Strictly Confidential: (For Internal and Restricted use only)
Senior School Certificate Examination-2020
Marking Scheme – PHYSICS THEORY (042)

(55/5/3)

General Instructions: -

1. You are aware that evaluation is the most important process in the actual and correct assessment of the candidates. A small mistake in evaluation may lead to serious problems which may affect the future of the candidates, education system and teaching profession. To avoid mistakes, it is requested that before starting evaluation, you must read and understand the spot evaluation guidelines carefully. **Evaluation is a 10-12 days mission for all of us. Hence, it is necessary that you put in your best efforts in this process.**
2. Evaluation is to be done as per instructions provided in the Marking Scheme. It should not be done according to one's own interpretation or any other consideration. Marking Scheme should be strictly adhered to and religiously followed. **However, while evaluating, answers which are based on latest information or knowledge and/or are innovative, they may be assessed for their correctness otherwise and marks be awarded to them.**
3. The Head-Examiner must go through the first five answer books evaluated by each evaluator on the first day, to ensure that evaluation has been carried out as per the instructions given in the Marking Scheme. The remaining answer books meant for evaluation shall be given only after ensuring that there is no significant variation in the marking of individual evaluators.
4. Evaluators will mark(√) wherever answer is correct. For wrong answer 'X"be marked. Evaluators will not put right kind of mark while evaluating which gives an impression that answer is correct and no marks are awarded. **This is most common mistake which evaluators are committing.**
5. If a question has parts, please award marks on the right-hand side for each part. Marks awarded for different parts of the question should then be totaled up and written in the left-hand margin and encircled. This may be followed strictly.
6. If a question does not have any parts, marks must be awarded in the left-hand margin and encircled. This may also be followed strictly.
7. If a student has attempted an extra question, answer of the question deserving more marks should be retained and the other answer scored out.
8. No marks to be deducted for the cumulative effect of an error. It should be penalized only once.
9. A full scale of marks 0-70 has to be used. Please do not hesitate to award full marks if the answer deserves it.
10. Every examiner has to necessarily do evaluation work for full working hours i.e. 8 hours every day and evaluate 20 answer books per day in main subjects and 25 answer books per day in other subjects (Details are given in Spot Guidelines).
11. Ensure that you do not make the following common types of errors committed by the Examiner in the past:-
    - Leaving answer or part thereof unassessed in an answer book.
    - Giving more marks for an answer than assigned to it.
    - Wrong totaling of marks awarded on a reply.
    - Wrong transfer of marks from the inside pages of the answer book to the title page.
    - Wrong question wise totaling on the title page.
    - Wrong totaling of marks of the two columns on the title page.
    - Wrong grand total.
    - Marks in words and figures not tallying.
    - Wrong transfer of marks from the answer book to online award list.
    - Answers marked as correct, but marks not awarded. (Ensure that the right tick mark is correctly and clearly indicated. It should merely be a line. Same is with the X for incorrect

answer.)

- Half or a part of answer marked correct and the rest as wrong, but no marks awarded.

12. While evaluating the answer books if the answer is found to be totally incorrect, it should be marked as cross (X) and awarded zero (0)Marks.

13. Any unassessed portion, non-carrying over of marks to the title page, or totaling error detected by the candidate shall damage the prestige of all the personnel engaged in the evaluation work as also of the Board. Hence, in order to uphold the prestige of all concerned, it is again reiterated that the instructions be followed meticulously and judiciously.

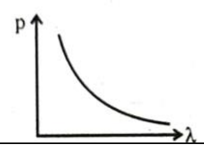
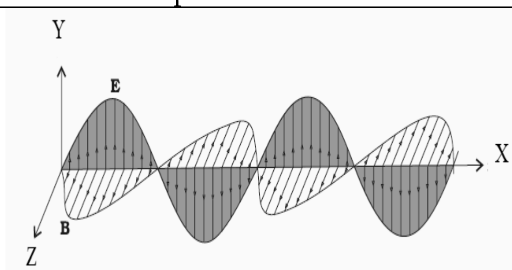
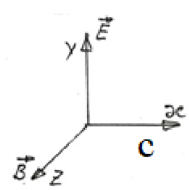
14. The Examiners should acquaint themselves with the guidelines given in the Guidelines for spot Evaluation before starting the actual evaluation.

