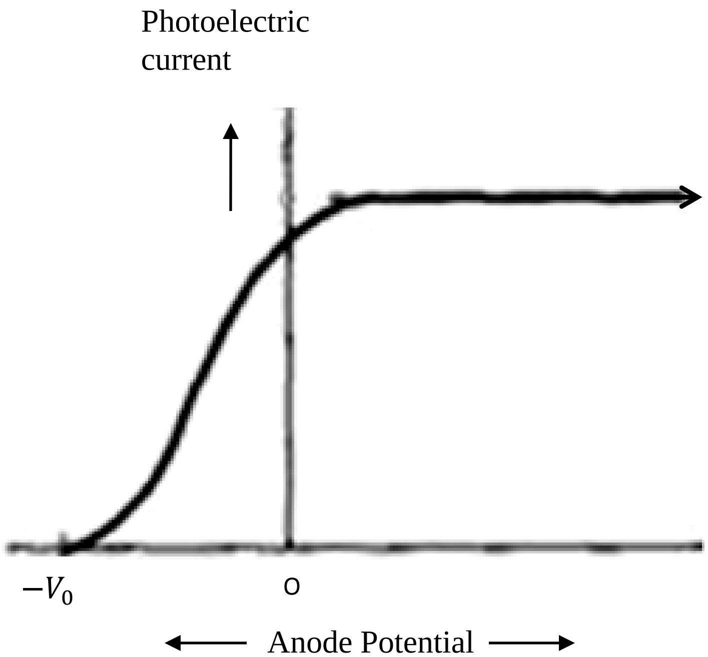
MARKING SCHEME
SET 55/2/2

Q. No.	Expected Answer / Value Points	Marks	Total Marks
1.	It is an equipotential surface, [**alternatively** if the electric field were not normal to the surface, then it would have a component along the surface which would cause work to be done in moving a charge on an equipotential surface.]	1	1
2.	Anticlockwise	1	1
3.	$\frac{\sin i}{\sin r} = \mu$ $\frac{\sin 60°}{\sin r} = \sqrt{3}$ gives r = 30° **(Note: if a student just gives the answer 30º, award this 1 mark.)**	½ ½	1
4.	$U_A > U_B$ ∴ $U_A - U_B$ is positive	½ ½	1
5.	γ rays, X rays, I.R, Microwaves	1	1
6.	$\vec{M} = I\vec{A}$ (or $\vec{M} = IA\,\hat{n}$)	1	1
7.	It is due to conversion of neutron to proton or proton to neutron inside the nucleus. **Alternatively:-** ${}^{A}_{Z}X \rightarrow \beta^{-} + {}_{Z+1}^{A}Y + \bar{\nu}$ ${}^{A}_{Z}X \rightarrow \beta^{+} + {}_{Z-1}^{A}Y + \bar{\nu}$	1	1

8.	Graph ½ Intercept ½  Intercept on potential axis gives the stopping potential	½ ½	1
9.	Formula for current and impedance ½ + ½ Calculation 1 $I = \frac{E_v}{Z} = \frac{E_\vartheta}{\sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}}$ $\omega = 2\Pi f = 100 s^{-1}$ On substitution and simplification, we get $I_V = 0.1\ A$	½ + ½ ½ + ½	2

10.	Identification of equivalent gate 1 Truth Table 1 AND Gate Truth Table A | B | Y 0 | 0 | 0 0 | 1 | 0 1 | 0 | 0 1 | 1 | 1	1 1	2
11.	Total resistance of the circuit 1 Current in arm CD 1 BC and CD are in series and their combination, is in parallel with AD $\therefore \frac{1}{R_p} = \frac{1}{6} + \frac{1}{3} \therefore R_p = 2\Omega$ Total resistance of the circuit $R_{AF} = (2+3)\Omega = 5\Omega$ $\therefore$Net current, $I = \frac{V}{R}$ $I = \frac{15}{5} A = 3A$, so $I_{CD} = 1A$	½ ½ ½ ½	2
12.	Calculation of resultant magnetic field 1 ½ Direction ½ $B = \frac{\mu_0 I r^2}{2(r^2+x^2)^{3/2}}$ Net field at O, $B_0 = \sqrt{2}B = \frac{\sqrt{2}\mu_0 I r^2}{2(r^2+x^2)^{3/2}}$ For small loop($r \ll x$), $B_0 = \frac{\sqrt{2}\mu_0 I}{2x^3}$ Direction of B_0 is at 45^o with the axis of any of the two loops.	½ ½ ½ ½	2
13.	Derivation of current flowing through capacitor 1 ½ To show current leads voltage ½		

