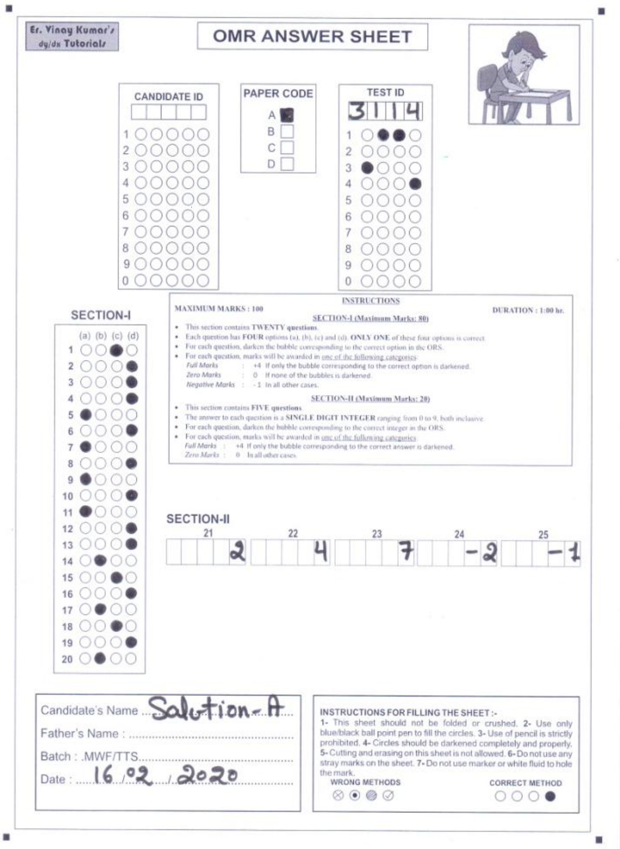
QUAT-14 (QJM014) JEE-MAIN-Pattern (Physics Solutions) Date : 16-02-2020

SET-A



Q1. $\boldsymbol{n_2 = n_1 \left(\frac{M_1}{M_2}\right)^1 \left(\frac{L_1}{L_2}\right)^1 \left(\frac{T_1}{T_2}\right)^{-2}}$

$$= 100 \left(\frac{gm}{kg}\right)^1 \left(\frac{cm}{m}\right)^1 \left(\frac{sec}{min}\right)^{-2}$$

$$= 100 \left(\frac{gm}{10^3 gm}\right)^1 \left(\frac{cm}{10^2 cm}\right)^1 \left(\frac{sec}{60\ sec}\right)^{-2}$$

$$n_2 = \frac{3600}{10^3} = 3.6$$

Q2.

$$\lambda_{max} = \frac{n^2(n+1)^2}{(2n+1)R} \Rightarrow \lambda_{\max(L)} = \frac{1^2(1+1)^2}{(2\times1+1)R}$$

$$\Rightarrow \lambda_{\max(L)} = \frac{4}{3R} \ldots (1)$$

$$\lambda_{max} = \frac{n^2(n+1)^2}{(2n+1)R} \Rightarrow \lambda_{\max(B)} = \frac{2^2(2+1)^2}{(2\times2+1)R}$$

$$\Rightarrow \lambda_{\max(B)} = \frac{36}{5R} \ldots.. (2)$$

$$\frac{(1)}{(2)} \Rightarrow \frac{\lambda_{\max(L)}}{\lambda_{\max(B)}} = \frac{\frac{4}{3R}}{\frac{36}{5R}} \Rightarrow \frac{\lambda}{\lambda_{\max(B)}} = \frac{4}{3R}\times\frac{5R}{36} = \frac{5}{27}$$

$$\Rightarrow \lambda_{max(B)} = \frac{27}{5}\lambda$$

Q3.

$$N = \frac{n(n-1)}{2} \Rightarrow N = \frac{4(4-1)}{2}$$

$$\Rightarrow N = \frac{4\times3}{2} \Rightarrow N = 6$$

Q4.

