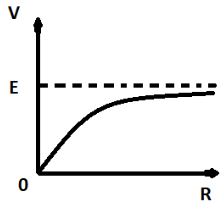
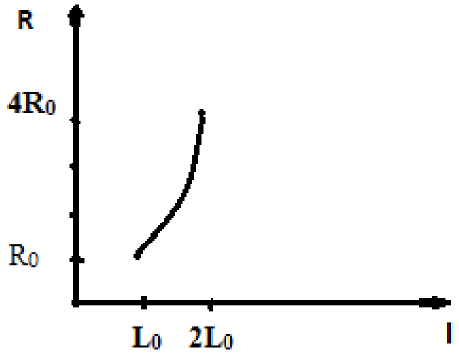
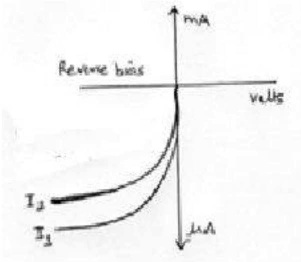
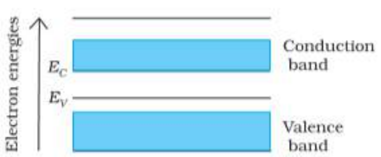
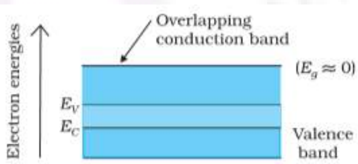
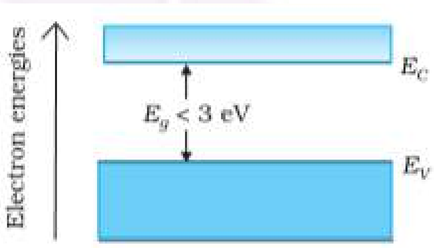
MARKING SCHEME: PHYSICS
QUESTION PAPER CODE: 55/4/1

Q.No.	Value Points/Expected Answer	Marks	Total Marks
	SECTION A		
1	(b) 	1	1
2	(c) $\frac{R}{2}$	1	1
3	(d) $\frac{\mu_0 I}{2R} \times (1 - \frac{1}{\pi})$	1	1
4	(b) Zero	1	1
5	(b) 1:1	1	1
6	(c) 4 I	1	1
7	(a) 2×10^{-5} T acting downwards	1	1
8	(c) π	1	1
9	(a) Infra red region	1	1
10	(a) Only on impact parameter	1	1
11	90^0 or $\frac{\pi}{2}$	1	1
12	Decreasing/Lower	1	1
13	Middle/mid point /center OR Decrease	1	1
14	Zero	1	1
15	$\beta^- / e^{-1} / electron$	1	1
16	Because the electrostatic force is conservative in nature **Alternatively:-** Electric field is conservative in nature / work done by or against the electric field does not depend upon the path followed.	1	1
17	Magnetic declination is the angle between the magnetic meridian and the geographic meridian at a place on the earth.	1	1
18	The displacement current will decrease. $Hint: -\left(I_C = \frac{V}{X_C} = \frac{V}{\left(\frac{1}{\omega C}\right)} = \omega CV\right)$ / the rate of change of electric flux/electric field will decrease	1	1
19	Reflecting type telescope Reason/Justification :- Mirror have large aperture/high resolving power/ free from chromatic aberration /free from spherical aberration. (Any one)	½ ½	1
20	No As there will be discontinuity for the flow of charge carriers / no contact at atomic level. (Any One Justification) OR The forward current is large due to majority charge carriers which are very large in number. Hence resistance in forward bias is low. Alternatively: Depletion region decreases or barrier potential decreases.	½ ½ 1	1