If $V = V_0 \sin\omega t$ ½

$q = CV = CV_0 \sin\omega t$ ½

$I = \frac{dq}{dt} = \omega C V_0 \cos\omega t$ ½

Or I = $\omega C V_0 \sin(\omega t + \frac{\pi}{2})$

So, the current leads the applied voltage, in phase by $\pi/2$. ½ 2

14.

Two points of difference	1 + 1

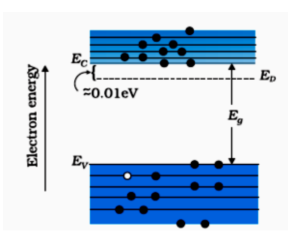
Diamagnetic	Paramagnetic
1. Weakly repelled by external magnetic field.	1. Weakly attracted by magnetic field.
2. Align perpendicular to the field	2. Align parallel to the field.
3. Move from stronger to weaker region.	3. Move from weaker to stronger region.
4. Not affected by temperature	4. Affected by temperature.
5. Susceptibility < 0	5. Susceptibility > 0
6. Permeability μ_r<1	6. Permeability μ_r>1

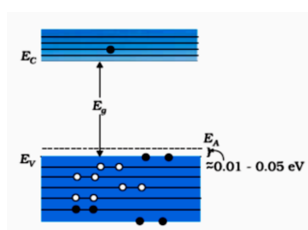
(Any two points of difference) 1+1 2

15.

Energy level diagrams for n & p type	½ + ½
Marking of donor & acceptor level	½ + ½

Energy bands of n-type at T > 0 Energy bands of p type at T > 0





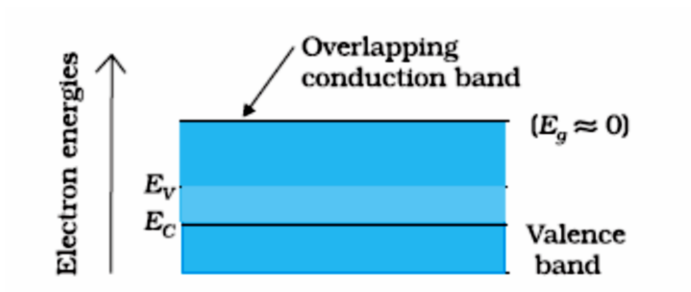
½ + ½

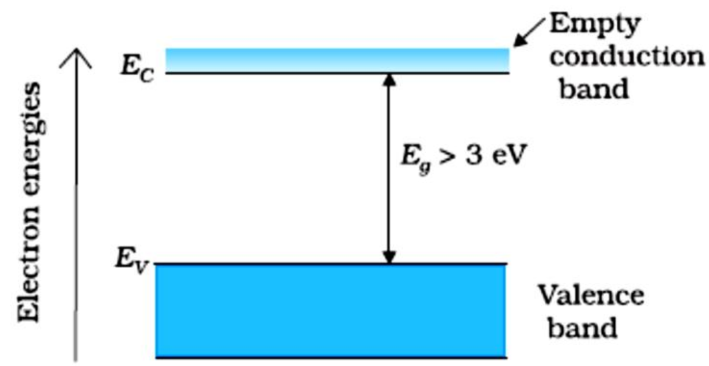
½ + ½

[Note: Deduct only ½ mark in total, if a student does not write the energy values corresponding to the donor and acceptor energy levels.]

