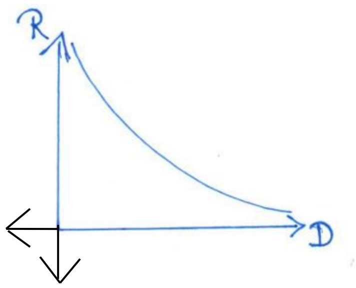
SECTION A

1. It is independent of the distance. It's a straight line parallel to x-axis. (1)

2.

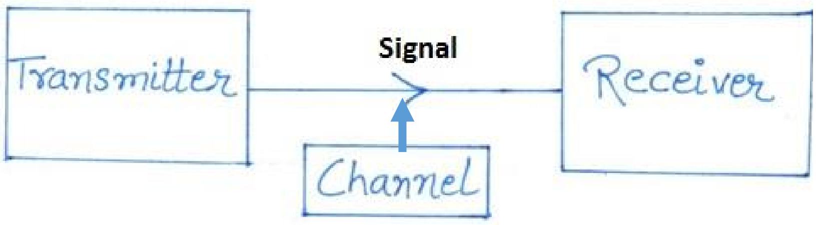


3. ε = Blv (½)
   = B cos θ x l x $(2gH)^{1/2}$ (½)

4.

$I = Io/2 \cos^2 (45)$ (½)
$= Io/4$ (½)

5.



(1)

SECTION B

6.

$A_A / A_B = 6$ (½)

$H = V^2 t / R$ (½)

$R = \rho l / A$ (½)

$H_A / H_B = 6$ (½)

7.

$1/f = (\mu -1) [1/R_1 - 1/R_2]$ (½)

$1/20 = ½ [1/R_1 - 1/R_2] =$ (½)

$1/f' = ¼ [1/R_1 - 1/R_2]$ (½)

$f' = 40$ cm (½)

OR

P = + 5 D f = 1/5 m = 20 cm (½)

For 3rd observation, when the object is at $< 2f$, (½)

then the image has to be at $> 2f$ (½)

hence this observation is wrong. (½)

8.

$m_p = 1u$ $m_\alpha = 4u$ and $q_p = e$ $q_\alpha = 4e$ (½)

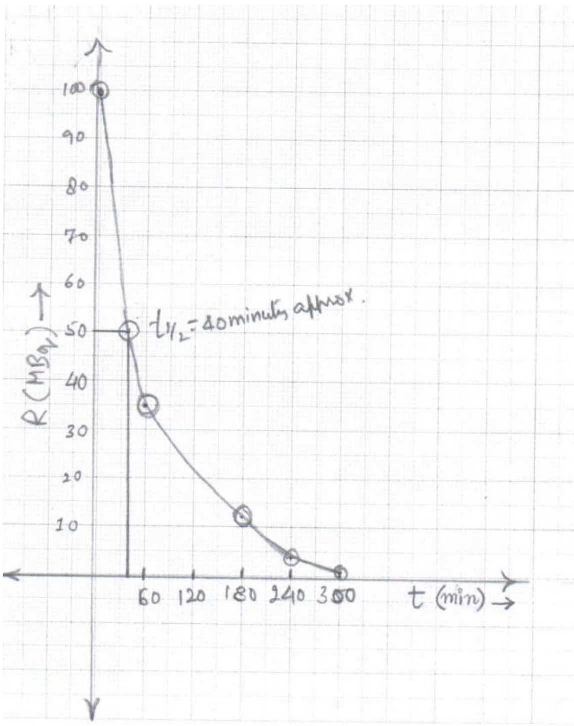
$½ \, m v^2 = qV$ (½)

$P = mv = [\sqrt{2qVm}]^{½}$ (½)

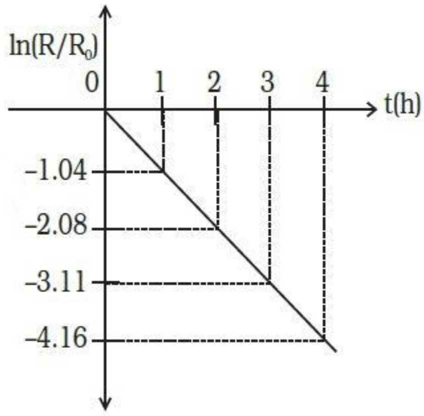
$P_P / P_\alpha = 1/8$ (½)

9.

a) $t_{1/2} = 0.693 / 1.05 = 39.6$ or appro. 40 min (½)



(½)



b) slope of graph = - λ

λ = - [- 4.16 + 3.11 /1] = 1.05 h (½)

$t_{1/2}$ = 0.693 / 1.05 = 39.6 or appro. 40 min (½)

10.

