SOLUTION
RAY OPTICS AND OPTICAL INSTRUMENTS

EXERCISE-I (MHT CET LEVEL)

Q.1 (3)
Q.2 **(3)**
Q.3 **(3)**
Q.4 **(3)**
Q.5 (2)

$$h' = \frac{d_1}{\mu_1} + \frac{d_2}{\mu_2} = d\left(\frac{1}{\mu_1} + \frac{1}{\mu_2}\right)$$

Q.6 (2)
Q.7 (2)
Q.8 (4)
Q.9 (2)
Q.10 (1)
Q.11 (2)
Q.12 **(4)**
Q.13 **(1)**
Q.14 **(1)**
Q.15 **(1)**
Q.16 (2)

$$\mu_g \sin i = \mu_{rms} \sin 90° \Rightarrow \mu_g = \frac{1}{\sin i}$$

Q.17 $C_{max} = 60°$

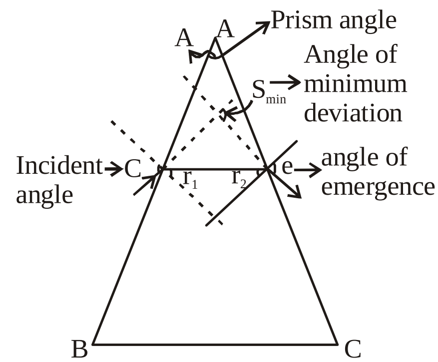
$$\therefore \; {}_r\mu_d = \frac{1}{\sin 60°}$$

or $$\frac{\mu_g}{\mu_\ell} = \frac{2}{\sqrt{3}}$$

$$\therefore \; \mu_\ell = \frac{\sqrt{3}}{2}\mu_g = \frac{\sqrt{3}}{2}\times 1.5$$

$= 1.3$

Q.18 (2)
Q.19 (3)
Q.20 (1)
Q.21 (3)
Q.22 **(1)**
Q.23 (2)



the angle of minimum deviation is given as

$\delta_{min} = i + e - A$ for minimum deviation $\delta_{min} = A$

2A = i + e in case of δ_{min} $i = e$ 2A = 2i

$r_1 = r_2 = \frac{A}{2}$ i = A = 90° from smell' law 1 sin i = n sin r_1

sin A = n sin $\frac{A}{2}$ $2\sin\frac{A}{2}\cos\frac{A}{2} = n\sin\frac{A}{2}$

$2\cos\frac{A}{2} = n$ when A = 90° = i_{min}

then $n_{min} = \sqrt{2}$

i = A = 0 $n_{max} = 2$

Q.24 (2)
Q.25 (4)
Q.26 (4)
Q.27 **(1)**
Q.28 **(4)**
Q.29 (1)
Q.30 **(4)**
Q.31 (2)

Cutting a lens in transverse direction doubles their focal length i.e. 2f Using the formula of equivalent focal length,

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + \frac{1}{f_4}$$

We get equivalent focal length as f/2.

Q.32 (3) **Q.33** (1) **Q.34** (1) **Q.35** (4) **Q.36** (4)
Q.37 (3) **Q.38** (3) **Q.39** (4) **Q.40 (4)** **Q.41 (3)**
Q.42 (1) **Q.43 (4)** **Q.44 (2)** **Q.45** (3) **Q.46** (1)

Q.47 (1)

$$\frac{f_0}{f_e} = 9 \qquad \therefore f_0 = 9f_e$$

Also, $f_0 + f_e = 20$ ($\because$ final image is at infinity)
$9f_e + f_e = 20$, $f_e = 2$ cm,
$\therefore f_0 = 18$ cm

Q.48 (4)

Here $\dfrac{X}{1000} = \dfrac{1.22\lambda}{D}$

or $x = \dfrac{1.22 \times 5 \times 10^3 \times 10^{-10} \times 10^3}{10 \times 10^{-2}}$

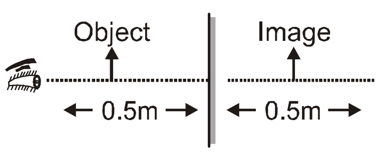
or $x = 1.22 \times 5 \times 10^{-3}$ m $= 6.1$ m

x is of the order of 5 mm.

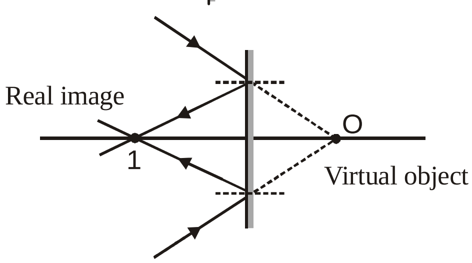
Q.49 (3)
Q.50 (3)
Q.51 **(2)**
Q.52 **(4)**

EXERCISE-II (NEET LEVEL)

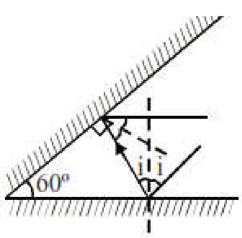
Q.1 (2)
Distance between object and image = 0.5 + 0.5 = 1 m



Q.2



Q.3 (3)



$i + 2l = 90°$...(i)
$i + 2l + 90° = 180°$ ...(ii)
$i + 2l = 90°$
$i + l = 60°$
$r = 30°$

Q.4 (3)
Mirror height = man height

$$= \frac{160}{2} = 80$$

Q.5 (4)
When objects is at the centre of curvature C then its image is also at C

Q.6 (4)

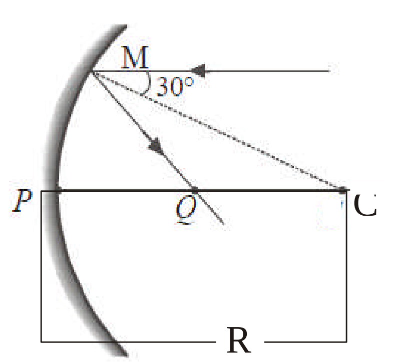
$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} + \frac{1}{-40} = \frac{1}{-20}$$

$v = -40$ cm

$$m = \frac{-v}{u} = -\frac{-(-40)}{40} = 1$$

Q.7 (4)
From similar triangles,



$$\frac{QC}{\sin 30°} = \frac{R}{\sin 120°}$$

$$\text{or } QC = R \times \frac{\sin 30°}{\sin 120°} = \frac{R}{\sqrt{3}}$$

Thus

$$PQ = PC - QC = R - \frac{R}{\sqrt{3}} = R\left(1 - \frac{1}{\sqrt{3}}\right)$$

Q.8 (2)

Q.9 (3)

$$\theta = \frac{d}{(15/2)} \qquad \left(\text{angle} = \frac{\text{arc}}{\text{radius}}\right)$$

$$d = \theta \times \frac{15}{2}$$

$= 8.7 \times 7.5 \times 10^{-3}$
$= 6.5 \times 10^{-2}$ cm

Q.10 (3)

$$m = -\frac{v}{u} = 3 = \frac{-v}{-u}$$

$u = 3u$ ...(i)
$u + v = 80$ ...(ii)

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \quad ....(iii)$$

from (i) and (ii)
$v = 60,\ u = 20$
Putting in equation (iii)

$$\frac{1}{f} = \frac{1}{60} + \frac{1}{-20}$$

$f = -30$ cm

Q.11 (4)

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

$$\frac{1}{6} + \frac{1}{(-15)} = \frac{1}{f}$$

$f = 10$ cm
$R = 2 \times 10 = 20$ cm

Q.12 (1)

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1}$$

$$\frac{n_1}{n_2} = \frac{v_2}{v_1} = \frac{\lambda_2}{\lambda_1}$$

$$\frac{n_1}{n_2} = \frac{v_1}{v_2}$$

Q.13 (2)

Q.14 (3)

Q.15 (2)

$$\text{velocity in medium} \propto \frac{1}{\text{Refactive index}}$$

$$\mu_g > \mu_w > \mu_c$$

$$v_W > v_g,\ v_W < v_c$$

Q.16 (3)

$${}_i\mu_j = \frac{\mu_j}{\mu_i}$$

$${}_2\mu_1 \times {}_3\mu_2 \times {}_4\mu_3$$

$$\frac{\mu_1}{\mu_2} \times \frac{\mu_2}{\mu_3} \times \frac{\mu_3}{\mu_4} = {}_4\mu_1$$

Q.17 (3)

$$6 = \frac{t_2}{\mu},\ t_2 = 9\text{cm}$$

$$4 = \frac{t_1}{1.5},\ t_1 = 6\text{cm}$$

$t_1 + t_2 = 15$cm

Q.18 (1)

4 Total Internal Reflection

Q.19 (3)

$$\lambda_x = 3500\text{Å}, \lambda_y = 7000\text{Å}$$

$\sin(x)\ n_x = \sin(y)\ n_y$

$$\sin(\theta_E) = \frac{\sin(x)}{\sin(y)} = \frac{n_y}{n_x} = \frac{\lambda_x}{\lambda_y}$$

$$n\frac{\lambda_x}{\lambda_y} = \frac{1}{2} \quad \Rightarrow \theta = \frac{\pi}{6}$$

Q.20 (1)

Q.21 (1)
Colour of light is determined by its frequency and an frequency does not change, colour will also not change and will remains green.