OR

Energy Band diagrams	1
Distinction between metal and insulator	1





1

Metal	Insulators
1. Conduction band and valence band overlap on each other. 2. Conduction band is partially filled and valence band is partially empty.	1. There is large energy gap between conduction band and valence band. 2. Conduction band is empty as no electrons can be excited to it from valence band

1

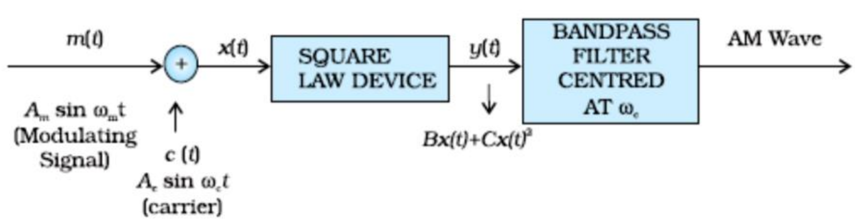
(Award 1 ½ marks for writing two relevant differences even when the diagrams have not been drawn.)

2

16.

Definition	1
Block Diagram of modulator	1

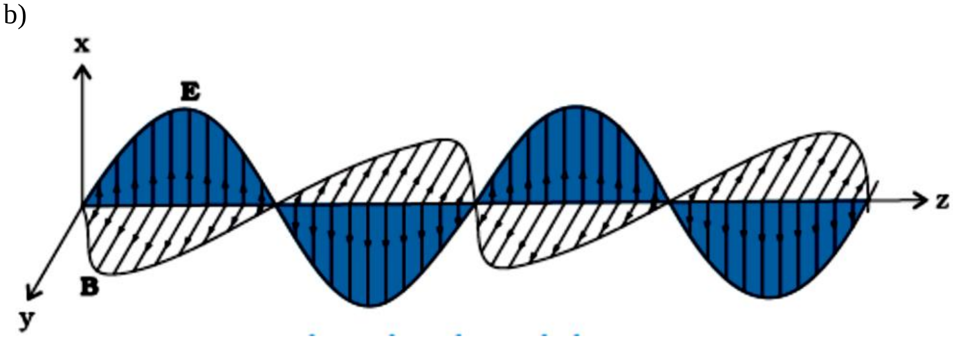
Process of (appropriate) superimposition of low frequency message signal, over a high frequency carrier wave, is called a Modulation. 1

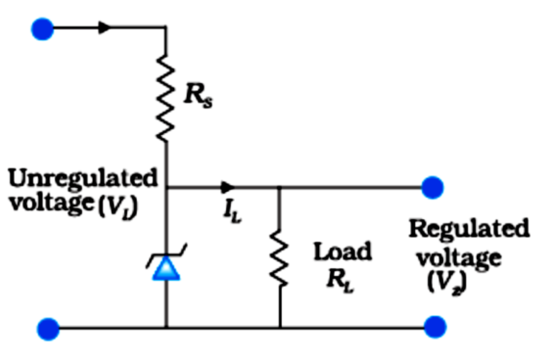


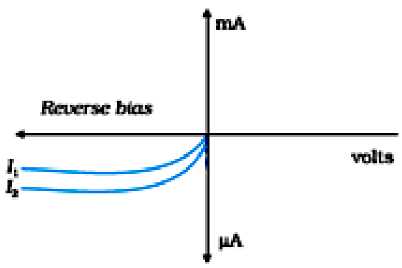
1

(Note: Award this 1 mark if the student just draws the boxes and writes their functions without writing any mathematical expressions.)

