H

Reg.No.:

COMMON FIRST REVISION TEST - 2023

Std - XII (THOOTHUKUDI DISTRICT)

PHYSICS

Time : 3.00 Hours | Marks: 70

Part - I

15 x 1 = 15

Answer all the questions:

1. When the dielectric is inserted between plates of the parallel plate capacitor, then the capacitance of capacitor will
   a) decrease b) increase c) remain same d) zero
2. A toaster operating at 240V has a resistance of 120 ohm. Its power is
   a) 400W b) 2W c) 480W d) 240W
3. The ratio of magnetic length and geometrical length is
   a) 0.833 (5/6) b) 0.633 c) 0.933 d) 0.733
4. A step down transformer reduces the supply voltage from 220V to 11V and increase the current from 6A to 100A. Then it's efficiency is
   a) 1.2 b) 0.83 c) 0.12 d) 0.9
5. Which of the following electromagnetic radiation is used for viewing objects through fog
   a) microwave b) gamma rays c) x rays d) infrared
6. Diamond appears dazzling because of
   a) reflection b) total internal reflection c) refraction d) polarisation
7. A Ray of light travelling in a transparent medium of refractive index n falls on a surface separating the medium from air at an angle of incidents of 30°. The ray can undergo total internal reflection for the following
   a) 2.41 b) 1.33 c) 1.4 d) 1.5
8. For a healthy eye, the distance of the near point is
   a) 30cm b) 20 cm c) 35 cm d) 25 cm
9. The cut off wavelength of X-rays from an x-ray tube of accelerating potential 6200V is = 12400 A / 6200 = 2A
   a) 0.5A b) 2A c) 3A d) 1A
10. The threshold wavelength for a metal surface whose photoelectric work function 3.313 eV is
    a) 4125A b) 3750A c) 6000A d) 2062A
11. Atomic number of H like atom with ionization potential 122.4V for n = 1 is
    a) 1 b) 2 c) 3 d) 4
12. The mass of a Li nucleus is 0.042 u less than the sum of the masses of all its nucleons. The average binding energy per nucleon of Li nucleus is nearly
    a) 46MeV b) 5.6MeV c) 3.9MeV d) 23MeV
13. If the input to the NOT gate is A = 1011. Its output is
    a) 0100 b) 1000 c) 1100 d) 0011
14. The variation of frequency of carrier wave with respect to the amplitude of the modulating signal is called
    a) amplitude modulation b) frequency modulation c) phase modulation
    d) pulse width modulation
15. The particle size of ZnO material is 30nm. Based on the dimension, it is classified as
    a) Bulk material b) Nano material c) Soft material
    d) Magnetic material

Part - II

6 x 2 = 12

Answer any six Questions. Question No. 24 is compulsory.

16. Define "Electric flux".
17. What is Peltier effect?
18. State Fleming's left hand rule.
19. The self inductance of an air core solenoid is 4.8 mH. If its core is replaced by iron core, then it's self inductance becomes 1.8H. Find out the relative permeability of iron.
20. What is displacement current?
21. What is the reason for reddish appearance of sky during sunset and sunrise?
22. Give the applications of photo cell (any four).
23. What do you mean by doping?
24. The radius of the 5th orbit of hydrogen atom is 13.25A. Calculate the de-broglie wavelength of the electron orbiting in the 5th orbit.

Part - III

6 x 3 = 18

Answer any six questions. Question No. 30 is compulsory.

25. Obtain the expression for capacitance of a parallel plate capacitor.
26. State Kirchchoff's current rule and voltage rule.
27. An electron moving perpendicular to a uniform magnetic field 0.500T undergoes circular motion of radius 2.5 mm. What is the speed of electron?
28. AC is advantages than DC. Explain.
29. What is optical path? Obtain the equation for optical path.
30. Calculate the distance upto which ray optics is a good approximation for light of wavelength 500nm falls on an aperture of width 0.5mm.
31. List out the laws of photoelectric effect.
32. Discuss the Alpha decay process with an example.
33. State De Morgan's first and second theorem.

Part - IV

5 x 5 = 25

Answer all the questions.

34. Derive the expression for electric field due to a dipole on its axial line. **(OR)**
    Explain about compound microscope and obtain the equation for the magnification.
35. How the emf of two cells are compared by using potentiometer? **(OR)**
    Derive the mirror equation.
36. Discuss the working of cyclotron in detail. **(OR)**
    Discuss the spectral series of hydrogen atom.
37. Explain the production of induced emf by changing relative orientation of the coil with respect to the magnetic field. **(OR)**
    Draw the circuit diagram of a full wave rectifier and explain its working.
38. Write down Maxwell equations in integral form. **(OR)**
    Describe briefly - Davison - Germer experiment which demonstrated the wave nature of electrons.

A. Muthuganesh., M.Sc., M.Phil., B.Ed
Dep. of Physics,
K.V.S. Matric. Hr. Sec. School.
Thoothukudi - 2.

COMMON QUARTERLY EXAMINATION – 2023

Std – XII

Physics

Time : 3.00 Hours **Marks : 70**

Part – I

Note : i) Answer all the questions. Choose the most appropriate answer from the given four alternatives and write the option code and the corresponding answer.

15 X 1 = 15

1) b) increase
2) c) 480W
3) a) 0.833
4) b) 0.83
5) d) infrared
6) c) refraction
7) a) 2.41
8) d) 25 cm
9) b) 2A
10) b) 3750A
11) c) 3
12) b) 5.6MeV
13) a) 0100
14) b) frequency modulation
15) b) Nano material

Prepared by
A. Muthuganesh., M.Sc., M.Phil., B.Ed., PhD.,
Department of Physics,
K. V. S. Matric. Hr. Sec. School,
Thoothukudi – 628002.

Part – II

6 x 2 = 12

Note : Answer any six Questions. Question No. 24 is Compulsory.