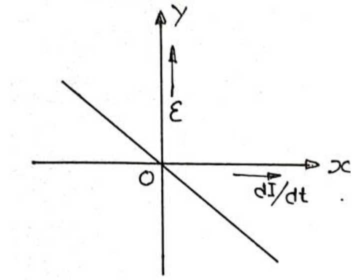
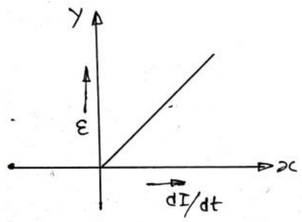
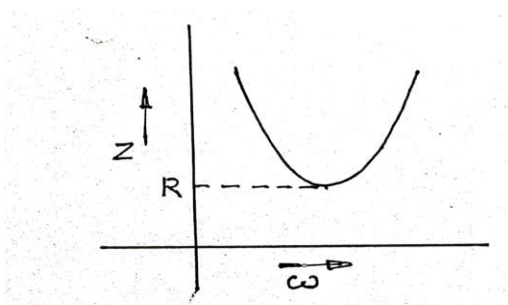
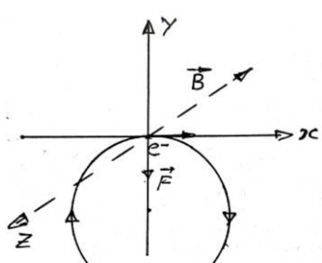
15. Every Examiner shall also ensure that all the answers are evaluated, marks carried over to the title page, correctly totaled and written in figures and words.

16. The Board permits candidates to obtain photocopy of the Answer Book on request in an RTI application and also separately as a part of the re-evaluation process on payment of the processing charges.

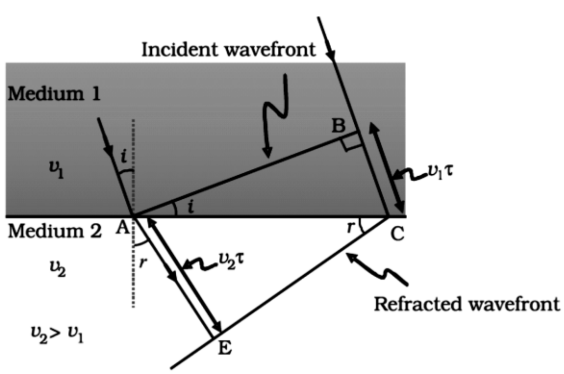
MARKING SCHEME: PHYSICS

QUESTION PAPER CODE: 55/5/3

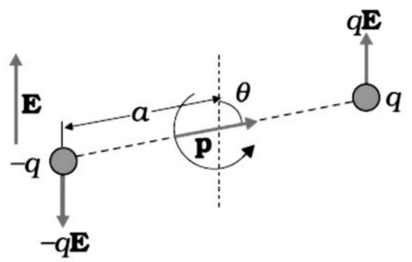
Q. No.	Value Points/Expected Answer	Marks	Total Marks
	SECTION A		
1.	(b) P/2	1	1
2.	(a) 1	1	1
3.	(b) 3:4	1	1
4.	(a) Net Charge enclosed and permittivity of the medium	1	1
5.	(b) $\sqrt{2}\, r$	1	1
6.	(a) Forward bias and energy gap of the semiconductor	1	1
7.	(b) 	1	1
8.	(c) L is large and R is small	1	1
9.	(d) Optical Signals	1	1
10.	(a) $\mathrm{v} \tan\theta = c$	1	1
11.	Rectify	1	1
12.	4:1	1	1
13.	Conductivity/ Resistivity (Also give full credit if a student writes semiconducting nature)	1	1
14.	Electric current	1	1
15.	Electrostatic potential difference/ Electric potential	1	1
16.	 Alternatively 	1	1
17.	(i) for constructive interference path difference, $\Delta p = \mathrm{n}\,\lambda$ (ii) for destructive interference path difference, $\Delta p = (2\mathrm{n}+1)\dfrac{\lambda}{2}, n = 0,1,2,3--$ Alternatively $\Delta p = (2\mathrm{n}-1)\dfrac{\lambda}{2}, n = 1,2,3--$	½ ½	1

18.	 Induced e.m.f. in a coil, $\varepsilon = -L\frac{dI}{dt}$	½	
	[Award one full mark even if the student just draws the graph without writing the expression of induced emf]	½	
	(Note: Award this one mark if a student draws the graph in first quadrant as shown below.) 		**1**
	OR		
	$Z = \sqrt{R^2 + (X_L - X_C)^2}$	½	
	 [Award one full mark even if the student just draws the graph without writing expression of impedance]	½	**1**
19.	Angular deflection of the galvanometer coil per unit current./deflection per unit current Alternatively $I_s = \frac{\phi}{I}$ alternatively $\frac{NAB}{K}$	1	1
20.		1	
	Alternatively: Circular path in the X-Y plane in clockwise sense. **[Note:** If the student just writes, force on the electron will be along negative Y axis, i.e. $F = -e(v\,\hat{i}) \times (B(-\hat{k}) = evB(-\hat{j})$ *award* $\frac{1}{2}$ *mark only*) **OR**	½+½	