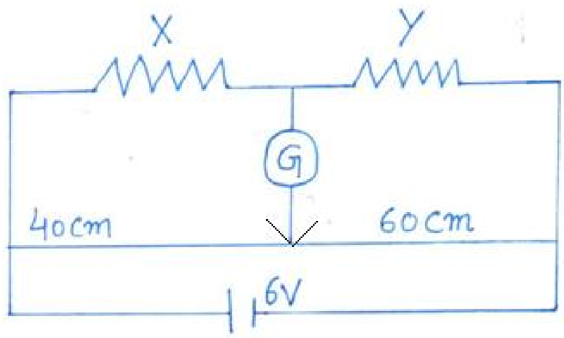
Any correct answer 1 mark each

SECTION C

11.

a) Q = ± N q (1)
b) V = Q/C   v = q / c   V / v = N (r/R) = $N^{2/3}$ (1)
c) C = $N^{1/3}$ c (1)

12.



X/Y = 40/60 = 2/3

X = 4 Ω (½)

4 Ω and 6 Ω are in series, = 10 Ω

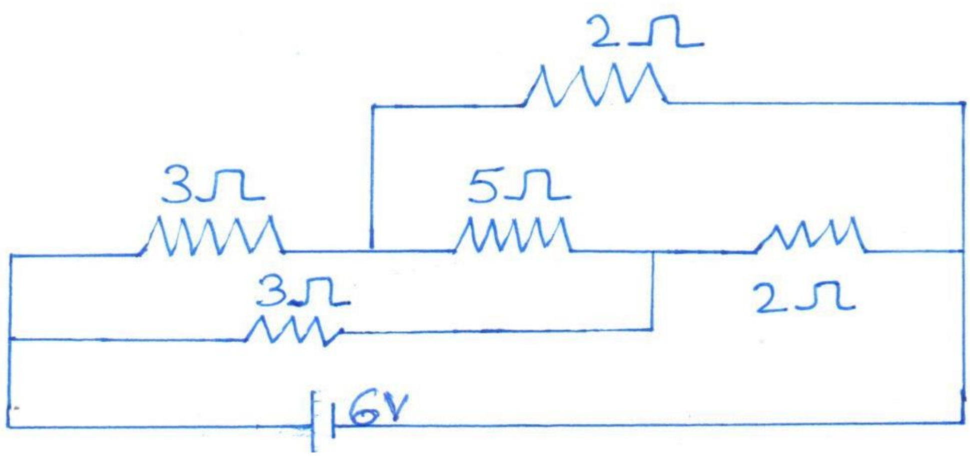
40 Ω and 60 Ω are in series, = 100 Ω

10 Ω and 100 Ω are in parallel, = 1000/110 Ω = 9.09 Ω (1)

There will be no change in the balancing length. (½)

Formula for series and parallel (½) each

OR



Balanced Wheatstone bridge (½)

Resultant resistance of the circuit = 2.5 Ω (½)

Current in the circuit = 6/2.5 = 2.4 A (1)

Statement and conservation of energy (½) each.

13.

Rate of change of flux = $d\Phi/dt = (\pi l^2)\ B_o\ l\ dz/dt = IR$ (½)

$I = (\pi l^2 \lambda) B_o\ v / R$ (½)

Energy lost per second = $I^2 R = (\pi l^2 \lambda)^2\ B_o^2\ v^2 / R$ (½)

Rate of change in PE = $m\ g\ dz/dt = m\ g\ v$ (½)

$mgv = (\pi l^2 \lambda)^2\ B_o^2\ v^2 / R$ (½)

$v = mgR / (\pi l^2 \lambda)^2\ B_o^2$ (½)

14.

a) In absence of magnetic field, the energy is determined by the principle quantum number n, while the orbital quantum number ι. If an electron is in nth state then the magnitude of the angular momentum is (h/2π) l (l+1) where l = 0, 1, 2,…….,(n-1), Since l = 0, 1, 2, . . . , (n– 1), different values of A are compatible with the same value of n. For example, when n= 3, the possible values of l are 0, 1, 2, and when n= 4, the possible values of l are 0, 1, 2, 3. Thus, the electron in one of the atoms could have n= 3, l= 2, while the electron in the other atom could have n= 4, l= 2. Therefore, according to quantum mechanics, it is possible for the electrons to have different energies but have the same orbital angular momentum.

b)

For a point nucleus in H-atom:

Ground state: $mvr = \text{h}, \frac{mv^2}{r_B} = -\frac{e^2}{r_B^{\ 2}}\cdot\frac{1}{4\pi\varepsilon_0}$

$$\therefore m\frac{\text{h}^2}{m^2 r_B^{\ 2}}\cdot\frac{1}{r_B} = +\left(\frac{e^2}{4\pi\varepsilon_0}\right)\frac{1}{r_B^{\ 2}}$$

$$\therefore \frac{\hbar^2}{m}\cdot\frac{4\pi\varepsilon_0}{e^2} = r_B = 0.51\,\dot{\text{A}}$$

If $R >> r_B$: the electron moves inside the sphere with radius r_B' (r_B' = new Bohr radius).