(a) Emission transition

$$\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \Rightarrow \frac{1}{\lambda_1} = R\times1\times\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$$

$$\Rightarrow \frac{1}{\lambda_1} = R\left[\frac{1}{1} - \frac{1}{4}\right] \Rightarrow \frac{1}{\lambda_1} = R\frac{3}{4} \Rightarrow \lambda_1 = 1.33R$$

(b) Absorption transition

(c) Absorption transition

(d) Emission transition

$$\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \Rightarrow \frac{1}{\lambda_2} = R\times1\times\left[\frac{1}{2^2} - \frac{1}{5^2}\right]$$

$$\Rightarrow \frac{1}{\lambda_2} = R\left[\frac{1}{4} - \frac{1}{25}\right] \Rightarrow \frac{1}{\lambda_2} = R\left[\frac{25-4}{100}\right]$$

$$\Rightarrow \frac{1}{\lambda_2} = R\frac{21}{100} \Rightarrow \lambda_2 = \frac{100R}{21}$$

$$\Rightarrow (\lambda_2 = 4.76R) > (\lambda_1 = 1.33R)$$

Q5. Total mass of reactants

= (2.0141) ×2=4.0282 amu

Total mass of products = 4.0024 amu

Mass defect = 4.0282 amu – 4.0024 amu

= 0.0258 amu

∴ Energy released E=931 × 0.0258 = 24 MeV

Q6.

$$n_\alpha = \frac{A - A'}{4} \Rightarrow n_\alpha = \frac{238-222}{4} \Rightarrow n_\alpha = 4$$

$$\Rightarrow Z - Z' = 2n_\alpha + n_{\beta^+} - n_{\beta^-}$$

$$\Rightarrow 90 - 83 = 2\times4 + 0 - n\beta^-$$

$$\Rightarrow 7 = 8 - n\beta^- \Rightarrow n\beta^- = 1$$

Q7. Number of half lives in two days for substances 1 and 2 respectively are

$\boldsymbol{n_1 = \frac{2\times24}{12} = 4}$ and $\boldsymbol{n_2 = \frac{2\times24}{1.6} = 3}$

By using $\boldsymbol{N = N_0\left(\frac{1}{2}\right)^n} \Rightarrow \frac{N_1}{N_2} = \frac{(N_0)_1}{(N_0)_2}\times\frac{\left(\frac{1}{2}\right)^{n_1}}{\left(\frac{1}{2}\right)^{n_2}}$

$$= \frac{2}{1}\times\frac{\left(\frac{1}{2}\right)^4}{\left(\frac{1}{2}\right)^3} = \frac{1}{1}$$

Q8. $\boldsymbol{\lambda = \frac{h}{\sqrt{2mE}}; \frac{\lambda}{\lambda} = \sqrt{\frac{E}{E}} \Rightarrow \frac{E}{\grave{E}} = \left(\frac{0.5}{1}\right)^2}$

$\Rightarrow \mathbf{E = \frac{E}{0.25} = 4E}$

The energy that should be added to decrease wavelength

= E – E = 3E

Q9. The work function has no effect on current. The photoelectric current is proportional to the intensity of light. Since there is no change in the intensity of light, therefore $I_1 = I_2$.

Q10. Peaks on the graph represent characteristic X-ray spectrum. Every peak has a certain wavelength, which depends upon the transition of electron inside the atom of the target. While $\boldsymbol{\lambda_{min}}$ depends upon the accelerating voltage (As $\boldsymbol{\lambda_{min} \propto 1/V}$).

Q11. Because *P*-side is more negative than *N*-side.

Q12. Arsenic has five valence electrons, so it is a donor impurity. Hence *X* becomes *N*-type semiconductor. Indium has only three outer electrons, so it is an acceptor impurity. Hence *Y* becomes *P*-type semiconductor. Also *N* (i.e. *X*) is connected to positive terminal of battery and *P* (i.e., *Y*) is connected to negative terminal of battery so *PN*-junction is reverse biased.

Q13. The output D for the given combination

$\boldsymbol{D = \overline{(A+B).C} = \overline{(A+B)} + \overline{C}}$

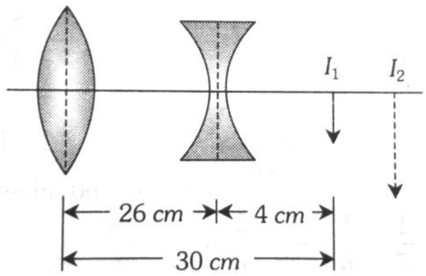
If A = B = C = 0

then $\boldsymbol{D = \overline{(0+0)} + \overline{0} = \overline{0} + \overline{0}}$ = 1 + 1 = 1

If A = B = 1, C = 0

then $\boldsymbol{D = \overline{(1+1)} + \overline{0} = \overline{1} + \overline{0} = 0 + 1 = 1}$

Q14. Convex lens will form image I_1 at it's focus which acts like a virtual object for concave lens.