Q.22 (3)

$$\mu = \frac{\sin[(\delta_{min} + A)/2]}{\sin(A/2)}$$

$$\frac{\sin\left(\frac{60+30}{2}\right)}{\sin(30)} = \frac{1 \times 2}{\sqrt{2}} = \sqrt{2}$$

Q.23 **(3)**

Q.24 (1)

$\sqrt{2}\sin 30° = \sin e$

$e = 45°$

Deviation $= 45° - 30° = 15°$

Q.25 (2)

$r_2 = \sin^{-1}\left(\frac{1}{\mu}\right) = 45°$

$r_1 = A - r_2 = 75° - 45° = 30°$

$\frac{\sin i}{\sin r_1} = \sqrt{2}$ $\Rightarrow \sin i = \sqrt{2}\sin 30 = \sqrt{2} \times \frac{1}{2}$ $\Rightarrow i = 45°.$

Q.26 (1)

$\frac{1}{V} - \frac{3}{2\times 30} = \frac{1-\frac{3}{2}}{+20}$ $\frac{1}{V} = -\frac{1}{40} + \frac{1}{20} = +\frac{1}{40}$ V = 40 cm.

Q.27 (3)

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

$\frac{1}{v} - \left(\frac{1}{-5}\right) = \frac{1}{10}$

v = 10 cm

|m| = 2 (magnified)

Q.28 (2)

Q.29 (1)

If be the equivalent focal length, then

$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$ $\frac{1}{F} = (\mu_1 - 1)\left(\frac{1}{\infty} + \frac{1}{R}\right)$

$+(\mu_2 - 1)\left(\frac{1}{-R} - \frac{1}{\infty}\right) = \frac{\mu_1 - \mu_2}{R}$

$F = \frac{R}{\mu_1 - \mu_2}$

Q.30 (3)

By covering aperture, focal length does not change.

But intensity is reduced by $\frac{1}{4}$ times, as aperture diameter $\frac{d}{2}$ is covered. $\therefore I' = I - \frac{I}{4} = \frac{3I}{4}$

$\therefore$ New focal length = f and intensity = $\frac{3I}{4}$

Q.31 (1)

Q.32 (4)

Q.33 **(2)**

Q.34 **(4)**

Q.35 (4)

$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2} = 0$

$= \frac{1}{25} + \frac{1}{-20} - \frac{d}{-500} = 0$

$= \frac{20-25}{500} = -\frac{d}{500}$

d = 5 cm.

Q.36 (1)

$P = P_1 + P_2$

$= +4 + (-3)$

$= +1$

Q.37 (3)

$P_L = P_1 + P_2$

$P_L = \frac{1}{f_L}$

Q.38 (4)

f’ of diverging = –ve

$P = \frac{-1}{f}$

$P = \frac{-1}{40}$

P = –2.5 D

Q.39 (1)

$\omega = \left(\frac{\mu_v - \mu_r}{\mu_y - 1}\right)$

Q.40 (3)

(3) $\delta \propto (\mu - 1) \Rightarrow \mu_R$ is least so δ_R is least.

Q.41 (4)

(4) We know that $\frac{\delta_\upsilon - \delta_r}{\delta_{mean}} = \omega$

$\Rightarrow$ Angular dispersion $= \delta_v - \delta_r = \theta = \omega\delta_{mean}$

Q.42 (2)

By constitution of simple microscope we can observe it

Q.43 (4)

$$MP = \left(1+\frac{D}{f}\right) = \left(1+\frac{25}{5}\right) = 6$$

Q.44 (3)
In normal adjustment

$$m = -\frac{f_0}{f_e}$$

$$\text{so } 50 = -\frac{100}{f_e} \quad \Rightarrow \quad f_e = -2\text{ cm}$$

($\because$ eyepiece is concave lens)
and $L = f_0 + f_e = 100 - 2 = 98$ cm

Q.45 (2)
γ = magnifying power

$$\gamma = 1+\frac{D}{F}$$

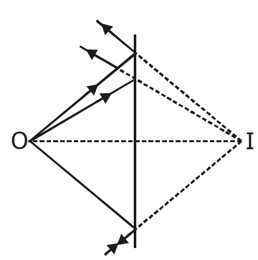
$$= 1+\frac{25}{f}$$

Q.46 (1)

$$m = 1 + \frac{D}{f}$$

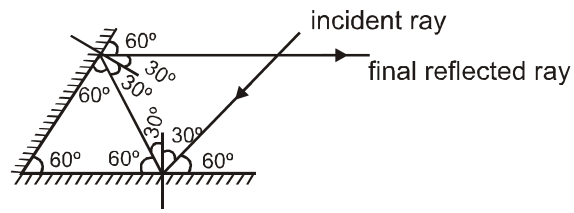
EXERCISE-III (JEE MAIN LEVEL)

Q.1 **(2)**
All the reflected rays meet at a point, when produced backwards.



Q.2 **(4)**
Irrespective of the type of mirror.

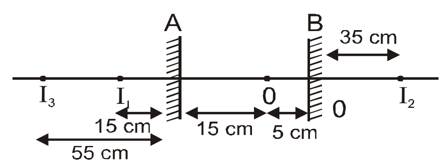
Q.3 **(2)**



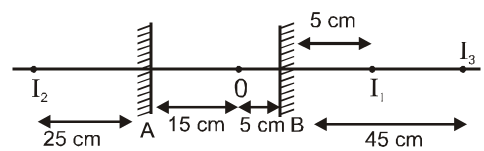
final ray is II to first mirror.

Q.4 **(3)**
If time in the clock is T_1 & time in image clock is T_2 then.
$T_1 + T_2 = 12 : 00 : 00$
$4 : 25 : 37 + T_2 = 12 : 00 : 00$
$T_2 = 07 : 34 : 37$

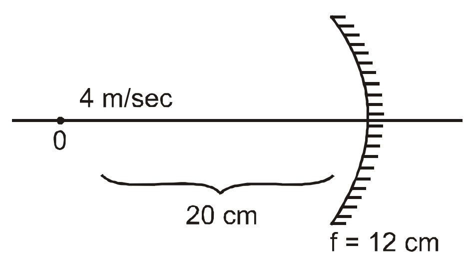
Q.5 **(3)**
Taking first reflection by A.



Taking first reflection by B



Q.6 **(3)**



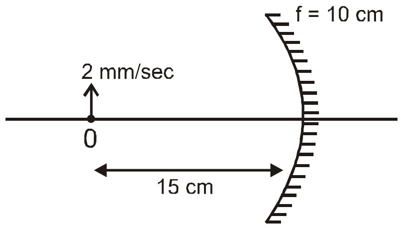
$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \quad \frac{1}{-12} = \frac{1}{v} + \frac{1}{-20} \Rightarrow \frac{1}{v} = \frac{1}{20} - \frac{1}{12} \Rightarrow$$

v = – 30 cm
velocity of image

$$\frac{dV}{dt} = -\left(\frac{V^2}{u^2}\right)\frac{du}{dt} = -\left(\frac{-30}{-20}\right)^2 4. = -9\text{ cm/sec.}$$

$\Rightarrow$ 9 cm/sec away from mirror.

Q.7 **(2)**



$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \Rightarrow \frac{1}{-10} = \frac{1}{v} + \frac{1}{-15} \Rightarrow \frac{1}{v} = \frac{2-3}{30}$

v = – 30 cm.

$m = \frac{I}{0} = -\frac{v}{u} = -\frac{-30}{-15} = -2$

$\frac{dI}{dt} = 2\ \frac{d\theta}{dt} = 4$ mm/sec.

Q.8 **(3)**

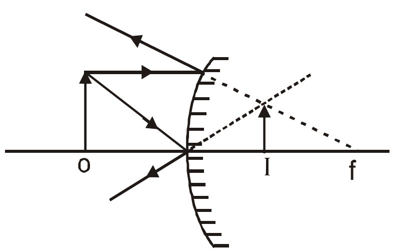
Using Newtons formula. x → distance of object from focus

$xy = f^2$ y → distance of object from focus

f → focal length.

$\Rightarrow by = (a/2)^2$, $y = \frac{a^2}{4b}$.

Q.9 **(3)**



Q.10 **(3)**

$\frac{I}{O} = -\frac{v}{u}$

If O and I are on same sides of PA . $\frac{I}{O}$ will be positive which implies v and u will be of opposite signs.

