HIGHER SECONDARY SECOND YEAR EXAMINATION – MARCH 2023
PHYSICS ANSWER KEY

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

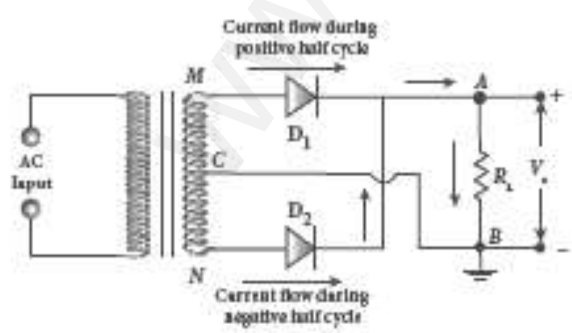
Answer all the questions. 15x1=15

Q. No.	OPTION	TYPE – A	Q. No.	OPTION	TYPE – B
1	(c)	$\lambda_p \propto \lambda_e^2$	1	(b)	Shape memory alloys
2	(c)	$\frac{3}{8}I$	2	(c)	900 Vm^{-1}
3	(c)	900 Vm^{-1}	3	(c)	4.5 Ω
4	(c)	4.5 Ω	4	(b)	Water
5	(d)	Yellow–Violet–Orange–Silver	5	(a)	–40 V
6	(d)	$\frac{h}{\pi}$	6	(a)	+Z direction
7	(b)	2D	7	(c)	Energy density
8	(c)	Energy density	8	(b)	2D
9	(a)	+Z direction	9	(d)	1.1 eV
10	(b)	30^0	10	(c)	$\frac{3}{8}I$
11	(c)	Voltage regulator	11	(b)	30^0
12	(a)	–40 V	12	(d)	Yellow–Violet–Orange–Silver
13	(b)	Water	13	(d)	$\frac{h}{\pi}$
14	(d)	1.1 eV	14	(c)	Voltage regulator
15	(b)	Shape memory alloys	15	(c)	$\lambda_p \propto \lambda_e^2$

DEPARTMENT OF PHYSICS, SRMHSS, KAVERIYAMPOONDI, TIRUVANNAMALAI.

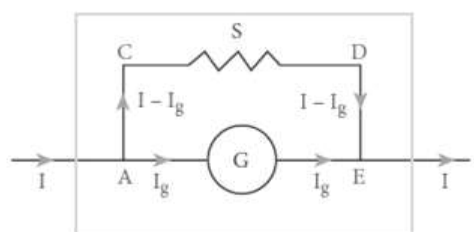
PART – II

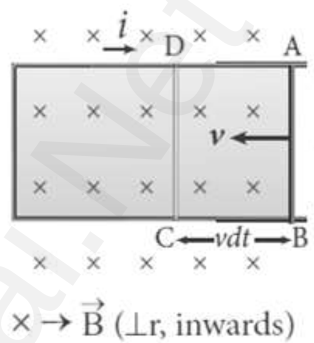
Answer **any six** questions. Question number **24 is compulsory.** 6x2=12

16	The electric field at a point **'P' at a distance 'r' from the point charge 'q'** is the force experienced by a unit positive charge placed at that point P. S.I unit is N C^{-1} **(or)** $\vec{E} = \frac{\vec{F}}{q_0} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$	2 1
17	The **ratio of voltage across L or C** to the **applied voltage** at resonance. (or) Q factor = $\frac{\text{Voltage across L (or)C}}{\text{Applied Voltage}}$ (or) Q factor = $\frac{1}{\sqrt{LC}}\frac{L}{R}$; Q factor = $\frac{1}{R}\sqrt{\frac{L}{C}}$	2 1
18	It state that the **line integral of magnetic field over a closed loop** is μ_0 times **net current enclosed by the loop.** $\oint \vec{B}.\vec{dl} = \mu_0 I_0$	2
19	The glittering of diamond is due to **the total internal reflection** of light happens inside the diamond. The **refractive index of diamond is 2.417** and the **critical angle is 24.4⁰**. Diamond has large number of cut plan faces. So light entering the diamond get total internally reflected from many cut faces before getting out. This gives a sparkling effect for diamond.	2
20	$\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2}$ or $\frac{a_1+a_2}{a_1-a_2} = \sqrt{\frac{I_{max}}{I_{min}}} = \sqrt{\frac{36}{1}} = 6$ $\frac{a_1}{a_2} = \frac{6}{1}$; $a_1 : a_2 = 6 : 1$	2
21	**Work function:** The minimum energy needed for an electron to escape from the metal surface -------- **1½** **Unit: electron volt (eV)** (or) J -------- **½** (or) $h\nu_0 = \phi_0$, ν_0 - threshold frequency -------- **1**	2
22	**The number of nuclei decayed per second** and it is denoted as R. or R = $\frac{dN}{dt}$ -------- **1½** Its unit is Becquerel (Bq) and curie (Ci) -------- **½**	2
23		2
24	$R_T = R_0(1 + \alpha(T-T_0))$ -------- **1** $R_{100} = 3(1 + 0.004 \times 80)$; $R_{100} = 3(1 + 0.32)$ $R_{100} = 3(1.32)$; $R_{100} = 3.96\ \Omega$ -------- **1**	2