2

17.	(i) To show $r_1 = r_2 = \frac{A}{2}$ — 1 (ii) To show $D_m = 2i - A$ — 1 (i) From given figure, $A = r_1 + r_2$ As ray QR is parallel to the base BC, then $r_1 = r_2$, and $i = e$ Therefore , $2r_1$ (or $2r_2$) $= A$ $\Rightarrow r_1 = r_2 = A/2$ (ii) $D = (i - r_1) + (e - r_2)$ $D = (i + e) - (r_1 + r_2)$ or $D = 2i - A$	½ ½ ½ ½	 2
18.	a) Explanation — 1 b) Schematic Diagram — 1 a) An oscillating charge produces an oscillating electric field in space, which produces an oscillating magnetic field. The oscillating electric and magnetic fields regenerate each other, and this results in the production of e-m waves in space. b) 	1 1	 2

19.	Calculation of : ratio of induced voltage 1 ratio of currents 1 ratio of energy stored 1 1) $e = -L\frac{dF}{dt} \quad \therefore \frac{e_1}{e_2} = \frac{L_1}{L_2}$ $= \frac{20}{15} = \frac{4}{3}$ 2) $e_1 I_1 = e_2 I_2$ $\frac{I_1}{I_2} = \frac{e_2}{e_1} = \frac{3}{4}$ 3) $U = \frac{1}{2} L I^2$ $\frac{U_1}{U_2} = \frac{L_1 I_1^2}{L_2 I_2^2} = \frac{3}{4}$	½ ½ ½ ½ ½ ½	3
20.	a) Reason of heavily doping of p and n sides 1 b) Circuit diagram 1 Working 1 (a) Due to heavy doping, the depletion layer become very thin and electric field, across the junction, becomes very high even for a small reverse bias voltage. (b) Circuit diagram  Any increase/ decrease in the input voltage results in increase/ decrease of the voltage drop across R_s, without any change in the voltage across the Zener diode.	1 1 1	

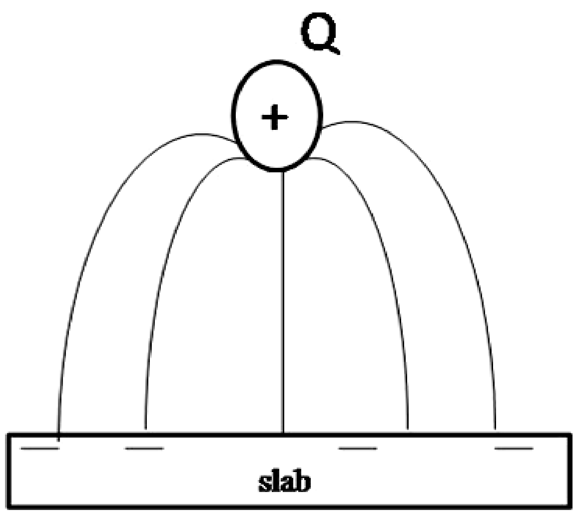
	OR a) Fabrication of photodiode 1 b) (i) Working of photo diode 1 (ii) V – I characteristics 1 (a) Photo diode is fabricated with a transparent window to allow light to fall on the diode. (b) (i) Working:- When reversed biased photo diode is illuminated with light of energy greater than the forbidden energy gap (Eg), electron hole pairs are generated in, or near, the depletion region. Due to junction field, electrons are collected on the n-side and holes on p-side, giving rise to a potential difference. (b)(ii)  $I_2 > I_1$	1 1 1	3

21.

(a) Sketching of electric field lines 1

(b) Magnitude and direction of net field in regions II and III 4 x ½ = 2

(a)



1

b) (i) For region II, $E_{II} = \frac{1}{2\epsilon_0}(\sigma_1 - \sigma_2)$ ½

towards right side / from Sheet A to Sheet B ½

(ii) For region III, $E_{III} = \frac{1}{2\epsilon_0}(\sigma_1 + \sigma_2)$ ½

towards right side /away from two sheets. ½

3

22.