	Magnitude of force on side NO is $= F$ **Alternatively** Let force on side MP be $= F_1$ Force on side $NO = \frac{F_1}{2}$ Magnitude of net force $= F_1 - \frac{F_1}{2} = \frac{F_1}{2} = F$ Therefore force on side NO $= \frac{F_1}{2} = F$ Give full credit if a student calculates the force as shown below. $F = \frac{\mu_0}{2\pi} I_1 I_2$	½ ½	1
	SECTION B		
21.	Shortcomings of Rutherford model 1 Use of Bohr's postulates to explain these short comings 1 **Rutherford's Model** (i) Could not explain the stability of the atom (ii) Could not explain the observed line spectrum of hydrogen **Bohr's Atomic Model postulates** (i) Explained the stability of the nucleus by postulating that the electron can orbit the nucleus in only those special orbits (given by $mvr = nh/2\pi$) in which it does not radiates energy. (ii) Explained the line spectrum by postulating that the electron emits photons of well defined unique energies when it undergoes a transition from one permitted orbit to another. [**Note:** (i) Award **one mark** for this part even if the student writes only the first of the two short comings (ii) Award **one mark** for this part even if the student just writes Bohr's two postulates: $mvr = nh/2\pi$ and $h\nu = E_2 - E_1$]	 ½ ½ ½ ½	2
22.	Finding Planck's constant from the graph 1 Effect on stopping potential ½ Justification ½ According to Einstein's Photo electric equation $h\nu = \phi_0 + eV_s$ $eV_s = h\nu - \phi_0$ $V_s = \frac{h\nu}{e} - \frac{\phi_0}{e}$ since $\nu = c/\lambda$	 ½	

	$\therefore V_s = \frac{hc}{e\lambda} - \frac{\phi_0}{e}$ $= \left(\frac{hc}{e}\right)\frac{1}{\lambda} + \left[\frac{-\phi_0}{e}\right]$ Comparing with the equation of straight line y=mx +c (a) The slope of the line $m = \frac{hc}{e}$. Hence, Planck's constant $h = \frac{me}{c}$ (b) Stopping potential will remain same **Justification** Variation of distance of light source from the metal surface will alter the intensity while the stopping potential however depends only on the frequency and not on the intensity of the incident light.	½ ½ ½	2
23.	Effect and justification ½+½ Effect and justification ½+½ **(i)** Intensity of light transmitted by P_1 remains unaffected when P_1 is rotated about the direction of propagation of light. **Justification:** The intensity of unpolarized light transmitted by a Polaroid does not depend on the orientation of the Polaroid with respect to the direction of propagation of light. **(ii)** The intensity of light transmitted by P_2 will vary from I_1 to zero. **Justification:** As per Malus' Law $I = I_0 \cos^2 \theta$ Where θ is the angle between the pass axis of the polaroid P_2 and the pass axis of polaroid P_1. As θ varies from 0^0 *to* $\pi/2$, I_2 will vary from I_1 *to* zero.	½ ½ ½ ½	2
	OR Definition of wave front 1 Obtaining refracted wave front 1 The wave front is a surface of constant phase. **Alternatively** The wave front is the locus of all points that are oscillating in phase. 	1 1	2

24.	Calculation of energy per atom ½ Calculations of atom in 2kg deuterium ½ Calculation of total energy released ½ Calculation of time ½ Energy released per atom $= \frac{3.27}{2} \times 1.6 \times 10^{-13}\, J$ No. of atoms in 2kg of deuterium $= \frac{6.023 \times 10^{23} \times 2000}{2} = 6.023 \times 10^{26}$ Total energy released $= 6.023 \times 10^{26} \times \frac{3.27}{2} \times 1.6 \times 10^{-13} = 15.76 \times 10^{13}\, J$ Time required $= \frac{\text{total energy}}{\text{power of lamp}} = \frac{15.76 \times 10^{13}}{800} = 1.97 \times 10^{11}\, \text{s}$ Time required $= \frac{1.97 \times 10^{11}}{365 \times 24 \times 60 \times 60} = 2.28 \times 10^{6}\, years$ [Note: Give full credit if student calculates time in seconds. Also give full credit if student make calculations by taking approximation of values up to nearest place of decimals.]	½ ½ ½ ½	**2**
25.	Finding Planck's constant from the graph 1 Effect on stopping potential ½ Justification ½ According to Einstein's Photo electric equation $h\nu = \phi_0 + eV_s$ $eV_s = h\nu - \phi_0$ $V_s = \frac{h\nu}{e} - \frac{\phi_0}{e}$ since $\nu = c/\lambda$ $\therefore V_s = \frac{hc}{e\lambda} - \frac{\phi_0}{e}$ $= \left(\frac{hc}{e}\right)\frac{1}{\lambda} + \left[\frac{-\phi_0}{e}\right]$ Comparing with the equation of straight line y=mx +c (a) The slope of the line $m = \frac{hc}{e}$. Hence, Planck's constant $h = \frac{me}{c}$ (b) Stopping potential will remain same **Justification** Variation of distance of light source from the metal surface will alter the intensity while the stopping potential however depends only on the frequency and not on the intensity of the incident light.	½ ½ ½ ½	2

