use supplementary answer sheet i.e. sheet B if required. Write your answers neatly and legibly.

SECTION - B (Marks 42)

Q.2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines.
(14 × 3 = 42)

- (i) What is the role of material medium if it is placed in between plates of Capacitor?
- (ii) Why the Terminal potential difference of a battery decreases when the current drawn from it is increased? Explain.
- (v) What is meant by Para, diamagnetic and ferromagnetic substances? Give examples for each.
- (vi) A wire has resistance 100Ω with its length 10 meter. If the wire is stretched as its length is increased 3 times, what will be its new resistance?
- (vii) A beam of red light and a beam of blue light have exactly the same energy. Which beam contains the greater number of photons?
- (viii) How can the spectrum of hydrogen contain so many lines when hydrogen contains only one electron?
- (ix) An electron is placed in a box about the size of an atom that is about $1 \times 10^{-10} \text{ m}$. What is the velocity of the electron?
- (x) An electron is to be confined to a box of the nucleus ($1.0 \times 10^{-14} \text{ m}$). What would the speed of the electron be if it were so confined?
- (xi) Explain why laser action could not occur without population inversion between atomic levels?
- (xii) The radioactive element $^{222}\text{Ra}_{88}$ has a half life of 1.6×10^3 years. Since the earth is about 5 billion years old, how can you explain why we still can find this element in nature?
- (xiii) How much energy is absorbed by a man of mass 80 kg who receives a lethal whole body equivalent dose of 400 rem in the form of low energy neutrons for which RBE factor is 10?
- (xiv) Define:
 - i. Young's modulus
 - ii. Bulk modulus
 - iii. Shear modulus
- (xv) A suspended magnet is oscillating freely in a horizontal plane. The oscillations are strongly damped when a metal plate is placed under the magnet. Explain why this occurs?

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

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442

Physics 12th

- (xvi) Why does the picture on a TV screen become distorted when a magnet is brought near the screen?
- (xvii) What is Drift velocity? What are the factors on which drift velocity depends?
- (xviii) What do you understand by the term "back emf effect in motors"?
- (xix) Show that " ε " and $\frac{\Delta\phi}{\Delta t}$ have the same units.

SECTION - C (Marks 26)

Note:-Attempt any TWO questions.

(2×13 = 26)

- Q. 3 a. Describe Millikan's oil drop experiment to determine charge on an electron? 06
- b. Discuss Coulomb's law for the interaction of charges in free space and in the presence of any dielectric in between Coulomb's charges. 04
- c. A capacitor has a capacitance of 2.5×10^{-8} F. In the charging process, electrons are removed from one plate and placed on the other one. When the potential difference between the plates is 450V, how many electrons have been transferred? 03
- Q. 4 a. What is A.C? Describe its principle, construction and theory (working)? Derive an expression for induced emf and current produced in a coil of the A.C generator. 06
- b. An alternating current generator operating at 50 Hz has a coil of 200 turns. The coil has an area of 120 cm^2 . What should be the magnetic field in which the coil rotates in order to produce an emf of maximum value of 240 volt? 04
- c. Derive an expression for the motional emf developed in a conductor, when moved across a magnetic field? 03
- Q. 5 a. What is Wheatstone bridge? Explain and prove the principle of Wheat stone bridge? How can it be used to find the unknown resistance of a wire? 06
- b. A platinum wire has resistance of 10Ω at 0°C and 20Ω at 273°C . Find the value of temperature coefficient of resistance of platinum? 04
- c. State and explain Kirchhoff's Voltage rule. 03

SOLUTION OF FBISE PAPER # (2015)

SECTION- A (MCQs)

i. D	ii. C	iii. D	iv. A	v. C	vi. A
vii. B	viii. A	ix. B	x. A	xi. D	xii. A
xiii. D	xiv. A	xv. D	xvi. B	xvii. D	

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

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443

Physics 12th

SECTION - B (Marks 42)

Q.2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines. (14 × 3 = 42)

(i) What is the role of material medium if it is placed in between plates of Capacitor?

Ans: The increase in the capacity of a capacitor due to presence of dielectric is due to electric polarization of dielectric. An insulating material which has the effect of increasing the capacitance of a vacuum-filled parallel plate capacitor, when it is inserted between its plates, is called a *dielectric* material. When a voltage is applied across a dielectric object, it becomes polarized. Since atoms are made of a positively charged nucleus and negatively charged electrons, polarization is an effect which slightly shifts electrons towards the positive voltage. Once the voltage source is removed from the material, it either returns to its original non-polarized state, or stays polarized if the molecular bonds in the material are weak.

(ii) Why the Terminal potential difference of a battery decreases when the current drawn from it is increased? Explain.

Ans: The terminal potential difference V_t of the battery of emf is E described by the formula: $V_t = E - Ir$

Where r is the internal resistance of the battery and I is the current flowing through outer circuit.

It is clear from equation that when I is large, the factor Ir becomes large and V_t becomes small. Hence terminal potential difference of a battery decreases when current drawn from it is increased.

(iii) Briefly describe the term "Resistance Tolerance".

Ans: Resistance Tolerance:

The tolerance of a resistor is the deviation that a resistor may vary from its nominal value resistance, measured at 25°C with no load applied.

In other words, the resistor tolerance is the amount by which the resistance of a resistor may vary from its stated value. The larger the resistor tolerance, the more it may vary, either up or down, from its nominal value. The smaller the resistor tolerance, the less it varies from its nominal value and, thus, the more stable it is.

For example:

A 1000 Ω resistor with a tolerance of $\pm 10\%$ will have an actual resistance anywhere between 900 Ω and 1100 Ω .

(iv) Why is electrical power lost in transformers? Discuss briefly.

Ans: Causes of power loss in transformer:

Only in an ideal transformer the output power is nearly equal to the input power. But in an actual transformer, this is not the case. The output is always less than input due to power losses. There are two main causes of power loss,

i. eddy currents

ii. magnetic hysteresis.

Eddy currents:

a. In order to enhance the magnetic flux, the primary and secondary coils of the transformer are wound on soft iron core.

b. The flux generated by the coils also passes through the core. As magnetic flux changes through a solid conductor, induced currents are set up in closed

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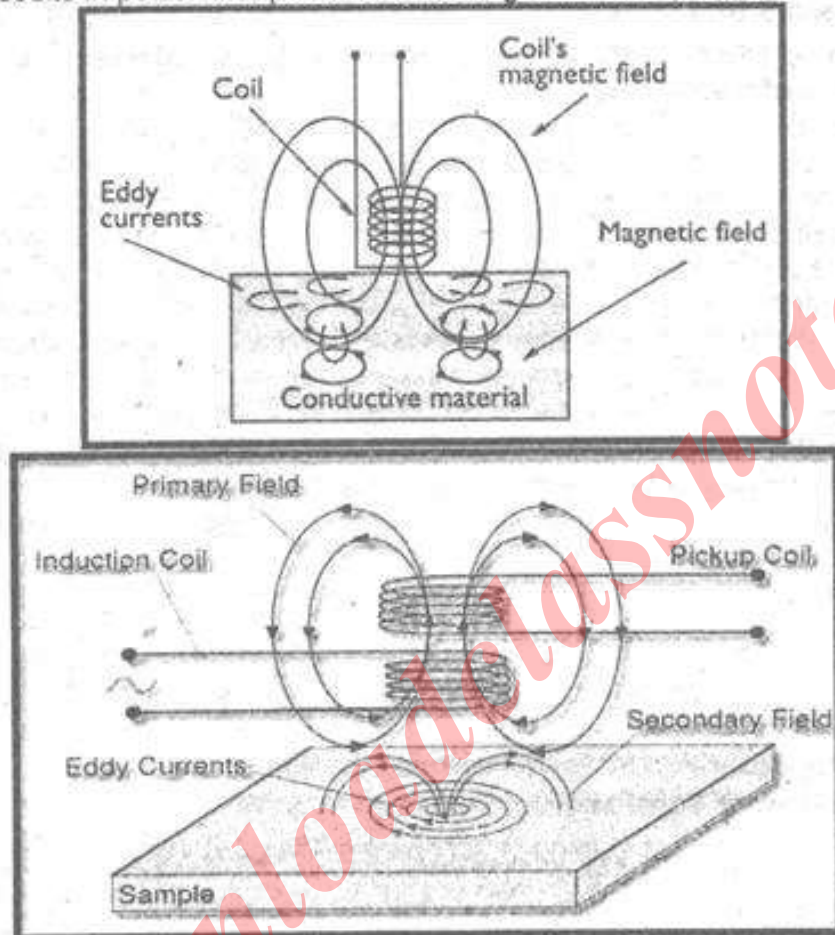
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444

Physics 12th

paths in the body of the conductor. These induced currents are set up in a direction perpendicular to the flux and are known as eddy currents.

- c. It results in power dissipation and heating of the core material.



Magnetic hysteresis:

Hysteresis loss is the energy expended to magnetize and demagnetize the core material in each cycle of the A.C.

Due to these power losses, a transformer is far from being an ideal. Its output power is always less than its input power.

(v) **What is meant by Para, diamagnetic and ferromagnetic substances? Give examples for each.**

Ans: Paramagnetic substances:

The orbits and the spin axes of the electrons in an atom are so oriented that their fields support each other and the atom behaves like a tiny magnet. Substances with such atoms are called paramagnetic substances.

Diamagnetic substances:

In second type of atoms there is no resultant field as the magnetic fields produced by both orbital and spin motions of the electrons might add upto zero. These are called diamagnetic substances, for example the atoms of water, copper, bismuth and antimony.

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445

Physics 12th

Ferromagnetic substances:

There are some solid substances e.g., Fe, Co, Ni, Chromium dioxide, and Alnico (an iron aluminium-nickel-cobalt alloy) in which the atoms co-operate with each other in such a way so as to exhibit a strong magnetic effect. They are called ferromagnetic substances.

