HIGHER SECONDARY SECOND YEAR QUARTERLY EXAMINATION – SEPTEMBER 2024

PHYSICS KEY ANSWER

Note:

1. Answers written with **Blue** or **Black** ink only to be evaluated.
2. Choose the most suitable answer in Part A, from the given alternatives and write the option code and the corresponding answer.
3. For answers in Part-II, Part-III and Part-IV like reasoning, explanation, narration, description and listing of points, students may write in their own words but without changing the concepts and without skipping any point.
4. In numerical problems, if formula is not written, marks should be given for the remaining correct steps.
5. In graphical representation, physical variables for X-axis and Y-axis should be marked.

PART – I

Answer all the questions. **15x1=15**

Q. No.	Option	Answer	Q. No.	Option	Answer
1	(b)	3×10^6 Vm^{-1}	9	(a)	γ - rays
2	(b)	8 mC	10	(b)	Its wavelength
3	(b)	n^2	11	(c)	1.5 cm
4	(a)	Straight line	12	(b)	300 Vm^{-1}
5	(a)	Current	13	(d)	Energy density
6	(c)	$\frac{q}{2m}$	14	(d)	820^0 C
7	(c)	0.1 J	15	(a)	refraction
8	(a)	$\frac{\pi}{4}$			

PART – II

Answer **any six** questions. Question number **19** is compulsory. 6x2=12

16	**Temperature coefficient of resistivity:** It is defined as the ratio of **increase in resistivity per degree** rise in temperature to its resistivity at T_0. Its unit is **per^{0}C**	1 ½ ½	2
17	**Phosphor - bronze is used as suspension wire:** Phosphor - bronze wire, the **couple per unit twist is very small**.	2	2
18	**Lenz's law:** Lenz's law states that the direction of the **induced current** is such that is **always opposes** the cause responsible for its production.	2	2
19	Refractive index of the medium, n = $\sqrt{\epsilon_r \mu_r}$; = $\sqrt{2.25 \times 2.5}$; = $\sqrt{5.625}$; **n =2.37 (No unit)**	1 1	2

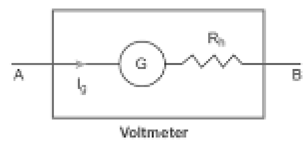
20	**Displacement current:** The displacement current can be defined as **the current which comes into play in the region in which the electric field and the electric flux are changing with time.** That is whenever the change in electric field takes place, displacement current is produced.	2	2
21	**Self-Induction:** The phenomenon of inducing an emf in a coil, when the **magnetic flux linked with the coil** itself changes is called self-induction. The emf induced is called self-induced emf. **Mutual Induction:** When an electric current passing through a coil changes with time, an emf is induced in the **neighbouring coil**. This phenomenon is known as mutual induction and the emf is called mutually induced emf	2	2
22	**Action of point or corona discharge:** **Smaller the radius of curvature, larger the charge density.** Hence charges are accumulated at the sharp points. Due to this, the electric field **near this sharp edge is very high and it ionized the surrounding air.** The **positive ions are repelled and negative ions are attracted** towards the sharp edge. This **reduces the total charge of the conductor near the sharp edge.** This is called action of points or corona discharge.	2	2
23	**Applications of capacitors** (i) **Flash capacitors are used in digital cameras** for taking photographs. The flash which comes from the camera when we take photographs is due to the energy released from the capacitor, called a flash capacitor. (ii) During cardiac arrest, a device called heart defibrillator is used to give a **sudden surge of a large amount of electrical energy** to the patient's chest to retrieve the normal heart function. (iii) Capacitors are used in **the ignition system of automobile engines** to eliminate sparking (iv) Capacitors are used **to reduce power fluctuations in power supplies** and to increase the efficiency of power transmission. **(Any Two only)**	2x1=2	2
24	**Power of a lens:** The power 'P' of a lens is defined as **the reciprocal of its focal length** (f) P = $\frac{1}{f}$ (or) $= \left(n - 1\left[\frac{1}{R_1} - \frac{1}{R_2}\right]\right)$ The **unit of power is diopter (D)** Power is positive for converging lens and negative for diverging lens.	1 ½ ½	2