26.	Derivation of the expression for the torque 1½ Identification of the orientation of stable equilibrium ½		
		½	
	Force on q is q**E** and a force on –q is –q**E**. Hence torque $\tau = qE \times 2a\sin\theta$	½	
	$\tau = PE\sin\theta$	½	
	$\vec{\tau} = \vec{P} \times \vec{E}$ For stable equilibrium $\theta = 0^0$	½	
	OR		
	Obtaining the expression for the energy stored 1½ Definition of energy density ½		
	Let the charge on the capacitor plates at any instant, during charging process be q, amount of work done to supply further charge dq to the capacitor $dW = Vdq$	½	
	where V is the potential difference and equals to $\frac{q}{C}$ *Total work done to* charge *the capacitor upto* charge *Q* $W = \int_0^Q Vdq$ $= \int_0^Q \frac{q}{C}dq = \frac{Q^2}{2C} \left(\frac{1}{2}CV^2 = \frac{1}{2}QV\right)$	½	
	Since *Energy stored = work done* $\Rightarrow U = \frac{Q^2}{2C} \left(\frac{1}{2}CV^2 = \frac{1}{2}QV\right)$	½	
	Energy density: Electrical energy stored per unit volume is known as energy density.	½	
	Alternatively: Energy density $= \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\frac{\sigma^2}{\varepsilon_0}$		2

27.	Origin of gamma rays and radio waves ½+½ Main application of each ½+½ Gamma rays are emitted by radioactive nuclei/produced in nuclear reactions. Radio waves are produced by accelerated /oscillating charges/LC circuit. Gamma rays are used for the treatment of cancer/in nuclear reactions. Radio waves are used in communication systems/radio or television communication systems/cellular phones. (or any other correct applications)	 ½ ½ ½ ½	 2
	SECTION C		
28.	(a) Definition of half life 1 (b) Calculation of activity 2 (a) The half life of a radioactive sample is the time in which half of the original number of its nuclei gets decayed. **Alternatively** $T_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.6931}{\lambda}$ Where λ is a decay constant of the given radioactive sample. **Alternatively** Half life of a radioactive sample is the time in which the activity of the sample becomes half of its original activity. **Alternatively** Half life $= (\ln 2)(Mean\ life)$ $= (0.6932)(Mean\ life)$ (b) Activity, $R = \lambda N$ $Now\ \lambda = \frac{0.69312}{T_{1/2}} = \frac{0.6931}{4.5} \times 10^{-9}\ year^{-1}$ Number of atoms in 5g sample of $^{238}_{92}U = N = \frac{5}{238} \times 6.023 \times 10^{23}$ atoms $R = \left(\frac{0.6931}{4.5} \times 10^{-9} \times \frac{5}{238} \times 6.023 \times 10^{23}\right)$ atoms/year $=0.0195 \times 10^{16}$ atoms/year $=1.95 \times 10^{14}$ atoms/year $= \frac{0.0195 \times 10^{16}}{86400 \times 365}$ atoms/second $=6.2 \times 10^{6}$ atoms/second (Note: Award the last 1/2 mark even if the student writes the answer in units of atoms/year)	 1 ½ ½ ½ ½	 **3**

29.

Formation of Potential Barrier	1
Formation of Depletion Region	1
Effect of applying forward bias	1

When a p-n junction is formed, there is a diffusion of the majority charge carriers, from either side, across the junction. ½

This results in making the p-side acquire a negative charge and the n-side acquire positive charge. The resulting electric field finally stops (decreases) the diffusion effect and a stage of equilibrium comes in.

The potential difference developed across the junction is called the barrier potential. ½

Due to diffusion, the diffusing electrons from the n-side combine with the holes on the p-side. Similarly the diffusing holes from the p-side combine with the electrons on the n-side. ½

The resulting charge free region on either side of the junction, is called the depletion region ½

When a forward bias is applied, the width of the depletion region decreases. 1 **3**

OR

Photodiode	1
Working of photodiode	1
V-I characteristics of photodiode	1

Photodiode is a special type of p-n junction diode fabricated with a transparent window to allow light to fall on the diode. 1

Alternatively

A photodiode is a special purpose p-n junction diode that enables it to detect optical signals or to observe change in light intensity.

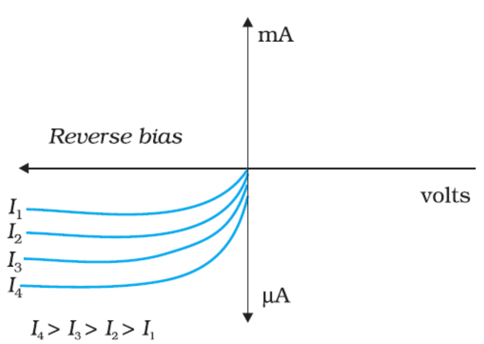
Working

When a photodiode is illuminated with light, (whose photon energy is greater than its energy gap) electron hole pairs get generated. The magnitude of the resulting photocurrent depends on the intensity of the incident light. ½

A photodiode is preferably used under reverse bias. This is because, under reverse bias, it is easier to observe the change in photocurrent with changes in light intensity. ½

It therefore becomes an efficient detector of optical signals.