(vi) A wire has resistance 100 Ω with its length 10 meter. If the wire is stretched as its length is increased 3 times, what will be its new resistance?

Ans: Let cross-section of the wire is $A = \pi r^2$, length of the wire is ℓ therefore volume of the wire is $A \cdot \ell$.

Now if the length of the wire is stretched to n times of its original length i.e. now length of the wire becomes $\ell' = n\ell$. Now if r' is the new radius of the cross-section of the wire then new cross-sectional area $A' = \pi r'^2$.

If the volume of the wire is same before and after stretching,

$$A \times \ell = A' \times \ell' \Rightarrow \pi r^2 n \ell = \pi r'^2 \ell \Rightarrow \pi r'^2 = \frac{\pi r^2}{n} \Rightarrow A' = \frac{A}{n}$$

Thus resistance of the wire after stretched is $\frac{\rho \ell'}{A'} = \frac{\rho n \ell}{A/n} = \frac{n^2 \rho \ell}{A} = n^2 R$.

New resistance of the wire after stretched = $n^2 R = (3)^2 \times 100 = 9 \times 100 = 900 \Omega$

(vii) A beam of red light and a beam of blue light have exactly the same energy. Which beam contains the greater number of photons?

Ans: Energy for single photon = $E = hf$
 Energy for 'n' photons = $E = n hf$ (1)

Since $c = f\lambda \Rightarrow f = \frac{c}{\lambda}$ put in Eq. 1

$$E = n h \times \frac{c}{\lambda}$$

$$n = \frac{E\lambda}{hc} \Rightarrow n \propto \lambda$$

Therefore longer wavelengths will have greater number of photons. The wave length of red colour is greater than blue colour. Therefore red beam contains greater number of photons.

$$\lambda_{\text{red}} > \lambda_{\text{blue}}$$

(viii) How can the spectrum of hydrogen contain so many lines when hydrogen contains only one electron?

Ans: Hydrogen atom contains one electron. It will emit one spectral line, if it jumps direct from higher energy state to the ground state.

The electron does not necessarily return to the ground state in the single jump, but may return by several jumps. That is why hydrogen spectrum contains many lines.

Though a hydrogen atom has only one electron, it contains a large number of shells, so when this single electron jumps from one shell to another, a photon is emitted, and the energy difference of the shells causes different wavelengths to be released...hence, mono-electronic hydrogen has many spectral lines.

(ix) An electron is placed in a box about the size of an atom that is about 1.0×10^{-10} m. What is the velocity of the electron?

Solution:

$$\text{Size of atom} = \Delta x = 1 \times 10^{-10} \text{ m}$$

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Maryam Key Series

446

Physics 12th

$$m = 9.1 \times 10^{-31} \text{ kg}$$

$$\Delta v = ?$$

According to Heisenberg uncertainty principle,

$$\Delta p \cdot \Delta x \approx h$$

$$\Delta p \approx \frac{h}{\Delta x} \Rightarrow m \Delta v \approx \frac{h}{\Delta x}$$

$$\Delta v = \frac{h}{m \Delta x}$$

$$\Delta v = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 1 \times 10^{-10}} = 0.729 \times 10^7 = 7.29 \times 10^6 \text{ ms}^{-1}$$

- (x) An electron is to be confined to a box of the nucleus ($1.0 \times 10^{-14} \text{ m}$). What would the speed of the electron be if it were so confined?

Solution:

Maximum uncertainty in the location of electron equals the size of the nucleus of the box itself that is $\Delta x = 1.0 \times 10^{-14} \text{ m}$. The minimum uncertainty in the velocity of electron is found from Heisenberg uncertainty principle

$$\Delta p \approx \frac{h}{\Delta x}$$

$$m \Delta v \approx \frac{h}{\Delta x}$$

$$\Delta v = \frac{h}{m \Delta x} = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 1.0 \times 10^{-14}} = 7.29 \times 10^6 \text{ ms}^{-1}$$

- (xi) Explain why laser action could not occur without population inversion between atomic levels?

Ans: Once the population inversion has been reached, the lasing action of a laser is simple to achieve. The atoms in the metastable state E_2 are bombarded by photons of energy $hf = E_2 - E_1$, resulting in an induced emission, giving an intense, coherent beam in the direction of the incident photon. Such a beam is called laser.

So population inversion between atomic levels is necessary for laser production or action because without it, all the input photons would have been consumed in raising the electrons from their ground states to the metastable states and there would have been no photons to cause induced emission which is the base of laser action.

- (xii) The radioactive element ${}^{226}_{88}\text{Ra}$ has a half life of 1.6×10^3 years. Since the earth is about 5 billion years old, how can you explain why we still can find this element in nature?

Ans: Half life:

It is the period in which half of the radioactive element atoms decay. An element completely decayed after an infinite time.

Thus with the passage of every half life the number of atoms remaining behind becomes half of the number of atoms already present. In this way an infinite time is required for all atoms to decay. As the earth five billion years old (not infinite time) so we can still find ${}^{226}_{88}\text{Ra}$ element in nature.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

448

Physics 12th

magnetic field due to magnet the beam must be deflected which causes distortion in the picture.

(xvii) What is Drift velocity? What are the factors on which drift velocity depends?

Ans: Drift velocity:

The average directed velocity along the conductor in the presence of applied electric field is called drift velocity and is given by

$$v_d = \frac{eE\tau}{m}$$

Where τ is relaxation time, E is electric field strength and m is mass of the electron.

The drift velocity is of the order of 10^{-3} ms^{-1} , whereas the velocity of free electrons at room temperature due to their thermal motion is several hundred kilometers per second.

Factors which effect Drift velocity:

(a) The drift velocity of free electrons increases with increases of potential difference because by increasing potential difference electric field increases.

$$v_d \propto V \quad \text{or} \quad v_d \propto E$$

(b) Decreasing resistance and temperature of the wire it increases electric current (rate of flow of charges) which demands increase in drift velocity because

$$v_d \propto \frac{1}{R} \quad \text{and} \quad v_d \propto \frac{1}{L}$$

(xviii) What do you understand by the term "back emf effect in motors"?

Ans: Back emf effect in motors:

i. A motor is just like a generator running in reverse. When the coil of the motor rotates across the magnetic field by the applied potential difference V , an emf $\mathcal{E}$ is induced in it. The induced emf is in such a direction that opposes the emf running the motor. **Due to this reason the induced emf is called back emf of the motor.** The magnitude of the back emf increases with the speed of motor.

ii. Since V and $\mathcal{E}$ are opposite in polarity, the net emf in the circuit is $V - \mathcal{E}$. If R is the resistance of the coil and I is the current drawn by the motor, then by Ohm's law

$$I = \frac{V - \mathcal{E}}{R} \quad \text{or} \quad V = \mathcal{E} + IR \quad (1)$$

iii. **Back emf and starting of motor:**

When the motor is just started, back emf is almost zero and hence a large current passes through the coil. As the motor speeds up, the back emf increases and the current becomes smaller and smaller.

However, the current is sufficient to provide torque on the coil to drive the load and to overcome losses due to friction.

v. **Burn out of motor:**

If the motor is overloaded, it slows down. Consequently, the back emf decreases and allows the motor to draw more current. If the motor is

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(xix) Show that ϵ and $\frac{\Delta\phi}{\Delta\epsilon}$ have the same units.

$$\text{Unit of } \epsilon = \frac{\text{joule}}{\text{Coulomb}} = \text{Volt}$$

Now, $\frac{\Delta \phi}{\Delta r} = \frac{E \Delta A}{\Delta r} = \frac{NA^{-1}m^{-1} \times Jm^2}{s} = \frac{Nm}{s \times A} = \frac{\text{joule}}{\text{Coulomb}} = \text{Volt}$

Hence ϵ and $\frac{\Delta\phi}{\Delta\epsilon}$ have the same units.

Note: Attempt any TWO questions.

(2×13 = 26)

Ans: Charge on an electron by Millikan's method:

Construction and working:

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(Page 113 of 136)

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

- vi. The space between the plates is illuminated by the light coming from the source S through the lens L and window W₁. The path of motion of these drops can be carefully observed by a microscope M.
- vii. A given droplet between the two plates could be suspended in air if the gravitational force $F_g = mg$ acting on the drop is equal to the electrical force $F_e = qE$, as shown in Fig.
- viii. The F_e can be adjusted equal to F_g by adjusting the voltage. In this case, we can write,



Oil drop balanced by the gravitational force and the Coulomb's law.

$$F_e = F_g \quad \text{or}$$

$$qE = mg \quad \dots\dots (1)$$

- ix. **Determination of the charge on electron:**

If V is the value of p.d. between the plates for this setting, then

$$E = \frac{V}{d}$$

We may write from Eq. 1

$$q \frac{V}{d} = mg$$

$$q = \frac{mgd}{V} \quad \dots\dots (2)$$

- x. **Determination the mass 'm' of the droplet:**

In order to determine the mass m of the droplet, the electric field between the plates is switched off. The droplet falls under the action of gravity through air. It attains terminal speed v_t almost at the instant the electric field is switched off.

Its terminal speed v_t is determined by timing the fall of the droplet over a measured distance. Since the drag force F due to air acting upon the droplet when it is falling with constant terminal speed is equal to its weight. Hence, using Stokes's law

$$F = 6\pi\eta r v_t = mg$$

Where r is the radius of the droplet and η is the coefficient of viscosity for air. If ρ is the density of the droplet, then

$$m = \frac{4}{3} \pi r^3 \rho \quad \dots\dots (3)$$

$$\frac{4}{3} \pi r^3 \rho g = 6\pi\eta r v_t$$

$$r^2 = \frac{9\eta v_t}{2\rho g}$$

Note:

- i. Knowing the value of r , the mass m can be calculated by using Eq. 3. This value of m is substituted in Eq. 2 to get the value of charge q on the droplet.
- ii. Millikan measured the charge on many drops and found that each charge was an integral multiple of a minimum value of charge equal to 1.6×10^{-19} C. He, therefore, concluded that this minimum value of the charge is the charge on an electron.