PART – II

Answer **any six** questions. Question number **29** is compulsory. 6x3=18

25	**Properties of electric field lines:** 1) They starts from **positive charge and end at negative charge** or at infinity. 2) The electric field vector at a point in space is tangential to the electric field line at that point. 3) The **electric field lines are denser in a region where the electric field has larger magnitude and less dense in region where the electric field** is of smaller magnitude. (i.e) the number of lines passing through a given **surface area perpendicular to the line is proportional to the magnitude of the electric field.** 4) **No** two electric field lines **intersect** each other 5) The number of electric field lines that emanate from the positive charge or end at a negative charge is **directly proportional to the magnitude of the charges.**	Any 3 3x1=3	3
26	**The expression for power in an electrical circuit:** Electric energy is given by, $dU = VdQ$ By definition, **the rate at which electric potential energy is delivered** is called power. (i.e) $P = \frac{dU}{dt}$; $= \frac{VdQ}{dt}$; $= V\frac{dQ}{dt}$ But $\frac{dQ}{dt} = I \longrightarrow$ electric current . ∴ **P = VI**	3	3
27	**Distinguish between Coulomb force and Gravitational force:** (see table below)	Any 3 3x1=3	3

S. No.	Coulomb Force	Gravitational Force
1	It acts between **two charges**	It acts between **two masses**
2	It can be **attractive or repulsive**	It is always **attractive**
3	It is **always greater** in magnitude	It is **always lesser** in magnitude
4	It **depends** on the nature of the medium	It is **independent** of the medium
5	If charges are in motion, another force called **Lorentz force** come in to play in addition to Coulomb force	**Gravitational force** is the same whether two masses are at rest or in motion
6	The value of the constant k in Coulomb law $\mathbf{k = 9 \times 10^{9}\ Nm^{2}\ C^{-2}}$	The value of the gravitational constant $\mathbf{G = 6.67 \times 10^{-11}\ Nm^{2}\ kg^{-2}}$

<table>
<tr>
<td>28</td>
<td><u>Galvanometer to a voltmeter:</u>
A voltmeter is an instrument used to measure potential difference across any two points. A galvanometer is converted in to voltmeter by connecting high resistance in series with the galvanometer. The scale is calibrated in volts.


Galvanometer resistance = R_g,
High resistance = R_h
Current flows through galvanometer= I_g
Voltage to be measured = V, Total resistance of this circuit = $R_g + R_h$
Here the current in the electrical circuit is same as the current passing through the galvanometer. (i.e) $I_g = I$
$I_g = \frac{V}{R_g+R_h}$ (or) $R_g + R_h = \frac{V}{I_G}$; $\therefore R_h = \frac{V}{I_G} - R_g$
Let R_V be the resistance of voltmeter, then $R_V = R_g + R_h$. Here, $R_g < R_h < R_V$
Thus an voltmeter is a high resistance instrument, and it always connected in parallel to the circuit element. An ideal voltmeter has infinity</td>
<td>1
1
1</td>
<td>3</td>
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<tr>
<td>29</td>
<td>Equation for refractive index is, $n = \frac{\sin\left(\frac{A+D}{2}\right)}{\text{Sin}\left(\frac{A}{2}\right)}$
Substituting the values, $n = \frac{\sin\left(\frac{60^0+37^0}{2}\right)}{\text{Sin}\left(\frac{60^0}{2}\right)}$; $= \frac{\sin(48.5^0)}{\text{Sin}(30^0)}$; $= \frac{0.75}{0.5}$; = 1.5;
The refractive index of the material of the prism is, n = 1.5 (No Unit)</td>
<td>1
1
1</td>
<td>3</td>
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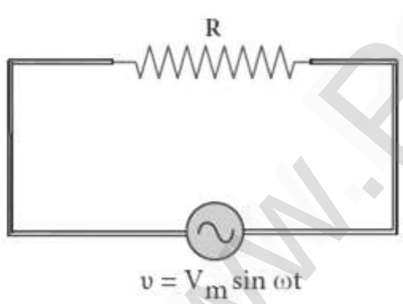
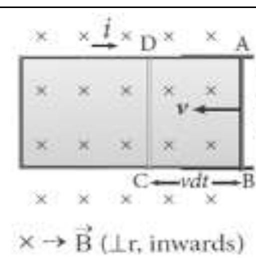
<tr>
<td>30</td>
<td><u>AC circuit containing pure resistor:</u>