V-I characteristics



1 **3**

30.	Calculating the total energy of the electron in the second excited state 1 Calculating associated kinetic energy 1 Calculating associated de-Broglie wavelength 1 Energy of the electron in the second excited state $= \frac{-13.6}{3^2} eV$ $= -1.51\, eV$ Kinetic energy (K) in this state $= 1.51\, eV$ de-Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$ $\lambda = \frac{6.63\times10^{-34}}{(2\times9.1\times10^{-31}\times1.51\times1.6\times10^{-19})^{1/2}}$ m $= \frac{6.63}{(43.97)^{1/2}}\times10^{-9}$ m $= 10^{-9}$ m $= 1 nm$	½ ½ 1 ½ ½	**3**
31.	(a) Difference between electrical resistance and resistivity 2 (b) Obtaining the expression for effective resistivity 1 (a) Electrical resistance (R) of a conductor equals the ratio of the potential difference (V) applied across it, to the resulting current (I) flowing through it. (Alternatively: $R = \frac{V}{I}$) The resistivity of a conductor equals the resistance of a wire of unit length and unit area of cross section, drawn from the material of that conductor. (Alternatively: $R = \rho\frac{l}{A}$ or $\rho = \frac{RA}{l}$) (or any other one relevant difference) (b) For the parallel combination equivalent resistance is given by $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{A_1 + A_2}{\rho_{eq}L} = \frac{A_1}{\rho_1 L} + \frac{A_2}{\rho_2 L}$ Where $(A_1 + A_2)$ is the effective area of cross section of combined rod in parallel combination of the rods. $\frac{\rho_1\rho_2}{(\rho_2 A_1 + \rho_1 A_2)} = \frac{\rho_{eq}}{(A_1 + A_2)}$	1 1 ½	

	$\Rightarrow \rho_{eq} = \dfrac{\rho_1\rho_2(A_1+A_2)}{(\rho_2 A_1+\rho_1 A_2)}$ **(Note :**If a student just writes the expression of equivalent resistance, award half mark of this part)	½	3
32.	(a) Calculation of work done 1½ (b) Calculation of the required distance 1½ (a) Work done in placing the charge Q_3 $= Q_3 \times$ net potential at the mid point $= Q_3\left[\dfrac{1}{4\pi\varepsilon_0}\left(\dfrac{Q_1}{r/2}\right)+\dfrac{1}{4\pi\varepsilon_0}\left(\dfrac{-Q_2}{r/2}\right)\right]$ $= \dfrac{1}{4\pi\varepsilon_0}\dfrac{2Q_3}{r}[Q_1\text{-}Q_2]$ (b) Let the required distance be x, to the right of Q_1. We then have net potential at this point = zero $\dfrac{1}{4\pi\varepsilon_0}\left[\dfrac{Q_1}{x}-\dfrac{Q_2}{(x-r)}\right]=0$ $(x-r)Q_1 = Q_2 x$ $x = \dfrac{r}{(Q_1-Q_2)}Q_1$ **Alternatively** Let the required distance be x to the left of Q_1. We then have $\dfrac{1}{4\pi\varepsilon_0}\left[\dfrac{Q_1}{x}-\dfrac{Q_2}{(x+r)}\right]=0$ $(x+r)Q_1 = Q_2 x$ $x = \dfrac{-r\,Q_1}{(Q_1-Q_2)} = \dfrac{r\,Q_1}{(Q_2-Q_1)}$	½ ½ ½ ½ ½ ½	**3**
33.	Identifying the optical instrument Calculation of angular magnification produced Focal length of objective lens $= \dfrac{1}{100}$ m = 1cm		

	Focal length of eye piece $= \frac{1}{40}$ m = 2.5cm Both the objective, as well as the eye piece, are convex lenses of short focal lengths. Hence the given optical instrument is a compound microscope (Note: Award this one mark if a student writes directly compound microscope) When the final image is formed at infinity, total magnification $= \frac{L}{f_0} \times \frac{D}{f_e}$ $L = 20$ cm, $f_0 = 1$cm $D = 25$cm, $f_e = 2.5$cm $\therefore$ Magnification $= \frac{20}{1} \times \frac{25}{2.5} = 200$	1 1 1	**3**
34.	Finding (i) The charge passed through the loop 1 (ii) Change in magnetic flux through the loop 1 (iii) Magnitude of the magnetic field applied 1 (i) Total charge passed through the loop (Q) $Q =$ area under the I-t graph $= \frac{1}{2} \times 0.4 \times 1$ coulomb $= 0.2C$ (ii) Change in magnetic flux Total charge passing $= \left(\frac{\text{change in magnetic flux}}{R}\right)$ Change in magnetic flux $= [R \times 0.2C]$ $= [10 \times 0.2]$ Wb $= 2$Wb (iii) Magnitude of magnetic field applied Let B be the magnitude of the magnetic field applied Initial magnetic flux $= B \times (10 \times 10^{-4})\ Wb$ Final magnetic flux = zero Change in magnetic flux $= (B \times 10^{-3} - 0) = 2$ $\Rightarrow B = 2 \times 10^3\ Wb/m^2$ (**Note:** Award two marks to a student who only calculates charge and not able to calculate correctly the remaining two parts of this question)	½ ½ ½ ½ ½ ½	3
	SECTION D		