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451

Physics 12th

- b. Discuss Coulomb's law for the interaction of charges in free space and in the presence of any dielectric in between Coulomb's charges.

Ans: Coulomb's law:

The force between two point charges is directly proportional to the product of the magnitudes of charges and inversely proportional to the square of the distance between them.

Mathematical form of Coulomb's law:

Coulomb's law mathematically expressed as:

$$F \propto \frac{q_1 q_2}{r^2} \quad \text{or} \quad F = k \frac{q_1 q_2}{r^2}$$

If the medium between the two point charges is free space and the system of units is SI, then k is represented as

$$k = \frac{1}{4\pi\epsilon_0}$$

Where ϵ_0 is an electrical constant, known as permittivity of free space.

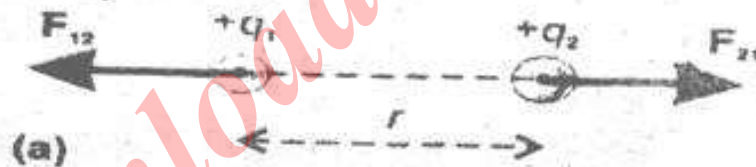
In SI units, its value is $8.85 \times 10^{-12} \text{ Nm}^2\text{C}^{-2}$. Substituting the value of ϵ_0 the constant

$$k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm C}^{-2}$$

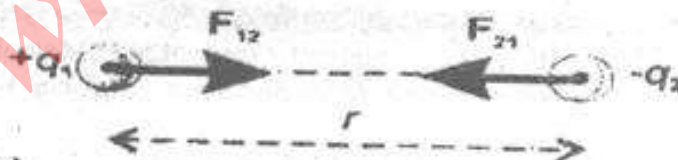
- i. **Coulomb's force in free space:**

Thus Coulomb's force in free space is

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \dots \dots \dots (1)$$



(a)



(b)

(a) Repulsive forces between like charges
 (b) Attractive forces between unlike charges

- ii. **Vectorial form of coulomb's law:**

If $\hat{r}_{21}$ is the unit vector directed from q_1 to q_2 and $\hat{r}_{12}$ is the unit vector directed from q_2 to q_1 , then

$$F_{21} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{21} \dots \dots \dots (2)$$

and

$$F_{12} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{r}_{12} \dots \dots \dots (3)$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

452

Physics 12th

It can be seen that $f_{21} = -f_{12}$, so Eqs. Show that

$$F_{21} = -F_{12}$$

Effect of medium between the two charges upon the Coulomb's force:

If the medium is an insulator, it is usually referred as dielectric. It has been found that the presence of a dielectric always reduces the electrostatic force as compared with that in free space by a certain factor which is a constant for the given dielectric. This constant is known as relative permittivity and is represented by ϵ_r .

iii. The Coulomb's force in a medium of relative permittivity ϵ_r is given by

$$F = \frac{1}{4\pi\epsilon_0\epsilon_r} \frac{q_1q_2}{r^2}$$



- c. A capacitor has a capacitance of 2.5×10^{-8} F. In the charging process, electrons are removed from one plate and placed on the other one. When the potential difference between the plates is 450V, how many electrons have been transferred?

$$(e = 1.60 \times 10^{-19} \text{ C})$$

Solution:

$$C = 2.5 \times 10^{-8} \text{ F} \quad \Rightarrow \quad V = 450 \text{ volts} \quad \Rightarrow \quad e = 1.6 \times 10^{-19} \text{ C}$$

$$n = ?$$

Since

$$Q = CV$$

Also

$$Q = ne$$

By comparing above two formulae,

$$ne = CV$$

$$\Rightarrow$$

$$n = \frac{CV}{e}$$

$$n = \frac{2.5 \times 10^{-8} \times 450}{1.6 \times 10^{-19}} = 7.0 \times 10^{13} \text{ electrons}$$

- Q. 4 a. What is alternating current generator? Describe its principle, construction and working? Also derive a relation for induced emf and current?

Ans: Alternating current generator (A.C. generator):

"A current generator is a device that converts mechanical energy into electrical energy."

Principle of A.C. generator:

The principle of an electric generator is based on Faraday's law of electromagnetic induction.

Working of A.C. generator:

When a coil is rotated in a magnetic field by some mechanical means, magnetic flux through the coil changes, and consequently an emf is induced in the coil.

If the generator is connected to an external circuit, an electric current is the output of the generator.

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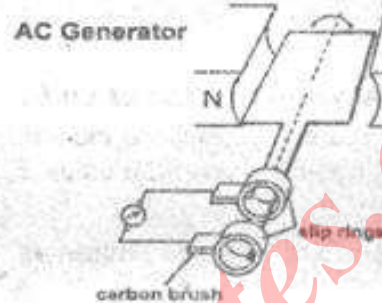
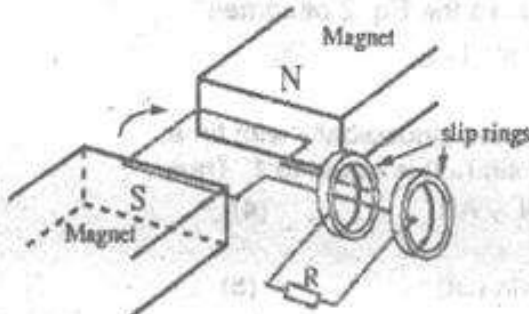
453

Physics 12th

Construction of A.C. generator:

Rectangular loop of wire:

Let a rectangular loop of wire of area A be placed in a uniform magnetic field B . The loop is rotated about z -axis through its centre at constant angular velocity ω .



Slip rings:

One end of the loop is attached to a metal ring R and the other end to the ring R' . These rings, called the slip rings are concentric with the axis of the loop and rotate with it.

Carbon brushes:

Rings R R' slide against stationary carbon brushes to which external circuit is connected.

Calculation of induced emf in the loop:

- i. To calculate the induced emf in the loop, consider its position while it is rotating anticlockwise. The figure shows the top view of the coil.
- ii. The vertical side ab of the loop is moving with velocity v in the magnetic field B . If the angle between v and B be θ , the motional emf induced in the side ab has the magnitude, $\mathcal{E}_{ab} = vBL \sin\theta$
 The direction of induced current in the wire ab is the same as that of force F experienced by the charges in the wire, i.e., from top to the bottom.
- iii. The same amount of emf is induced in the side cd but the direction of current is from bottom to the top. Therefore $\mathcal{E}_{cd} = vBL \sin\theta$
- iv. The net contribution to emf by sides bc and da is zero because the force acting on the charges inside bc and da is not along the wire. Thus $\mathcal{E}_{bc} = \mathcal{E}_{da} = 0$
- v. Since both the emfs in the sides ab and cd drive current in the same direction around the loop, the total emf in the loop is $\mathcal{E} = \mathcal{E}_{ab} + \mathcal{E}_{cd}$
 $\mathcal{E} = vBL \sin\theta + vBL \sin\theta = 2vBL \sin\theta$
- vi. If the loop is replaced by a coil of N turns, the total emf in the coil will be, $\mathcal{E} = 2NvBL \sin\theta$ (1)
- vii. The linear speed v of the vertical wire is related to the angular speed ω by the relation $v = \omega r$
 where r is the distance of the vertical wires from the centre of the coil. Substituting ωr for v in Eq. (1), We get

$$\mathcal{E} = 2N(\omega r)BL \sin\theta$$

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

454

Physics 12th

$$\begin{aligned}\mathcal{E} &= N\omega (2rL) B \sin\theta \\ \mathcal{E} &= N\omega AB \sin\theta \dots\dots\dots (2)\end{aligned}$$

where $A = 2rL =$ area of the coil

As the angular displacement $\theta = \omega t$, so the Eq. 2 becomes

$$\mathcal{E} = N\omega AB \sin(\omega t) \dots\dots\dots (3)$$

viii. Maximum value of emf ($\mathcal{E}_0$):

Eq. 3 shows that the induced emf varies sinusoidally with time.

It has the maximum value $\mathcal{E}_0$ when $\sin(\omega t)$ is equal to 1. Thus

$$\mathcal{E}_0 = N \omega AB \dots\dots\dots (4)$$

The Eq. 3 can be written as,

$$\mathcal{E} = \mathcal{E}_0 \sin(\omega t) \dots\dots\dots (5)$$

ix. Induced current:

If R is the resistance of the coil, then by Ohm's law, induced current in the coil will be

$$I = \frac{\mathcal{E}}{R} = \frac{\mathcal{E}_0 \sin(\omega t)}{R} = \frac{\mathcal{E}_0}{R} \sin(\omega t)$$

or

$$I = I_0 \sin(\omega t) \dots\dots\dots (6)$$

where I_0 is maximum current.

x. Relation of induced emf and induced current with frequency:

Angular speed ω of the coil is related to its frequency of rotation f as, $\omega = 2\pi f$

The Eqs. 5 and 6 can be written as

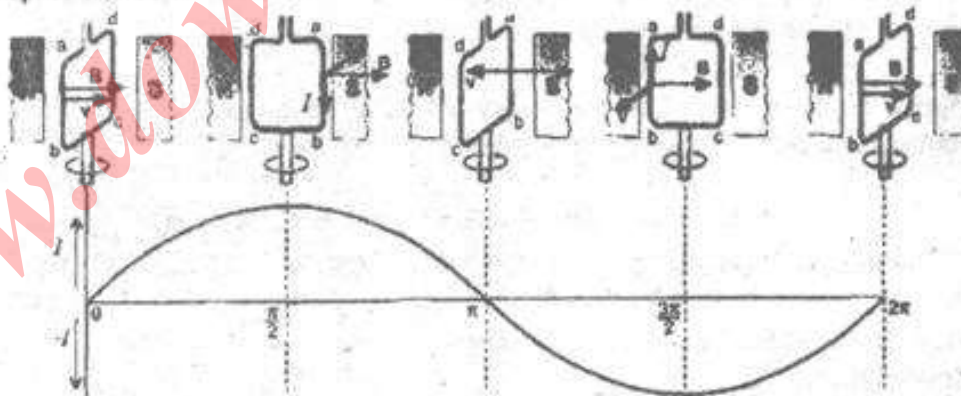
$$\mathcal{E} = \mathcal{E}_0 \sin(2\pi f t) \dots\dots\dots (7)$$

$$I = I_0 \sin(2\pi f t) \dots\dots\dots (8)$$

Eq. 8 indicates the variation of current as a function of $\theta = 2\pi f t$.