PART – II

Answer **any six** questions. Question number **33 is compulsory.** 6x3=18

25	Consider a point charge +q at origin. 'P' be a point at a distance 'r' from origin.  By definition, the electric field at 'P' is $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$ Hence electric potential at 'P' is $V = -\int_\infty^r \vec{E}.\overrightarrow{dr} = -\int_\infty^r \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}\ .\overrightarrow{dr}$ $V = -\int_\infty^r \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}\ .dr\,\hat{r}$ $[\because \overrightarrow{dr} = dr\,\hat{r}]$ $V = -\frac{q}{4\pi\varepsilon_0}\int_\infty^r \frac{1}{r^2}dr$ $[\because \hat{r}.\hat{r} = 1]$ $V = -\frac{q}{4\pi\varepsilon_0}\left[-\frac{1}{r}\right]_\infty^r ; = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r} - \frac{1}{\infty}\right]$ $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$. If the source charge is negative $(-q)$, then the potential also negative and it is given by $V = -\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$	3
26	**Kirchhoff's first law**: It states that the **algebraic sum of currents at any junction** in a circuit **is zero.** $(\sum I = 0)$. It is a statement of conservation of electric charge. **Kirchhoff's second law** The **product of current** and **resistance** is taken as **positive** when the direction of the current is followed and is taken as **negative** when the **direction of current is opposite** to the loop. (or) ($\sum$ **IR** = $\sum \xi$) ------- 1 Mark	1 ½ 1 ½
27	**Galvanometer to an Ammeter:** Ammeter is an instrument used to measure current. A galvanometer is **converted into an ammeter by connecting a low resistance** called shunt in parallel with the galvanometer. The scale is calibrated in amperes.  Ammeter Galvanometer resistance = R_G; Shunt resistance = S Current flows through galvanometer = I_G Current flows through shunt resistance = I_S Current to be measured = I **The potential difference across galvanometer is same as the potential difference shunt resistance.** (i.e.) $V_{\text{Galvanometer}} = V_{\text{shunt}}$ $I_G R_G = I_S S$ $I_G R_G = (I - I_G) S$ – – – (1) ; $S = \frac{I_G}{I - I_G} R_G$ From equation (1) $I_G R_G = S I - I_G S$	3

	$I_G (S + R_G) = S I$; $I_G = \frac{S}{S+R_G} I$ Let Ra be the resistance of ammeter, then $\frac{1}{R_a} = \frac{1}{R_G} + \frac{1}{S}$ $\Longrightarrow R_a = \frac{R_G S}{R_G+S}$ Here, $R_G > S > R_a$ Thus an ammeter is a low resistance instrument, and it always **connected in series to the circuit. An ideal ammeter has zero resistance.**	
28	**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.  The change in magnetic flux in time 'dt' is $d\phi_B =$ $B\,dA = B(l \text{ x } v\,dt)$ $\frac{d\phi_B}{dt} = B\,lv$ This change in magnetic flux results and induced emf and it is given by, $\epsilon = \frac{d\phi_B}{dt}$; $\epsilon = B\,lv$ This emf is called motional emf. **The direction of induced current is found to be clock wise from Fleming's right hand rule.**	3
29	**When the spectrum obtained from the Sun is examined,** it consists of **large number of dark lines** (line absorption spectrum). These dark lines in the solar spectrum are known as Fraunhofer lines. The absorption spectra for various materials are compared with the Fraunhofer lines in the solar spectrum, which helps to identifying elements present in the Sun's atmosphere.	2 1
30	Diode D_1 is reverse biased so, it will block the current and Diode D_2 is forward biased, so it will pass the current. Current in the circuit is $I = \frac{V}{R}$; $= \frac{10}{2+2} = \frac{10}{4}$; $I = 2.5A$	3
31	**The distance (d') light travels in vacuum in the same time it travels a distance (d) in the medium.** $v = \frac{d}{t}, t = \frac{d}{v}$ or $\frac{d'}{c} = \frac{d}{v}$ $or\ d' = \frac{c}{v} d$ If 'n' is the refractive index of the medium, then optical path is; $\boldsymbol{d'}$ **= n d**	1 1 1