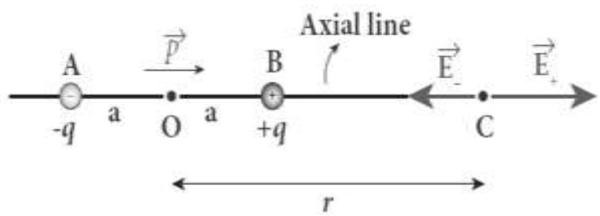
Let a pure resistor of resistance "R" connected across an alternating voltage source "v". The instantaneous value of the alternating voltage is given by
$v = v_m \sin \omega t$ ....(1)
Let 'i' be the alternating current flowing in the circuit due to this voltage, then the potential drop across "R" is
$V_R = i R$ .... (2)
From Kirchhoff's loop rule, $v - v_R = 0$ (or) $v = v_R$
$v_m \sin \omega t = i R$;
$i = \frac{v_m}{R} \sin \omega t$;
$i = I_m \sin \omega t$............. (3)
Here, $\frac{v_m}{R} = I_m$ → Peak value of AC
From equation (1) and (3), it is clear that, the applied voltage and the current are in phase with each other</td>
<td>1
1
1</td>
<td>3</td>
</tr>
</table>

31	**Microwaves:** It is produced by special vacuum tubes such as klystron, magnetron and gunndiode. The frequency range of microwaves is 10^9 Hz to 10^{11} Hz. They obey reflection and polarization It is used in, (i) Radar system for **aircraft navigation,** (ii) Speed of the vehicle, (iii) Microwave oven for cooking (iv) Very long distance **wireless communication** through satellites	1 ½	3
	X - Rays: It is produced when there is a sudden deceleration of high speed electrons at high atomic number target, also by electronic transitions among the innermost orbits of atoms. The frequency range of X-rays is from 10^{17} Hz to 10^{19} Hz. It has more penetrating power than UV - rays. It is used in, (i) Studying structures of **inner atomic electron shell** and crystal structures. (ii) Detecting **fracture, diseased organs, formation of bones** and stones, observing the progress of healing bones (iii) **Detect faults, cracks, flaws and holes** in a finished metal product.	1 ½	
32	**Total internal reflection:** **If the angle of incidence in the denser medium is greater than the critical angle**, there is no refraction possible in the rarer medium. The **entire light is reflected back in to the denser medium** itself; this phenomenon is called total internal reflection.	2	3
	Conditions to achieve total internal reflection: Light must travel from **denser to rarer medium** Angle of incidence must be **greater than critical angle** ($i > i_C$)	1	
33	**EMF induced by changing area enclosed by the coil:**  Consider a conducting rod of length 'l' moving with a velocity 'v' towards left on a rectangular metallic frame work. **The whole arrangement is placed in a uniform magnetic field** $\vec{B}$ acting perpendicular to the plane of the coil inwards. As the rod moves from AB to DC in a time 'dt', the area enclosed by the loop and hence **the magnetic flux through the loop decreases.**	1	3
	The change in magnetic flux in time 'dt' is $d\phi_B = B\,dA = B(l \times v\,dt)$	1	
	$\frac{d\phi_B}{dt} = B\,lv$. This change in magnetic flux results and induced emf and it is given by, $\in = \frac{d\phi_B}{dt}$; $\in = B\,lv$. This emf is called motional emf. **The direction of induced current is found to be clock wise from Fleming's right hand rule.**	1	

PART – IV

Answer **all** the questions. 5x5=25

34. (a) **<u>Electric field due to dipole on its axial line:</u>**



½

Consider a dipole AB along X - axis. Its dipole moment be p = **2**qa and its direction be along – q to + q. ½

Let 'C' be the point at a distance 'r' from the midpoint 'O' on its axial line.

Electric field at C due to +q

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

Electric field at C due to −q

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

1

Since +q is located closer to point 'C' than −q , $\vec{E}_+ > \vec{E}_-$.