a) Magnitude and direction of magnetic field at 'b' ½ + ½

Magnitude and nature of force ½ + ½

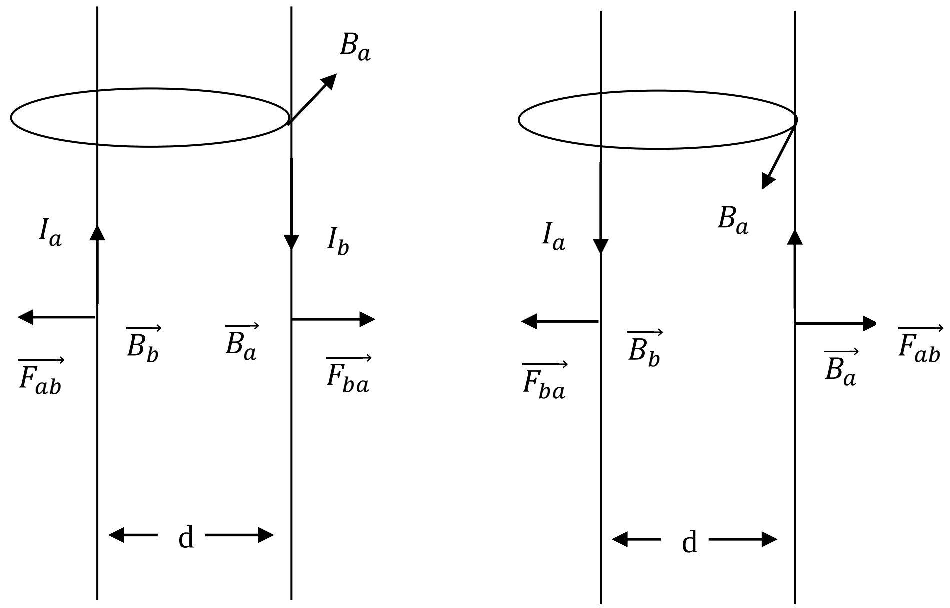
b) Diagram showing magnetic field and force 1

a) The magnitude of magnetic field produced by conductor 'a', at a point on the conductor b:

$B = \frac{\mu_0 I_a}{2\pi d}$ ½

<table>
<tr>
<td></td>
<td>
Direction of magnetic field will be inward / outward perpendicular to the plane of two conductors, depending on the direction of flow of current in conductor ‘a’.

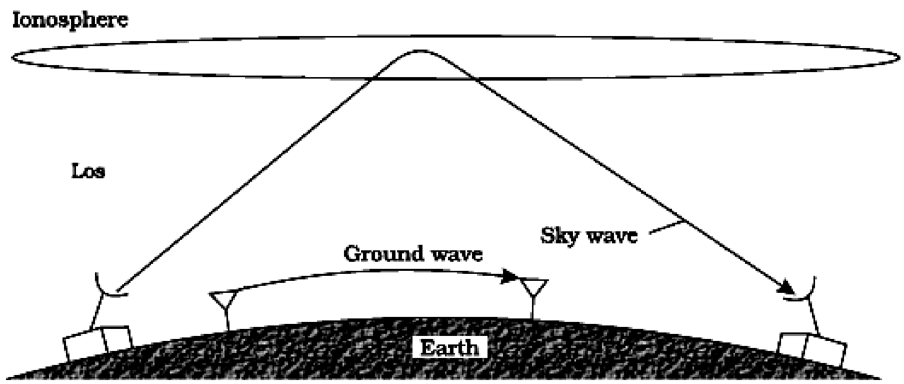
Force per unit length $= \frac{\mu_0 I_a I_b}{2\pi d}$,
Nature: attractive

