SECOND YEAR HSE MODEL EXAMINATION, FEB 2024

HSE II — PHYSICS

I Any 5 (1-7) $5 \times 1 = 5$

1) Electric flux density $\left(\frac{\phi_E}{A} = E\right)$ (OR) Electric intensity
2) Polarization
3) Paramagnetic
4) Visible light
5) Hertz
6) $\frac{h}{2\pi}$
7) Insulator

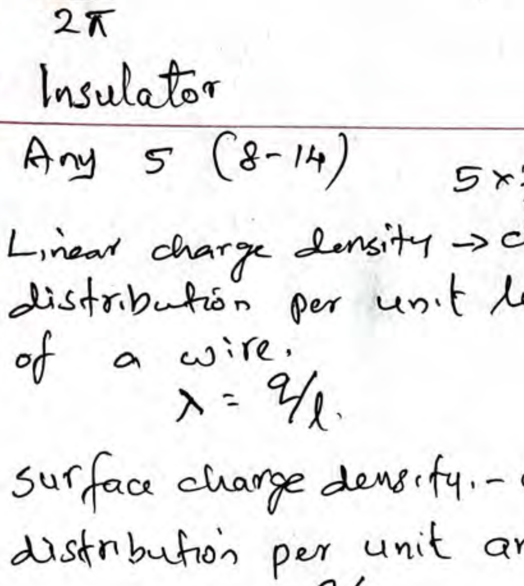
II Any 5 (8-14) $5 \times 2 = 10$

8) Linear charge density → charge distribution per unit length of a wire.

$$\lambda = q/l$$

Surface charge density – charge distribution per unit area.

$$\sigma = q/A$$

9) 

10) (i) whenever magnetic flux linked with a conductor/coil changes, an emf is induced in the coil. This induced emf lasts so long as the change in magnetic flux lasts.

(ii) Induced emf, $e = \frac{d\phi_E}{dt}$

(OR) statement

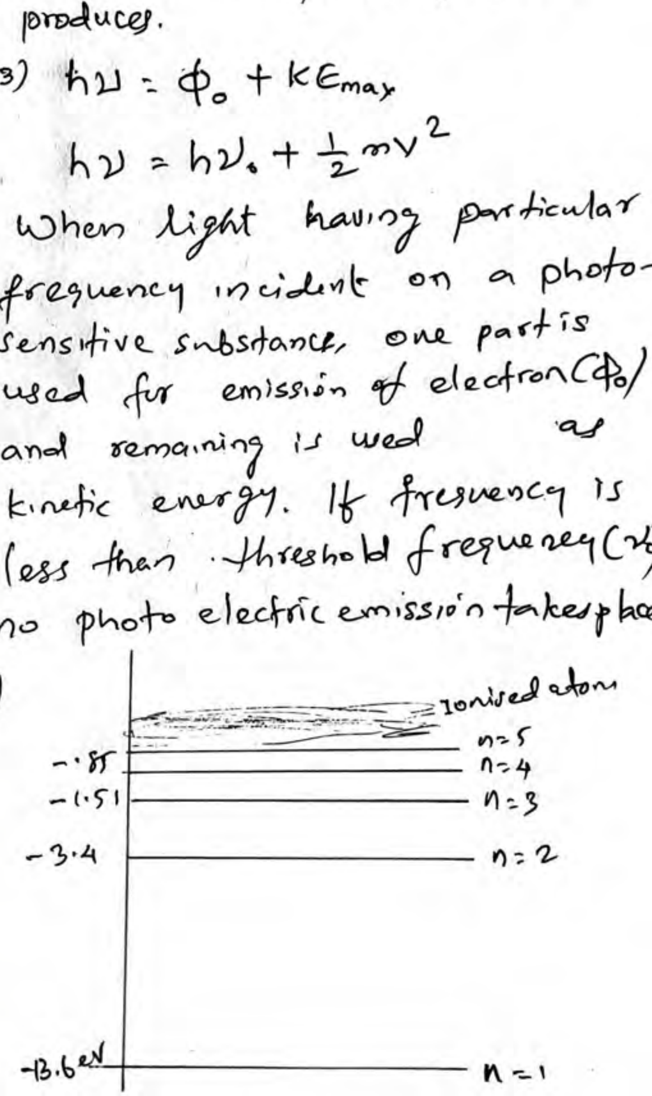
11) $P = \frac{V^2}{R}$ $\quad R = \frac{V^2}{P} = \frac{220^2}{100} = 484\Omega$

12) Sources which emits light with same frequency, wavelength and zero or constant phase difference. When light waves from coherent sources superimposed, sustained interference patterns produces.