16) Define "Electric flux"

- The number of electric field lines crossing a given area kept normal to the electric field lines is called electric flux (Φ_E).
- Its S.I unit is $\boldsymbol{N\ m^2\ C^{-1}}$. It is a scalar quantity.

17) What is Peltier effect?

- When an electric current is passed through a circuit of a thermocouple, heat is evolved at one junction and absorbed at the other junction. This is known as Peltier effect.
- Peltier effect is reversiable.

18) State Fleming's left hand rule

- Stretch fore finger, the middle finger and the thrumb of the left hand in mutully perpendicular directions. If,
  - fore finger points the direction of magnetic field,
  - the middle finger points the direction of the electric current, then
  - thumb will point the direction of the force experienced by the conductor.

19) The self inductance of an air core solenoid is 4.8 mH. If its core is replaced by iron core, then it's self inductance becomes 1.8 H. Find out the relative permeability of iron.

$L_{air}=4.8\times10^{-3}H=4.8\times10^{-3}$

$L_{iron}=1.8H$

$L_{air}=\mu_0 n_2 Al=4.8\times10^{-3}H$

$\therefore \mu r=L_{iron} / L_{iron} =1.8 / 4.8\times10^{-3}=375$

20) What is displacement current?

The displacement current can be defined as the current which comes into play in the region in which the electric field and the electric flux are changing with time.

That is when ever the change in electric field takes place, displacement current is produced.

21) What is the reason for reddish appearance of sky during sunset and sunrise?

During sunrise and sunset, the light from sun travels a greater distance through the atmosphere.

Hence, the blue light which has shorter wavelength is scattered away and the less-scattered red light of longer wavelength manages to reach our eye.

This is the reason for the reddish appearance of sky during sunrise and sunset.

22) Give the applications of photo cell (any four)

It is used in switches and sensors.

It is used to automatic on or off the street lights during night and day respectively.

It is used for reproduction of sound in motion pictures.

It is used as timers to measure the speeds of athletes during a race.

It is used in exposure meters to measure the intensity of the given light and to calculate the exact time of exposure of light in photography.

23) What do you mean by doping?

The process of adding impurities to the intrinsic semiconductor is called doping. (Normal doping Value is approximately 100ppm(parts per million)).

24) The radius of the 5th orbit of hydrogen atom is 13.25A. Calculate the de-broglie wavelength of the electron orbiting in the 5th orbit.

Solution

$2\pi r = n\lambda$

$2 \times 3.14 \times 13.25\ \text{Å} = 5 \times \lambda$

$\therefore \lambda = 6.64\ \text{Å}$

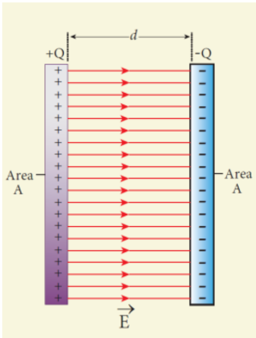
Part – III

Note : Answer any six questions. Question No. 30 is compulsory. 6 x 3 = 18

25) Obtain the expression for capacitance of a parallel plate capacitor.

Capacitance of a parallel plate capacitor

Consider a capacitor with two parallel plates each of cross-sectional area *A* and separated by a distance *d*.The electric field between two infinite parallel plates is uniform and is given by $E = \frac{\sigma}{\varepsilon_0}$. where σ is the surface charge density on either plates $\sigma = \frac{Q}{A}$. If the separation distance *d* is very much smaller than the size of the plate ($d^2 << A$), then the above result can be used even for finite–sized parallel plate capacitor.



The electric field between the plates is

$E = \frac{Q}{\varepsilon_0 A}$. ---------------------------- (1)

Since the electric field is uniform, the electric potential difference between the plates having separation *d* is given by

$V = Ed = \frac{Qd}{A\varepsilon_0}$. ---(2)

Therefore the capacitance of the capacitor is given by

$C = \frac{Q}{V} = \frac{Q}{\left(\frac{Qd}{A\varepsilon_0}\right)} = \frac{\varepsilon_0 A}{d}$ ------------------- (3)

From equation (4), it is evident that capacitance is directly proportional to the area of cross section and is inversely proportional to the distance between the plates. This can be understood from the following.

(i) If the area of cross-section of the capacitor plates is increased, more charges can be distributed for the same potential difference. As a result, the capacitance is increased.

(ii) If the distance *d* between the two plates is reduced, the potential difference between the plates (*V* = *Ed*) decreases with *E* constant. As a result, voltage difference between the terminals of the battery increases which in turn leads to an additional flow of charge to the plates from the battery, till the voltage on the capacitor equals to the battery's terminal voltage. Suppose the distance is increased, the capacitor voltage increases and becomes greater than the battery voltage. Then, the charges flow from capacitor plates to battery till both voltages becomes equal.

26) State Kirchchoff's current rule and voltage rule.

Kirchhoff's first rule (Current rule or Junction rule)

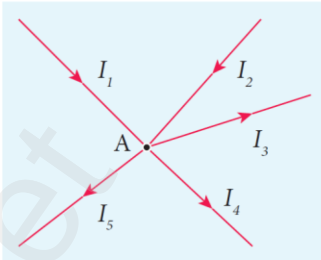
It states that the algebraic sum of the currents at any junction of a circuit is zero. It is a statement of law of conservation of electric charge. The charges that enter a given junction in a circuit must leave that junction since charge cannot build up or disappear at a junction. By convention, current entering the junction is taken as positive and current leaving the junction is taken as negative.