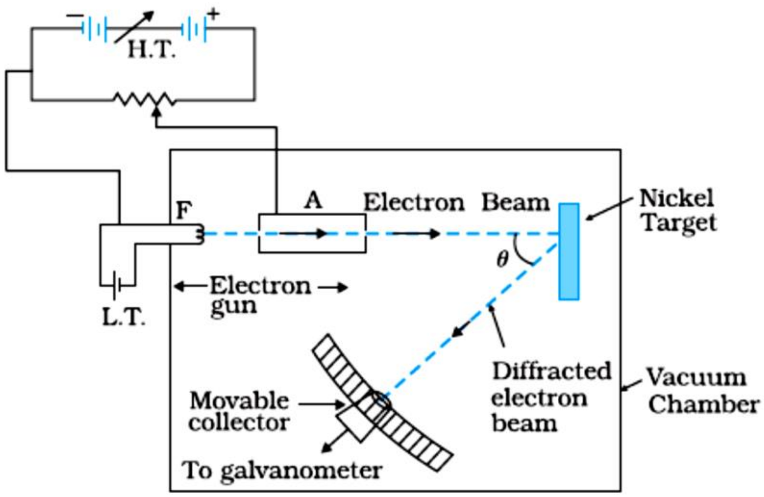
(b)


(Any one of the diagrams)
</td>
<td>½
½
½
1</td>
<td>3</td>
</tr>
<tr>
<td>23.</td>
<td>
Calculation of : Capacitance 1
Charge 1
New Charge 1

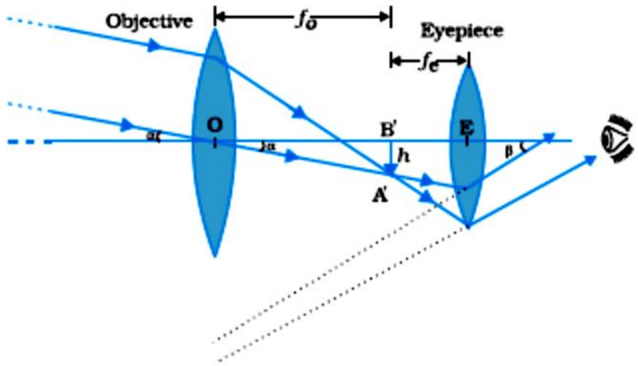
1) $C = \frac{\varepsilon_0 A}{d}$
$= \frac{8.85 \times 10^{-12} \times 5 \times 10^{-3}}{2.5 \times 10^{-3}} \mathrm{F} = 17.7 \times 10^{-12}\mathrm{F}$
2) $Q = CV$
$= 17.7 \times 10^{-12} \times 100\mathrm{C} = 17.7 \times 10^{-10}\mathrm{C}$

3) $Q' = kQ$
$= 8 \times 17.7 \times 10^{-10}\mathrm{C} = 1.416 \times 10^{-8}\mathrm{C}$
</td>
<td>½
½
½
½
½
½</td>
<td>3</td>
</tr>
</table>

24.	Diagrams of ground wave and sky wave ½ + ½ Explanation 1 Frequency range of ground wave & sky wave ½ + ½  Ground wave propagation – The wave glides over the surface or it follows the curvature of earth Sky wave propagation is ionospheric reflection of radio wave back to the earth. Frequency range of ground wave(few MHz) < 2 MHz Frequency range of sky wave(2 MHz) to 40 MHz	1 ½ ½ ½ ½	3
25.	i) Distinction 1 ii) Polaroid & its working ½ + ½ iii) Polarization of sunlight – explanation 1 i) In a beam of Unpolarized light, the vibrations of light vectors are in all directions in a plane perpendicular to direction of propagation. In polarized light, these vibrations are only along one direction. ii) Polaroids consist of long chain of molecules aligned in a particular direction. It polarizes light as it allows only one component of light (electric vectors parallel to the pass axis) to pass through it while the other component is absorbed. iii) The observer receives scattered light corresponding to only one of the two sets of accelerated charges i.e. electrons oscillating perpendicular to the direction of propagation.	1 ½ + ½ 1	3

