<table>
<thead>
<tr>
<th>Q. No.</th>
<th>Expected Answer / Value Points</th>
<th>Marks</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SECTION-A</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SET1,Q1</td>
<td>No work is done / ( W = qV_{AB} = q \times 0 = 0 )</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SET1,Q2</td>
<td>A diamagnetic specimen would move towards the weaker region of the field while a paramagnetic specimen would move towards the stronger region. / A diamagnetic specimen is repelled by a magnet while a paramagnetic specimen moves towards the magnet. / The paramagnetic get aligned along ( B ) and the diagrammatic perpendicular to the field.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>SET1,Q3</td>
<td>Transmitter, Medium or Channel and Receiver.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SET1,Q4</td>
<td>It is due to least scattering of red light as it has the longest wavelength / As per Rayleigh’s scattering, the amount of light scattered ( \propto \frac{1}{\lambda^4} )</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SET1,Q5</td>
<td>( E = 2V ) ( r = 2\Omega )</td>
<td>( \frac{1}{2} )</td>
<td>1</td>
</tr>
<tr>
<td><strong>SECTION B</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SET1,Q6</td>
<td>Definition- 1 Reason- ( \frac{1}{2} ) Role of bandpass filter- ( \frac{1}{2} )</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Modulation index is the ratio of the amplitude of modulating signal to that of carrier wave</td>
<td></td>
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<tr>
<td></td>
<td>Alternatively ( \mu = \frac{A_m}{A_c} )</td>
<td>( \frac{1}{2} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reason- To avoid distortion.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Role- A bandpass filter rejects low and high frequencies and allows a band of frequencies to pass through.</td>
<td>( \frac{1}{2} )</td>
<td>2</td>
</tr>
</tbody>
</table>
Face-AC

Here \( \theta = \sin^{-1}\left(\frac{2}{3}\right) \)

\[ = \sin^{-1}(0.6) \]

\( \angle i \) on face AC is 30° which is less than \( \angle i_c \). Hence the ray get replaced here.

Kinetic Energy for the second state-

\[ E_k = \frac{13.6eV}{n^2} = \frac{13.6eV}{4} = 3.4 \times 10^{-19} \text{ J} \]

De Broglie's wavelength\( \lambda = \frac{h}{\sqrt{2mE_k}} \)

\[ = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 3.4 \times 1.6 \times 10^{-19}}} \]

\[ = 0.067 \text{ nm} \]

The minimum energy, required to free the electron from the ground state of the hydrogen atom, is known as Ionization Energy.
\[ E_o = \frac{me^4}{8\varepsilon_0^2\hbar^2} \text{i.e., } E_o \propto m \]

Therefore, Ionization Energy will become 200 times

**OR**

<table>
<thead>
<tr>
<th>Formula</th>
<th>Calculation and Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \frac{1}{\lambda} = R \left( \frac{1}{2^2} - \frac{1}{\alpha^2} \right) )</td>
</tr>
<tr>
<td></td>
<td>For shortest wavelength, ( n = \alpha )</td>
</tr>
<tr>
<td></td>
<td>Therefore, ( \frac{1}{\lambda} = \frac{R}{4} \Rightarrow \lambda = \frac{4}{R} = 4 \times 10^{-7} \text{m} )</td>
</tr>
</tbody>
</table>

### SET1,Q10
SET2,Q7
SET3,Q9

| a) Effective resistance of the circuit \( R_E = 6 \Omega \)  
\[ \therefore I = \frac{12A}{6} = 2A \]  
Terminal potential difference across the cell, \( V = E - ir \)  
Also p.d. across 4Ω resistor =4X2V= 8V  
Hence the voltmeter gives the same reading in the two cases. | \( \frac{1}{2} \) |
| b) In series - current same  
In parallel – potential same | \( \frac{1}{2} \) |

### SET1,Q11
SET2,Q15
SET3,Q22

| Definition-  
i.Diagram of Equipotential Surface | \( \frac{1}{2} \) |
| i.Diagram and reason | \( \frac{1}{2} + \frac{1}{2} \) |
| iii.Answer and Reason | \( \frac{1}{2} + \frac{1}{2} \) |

Surface with a constant value of potential at all points on the surface. | \( \frac{1}{2} \) |
i. If the field lines are tangential, work will be done in moving a charge on the surface which goes against the definition of equipotential surface.