35.

(a) Showing No dissipation of power	2
(b) (i) Calculation of self inductance	1
(ii) Calculation of capacitance	2

(a)

$V = V_0 \sin \omega t$

$I = I_0 \sin(\omega t - \pi / 2)$

The instantaneous power supplied to the inductor

$P_L = IV$

$= I_0 \sin(\omega t - \pi / 2)(V_0 \sin \omega t)$ ½

$= -I_0 V_0 \cos\omega t \sin\omega t$ ½

$= -\dfrac{I_0 V_0}{2} \sin 2\omega t$

Now average power over a completer cycle, ½

$\langle P_L \rangle = \left\langle -\dfrac{I_0 V_0}{2} \sin 2\omega t \right\rangle$

$= -\dfrac{I_0 V_0}{2} \langle \sin 2\omega t \rangle = 0$

$\therefore$ Average value of $\sin 2\omega t$ over a complete cycle is zero. ½

Thus average power dissipated over a complete cycle is zero. ½

(b) $(i) X_L = 2\pi f L$ ½

$L = \dfrac{X_L}{2\pi f} = \dfrac{40}{2\pi \times 200} = 0.1 / \pi \text{ henry} = 0.032 H$

Maximum power dissipation takes place at resonance ½

$\nu = \dfrac{1}{2\pi\sqrt{LC}}$ ½

$\therefore C = \dfrac{1}{L \times 300^2 \times 4\pi^2} F$ ½

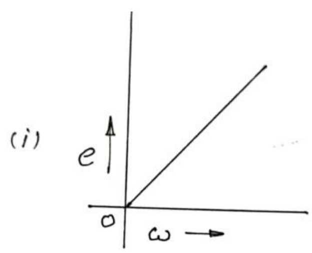
$C = \dfrac{\pi}{0.1 \times 9 \times 10^4 \times 4\pi^2} F = 8.8 \mu F$ ½ 5

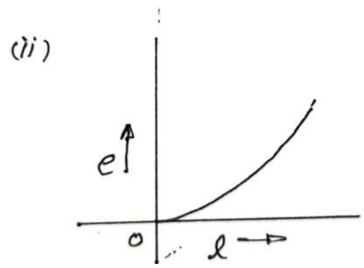
OR

(a) Formula	1		
Plot of two graphs	½+½		
(b) (i) Finding the coefficient of mutual induction	1½		
(ii)Finding the induced emf	1½		

e.m.f. induced in the rod $= \left|-\frac{d\phi}{dt}\right|$ ½

$\therefore e = \frac{1}{2}Bl^2\omega$ ½





½+½

(i) Imagine a current I to flow through the larger coil.

Magnetic flux linked with linked with the smaller coil $= MI$

$= B_{centre} \times \pi \times 10^{-4}$ Wb ½

$= \frac{\mu_0 I}{2 \times 20 \times 10^{-2}} \times \pi \times 10^{-4}$ Wb

$\Rightarrow M = \frac{\mu_0 \pi}{4} \times 10^{-3}$ H ½

$= \frac{4\pi \times 10^{-7} \pi \times 10^{-3}}{4} H$

$= 9.9 \times 10^{-10} H$

$= 10^{-9} H$ ½

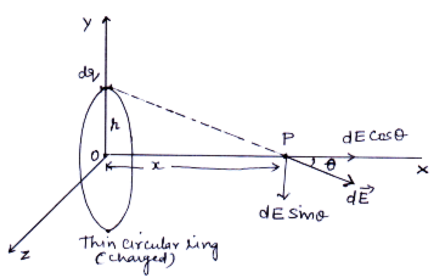
(ii)

$e.m.f.\ induced = -M\frac{dI}{dt}$ ½

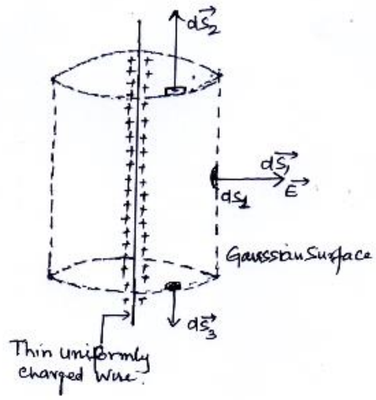
$= -10^{-9} \times \frac{5}{10^{-3}} V$ ½