By superposition principle, the total electric field at 'C' due to dipole is, 5

$$\vec{E}_{tot} = \vec{E}_+ + \vec{E}_-$$

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

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}q\left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right]\hat{p} \;;$$

1

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}q\left[\frac{(r+a)^2-(r-a)^2}{(r-a)^2\,(r+a)^2}\right]\hat{p}$$

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}q\left[\frac{r^2+a^2+2ra-r^2-a^2+2ra}{((r-a)\quad(r+a))^2}\right]\hat{p}$$

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

1

Here the direction of total electric field is the dipole moment $\hat{p}$

If $r \gg a$, then neglecting a^2. We get $\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}q\left[\frac{4ra}{r^4}\right]\hat{p}$;

$$= \frac{1}{4\pi\varepsilon_0}q\left[\frac{4a}{r^3}\right]\hat{p}$$

1

$$\vec{E}_{tot} = \frac{1}{4\pi\varepsilon_0}\frac{2\vec{p}}{r^3} \qquad [q\,2a\hat{p} = \vec{p}]$$

34. (b)

Emission spectra:

The **light from self-luminous source gives emission** spectrum.

Each source has its own characteristic emission spectrum. ½

The emission spectrum can be divided in to three types;

(i) Continuous emission spectrum (or continuous spectrum):

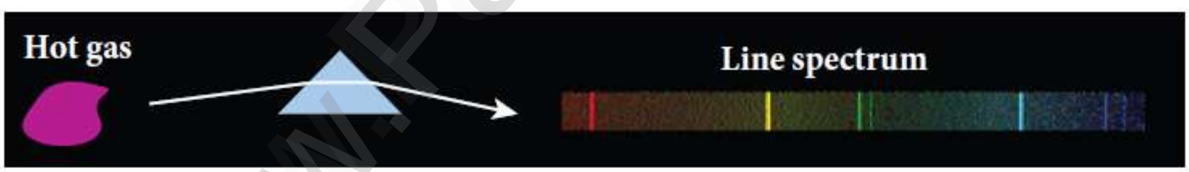
If the light from **incandescent lamp (filament bulb)** is allowed to pass through **prism** (simplest spectroscope), it **splits up into seven colours**. Thus, it consists of wavelengths containing all the **visible colours ranging from violet to red.** 1

Examples: spectrum obtained from carbon arc and incandescent solids. ½

(ii) Line emission spectrum (or line spectrum):

Suppose light from **hot gas is allowed to pass through prism**, line spectrum is observed. Line spectra are also known as discontinuous spectra. The **line spectra consist of sharp lines of definite wavelengths or frequencies.** Such spectra arise due to excited atoms of elements. These lines are the **characteristics of the element and are different for different elements**. 1 5

Examples: spectra of atomic hydrogen, helium, etc. ½



(iii) Band emission spectrum (or band spectrum):

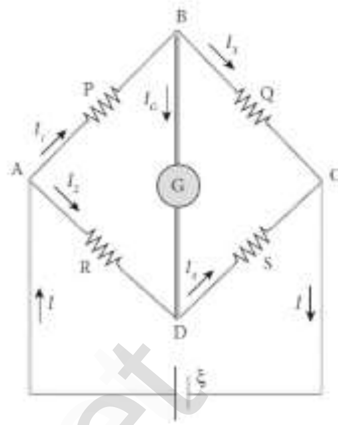
Band spectrum consists of **several number of very closely spaced spectral lines** which overlap together forming specific bands which are separated by **dark spaces**. This **spectrum has a sharp edge at one end and fades out at the other end**. Such spectra arise when the molecules are excited. Band spectrum is the characteristic of the molecule and hence the structure of the molecules can be studied using their band spectra. 1

Example: spectra of ammonia gas in the discharge tube etc. ½

35 (a)

Wheatstone's bridge:

An important application of **Kirchhoff's laws is the Wheatstone's bridge.** It is used to compare resistances and also helps in **determining the unknown resistance in the electrical network**. The bridge consists of **four resistances P, Q, R, S connected** as shown. A galvanometer 'G' is connected between B and D. A battery 'ξ' is connected between A and C. Let I_1, I_2, I_3, I_4 currents through various branches and I_G be the **current through the galvanometer**. [1]