Similarly if O and I are on opp. sides, $\frac{I}{O}$ will be -ve which implies v and u will have same sign.

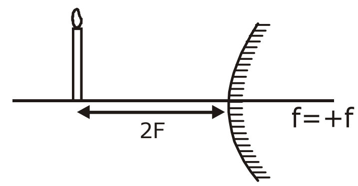
If O is on PA, $I = \left(-\frac{V}{u}\right)(O) = 0 \Rightarrow$ I will also be on. P.A.

Q.11 **(2)**

$\frac{1}{-f} = \frac{1}{-v} + \frac{1}{-u} \Rightarrow \frac{1}{v} = \frac{-1}{u} + \frac{1}{f}$

Slope = – 1 intercept = $\frac{1}{f}$ (positive)

Q.12 **(2)**



Taking u = – 2f & f = +f

$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} + \frac{1}{-2f} = \frac{1}{f}$

$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{2f} = \frac{2+1}{2f}$

$m = -\frac{v}{u} = \frac{-2f/3}{-2f} = \frac{1}{3}$

Q.13 **(2)**

Magnification is –3 because image is real & inverted.

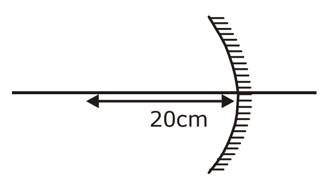
$m = \frac{-v}{u}$

$-3 = \frac{-v}{u}$

v = 3u.

given u = –20 cm

v = –60 cm



By using mirror formula

$\frac{1}{60} - \frac{1}{20} = \frac{1}{f}$

f = –15 cm

Q.14 **(2)**

Using mirror formula $\frac{h_i}{h_0} = \frac{-v}{u}$

Given $\frac{h_i}{h_0} = \frac{1}{2} = -\frac{v}{u}$

hence $v = -\frac{u}{2}$

given

$u = -40 \Rightarrow v = 20$

Using mirror formula

$$-\frac{1}{40} + \frac{1}{20} = \frac{1}{f}$$

$$\frac{1}{f} = \frac{1}{40}$$

f = 40

convex mirror with focal length = 40 cm

Q.15 **(1)**

Incorrect statement

A concave mirror forms only virtual image for any position of real object.

Q.16 **(4)**

Given $\frac{-v}{u} = \pm 2 \Rightarrow v = \pm 2$

from $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$$\pm\frac{1}{2u} + \frac{1}{u} = \frac{1}{-f}$$

after solving u = –30, –10 cm

Q.17 **(3)**

i = 2r

1 sin i = n sin r

$\Rightarrow$ 2 sin i/2 cos i/2 = n sin i/2

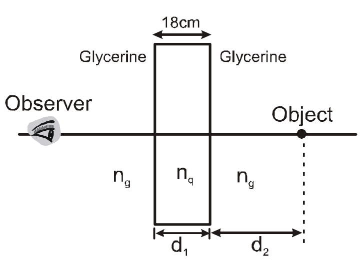
$\Rightarrow$ cos i/2 = (n/2)

$\Rightarrow$ i = 2 $\cos^{-1}$ (n/2)

Q.18 **(1)**

$$n_{quartz} = 2\ ;\ n_{glycerine} = \frac{4}{3} \Rightarrow \frac{n_{quartz}}{n_{glycerine}} = \frac{2}{4/3} = \frac{3}{2}$$

$= \mu_{rel}$



$$\text{shift} = t\left(1 - \frac{1}{\mu_{rel}}\right) = 18\left(1 - \frac{1}{3/2}\right) = 6 \text{ cm}$$

Q.19 **(3)**

From the formula

$$\frac{\text{Appartent depth}}{\text{Real depth}} = \frac{n_{air}}{n_{glass}}$$

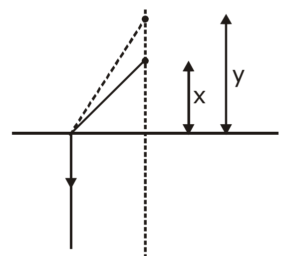
$$\text{Apparent depth} = \text{Real depth} \times \frac{n_{air}}{n_{glass}}$$

The letter which appear least raised has maximum Apparent depth and hence it has minimum μ for glass.

$$\mu \propto \frac{1}{\lambda}$$

for μ to be minimum λ should be maximum which is for Red.

Q.20 **(1)**

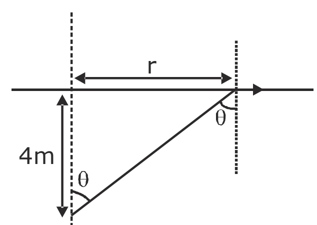


$$\frac{y}{x} = \frac{4}{3} \Rightarrow \frac{dy}{dt} = \frac{4}{3}\frac{dx}{dt}$$

= 8 m/sec

Q.21 **(3)**

In order to find the minimum diameter to block all the light we need to find the maximum radius of the circle formed.



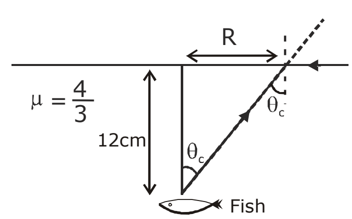
$$\tan\theta = \frac{r}{4} \Rightarrow \sin^{-1}\frac{3}{5} = \theta$$

$$\tan^{-1}\frac{3}{4} = \theta \Rightarrow \frac{r}{4} = \frac{3}{4}$$

[For radius to be maximum $\theta = \theta_C$] $\Rightarrow$ r = 3m

Diameter = 6 m

Q.22 **(4)**



$\tan\theta_C = \frac{R}{12}$ ...... (1)

A ray of light intering at 90º from rarer medium makes an angle of refraction equal to critical angle in the denser medium and critical angle is given by

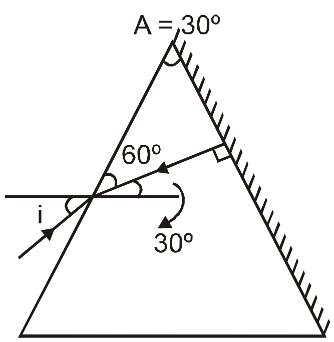
$\theta_C = \sin^{-1}\frac{3}{4}$

$\theta_C = \tan^{-1}\frac{3}{\sqrt{7}}$ ...... (2)

Equation (1) & (2)

$\frac{3}{\sqrt{7}} = \frac{R}{12} \Rightarrow R = \frac{12\times 3}{\sqrt{7}}$

Q.23 **(3)**

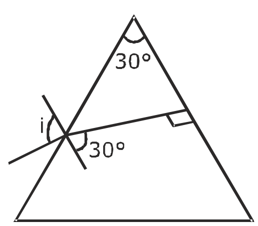


$\frac{\sin i}{\sin 30^o} = \sqrt{2} \Rightarrow \sin i = \sqrt{2}\times\frac{1}{2} = \frac{1}{\sqrt{2}} \Rightarrow i = 45^o$.

Q.24 **(3)**

Using $A = r_1 + r_2$

$r_1 = 30^o$

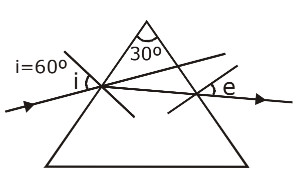


$\because r_2 = 0$

$1.\sin i = \sqrt{2}\sin 30^o$

$i = 45^o$

Q.25 **(1)**



$\delta = 30^o = i + e - A$

$60 + e - 30 = 30$

$e = 0$

Q.26 **(1)**

For minimum deviation

$r_1 = r_2 = r \Rightarrow 2r = A$

$r = \frac{A}{2} = 30^o$

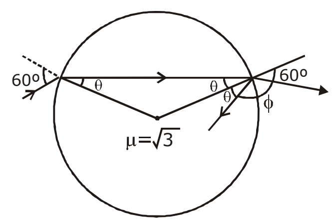
Now from Snell's law

$1\sin i = \sqrt{2}\sin 30^o$

$i = 45^o$

Q.27 **(2)**

Applying Snell's law on surface of incidence $\theta = \sin^{-1}\left(\frac{\sin 60}{\sqrt{3}}\right)$

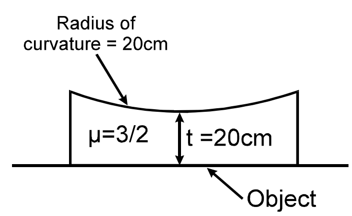


$\phi = 180 - [60 + \theta]$

$\phi = 180 - \left[60^o + \sin^{-1}\left(\frac{\sin 60^o}{\sqrt{3}}\right)\right]$

$= 180^o - [60 + 30] = 90^o$

Q.28 **(1)**



Considering refraction at the curved surface,

$u = -20$; $\mu_2 = 1$

$\mu_1 = 3/2$; $R = +20$

applying $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R} \Rightarrow \frac{1}{v} - \frac{3/2}{-20} = \frac{1-3/2}{20} \Rightarrow v = -10$

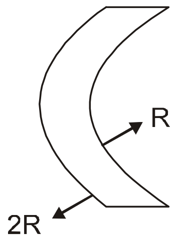
i.e. 10 cm below the curved surface or 10 cm above the actual position of flower.