32	**Laws of photoelectric effect:** For a given surface, the emission of photo electrons takes place only if the **frequency of incident light is greater than a certain minimum frequency** called the **threshold frequency. ------------------ 1** For a given frequency of incident light, the number of photoelectrons emitted is directly proportional to the intensity of the incident light. The saturation current is also **directly proportional to the intensity of incident light. -------------- ½** Maximum kinetic energy of the photo electrons is **independent of intensity of the incident light. -------------- ½** Maximum kinetic energy of the photo electrons from a given metal is **directly proportional to the frequency of incident light. ------------ ½** There is **no time lag between incidence of light and ejection of photoelectrons.** (i.e.) photo electric effect is an instantaneous process. **--------------- ½**	Any 3 3x1=3
33	235 g of $^{235}_{92}U$ has 6.02 x 10^{23} atoms. In one gram of $^{235}_{92}U$, the number of atoms is equal to $\frac{6.02x10^{23}}{235}$ = 2.56 x 10^{21} ; So the number of atoms present in 1 kg of $^{235}_{92}U$ = 2.56 x 10^{21} x 1000 = 2.56 x 10^{24} Each $^{235}_{92}U$ nucleus releases 200 Mev of energy during the fission. The total energy released by 1 kg of $^{235}_{92}U$ is Q= 2.56 x 10^{24} x 200 Mev = 5.12 x 10^{26} MeV In terms of joules, 5.12 x 10^{26} x 1.6 x 10^{-13} J = 8.192 x 10^{13} J In terms of kilowatt hour, Q = $\frac{8.192\ x10^{13}}{3.6\ x10^{6}}$ **Q = 2.27 x 10^7 kwh**	1 1 1

PART – IV

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

34 (a) (i) The electrostatic force is directly proportional to the **product of the magnitude of the two point charges** and is inversely proportional to the **square of the distance** between the two point charges. Or

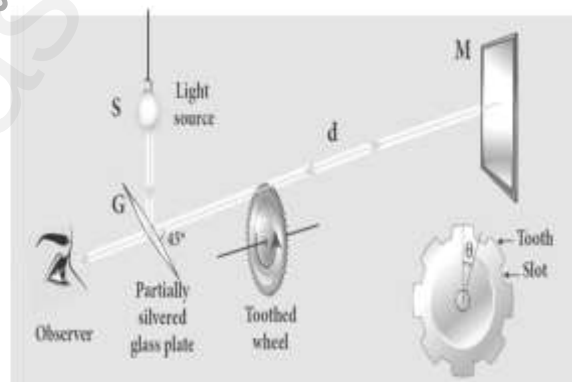
$$\vec{F}_{21} = k\frac{q_1 q_2}{r^2}\hat{r}_{12}$$ — 2

(ii)

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

3

34 (b) **Fizeau's method:**



The light from the source S was first allowed to fall on a partially silvered glass plate G kept at an **angle of 45⁰** to the vertical. The light then allowed to pass through a rotating toothed-wheel with N - teeth and N - cuts.

The speed of rotation of the wheel could be varied through an external mechanism. The light passing through one cut in the wheel get reflected by a mirror M kept at a long distance 'd' **(about 8 km) from the toothed wheel**. If the toothed wheel was not rotating, the reflected light from the mirror would again pass through the same cut and reach the observer through G.

Working:

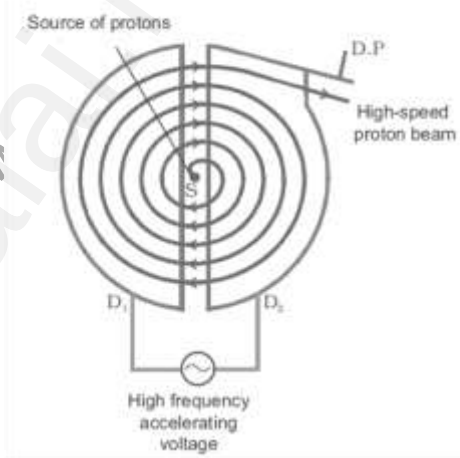
The angular speed of the rotation of the toothed wheel was increased until light passing through one cut would completely be blocked by the adjacent tooth. Let that angular speed be ω

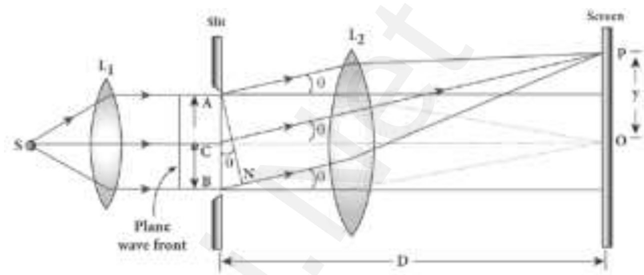
The **total distance traveled by the light from the toothed wheel to the mirror and back to the wheel is '2d' and the time taken be 't'.**

Then the speed of light in air, $v = \frac{2d}{t}$

But the angular speed is, $\omega = \frac{\theta}{t}$

Here θ is angle between the tooth and the slot which is rotated by the toothed wheel within that time "t". Then, — 5