SECTION B			
21	(i) Net capacitance of the combination 1 (ii) Total Charge stored in the network 1 (i) Net Capacitance => $\frac{1}{C_{net}} = \frac{1}{10} + \frac{1}{5}$ $C_{net} = \frac{10}{3}\,\mu F$ (ii) $q = C_{net}\ V = \frac{10}{3} \times 3 = 10\ \mu\, C$	½ ½ ½+ ½	2
22	(a) Graph 1 (b) Final resistance 1 (a) $R = S\frac{l}{A} = S\frac{l^2}{V}$  [Note if a student draws only the graph correctly, award full 1 mark] (b) Resistance becomes 4 R_0 (Hint :- As $R = \frac{\rho l}{A} = \frac{\rho l^2}{Al} = \frac{\rho l^2}{V}$) (V= Volume) $R \propto l^2$	½ ½ 1	 2
23	(i) Finding average power dissipated 1 (ii) Finding instantaneous current 1 (i) Average power dissipated $P_1 = I_{eff} \times V_{eff} \times \cos 0^0$ $= I_{eff} \times I_{eff} \times R \times 1 = I_{eff}^2 R = \frac{{V_0}^2}{R}$ (ii) Instantaneous Current $I = \frac{V}{R} = \frac{V_0}{R} \sin \omega t = I_0 \sin \omega t$	½ ½ ½+ ½	 2

24	(a) Comparison of frequencies 1 (b) Justification 1 (a) Let υ_{0A} , υ_{0B} and υ_{0C} be their threshold frequencies for the surfaces A,B and C Therefore $\upsilon_{0A} > \upsilon_{0B} > \upsilon_{0C}$ (b) Justification :- If the frequency of incident light/photon is υ $h\upsilon = h\upsilon_0 + E_k$ Therefore $\upsilon_{0A} > \upsilon , \upsilon_{0B} = \upsilon \; and \; \upsilon_{0C} < \upsilon$ OR (i) Effect on the energy of the photo electrons 1 (ii) Effect on photoelectric current 1 (i) The energy of the emitted photoelectrons increases As $E_k = h\upsilon - \phi_0$ As υ increases, $\mathbf{E_k}$ also increases (ii) Photo current will not be affected As, increase of υ, $\mathbf{E_k}$ will increase but not the number of photoelectrons [Alternatively photocurrent depends upon intensity of light and not on frequency]	1 ½ ½ ½ ½ ½ ½	2 2
25	Explanation of set up of potential barrier 2 Diffusion current is set up across the junction due to the concentration difference of the majority charge carriers on the two sides of the junction. This diffusion develops an electric field from n- side to p- side across the junction which creates a drift current in the opposite direction. When diffusion and drift current become equal in magnitude the potential difference across the junction is the barrier potential.	1 ½ ½	2
26	(a) Photo diode in reverse biasing 1 (b) V-I Characteristics of photodiode 1 (a) Because the fractional change in the minority carriers dominated very weak reverse current is more easily measurable than fractional change in forward biased large current	1	

	(b)  $I_1 > I_2$ OR (a) Level of doping and biasing in LED 1 (b) Any two advantages of LED 1 (a) It is a heavily doped p-n junction. It operates in forward biasing (b) Advantages Low operational voltage/less power /fast action / nearly monochromatic / long life (Any two)	1 ½ ½ ½ + ½	2 2
27	(a) Energy bands in solids 1 (b) Drawing energy band diagram (i) Metal ; (ii) Semiconductor ½ + ½ (a) Note: Out of syllabus; marks are distributed in part(b) (b) [A student may draw both or any one] (i)  (ii) 	1 1	 2

SECTION C

28

(a) Giving the value of surface charge density of
(i) Inner surface (ii) Outer Surface ½ + ½
(b) Deriving expression for electric field 2

(a) Surface charge density on the inner surface$= \frac{q}{4\pi r_1^2}$ ½

On the outer surface$= \frac{Q-q}{4\pi r_2^2}$ ½

(b) For a spherical Gaussian surface $x > r_2$

$$\oint \vec{E}\vec{ds} = \frac{Q-q}{\epsilon_0}$$ 1

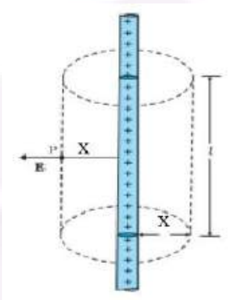
$$E \times 4\pi x^2 = \frac{Q-q}{\epsilon_0}$$ ½

$$E = \frac{1}{4\pi\epsilon_0}\frac{Q-q}{x^2}$$ ½ 3

OR

(a) Derivation for electric field due to a uniformly charged straight wire 2
(b) Graph showing variation of electric field E vs distance x 1

(a)