Q.29 **(1)**

$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \Rightarrow \frac{1}{-24} = (1.5-1)\left(\frac{1}{2R} - \frac{1}{R}\right)$

$\Rightarrow \frac{1}{-24} = \frac{1}{2}\left(-\frac{1}{2R}\right)$

R = 6 cm ⇒ 2R = 12 cm



Q.30 **(3)**

$P = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ ....(i)

$P_0 = \left(\frac{\mu}{\mu_0}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

.....(ii)

$\frac{P}{P_0} = \frac{(\mu-1)\,\mu_0}{(\mu-\mu_0)}$ $P_0 = \frac{P\,(\mu-\mu_0)}{\mu_0(\mu-1)}$

Q.31 **(1)**

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ ...(1)

$m = \frac{v}{u}$ ...(2)

from (1) and (2) $m = \frac{f}{f+u}$

here $m = -\frac{18}{2} = -9$ {only real images can be formed on the screen, which is inverted}

$\therefore\ -9 = \frac{f}{f+(-10)}$

$\therefore\ -9f + 90 = f$

10f = 90

f = 9 cm

Q.32 **(1)**

Given $R_A = 0.9\ R_B$

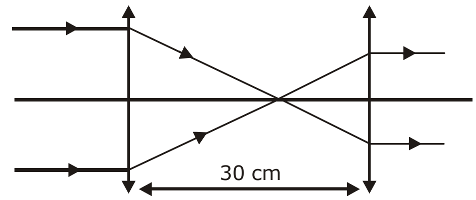
$\frac{1}{f_A} = \frac{1}{f_B}$

$(1.63-1)\ \frac{2}{R_A} = (x_B-1)\ \frac{2}{R_B}$

$x_B = 1.7$

Q.33 **(2)**

The rays coming from infinity parallel to principal axis and paraxial meet on focus after refraction and the rays originating from focus of the lens originate parallel to principal axis afer refraction.



Q.34 **(4)**

$f_A = f_B = f_C = f_{net}\ \Rightarrow P_A = P_B = P_C = P_{net} = P$

Q.35 **(1)**

Using the formula $P = \frac{1}{f\,(\text{in m})}$

$p_1 = 2D$

$f_1 = \frac{100}{2} = +50$ cm

$f_2 = -10$

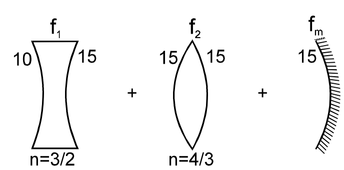
$f_2 = -100$ cm

$\frac{1}{f_{eq}} = \left[\frac{1}{f_1} - \frac{1}{f_2}\right]$

$= \left[\frac{1}{50} - \frac{1}{100}\right] = \left[\frac{2-1}{100}\right] = \frac{1}{100}$

$f_{eq} = 100$ cm

Q.36 **(4)**

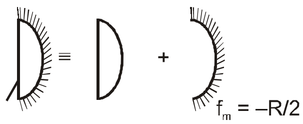


$\frac{1}{f_1} = \left(\frac{3}{2}-1\right)\left(\frac{-1}{10}-\frac{1}{15}\right) = -\frac{1}{12}$; $\frac{1}{f_2} = \left(\frac{4}{3}-1\right)\left(\frac{2}{15}\right) = \left(\frac{2}{45}\right)$; $\frac{1}{f_m} = -\frac{2}{15}$

$\Rightarrow \frac{1}{f_\ell} = \frac{1}{f_1} + \frac{1}{f_2}$ $\frac{1}{f_{eq}} = \frac{1}{f_m} - \frac{2}{f_\ell} = -\frac{1}{18} \Rightarrow f_{eq} = -18$ cm

So, the combination behaves as a concave mirror

Q.37 **(2)**



$$\frac{1}{-10} = \frac{2}{-R} - \frac{2}{f_\ell}$$

$$\frac{2}{R} = \frac{1}{10} - \frac{2}{56} = \frac{56-20}{560} = \frac{36}{560}$$

$$\frac{1}{R} = \frac{18}{560}$$

$$(\mu - 1)\frac{18}{560} = \frac{1}{56}$$

$$\mu - 1 = \frac{10}{18}$$

$$\mu = 1 + \frac{10}{18} = \frac{28}{18} = \frac{14}{9}.$$

Q.38 **(2)**

Using formula

$$\omega = \frac{n_v - n_R}{n_y - 1} \quad n_y = \frac{n_v + n_R}{2}$$

$$\omega = \frac{1.56 - 1.44}{1.5 - 1} \quad n_y = \frac{1.56 + 1.44}{2} = 1.5$$

$$\omega = \frac{0.12}{0.5} = 0.24$$

Q.39 **(1)**

1.6333 - 1 = 1.6161 = 0.0172

n_y-1

$$\frac{1.6333 - 1.6161}{1.6247 - 1} = 0.276$$

Q.40 **(2)**

Ray of Red light bends minimum because it has maximum λ & minimum μ .

EXERCISE-IV

Q.1 **5 cm**

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$$

$$\Rightarrow \frac{-df}{F^2} = \frac{-df_1}{f_1^2} - \frac{df_2}{f_2^2} - \frac{df_3^2}{f_2^2}$$

$$\frac{\omega}{F} = \frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} + \frac{\omega_3}{f_3}$$

for achromatism w = 0

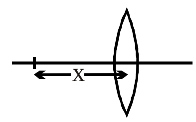
$$\Rightarrow \frac{-0.066}{22} - \frac{0.055}{11} + \frac{0.040}{f} = 0$$

$$-3 - 5 + \frac{40}{f} = 0$$

f = 5 cm **Ans.**

Q.2 0012

Final image at 2f $\Rightarrow$ object is at 2f.



for mirror, image is 2f behind.

$\Rightarrow$ object is 2f in front.

$\Rightarrow$ for lens u = –x ; v = –2f

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

$$\frac{1}{x} = \frac{1}{f} + \frac{1}{2f} = \frac{3}{2f}$$

$$x = \frac{2f}{3} = \frac{2 \times 18}{3} = 12 \text{ cm}$$

Q.3 16

In one case image is virtual (u = – 15 cm)

In another case image is real (u = – 40 cm)

$$v_1 = \frac{uf}{u+f} = \frac{-10f}{-10+f}$$

$$v_2 = \frac{-40f}{-40+f}$$

In both situations, sign convention is opposite

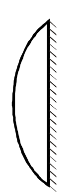
$\Rightarrow v_2 = v_1$

$$\Rightarrow v_2 = \frac{-10f}{-10+f} = \frac{40f}{-40+f}$$

f = 16 cm

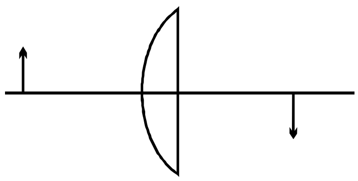
Q.4 0180

$$\frac{1}{f_{eq}} = \frac{-2}{f_2} + \frac{1}{f_M} \qquad f_M = \infty$$



$$\Rightarrow -\frac{1}{30} = -\frac{2}{f_2} \Rightarrow f_L = 60 \text{ cm}$$

$$m = -2 = \frac{v}{u}$$



$$u = \frac{-v}{2}$$

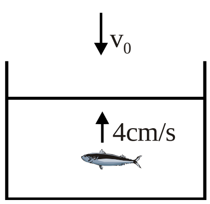
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_L} = \frac{1}{60}$$

$$\frac{1}{v} + \frac{2}{u} = \frac{1}{60}$$

v = 180 cm

Q.5 0009

$$\frac{v_I - v_S}{4/3} = \frac{v_0 - v_S}{1}$$



$$v_I = \frac{4v_0}{3}$$

$$v_I - v_f = 16 = \frac{4}{3} v_0 + 4 = 16$$

$$\frac{4}{3} v_0 = 12 \quad \Rightarrow v_0 = 9 \text{ cm/s}$$

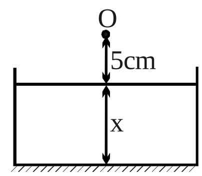
Q.6 0090

$$NS = 15\left(1 - \frac{1}{1.5}\right) = \frac{15}{3} = 5 \text{ cm}$$

Mirror is at 50 – 5 = 45 cm
⇒ Image is 45 cm behind the mirror.
Final image =- 45 + 50 – 5 = 90 cm

Q.7 0010

$$NS = x\left(1 - \frac{1}{4/3}\right) = \frac{x}{4} \text{ cm}$$



obj. at $5 + x - \frac{x}{4} = 5 + \frac{3x}{4}$

Image at $5 + \frac{3x}{4}$ behind mirror.