	$\theta = \frac{\text{Total angle of the circle in radian}}{\text{Number of teeth+Number of cuts}}$; $\theta = \frac{2\pi}{2N} = \frac{\pi}{N}$ Hence, angular speed, $\omega = \frac{\left(\frac{\pi}{N}\right)}{t} = \frac{\pi}{Nt}$ (or) $t = \frac{\pi}{N\omega}$ Therefore the speed of light in air, $v = \frac{2\,d}{t} = \frac{2d}{\left(\frac{\pi}{N\omega}\right)}$; $v = \frac{\mathbf{2\,d\,N\omega}}{\boldsymbol{\pi}}$ **The speed of light in air was determined as , v = 2.99792 x 10^8 ms^{-1}**	
35 (a)	**Cyclotron:** It is a device used to **accelerate the charged particles to gain large kinetic energy.** It is also called as **high energy accelerator**. It is invented by Lawrence and Livingston. **Principle:** When a **charged particle** moves normal to the **magnetic field**, it experience **magnetic Lorentz force.** **Construction**:  It consists two semicircular metal containers called Dees. The Dees are enclosed in an evacuated chamber and it is kept in a region of uniform magnetic field acts normal to the plane of the Dees. The two Dees are kept separated with a gap and the source 'S' of charged particles to be accelerated is placed at the centre in the gap between the Dees. Dees are connected to high frequency alternating potential difference. **Working:** Let the positive ions are ejected from source 'S'. It is accelerated towards a Dee-1 which has negative potential at that instant. 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 is provided by Lorentz force, then $\frac{mv^2}{r}$ = Bqv ; r = $\frac{\text{m v}}{\text{Bq}}$; ∴ $r \propto v$ Thus the increase in velocity increases the radius of the circular path. Hence the particle undergoes spiral path of increasing radius. Once it reaches near the edge, it is taken out with help of deflector plate and allowed to hit the target T. The important condition in cyclotron is the resonance condition. (i.e.) the frequency 'f' of the charged particle must be equal to the frequency of the electrical oscillator 'f_{osc}' . Hence $f_{osc} = \frac{\text{Bq}}{2\pi\text{m}}$	5

	The time period of oscillation is, $T = \frac{2\pi m}{Bq}$, The kinetic energy of the charged particle is, $KE = \frac{1}{2}mv^2 = \frac{B^2q^2r^2}{2m}$ **Limitations of cyclotron:** (i) The speed of the ion is limited (ii) Electron cannot be accelerated (iii) Uncharged particles cannot be accelerated	
35 (b)	**Diffraction at single slit:** Let a parallel beam of light fall normally on a single slit AB. The centre of the slit is C . A straight line through 'C' perpendicular to the plane of slit meets the centre of the screen at 'O' .Let y be the distance of of point 'P' from 'O'. The lines joining 'P' to the  different points on the slit can be treated as parallel lines, making and angle θ with the normal 'CO'. All the parallel waves from different points on the slits get interfere at 'P' to give resultant intensity. **Condition for minima:** To explain minimum intensity, divide the slit in to even number of parts. **(1) Condition for P to be first minimum:** Let us divide the slit AB in to two half's each of width $\frac{a}{2}$ The various points on the slit which are separated by the same width $\left(\frac{a}{2}\right)$ called **Corresponding points.** The path difference of light waves from different corresponding points meeting at point P. $\delta = \frac{a}{2}sin\theta$. The condition for P to be first minimum, $\frac{a}{2}sin\theta = \frac{\lambda}{2}$ (or) $a\ sin\theta = \lambda$ **(2) Condition for P to be second minimum** Let us divide the slit AB into four equal parts. Now, the width of each part is $\frac{a}{4}$. Here varies corresponding points on the slit which are separated by the same width$\left(\frac{a}{4}\right)$. The path difference of light waves from different corresponding points meeting at "P" $= \frac{a}{4}\ sin\theta$. The condition for P to be first minimum, $\frac{a}{4}sin\theta = \frac{\lambda}{4}$ (or) $a\ sin\theta = 2\lambda$ **(3) Condition for P to be nth minimum:** Let us divide the slit AB in to 2n equal parts of width $\frac{a}{2n}$ The condition for P to be nth minimum (or) $\boldsymbol{a \sin\theta = n\lambda}$	5

Condition for maxima:

To explain maximum intensity, divide the slit in to odd number of parts. For first maximum, the slit is divided in to three equal parts each of width $\left(\frac{a}{3}\right)$.