Charge inside $r_B'^{\,4} = e\left(\frac{r_B'^3}{R^3}\right)$

(1)

$$\therefore r'_B = \frac{h^2}{m}\left(\frac{4\pi\varepsilon_0}{e^2}\right)\frac{R^3}{r'^3_B}$$

$$r'^4_B = (0.51\,\text{Å}).R^3. \qquad R = 10\,\text{Å}$$

$$= 510(\text{Å})^4$$

$$\therefore r'_B \approx (510)^{1/4}\,\text{Å} < R.$$

$$K.E = \frac{1}{2}mv^2 = \frac{m}{2}.\frac{h}{m^2 r'^2_B} = \frac{h}{2m}.\frac{1}{r'^2_B}$$

$$= \left(\frac{h^2}{2mr_B{}^2}\right).\left(\frac{r_B^2}{r'^2_B}\right) = (13.6\text{eV})\frac{(0.51)^2}{(510)^{1/2}} = \frac{3.54}{22.6} = 0.16\text{eV}$$ (1)

$$P.E = +\left(\frac{e^2}{4\pi\varepsilon_0}\right).\left(\frac{r'^2_B - 3R^2}{2R^3}\right)$$

$$= +\left(\frac{e^2}{4\pi\varepsilon_0}.\frac{1}{r_B}\right).\left(\frac{r_B(r'^2_B - 3R^2}{R^3}\right)$$

$$= +(27.2\text{eV})\left[\frac{0.51(\sqrt{510} - 300)}{1000}\right]$$

$$= +(27.2\text{eV}).\frac{-141}{1000} = -3.83\text{eV}.$$

(1)

15.

E/B = v when E, V and B are perpendicular to each other. (1)

Cyclotron, E is perpendicular to B is perpendicular to V, In presence of E parabolic path and in presence of B circular path. T and V are independent of radius of the path. (1)

When frequency of oscillator is same as frequency of cyclotron then resonance occurs. (1)

16.

$T_2P = D + x$, $T_1 P = D - x$

$S_1P = \sqrt{(S_1T_1)^2 + (PT_1)^2}$

$= [D^2 + (D - x)^2]^{1/2}$

$S_2P = [D^2 + (D + x)^2]^{1/2}$

Minima will occur when

$$[D^2 + (D + x)^2]^{1/2} - [D^2 + (D - x)^2]^{1/2} = \frac{\lambda}{2}$$

If $x = D$

$$(D^2 + 4D^2)^{1/2} = \frac{\lambda}{2}$$

$$(5D^2)^{1/2} = \frac{\lambda}{2}, \quad \therefore D = \frac{\lambda}{2\sqrt{5}}.$$

17.

Diagram (1)

L = length of the telescope = fo + fe = 15.05 m (1)

m = fo/fe = 15/0.05 =300 (1)

18. A – Incident energy is less than the work function of the metal (1)

B – Incident energy is equal to the work function of the metal (1)

C – Incident energy is greater than the work function of the metal (1)

19.

Proton	alpha particle
e	2e
1 u	4 u

r = mv/Bq

For same momentum: p = mv $r \propto 1/q$ (1)

R(proton) > r(alpha) (½)

For same kinetic energy: KE = ½ m v^2 (1)

$r^2 \alpha m/q^2$

Radius is independent of KE (½)

20. a)

$E = h \mu$ (½)

$= hc/\lambda = hc / \lambda e$ (½)

$= 2$ eV (½)

Hence D_1 and D_3 can detect light. (½)

b)

Number of Free electrons are very small leading to negligible conduction. Hence not possible. (1)

21.