½

$$\oint \vec{E}.\vec{dS} = \frac{q}{\epsilon_0}$$

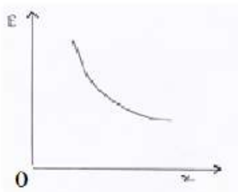
$$\int \vec{E}.\vec{dS_1} + \int \vec{E}.\vec{dS_2} + \int \vec{E}.\vec{dS_3} = \frac{\lambda l}{\epsilon_0}$$

$$E\,dS_1 \cos 90^0 + E dS_2 \cos 90^0 + E dS_3 \cos 0^0 = \frac{\lambda l}{\epsilon_0}$$ ½

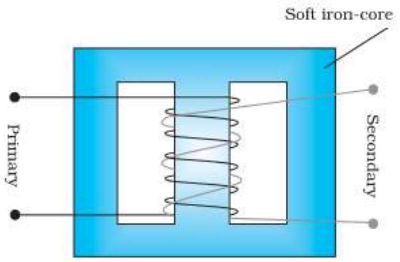
$$0 + 0 + E \times 2\pi x l = \frac{\lambda l}{\epsilon_0}$$ ½

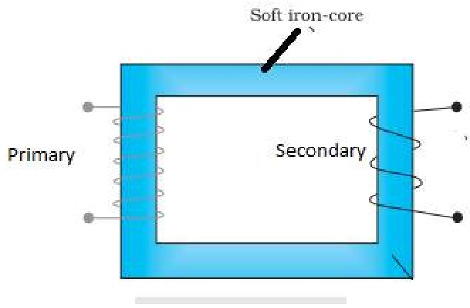
$$E = \frac{\lambda}{2\pi\epsilon_0 x}$$ ½

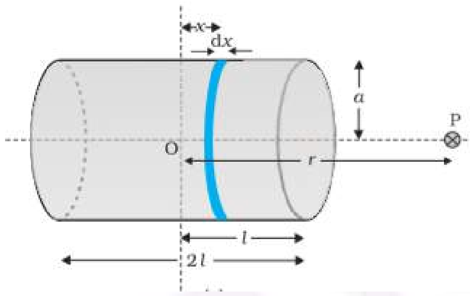
(b)

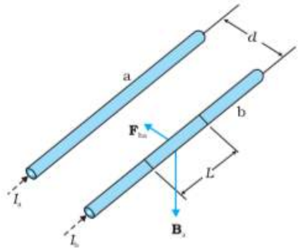


1 3

29	(a) Principle of working of potentiometer 1 (b) Finding emf of two cells 1+1		
	(a) For a steady current flowing through a uniform wire , the potential difference between any two points is directly proportional to the length of the wire between the two points	1	
	(b) Potential gradient = $\frac{5}{1000}\ Vcm^{-1}$	½	
	$E_1 + E_2 = 700 \times \frac{5}{1000} = 3.5\ V$ (i)	½	
	$E_1 - E_2 = 100 \times \frac{5}{1000} = 0.5\ V$ (ii)	½	
	Solving these two equations, we get E_1=2V and E_2 = 1.5 V	½	3
30	(a) Difference between self-inductance and mutual inductance 1 (b) Finding (i) Change in magnetic flux 1 (ii) EMF induced 1		
	(a) Self inductance is the response of the coil/ solenoid to the charge in current in the coil/ solenoid itself (or definition of self inductance)	½	
	Mutual inductance is the response of a coil to the charge of current in a neighbouring coil (or definition of mutual inductance)	½	
	Alternatively Self-inductance is the property of given coil/solenoid Mutual inductance is the property of given pair of coils /solenoids		
	(b) (i) $\Delta\phi = M\Delta I = 2 \times 0.5 = 1Wb$	½ + ½	
	(ii) $e = -\frac{d\phi}{dt} = \frac{1}{100\times10^{-3}} = 10V$	½+ ½	3
31	Diagram of step down transformer 1 Working 1 Use of laminated core 1		
	(a) 	1	
	Alternatively		