Hence $\frac{a}{3}\,sin\theta = \frac{\lambda}{2}$ (or) $a\,sin\theta = 3\frac{\lambda}{2}$

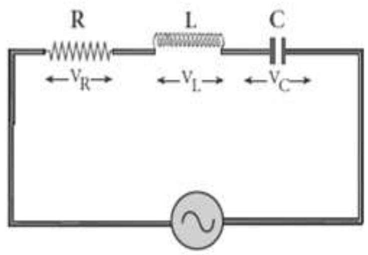
For second maximum, the slit is divided in to five equal parts each of width $\left(\frac{a}{5}\right)$.

Hence $\frac{a}{5}\,sin\theta = \frac{\lambda}{2}$ (or) $a\,sin\theta = 5\frac{\lambda}{2}$

In general, for nth first maximum, the slit is divided in to (2n+1) equal parts each of width $\left(\frac{a}{2n+1}\right)$. Hence $\frac{a}{2n+1}\,sin\theta = \frac{\lambda}{2}$ (or) $a\,sin\theta = (2n+1)\frac{\lambda}{2}$

36 (a)

Series RLC circuit:



$\upsilon = V_m \sin \omega t$

Consider a circuit containing a resistor of resistance 'R', a inductor of inductance 'L' and a capacitor of capacitance 'C' connected across an alternating voltage source.

The applied alternating voltage is given by,

$$\mathbf{v} = \mathbf{v_m} \sin \omega t \qquad ------(1)$$

Let 'i' be the current in the circuit at that instant.

Hence the voltage developed across R, L and C

$V_R = iR$ (V_R is in phase with i)

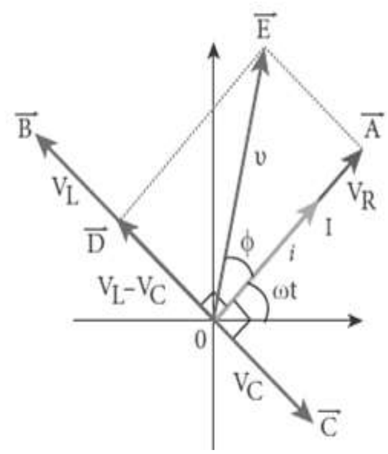
$V_L = iX_L$ (V_L leads i by $\frac{\pi}{2}$)

$V_C = iX_C$ (V_C lags i by $\frac{\pi}{2}$)

The Phasor diagram is drawn by representing current along $\overrightarrow{OI}$, V_R along $\overrightarrow{OA}$, V_L along $\overrightarrow{OB}$ and V_C along $\overrightarrow{OC}$,

If $V_L > V_C$ then the net voltage drop across LC combination is ($V_L - V_C$) which is represented by $\overrightarrow{AD}$ 5

By parallelogram law, the diagonal $\overrightarrow{OE}$ gives the resultant voltage"v"



$v = \sqrt{V_R^2 + (V_L - V_C)^2}$;

$v = \sqrt{i^2R^2 + (iX_L - iX_C)^2}$

$v = i\sqrt{R^2 + (X_L - X_C)^2}$(or)

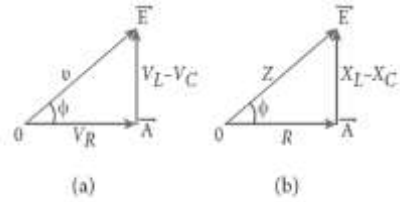
$\boldsymbol{i} = \frac{\boldsymbol{v}}{\sqrt{\mathbf{R^2 + (X_L - X_C)^2}}}$ (or)

$$i = \frac{v}{Z}$$

Where, Z = $\mathbf{R^2 + (X_L - X_C)^2}$ is called **impedance of the circuit**, which refers to the effective opposition to the circuit current by the series RLC circuit.

From the Phasor diagram, the phase angle between 'v' and 'i' is found out by

$\tan \phi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R}$



Special cases:

(i) When $X_L > X_C$, the phase angle ϕ is **Positive.**

It means that $\boldsymbol{v}$ leads $\boldsymbol{i}$ by ϕ.

$(i.e.)\ \ v = V_m \sin \omega t \qquad \& \qquad i = I_m \sin(\omega t - \phi)$

This circuit is inductive.

(ii) When $X_L < X_C$, the phase angle $\boldsymbol{\phi}$ is **negative.**

It means that $\boldsymbol{v}$ lags behind $\boldsymbol{i}$ by ϕ.

$(i.e.)\ \ v = V_m \sin \omega t \qquad \& \qquad i = I_m \sin(\omega t + \phi)$

This circuit is capacitive

(iii) When $X_L = X_C$ the phase angle ϕ ***is zero***.