Applying this law to the junction A .

$$I_1 + I_2 - I_3 - I_4 - I_5 = 0$$

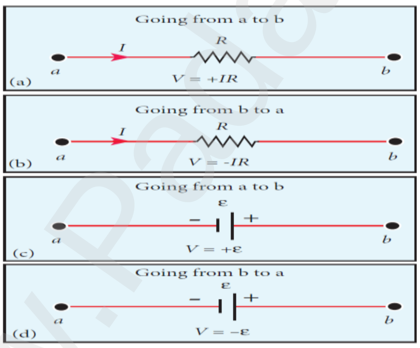
(or)

$$I_1 + I_2 = I_3 + I_4 + I_5$$



Kirchhoff's Second rule (Voltage rule or Loop rule)

It states that in a closed circuit the algebraic sum of the products of the current and resistance of each part of the circuit is equal to the total emf included in the circuit. This rule follows from the law of conservation of energy for an isolated system (The energy supplied by the emf sources is equal to the sum of the energy delivered to all resistors). The product of current and resistance is taken as positive when the direction of the current is followed. Suppose if the direction of current is opposite to the direction of the loop, then product of current and voltage across the resistor is negative. The emf is considered positive when proceeding from the negative to the positive terminal of the cell.



Kirchhoff voltage rule has to be applied only when all currents in the circuit reach a steady state condition (the current in various branches are constant)

27) An electron moving perpendicular to a uniform magnetic field 0.500T undergoes circular motion of radius 2.5 mm. what is the speed of electron?

Charge of an electron $q = -1.60 \times 10^{-19}$ C

$\Rightarrow |q| = 1.60 \times 10^{-19}$ C

Magnitude of magnetic field $B = 0.500$ T

Mass of the electron, $m = 9.11 \times 10^{-31}$ kg

Radius of the orbit, $r = 2.50$ mm $= 2.50 \times 10^{-3}$ m

Speed of the electron, $v = |q| \frac{rB}{m}$

$$v = 1.60 \times 10^{-19} \times \frac{2.50 \times 10^{-3} \times 0.500}{9.11 \times 10^{-31}}$$

$$v = 2.195 \times 10^{8}\ ms^{-1}$$

28) Write advantages and disadvantages of AC over DC.

Advantages:

(i) The generation of AC is cheaper than that of DC.
(ii) When AC is supplied at higher voltages, the transmission losses are small compared to DC transmission.
(iii) AC can easily be converted into DC with the help of rectifiers.

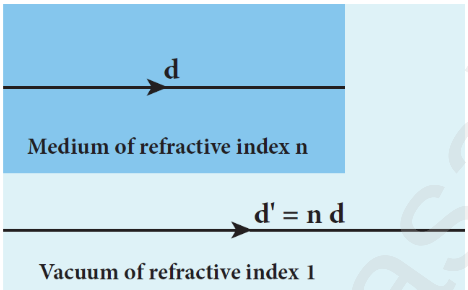
Disadvantages:

(i) Alternating voltages cannot be used for certain applications such as charging of batteries, electroplating, electric traction etc.
(ii) At high voltages, it is more dangerous to work with AC than DC.

29) What is optical path? Obtain the equation for optical path.

Optical path:

Optical path of a medium is defined as the distance d' travelled by the light in vacuum in the same time it travels a distance d in the medium.



Let us consider a medium of refractive index n and thickness d. Light travels with a speed v through the medium in a time t. The speed of light through the medium is written as,

$v = \frac{d}{t}$; rewritten for t as $t = \frac{d}{v}$

In the same time t, light can cover a longer distance d' in vacuum as it travels with greater speed c in vacuum.

$c = \frac{d'}{t}$; rewritten for t as, $t = \frac{d'}{c}$

As the time taken in both the cases is the same, we can equate the time t,

$\frac{d'}{c} = \frac{d}{v}$ dcddcdvvrewrittenfortheopticalpathas(d),

Rewritten for the optical path d' as,

$d' = \frac{c}{v} d$

As, $\frac{c}{v}$ n; the optical path d' is,

$d' = n\,d$

The value of n is always greater than 1, for a medium. Thus, the optical path d' of a medium is always greater than d.

30) Calculate the distance upto which ray optics is a good approximation for light of wavelength 500nm falls on an aperture of width 0.5mm.

Aperture Width $a = 4mm$

Fresnel distance, $Z_F = a^2 / \lambda = (4\times10^{-3})^2 / 500\times10^{-9}$

$\therefore z_F = 0.5m$

31) List out the laws of photoelectric effect.

1. For a given frequency of incident light, the number of photoelectrons emitted is directly proportional to the intensity of the incident light.
2. The maximum kinetic energy of the photoelectrons is independent of the intensity of the incident light.
3. The maximum kinetic energy of the photoelectrons from a given metal is directly proportional to the frequency of incident light.
4. For a given surface, the emission of photoelectrons takes place only if the frequency of incident light is greater than a certain minimum frequency called the threshold frequency.
5. There is no time lag between the incidence of light and emission of photoelectrons.

32) Discuss the Alpha decay process with an example.

When an unstable nucleus decay by emitting an α-particle (^4_2He nucleus), it loses two protons and two neutrons. As a result, its atomic number Z decreases by 2 and the mass number decreases by 4. We write the alpha decay process symbolically in the following way

$$^A_ZX \rightarrow ^{A-4}_{Z-2}Y + ^4_2He \qquad (9.26)$$

Here X is called the parent nucleus and Y is called the daughter nucleus.

Example: Decay of Uranium $^{238}_{92}U$ to thorium $^{234}_{90}Th$ with the emission of ^4_2He nucleus (α-particle)

$$^{238}_{92}U \rightarrow ^{234}_{90}Th + ^4_2He$$

As already mentioned, the total mass of the daughter nucleus and ^4_2He nucleus is always less than that of the parent nucleus. The difference in mass ($\Delta m = m_X - m_Y - m_\alpha$) is released as energy called **disintegration energy** Q and is given by

$$Q = (m_X - m_Y - m_\alpha)c^2 \qquad (9.27)$$

Note that for spontaneous decay (natural radioactivity) $Q > 0$. In alpha decay process, the disintegration energy is certainly positive ($Q > 0$). In fact, the disintegration energy Q is also the net kinetic energy gained in the decay process or if the parent nucleus is at rest, Q is the total kinetic energy of daughter nucleus and the ^4_2He nucleus. Suppose $Q < 0$, then the decay process cannot occur spontaneously and energy must be supplied to induce the decay.