Graphical representation for the current and different positions of coil during one loop:

Fig. shows the graph for the current corresponding to different positions of one loop of the coil.



Case 1:

When the angle between $\mathbf{v}$ & $\mathbf{B}$ is $\theta = 0^\circ$, the plane of the loop is perpendicular to $\mathbf{B}$, current is zero.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

455

Physics 12th

Case 2:

As θ increases, current also increases and at $\theta = 90^\circ = \pi/2$ rad, the loop is parallel to B, current is maximum, directed along abcd.

Case 3:

On further increase in θ current decreases, and at $\theta = 180^\circ = \pi$ rad the current becomes zero as the loop is again perpendicular to B.

Case 4:

For $180^\circ < \theta < 270^\circ$ current increases but reverses its direction as is clear from the figure. Current is now directed along dcba. At $\theta = 270^\circ = 3\pi/2$ rad, current is maximum in the reverse direction as the loop is parallel to B.

Case 5:

At $\theta = 360^\circ = 2\pi$ rad, one rotation is completed, the loop is perpendicular to B and the current decreases to zero. After one rotation the cycle repeats itself.

Note:

The current alternates in direction once in one cycle. Therefore, such a current is called the alternating current. It reverses its direction f times per second.

- b. **An alternating current generator operating at 50 Hz has a coil of 200 turns. The coil has an area of 120 cm^2 . What should be the magnetic field in which the coil rotates in order to produce an emf of maximum value of 240 volt?**

Solution: Frequency of rotation $= f = 50 \text{ Hz}$
 No. of turns of the coil $= N = 200$
 Area of the coil $= A = 120 \text{ cm}^2 = 1.2 \times 10^{-2} \text{ m}^2$

Max. value of emf $= \epsilon_{\text{max}} = \epsilon_0 = 240 \text{ V}$

Magnetic flux density $= B = ?$

First of all we will find the angular speed ω :

$$\omega = 2\pi f$$

$$\omega = 2 \times 3.14 \times 50 = 314.3 \text{ rads}^{-1}$$

Maximum value of emf is given by the relation

$$\epsilon_0 = N \omega AB \Rightarrow B = \frac{\epsilon_0}{N \omega A} \Rightarrow B = \frac{240}{200 \times 314.3 \times 1.2 \times 10^{-2}} = 0.32 \text{ T}$$

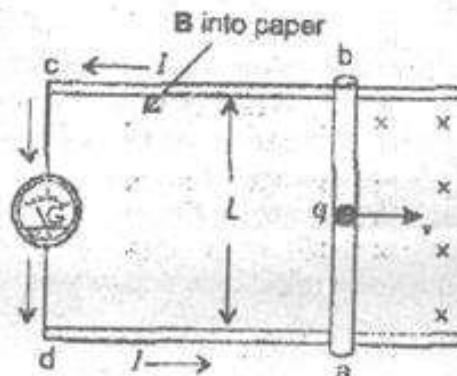
- c. **Derive an expression for the motional emf developed in a conductor, when moved across a magnetic field?**

Ans: Motional emf:

The emf induced by the motion of a conductor across a magnetic field is called motional emf.

Derivation of motional emf:

- Consider a conducting rod of length L placed on two parallel metal rails separated by a distance L .
- A galvanometer is connected between the ends c and d of the rails. This forms a complete



PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

456

Physics 12th

- conducting loop abcd.
- iii. A uniform magnetic field B is applied directed into the page.
- iv. Initially when the rod is stationary, galvanometer indicates no current in the loop. If the rod is pulled to the right with constant velocity v , the galvanometer indicates a current flowing through the loop. Obviously, the current is induced due to the motion of the conducting rod across the magnetic field. The moving rod is acting as a source of emf

$$\mathcal{E} = V_b - V_a = \Delta V.$$
- v. When the rod moves, a charge q within the rod also moves with the same velocity v in the magnetic field B and experiences a force given by

$$F = qv \times B$$

$$F = q v B \sin \theta$$
 The magnitude of the force is
 Since angle θ between v and B is 90° , so $F = q v B$
- vi. Applying the right hand rule, we see that F is directed from a to b in the rod. As a result the charge migrates to the top end of the conductor. As more and more of the charges migrate, concentration of the charge is produced at the top b and deficiency of charges at the bottom a . This redistribution of charge sets up an electrostatic field E directed from b to a .
- vii. The electrostatic force on the charge is $F_e = qE$ directed from b to a . The system quickly reaches an equilibrium state in which these two forces on the charge are balanced. If E_0 is the electric intensity in this state then

$$qE_0 = qvB$$

$$E_0 = vB \quad \dots\dots\dots (1)$$
- viii. The motional emf $\mathcal{E}$ will be equal to the potential difference $\Delta V = V_b - V_a$ between the two ends of the moving conductor in this equilibrium state. The gradient of potential will be given by $\Delta V/L$. As the electric intensity is given by the negative of the gradient therefore,

$$E_0 = - \frac{\Delta V}{L} \quad \dots\dots\dots (2)$$
 or $\Delta V = -LE_0 = -(LvB)$
- ix. **The motional emf:**

$$\mathcal{E} = \Delta V = -LvB \quad \dots\dots\dots (3)$$
 This is the magnitude of motional emf.
- x. If the angle between v and B is θ , then

$$\mathcal{E} = -vBL \sin \theta \quad \dots\dots\dots (4)$$
 Due to induced emf positive charges would flow along the path abcd, therefore the induced current is anticlockwise in the diagram.

Q.5 a. What is Wheatstone bridge? Explain and prove the principle of Wheatstone bridge? How can it be used to find the unknown resistance of a wire?

Ans: Wheatstone bridge:

Wheatstone Bridge is an electric circuit that is used to measure the value of an unknown resistance accurately.

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Maryam Key Series

457

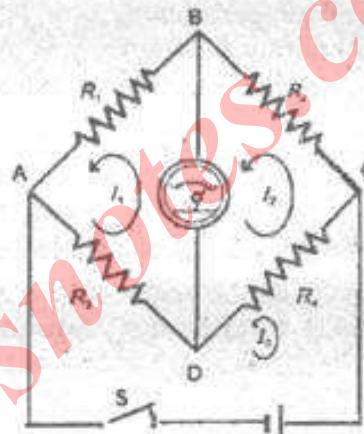
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Working principle of Wheatstone bridge:

A Wheatstone bridge is widely used to measure the electrical resistance. This circuit is built with two known resistors, one unknown resistor and one variable resistor connected in the form of bridge. When the variable resistor is adjusted, then the current in the galvanometer becomes zero, the ratio of two unknown resistors is equal to the ratio of value of unknown resistance and adjusted value of variable resistance. By using a Wheatstone Bridge the unknown electrical resistance value can easily measure.

Construction of Wheatstone bridge:

The Wheatstone bridge circuit shown in Fig. consists of four resistances R_1 , R_2 , R_3 and R_4 connected in such a way so as to form a mesh ABCDA. A battery is connected between points A and C. A sensitive galvanometer of resistance R_g is connected between points B and D.



Working of Wheatstone bridge:

If the switch S is closed, a current will flow through the galvanometer. We are to determine the condition under which no current flows through the galvanometer even after the switch is closed. For this purpose we analyse this circuit using Kirchhoff's second rule. We consider the loops ABDA, BCDB and ADCA and assume anticlockwise loop currents I_1 , I_2 and I_3 through the loops respectively.

Application of Kirchhoff's second rule:

The Kirchhoff's second rule as applied to loop ABDA gives

$$-I_1 R_1 - (I_1 - I_2) R_g - (I_1 - I_3) R_3 = 0 \quad \text{..... (1)}$$

Similarly by applying the Kirchhoff's second rule to loop BCDB we have

$$-I_2 R_2 - (I_2 - I_3) R_4 - (I_2 - I_1) R_g = 0 \quad \text{..... (2)}$$

The current flowing through the galvanometer will be zero if,

$$I_1 - I_2 = 0 \quad \text{or} \quad I_1 = I_2.$$

With this condition Eq. 1 and Eq. 2 reduce to

$$-I_1 R_1 = (I_1 - I_3) R_3 \quad \text{..... (3)}$$

$$-I_1 R_2 = (I_2 - I_3) R_4 \quad \text{..... (4)}$$

Dividing Eq. 3 by Eq. 4 we get,

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad \text{..... (5)}$$

Note:

- i. Whenever the condition of Eq. 5 is satisfied, no current flows through the galvanometer and it shows no deflection, or conversely when the galvanometer in the Wheatstone bridge circuit shows no deflection, Eq. 5 is satisfied.
- ii. If we connect three resistances R_1 , R_2 and R_3 of known adjustable values and a fourth resistance R_4 of unknown value and the resistances R_1 , R_2 and R_3 are so adjusted that the galvanometer shows no deflection then, from the known resistances R_1 , R_2 and R_3 the unknown resistance R_4 can be determined by using Eq. 5.

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

458

Physics 12^a

- b. A platinum wire has resistance of $10\ \Omega$ at 0°C and $20\ \Omega$ at 273°C .
 Find the value of temperature coefficient of resistance of platinum?