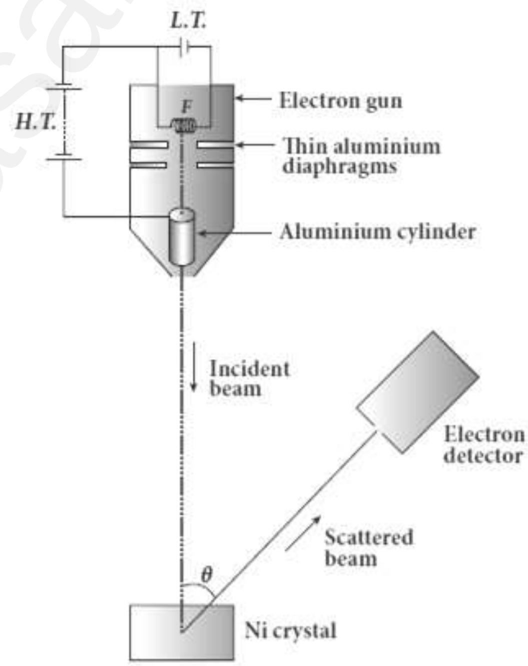
It means that $\boldsymbol{v}$ in-phase with $\boldsymbol{i}$ $(i.e.)\ \ v = V_m \sin \omega t \qquad \& \qquad i = I_m \sin \omega t$

This circuit is resistive

36 (b)

Davisson - Gerner experiment:

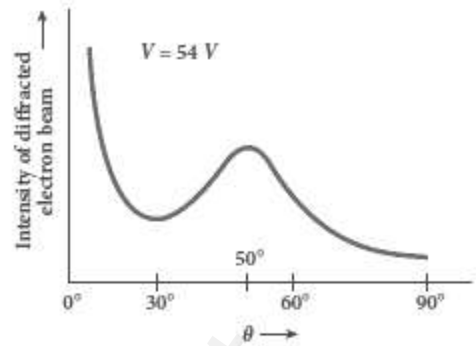
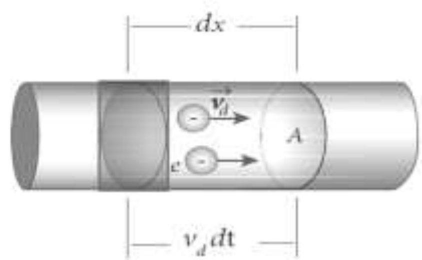
De Broglie hypothesis of matter waves was experimentally confirmed by Clinton Davisson and Lester **Germer in 1927**. They demonstrated that **electron beams are diffracted when they fall on crystalline solids**. Since crystal can act as a three-dimensional diffraction grating for matter waves, the electron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



The **filament F is heated by a low tension (L.T.)** battery so that 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.** 5

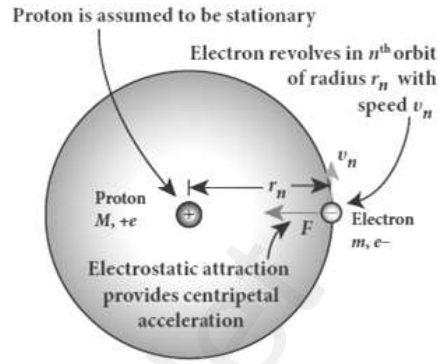
The detector is rotatable in the plane of the paper so that the angle θ between the incident beam and the scattered beam can be changed at our will. **The intensity of the scattered electron beam is measured as a function of the angle θ.**

	The graph shows the variation of intensity of the scattered electrons with the angle θ for the **accelerating voltage of 54V.** For a given accelerating voltage V, the scattered wave shows a peak or **maximum at an angle of 50^0** 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 inter planar spacing of Nickel, the wavelength of the electron wave has been experimentally calculated as **1.65Å. The wavelength can also be calculated from de Broglie relation for V = 54 V as** $\boldsymbol{\lambda} = \frac{12.27}{\sqrt{V}}$ Å $= \frac{12.27}{\sqrt{54}}$ Å **= 1.67** Å This value agrees 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.	
37(a)	**Microscopic model of current and Ohm' law:** Area of cross section of the conductor = A Number of electrons per unit volume = n, Applied electric field =$\vec{E}$ Drift velocity of electrons = $\boldsymbol{vd}$, Charge of an electrons = e Let 'dx' be the distance travelled by the electron in time 'dt', then  $v_d = \frac{dx}{dt}$ (or) $dx = v_d\ dt$ The number of electrons available in the volume of length 'dx' is = A dx X n ; = A v_d dt X n Then the total charge in this volume element is, $dQ = A\ v_d\ dt\ n\ e$ By definition, the current is given by I = $\frac{dQ}{dt}$; = $\frac{A\, v_d\, dt\, n\, e}{dt}$; **I = n e A V_d** **Current density (J):** Current density (J) is defined as the current per unit area of cross section of the conductor. J = $\frac{I}{A}$; = $\frac{n\, e\, A\, v_d}{A}$. J = ne v_d. Its **unit is Am^{-2}** In vector notation, $\vec{J}$ = ne$\vec{v}_d$; $\vec{J}$ = ne$\left[-\frac{e\tau}{m}\vec{E}\right]$; = $-\frac{ne^2\tau}{m}\vec{E}$ Where, $\frac{ne^2\tau}{m} = \sigma \rightarrow$ Conductivity; ∴ $\vec{J} = -\sigma\vec{E}$ But conventionally, we take the direction of current density as the direction of electric field. So the above equation becomes, $\vec{J} = \sigma\vec{E}$ This is called microscopic form of Ohm's law.	5