Final image $= 5 + x - \frac{x}{4} + 5 + \frac{3x}{4} = 10 + \frac{3x}{2} = 25$ cm

x = 10 cm

Q.8 0010
Refraction plane surface

$$h' = h\frac{\mu_r}{\mu_i} = \frac{20 \times 3/2}{1} = 30 \text{ cm}$$

Mirror

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \qquad \Rightarrow$$

$$\frac{1}{v} + \frac{1}{-45} = \frac{1}{-10}$$

$v = -\frac{90}{7}$ from pole of mirror.

Distance of object from plane surface

$$l = 15 - \frac{90}{7} = \frac{105 - 90}{7} = \frac{15}{7}$$

Refraction at plane surface $\quad x = 10 \; l' = l\frac{\mu_r}{\mu_i}$

$$x = l' = \frac{15}{7} \times \frac{1}{3/2} = \frac{10}{7} \qquad \Rightarrow \quad 7x = 10$$

(location of final image from plane surface)

Q.9 0002
The "Scotchlite" sphere is a ball of index of refraction n, whose rear semi-spherical interface is a reflecting surface. The focal length in the image space, f, for a single refractive interface is given by

$$f = \frac{nr}{n-1}$$

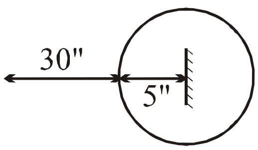
where r is the radius of the sphere. The index of refraction of air is unity. The index of refraction of the glass is chosen so that the back focal point of the front semi-spherical interface coincides with the apex of the rear semi-spherical interface i.e.,

$$f = 2r$$

Hence n = 2.

Q.10 0021

$$\frac{4}{3v} - \frac{1}{-30} = \frac{\frac{4}{3}-1}{5}$$



$$\frac{4}{3v} = \frac{1}{15} - \frac{1}{30} = \frac{1}{30}$$

v = 40" $\Rightarrow$ u = 35"

$$\frac{1}{v} - \frac{4/3}{+30} = \frac{1-4/3}{-5}$$

$$\frac{1}{v} - \frac{6}{90} + \frac{4}{90}$$

v = 9"

distance from observer = 21"

Q.11 (1)
Q.12 (1)
Q.13 (1)
Q.14 (1)
Q.15 (4)
Q.16 (3)

PREVIOUS YEAR'S

MHT CET

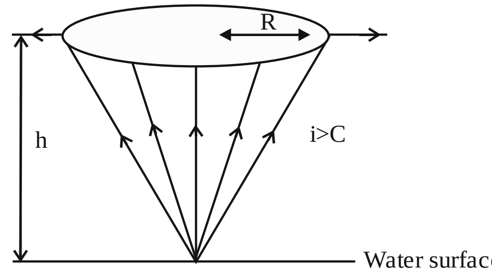
Q.1 (2)	**Q.2** (4)	**Q.3** (1)	**Q.4** (2)	**Q.5** (1)
Q.6 (3)	**Q.7** (3)	**Q.8** (2)	**Q.9** (1)	**Q.10** (3)
Q.11 (1)	**Q.12** (3)	**Q.13** (2)	**Q.14** (4)	**Q.15** (2)
Q.16 (4)	**Q.17** (4)	**Q.18** (2)	**Q.19** (2)	**Q.20** (2)
Q.21 (2)	**Q.22** (4)	**Q.23** (1)	**Q.24** (4)	**Q.25** (4)
Q.26 (2)	**Q.27** (2)	**Q.28** (4)	**Q.29** (4)	**Q.30** (4)
Q.31 (1)	**Q.32** (4)	**Q.33** (1)		

Q.34 **(2)**

The law of reflection is true for all points of the remaining part of tghe mirror, so the image will be that of the whole object. However, as the area of the reflecting surface has been reduced, hence the intensity of the image will be low.

Q.35 **(2)**

The given situation is shown below



From the figure we can see the light from the LED will not emerge out of the water, if at the edge of the disc, the incidence angle is greater than critical angle.

i.e., i > C

or sini > sin C

Now, if R is the radius of disc and λ is the depth of the LED, then

sini = $\frac{R}{\sqrt{R^2+h^2}}$ **and sic C =** $\frac{1}{\mu}$

From Eq(i), we have

$$\frac{R}{\sqrt{R^2+h^2}} > \frac{1}{\mu} \Rightarrow R > \frac{h}{\sqrt{\mu-1}}$$

Q.36 **(3)**

The angle between any two lines is equal to the angle between their perpendiculars.

$\therefore$ i = 30°

From Snell's law, we have

$$\frac{1}{1.5} = \frac{\sin 30°}{\sin r}$$

$\Rightarrow$ sinr = 0.75 or r = 48.6°

$\therefore$ Required angle between two emergent rays

= 2×18.6°

= 37.2° C ≈ 37°

Q.37 **(3)**

For dispersion without deviation

$$\frac{A}{A_1} = \frac{\mu' - 1}{\mu - 1}$$

$$\Rightarrow \frac{4}{A_1} = \frac{1.72-1}{1.54-1} = \frac{0.72}{0.54}$$

$$\Rightarrow A_1 = \frac{4 \times 0.54}{0.72} = 3°$$

Q.38 **(3)**

In the phenomenon of refraction, frequency of light remains unchanged.

Q.39 (2)

Given, $\mu_g = \sqrt{3}, \quad \delta_m = A$

As we know, refractive index of prism,

$$\mu_g = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}} \Rightarrow \sqrt{3} = \frac{\sin\left(\frac{A+A}{2}\right)}{\sin\frac{A}{2}}$$

$$= \frac{\sin A}{\sin\frac{A}{2}} = \frac{2\sin\frac{A}{2}\cos\frac{A}{2}}{\sin\frac{A}{2}} \quad (\because \sin 2\theta = 2\sin\theta\cos\theta)$$

$$= 2\cos\frac{A}{2}$$

$$\Rightarrow \cos\frac{A}{2} = \frac{\sqrt{3}}{2} = \cos 30° \Rightarrow \frac{A}{2} = 30°$$

or $A = 60°$

Q.40 (3)

The linear magnification of objective lens is

$$m_0 = \frac{v_0}{u_0} \qquad \text{...... (i)}$$

Using lens formula, $\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$

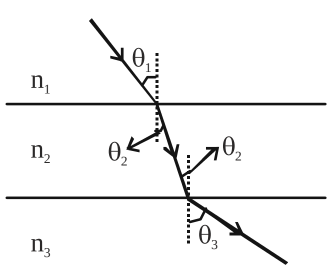
$$\Rightarrow \frac{1}{v_0} = \frac{1}{f_0} + \frac{1}{u_0} = \frac{u_0 + f_0}{u_0 f_0} \text{ or } v_0 = \frac{u_0 f_0}{f_0 + u_0}$$

Putting this value in Eq. (i), we get

$$m_0 = \frac{f_0}{f_0 + u_0}$$

Q.41 (4)

Given, path of ray through different medium are as shown below



It is clear that, $\theta_3 > \theta_1 > \theta_2$ or $\sin\theta_3 > \sin\theta_1 > \sin\theta_2$

$\therefore \; n_2 > n_1 > n_3$

Q.42 (2)

Since, refractive index of a medium can be given by

$$\mu = \frac{\text{real depth}}{\text{apparent depth}}$$

$$\Rightarrow \text{Apparent depth} = \frac{\text{Real depth}}{\mu}$$

$$\because \text{ Total apparent depth} = \frac{d}{\mu_1} + \frac{d}{\mu_2} = d\left(\frac{1}{\mu_1} + \frac{1}{\mu_2}\right)$$

Q.43 (1)

The deviation produced in a prism is given by

$$\delta = (\mu - 1)A$$

where, A = angle of prism.

In air, $\delta_a = ({}_a\mu_g - 1)A = \left(\frac{3}{2} - 1\right)A = \frac{A}{2}$

.......(i)

In water, $\delta_w = ({}_w\mu_g - 1)A = \left(\frac{{}_a\mu_g}{{}_a\mu_w} - 1\right)A$

$$= \left(\frac{3}{2} \times \frac{3}{4} - 1\right)A = \frac{A}{8} \qquad \text{.......(ii)}$$

From Eqs. (i) and (ii) we get $\frac{\delta_a}{\delta_w} = \frac{A}{2} \times \frac{8}{A} = 4:1$

NEET/AIPMT

Q.1 **(1)**

For telescope, angular magnification = $\frac{f_0}{f_E}$

So, focal length of objective lens should be large.

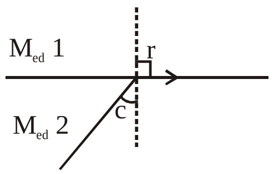
Angular resolution = $\frac{D}{1.22\lambda}$ should be large.