Solution:

Resistance of wire at 0°C = $R_0 = 10\ \Omega$

Resistance of wire at 273°C = $R = 20\ \Omega$

Initial temperature = $t_1 = 0 + 273 = 273\ \text{K}$

Final temperature = $t_2 = 273 + 273 = 546\ \text{K}$

Temperature difference = $t = t_2 - t_1 = 546\ \text{K} - 273\ \text{K} = 273\ \text{K}$

Temperature coefficient of resistance = $\alpha = ?$

Temperature coefficient of resistance = $\alpha = \frac{R_t - R_0}{R_0 t}$

$$\alpha = \frac{20 - 10}{10 \times 273} = \frac{1}{273} = 3.66 \times 10^{-3}\ \text{K}^{-1}$$

- c. State and explain Kirchhoff's Voltage rule.

Ans: Kirchhoff's Voltage rule:

It states that the algebraic sum of voltage changes in a closed circuit or a loop must be equal to zero.

Explanation:

- i. Consider a closed circuit shown in Fig. The direction of the current I flowing through the circuit depends on the cell having the greater emf.

- ii. Suppose E_1 is greater than E_2 , so the current flows in counter clockwise direction. We know that a steady current is equivalent to a continuous flow of positive charges through the circuit.

- iii. When a positive charge ΔQ due to the current I in the closed circuit, passes through the cell E_2 , from low (-ve) to high potential (+ve), it gains energy because work is done on it. The energy gain is $E_2 \Delta Q$.

- iv. When the current passes through the cell E_1 it loses energy equal to $-E_1 \Delta Q$ because here the charge passes from high to low potential.

- v. In going through the resistor R_1 , the charge ΔQ loses energy equal to $-IR_1 \Delta Q$ where IR_1 is potential difference across R_1 . The minus sign shows that the charge is passing from high to low potential.

- vi. Similarly the loss of energy while passing through the resistor R_2 is $-IR_2 \Delta Q$.

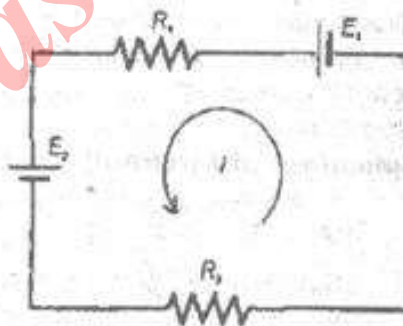
- vii. Finally the charge reaches the negative terminal of the cell E_1 , from where we started.

- viii. According to the law of conservation of energy the total change in energy of our system is zero. Therefore, we can write which is Kirchhoff's second rule and it states that

$$E_2 \Delta Q - IR_1 \Delta Q - E_1 \Delta Q - IR_2 \Delta Q = 0$$

$$E_2 - IR_1 - E_1 - IR_2 = 0 \quad \dots\dots\dots (1)$$

"The algebraic sum of potential changes in a closed circuit is zero."



PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Maryam Key Series

459

Physics 12*

FBISE PAPER # (2016)

PHYSICS HSSC-II (2016)

SECTION-A (Marks 17)

Time: 25 Minutes

Marks: 17

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 25 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

- Q.1 Circle the correct option i.e. A/B/C/D. Each part carries one mark.**
- (i) A radioactive decay rate of 3.7×10^{10} disintegrations per second defines the unit of measurement known as the:
A. Curie B. Rutherford C. Rontgen D. Rad
- (ii) Two charges of $10 \mu\text{C}$ and $14.4 \mu\text{C}$ are 12 cm apart. The force between them:
A. 0.01N B. 90N C. 9×10^5 D. 9×10^7
- (iii) The minimum indivisible unit of charge is:
A. One micro coulomb B. One coulomb
C. The charge on α -particle D. The charge on an electron
- (iv) The proportionality constant between current and potential difference is:
A. $\frac{1}{\rho}$ B. ρ C. $\frac{1}{R}$ D. R
- (v) Which of the following properties affect the resistivity of all metals to a great extent?
A. Applied magnetic field B. Pressure
C. Volume D. Temperature
- (vi) The magnetic force on an electron travelling 10^8 ms^{-1} perpendicular to a field of strength 1 Wbm^{-2} is :
A. $1.6 \times 10^{-11} \text{ N}$ B. Zero
C. 10^5 N D. 10^{11} N
- (vii) If current in two nearby loops is in same order. They:
A. Attract and repel B. Attract
C. Repel D. Neither attracts nor repel
- (viii) The direction of induced current is always so as to oppose the change which causes the current. This is the statement of:
A. Ampere's law B. Faraday's law
C. Lenz's law D. Gauss's law
- (ix) Devices that consume electrical energy in the external circuit of generator are known as:
A. Appliances B. Loads C. Machines D. Motors
- (x) Which of the following is NOT an advantage of using A.C?
A. Maximum line losses
B. Minimum line losses
C. Low cost long distance Transmission

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

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| Maryam Key Series | 460 | Physics 12th |
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- D. Stopping up or down to required voltage
- (xi) **Impedance of series circuit at resonance is:**
 A. Inductive and Capacitive
 B. Inductive
 C. Capacitive
 D. Resistive
- (xii) **The smallest 3-dimensional structure of crystalline solid which repeats over and over again is:**
 A. Unit cell
 B. Polymer
 C. Amorphous
 D. Crystal
- (xiii) **A crystalline structure yttrium copper oxide ($\text{YBa}_2\text{Ca}_3\text{O}_7$) becomes upper conductor at::**
 A. 173 K
 B. 100k
 C. 163K
 D. 200K
- (xiv) **Photo diode is NOT used in?**
 A. Photo voltaic cell
 B. Automatic Switching
 C. Detection of light
 D. Logic circuits
- (xv) **The gain of inverting amplifier of external resistances, $R_1=50k\Omega$ and $R_2=200 k\Omega$:**
 A. -6
 B. -1
 C. -2
 D. -4
- (xvi) **The Stefan-Boltzman law which relates of radiation for a black body to its surface temperature "T" has the form:**
 A. $E=\sigma T^{-2}$
 B. $E=\sigma T^4$
 C. $E=\sigma T^{-4}$
 D. $E=\sigma T^2$
- (xvii) **Molecular spectra are examples of:**
 A. Solar spectra
 B. Continuous spectra
 C. Band spectra
 D. Line spectra

Physics HSSC-II

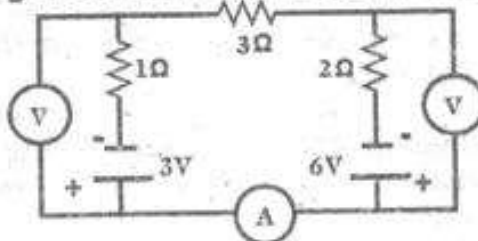
Time allowed: 2:35 Hours

Total Marks = 68

Note: Sections 'B' and 'C' are to be answered on the separately provided answer book. Answer eleven the questions from section 'B' and attempt any two questions from section 'C' Use supplementary answer sheet i.e., sheet B if required. Write your answers neatly and legibly.

SECTION - B (Marks 42)

- Q. 2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines. (14 × 3 = 42)**
- (i) How can you identify that which plate of capacitor is positively charged?
- (ii) How do Shark fish locate their prey precisely?
- (iii) Why does the resistance of a conductor rise with temperature?
- (iv) Find the reading of the ammeter in the circuit diagram:



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461

Physics 12th

- (v) If solenoid is 1 m long and 10 cm in diameter and wound with 10 turns per cm of wire which carries a current of 100A. Calculate the magnetic flux density within it.
- (vi) How can you use a magnetic field to separate isotopes of chemical elements?
- (vii) What do you understand by electromagnetic induction?
- (viii) Can a D.C motor be turned into a D.C generator? What changes are required to be done?
- (ix) What is meant by A.M and F.M?
- (x) What is meant by strain energy? How can it be determined from the force-extension graph?
- (xi) How would you obtain n-type and p-type material from pure silicon? Illustrate it by schematic diagram.
- (xii) What is meant by open loop gain of op-amplifier?
- (xiii) Why a photo diode is operated in reverse biased state?
- (xiv) Find the velocity at which the relativistic length 'L' of a body reduces to half of its rest length 'L₀'.
- (xv) Photon A has twice the energy of photon B. What is the ratio of the momentum of A to that of B?
- (xvi) How can the spectrum of hydrogen contain so many lines when hydrogen contains one electron?
- (xvii) Prove that the shortest wavelength photon emitted in Balmer series is 364.6nm.
- (xviii) What is a mass spectrograph?
- (xix) What is the phenomenon of fluorescence?

SECTION - C (Marks 26)

Note:- Attempt any TWO questions.

(2×13 = 26)

- Q. 3 a. Define electric field intensity and its unit. Calculate the electric field intensity at a point in the electric field.
(1+1+3=05)

- b. Find the electric field strength required to hold suspended a particle of mass 1.0×10^{-6} kg and charge $1\mu C$ between two plates 10 cm apart. (04)

- c. Describe the construction and working of photocopier machine. (2+2=04)

- Q. 4 a. State and explain Ampere's law. Apply it to calculate the magnetic field due to current flowing through a solenoid. (1+1+4=06)

- b. What current should pass through a solenoid that is 0.5 m long with 10,000 turns of copper wire so that it will have a magnetic field of 0.4T? (04)

- c. What is an AVO meter? Describe its any two functions. (1+2=03)

- Q. 5 a. What are X-rays? Describe the production of X-rays.

