MARKING SCHEME
SET 55/B (Compartment)

Q. No.	Expected Answer / Value Points	Marks	Total Marks
Section A			
Q1	$P_c \propto \frac{1}{V^2}$	1	1
Q2	10^{12} to 10^{14} Hz Physical therapy, Remote Switches **(Any one use)**	½ ½	1
Q3	$\lambda = \frac{h}{\sqrt{2meV}}$	1	1
Q4	For stable orbits,Angular momentum of an electron is an integral multiple of $\frac{h}{2\pi}$ **Alternatively,** $L = n\frac{h}{2\pi}$	1	1
Q5	Providing Locational Information (**Alternatively: any one (other) use**)		1
Section B			
Q6	Nature of change ½ + ½ Reason ½ + ½ (i) P.E. decreases as the movement of the charge is due to the attraction of the negative charge. (ii) P.E. increases as an external force has to do work to bring charge closer to the positive charge	½ + ½ ½ + ½	2
Q7	Two Factors 1+1 (i) Having appropriate size of transmission antenna (ii) To have effective power radiation (iii) To avoid overlapping of different signals. **(Note: Any two)**	1+1	2
Q8	Formula ½ Substitution ½ Calculation 1 We have, $i = neAv_d$	½	

	$\therefore\ v_d = \frac{i}{neA}$ $= \frac{3.2}{10^{29} \times 1.6 \times 10^{-19} \times 2 \times 10^{-7}}\ m/s$ $= 10^{-3}\ m/s$	 ½ 1	2
Q9	Formula ½ Substitution ½ Calculation 1 At the poles, $B = \frac{\mu_0}{4\pi}\frac{2m}{r^3}$ $\therefore B = \frac{10^{-7} \times 2 \times 10^{23}}{(6.4 \times 10^6)^3} T$ $= \frac{2}{(6.4)^3} \times 10^{-2}\ T$ $\cong 0.76 \times 10^{-4}\ T$	½ ½ 1	2
Q10	Condition 1 Expression 1 The displacement current arises only when the potential difference between the plates (or electric field) between the plates) is changing. **Alternatively:** During the time when the charge, on the capacitor plates is changing. We have $i = \epsilon_o \left(\frac{d\phi_E}{dt}\right)$ **Alternatively:** $i = \epsilon_o\ A\left(\frac{dE}{dt}\right)$ **OR** Arguments for each case 1+1 The e.m. waves carry energy because they contain both oscillating electric and magnetic fields which have an energy density associated with them. [**Alternatively:** e.m. waves can impart energy to charges.] e.m. waves can set charges in motion and can also sustain their motion. Hence, they must carry momentum.	1 1 1 1	2 2

Section C			
Q11	Equivalent capacitance of the two systems ½ + ½ (i)+(ii) condition for each case 1 + 1 Equivalent capacitance of system (i) $\frac{C_1}{n}$ Equivalent capacitance of system (ii) nC_2 (i) We have $Q_1 = C_1.\frac{V}{n}$ And $Q_2 = total\ charge\ = nC_2.V$ $\therefore Q_1 = Q_2\ if$ $C_1.\frac{V}{n} = \mathrm{n}C_2V$ $or\ C_1 = n^2C_2$ (ii) $Energy\ Stored = \frac{1}{2}CV^2$ $\therefore \frac{1}{2}.\left(\frac{C_1}{n}\right)V^2 = \frac{1}{2}.(nC_2)V^2$ $or\ C_1 = n^2C_2$	½ ½ ½ ½ ½ ½	3
Q12	Identifying the device K, M, N ½ + ½ + ½ Writing the expression for Net impedance 1 ½ (i) Device K is a resistor (ii) Device M is a capacitor (iii) Device N is an inducer Impedence of K, M and N are R, $\frac{1}{\omega C}$ and ωL respectively. Net Impedence $\cancel{Z} = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$	½ ½ ½ ½ 1	3
Q13	a) Obtaining the expression 1 ½ b) Showing that energy required equals $\frac{1}{2}LI^2$ 1 ½ a) Let a current I flow through the solenoid. B= Magnetic field along the axis = $\mu_o nI$ $\therefore \phi =$ Flux linked with a unit length $= (n.\pi r^2)B$	½ ½	