Note: If the student writes the formula $I = I_0 \cos^2 \theta$ and draws the
diagram give 1 mark.

i.  

\[ \mu = \tan \beta \]

\[ = \tan 60^\circ = \sqrt{3} = 1.7 \]

### SET1, Q13

<table>
<thead>
<tr>
<th>Sketch of the Graph</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Stopping Potential and Reason</td>
<td>½</td>
</tr>
<tr>
<td>ii. Dependence of Slope and Explanation</td>
<td>½+ ½</td>
</tr>
</tbody>
</table>

(ii) No

As slope is given by \( \frac{h}{e} \) which is constant.

(i) For material B

From the graph for the same value of \( v \), stopping potential is more for material 'B'/

\[ V_0 = \frac{h}{e} (v - v_0) \]

\( \therefore V_0 \) is higher for lower value of \( v_0 \)
### SET1,Q14, SET2,Q12, SET3,Q19

<table>
<thead>
<tr>
<th>Question</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Basic nuclear reaction</td>
<td>1</td>
</tr>
<tr>
<td>[ P \rightarrow n + e^+ + \nu ]</td>
<td></td>
</tr>
<tr>
<td>(b) (i) value of x, y, z</td>
<td>1</td>
</tr>
<tr>
<td>(ii) value of a, b, c</td>
<td>1</td>
</tr>
</tbody>
</table>

---

### SET1,Q15, SET2,Q11, SET3,Q21

<table>
<thead>
<tr>
<th>Question</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Relation for drift velocity</td>
<td>2</td>
</tr>
<tr>
<td>(ii) Effect of temperature</td>
<td>1</td>
</tr>
</tbody>
</table>

---

#### i. When a potential difference is applied across a conductor, an electric field is produced and free electrons are acted upon by an electric force \((-\mathbf{Ee})\). Due to this, electrons accelerate and keep colliding with each other and acquire a constant (average) velocity \(v_d\)

\[ \therefore F_e = -Ee \]

\[ \therefore F_e = \frac{-eV}{l} \]

As \(a = -\frac{F}{m} = -\frac{eV}{m} \)

as \(v = u + at\)

\(u = 0\), \(t = \tau\) (relaxation time)

\(v_d = -a \tau\)

\(v_d = \frac{-eV}{lm} \tau\)

#### ii. Decreases, as time of relaxation decreases.

---

### SET1,Q16, SET2,Q22, SET3,Q15

<table>
<thead>
<tr>
<th>Question</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proof for average power</td>
<td>(1\frac{1}{2})</td>
</tr>
<tr>
<td>Effect on brightness</td>
<td>(1\frac{1}{2})</td>
</tr>
<tr>
<td>Explanation</td>
<td>1</td>
</tr>
</tbody>
</table>
i) \[ P_{av} = I_{av} \times e_{av} \cos \phi \]

For an ideal inductor, \( \phi = \frac{\pi}{2} \)

\[ \therefore P_{av} = I_{av} \times e_{av} \cos \frac{\pi}{2} \]

\[ P_{av} = 0 \]

ii) Brightness decreases

Because as iron rod is inserted inductance increases. Thus, current decreases and brightness decreases.

<table>
<thead>
<tr>
<th>SET1,Q17</th>
<th>SET2,Q21</th>
<th>SET3,Q16</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Diagram of Formation</td>
<td>½</td>
<td>½</td>
</tr>
<tr>
<td>Explanation of formation of Depletion region</td>
<td>½</td>
<td>½</td>
</tr>
<tr>
<td>Barrier potential</td>
<td>½</td>
<td>½</td>
</tr>
<tr>
<td>ii. Circuit diagram of Half wave rectifier</td>
<td>½</td>
<td>½</td>
</tr>
<tr>
<td>Explanation</td>
<td>1</td>
<td>½</td>
</tr>
</tbody>
</table>

i. Due to diffusion and drift, the electrons and holes move across the junctions, creating a final stage in which a region is created across the junction wall, which gets devoid of the mobile charge carriers. This region is called depletion region; the potential difference across the region is called Barriers potential

\[ \frac{1}{2} + \frac{1}{2} \]

ii
Working- If an alternating voltage is applied across a diode in series with a load, a pulsating voltage will appear across the load only during that half cycle of the ac input during which the diode is forward biased.

Therefore, in the positive half-cycle of ac input there is a current through the load resistor $R_L$ and we get an output voltage whereas half-cycle. There is no output during the negative half cycle. Thus, the output voltage is restricted to only one direction and is said to be rectified.