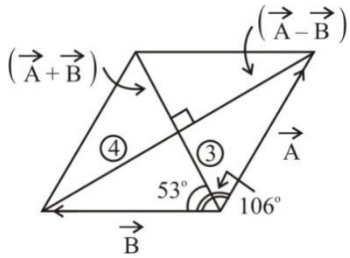


Hence for concave lens u = + 4 cm, f = 20 cm. So by

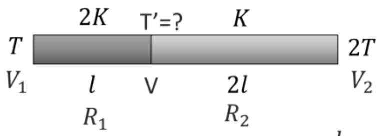
Lens formula $\frac{1}{-20} = \frac{1}{v} - \frac{1}{4} \Rightarrow \mathbf{v = 5\ cm}$ i.e. distance of final image (I_2) from concave lens v = 5 cm by using $\boldsymbol{\frac{v}{u} = \frac{I}{O} \Rightarrow \frac{5}{4} = \frac{I_2}{2} \Rightarrow I_2 = 2.5\ cm}$

Q15. Tension = [MLT^{-2}], surface Tension = [MT^{-2}]

Q16.



Q17.



$V_1 - V = iR_1$....(1)

$V - V_2 = iR_2$ ... (2)

$\frac{(1)}{(2)} \Rightarrow \frac{V_1 - V}{V - V_2} = \frac{R_1}{R_2}$

$\Rightarrow \frac{T - T'}{T' - 2T} = \frac{\frac{l}{2KA}}{\frac{2l}{KA}} \Rightarrow \frac{T - T'}{T' - 2T} = \frac{1}{4}$

$\Rightarrow 4T - 4T' = T' - 2T$

$\Rightarrow 5T' = 6T \quad \Rightarrow \boldsymbol{T' = 1.2T}$

Q18.

$\frac{dT}{dt} = \mathrm{k}(T - T_0)$

$\Rightarrow \frac{60 - 40}{10} = \mathrm{k}\left(\frac{60 + 40}{2} - T_0\right) \Rightarrow 2 = \mathrm{k}(50 - T_0)$......(1)

$\frac{40 - 30}{10} = \mathrm{k}\left(\frac{40 + 30}{2} - T_0\right) \Rightarrow 1 = \mathrm{k}(35 - T_0)$......(2)

$\Rightarrow 2 = \mathrm{k}(50 - T_0)$......(1)

$\Rightarrow 1 = \mathrm{k}(35 - T_0)$......(2)

$\frac{(1)}{(2)} \Rightarrow \frac{2}{1} = \frac{\mathrm{k}(50 - T_0)}{\mathrm{k}(35 - T_0)}$

$\Rightarrow 70 - 2T_0 = 50 - T_0 \Rightarrow T_0 = 20°\mathrm{C}$

Q19. Here, $\boldsymbol{V_{max} = \frac{24}{2} = 12mV}$ and $\boldsymbol{V_{min} = \frac{8}{2} = 4mV}$

Now,

$\boldsymbol{m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} = \frac{12-4}{12+4} = \frac{8}{16} = \frac{1}{2} = 0.5 = 50\%}$

Q21. $1 \sin 30^\circ = \mu \sin\theta$ ...... (1)

$\tan\theta = \frac{dx}{dy}$ .... (2)

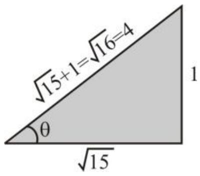
$y = 4x^2 \Rightarrow \frac{dy}{dx} = 8x \Rightarrow \frac{dx}{dy} = \frac{1}{8x}$

$\Rightarrow \frac{dx}{dy} = \frac{1}{8\frac{\sqrt{y}}{2}} \Rightarrow \frac{dx}{dy} = \frac{1}{4\sqrt{y}}$ .... (3)

$$\left[y = 4x^2 \;\Rightarrow\; x^2 = \frac{y}{4} \;\Rightarrow\; x = \sqrt{\frac{y}{4}} = \frac{\sqrt{y}}{2} \right]$$

from (2) & (3) : $\tan\theta = \dfrac{1}{4\sqrt{y}} \;\Rightarrow$

at $y = \dfrac{15}{16} \;\Rightarrow\; \tan\theta = \dfrac{1}{4\sqrt{\dfrac{15}{16}}} \;\Rightarrow\; \tan\theta = \dfrac{1}{\sqrt{15}}$