33) State De – Morgan's first and second theorem.

De Morgan's First Theorem

Statement

The first theorem states that the complement of the sum of two logical inputs is equal to the product of its complements.

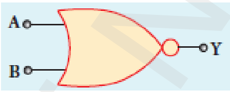
Proof

The Boolean equation for NOR gate is $Y = \overline{A + B}$.

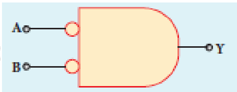
The Boolean equation for a bubbled AND gate is $Y = \bar{A} \cdot \bar{B}$.

Both cases generate same outputs for same inputs. It can be verified using the following truth table.

A	B	$A+B$	$\overline{A+B}$	$\overline{A}$	$\overline{B}$	$\overline{A}.\overline{B}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0



=



From the above truth table, we can conclude $= \overline{A + B} = \bar{A} \cdot \bar{B}$.

Thus De Morgan's first theorem is proved. Hence, a NOR gate is equal to a bubbled AND gate.

De Morgan's SecondTheorem

Statement

The second theorem states that the complement of the product of two inputs is equal to the sum of its complements.

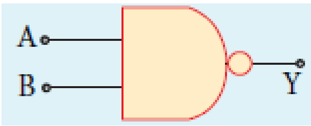
Proof

The Boolean equation for NAND gate is $Y = \overline{A.B}$

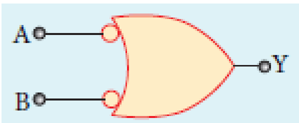
The Boolean equation for bubbled OR gate is $Y = \overline{A} + \overline{B}$

A and B are the inputs and Y is the output. The above two equations produces the same output for the same inputs. It can be verified by using the truth table

A	B	$A.B$	$\overline{A.B}$	$\overline{A}$	$\overline{B}$	$\overline{A}+\overline{B}$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	0	0	1	0	1	1
1	1	1	0	0	0	0



=



From the above truth table we can conclude $\overline{A.B} = \overline{A} + \overline{B}$

Thus De Morgan's second theorem is proved. Hence, a NAND gate is equal to a bubbled OR gate.

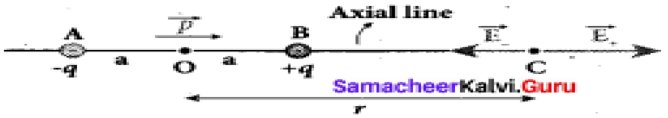
Part – IV

Note : Answer all the questions. **5 x 5 = 25**

34) a) Calculate the electric field due to a dipole on its axial line.

Case (I) :

Electric field due to an electric dipole at points on the axial line. Consider an electric dipole placed on the x-ax is as shown in the figure. A point C is located at a distance of r from the midpoint O of the dipole along the axial line. Axial line



Electric field of the dipole along the axial line

The electric field at a point C due to +q is

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2} \text{ along BC}$$

Since the electric dipole moment vector $\vec{P}$ is from -q to +q and is directed along BC, the above equation is rewritten as

$$\vec{E}_+ = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}\hat{p} \qquad ...(1)$$

where $\hat{p}$ is the electric dipole moment unit vector from -q to +q. The electric field at a point C due to -q is

$$\vec{E}_- = -\frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}\hat{p} \qquad ...(2)$$

Since +q is located closer to the point C than -q, $\vec{E}_+$ is stronger than $\vec{E}$.
Therefore, the length of the $\vec{E}_+$ vector is drawn large than that of $\vec{E}_-$ vector.
The total electric field at point C is calculated using the superposition principle of the electric field.

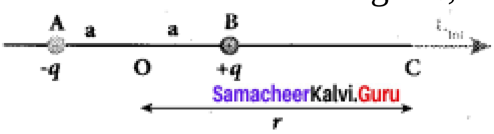
$$\vec{E}_{tot} = \vec{E}_+ + \vec{E}_- \qquad ...(3)$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}\hat{p} - \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}\hat{p}$$

$$\Rightarrow \vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\left(\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right)\hat{p} \qquad ...(4)$$

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}q\left(\frac{4ra}{(r^2-a^2)^2}\right)\hat{p} \qquad ...(5)$$

Note that the total electric field is along $\vec{E}_+$, since +q is closer to C than -q.



Total electric field of the dipole on the axial line

The direction of $\vec{E}_{tot}$ is shown in Figure.
If the point C is very far away from the dipole then (r >> a). Under this limit the term $(r^2 - a^2)^2 \approx r^4$ Substituting this into equation, we get

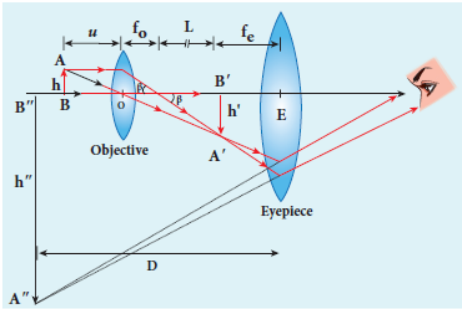
$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\left(\frac{4aq}{r^3}\right)\hat{p} \quad (r >> a) \quad ...(6)$$

 since $2aq\,\hat{p} = \vec{p}$

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\frac{2\vec{p}}{r^3} \quad (r >> a)$$

If point C is chosen on the left side of the dipole, the total electric field is still in the direction of $\vec{p}$

34) b) Explain about compound microscope and obtain the equation for the magnification.