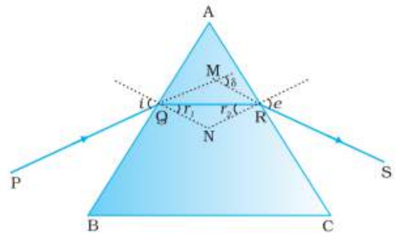
	 (b) When an a.c. voltage is applied across the primary coil, the resulting a.c. current in the primary coil changes the magnetic flux linked with the secondary coil, as a result an emf is induced across the secondary coil. As the number of turns in the secondary coil is less than that in the primary coil in the step down transformer, the output voltage is less than the input voltage. (c) Use of laminated core :- Use of laminated sheets minimizes the eddy currents, hence the energy loss.	1 1	3
32	(i) Naming electromagnetic waves 1½ (ii) Their frequency range 1 ½ (a) Gamma rays, frequency range 10^{19} to 10^{24} Hz (a) UV rays, frequency range 10^{15} to 10^{17} Hz (b) Infrared rays, frequency range 10^{12} to 10^{14} Hz	½+ ½ ½+ ½ ½+ ½	3
33	(a) Phase difference between the waves 1 (b) Resultant intensity at the point 1 (c) Resultant intensity in terms of intensity at maximum 1 (a) Phase difference $\emptyset = \frac{2\pi}{\lambda} \times \frac{\lambda}{6} = \frac{\pi}{3}$ (b) $I_1 = I_2 + I_3 + 2\sqrt{I_3 I_2} cos\, \emptyset$ $= I + I + 2\, I \times \frac{1}{2} = 3\, I$ $= 15 \times 10^{-2}\, Wm^{-2}$ (c) $I_{max} = 4I$ $I_1 = \frac{3I}{4I} \times 4I = \frac{3}{4} I_{max}$	½+ ½ ½+ ½ ½+ ½	3
34	Calculating the distance of Q from the mirror formula 1 Calculation and result 2 For object P $m = \frac{h_2}{h_1} = \frac{f}{f - u_1}$ For Object Q $m' = \frac{h_2'}{h_1'} = \frac{f}{f - u_2}$	½ ½	

	Now $h_1 = 3h_1'$; $h_2 = h_2'$; $f = -20\ cm$; $u_1 = -50\ cm$ $\frac{m}{m'} = \frac{h_2}{h_1} \times \frac{h_1'}{h_2'} = \frac{f-u_2}{f-u_1}$ $\frac{m}{m'} = \frac{1}{3} = \frac{-20-u_2}{-20+50}$ $10 = -20 - u_2 => u_2 = -30\ cm$	½ 1 ½	3
	SECTION D		
35	(a) Solenoid as a small bar magnet 1 Expression for magnitude of magnetic field 2 (b) Magnitude of magnetic dipole moment 1 ½ Direction ½ (a) A solenoid may be regarded as a combination of large number of identical circular current loops in which each behaves like a magnetic dipole. Hence, the current carrying solenoid will behave like a small bar magnet. Expression for magnetic field :-  Figure shows a solenoid consisting of n turns per unit length Consider a circular element of thickness dx at a distance x from the centre of the solenoid Therefore magnetic field at point P due to this circular element $dB = \frac{\mu_0 n dx I a^2}{2[(r-x)^2 + a^2]^{\frac{3}{2}}}$ $B = \frac{\mu_0 n I a^2}{2} \int_{-l}^{+l} \frac{dx}{[(r-x)^2 + a^2]^{\frac{3}{2}}}$ For point P, r >> a and $r \gg l$ $B = \frac{\mu_0 n I a^2}{2 r^3} \int_{-l}^{+l} dx = \frac{\mu_0 n I 2 l a^2}{2r^3}$ $B = \frac{\mu_0}{4\pi} \frac{2m}{r^3}$ (b) $M = NI\pi a^2$ $= 5 \times 2 \times \frac{22}{7} \times 49 \times 10^{-4}$ $= 154 \times 10^{-3}$ $= 0.154\ Am^2$ $\vec{M}$ *will be perpendicular to x − y plane or parallel to Z axis*	½ ½ ½ ½ ½ ½ ½ ½ ½ ½	5