	$\phi = Li$ $\therefore L = \mu_o n^2 \pi r^2$ (per unit length of solenoid) b) Let the current be I at any instant $\therefore$ instantaneous induced emf = $-L\frac{di}{dt}$ $d\omega$ = work done in transporting a charge dq = (idt) at this instant =$dq\ \left(L\frac{di}{dt}\right)$ = $Lidi$ $\therefore W = \int_o^I Lidi = \frac{1}{2}LI^2$ Hence, energy required = $\frac{1}{2}LI^2$	½ ½ ½ ½	3
Q14	(a) Finding the relation 1½ (b) Finding angle of incidence , (i) 1½ (a) The angle of deviation δ, is the angle between the final emergent ray and the incident ray. It is related to the angle of incidence $\angle i$, angle of emergence $\angle e$ and the angle of prism $\angle A$ through the relation $\delta = (i + e - A)$ (b) When the ray moves parallel to the base $r_1 = r_2 = \frac{A}{2} = 30^o$ $\therefore \frac{\sin i}{\sin 30^o} = \sqrt{3}$ or sin i = $\sqrt{3} \times \frac{1}{2}$ $\therefore i = 60^o$	½ 1 ½ ½ ½	3
Q15	Expression for Resultant Intensity 2 Conditions for constructive and destructive interference ½ + ½ We have $y_1 = a\cos\omega t$ $y_2 = a\cos(\omega t + \phi)$ $\therefore$ Resultant Displacement $y = y_1 + y_2$ $= a[\cos\omega t + \cos(\omega t + \phi)]$ $= 2a\left[\cos\left(\frac{-\phi}{2}\right)\cos\left(wt + \frac{\phi}{2}\right)\right]$ $= \left[2a\cos\frac{\phi}{2}\right]\cos\left(\omega t + \frac{\phi}{2}\right)$ $\therefore$ Resultant amplitude $= 2a\cos\frac{\phi}{2}$ Resultant intensity $= 4a^2 cos^2\frac{\phi}{2}$	½ ½ ½ ½	

	∴ For constructive interference, we must have, $\phi = \pm n(2\pi) \qquad n = 0, 1, 2 \ldots$ For destructive interference, we must have, $\phi = \pm (2n + 1)\pi \qquad n = 0,1,2,\ldots$	½ ½	3
Q16	Definitions 1+1 One feature 1 Stopping Potential: The minimum(reverse or negative) potential which can stop the emmision of the most energetic photoelectrons. Threshold Frequency: The minimum frequency of incident light that can cause photoemmision from a given photosensitive surface. One feature: That cannot be explained by the wave theory is Independence if maximum K.E.; of emitted photoelectrons, from the intensity of incident light. (or existence of threshold frequency or instanteous nature of photelectric effect.)	1 1 1	3
Q17	Meaning of Universal gates 1 Truth tables for each case 1 + 1 Universal Gates are gates that can be combined to give the other basic logic gates (for example : NAND gate, NOR gate)	1	