The lens near the object is called as objective. It forms a real, inverted and magnified image of the object. This serves as the object for the lens close to the eye called as eyepiece. The eyepiece serves as a simple microscope that produces finally an enlarged and virtual image. The first inverted image formed by the objective is to be adjusted within the focus of the eyepiece so that the final image is formed nearly at infinity (or) at the near point. The final image is inverted with respect to the object.

Magnification in compound microscope

The lateral magnification produced by the objective is given by the equation .

$$m_0 = \frac{h'}{h}$$

From the Figure 7.39, $\tan\beta = \frac{h}{f_o} = \frac{h'}{L}$, then

$$\frac{h'}{h} = \frac{L}{f_o} \quad (7.74)$$

$$m_o = \frac{L}{f_o} \quad (7.75)$$

Here, the distance L is measured between the focal point of the eyepiece to the focal point of the objective. This is called the tube length of the microscope as f_o and f_e are comparatively smaller than L.

If the final image is formed at the near point, the magnification m_e of the eyepiece is,

$$m_e = 1 + \frac{D}{f_e} \quad (7.76)$$

The total magnification m for near point focusing is,

$$m = m_o m_e = \left(\frac{L}{f_o}\right)\left(1 + \frac{D}{f_e}\right) \quad (7.77)$$

If the final image is formed at infinity (normal focusing), the magnification m_e of the eyepiece is,

$$m_e = \frac{D}{f_e} \quad (7.78)$$

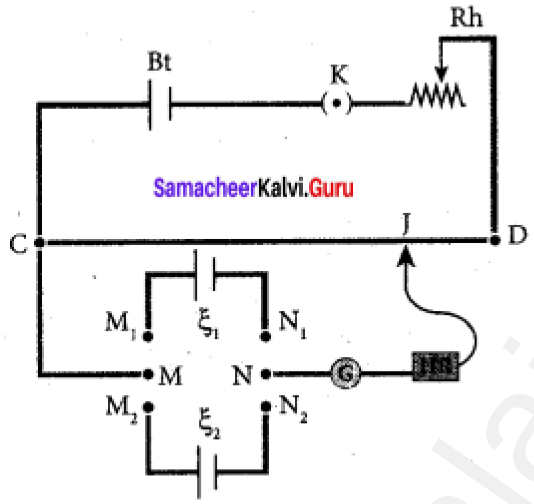
The total magnification m for normal focusing is,

$$m = m_o m_e = \left(\frac{L}{f_o}\right)\left(\frac{D}{f_e}\right) \quad (7.79)$$

35) a) How the emf of two cells are compared using potentiometer.

Comparison of emf of two cells with a potentiometer:

To compare the emf of two cells, the circuit connections are made as shown in the figure. Potentiometer wire CD is connected to a battery Bt and a key K in series. This is the primary circuit. The end C of the wire is connected to the terminal M of a DPDT (Double Pole Double Throw) switch and the other terminal N is connected to a jockey through a galvanometer G and a high resistance HR. The cells whose emf ξ_1 and ξ_2 to be compared are connected to the terminals M_1, N_1 and M_2, N_2 of the DPDT switch.



The positive terminals of Bt, ξ_1, and ξ_2 should be connected to the same end C. The DPDT switch is pressed towards M_1, N_1 so that cell ξ_1 is included in the secondary circuit and the balancing length l_1 is found by adjusting the jockey for zero deflection.

Then the second cells ξ_2 is included in the circuit and the balancing length l_2 is determined. Let r be the resistance per unit length of the potentiometer wire and I be the current flowing through the wire.

we have.

$\xi_1 = Irl_1$ …… (1)

$\xi_2 = Irl_2$ ……. (2)

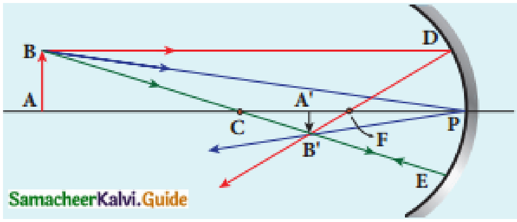
By dividing (1) by (2)

$\xi 1 \xi 2 = l1 l2$ ……. (3)

By including a rheostat (Rh) in the primary circuit, the experiment can be repeated several times by changing the current flowing through it.

35) b) Derive the mirror equation and the equation for lateral magnification.

Mirror equation



1. AB is an object considered on the principal axis of a concave mirror.
2. Consider three paraxial rays from point B on the object.
3. The three reflected rays intersect at the point 'B'.
4. A perpendicular drawn as A' B' to the principal axis is the real, inverted image of the object AB.
5. Δ BPA and Δ B'PA are similar

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

Δ DPF and Δ B'A' F are also almost similar

$$\frac{A'B'}{PD} = \frac{A'F}{PF}$$

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

$$\frac{PA'}{PA} = \frac{A'F}{PF}$$

$$\frac{PA'}{PA} = \frac{PA' - PF}{PF}$$

PA = -u, PA' = -v, PF = -f

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

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

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

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

$$\boxed{\frac{1}{v} + \frac{1}{u} = \frac{1}{f}}$$

This is called mirror equation.

Lateral magnification

$$\text{Magnification (m)} = \frac{\text{height the image (h')}}{\text{height of the object (h)}}$$

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

$$\frac{-h'}{h} = \frac{-v}{u}$$

$$m = \frac{h'}{h} = \frac{-v}{u}$$

Using mirror equation

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

36) a) Discuss the working of cyclotron in detail.

Cyclotron:

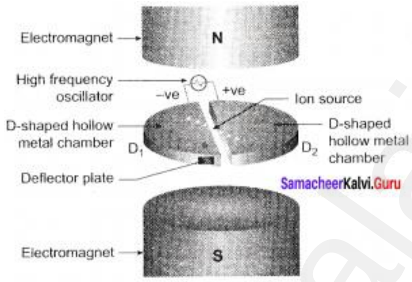
A cyclotron is a device used to accelerate the charged particles to gain large kinetic energy. It is also called as high energy accelerator. It was invented by Lawrence and Livingston in 1934.