	OR (a) Derivation for the force between two current carrying wires 2 Definition of 1 A 1 (b) Calculation of value of F 1 ½ Effect on equilibrium if F is withdrawn ½		
	(a) 	½	
	Magnetic field due to the current I_a flowing in conductor 'a' at any point on conductor 'b' $B_a = \frac{\mu_0 I_a}{2\pi d}$	½	
	(Acting perpendicular downward) Therefore force on conductor 'b' due to field B_a $\vec{F} = I_b(\vec{l_b} \times \vec{B_a})$	½	
	$\lvert\vec{F_{ba}}\rvert = I_b l_b \times \frac{\mu_0 I_a}{2\pi d}$ $= \frac{\mu_0 I_a I_b l_b}{2\pi d}$ $\frac{\lvert\vec{F_{ba}}\rvert}{l_b} = \frac{\mu_0 I_a I_b}{2\pi d}$	½	
	Definition of 1 A : Two straight infinitely long parallel conductors are said to carry 1 A current each when they interact each other with a force of $2 \times 10^{-7}\, Nm^{-1}$, when kept 1m apart in vacuum	1	
	(b) In equilibrium Restoring Torque = Deflecting Torque	½	
	$F \times r = m\,B\, \sin\theta$ $F \times 10 \times 10^{-2} = 3 \times 0.25 \times \sin 30^0$	½	
	$F = \frac{3 \times 0.25 \times 1}{10 \times 10^{-2} \times 2}$ = 3.75 N	½	
	The magnet oscillates for sometime but finally aligns along the original direction of the external magnetic field.	½	5
36	(a) (i) Ray diagram showing refraction in a prism 1 (ii) Derivation $\mu = \frac{\sin^{(A+\delta_m)}/_2}{\sin\frac{A}{2}}$ 2 (b) (i)Tracing the path of the ray 1 (ii) Effect on path of the ray 1		

(a)

(i)



1

(ii) Derivation

From the figure

$\angle A + \angle QNR = 180^0$ (i)

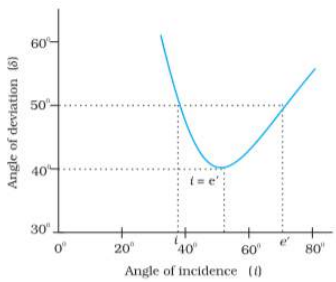
In $\Delta\, QNR$ $r_1 + r_2 + \angle QNR = 180^0$ (ii) ½

Comparing equation (i) and (ii) we get

$r_1 + r_2 = A$ (iii)

Total deviation produced $\delta = (i - r_1) + (e - r_2)$

$\delta = i + e - (r_1 + r_2) = i + e - A$ (iv) ½



From the graph $\delta\ vs\ i$ we find that when δ becomes minimum i.e. δ_m

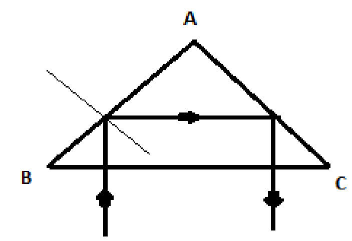
i = e and $r_1 = r_2$ ½

From (iv) $i = \frac{(A + \delta_m)}{2}$

and from (iii) $r = \frac{A}{2}$

$\mu = \frac{\sin i}{\sin r} = \frac{\sin{(A + \delta_m)}/_2}{\sin\frac{A}{2}}$ ½

(a) (i)



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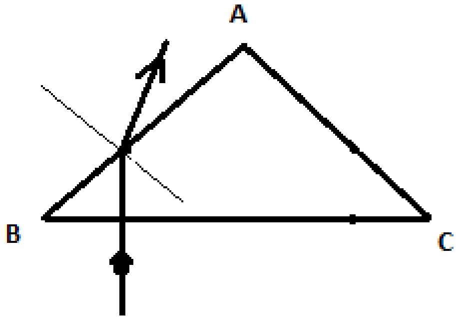
(ii) If $\mu = 1.4$ Total Internal Reflection will not occur as shown in the figure



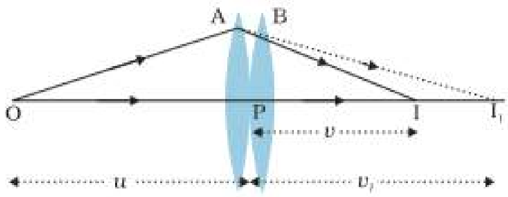
1 | 5

(Note: Award this last one mark if student does not draw the diagram and conclude correctly.)