$= -5 \times 10^{-6} V$ ½

Alternatively

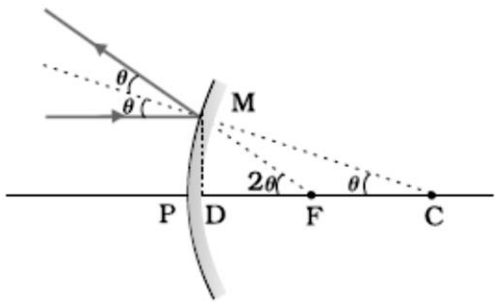
	$e.m.f.\ induced = -\frac{d\phi}{dt}$ $= -\frac{d}{dt}(B_c A_i) = -A_i \frac{dB_c}{dt}$ $= -A_i \frac{d}{dt}\left(\frac{\mu_0 I}{2R}\right)$ $= -\frac{A_i \mu_0}{2R}\frac{dI}{dt}$ $= \frac{-\pi \times 10^{-4} \times 4\pi \times 10^{-7} \times 5}{2 \times \left(20 \times 10^{-2}\right) \times 10^{-3}} V$ $= -\frac{20\pi^2 \times 10^{-6}}{2 \times 20} V$ $= -5 \times 10^{-6} V$	½ ½ ½	5
36.	(a) Two important characteristics 1+1 (b) Derivation of the expression of the electric field 2½ Showing the behaviour as point charge ½ (a) For equipotential surfaces (i) Potential has the same value at all points on the surface. (ii) Electric field is normal to the equipotential surface at all points (iii) Work done in moving any charge between any two points on the equipotential surface is zero (any two) (b)  Electric field due to any elemental (point) charge dq, at point P. $= dE = \frac{1}{4\pi\varepsilon_0}\frac{dq}{(x^2 + r^2)}$ This is directed along AP Its component along the axis OP of the ring is $= dE\ \cos\theta = dE \frac{x}{\sqrt{x^2 + r^2}}$	1+1 ½ ½	

	The component, perpendicular to the axis gets cancelled by the elemental electric field due to another elemental charge symmetrically located on the other side of the axis. Hence total electric field $E = \int \mathrm{dE}\cos\theta$ $= \frac{1}{4\pi\varepsilon_0}\int \frac{\mathrm{dq}}{\left(x^2+r^2\right)}\frac{x}{\sqrt{x^2+r^2}}$ $= \frac{1}{4\pi\varepsilon_0}\frac{x}{(x^2+r^2)^{3/2}}\int \lambda \mathrm{d}l$ $= \frac{1}{4\pi\varepsilon_0}\frac{x\lambda}{(x^2+r^2)^{3/2}}\times 2\pi r$ $= \frac{Q}{4\pi\varepsilon_0}\frac{x}{(x^2+r^2)^{3/2}}$ $Where\ Q = \lambda\times 2\pi r = \text{total charge on the ring}$ This field is directed along the axis. When x much larger than r, we have $E = \frac{Q}{4\pi\varepsilon_0}\frac{x}{(x^2)^{3/2}} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{x^2}$ This corresponds to the expression for the electric field due to a point charge. Thus at large distances the ring behaves like a point charge. (**Note:** Award these three marks even if a student tries to attempt this part) OR (a) Statement of Gauss's law — 1 Derivation of the expression of the electric field — 2½ (b) Finding the increase in potential — 1½ (a) Gauss law: Electric flux through of a closed surface is $\frac{1}{\varepsilon_0}$ times the charge enclosed by the surface. Alternatively $\phi_E = \frac{q}{\varepsilon_0}$	½ ½ ½ ½ 1	5

		½ ½	
	Let the charge be uniformly distributed on a wire $\phi = \oint d\phi = \int_{s_1} \vec{E} \cdot d\vec{s}_1 + \int_{s_2} \vec{E} \cdot d\vec{s}_2 + \int_{s_3} \vec{E} \cdot d\vec{s}_3$		
	$= \int_{s_1} Eds_1 \cos 0^0 + \int_{s_2} Eds_2 \cos 90^0 + \int_{s_3} Eds_3 \cos 90^0$	½	
	$= E\int_{s_1} ds_1 = E.2\pi rl$		
	by Gauss's law	½	
	$\frac{q}{\varepsilon_0} = E \cdot 2\pi rl$		
	$E = \frac{q}{2\pi\varepsilon_0 rl} = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}$	½	
	(b) $E = 10r + 5$ $dV = -E \cdot dr$		
	$\int dV = -\int_1^{10} \vec{E}\, d\vec{r}$	½	
	$= -\int_1^{10} (10r+5)dr$		
	$V = -\left[\int_1^{10} 10r\, dr + \int_1^{10} 5dr\right]$	½	
	$V = 10\left[\frac{r^2}{2}\right]_1^{10} + 5(r)_1^{10}$		5
	$V = -5[100-1] + 5[10-1]$ $V = -5 \times 99 + 5 \times 9 = -540V$	½	
37.	(a)Definition of focal length 1 Obtaining the relation between focal length and radius of curvature 1½ (b)Calculation of angle of emergence 2 Qualitative change in the angle of emergence ½		