Applying Kirchhoff's current law at B and D,

$I_1 - I_G - I_3 = 0$ ---- (1) [½]

$I_2 + I_G - I_4 = 0$ ---- (2)

Applying Kirchhoff's voltage law ABDA and ABCDA,

$I_1 P + I_G G - I_2 R = 0$ ---- (3) [½]

$I_1 P + I_3 Q - I_2 R - I_4 S = 0$ ---- (4)

At balanced condition, the **potential at B and D are same**, and hence the galvanometer shows **zero deflection**. So $\mathbf{I_G = 0}$ [½]

Put this in equation (1), (2) and (3)

$I_1 - I_3 = 0$ (or) $I_1 = I_3$ ---- (5)

$I_2 - I_4 = 0$ (or) $I_2 = I_4$ ---- (6) [1]

$I_1 P - I_2 R = 0$ (or) $I_1 P = I_2 R$ ---- (7)

Put equation (5) and (6) in (4)

$I_1 P + I_1 Q - I_2 R - I_2 S = 0$;

$I_1 (P + Q) - I_2 (R + S) = 0$

$\therefore I_1 (P+Q) = I_2 (R + S)$ ---- (8)

Divide equation (8) by (7)

$\frac{I_1(P+Q)}{I_1 P} = \frac{I_2(R+S)}{I_2 R}$; $\frac{(P+Q)}{P} = \frac{(R+S)}{R}$ [1]

$1 + \frac{Q}{P} = 1 + \frac{S}{R}$;

$\frac{Q}{P} = \frac{S}{R}$

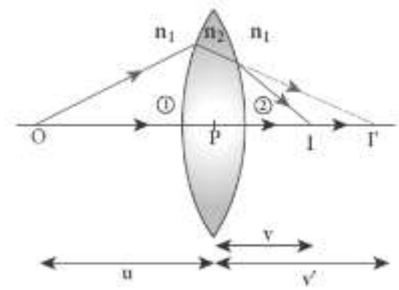
(or) [½]

$\mathbf{\frac{P}{Q} = \frac{R}{S}}$ ....(9)

[Total: 5]

35 (b)

Lens maker's formula:



A thin lens of refractive index n_2 is placed in a medium of refractive index n_1. Let R_1 and R_2 be radii of curvature of two spherical surfaces ① and ② respectively. Let P be pole of the lens and O be the Point object. Here I' be the image to be formed due the refraction at the surface ① and I be the final image obtained due the refraction at the surface ② — 1

We know that, equation for single spherical surface

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$ — ½

For refracting surface ①, the light goes from n_1 to n_2, Hence

$$\frac{n_2}{v'} - \frac{n_1}{u} = \frac{n_2 - n_1}{R_1} \quad .... (1)$$ — ½

For refracting surface ②, the light goes from n_2 to n_1, Hence

$$\frac{n_1}{v} - \frac{n_2}{v'} = \frac{n_1 - n_2}{R_2} \quad .... (2)$$ — ½

Adding equation (1) and (2), we get,

$$\frac{n_2}{v'} - \frac{n_1}{u} + \frac{n_1}{v} - \frac{n_2}{v'} = \frac{n_2 - n_1}{R_1} + \frac{n_1 - n_2}{R_2}$$ — 1

$$\frac{n_1}{v} - \frac{n_1}{u} = (n_2 - n_1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{v} - \frac{1}{u} = \frac{(n_2 - n_1)}{n_1}\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{v} - \frac{1}{u} = \left(\frac{n_2}{n_1} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad ....(3)$$ — ½

If the object is at infinity, the image is formed at the focus of the lens. Thus, $u = \infty, v = f$

Then equation becomes, $\frac{1}{f} - \frac{1}{\infty} = \left(\frac{n_2}{n_1} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$ — ½

$$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad ....(4)$$

Here first medium is air and hence n_1 = 1 and let the refractive index of second medium be $n_2 = n$. Therefore $\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$.............(5) — ½

The above equation is called lens maker's formula.

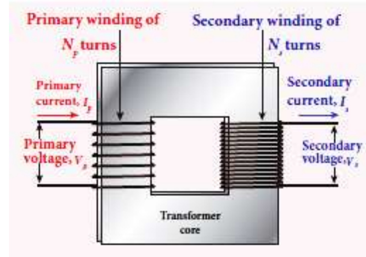
By comparing equation (3) and (4) $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

This equation is known as lens equation.