As $V_{be} = 0$, potential drop across R_b is 10V.

$$\therefore I_b = \frac{10}{400 \times 10^3} = 25\mu A$$

Since $V_{ce} = 0$, potential drop across R_c, i.e. $I_c R_c$ is 10V.

$$\therefore I_c = \frac{10}{3 \times 10^3} = 3.33 \times 10^{-3} = 3.33 mA.$$

$$\therefore \beta = \frac{I_c}{I_b} = \frac{3.33 \times 10^{-3}}{25 \times 10^{-6}} = 1.33 \times 10^2 = 133.$$

22. a)

μ is kept less than 1 so that the noise level can be kept small in the signal. (1)

b)

μ = a(max) + a(min) / a(max) – a(min) = 18/12= 9/6 = 3/2 = 1.5 (1)

c)

Fading of a signal is prominent in case of amplitude modulation and hence noise level is more in AM than FM (1)

SECTION D

23.

i) Any one relevant value (1)

ii) Nuclear fission (1)

iii) Fuel, moderator, cadmium rods, any two (1)

iv) to slow down the speed of neutrons (1)

SECTION E

24.

$U = ½ CV^2$ (2)

Loss in energy (2)

It appears in the form of heat. (1)

OR

Diagram (½)

Net force = 0 no translator motion (½)

Defination of torque (½)

SI unit (½)

troque = pE sin θ (1)

$C_{eq} = 11/6\ C$ (½)

where C = A εo/3d, (½)

C1 = C, C2 = C/2, C3 = C/3 (½)

and all of these capacitors are connected in parallel. (½)

25. a)

$X_C = X_L$ (2)

b)

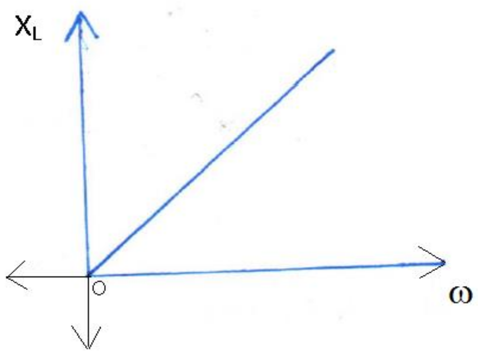
$I_o = V_o / \sqrt{(R^2 + X_L^2)}$ (½)

$Vo = \sqrt{2}\ V_{rms}$ (½)

$X_L = 2\pi fL$ (½)

I_o = 15.54 (½)

Current lags behind the voltage by phase Φ (½)



(½)

OR

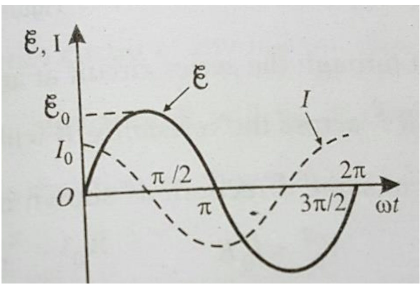
a)

V = Vo sin ωt   V = Q/C (½)

I = dQ/dt (½)

Io = Vo / (1/ωC) (½)

I = Io sin (ωt + π/2) (½)



(1)

b)

X_c = 1/ 2πfc = 212.3 Ω

Z = $\sqrt{R^2 + Xc^2}$ = 291.5 Ω (½)

I_{rms} = v_{rms} / Z = 220 / 291.5 = 0.755 A (½)

V_R(rms) = 151 V V_c(rms) = 160.3 V (½)

Two voltages are out of phase. Hence they are added vectorially and hence the difference is! (½)

26. a)

$\mu = c/v = \sin i / \sin r$, (1)

$v \propto \sin r$ Hence v_{min} for light will be for $r = 15^o$. (1)

Diagram (1)
derivation (1½)
final expression (½)

OR

a. The ray coming from the object has to pass from denser to rarer medium and angle of incidence is greater than the critical angle. (1+1)

b.

i) $\sin c = n_1 / n$ $(90 - r_1) + 45 + (90 - c) = 180$

$r_1 = 45 - c$ (½)

$\sin i / \sin r_1 = n$ $\sin i = n \sin r_1 = n \sin (45 - c)$

$= n (\sin 45 \cos c - \cos 45 \sin c)$

$= n/\sqrt{2} (\cos c - \sin c)$ (½)

$= n/\sqrt{2} (\sqrt{[1 - \sin^2 C]} - \sin c)$

$= 1/\sqrt{2} (\sqrt{n^2 - n_1^2}) - n_1$

$i = \sin^{-1} (1/\sqrt{2} (\sqrt{n^2 - n_1^2}) - n_1)$ (½)

ii) $r_2 = 0$ $r_1 + r_2 = 45$ $r_1 = 45$ (½)

$\sin i / \sin r_1 = n$

$\sin i = n \sin r_1 = 1.352 \sin 45 = 0.956$ (½)

$i = \sin^{-1} (0.956) = 72.58$ (½)