13) $h\nu = \phi_0 + KE_{max}$

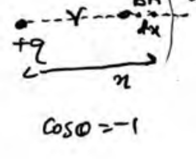
$$h\nu = h\nu_0 + \frac{1}{2}mv^2$$

When light having particular frequency incident on a photosensitive substance, one part is used for emission of electron (ϕ_0) and remaining is used as kinetic energy. If frequency is less than threshold frequency (ν_0) no photo electric emission takes place.

14) 

III Any 6 (15-21) $6 \times 3 = 18$

15) (a) $E = \frac{1}{4\pi\epsilon_0}\frac{q}{x^2}$



$\cos\theta = -1$

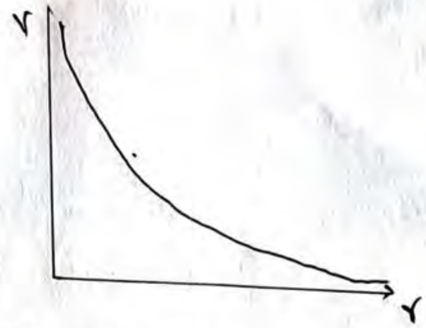
$$dw = \int_{x_1}^{x_2} \vec{E} \cdot d\vec{x}$$

$$= \int_{\infty}^{r} \frac{1}{4\pi\epsilon_0}\frac{q}{x^2} dx \cdot \cos\theta$$

$$= \frac{-q}{4\pi\epsilon_0}\left(\frac{x^{-2+1}}{-2+1}\right)_{\infty}^{r}$$

$$\boxed{V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}}$$

(15) (b)



(16) a) Statement (OR)

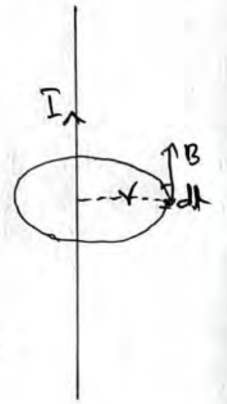
$$\oint \vec{B}\cdot\vec{dl} = \mu_0 I_{enclosed}.$$

b) $\int \vec{B}\cdot\vec{dl} = \mu_0 I$

$B\int dl = \mu_0 I$

$B \times 2\pi r = \mu_0 I$

$$\boxed{B = \frac{\mu_0}{2\pi}\frac{I}{r}}$$



(17) Rate of work done

$$\frac{dw}{dt} = eI$$

$$= LI\frac{dI}{dt}$$

$$dW = LI\,dI$$

$$U = W = \int_0^I LI\,dI = L\left(\frac{I^2}{2}\right)_0^I = \frac{1}{2}LI^2$$

$$L = \mu_0\frac{N^2A}{l} \qquad B = \mu_0 nI$$

$$= \mu_0\frac{NI}{l}.$$

$$I = \frac{Bl}{\mu_0 N}$$

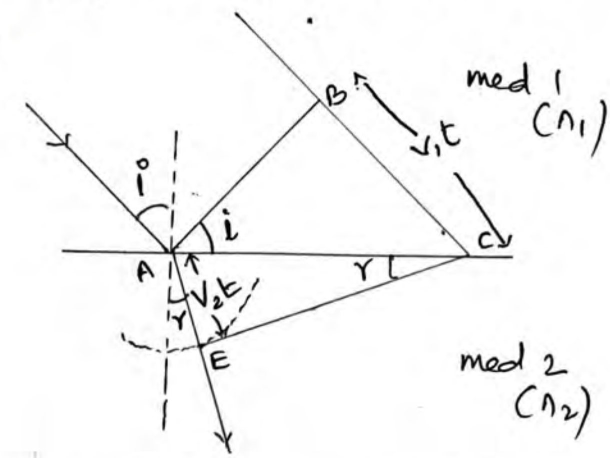
$$U = \frac{1}{2}\times\frac{\mu_0 N^2 A}{l}\times\frac{B^2l^2}{\mu_0^2 N^2}$$

$$\boxed{U = \frac{1}{2\mu_0}B^2lA}$$

(18) (a) An oscillating charged particle like electrons or ions produces oscillating electric field and magnetic field in space, which results in em waves.

(b) When Infrared waves passes through water molecules, CO_2, NH_3 etc, they readily absorb IR and their thermal motion increases. They heat up and heat the surroundings. So IR are called heat waves.