Truth Table for NAND Gate

Input		Output
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

1

Truth Table for NOT Gate

Input	Output
A	Y
0	1
1	0

1

3

	OR What is an LED — 1 Operation of LED — 1 Two Advantages — ½ + ½ The LED is a heavily doped p-n function which, under forward bias, emits spontaneous radiation. When the LED is formed biased, the excess minority carriers recombine with majority carriers, on either side of the junction. On recombination, energy is released in the form of photons. The enrgy of the emitted photons is slightly less than, or equal to, the band gap energy. <u>Two advantages:</u> (i) Low operational voltage (ii) Less power consumption (iii) Fast action (iv) No warm up time (v) Emitted light is nearly monocromatic (vi) Long life (vii) Ruggedness (viii) Fast on-off switching **[Any two]**	1 1 ½ + ½	3
Q18	Working — 1½ Obtaining the expression — 1½ **<u>Working:</u>** The sinusoidal variations, of the base signal causes sinusoidal variations in collector current. This results in an amplified 'output' for the given 'input' signal. We get, Input signal $= v_i = r\Delta i_B$ Output signal $= v_o = \Delta V_{CE} = -R_L \Delta I_C$ $= \beta_{ac} R_L \Delta i_B$ $\therefore A_v = \frac{v_o}{v_i} = \frac{-\beta_{ac} R_L}{r}$	1½ ½ ½ ½	3
Q19	Reasons for each case — 1+1+1 (i) This is done to avoid overlapping of different signals. (ii) The ionosphere does not 'reflect back' these high frequency signals and they just pass through. (iii) The different 'web pages' on the internet, are interlinked with one another.	1 1 1	3

Q20	Calculating the value of Point charge 2 Effect of doubling the radius 1 We have By Gauss's Law $\phi = Flux = \frac{q}{\epsilon_o}$ $\therefore q = \epsilon_o.\phi = \epsilon_o(-4\pi \times 10^3)C$ $= -4\pi\epsilon_o \times 10^3\ C$ $= -\frac{1}{9 \times 10^9} \times 10^3\ C$ $= -\frac{1}{9}\mu C$ (ii)The flux would remain unchanged. Hence flux $= -4\pi \times 10^3\ \mathrm{Nm^2/C}$	½ ½ ½ ½ ½ ½	3
Q21	Calculating the voltage generated 1 Calculating the rms value of the current 2 We have, $\varepsilon_o = NBA\omega$ $\therefore\ \varepsilon_o = 100 \times 10^{-2} \times 10^{-1} \times \left(\frac{10}{\pi} \times 2\pi\right) V$ $= 2V$ We also have, $Z^2 = R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2$ $= 10^2 + \left(20 \times 1 - \frac{10^3}{20 \times 5}\right)^2$ $= 10^2 + (20 - 10)^2 = 200$ $Z = 2\sqrt{10}\ \Omega$ $\therefore\ i_{rms} = \left(\frac{\varepsilon_o}{\sqrt{2}}\right).\frac{1}{Z} = \frac{2}{\sqrt{2}}.\frac{1}{\sqrt{2} \times 10} A$ $= 0.1\ A$	½ ½ ½ ½ ½ ½	3
Q22	Formula ½ Calculation of (i) μ 1½ (ii) Power 1		

	We have, $$\frac{1}{f}=(\mu-1)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$$	½	
	$$\therefore \frac{1}{20}=(\mu-1)\left(\frac{1}{20}-\frac{1}{(-25)}\right)$$	½	
	$$=(\mu-1)\times\frac{5}{20\times 25}=(\mu-1).\frac{1}{100}$$	½	
	$$(\mu-1)=\frac{100}{20}=5$$	½	
	$$\therefore \mu=5+1=6$$		
	$$\text{Power of the lens}=\frac{1}{\text{f (in metre)}}=\frac{1}{0.2}\text{D}$$	½	
	$$=5\text{D}$$	½	3
Section D			
Q23	(a) Values Displayed 1+1 (b) Reason 1 (c) Explanation 1		
	(a) Understanding nature (knowledgable) Helpful nature.	1 1	
	(b) The p.d., between the feet of the bird is zero; hence no current flows through its body.	½	
	The live wire, being at a high potential (220 V) w.r.t the ground, can send a strong current through the body which can prove fatal.	½	
	(c) This is done because power losses, during transmission, are proportional to $\frac{1}{V^2}$. Hence using high voltages for transmission, reduces power losses by a very large factor.	1	4
Section E			
Q24	(a) Principle ½ Relation 2 Condition ½ (b) Conversion Method 2		
	(a) A moving coil galvanometer works on the principle that a current carrying coil experiences a torque in a magnetic field.	½	
	The torque acting on the current carrying coil: $$=\left\|\vec{m}\times\vec{B}\right\|$$	½	