OR

(a)	Expression for focal length of combination with labelled diagram	3
(b)	Finding refractive index of the liquid	2

(a)



½

For lens A

$\frac{1}{v_1} - \frac{1}{u} = \frac{1}{f_1}$ (i) ½

For lens B :

virtual image I_1 *formed by A acting as object*

$\frac{1}{v} - \frac{1}{v_1} = \frac{1}{f_2}$ (ii) ½

Adding equations (i) and (ii)

$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u}$ ½

Hence $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Therefore $\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{F}$ ½

(b) ½

In air $P_1 = \frac{1}{f_1} = ({}_a\mu_g - 1)(\frac{1}{R_1} - \frac{1}{R_2})$ (i)

For Liquid ½

$P_2 = \frac{1}{f_2} = ({}_l\mu_g - 1)(\frac{1}{R_1} - \frac{1}{R_2})$ (ii)

From (i) and (ii) ½

$\frac{P_1}{P_2} = \frac{({}_a\mu_g - 1)}{({}_l\mu_g - 1)}$ ½

$\frac{10}{-2} = \frac{(1.5-1)}{(\frac{1.5}{\mu_l}-1)}$

	$\mu_l = \frac{5}{3}$	½	5
37	(a) Derivation for decay law 2 ½ (b) Calculation of mean life 1 ½ (c) Calculation of fraction of initial mass 1 (a) Let N_0 be the initial (t =0) number of radioactive substance and N be the number of radioactive substance at interval t = t Hence rate of radioactive decay = $-\frac{dN}{dt} \propto N$ $\frac{dN}{dt} = -\lambda N$ $\int_{N_0}^{N} \frac{dN}{N} = -\int_0^t \lambda\, dt$ $\ln N - \ln N_0 = -\lambda t$ $\frac{N}{N_0} = e^{-\lambda t}$ $N = N_0 e^{-\lambda t}$ (b) $\tau = \frac{T_{\frac{1}{2}}}{\log 2}$ $= \frac{4.5 \times 10^9}{0.693}$ $\tau = 6.493 \times 10^9\ years$ (c) $\frac{N}{N_0} = \frac{1}{2^n}$ $\frac{N}{N_0} = (\frac{1}{2})^5$ $\frac{N}{N_0} = \frac{1}{32}$ therefore fraction decaying= (1-$\frac{1}{32}$)= $\frac{31}{32}$ OR (a) Bohr's Postulate and Derivation of expression 3 (b) Finding ratio of wavelengths 2 (a) Bohr's Postulates:- 1) An electron in an atom could revolve in certain stable orbits without the emission of radiant energy 2) The electron revolves around the nucleus only in those orbits for which the angular momentum is some integral multiple of h/2π where h is the Planck's constant 3) The frequency of the emitted photon when an electron makes a transition from higher orbit to lower energy orbit is given by $h\nu = E_2 - E_1$ $L_n = mv_nr_n = \frac{nh}{2\pi}$ (i)	½ ½ ½ ½ ½ ½ ½ ½ ½ ½ ½ ½ ½	 5

	$\frac{mv_n^2}{r_n} = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r_n^2}$ $v_n = \frac{e}{\sqrt{4\pi\epsilon_0 m r_n}}$ Combining wit h equation (i) $v_n = \frac{1}{n}\frac{e^2}{4\pi\epsilon_0}\frac{1}{(h/\pi)}$ $r_n = \left(\frac{n^2}{m}\right)\left(\frac{h}{2\pi}\right)^2 \left(\frac{4\pi\epsilon_0}{e^2}\right)$ (b) For shortest wave length $\frac{1}{\lambda_S} = R\left(\frac{1}{2^2} - \frac{1}{\infty}\right)$ $\frac{1}{\lambda_S} = \frac{R}{4}$ (i) For longest wave length $\frac{1}{\lambda_L} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$ $= R\left(\frac{1}{4} - \frac{1}{9}\right)$ $= R\left(\frac{5}{36}\right)$ (ii) Dividing equation (i) by equation (ii) we get $\frac{(1/\lambda_S)}{(1/\lambda_L)} = \frac{(R/4)}{(5R/36)}$ $\frac{\lambda_L}{\lambda_S} = \frac{9}{5}$ OR $\lambda_L : \lambda_S = 9:5$	½ ½ ½ ½ ½ ½ ½	5