(1+4=05)

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- b. Electrons in an X-ray tube are accelerated through a potential difference of 3000 V. If these electrons are slowed down in a target, what will be the minimum wavelength of X-rays produced? (04)
- c. What are continuous X-rays spectrum? Describe the properties and uses of X-rays. (2+1+1=04)

SOLUTION OF FBISE PAPER # (2016)

SECTION- A (MCQs)

i. A	ii. B	iii. D	iv. C	v. D	vi. A
vii. B	viii. C	ix. B	x. A	xi. D	xii. A
xiii. C	xiv. A	xv. D	xvi. B	xvii. C	

SECTION - B (Marks 42)

Q. 2 Attempt any FOURTEEN parts. The answer to each part should not exceed 3 to 4 lines. (14 × 3 = 42)

- (i) How can you identify that which plate of capacitor is positively charged?

Ans: Case 1.

Bring a positively charged object close to the plate if it is repelled the plate is positive otherwise not.

Case 2.

Bring the plate close to a positively charged electroscope if the leaves further diverge due to electrostatic induction it has positive charge otherwise not.

- (ii) How do Shark fish locate their prey precisely?

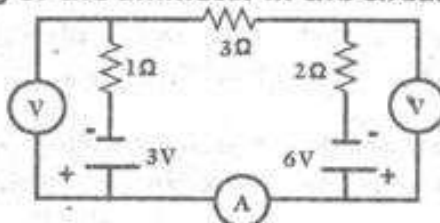
Ans: Fish and the other sea creatures produce electric field in a variety of ways. Shark have special organs called the ampullae of Lorenzini that are very sensitive to electric field and can detect potential difference of the order of nanovolt and can locate their prey very precisely.

- (iii) Why does the resistance of a conductor rise with temperature?

Ans: Effect of Temperature upon Resistance:

When the temperature of the conductor rises, average speed of the random motion of the free electrons increases which enhances the rate of collision of electrons and the atoms. This causes an increase in the resistance of the conductor. The increase in resistance is directly proportional to the increase of temperature. i.e. $T \propto R$.

- (iv) Find the reading of the ammeter in the circuit diagram:



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Ans: $V=IR$; $I=\frac{V}{R}$; $\Delta V = 6 - 3 = 3$;

$R_e = 3+2+1=6$; $I=\frac{3}{6} = 0.5$ Ampere

- (v) If solenoid is 1 m long and 10 cm in diameter and wound with 10 turns per cm of wire which carries a current of 100A. Calculate the magnetic flux density within it.

Ans: Length = 1 m

Turns per cm=10 ; (1 cm=10 ; 100cm=1000 ; 1m= 1000)

Now $n = \frac{N}{L} = \frac{1000}{1} = 1000$

$B = \mu_0 n I = 4\pi \times 10^{-2} \times 1000 \times 100 = 12.56 \times 10^{-2} = 0.1256$ Tesla

- (vi) How can you use a magnetic field to separate isotopes of chemical elements?

Ans: $r = \frac{mv}{qB} \Rightarrow r \propto m$

If isotopes in the ions form are projected into the field, they will be deflected due to the magnetic field in circular paths whose radii will depend on their masses (radii being directly proportional to the masses). Hence, they will be separated easily

- (vii) What do you understand by electromagnetic induction?

Ans: The emf produced in the conductor is called induced emf, and the current generated is called the induced current. This phenomenon is known as electromagnetic induction.

An emf is set up in a conductor when it moves across a magnetic field. If the moving conductor was connected to a sensitive galvanometer, it would show an electric current flowing through the circuit as long as the conductor is kept moving in the magnetic field.

- (viii) Can a D.C motor be turned into a D.C generator? What changes are required to be done?

Ans: Yes D.C. motor can be turned into D.C. generator. The following changes are required to do:

- The magnetic field should be provided by permanent magnet.
- There should be an arrangement to rotate the coil (armature).

- (ix) What is meant by A.M and F.M?

Ans: **Amplitude modulation (A.M):**

In this type of modulation the amplitude of the carrier wave is increased or diminished as the amplitude of the superposing modulating signal increases and decreases.

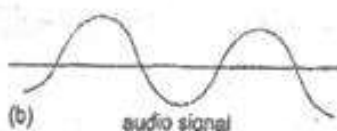


Fig. (a) Represents a high frequency carrier wave of constant amplitude and frequency. Fig. (b) represents a low or audio frequency signal of a sine waveform. Fig. (c) shows the result obtained by modulating the carrier waves with the modulating wave.

Transmission frequencies range of A.M:

The A.M. transmission frequencies range from 540 kHz to 1600 kHz.

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464

Physics 12th

Frequency modulation (F.M):

In this type of modulation the frequency of the carrier wave is increased or diminished as the modulating signal, amplitude increases or decreases but the carrier wave amplitude remains constant.

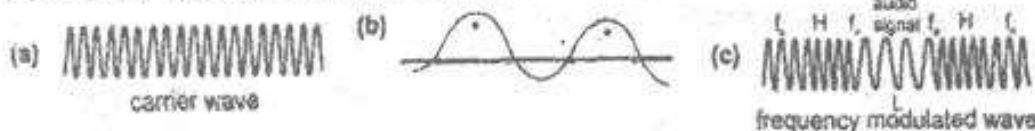


Fig. shows frequency modulation. The frequency of the modulated carrier wave is highest (point H) when the signal amplitude is at its maximum positive value and is at its lowest frequency (point L) when signal amplitude has maximum negative. When the signal amplitude is zero, the carrier frequency is at its normal frequency f_0 .

Transmission frequencies range of F.M:

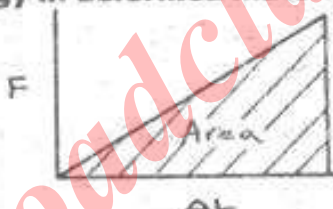
The F.M. transmission frequencies range from 88 MHz to 108 MHz.

(x) **What is meant by strain energy? How can it be determined from the force-extension graph?**

Ans: Strain energy:

Strain energy is the gain in potential energy of the molecules due to their displacement from mean position.

Explanation of strain energy in deformed materials:



Consider a wire suspended vertically from one end. It is stretched by attaching a weight at the other end.

Force exerted on the wire = F

Extension occurs = $\Delta L = l$

Now the amount of work done on the wire is

$W = \text{average force} \times \text{displacement}$

As the force is not constant so $F_{av} = \frac{0+F}{2} = \frac{1}{2}F$

Now $W = \frac{1}{2}F \times l$ (i) Eq (i) in terms of modulus.

$$E = \frac{F}{A} \times \frac{X}{l}$$

Where A = area of cross section ;

X = total length

$$F = \frac{EAl}{X} \text{(ii)}$$

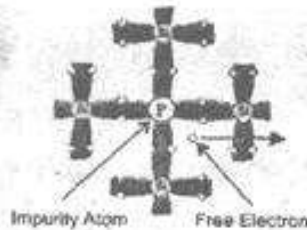
Putting (ii) in (i) $W = \frac{EAl}{2X}$

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(xi) How would you obtain n-type and p-type material from pure silicon? Illustrate it by schematic diagram.

Ans: N-type:

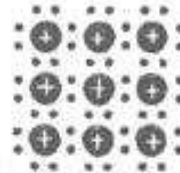
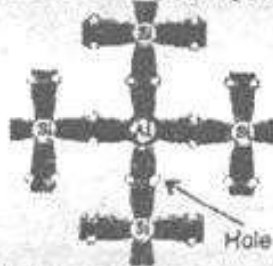
N-type semi-conductor is formed by adding pentavalent impurity may be N, P etc of group five having 5 electrons in the valence shell. By doing this type of doping we have excess of free electrons through out the semiconductor it will start to conduct electric current.



P-type:

It is formed by adding tri-valent impurity. May be Al, Ga, etc having 3 electrons in the valence shell.

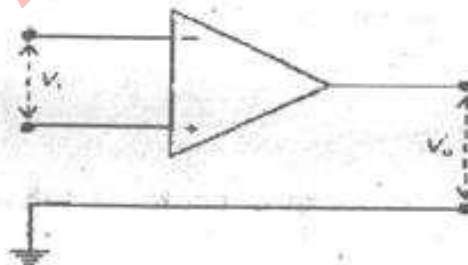
By doing this type of doping we have excess of holes through out the semiconductor which act as a charge carriers.



(xii) What is meant by open loop gain of op-amplifier?

Ans: Open loop gain:

It is the ratio of output voltage V_o to the voltage difference between non-inverting and inverting inputs when there is no external connection between the output and the inputs i.e.,



$$A_{OL} = \frac{V_o}{V_+ - V_-} = \frac{V_o}{V_i} \quad (1)$$

Note: The open loop gain of the amplifier is very high. It is of the order of 10^5 .

(xiii) Why a photo diode is operated in reverse biased state?

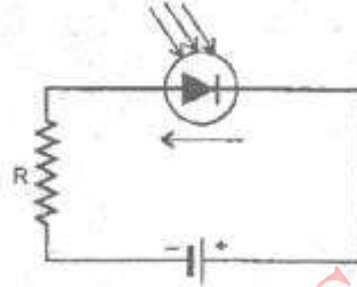
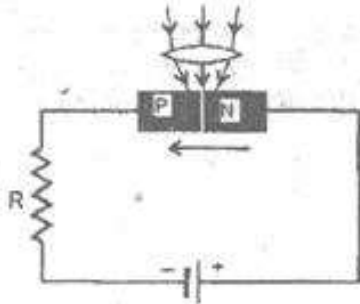
Ans: Photo diode:

A photo diode is a semi-conductor diode made from silicon. It converts light energy directly into electrical energy.

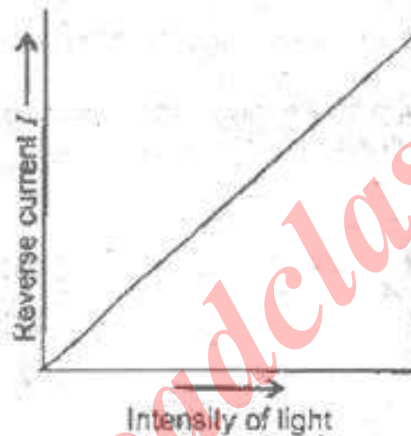
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Working of photo diode:

Photo diode is used for the detection of light. It is operated in the reverse biased condition. A photo diode symbol is shown in Fig.