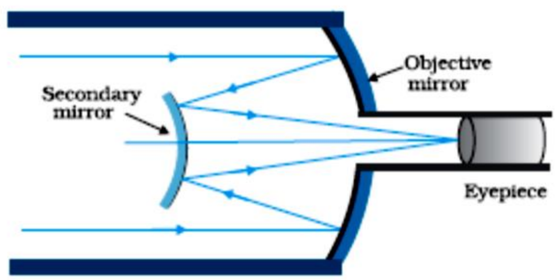
26.	a) Description with the help of diagram 1½ b) Derivation of expression 1½ (a) Diagram  This experiment confirms the wave nature of electron. (b) $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$ $\because$ But K = K.E. = eV $\therefore \quad \lambda = \frac{h}{\sqrt{2meV}}$	1 ½ ½ ½ ½	3
27.	a) Two values displayed by Puja and her father 1+1 b) Stating the phenomenon 1 (a) Any one of the values displayed by Puja – curiosity / observation etc. Any one of the values displayed by father – concern / knowledge / sense of duty etc. (b) Interference of sunlight due to the soap bubble.	1 1 1	3
28.	(a) Labelled ray diagram 2 Considerations required in selection of lenses (i) for large magnifying power ½ (ii) high Resolution ½ (b) Calculation of the distance between objective and eye piece 2		

(a)



2

Alternatively



(Note : deduct 1 mark for not labelling of the diagram)

For large magnifying power f_0 should be large and f_e should be small. ½

For higher resolution diameter of the objective should be large. ½

(b) $\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$ ½

$\frac{1}{v_0} = \frac{1}{f_0} + \frac{1}{u_0} = \frac{1}{1.25} - \frac{1}{2.5} = \frac{1}{2.5}$ ½

$v_0 = 2.5$ cm ½

$L = |f_0| + |f_e|$ (∵ $v_o = f_o$)

= (2.5 + 5.0)cm = 7.5 cm ½

OR

(a) Three distinctive features between the patterns of interference and diffraction fringes. 3
(b) Calculation of width of slit. 2

	<table><tr><th>Interference</th><th>Diffraction</th></tr><tr><td>1. Width of central maxima is same as that of the other fringes. 2. All bright fringes are of equal intensity. 3. Large number of fringes.</td><td>1. Width of central maxima is more than of the other fringes. 2. Intensity of secondary maxima keeps on decreasing. 3. Only a small number of fringes.</td></tr></table>	1 1 1	
	(or any other relevant difference)		
	(b) $y_n = \frac{n\lambda D}{d}$ $d = \frac{n\lambda D}{y_n}$ $= \frac{1 \, X \, 500 X 10^{-9} X \, 1}{2.5 \, X \, 10^{-3}}$m $=2 \times 10^{-4}$ m (=0.2mm)	½ ½ 1	5
29.	a) Expression for total energy of electron 3 b) Calculation of wavelengths 1+1 a) $mvr = \frac{nh}{2\pi}$ $\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_o} \frac{e^2}{r^2}$ $r = \frac{e^2}{4\pi\epsilon_o mv^2}$ $r = \frac{ze^2}{4\pi\epsilon_o m\left(\frac{nh}{2\pi mr}\right)^2}$ $\Rightarrow \; r = \frac{\epsilon_o n^2 h^2}{\pi m e^2}$ Potential energy U = - $\frac{1}{4\pi\epsilon_o} \cdot \frac{e^2}{r}$ $= - \frac{me^4}{4\epsilon_o n^2 h^2}$ KE = $\frac{1}{2} mv^2 \quad = \frac{1}{2} m \left(\frac{nh}{2\pi mr}\right)^2$ $= \frac{n^2 h^2 \pi^2 m^2 e^4}{8\pi^2 m \epsilon_o{}^2 n^4 h^4}$	 ½ ½ ½ ½ ½ ½	

$$KE = \frac{me^4}{8\epsilon_o^2 n^2 h^2}$$

½

$$TE = KE + PE$$
$$= - \frac{me^4}{8\epsilon_o^2 n^2 h^2}$$

(Note: If a candidate does not use Bohr's postulates and writes the final expression for the energy in terms of r award 1 mark.)

b) Rydberg formula :For first member of Lyman series

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$ ½

$$\lambda = \frac{4}{3R}$$ ½

For first member of Balmer Series ½

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$ ½

$$\lambda = \frac{36}{5R}$$

(Note: Award full marks if the student calculates the value of **λ** in the two cases by taking the value of $R = 1.097 \times 10^7 m^{-1}$)

OR

a)	Definition of (i) half life	1
	(ii) average life	1
	Relationship of half life & average life with decay constant	½+ ½
b)	Calculation of time taken	2

(a) Definition: 1

(i) Half life: Time taken by a radioactive nuclei to reduce to half of the initial number of radio nuclei.