Total: 5

36 (a)

Transformer:



It is a stationary device used to transform electrical power from one circuit to another without changing its frequency. It is done with either increasing or decreasing the applied alternating voltage with corresponding decrease or increase of current in the circuit. 1

If the transformer **converts an alternating current with low voltage in to an alternating current with high voltage,** it is called **step-up transformer**. If the transformer **converts an alternating current with high voltage in to an alternating current with low voltage, it is called step-down transformer**.

Principle: Mutual induction between two coils. ½

Construction:

It consists of two coils of high mutual inductance wound over the same transformer core made up of silicone steel. To avoid eddy current loss, the core is generally laminated. The alternating voltage is applied across primary coil (P), and the output is taken across secondary coil (S) 1

The assembled core and coils are kept in a container which is filled with suitable medium for better insulation and cooling purpose.

Working:

The **alternating voltage given to the primary coil**, set up an **alternating magnetic flux in the laminated core**. As the result of flux change, emf is induced in both primary and secondary coils. 5

The emf induced in the primary coil 'ϵ_P' is almost equal and opposite to the applied voltage 'V_P' and is given by, $V_P = \epsilon_P = -N_P \frac{d\phi_B}{dt}$ -------- (1) 1

The frequency of alternating magnetic flux is same as the frequency of applied voltage. Therefore induced in secondary will also have same frequency as that of applied voltage,

The emf induced in the secondary coil 'ϵ_S' is, $V_S = \epsilon_S = -N_S \frac{d\phi_B}{dt}$ -------- (2)

Dividing equating (1) by (2), $\frac{V_S}{V_P} = \frac{N_S}{N_P}$ -------- (3)

For an **ideal transformer, Input Power = Output Power** $V_P i_P = V_S i_S$; $\frac{V_S}{V_P} = \frac{i_P}{i_S}$ -------- (4) ½

From equation (3) and (4), we have $\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{i_P}{i_S} = K$ -------- (5) ½

Where, K → Transformation ratio

(i) If $K > 1$ (or) $N_S > N_P$, then $V_S > V_P$ and $i_S < i_P$

This is **step up transformer** in which **voltage increased** and the corresponding **current is decreased.**

(ii) If $K < 1$ (or) $N_S < N_P$, then $V_S < V_P$ and $i_S > i_P$ ½

This is **step down transformer** in which **voltage decreased** and the corresponding **current is increased.**

Efficiency of a transformer:

The efficiency (η) of a transformer is defined as the ratio of the useful output power to the input power. $\eta = \frac{\text{Output Power}}{\text{Input Power}}$ x 100%

36 (b)	**Maxwell equations - Integral form:** Electrodynamics can be summarized into four basic equations, known as Maxwell's equations. Maxwell's equations completely explain the behaviour of charges, currents and properties of electric and magnetic fields. This equation ensures the existence of electromagnetic waves. **Equation - 1 :** It is nothing but Gauss's law It relates the net electric flux to net electric charge enclosed in a surface. Mathematically, Gauss law is expressed **as,** $\oint_s \vec{\mathbf{E}}.\overrightarrow{dA} = \frac{Q_{Closed}}{\varepsilon_0}$ ....(1) Here, $\vec{E}$ → Electric field, Q_{Closed} → Charge enclosed This equation is true for either discrete or continuous distribution of charges. It also indicates that the electric field lines start from positive charge and terminate at negative charge. The electric field lines do not form a continuous closed path (i.e.) isolated positive or negative charges can exist. **Equation - 2 :** It has no name. But **this law of similar to Gauss law in electrostatics.** Hence this law can be called as **Gauss's law in magnetism**. According to this law, the surface integral of magnetic field over a closed surface is zero. Mathematically, this law can be expressed as, $\oint_s \vec{\mathbf{B}}.\overrightarrow{dA} = \mathbf{0}$ ....(2) $\vec{B}$ → Magnetic field. This equation implies that the magnetic field lines form a continuous closed path. (i.e.) no isolated magnetic monopole exists **Equation - 3 :** This is Faraday's laws of electromagnetic induction. This law relates **electric field with the changing magnetic flux.** 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.** Mathematically it is expressed as, $\oint_l \vec{E}.\overrightarrow{dl} = -\frac{d\phi_B}{dt}$ ....(3) $\vec{E}$ → Electric field The electrical energy supplied to our houses from electricity board by using Faraday's law of induction. **Equation - 4 :** It is **modified Ampere's circuital law** and also **called 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. Mathematically, $\oint_s \vec{B}.\overrightarrow{dl} = \mu_0(I_C + I_D)$ (or) $\oint_l \vec{B}.\overrightarrow{dl} = \mu_0 I_C + \mu_0\varepsilon_0 \frac{d}{dt}\oint_s \vec{E}.\overrightarrow{dA}$ Here, $\vec{B}$ → Magnetic field. It implies that **both conduction and displacement current produces magnetic field.**	1 1 1 ½ 1 ½	5