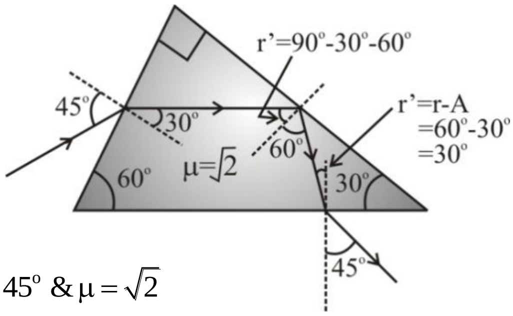


$\sin\theta = \dfrac{1}{4}$ .... (4)

from (1) & (4)

$\sin 30^\circ = \mu \sin\theta \;\Rightarrow\; \dfrac{1}{2} = \mu \times \dfrac{1}{4} \;\Rightarrow\; \mu = 2$

Q22.



For $i = 45^\circ$ & $\mu = \sqrt{2}$

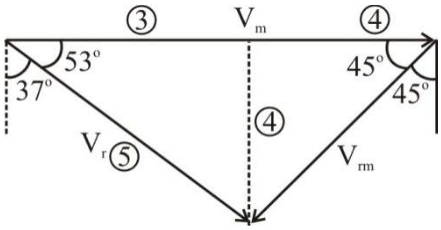
r is 30°

$\delta = \delta_1 + \delta_2 + \delta_3$

$= (45^\circ - 30^\circ) + 2(90^\circ - 60^\circ) - (45^\circ - 30^\circ) = 60^\circ$

$\delta = 15x = 60^\circ \;\Rightarrow\; x = 4$

Q23.

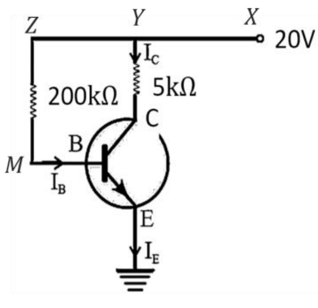


$V_m = 3 + 4 = 7$ m/s

Q24.

$\beta = \dfrac{I_C}{I_B} \Rightarrow 50 = \dfrac{2\,mA}{I_B}$

$I_B = \dfrac{2\,mA}{50} = 4 \times 10^{-2} mA$



Through path XYCE

$20V - 0 = I_C \times 5k\,\Omega + V_{CE}$

$20V = 2\,mA \times 5k\,\Omega + V_{CE}$

$20V = 10\,V + V_{CE} \;\Rightarrow\; V_{CE} = 10\,V$

Through path XYZMBE

$20\,V - 0 = I_B \times 200k\,\Omega + V_{BE}$

$20V - 0 = 4 \times 10^{-2} mA \times 200k\,\Omega + V_{BE}$

$20V = 8\,V + V_{BE} \;\Rightarrow\; V_{BE} = 12\,V$

$V_{CE} = V_{CB} + V_{BE} \;\Rightarrow\; V_{CB} = V_{CE} - V_{BE},$

$\Rightarrow V_{CB} = 10\,V - 12\,V = -2V \;\Rightarrow\; \boldsymbol{V_{BC} = -2\,V}$

Q25.

$v_c = \eta^{\,x} \rho^{\,y} r^{\,z}$

$\Rightarrow [LT^{-1}] = [ML^{-1}T^{-1}]^x [ML^{-3}]^y [L]^z$

$\Rightarrow [LT^{-1}] = [M^{x+y} L^{-x-3y+z} T^{-x}]$

$x + y = 0 \;\ldots\ldots (1)$

$-x - 3y + z = 1 \;\ldots\ldots (2)$

$-x = -1 \;\ldots\ldots (3)$

From eq (3): $x = 1 \;\ldots\ldots (4)$

From eq (1)& (4):

$1 + y = 0 \;\Rightarrow y = -1 \;\ldots\ldots (5)$

From eq (2), (4) & (5): $-1 - 3(-1) + z = 1 \Rightarrow \boldsymbol{z = -1}$