(ii) Average life – Ratio of total life time of all radioactive nuclei, to the total number of nuclei in the sample. 1

Relation between half life and decay constant: ½

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

Relation between average life and decay constant $\tau = \frac{1}{\lambda}$ ½

(b)

$$N = N_o\, e^{-\lambda t}$$ ½

$$\frac{3}{4} N_o = N_o\, e^{-(0.3465)t}$$ ½

$$e^{(0.3465)t} = \frac{4}{3}$$

	$0.3465 \times t = log_e(4/3)$ $= 2.303[\log 4 - \log 3]$ $= 2.303[0.6020 - 0.4771]$ $= 2.303 \times 0.1249$ $t = \frac{2.303 \times 0.1249}{0.3465}$ $\therefore$ t = 0.83 days or 19.92 hours **Alternatively:** Also accept if the student takes N=25% $N_o = \frac{1}{4} N_o$ and does the calculations as follows. $T_{\frac{1}{2}} = \frac{0.693}{\lambda} = = \frac{0.693}{0.3465} = 2$ days $N = = \frac{N_0}{2^n}$ or $\frac{25}{100} = \frac{1}{2^n}$ $\Rightarrow n = 2$ But $\frac{t}{T_{\frac{1}{2}}} = n$, $\Rightarrow t = 4$ days Time taken to reduce to 50% = 2days (one half) Additional time taken to reduce to (one fourth) 25% = 2days $\therefore$ Total time taken to reduce to one fourth (25%)=2+2days = 4days	½ ½ ½ ½ ½ ½	5
30.	(a) Principle of potentiometer ½ Definition of potential gradiant ½ Expression for potential gradiant 1 (b) Determination of i. $\frac{e_1}{e_2}$ 1½ ii. Position of null point for cell E_1only 1 ½ (a) Principle: When a steady current flows through a wire of uniform cross -section, the potential drop across any segment is directly proportional to the length of the segment of the wire i.e. $V \propto l$ Potential gradiant is the potential drop across the wire per unit length of the wire i.e. $K = \frac{V}{l}$	½ ½	

	Potential gradient $K = \frac{V}{l} = \frac{IR}{l}$ $K = \frac{I\rho\frac{l}{A}}{l}$ $K = \frac{I\rho}{A}$ (b) (i) $\frac{e_1 - e_2}{e_1 + e_2} = \frac{120}{300} = \frac{2}{5}$ $\frac{e_1}{e_2} = \frac{7}{3}$ (ii) $\frac{e_1 + e_2}{e_1} = \frac{300}{x}$ $\Rightarrow x = 210$cm (where x is the position of null point with cell e_1 only.) **OR** (a) Definition of drift velocity 1 Expression for current density 1 (b) Calculation of power 3 (a) Drift velocity – The average velocity gained by free electrons, when a unit electric field is applied across the conductor. $I = neAv_d$ $= neA\frac{eE}{m}\tau$ $\therefore$ current density $J = \frac{I}{A} = \frac{ne^2E\tau}{m}$ (b) $P = I^2R$ Current flowing through the resistance 2Ω $I = \sqrt{\frac{200}{2}} = 10$A ∴Potential drop across the 2Ω resistor =20V Therefore Potential across parallel combination of 40Ω and 10 Ω = 80V Current through 5Ω; $I = \frac{80}{10}$ A= 8A ∴Power dissipated in the 5Ω resistor $= (8)^2 X\ 5W = 320$W	½ ½ 1 ½ 1 ½ 1 ½ ½ ½ ½ ½ 1 ½	5