So, objective should have lare focal length (f_0) and large diameter D.7

Q.2 (3)

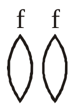
To see the rainbow the sun should be his backside.

Q.3 (4)



Angle of reflection 90º

Q.4 **(2)**



$f_{eq} = f_1$ | $\frac{1}{f} = (1.5-1)2/R$

$\frac{1}{f_1} = \frac{1}{f} + \frac{1}{f} = \frac{2}{f}$ | $\frac{1}{2} \times \frac{2}{R} = \frac{1}{R}$

$f_1 = \frac{f}{2} = \frac{R}{2}$ | $\frac{1}{f_2} = \frac{1}{R} - \frac{1}{R} + \frac{1}{R} = \frac{1}{R}$

$f_2 = R$

with glycerin : focal length of concave lens is formed

$$\frac{1}{f'} = (m-1)\left(-\frac{1}{R} - \frac{1}{R}\right) = \frac{1}{2}\left(-\frac{2}{R}\right) = \frac{-1}{R}\frac{f_1}{f_2} = \frac{R/2}{R} = \frac{1}{2}$$

Q.5 **(2)**
Q.6 (1)
Q.7 (3)
Q.8 (4)
Q.9 (3)
Q.10 (1)

$$\mu = \frac{C}{u} \Rightarrow u \propto \frac{1}{\mu}$$

$$\sin i_C = \frac{\mu_R}{\mu_D} = \frac{u_D}{u_R}$$

Critical angle $i_C = \sin^{-1}\left(\frac{3}{4}\right)$

$$\sin i_C = \frac{\mu_R}{\mu_D} = \frac{u_D}{u_R} = \frac{1.5}{2} = \frac{3}{4}$$

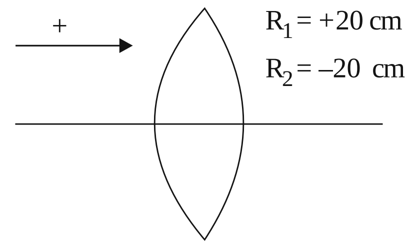
$$i_C = \sin^{-1}\left(\frac{3}{4}\right)$$

Q.11 (2)
Q.12 (2)

$R_1 = R_2 = 20\text{ cm} = 0.2\text{ m}$

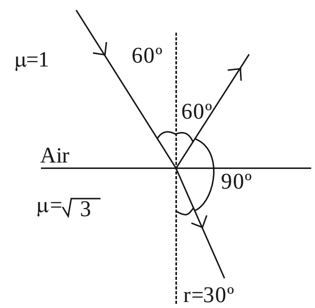
$$\mu = \frac{3}{2}$$

$$P = \frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$



$$P = \left(\frac{3}{2} - 1\right)\left(\frac{1}{0.2} + \frac{1}{0.2}\right)$$

$$P = \frac{1}{2}\left(\frac{2}{0.2}\right) = \frac{10}{2} = +5D$$



Method (i)

By Snell's law

$1 \sin 60º = \sqrt{3}\ \sin r$

$$\frac{\sqrt{3}}{2} = \sqrt{3}\sin r$$

$$\sin r = \frac{1}{2}$$

$r = 30º$

Angle between refracted and reflected ray is 90º

Method (ii)

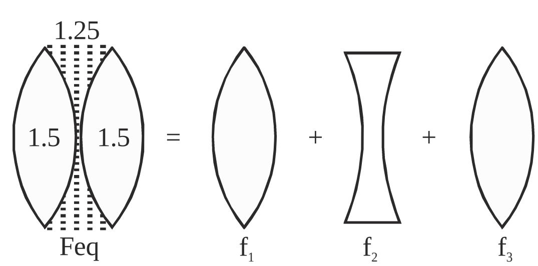
Because angle of incidence is Brewster's angle so that angle between reflected and refracted ray is 90º

$\tan i_p = \mu = \sqrt{3}$

$\boxed{i_p = 60º = i}$

JEE MAIN

Q.1 **(10)**



$f_1 = f_2 = 15$ cm

$$\frac{1}{f_1} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{15} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{R} - \frac{1}{(-R)}\right) = \left(\frac{1}{2}\right)\left(\frac{2}{R}\right)$$

R = 15 cm

$$\frac{1}{f_2} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$= (1.25 - 1)\left(\frac{-1}{15} - \frac{1}{15}\right)$$

$$\frac{1}{f_2} = (0.25)\left(-\frac{2}{15}\right)$$

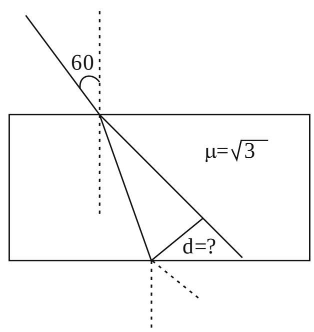
$f_2 = -30$

$f_1 = f_3 = 15$ cm

$$\Rightarrow \frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} = \frac{1}{15} + \frac{1}{(-30)} + \frac{1}{15} = \frac{2-1+2}{30}$$

$$\Rightarrow \frac{1}{f_{eq}} = \frac{3}{30} \Rightarrow f_{eq} = 10\,\text{cm}$$

Q.2 (12)



$d = t \sec r \sin(i - r)$

By Snell's law

$1 \sin 60^\circ = \sqrt{3} \sin r$

$$\frac{\sqrt{3}}{2} = \sqrt{3} \sin r$$

$$\sin r = \frac{1}{2}$$

r = 30

$d = t \times \sec 30 \sin(60 - 30)$

$$4\sqrt{3} = t \times \frac{2}{\sqrt{3}} \times \frac{1}{2}$$

$t = 4\sqrt{3} \times \sqrt{3} = 12\,\text{cm}$

Q.3 **(4)**

for total internal reflection, $I > \theta_C$

Also, $\mu = \sqrt{\mu_r \in_r}$

$$\frac{\mu_R}{\mu_D} = \frac{\sqrt{1\times1}}{\sqrt{4\times1}} = \frac{1}{2}$$

$$\Rightarrow \sin\theta_C = \frac{\mu_r}{\mu_D}$$

$$\sin\theta_C = \frac{1}{2} \Rightarrow \theta_C = 30^\circ$$

$i > 30^\circ$ ray gets TIR

$i = 60^\circ$ (TIR)

Q.4 **(3)**

Using $\mu = \frac{c}{v}$

$$v = \frac{c}{\mu}$$

$$\Rightarrow v_B = \frac{3\times10^8}{1.47} = 20.4 \times 10^8 = 20.4 \times 10^7\ \text{m/s}$$

$\because\ v_A - v_B = 2.6 \times 10^7$ m/s

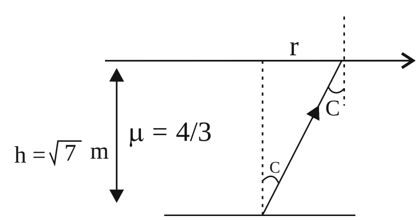
$\therefore\ v_A = (20.4 + 2.6) \times 10^7 = 23 \times 10^7$ m/s

$$\therefore \frac{\mu_B}{\mu_A} = \frac{v_A}{v_B} = \frac{23\times10^7}{20.4\times10^7} = 1.13$$

Q.5 **(210)**

Q.6 **[9]**

C : Critical angle



$$\tan C = \frac{r}{h}$$

$r = h \tan C$

$$\sin C = \frac{1}{\mu} = \frac{3}{4}$$

$$\tan C = \frac{3}{\sqrt{7}}$$

$$r = \sqrt{7} \times \frac{3}{\sqrt{7}} = 3$$

Area of surface = $\pi r^2 = 9\pi m^2$

Q.7 (4)

$i = 2r$

$\sin i \times n_1 = \sin r \times n_2$

$$\sin i \times 1 = \sin\frac{i}{2} \times \sqrt{2n}$$

$$\frac{\sin i}{\sin\frac{i}{2}} = \sqrt{2n}$$

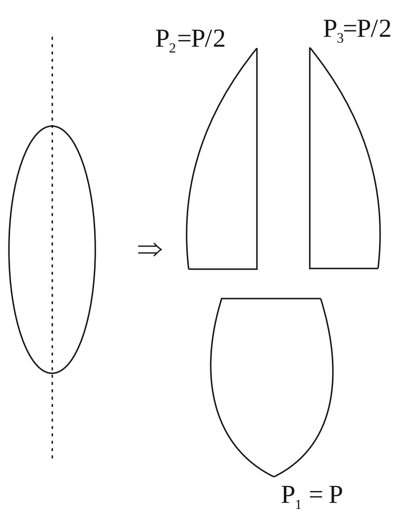
$$\frac{2\sin\frac{i}{2}\cos\frac{i}{2}}{\sin\frac{i}{2}} = \sqrt{2n}$$

$$\cos\frac{i}{2} = \sqrt{\frac{n}{2}}$$

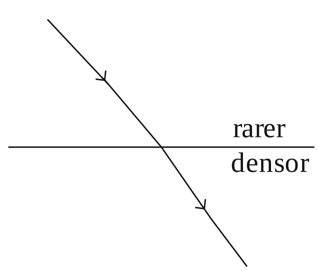
$$\frac{i}{2} = \cos^{-1}\left(\sqrt{\frac{n}{2}}\right)$$

$$i = 2\cos^{-1}\left(\sqrt{\frac{n}{2}}\right)$$

Q.8 (1)



Q.9 (3)



No change in frequency but speed and wave length decreases.