	$= mB\sin\theta \ = mB \ \left(when\ \theta = \frac{\pi}{2}\right)$	½	
	$= (nIA)B \ (\because m = nIA)$	½	
	Restoring torque $= c\,\theta$ (c=torsional constant of the suspension wire) $\therefore$ For equilibrium		
	$nIAB = c\theta$	½	
	$or\ I = \left(\frac{c}{nAB}\right)\theta$	½	
	The condition required is $\theta = {}^{\pi}/_{2}$. This is achieved by using a radial magnetic field.	½	
	(b) This conversion can be achieved by connecting a shunt, of resistance S, in parallel with the coil. We have $(I - I_G)S = I_G$	1	
	$or\ S = \frac{G.I_G}{(I - I_G)}$	½	5
	OR		
	(a) Two differences 1+1 (b) Selecting materials ½ + ½ Reasons 1+1		
	a) Paramagnetics are weakly attracted by a magnetic field. Ferromagnetics are strongly attracted.	1	
	Paramagnetics do not show the phenomenon of hysteresis while ferromagnetic show this phenomenon **(Also accept other differences)**	1	
	b) For permanent magnets, the material should have high retentivity and high permeability	½	
	This is done to ensure that the magnets can be made to have strong magnetization which does not get easily erased.	1	
	For electromagnets materials should have low retentivity and high permeability.	½	
	This is done to ensure that electromagnets can be made strong enough so that but they work as magnets only when the current is flowing through the coil.	1	5

Q25	Statement of law 1 Obtaining the relation $N = N_o e^{-\lambda t}$ 1½ Obtaining the relation between λ and T_m, $\left(T_m = {}^{1}/_{\lambda}\right)$ and λ and $T_{\frac{1}{2}}$ 2½			
	<u>Law of Radioactive Decay</u> In a radioactive material the number of nuclei undergoing the decay per unit time is proportional to the total number of the nuclei in the sample at that instant. Let the number of nuclei in the sample at time 't' be N and the number of nuclei that undergo decay in time Δt is ΔN, then $$\frac{\Delta N}{\Delta t} \propto N \ or \ \frac{\Delta N}{\Delta t} = \lambda N$$ $(\lambda \rightarrow \text{radioactive decay constant})$ $$\text{Here, } dN = -\Delta N$$ $$\therefore \ \frac{dN}{dt} = -\lambda N$$	1		
	$$\Rightarrow \frac{dN}{N} = -\lambda dt$$	½		
	On integrating both sides, we have $$\int_{N_o}^{N} \frac{dN}{N} = -\lambda \int_{t_o}^{t} dt$$ $$\log_e(N) - \log_e(N_o) = -\lambda(t - t_o)$$	½		
	Setting t_o=0, we have $$\log_e N \left(\frac{N}{N_o}\right) = -\lambda t$$ which gives $$N(t) = N_o e^{-\lambda t}$$	½		
	(i) Relation between decay constant 'λ' and Mean lifetime T_m Number of nuclei which decay in time interval t to t +Δt $$= \lambda N_o e^{-\lambda t} \Delta t$$	½		
	$$\therefore \text{Mean Life } \ \tau = \frac{\lambda N_o \int_0^{\infty} t \, e^{-\lambda t} \, dt}{N}$$ $$= \lambda \int_0^{\infty} t \, e^{-\lambda t} \, dt$$ On integrating	½		

$$\Rightarrow \tau = \frac{1}{\lambda}$$ ½

(ii) Relation between decay constant and half life.
After one half life($T_{½}$), number. of nuclei = $N_o/2$

$$\Rightarrow \frac{N_o}{2} = N_o e^{-\lambda T_{\frac{1}{2}}}$$ ½

$$2 = e^{-\lambda T_{\frac{1}{2}}}$$

$$\log_e 2 = \lambda T_{\frac{1}{2}}$$

$$\Rightarrow T_{\frac{1}{2}} = \frac{\log_e 2}{\lambda} = \frac{0.693}{\lambda}$$ ½