When no light is incident on the junction, the reverse current I is almost negligible but when its p-n junction is exposed to light, the reverse current increases with the intensity of light that is why it is operated in reverse biased state.



A photo diode can turn its current ON and OFF in nano-seconds. Hence it is one of the fastest photo detection devices.

(xiv) Find the velocity at which the relativistic length ' L ' of a body reduces to half of its rest length ' L_0 '.

Ans: $L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$; Given $L' = \frac{L_0}{2}$

$$L_0 \sqrt{1 - \frac{v^2}{c^2}} = \frac{L_0}{2} ; \sqrt{1 - \frac{v^2}{c^2}} = \frac{1}{2} ; 1 - \frac{v^2}{c^2} = \frac{1}{4}$$

$$\frac{v^2}{c^2} = 1 - \frac{1}{4} ; v^2 = \frac{3}{4} c^2 ; v = \frac{\sqrt{3}}{2} c$$

(xv) Photon A has twice the energy of photon B. What is the ratio of the momentum of A to that of B?

Ans: Since energy of photon $= E = \frac{hc}{\lambda}$ or $E = pc$

Let energy of photon A $= E_1$, Let energy of photon B $= E_2$

Let momentum of photon A $= P_1$, Let momentum of photon B $= P_2$

Therefore $E_1 = P_1 c$ (1) and $E_2 = P_2 c$ (2)

Given that $E_1 = 2 E_2$

Put in Eq. 1 $2E_2 = P_1 c$ (3) ; Dividing Eq. 3 by Eq. 2

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467

Physics 12th

$$\frac{2E_2}{E_2} = \frac{P_1c}{P_2c} ; \frac{P_1}{P_2} = 2$$

Hence momentum of photon A is 2 times the momentum of photon B.

(xvi) How can the spectrum of hydrogen contain so many lines when hydrogen contains one electron?

Ans: Hydrogen atom contains one electron. It will emit one spectral line, if it jumps direct from higher energy state to the ground state.

The electron does not necessarily return to the ground state in the single jump, but may return by several jumps. That is why hydrogen spectrum contains many lines.

(xvii) Prove that the shortest wavelength photon emitted in Balmer series is 364.6nm.

Ans: Solution:

For Balmer series $P = 2$; $n = \infty$ (infinity only for shortest wavelength)

$$R_H = 1.0974 \times 10^7 \text{ m}^{-1} \quad \lambda_{\min} = ?$$

The general formula to find wavelength in hydrogen spectrum: $\frac{1}{\lambda} = R_H \left(\frac{1}{p^2} - \frac{1}{n^2} \right)$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{(2)^2} - \frac{1}{(\infty)^2} \right) = 1.097 \times 10^7 \times \frac{1}{4} \quad (\because \frac{1}{\infty} = 0)$$

$$\lambda = \frac{4}{1.097 \times 10^7} = 364.5 \times 10^{-9} = 364.5 \text{ nm} ; \quad \text{The value of } n: \quad n = \infty$$

(xviii) What is a mass spectrograph?

Ans: Spectrograph:

A device with the help of which not only the isotopes of any element can be separated from one another but their masses can also be determined quite accurately is called mass spectrograph.

(xix) What is the phenomenon of fluorescence?

Ans: Fluorescence:

"Fluorescence is the property of absorbing radiant energy of high frequency and re-emitting energy of low frequency in the visible region of electromagnetic spectrum".

Charged particles α or β and γ -radiation produce fluorescence or glow on striking some substance like zinc sulphide, sodium iodide or barium platinocyanide coated screens.

SECTION - C (Marks 26)

Note: Attempt any TWO questions.

(2×13 = 26)

Q. 3 a. Define electric field intensity and its unit. Calculate the electric field intensity at a point in the electric field. (1+1+3=05)

Ans: Electric field intensity:

Electric field intensity at a point is the force experienced by a unit positive charge at that point.

$$E = \frac{F}{q_0} \quad \dots\dots\dots (1)$$

SI unit: SI unit of Electric field intensity is $\frac{N}{C}$.

Electric intensity due to a point charge:

Let we place a positive test charge q_0 at this point. The Coulomb's force that this charge will experience due to q is

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Maryam Key Series

468

Physics 12th

$$F = \frac{1}{4\pi\epsilon_0} \frac{qq_0}{r^2} \hat{r} \dots\dots\dots (2)$$

Where $\hat{r}$ is a unit vector directed from the point charge q to the test point where q_0 has been placed, i.e., the point where the electric intensity is to be evaluated. By Eq. 1

$$E = \frac{F}{q_0} = \frac{1}{4\pi\epsilon_0} \frac{qq_0}{r^2} \hat{r} \times \frac{1}{q_0} = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \hat{r} \dots\dots (3)$$

- b. Find the electric field strength required to hold suspended a particle of mass 1.0×10^{-6} kg and charge $1\mu\text{C}$ between two plates 10 cm apart. (04)

Solution:

$m = 1.0 \times 10^{-6}$ kg ; $q = 1.0 \times 10^{-6}$ kg ; $d = 10 \text{ cm} = 0.1 \text{ m}$

The magnitude of electric force is given by $F = qE$

And $W = mg$

In order to suspend the particle the magnitude of electric force must be equal but opposite to the weight of the particle.

$$qE = \frac{mg}{q} \dots\dots (1) \quad ; \text{ Using values in equation (1)}$$

$$E = \frac{1.0 \times 10^{-6} \times 9.8}{1.0 \times 10^{-6}} = 9.8 \text{ NC}^{-1} = 9.8 \text{ V m}^{-1}$$

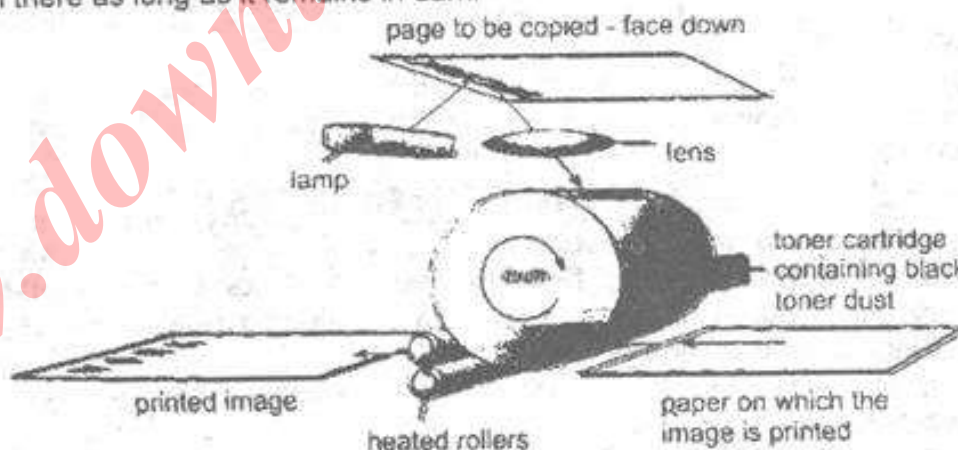
- c. Describe the construction and working of photocopier machine.

Ans: Xerography (photocopier):

The copying process is called xerography, from the Greek word "xeros" and "graphos", meaning "dry writing".

Construction:

The heart of machine is a drum which is an aluminium cylinder coated with a layer of selenium. Aluminium is an excellent conductor. On the other hand, selenium is an insulator in the dark and becomes a conductor when exposed to light; it is a photoconductor. As a result, if a positive charge is sprinkled over the selenium it will remain there as long as it remains in dark.



The basics of photocopying. The lamp transfers an image of the page to the drum, which leaves a static charge. The drum collects toner dust and transfers it to the paper. The toner is melted onto the page.

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Working:

If the drum is exposed to light, the electrons from aluminium pass through the conducting selenium and neutralize the positive charge.

Function of drum:

If the drum is exposed to an image of the document to be copied, the dark and light areas of the document produce corresponding areas on the drum. The dark areas retain their positive charge, but light areas become conducting, lose their positive charge and become neutral.

In this way, a positive charge image of the document remains on the selenium surface. Then a special dry, black powder called "toner" is given a negative charge and spread over the drum, where it sticks to the positive charged areas.

The toner from the drum is transferred on to a sheet of paper on which the document is to be copied.

Function of toner:

Heated pressure rollers then melt the toner into the paper which is also given an excess positive charge to produce the permanent impression of the document.

Q. 4 a. State and explain Ampere's law. Apply it to calculate the magnetic field due to current flowing through a solenoid. (06)

Ans: Ampere's law and determination of flux density (B):

According to ampere's law total flux density or magnetic field, over a closed path due to current is equal to μ_0 times the total current enclosed by the closed path.

Mathematical form of ampere's law: $\sum_{r=1}^N (B \cdot \Delta L)_r = \mu_0 I$

Solenoid:

A solenoid is a long, tightly wound, cylindrical coil of wire. When current passes through such a coil, it behaves like a bar magnet.

The field inside a long solenoid is uniform and much strong whereas outside the solenoid, it is so weak that it can be neglected as compared to the field inside.

Field due to a current carrying solenoid:

The value of magnetic field **B** can be easily determined by applying Ampere's circuital law. Consider a rectangular loop abcd as shown in Fig.

Divide it into four elements of length

$ab = \ell_1$, $bc = \ell_2$, $cd = \ell_3$, and $da = \ell_4$.

Applying Ampere's law, we have

$$\sum_{r=1}^4 (B \cdot \Delta L)_r = \mu_0 \times \text{current enclosed}$$

$$(B \cdot \Delta L)_1 + (B \cdot \Delta L)_2 + (B \cdot \Delta L)_3 + (B \cdot \Delta L)_4 = \mu_0 \times \text{current enclosed}$$

Calculation of the value of $B \cdot \Delta L$:

Now we will calculate the value of $B \cdot \Delta L$ for each of the elements.