37 (a)

Lorentz force:

When an electric charge q is kept at rest in a magnetic field, no force acts on it. At the same time, if the charge moves in the magnetic field, it experiences a force. This force is known as magnetic force. It is given by the equation $\vec{F} = q(\vec{v} \times \vec{B})$

In general, if the charge is moving in both the electric and magnetic fields, the total force experienced by the charge is given by $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$. It is known as Lorentz force. — 2

When an electric charge 'q' moves with velocity $\vec{v}$ in the magnetic field $\vec{B}$, it experiences a force called Lorentz magnetic force $\vec{F}_m$. $\vec{F}_m = q(\vec{v} \times \vec{B})$ ----------1

In magnitude, $F_m = Bqv \sin\theta$ ----------2

The equations (1) and (2) imply,

Properties of Lorentz magnetic force:

(i) $\vec{F}_m$ is directly proportional to the **magnetic field** ($\vec{B}$)

(ii) $\vec{F}_m$ is directly proportional to the **velocity** ($\vec{v}$)

(iii) $\vec{F}_m$ is directly proportional to **sine of the angle between the velocity and magnetic field.** — 3

(iv) $\vec{F}_m$ is directly proportional to the **magnitude of the charge**

(v) The direction of $\vec{F}_m$ is always perpendicular to $\vec{v}$ and $\vec{B}$

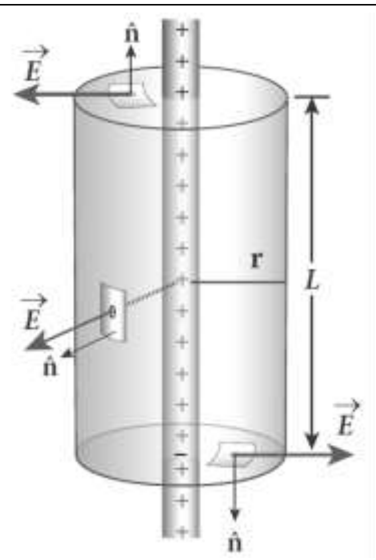
(vi) The direction of $\vec{F}_m$ on negative charge is opposite to the direction of $\vec{F}_m$ on positive charge

(vii) If the of the charge is along the magnetic field, then $\vec{F}_m$ is **zero.**

Total: 5

37 (b)

Electric field due to infinitely long charged wire:



Consider an infinitely long straight wire of uniform linear charge density 'λ'. Let 'P' be a point at a distance 'r' from the wire. Let 'E' be the electric field at 'P'. Consider a cylindrical Gaussian surface of length 'L' and radius 'r'

The electric flux through the top surface,

$\Phi_{tap} = \int \vec{E}.\vec{dA} = \int E\, dA \cos 90^0 = 0$ — 2

The electric flux through the bottom surface,

$\Phi_{bottom} = \int \vec{E}.\vec{dA} = \int E\, dA \cos 90^0 = 0$

Then the total electric flux through the curved surface,

$\Phi_{curve} = \int \vec{E}.\vec{dA} = \int E\, dA \cos 0^0 = E\int dA$ — 1

$\Phi_{curve} = E\, 2\pi rL$

Then the **total electric flux** through the **Gaussian surface**,

$\Phi_E = \Phi_{top} + \Phi_{bottom} + \Phi_{curve}$; $\Phi_E = E\,(2\pi rL)$

By Gauss law, $\Phi_E = \frac{Q_{in}}{\varepsilon_0}$; $E\,(2\pi rL) = \frac{\lambda L}{\varepsilon_0}$; — 1

$E = \frac{\lambda}{2\pi\varepsilon_0 r}$ In vector notation, $\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 r}\hat{r}$ — 1

Here $\hat{r} \rightarrow$ unit vector perpendicular to the curved surface outwards.