37 (b)

Radius of n^th orbit:

Consider an atom which contains the nucleus at rest which is made up of protons and neutrons. Let an electron revolving around the state nucleus



Atomic number = Z,

Total charge of n^th nucleus = + e;

Charge of an electron = − e ,

Mass of the electron = m

From Coulomb's law, the force of attraction between the nucleus and the electron is

$$\vec{F}_{Coulomb} = \frac{1}{4\pi\epsilon_0}\frac{(+Ze)\,(-e)}{r_n^2}\hat{r} \quad ;$$

$$\vec{F}_{Coulomb} = -\frac{1}{4\pi\epsilon_0}\frac{Ze_2}{r_n^2}\hat{r}$$

This force provides necessary centripetal force given by.

$$\vec{F}_{Centripetal} = -\frac{mv_n^2}{r_n}\hat{r} \ ;$$

At equilibrium, $\vec{F}_{Coulomb} = \vec{F}_{Centripetal}$

$$-\frac{1}{4\pi\epsilon_0}\frac{Ze_2}{r_n^2}\hat{r} = -\frac{mv_n^2}{r_n}\hat{r} \ ; \frac{1}{4\pi\epsilon_0}\frac{Ze_2}{r_n^2} = \frac{mv_n^2}{r_n} \ .... (1)$$

$$r_n = \frac{(4\pi\epsilon_0)\, m\, v_n^2\, r_n^2}{Z\, e^2} \ ; r_n = \frac{(4\pi\epsilon_0)\, m^2\, v_n^2\, r_n^2}{Z\, e^2 m} \ ; r_n = \frac{(4\pi\epsilon_0)\, [m\, v_n r_n]^2}{Z\, e^2 m}$$

From Bohr's Postulate, $l_n = mv_n r_n = n\frac{h}{2\pi} = n\hbar$

Hence, $r_n = \frac{(4\pi\epsilon_0)\,[l_n]^2}{Z\, e^2 m}$; $r_n = \frac{(4\pi\epsilon_0)\left[\frac{nh}{2\pi}\right]^2}{Z\, e^2 m}$ 5

$$r_n = \frac{(4\pi\epsilon_0)\, n^2 h^2}{Z\, e^2 m \times 4\pi^2} \ ; r_n = \left[\frac{h^2\epsilon_0}{\pi\, m\, e^2}\right]\frac{n^2}{Z} .... (2)$$

$$r_n = \alpha_0 \frac{n^2}{Z} \ .... (3)$$

Where, $\alpha_0 \rightarrow \frac{h^2\epsilon_0}{\pi\, m\, e^2}$ = **0.529Å →Bohr Radius**

For hydrogen, (Z = 1), So radius of n^{th} orbit, $r_n = \alpha_0 n^2$............... (4)

For first orbit, n = 1, (ground level) $r_1 = \alpha_0$ = 0.529Å

For second orbit, n = 2, (first excited level)

$r_2 = 4\alpha_0$ = 4 x 0.529Å = 2.116 Å

For third orbit, n = 3, (second excited level)

$r_3 = 9\alpha_0$ = 9 x 0.529Å = 4.761 Å Thus, radius of the orbit, $\boldsymbol{r_n \propto n^2}$

Velocity of electron in n^th orbit:

According to Bohr's quantization condition, $m\, v_n\, r_n = n\frac{h}{2\pi}$; $m\, v_n \alpha_0 \frac{n^2}{Z} = n\frac{h}{2\pi}$

$$v_n = \frac{h}{2\,\pi\, m\, \alpha_0}\frac{Z}{n} \ ....(5)$$

Hence, $\boldsymbol{v_n} \propto \frac{1}{n}$ (i.e.) the velocity of the electron decreases as the principal quantum number increases.

38 (a) (i)

Properties of electromagnetic waves:

(1) Electromagnetic waves are **produced by any accelerated charge.**

(2) They do not require any medium for propagation. So **electromagnetic waves are non-mechanical wave**. They are **transverse in nature**, (i.e) the oscillating electric field vector, oscillation magnetic field vector and direction of propagation are mutually perpendicular to each other. They **travel with speed of light in vacuum or free space** and it is given by, C = $\frac{1}{\sqrt{\varepsilon_0 \mu_0}}$ = $3 \times 10^8 ms^{-1}$

(3) In a medium with permittivity 'ε' and permeability 'μ', the speed of electromagnetic wave is less than speed in free space or vacuum. (i.e.) $\boldsymbol{v} < \boldsymbol{c}$