Calculation of the value of $(B \cdot \Delta L)_1$:

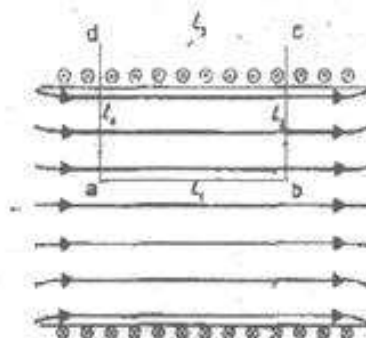
First we will consider the element $ab = \ell_1$, that lies inside the solenoid.

Field inside the solenoid is uniform and is parallel to:

$$(B \cdot \Delta L)_1 = \ell_1 B \cos 0^\circ = \ell_1 B$$

Calculation of the value of $(B \cdot \Delta L)_3$:

For the element $cd = \ell_3$, that lies outside the solenoid, the field **B** is zero, so



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470

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$$(B \cdot \Delta L)_3 = 0$$

Calculation of the value of $(B \cdot \Delta L)_2$ and $(B \cdot \Delta L)_4$:

Again B is perpendicular to ℓ_2 and ℓ_4 inside the solenoid and is zero outside, so

$$(B \cdot \Delta L)_2 = (B \cdot \Delta L)_4 = 0$$

Calculation of the value of $\sum_{r=1}^4 (B \cdot \Delta L)_r$:

$$\sum_{r=1}^4 (B \cdot \Delta L)_r = B \ell_1 \times \text{current enclosed}$$

Calculation of the value of flux density along a loop:

To find the current enclosed, consider the rectangular surface bounded by the loop abcd.

If n is the number of turns per unit length of the solenoid, the rectangular surface will intercept $n\ell_1$ turns, each carrying a current I. So the current enclosed by the loop is $n\ell_1 I$. Thus Ampere's law gives

$$B \ell_1 = \mu_0 \times n \ell_1 I$$

$$B = \mu_0 n I \quad \dots \dots \dots (1)$$

Direction of field B along the axis of solenoid:

The field B is along the axis of the solenoid and its direction is given by right hand grip rule which states "hold the solenoid in the right hand with fingers curling in the direction of the current, the thumb will point in the direction of the field".

b. What current should pass through a solenoid that is 0.5 m long with 10,000 turns of copper wire so that it will have a magnetic field of 0.4T? (04)

Solution: $L = 0.50 \text{ m}$; $N = 10,000 \text{ turns}$

$$n = \frac{N}{L} = \frac{10000}{0.5} = 20000 \text{ turns/meter}$$

Permeability of free space = $\mu_0 = 4\pi \times 10^{-7} \text{ Wb A}^{-1} \text{m}^{-1}$

$$B = 0.4 \text{ T} \quad \quad \quad I = ?$$

$$\text{Since, } B = \mu_0 n I ; \quad I = \frac{B}{\mu_0 n} ; \quad I = \frac{0.4}{4\pi \times 10^{-7} \times 20000} = 15.9150 \text{ A} \approx 16 \text{ A}$$

c. What is an AVO meter? Describe its any two functions. (1+2 = 03)

Ans: AVO meter (Multimeter):

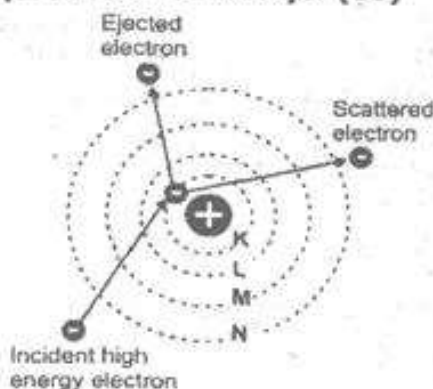
It is an instrument which can measure current in amperes, potential difference in volts and resistance in ohms.

- Functions:**
- (i) It is use to measure current.
 - (ii) It is use to measure potential difference.
 - (iii) It is use to measure resistance.

Q. 5 a. What are X-rays? Describe the production of X-rays. (05)

Ans: The inner shell electrons are tightly bound and large amount of energy is required for their displacement from their normal energy levels. After excitation, when an atom returns to its normal state, photons of larger energy are emitted.

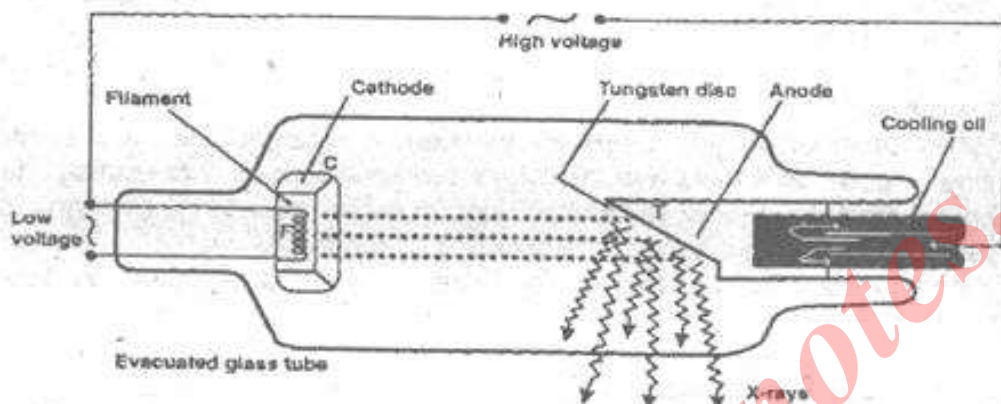
The transition of inner shell electrons in heavy atoms gives rise to the emission of high energy photons or X-rays. These X-rays consist of series of specific wavelengths or frequencies and hence are called characteristic X-rays.



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X-rays production:

- i. **X-ray tube:** It consists of a high vacuum tube called X-ray tube.
- ii. **Function of filament:**
 When the cathode is heated by the filament F, it emits electrons which are accelerated towards the anode T.



ii. **Kinetic energy of electron:**

If V is the potential difference between C and T the kinetic energy K.E. with which the electron strike the target is given by $K.E. = Ve$ (1)

Production of K_{α} X-ray:

Suppose that one of the electrons in the K shell is removed, thereby producing a vacancy or hole in that shell. The electron from the L shell jumps to occupy the hole in the K shell, thereby emitting a photon of energy $hf_{k\alpha}$ called the K_{α} X-ray given by

$$hf_{k\alpha} = E_L - E_K \text{ (2)}$$

Production of K_{β} X-ray:

It is also possible that the electron from the M shell might also jump to occupy the hole in the K shell. The photons emitted are K_{β} X-ray with energies

$$hf_{k\beta} = E_M - E_K \text{ (3)}$$

These photons give rise to K_{β} X-ray and so on.

Characteristic X-rays:

The photons emitted in such transitions i.e., inner shell transitions are called characteristic X-rays, because their energies depend upon the type of target material.

Creation of holes:

The holes created in the L and M shells are occupied by transitions of electrons from higher states creating more X-rays. The characteristic X-rays appear as discrete lines on a continuous spectrum.

- b. **Electrons in an X-ray tube are accelerated through a potential difference of 3000 V. If these electrons are slowed down in a target, what will be the minimum wavelength of X-rays produced?** (04)

Solution: $V = 3000$ volts ; $\lambda_{\min} = ?$

The energy of a photon is given by $E = \frac{hc}{\lambda}$ (1)

The electric potential energy is given by $U = eV$ (2)

PHYSICS FOR 2ND YEAR / HSSC-II (GUESS PAPERS OF 10 YEARS)

Mariam Key Series

By equating above two energies we get, $eV = \frac{hc}{\lambda_{\min}}$; $\lambda_{\min} = \frac{hc}{eV}$

$$\lambda_{\min} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19} \times 3000} = \frac{19.89 \times 10^{-26} \times 10^{16}}{4.8} = 4.14 \times 10^{-10} \text{ m}$$

c. **What are continuous X-rays spectrum? Describe the properties and uses of X-rays.** (2+1+1=04)

Ans: Continuous X-rays spectrum:

The continuous spectrum is due to an effect known as **bremsstrahlung** or **braking radiation**.

i. When the fast moving electrons bombard the target, they are suddenly slowed down on impact with the target. We know that an accelerating charge emits electromagnetic radiation. Hence, these impacting electrons emit radiation as they are strongly decelerated by the target.

ii. Since the rate of deceleration is so large, the emitted radiation corresponds to short wavelength and so the bremsstrahlung is in the X-ray region. In the case when the electrons lose all their kinetic energy in the first collision, the entire kinetic energy appears as a X-ray photon of energy $hf_{\max}$ i.e.,

$$\text{K.E.} = hf_{\max}$$

iii. The wavelength $\lambda_{\min}$ in Fig. corresponds to frequency $f_{\max}$. Other electrons do not lose all their energy in the first collision. They may suffer a number of collisions before coming to rest. This will give rise to photons of smaller energy or X-rays of longer wavelength. Thus the continuous spectrum is obtained due to deceleration of impacting electrons.

Properties and uses of X-rays:

X-rays have many practical applications in medicine and industry.

X-rays can penetrate several centimeters into a solid matter, so they can be used to visualize the interiors of the materials opaque to ordinary light, such as fractured bones or defects in structural steel.

The object to be visualized is placed between an X-ray source and a large sheet of photographic film; the darkening of the film is proportional to the radiation exposure.

A crack or air bubble allows greater amount of X-rays to pass. This appears as a dark area on the photographic film. Shadow of bones appears lighter than the surrounding flesh. It is due to the fact that bones contain greater proportions of elements with high atomic number and so they absorb greater amount of incident X-rays than flesh. In flesh, light elements like carbon, hydrogen and oxygen predominate. These elements allow greater amount of incident X-rays to pass through them.