Q.10 (1)

Angle of prism = A

$\mu = \cot A/2$

$$\mu = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin(A/2)}$$

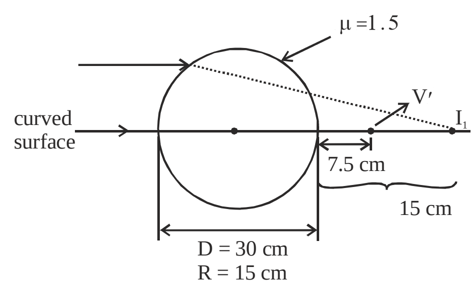
$$\cot\frac{A}{2} = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin(A/2)}$$

$$\frac{\cos A/2}{\sin A/2} = \frac{\text{Sin}\left(\frac{A+\delta m}{2}\right)}{\text{Sin}(A/2)}$$

$$\text{Sin}\left(90 - \frac{A}{2}\right) = \text{Sin}\left(\frac{A+\delta_m}{2}\right)$$

$\delta_m = 180 - 2A$

Q.11 (225)



I[st] refraction

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$\mu_2 = 1.5$; μ_1 = air = 1

$$\frac{1.5}{v} - \frac{1}{\infty} = \frac{0.5}{15}$$

$\boxed{v = 45\text{cm}}$

2[nd] surface refraction

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$\mu_2 = 1$; $\mu_1 = 1.5$

$$\frac{1}{v'} - \frac{1.5}{15} = \frac{0.5}{15}$$

$\boxed{v' = 7.5\text{cm}}$

∴ distance from centre of globe at which light rays convergen = (R + 7.5) cm

= (15+7.5) cm

= 22.5 cm

= 225 mm

Q.12 (4)

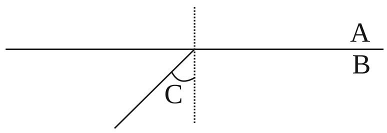
We known that

$$\boxed{\mu = \frac{c}{v}}$$

using this

$$\mu_A = \frac{3\times10^8}{2\times10^8} = 1.5$$

$$\mu_B = \frac{3\times10^8}{1.5\times10^8} = 2$$



For light going from B to A, For TIR to occur the angle of incidence must be greater than critical angle. $\mu_B \sin C = \mu_A \sin 90^o$

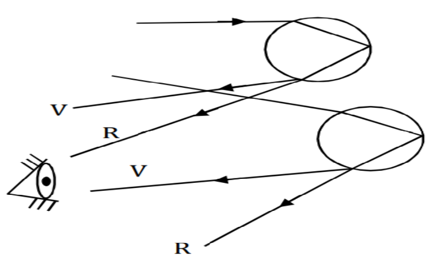
$$2 \sin C = \frac{3}{2}\times1$$

$$\Rightarrow \sin C = \frac{3}{4} \Rightarrow C = \sin^{-1}\frac{3}{4}$$

For TIR

$$\theta > C \Rightarrow \theta > \sin^{-1}\frac{3}{4}$$

Q.13 (1)



From the lower drop the red light will be below the line of sight and from upper drop violet light will be above the line of sight.
So red colour at the top and violet colour will on the bottom in primary rainbow

Q.14 (1)

$t_2 - t_1 = 5 \times 10^{-10}$sec

$$\frac{d}{v_B} - \frac{d}{v_A} = 5x10^{-10}$$

$$\frac{d}{v_A}\left(\frac{v_A}{v_B} - 1\right) = 5x10^{-10}$$

$$\frac{d}{v_A}\left(\frac{\mu_B}{\mu_A} - 1\right) = 5x10^{-10}$$

$$\frac{d}{v_A}(2-1) = 5x10^{-10}$$

$d = 5 \times 10^{-10}\, V_A$

Q.15 B

$$U = 240 \text{ cm } v = 12 \text{ cm } f = \frac{240}{21} = \frac{80}{7}$$

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

$$= \frac{1}{12} + \frac{1}{240}$$

$$\text{shift} = t\left(1 - \frac{1}{\mu}\right)$$

$$\frac{1}{f} = -\frac{20+1}{240} = 1\left(1 - \frac{1}{3/2}\right)$$

$$= \frac{3-2}{3} = \frac{1}{3}$$

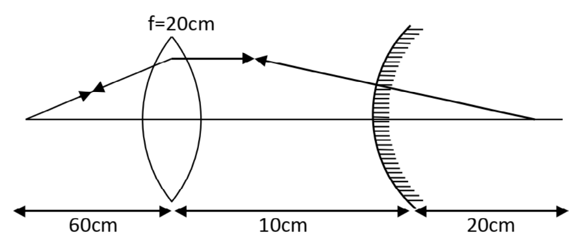
$$v' = 12 - \frac{1}{3} = \frac{35}{3}\text{cm} \Rightarrow \frac{1}{u'} = \frac{1}{v'} - \frac{1}{f}$$

$$= \frac{3}{35} - \frac{7}{80} = \frac{240-245}{35\times80}$$

$$\frac{1}{u'} = \frac{5}{36\times80} \Rightarrow u' = 560\text{cm}$$

u' = 5.6m
shifted = 5.6 – 2.4 = 3.2 m

Q.16 [10]



lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, U = –60, f = 20

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{U}$$

$$\Rightarrow v = \frac{f\,U}{U+f} = \frac{(20)(-60)}{-60+20} = \frac{(20)(-60)}{-40} = 30\text{cm}$$

v = 30 cm
According to question final image formed at combination coincides the object itself, so this is happened when ray incident on the centre of curvature of convex mirror.
So, U = 20 cm and V also be 20 cm, radius of curvature of mirror is R = 20 cm
f = R/2 = 10 cm

Q.17 [10]

$$\frac{1}{f}=(\mu-1)\left(\frac{1}{R}-\frac{1}{-R}\right)=\frac{(\mu-1)2}{R}$$

$R = 2(\mu-1)f$

$R = 2(1.5-1)\times f$

$\boxed{R=f}$ ...(1)

From given graph

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

$$y-x=\frac{1}{f}$$

$$y=x+\left(\frac{1}{f}\right)\Rightarrow \text{Intercept on y axis}$$

$$\frac{1}{f}=0.1 \text{ From graph}$$

$$f=\frac{1}{0.1}=10$$

$\boxed{R=f=10cm}$

Q.18 (1)

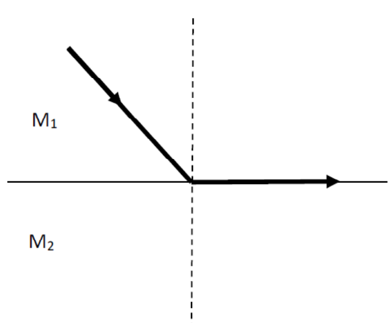
velocity in any medium is inversely proportional to the refractive index.

$$\therefore \frac{\mu_2}{\mu_1}=\frac{v_1}{v_2}=\frac{1.5}{2}$$

$$\frac{\mu_2}{\mu_1}<1$$

$\therefore \mu_2 < \mu_1$

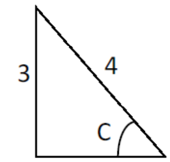
So for critical angle light will go from denser to rarer i.e., Medium 1 to Medium 2. Now,



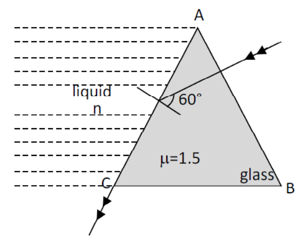
$\mu_1 \sin C = \mu_2 \sin 90^o$

$$\Rightarrow \sin C=\frac{\mu_2}{\mu_1}=\frac{1.5}{2}=\frac{15}{20}=\frac{3}{4}$$

Using this relation, we get $\tan C = \frac{3}{\sqrt{7}}$



Q.19 [27]



Hence the prism is equilateral, so angle of prism =60°

Therefore on 1st surface angle of refraction r_1=0°.