5

OR

a)	Writing the relation for radius R of nucleus in terms of Mass number (A)	1
	Showing density of nucleus is independent of Mass Number	1
b)	Three characteristic features	3

(a)

$$R = R_o A^{\frac{1}{3}}$$ 1

$$\text{density } \rho = \frac{\text{mass}}{\text{volume}}$$

Let mass of one nucleon be 'm' and number of nucleon in the nucleus= A(mass Number)

$$\therefore\ \rho = \frac{mA}{\frac{4}{3}\pi R^3}$$ ½

$$= \frac{mA}{\frac{4}{3}\pi\left(R_o A^{\frac{1}{3}}\right)^3}$$

$$\rho = \frac{3m}{4\pi {R_o}^3}$$ ½

(b)

(i) Nuclear force is much stronger than the coulomb's force acting between charges or gravitational force between masses. 1

(ii) The nuclear force between two nucleons falls rapidly to zero for large distances, i.e. short range force. 1

(iii) The Nuclear force does not depend on electric charge. 1

(or any other three characteristics) 5

Q26	a) Statement of Huygen's Principle — 1 Statement explaining the diffraction pattern — 1 b) Showing the required relation — 2 c) Effect of white light — 1		
	a) According to Huygens's Principle: Each point of a wave front is the source of a secondary disturbance and the wavelets, emanating from these points, spread out in all directions with the speed of the wave.	1	
	<u>Diffraction due to a single slit</u>		
	The wavelets, at the central point, all arrive in phase. Hence, this is a point of maxima.	½	
	At points for which $\theta = \left(n + \frac{1}{2}\right)\frac{\lambda}{a}$, only a fraction $\left(\frac{1}{3}, \frac{1}{5}, \ldots.\right)$ of the incident wave front gives a non-zero contribution. Hence, these are points of (secondary) maxima. At points for which $\theta = \frac{n\lambda}{a}$, the wavelet contributions get cancelled out in pairs. These are, therefore, points of minima.	½	
	We thus get a diffraction pattern on the screen.		
	(b) Angular width of the central maxima $= 2.\frac{\lambda}{a}$	½	
	<u>For the first fringe:</u> First Minima is at $\theta = \frac{\lambda}{a}$		
	Second Minima is at $\theta = 2.\frac{\lambda}{a}$	½	
	∴ Angular width of first diffraction fringe $= \left(\frac{2\lambda}{a} - \frac{\lambda}{a}\right) = \frac{\lambda}{a}$	½	
	$= \frac{1}{2} \times$ angular width of central maxima	½	
	(c) The central maxima would be white followed by very few coloured secondary maxima which would tend to overlap.	1	5

	OR (a) Obtaining the expressions 2+1 (b) Explaining the two features ½ + ½ (c) Two advantages ½ + ½ (a) Let f_0 and f_e be the focal lengths of the objective and eyepiece and a parallel beam from distant objects forms an image at the focus of objective of height 'h'. This acts as an object for the eyepiece. Let the angle subtended at the objective and eyepiece α and β. Therefore, Magnifying Power is defined as: $m = \frac{\beta}{\alpha} \cong \left(\frac{h}{f_e}\right) \div \left(\frac{h}{f_o}\right)$ $= \frac{f_o}{f_e}$ In the normal adjustment, when the final image is at infinity, the image formed by the objective is at the first focus of the eye-piece. Hence L= distance between objective and eye-piece. $= (f_o + f_e)$ b) Larger Aperture Helps to collect more light from the (faint) distant objects. Objective Focal Length : larger than the eye piece Focal Length This helps to increase the magnifying power$\left(= \frac{f_o}{f_e}\right)$ c) Two advantages of reflecting telescopes (i) Absence of Chromatic aberration (ii) Spherical aberration can be removed (iii) Less problem in providing the required mechanical support. **[Any Two]**	1½ ½ ½ ½ ½ ½ (½+½)	5