Principle:

When a charged particle moves normal to the magnetic field, it experiences magnetic Lorentz force.

Construction:

The particles are allowed to move in between two semicircular metal containers called Dees (hollow D – shaped objects). Dees are enclosed in an evacuated chamber and it is kept in a region with uniform magnetic field controlled by an electromagnet. The direction of the magnetic field is normal to the plane of the Dees. The two Dees are kept separated with a gap and the source S (which ejects the particle to be accelerated) is placed at the center in the gap between the Dees. Dees are connected to high frequency alternating potential difference.



Working:

Let us assume that the ion ejected from source S is positively charged. As soon as ion is ejected, it is accelerated towards a Dee (say, Dee – 1) which has negative potential at that time. Since the magnetic field is normal to the plane of the Dees, the ion undergoes circular path. After one semi-circular path in Dee-1, the ion reaches the gap between Dees. At this time, the polarities of the Dees are reversed so that the ion is now accelerated towards Dee-2 with a greater velocity. For this circular motion, the centripetal force of the charged particle q is provided by Lorentz force.

$$mv^2 / r = qvB$$
$$\Rightarrow r = m / qb \; v$$
$$\Rightarrow r \propto v$$

From the equation, the increase in velocity increases the radius of circular path. This process continues and hence the particle undergoes spiral path of increasing radius. Once it reaches near the edge, it is taken out with the help of deflector plate and allowed to hit the target T. Very important condition in cyclotron operation is the resonance condition. It happens when the frequency f at which the positive ion circulates in the magnetic field must be equal to the constant frequency of the electrical oscillator f_{osc} From equation

$$f_{osc} = qB / 2\pi m \qquad T = 1/ f_{osc}$$

The time period of oscillation is

$$T = 2\pi m / qB$$

The kinetic energy of the charged paricle is

$$K\,E = 1/2 \; mv^2 = q^2B^2r^2 / 2\,m$$

Limitations of cyclotron:

(a) the speed of the ion is limited
(b) electron cannot be accelerated
(c) uncharged particles cannot be accelerated

36) b) Discuss the spectral series of hydrogen atom.

Spectral series of hydrogen atom:

Since electrons in excited states have very small life time, these electrons jump back to ground state through spontaneous emission in a short duration of time (approximately 10^{-8} s) by emitting the radiation with same wavelength (or frequency) corresponding to the colours it absorbed (Figure 9.22 (a)). This is called emission spectroscopy.

The wavelengths of these lines can be calculated with great precision. Further, the emitted radiation contains wavelengths both lesser and greater than wavelengths of lines in the visible spectrum.

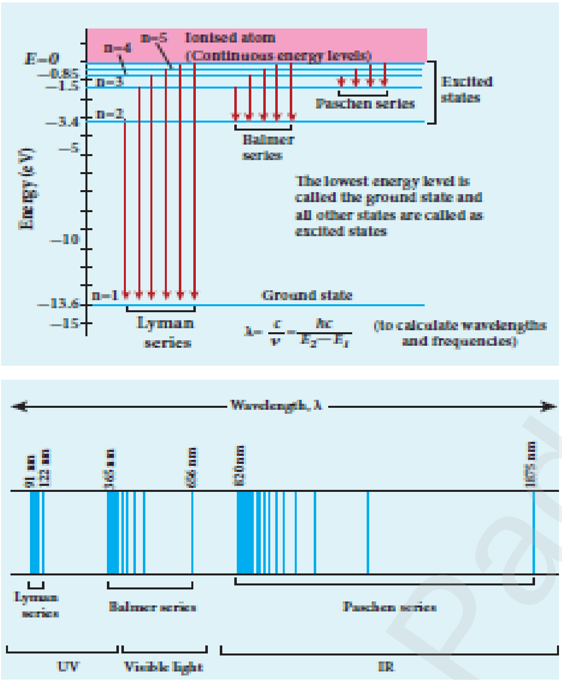


Figure 9.23 Spectral series – Lyman, Balmer, Paschen series

Notice that the spectral lines of hydrogen as shown in Figure 9.23 are grouped in separate series. In each series, the distance of separation between the consecutive wavelengths decreases from higher wavelength to the lower wavelength, and also wavelength in each series approach a limiting value known as the series limit. These series are named as Lyman series, Balmer series, Paschen series, Brackett series, Pfund series, etc. The wavelengths of these spectral lines perfectly agree with the wavelengths calculate using equation derived from Bohr atom model.

$$\frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right) = \bar{\nu} \qquad (9.18)$$

where $\bar{\nu}$ **is known as wave number which is inverse of wavelength,** R is known as Rydberg constant whose value is $1.09737 \times 10^7\ m^{-1}$ and m and n are positive integers such that $m > n$. The various spectral series are discussed below:

(a) Lyman series

For $n = 1$ and $m = 2,3,4.......$ in equation (9.18), the wave numbers or wavelength of spectral lines of Lyman series which lies in ultra-violet region,

$$\bar{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{m^2}\right)$$

(b) Balmer series

For $n = 2$ and $m = 3,4,5.......$ in equation (9.18), the wave numbers or wavelength of spectral lines of Balmer series which lies in visible region,

$$\bar{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{m^2}\right)$$

(c) Paschen series

Put $n = 3$ and $m = 4,5,6.......$ in equation (9.18). The wave number or wavelength of spectral lines of Paschen series which lies in infra-red region (near IR) is

$$\bar{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{m^2}\right)$$

(d) Brackett series

For $n = 4$ and $m = 5,6,7........$ in equation (9.18), the wave numbers or wavelength of spectral lines of Brackett series which lies in infra-red region (middle IR),

$$\bar{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{m^2}\right)$$

(e) Pfund series

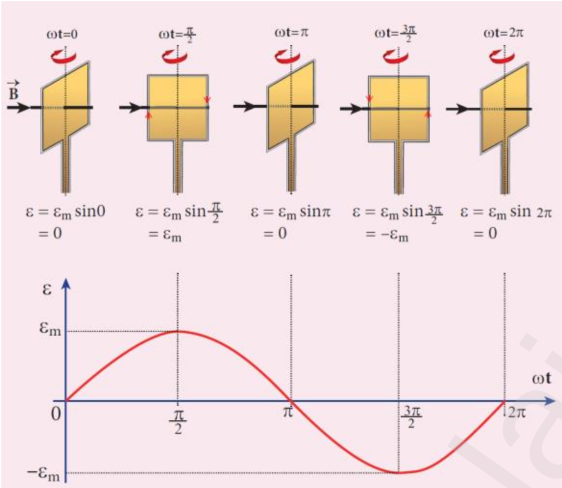
For $n = 5$ and $m = 6,7,8........$ in equation (9.18), the wave numbers or wavelength of spectral lines of Pfund series which lies in infra-red region (far IR),

$$\bar{\nu} = \frac{1}{\lambda} = R\left(\frac{1}{5^2} - \frac{1}{m^2}\right)$$

37) a) Explain the production of induced emf by changing relative orientation of the coil with respect to the magnetic field.

Consider a rectangular coil of N turns kept in a uniform magnetic field $\vec{B}$. The coil rotates in anti-clockwise direction with an angular velocity ω about an axis, perpendicular to the field and to the plane of the paper.

At time $t = 0$, the plane of the coil is perpendicular to the field and the flux linked with the coil has its maximum value $\Phi_m = NBA$ (where A is the area of the coil).



In a time t seconds, the coil is rotated through an angle θ (= ωt) in anti–clockwise direction. In this position, the flux linked $NBAcos\omega t$ is due to the component of $\vec{B}$ normal to the plane of the coil. The component ($B\ sin\omega t$) parallel to the plane has no role in electromagnetic induction. Therefore, the flux linkage with the coil at this deflected position is

$$N\Phi_B = NBA\cos\theta = NBA\cos\omega t$$

According to Faraday's law, the emf induced at that instant is

$$\varepsilon = -\frac{d}{dt}(N\Phi_B) = -\frac{d}{dt}(NBA\cos\omega t)$$

$$= -NBA(-\sin\omega t)\,\omega$$

$$= NBA\omega \sin\omega t$$

When the coil is rotated through 90o from initial position, $\sin\omega t = 1$. Then the maximum value of induced emf is

$$\varepsilon_m = NBA\omega$$

Therefore, the value of induced emf at any instant is then given by

$$\varepsilon = \varepsilon_m \sin\omega t$$

It is seen that the induced emf varies as sine function of the time angle ωt. The graph between induced emf and time angle for one rotation of the coil will be a sine curve and the emf varying in this manner is called **sinusoidal emf** or **alternating emf**.

If this alternating voltage is given to a closed circuit, a sinusoidally varying current flows in it. This current is called **alternating current** and is given by

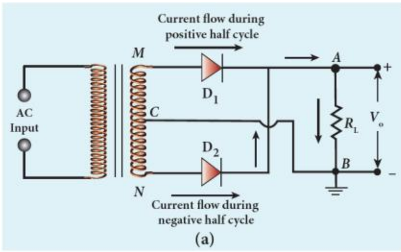
$$i = I_m \sin\omega t$$

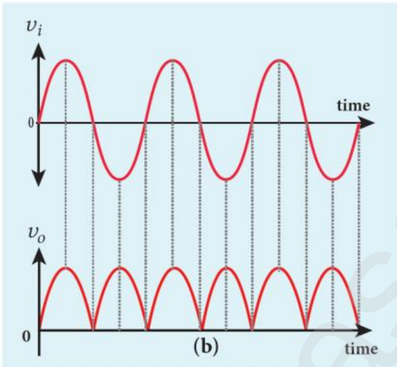
where I_m is the maximum value of induced current.

37) b) Draw the circuit diagram of a full wave rectifier and explain its working.

Full wave rectifier

The positive and negative half cycles of the AC input signal are rectified in this circuit and hence it is called the full wave rectifier. It consists of two *p-n* junction diodes, a centre tap transformer and a load resistor R_L. The centre is usually taken as the ground or zero voltage reference point. With the help of the centre tap transformer, each diode rectifies one half of the total secondary voltage.





During positive half cycle

When the positive half cycle of the AC input signal passes through the circuit, terminal *M* is positive, *C* is at zero potential and *N* is at negative potential. This forward biases diode *D*1 and reverse biases diode D_2. Hence, being forward biased, diode D_1conducts and current flows along the path MD_1ABC.

During negative half cycle

When the negative half cycle of the AC input signal passes through the circuit, terminal *N* becomes positive, *C* is at zero potential and *M* is at negative potential. This forward biases diode D_2 and reverse biases diode D_1. Hence, being forward biased, diode D_2 conducts and current flows along the pathND_2ABC.

During both postive and negative half cycles of the input signal, the current flows through the load in the same direction. The output signal corresponding to the input signal is shown in Figure 10.18(b). Though both half cycles of AC input are rectified, the output is still pulsating in nature.

The efficiency (η) of full wave rectifier is twice that of a half wave rectifier and is found to be 81.2 %. It is because of power losses in the winding, the diode and the load resistance.

38) a) Write down Maxwell equations in integral form.