**Note**-If the student draws only the input and output wave form, then award ½ marks only.

<table>
<thead>
<tr>
<th>SET1,Q18</th>
<th>SET2,Q20</th>
<th>SET3,Q13</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Mode of propagation</td>
<td>½</td>
<td>½</td>
</tr>
<tr>
<td>Labeled diagram</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Explanation</td>
<td>½</td>
<td></td>
</tr>
<tr>
<td>b) Reason</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**a) Sky wave propagation**

Long distance communication can be achieved by reflection of radio waves by the ionosphere, back towards the Earth. This ionosphere layer acts as a reflector only for a certain range of frequencies (few MHz to 30 MHz).

**b) Electromagnetic waves of frequencies higher than 30 MHz, penetrate the ionosphere and escape whereas the waves less than 30 MHz are**
reflected back to the earth by the ionosphere.

<table>
<thead>
<tr>
<th>SET1,Q19</th>
<th>SET2,Q19</th>
<th>SET3,Q17</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Identiﬁcation</td>
<td>1+1</td>
<td></td>
</tr>
<tr>
<td>ii. Momentary deflection of galvanometer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reason</td>
<td>$\frac{1}{2}$</td>
<td></td>
</tr>
<tr>
<td>Expressions</td>
<td>$\frac{1}{2}$</td>
<td></td>
</tr>
</tbody>
</table>

i. a. Microwaves  
b. X-rays  

ii. Due to conduction current in the connecting wires and a displacement current between the plates

$$I_d = \epsilon_0 \frac{d\Phi_E}{dt}$$

<table>
<thead>
<tr>
<th>SET1,Q20</th>
<th>SET2,Q18</th>
<th>SET3,Q11</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Collection current</td>
<td>$\frac{1}{2} + \frac{1}{2}$</td>
<td></td>
</tr>
<tr>
<td>ii. Base Current</td>
<td>$\frac{1}{2} + \frac{1}{2}$</td>
<td></td>
</tr>
<tr>
<td>iii. Base voltage</td>
<td>$\frac{1}{2} + \frac{1}{2}$</td>
<td></td>
</tr>
</tbody>
</table>

i. Input signal Voltage

AC Collector Current - $i_c = \frac{V_{ce}}{R_c} = 1.0mA$

Base Current - $i_b = \frac{1.0mA}{100} = 0.01mA$

Base signal Voltage - $i_bR = 0.01mA \times 1k\Omega = 10mv$
Definition- Locus of all points which oscillate in phase.

i. Huygen’s Principle- Each point of the wave front is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions. These travel with the same velocity as that of the original wave front.

ii. The shape and position of the wave front, after time ‘t’, is given by the tangential envelope to the secondary wavelets.

OR

i. Reflection and refraction arise through interaction of incident light with atomic constituents of matter which vibrate with the same frequency as that of the incident light. Hence frequency remains unchanged.

ii. No. [Energy carried by a wave depends on the amplitude of the wave, not on the speed of wave propagation].

iii. For a given frequency, intensity of light in the photon picture is
determined by the number of photon incident normally on a crossing an unit area per unit time.

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**SECTION D**

<table>
<thead>
<tr>
<th>SET1,Q23</th>
<th>SET2,Q23</th>
<th>SET3,Q23</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Principle and working</td>
<td>b. Two values, each, displayed by</td>
<td></td>
</tr>
<tr>
<td>i. Ram</td>
<td>ii. School teacher</td>
<td></td>
</tr>
<tr>
<td>1+1</td>
<td>½+½</td>
<td>½+½</td>
</tr>
</tbody>
</table>

**a. Principle:**
Whenever a coil is rotated in a magnetic field, an emf is induced in it due to the change in magnetic flux linked with it.

**Working:**
As the coil rotates, its inclination (θ) with respect to the field changes. Hence sinusoidal varying emf \( (e = e_0 \sin \omega t) \) is obtained. May also be explained graphically.

**[Note- Give full marks if the student obtains the expression for induced emf mathematically.]**

**b. Values**
- Ram - Scientific aptitude, curiosity, keenness to learn, positive approach, etc (any two) ¼+½
- Teacher - Dedication, concern for students, depth of knowledge, generous, positive attitude towards queries, motivational approach (any two) ¼+½ 3
SECTION E

<table>
<thead>
<tr>
<th>SET1,Q24</th>
<th>SET2,Q26</th>
<th>SET3,Q25</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Labelled diagram</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ii. Expression for the turn ratio in terms of voltage</td>
<td>½</td>
<td></td>
</tr>
<tr>
<td>iii. Ratio of primary and secondary currents in terms of turns</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>iv. Current drawn by primary</td>
<td>½ +½</td>
<td></td>
</tr>
</tbody>
</table>

i. Labelled diagram

SOFT IRON CORE
Principle-
When the current flowing through the primary coil changes, an emf is induced in the secondary coil due to the change in magnetic flux linked with it.