If $\lambda > 0$, then $\vec{E}$ points perpendicular outward ($\hat{r}$) from the wire and if $\lambda < 0$, then $\vec{E}$ points perpendicular inward ($-\hat{r}$).

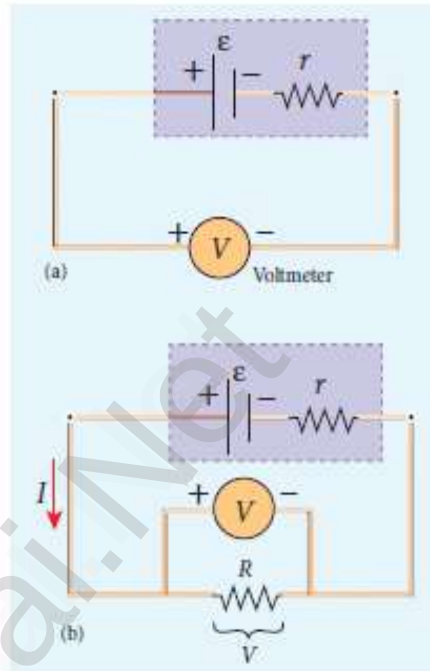
Total: 5

38 (a)

Internal resistance of a cell using voltmeter:

A real battery is made of electrodes and electrolyte. There is resistance to the flow of charges within the battery and this resistance is called internal resistance (r)

The **emf of the cell** is measured by **connecting high resistance** voltmeter across it without connecting the external resistance R. This circuit may be considered as open, the voltmeter reading gives the emf (ξ) of the cell. Then external resistance is included in the circuit and current 'I' is established in the circuit.



2

This circuit is then considered as close, the voltmeter reading gives the potential difference (V) across 'R'

By Ohm's law, = IR (or) $I = \frac{V}{R}$ ……….(1)

1

5

Due to internal resistance of the cell, the voltmeter reads the value "V" which is less than the emf (ξ). It is because, certain amount of voltage (Ir) has dropped across the internal resistance 'r'. Hence

$$V = \xi - Ir \quad ----(2)$$

$$(or)\ \ Ir = \xi - V$$

1

$$\therefore \quad r = \frac{\xi - V}{I}; \ = \left[\frac{\xi - V}{V}\right]R$$

Since ξ, V and R are known, internal resistance 'r' and total current 'I' can be determined.

1

The power delivered to the circuit is, I = I ξ ; = I (V + Ir); = I (IR + Ir)

$P = I^2R + I^2r$

where, $I^2R \rightarrow$ power delivered to R

$I^2r \rightarrow$ power delivered to r

38 (b)	**(i) Faraday's laws of electromagnetic induction.** **Faraday's first law:** Whenever **magnetic flux linked** with a **closed circuit** changes, an emf is induced in the circuit. The induced emf lasts so long as the change in magnetic flux continues.	1	5
	Faraday's second law: The magnitude of induced emf in a closed circuit is **equal to the time rate of change of magnetic flux linked with the circuit.** If magnetic flux linked with the coil changes by $d\Phi_B$ in time dt, then the induced emf is given by, $\varepsilon = -\frac{d\phi_B}{dt}$ The negative sign in the above equation gives the direction of the induced current. If a coil consisting of 'N' turns, then $\varepsilon = -N\frac{d\phi_B}{dt}$ $\varepsilon = -\frac{d(N\phi_B)}{dt}$. Here $N\phi_B$ is called flux linkage.	2	
	(ii) The magnitude of induced emf (e) = $\frac{d\phi}{dt}$	1	
	$= \frac{4 \times 10^{-3}}{0.4} = 10 \times 10^{-3}$ e = 10 mV	1	