Maxwell's equations in integral form:

Electrodynamics can be summarized into four basic equations, known as Maxwell's equations. These equations are analogous to Newton's equations in mechanics. Maxwell's equations completely explain the behavior of charges, currents and properties of electric and magnetic fields. So we focus here only in integral form of Maxwell's equations:

(i) First equation is nothing but the Gauss's law. It relates the net electric flux to net electric charge enclosed in a surface. Mathematically, it is expressed as

$$\oint \vec{E}.d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0}$$

Where $\vec{E}$ is the electric field and Q enclosed is the charge enclosed. This equation is true for both discrete or continuous distribution of charges. It also indicates that the electric field lines start from positive charge and terminate at negative charge. This implies that the electric field lines do not form a continuous closed path. In other words, it means that isolated positive charge or negative charge can exist.

(ii) Second equation has no name. But this law is similar to Gauss's law in electrostatics. So this law can also be called as Gauss's law in magnetism. The surface integral of magnetic field over a closed surface is zero. Mathematically,

$$\oint \vec{B}.d\vec{A} = 0$$

where $\vec{B}$ is the magnetic field. This equation implies that the magnetic lines of force form a continuous closed path. In other words, it means that no isolated magnetic monopole exists.

(iii) Third equation is Faraday's law of electromagnetic induction. This law relates electric field with the changing magnetic flux which is mathematically written as

$$\oint \vec{E} \, . \, \overrightarrow{dl} = ddt \, \Phi_B$$

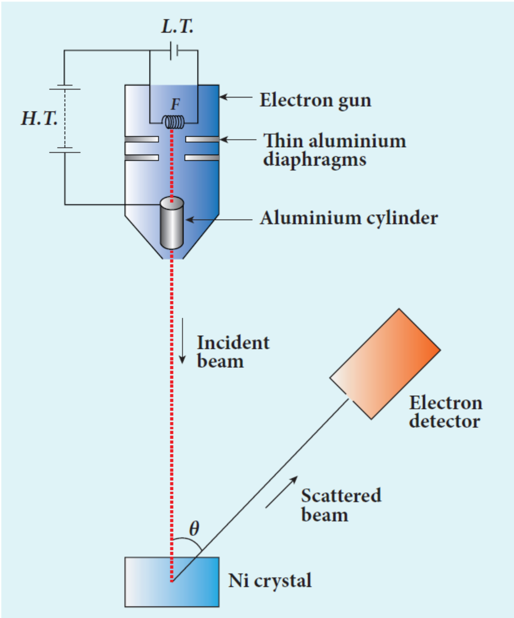
where $\vec{E}$ is the electric field. This equation implies that the line integral of the electric field around any closed path is equal to the rate of change of magnetic flux through the closed path bounded by the surface.

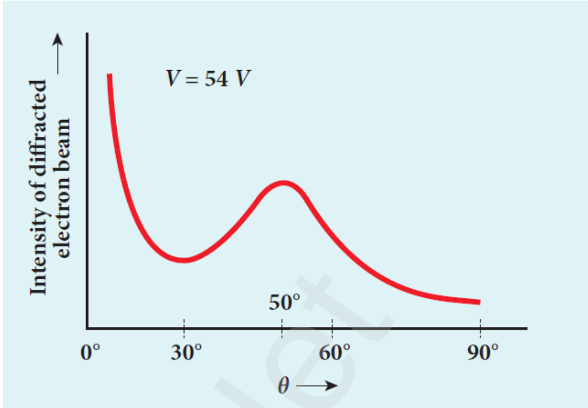
(iv) Fourth equation is modified Ampere's circuital law. This is also known as ampere-Maxwell's law. This law relates the magnetic field around any closed path to the conduction current and displacement current through that path.

$$\oint \vec{B}.d\vec{l} = \mu_0 I_{enclosed} + \mu_0 \varepsilon_0 \int_s \vec{E}.d\vec{A}$$

Where $\vec{B}$ is the magnetic field. This equation shows that both conduction and also displacement current produces magnetic field. These four equations are known as Maxwell's equations in electrodynamics.

38) b) Describe briefly – Davision – Germer experiment which demonstrated the wave nature of electrons.





Louis de Broglie hypothesis of matter waves was experimentally confirmed by Clinton Davisson and Lester Germer in 1927. They demonstrated that electron beams are diffracted when they fall on crystalline solids. Since crystal can act as a three-dimensional diffraction grating for matter waves, the electron waves incident on crystals are diffracted off in certain specific directions. Figure 8.17 shows a schematic representation of the apparatus for the experiment.

The filament *F* is heated by a low tension (L.T.) battery. Electrons are emitted from the hot filament by thermionic emission. They are then accelerated due to the potential difference between the filament and the anode aluminium cylinder by a high tension (H.T.) battery. Electron beam is collimated by using two thin aluminium diaphragms and is allowed to strike a single crystal of Nickel.

The electrons scattered by Ni atoms in different directions are received by the electron detector which measures the intensity of scattered electron beam. The detector is capable of rotation in the plane of the paper so that the angle θ between the incident beam and the scattered beam can be changed at our will. The intensity of the scattered electron beam is measured as a function of the angle θ.

Figure 8.18 shows the variation of intensity of the scattered electrons with the angle θ for the accelerating voltage of 54*V*. For a given accelerating voltage *V*, the scattered wave shows a peak or maximum at an angle of 50° to the incident electron beam. This peak in intensity is attributed to the constructive interference of electrons diffracted from various atomic layers of the target material. From the known value of interplanar spacing of Nickel, the wavelength of the electron wave was experimentally calculated as 1.65Å.

The wavelength can also be calculated from de Broglie relation for *V* = 54 V from equation (8.18).

$$\lambda = \frac{12.27}{\sqrt{V}}\text{Å} \quad = \frac{12.27}{\sqrt{54}}\text{ Å}$$

$$\lambda = 1.67\text{ Å}$$

This value agrees very well with the experimentally observed wavelength of 1.65Å. Thus this experiment directly verifies de Broglie's hypothesis of the wave nature of moving particles.