[Note- Give $\frac{1}{2}$ mark to the student who writes only mutual induction only.

\[ \frac{V_s}{V_p} = \frac{N_s}{N_p} \]

iii. For an ideal transformer,
\[ i_p V_p = i_s V_s \therefore \frac{i_p}{i_s} = \frac{V_s}{V_p} = \frac{N_s}{N_p} \]

iv. We have
\[ i_p V_p = i_s V_s = 550 \text{w} \]

\[ V_p = 220 \text{V} \]

\[ i_p = \frac{550}{220} = \frac{5}{2} = 2.5 \text{A} \]

OR

<table>
<thead>
<tr>
<th>a. Meaning of Mutual Inductance</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Proof</td>
<td>2</td>
</tr>
<tr>
<td>c. Diagram</td>
<td>$\frac{1}{2}$</td>
</tr>
</tbody>
</table>

a. Mutual Inductance is the property of a pair of coils due to which an emf induced in one of the coils due to the change in the current in the other coil.
Mathematically \[ e_2 = -\frac{M}{d} \frac{di_1}{dt} \]

\[ M = -\frac{e_2}{d} \frac{di_1}{dt} \]

Let a current \( I_2 \) flow through the outer circular coil. Then
\[ B_2 = \mu I_2 / 2r_2 \]
\[ \phi_1 = \pi r^2 B_2 = \frac{\mu \pi r_1^2}{2r_2} I_2 = M_{12} I_2 \]
Thus \[ M_{12} = \frac{\mu \pi r_1^2}{2r_2} = M_{21} \]

**b.**

Flux at any time ‘t’.
\[ \phi_B = BACos\theta = BACos\omega t \]

From Farday’s Law, induced emf
\[ e = -N \frac{d\phi_B}{dt} = NBA \frac{d}{dt} (Cos\omega t) \]

Thus the instantaneous value of emf is
\[ E = NBA\omega Sin\omega t \]
For maximum value of emf \( Sin\omega t = \pm 1 \)
i.e, \[ e_0 = NBA\omega = 2\pi f NBA \]
Ray diagram showing real image formation as per prescription

\[ \theta_1 = \alpha + \beta \]
\[ \theta_2 = \beta - \gamma \quad \therefore \gamma = \beta - \theta \]

For paraxial rays \( \theta_1 \) and \( \theta_2 \) are small
Therefore, \( n_2 \sin \theta_2 = n_1 \sin \theta_1 \) (Snell's law)
Reduces to
At \( N \)
\[ \sin i = \frac{n_2}{n_1} \]
\[ \therefore n_1 = rXn_2 \]
\[ (\alpha + \beta)n_1 = (\beta - \theta)n_2 \]
\[ n_1 \left( \frac{NM}{OM} + \frac{NM}{MC} \right) = \left( \frac{NM}{MC} - \frac{NM}{MI} \right)n_2 \]
\[ n_1 \left( \frac{1}{-u} + \frac{1}{+R} \right) = \left( 1 + \frac{1}{u} \right)n_2 \]
\[ \frac{n_2}{v'} = \frac{n_1}{u} \quad \frac{n_2 - n_1}{R_1} \]

Applying above relations to refraction through a lens
For surface 1
\[
\frac{n_2 - n_1}{R_1} = \frac{n_2}{v'} - \frac{n_1}{u}
\]  \hspace{2cm} \text{(i)}

For surface 2
\[
\frac{n_1 - n_2}{R_2} = \frac{n_1}{v} - \frac{n_2}{v'}
\]  \hspace{2cm} \text{(ii)}

Adding eqn. (i) and (ii)
\[
(n_2 - n_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = n_1\left(\frac{1}{v} - \frac{1}{u}\right)
\]

For \(u = \infty\) \(v = f\)
\[
\therefore \frac{n_1}{f} = (n_2 - n_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)
\]
\[
\Rightarrow \frac{1}{f} = \left(n_2 - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)
\]