Hence**, refractive index of the medium** is, $\mu = \frac{C}{v} = \sqrt{\varepsilon_r \mu_r}$

(4) They are **not deflected by electric or magnetic field.**

(5) They **show interference, diffraction and polarization.**

(6) The energy density (energy per unit volume) associated with and electromagnetic wave propagating in free space is $u = \varepsilon_0 E^2 = \frac{1}{\mu_0} \mathrm{B}^2$

The average energy density for electromagnetic wave is

$$\langle u \rangle = \frac{1}{2} \varepsilon_0 E^2 = \frac{1}{2\mu_0} \mathrm{B}^2$$

(7) The **energy crossing per unit area per unit time and perpendicular to the direction of propagation of electromagnetic wave** is called the intensity.

(8) They carry energy and momentum. The force exerted by an electromagnetic surface is called radiation pressure.

(9) If the electromagnetic wave incident on a material surface is completely absorbed, then the energy delivered is 'U' and the momentum imparted on the surface is $p = \frac{U}{C}$,

(10) If the incident electromagnetic wave of energy 'U' is totally reflected from the surface, then the momentum delivered to the surface is

$$\Delta p = \frac{U}{c} - \left(-\frac{U}{c}\right) = 2\frac{U}{c}$$

The rate of flow of energy crossing a unit area is known as pointing vector for electromagnetic waves. $\vec{S} = \frac{1}{\mu_0}\left(\vec{E} \times \vec{B}\right) = c^2 \varepsilon_0 \left(\vec{E} \times \vec{B}\right)$

(Any 6) 6x½ =3

(ii)

2

Dielectric constant (relative permeability of the medium) is $\varepsilon_r = 2.25$

Magnetic permeability is $\mu_r = 2.5$

Refractive index of the medium,

n = $\sqrt{\epsilon_r \mu_r}$; = $\sqrt{2.25 \times 2.5}$;

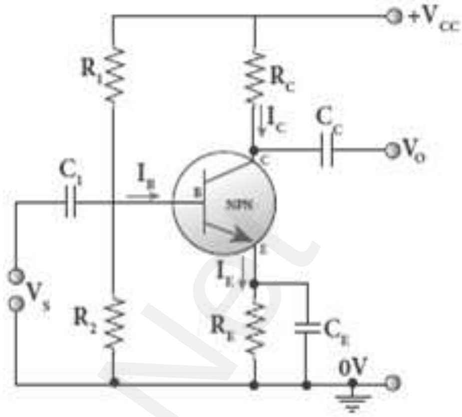
= $\sqrt{5.625}$; n = 2.37

No.	Log
$\sqrt{5.625}$	0.7501 x ½ 0.3751
Antilog	2.372×10^0

38 (b)

Transistor as an amplifier:

Amplification is the process of increasing the signal strength (increase in the amplitude). If a large amplification is required, multistage amplifier is used. Here, the amplification of an electrical signal is explained with a single stage transistor amplifier.



Single stage indicates that the circuit consists of one transistor with the allied components. An NPN transistor is connected in the common emitter configuration. A load resistance, R_C is connected in series with the collector circuit to measure the output voltage.

The capacitor C_1 allows only the ac signal to pass through. The emitter bypass capacitor CE provides a low reactance path to the amplified ac signal.

The coupling capacitor CC is used to couple one stage of the amplifier with the next stage while constructing multistage amplifiers. V_S is the sinusoidal input signal source applied across the base-emitter. The output is taken across the collector-emitter. $I_c = \beta I_B$

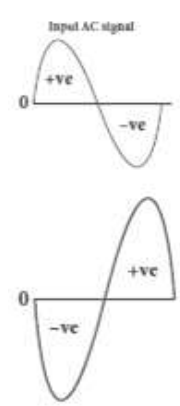
Applying Kirchhoff's voltage law in the output loop, the collector-emitter voltage is $V_{CE} = V_{CC} - I_C R_C$

Working of the amplifier:

(1) During the positive half cycle: Input signal (Vs) increases the forward voltage across the emitter-base. As a result, the base current (I_B) increases. Consequently, the collector current (I_C) increases β times. This **increases the voltage drop across R_C which in turn decreases the collector-emitter voltage (V_{CE}).** 5

Therefore, the input signal in the positive direction produces an amplified signal in the negative direction at the output. Hence, the output signal is reversed by 180^0.

(2) During the negative half cycle:



Input signal (Vs) decreases the forward voltage across the emitter-base. As a result, base current (IB) decreases and in turn increases the collector current (I_C). The increase in collector current (I_C) decreases the potential drop across RC and increases the collector-emitter voltage (V_{CE}).

Thus, the input signal in the negative direction produces an amplified signal in the positive direction at the output. Therefore, **180^0 phase reversal is observed during the negative half cycle of the input signal**