(19)



AB is incident wavefront CE is refracted wavefront.

$$\Delta ABC \rightarrow \sin i = \frac{BC}{AC} = \frac{v_1t}{AC}$$

$$\Delta AEC \rightarrow \sin r = \frac{AE}{AC} = \frac{V_2t}{AC}$$

$$\frac{\sin i}{\sin r} = \frac{BC}{AE} = \frac{V_1t}{V_2t} = \frac{V_1}{V_2}$$

We have $n_1 = \frac{c}{V_1}$ and $n_2 = \frac{c}{V_2}$

$$\frac{V_1}{V_2} = \frac{n_2}{n_1}$$

$$\therefore \frac{\sin i}{\sin r} = \frac{V_1}{V_2} = \frac{n_2}{n_1} \Rightarrow \text{Snell's law.}$$

(20) It is the spontaneous disintegration of heavier unstable nucleus with the emission of particles or radiation and release of energy.

20 (b)

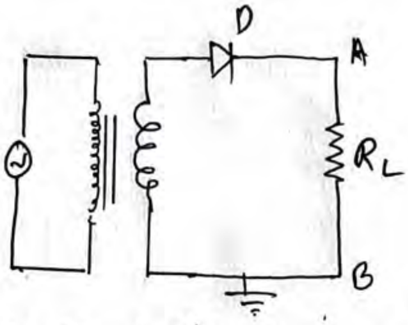
$${}_1H^1 + {}_1H^1 \rightarrow {}_1H^2 + e^+ + \nu + 0.42\,MeV$$

$${}_1H^2 + {}_1H^1 \rightarrow {}_2He^3 + \gamma + 5.49\,MeV$$

$${}_2He^3 + {}_2He^3 \rightarrow {}_2He^4 + {}_1H^1 + {}_1H^1 + 12.86\,MeV$$

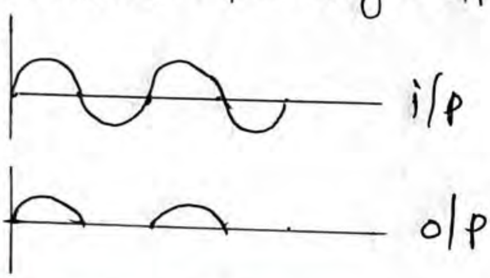
This is the proton-proton cycle occurs in stars.

(21) (a)



During positive half cycle of ac, Diode D is forward biased and it conducts current from A to B. During negative half cycle, D is reverse biased and it act as insulator, does not conduct. So, we get a unidirectional pulsating output

(b)



IV Any 3 (22-25) $3 \times 4 = 12$

(22)(a) $U = \frac{1}{2}CV^2$ (derivation not required)

(b) when 2 capacitors are connected together, they attain same potential.

$V_1 = V_2$

$\frac{Q_1}{C} = \frac{Q_2}{C} \Rightarrow Q_1 = Q_2$

Also, $Q_1 + Q_2 = Q \Rightarrow Q_1 = Q_2 = \frac{Q}{2}$

$\therefore V_1 = \frac{Q_1}{C} = \frac{Q}{2C} = \frac{V}{2} = \frac{100}{2} = 50V$

Also, $V_2 = 50V$

$\therefore U = \frac{1}{2}C_1V_1^2 + \frac{1}{2}C_2V_2^2$

$= \frac{1}{2} \times 900 \times 10^{-12}(50^2 + 50^2)$

$= \frac{1}{2} \times 900 \times 10^{-12} \times 5000$

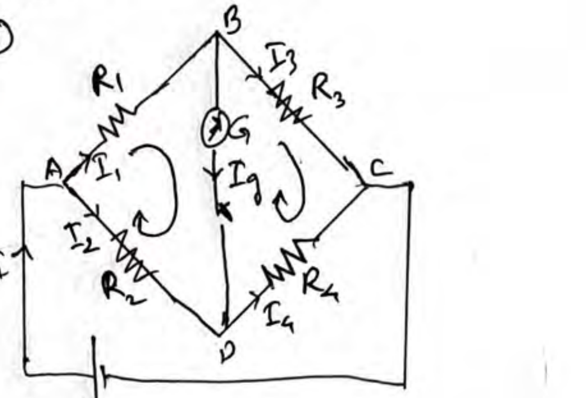
$= 2.25 \times 10^{-6}$ J //

(23)(a) statement

OR

$\Sigma IR + \Sigma E = 0$.