(iii) \(R = 20\, \text{cm} \quad n_2 = 1.5 \quad n_1 = 1 \quad u = -100\, \text{cm}\)
\[
\frac{n_2}{v} = \frac{(n_2 - n_1)}{R} + \frac{n_1}{u}
\]
\[
= \frac{0.5}{20\, \text{cm}} - \frac{1}{100\, \text{cm}}
\]
\[
= \frac{1.5}{100} \, \text{cm}
\]
\[
\Rightarrow V = 100\, \text{cm} \quad \text{a real image on the other side, 100 cm away from the surface.}
\]

OR

i. Labelled ray diagram of Astronomical Telescope \(1\frac{1}{2}\)
ii. Identification of lenses \(\frac{1}{2} + \frac{1}{2}\)
   Justification \(\frac{1}{2} + \frac{1}{2}\)
   Reason \(\frac{1}{2}\)
Definition:
It is the ratio of the angle subtended at the eye, by the final image, to the angle which the object subtends at the lens, or the eye.

b. 
   i. Objective = .5D
      Eye lens = 10D
      This choice would give higher magnification as
      \[ M = \frac{f_o}{f_e} = \frac{P_e}{P_o} \]
      \[ \frac{1}{2} + \frac{1}{2} \]
      \[ \frac{1}{2} \]

   ii. High resolving power / Brighter image / lower limit of resolution (any one)
      \[ \frac{1}{2} \]
      \[ 5 \]
**SET1, Q26**

**SET2, Q25**

**SET3, Q24**

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Symmetry of situation suggests that \( \mathbf{E} \) is perpendicular to the plane and a Gaussian surface through P like a cylinder of flat caps parallel to the plane and one cap passing through P. the plane being the plane of symmetry for the Gaussian surface.

\[
\int E \cdot ds = \int E \cdot ds \quad \text{through caps}
\]

\( \mathbf{E} \perp ds \) for all over curved surface and hence \( E \cdot ds = 0 \)

\[
\int E ds = 2E \Delta s
\]

\( \Delta s = \text{area of each cap} \)

By Gauss' law

\[
\oint \mathbf{E} \cdot d\mathbf{A} = \frac{q}{\varepsilon_0} = \frac{\sigma \Delta s}{\varepsilon_0}
\]

\[
\therefore 2E \Delta s = \frac{\sigma \Delta s}{\varepsilon_0}
\]

\[
E = \frac{\sigma}{2\varepsilon_0}
\]

If \( \sigma \) is positive \( \mathbf{E} \) points normally outwards/away from the sheet

If \( \sigma \) is (-)ve \( \mathbf{E} \) points normally inwards/towards the sheet
Outside

i. Deriving the expression for Field between the plate & outside

ii. Direction of flow of charge

Potential difference between the plates

Capacitance

$U_s = \frac{1}{2} C_s V_s^2$

$U_p = \frac{1}{2} C_p V_p^2$

$\Rightarrow \frac{V_{\text{series}}}{V_{\text{parallel}}} = \sqrt{\frac{C_{\text{equivalent parallel}}}{C_{\text{equivalent series}}}}$

$= \sqrt{\frac{C_1 + C_2}{C_1 C_2}}$

$= \frac{C_1 + C_2}{\sqrt{C_1 C_2}} = \frac{3}{\sqrt{2}}$

OR

Outside

i. Deriving the expression for Field between the plate & outside

Direction of electric field inside and outside

Potential difference between the plates

Capacitance

ii. Direction of flow of charge
Inside
\[ E = E_1 + E_2 \]
\[ \frac{\sigma + \sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0} \]

Outside
\[ E = E_2 - E_1 \]
\[ \frac{\sigma - \sigma}{2\varepsilon_0} = 0 \]

b. Potential difference between plates
\[ V = Ed = \frac{1}{\varepsilon_0} \frac{Qd}{A} \]
\[ \frac{1}{2} + \frac{1}{2} \]

c. Capacitance
\[ C = \frac{Q}{V} = \frac{\varepsilon_0 A}{d} \]
\[ \frac{1}{2} + \frac{1}{2} \]
i. As potential on and inside a charged sphere is given
\[ V = \frac{1}{4\pi\varepsilon_0} \frac{q}{r} = \frac{1}{4\pi\varepsilon_0} \frac{4\pi r^2 \sigma}{r} \]
\[ \frac{1}{2} \]
\[ \therefore, V \propto r \]
\[ \frac{1}{2} \]

Hence, the bigger sphere will be at higher potential, so charge will flow from bigger sphere to smaller sphere.