(a) **Focal length of mirror**: It is the distance of the point from the pole of mirror through which ray of light moving parallel to its principle axis passes (or appear to come from). 1

Alternatively: It is half of the distance of its centre of curvature from the pole of a mirror.



½

Let C be the centre of curvature of mirror, MD be the perpendicular from M to the principal axis.

$\angle MCP = \theta$ and $\angle MFP = 2\theta$

$$\tan\theta = \frac{MD}{CD} \quad , \quad \tan 2\theta = \frac{MD}{FD} \qquad (1)$$ ½

For small angles, $\tan\theta \approx \theta$ and $\tan 2\theta \approx 2\theta$

From equation 1, $\frac{MD}{FD} = 2\frac{MD}{CD}$

$FD = \frac{CD}{2} \quad ----equation\ (2)$

For small θ, the point D is very close to the point P

$\therefore\ FD \simeq FP = f$ and $CD \simeq CP = R$

$\therefore$ from equation 2, we get $f = \frac{R}{2}$ ½

(b) Applying Snell's law at face AB, we get

$\sqrt{3}\sin 30 = 1 \cdot \sin e$ ½

$\sqrt{3} \times \frac{1}{2} = \sin e$ ½

$\frac{\sqrt{3}}{2} = \sin e$

$\sin 60 = \sin e$

$e = 60^0$ ½

When the medium (the air) in which the prism is kept is replaced with a liquid of refractive index 1.3 the angle of emergence would decrease. It is because bending in the ray of light will be lesser. ½ ½

OR

(a) Definition of resolving power	1
(i) Effect and justification	½+½
(ii) Effect and justification	½+½
(b) Calculation of focal length	2

Resolving power of a telescope is defined as the reciprocal of the smallest angular separation between two distinct objects whose image can be just resolved by it. 1

Alternatively: Resolving power $= \frac{1}{d\theta} = \frac{D}{1.22\lambda}$

Alternatively

It is the reciprocal of the limit of resolution.

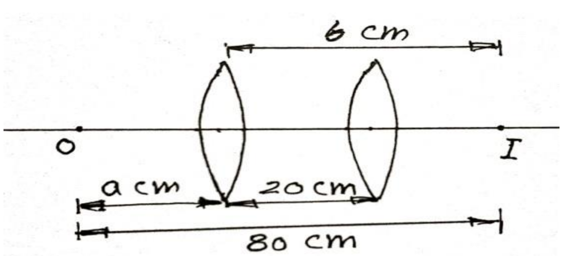
(i) As λ increases, R.P. decreases ½

Reason R.P.$= \frac{D}{1.22\lambda}$ i.e. $R.P. \alpha \frac{1}{\lambda}$ ½

(*ii*) As D increases, R.P. increases ½

Reason R.P.$= \frac{D}{1.22\lambda}$ i.e. $R.P. \alpha D$ ½

The two positions of the lens are as shown



$$\begin{aligned}
&for\ position\ 1\\
&u = -a\ cm\\
&v = b = +(80 - a)\ cm
\end{aligned}$$ ½

for position 2

$$\begin{aligned}
&\text{u} = -(a + 20)\ cm\\
&\text{v} = +\left(b - 20\right) = +(60 - a)\ cm
\end{aligned}$$ ½

	By lens formula $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$ $\therefore \frac{1}{(80-a)}+\frac{1}{a}=\frac{1}{(60-a)}+\frac{1}{(20+a)}$ This gives a(80-a)=(a+20)(60-a) or $80a-a^2=40a+1200-a^2$ *or* $a=30cm$ $\therefore \frac{1}{f}=\frac{1}{50}+\frac{1}{30}=\frac{3+5}{150}=\frac{8}{150}$ $\therefore f=\frac{150}{8}cm=18.75cm$ **Alternatively** $F=\left(\frac{D^2-x^2}{4D}\right)=\frac{80^2-20^2}{4\times 80}=18.75cm$ **Alternatively** The values of $a=\|u\|$ *and* $b=\|v\|$ simply get interchanged in the two positions. $b+a=80cm$ $b-a=20cm$ *This gives* $b=50cm$ *and* $a=30cm$ $\therefore \frac{1}{f}=\frac{1}{50}-\left(\frac{1}{-30}\right)=\frac{8}{150}$ $f=18.75\ cm$	½ ½ 1+1 ½ ½ ½ ½	5