(b)



For loop ABDA,

$I_1R_1 + I_gR_G + {}^{-}I_2R_2 = 0$ — (1)

For loop BCDB

$I_3R_3 + {}^{-}I_4R_4 + {}^{-}I_gR_G = 0$ — (2)

when bridge is balanced, $I_g = 0$

$I_1 = I_3$

$I_2 = I_4$

$\therefore (1) \Rightarrow I_1R_1 = I_2R_2$ — (3)

$I_1R_3 = I_2R_4$ — (4)

$\frac{(3)}{(4)} \Rightarrow \frac{R_1}{R_3} = \frac{R_2}{R_4}$ OR $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

(24) a) Statement

OR

$\int \vec{B} \cdot \vec{ds} = 0$

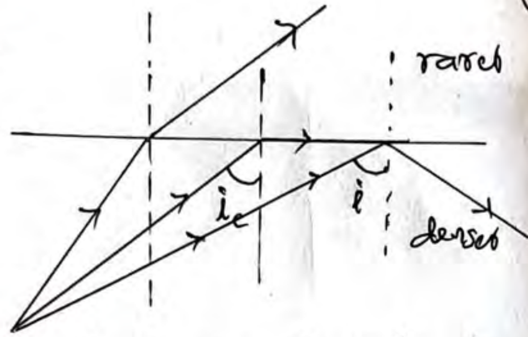
b) If monopoles exists, the law becomes, $\int \vec{B} \cdot \vec{ds} = \mu_0 q_m$

$q_m \rightarrow$ monopole (magnetic charge)

(25) (a) (i) Incident ray, normal, refracted ray in the same plane

(ii) $\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$ = constant $\rightarrow$ Snell's law

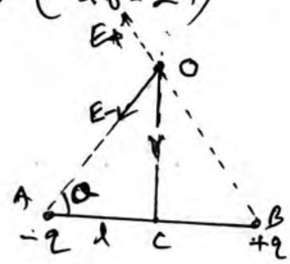
(25)(b)



when light ray travels from denser to rarer and if the angle of incidence is greater than critical angle ($i > i_c$), light ray totally reflected back to the same medium. This is Total internal reflection.

V Any 3 (26-29) $3 \times 5 = 15$

26) a)



$E_{-q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2+l^2}$ along OA —(1)

$E_{+q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2+l^2}$ along BO —(2)

$E = 2E_{+q}\cos\theta$

$= 2 \times \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2+l^2} \times \frac{l}{(r^2+l^2)^{\frac{1}{2}}}$

$= \frac{1}{4\pi\varepsilon_0}\frac{P}{(r^2+l^2)^{3/2}}$

since $l^2 << r^2$

$$\boxed{E = \frac{1}{4\pi\varepsilon_0}\frac{P}{r^3}}$$

(b) $|q_A| = |q_B| = 2.5 \times 10^{-7}$ C

$2l = Z_2 - Z_1 = 15 - -15$
$= 30$ cm
$= 30 \times 10^{-2}$ m

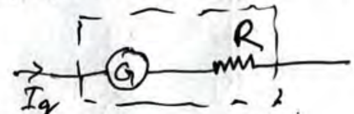
Total charge, $q = q_A + q_B = 0$

dipole moment

$P = q \times 2l = 2.5 \times 10^{-7} \times 30 \times 10^{-2}$
$= 7.5 \times 10^{-8}$ Cm

(27)(a) $S_I = \frac{\phi}{I}$, deflection per unit current

(b) A galvanometer can be converted into voltmeter by connecting a high resistance in series with it.



$V = I_g(G+R)$

$$\boxed{R = \frac{V}{I_g} - G}$$

(c) $R_A = 60\Omega$
$R_1 = 3\Omega$
$R = R_1 + R_A = 63\Omega$
$V = 3V$
$I = \frac{V}{R} = \frac{3}{63} = 0.048A$

(28)(a) Mutual induction

(b)

step up	step down
(i) $N_p < N_s$	(i) $N_p > N_s$
(ii) $V_s > V_p$	(ii) $V_s < V_p$
iii) Thickness of primary is more	iii) Thickness is secondary is more
(iv) $I_s < I_p$	(iv) $I_s > I_p$

(c) Copper loss, Flux leakage loss
Eddy current loss, hysterises loss.

29)(a) Diagram

Derivation of $n = \frac{\sin\frac{A+D}{2}}{\sin A/2}$

(OR)

$A = r_1 + r_2$
$d = i + e - A$
$n = \frac{\sin i}{\sin r}$

(b) For small angle, $n \approx \frac{\frac{A+D}{2}}{A/2}$
$= 1 + D/A$

$$\boxed{D = (n-1)A}$$

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