$r_1+i_2=A$

$\Rightarrow 0 + i_2 = 60^o$

$\Rightarrow i_2 = 60^o$

On second surface, i_2 will be critical angle. Applying snell's law on second surface, we get

$\mu_1\sin\theta_1 = \mu_2\sin\theta_2$

$$\Rightarrow \frac{3}{2}\sin i_2=\mu\sin 90^o$$

$$\Rightarrow \mu=\frac{3}{2}\times\frac{\sqrt{3}}{2}=\frac{3\sqrt{3}}{4}=\frac{\sqrt{27}}{4}$$

Q.20 (2)

$$\text{Resolving power} \propto \frac{\mu_{med}}{\lambda_{med}}$$

$$\frac{(R.P.)_2}{(R.P.)_1}=\frac{2}{1}=\left(\frac{\mu_{med}}{\lambda_{med}}\right)\times\left(\frac{\lambda_{air}}{\mu_{air}}\right)=\frac{\mu m}{\mu\, air}\times\left(\frac{\lambda_{air}}{\lambda_{air}/\mu_m}\right)=\mu_m^2=\frac{4}{1}$$

Q.21 (4)

$\delta_{net} = \delta_1 - \delta_2$

$\delta_{net} = (1.5-1)6^o - (1.55-1)5^o$

$= 3^o - 2.75^o = 0.25^o$

$$\frac{1}{x}=\frac{1}{0.25}\Rightarrow x=4$$

Q.22 (1)

$$\frac{\mu_2}{\mu_{air}}=\frac{C}{v_2}$$

$$\therefore \frac{\sqrt{\mu_{r_2}\varepsilon_{r_2}}}{(1)}=\frac{C}{v_2} \quad \therefore \sqrt{(1)(9)}=\frac{C}{v_2} \quad \therefore v_2=\frac{C}{3}$$

Q.23 (1)

$f_0 + f_e = 30$

$m = \frac{f_0}{f_e}$

$2 = \frac{f_0}{f_e} \Rightarrow f_0 = 2f_e$

So $f_0 + \frac{f_0}{2} = 30$

$f_0 = 20$ cm

Q.24 (2)

$P = \frac{\mu_2}{f} = (\mu_1 - \mu_2)\left(\frac{1}{R_1} - \frac{1}{R2}\right)$ (For this formula refer to NCERT Part-2, Chapter-9, Page no 328, solved example 8)

(μ_1 is refractive index of lens and μ_2 is of surrounding medium)

$1.25 = (1.5 - \mu_2)\left(\frac{1}{0.2} + \frac{1}{0.4}\right)$

$\frac{1.25 \times 0.08}{0.6} = (1.5 - \mu_2)$

$\Rightarrow \mu_2 = \frac{4}{3}$

Q.25 [400]

R = 200 cm

$V_0 = 2$ cm/s

position of object after 10 sec

u = 100 – distance covered

u = 100 – 2 × 10 = 80 cm

$f = \frac{R}{2} = \frac{200}{2} = 100$ cm

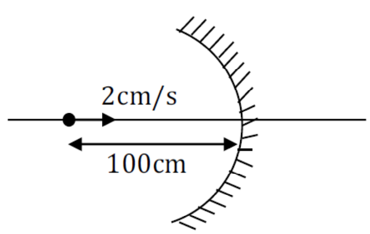
u = 80 cm

sign conservation

f = – 100 cm

u = – 80 cm

$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u}$



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

$\frac{1}{v} = \frac{-80 + 100}{80 \times 100}$

$v = \frac{80 \times 100}{20} = 400$ cm

Q.26 [15]

$v'.\mu' = 225$

we know that

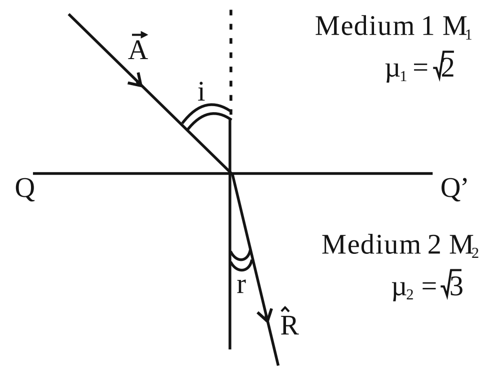
$f = \sqrt{v.u}$

$= \sqrt{225}$

= 15 cm

Q.27 (15)

$\vec{A} = 4\sqrt{3}\,\hat{i} - 3\sqrt{3}\,\hat{j} - 5\hat{k}$



$\mu_1 \sin i = \mu_2 \sin r$

As incident vector A makes i angle with normal z-axis & refracted vector R makes r angle with normal z-axis with help of direction cosine

$i = \cos^{-1}\left(\frac{A_Z}{A}\right) = \cos^{-1}\left(\frac{5}{\sqrt{(4\sqrt{3})^2 + (3\sqrt{3})^2 + (5^2)}}\right)$

$= \cos^{-1}\left(\frac{5}{10}\right) \Rightarrow i = 60°$

$\sqrt{2}\sin 60 = \sqrt{3} \times \sin r$

r = 45°

Difference between i and r = 60 – 45 = 15

Q.28 (3)

i = 45º

D = i – r

15º = 45 – r ⇒ r = 30º

$n_1 \sin i = n_2 \sin r$

1 sin 45º = μ sin 30º

$\frac{1}{\sqrt{2}} = \mu\frac{1}{2}$

$\mu = \sqrt{2} = 1.414$

WAVE OPTICS

EXERCISE-I (MHT CET LEVEL)

Q.1 (2)

Q.2 (3)
Huygen's wave theory fails to explain the particle nature of light (*i.e.* photoelectric effect)

Q.3 (3)

$$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{I} + \sqrt{4I}\right)^2 = 9I$$

$$I_{min} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{I} + \sqrt{4I}\right)^2 = I$$

Q.4 (3)

Q.5 (4)

$$\frac{I_1}{I_2} = \frac{1}{25}, \therefore \frac{a_1^2}{a_2^2} = \frac{1}{25} \Rightarrow \frac{a_1}{a_2} = \frac{1}{5}$$

Q.6 (3)

$$\frac{a_1}{a_2} = \frac{3}{5}.$$

$$\therefore \frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(3+5)^2}{(3-5)^2} = \frac{16}{1}$$

Q.7 (2)
Direction of wave is perpendicular to the wavefront.

Q.8 (1)
$I \propto a^2$

$$I \Rightarrow \frac{a_1}{a_2} = \left(\frac{4}{1}\right)^{1/2} = \frac{2}{1}$$

Q.9 (3)
$I \propto a^2$

$$1 \Rightarrow \frac{I_1}{I_2} = \left(\frac{a_1}{a_2}\right)^2 = \left(\frac{3}{4}\right)^2 = \frac{9}{16}$$

Q.10 (2)
$\phi = \pi/3, a_1 = 4, a_2 = 31$

So, $A = \sqrt{a_1^2 + a_2^2 + 2a_1.a_2 \cos\phi} \Rightarrow A \approx 6$

Q.11 (4)
Diffraction shows the wave nature of light and photoelectric effect shows particle nature of light.

Q.12 (3)
In interference of light the energy is transferred from the region of destructive interference to the region of constructive interference. The average energy being always equal to the sum of the energies of the interfering waves. Thus the phenomenon of interference is in complete agreement with the law of conservation of energy.

Q.13 (3)
For brightness, path difference
So second is bright.

Q.14 (3)
Suppose slit width's are equal, so they produces waves of equal intensity say I'. Resultant intensity at any point $I_R = 4I' \cos^2 \phi$ where ϕ is the phase difference between the waves at the point of observation.
For maximum intensity $\phi = 0° \Rightarrow I_{max} = 4I' = I$ .....(i)
If one of slit is closed, Resultant intensity at the same point will be I'only *i.e.* $I' = I_O$ …(ii)
Comparing equation (i) and (ii) we get $I' = 4I_O$

Q.15 (1)
In the normal adjustment of young's, double slit experiment, path difference between the waves at central location is always zero, so maxima is obtained at central position.

Q.16 (1)

$\theta = \frac{\lambda}{d}$; θ can be increased by increasing λ, so here λ has to be increased by 10%

i.e., % Increase $= \frac{10}{100} \times 5890 = 589Å$

Q.17 (2)
If intensity of each wave is *I*, then initially at central position $I_0 = 4I$. when one of the slit is covered then intensity at central position will be *I* only *i.e.*, $\frac{I_0}{4}$.

Q.18 (2)

Q.19 (4)
Distance of the n^{th} bright fringe from the centre $x_n = \frac{n\lambda D}{d}$

$$\Rightarrow x_3 = \frac{3 \times 6000 \times 2.5}{0.5 \times 10^{-3}} = 9 \times 10^{-3}\,m = 9\,mm$$

Q.20 (2)

Q.21 (1)
When white light is used, central fringe will be white with red edges, and on either side of it, we shall get few coloured bands and then uniform illumination.

Q.22 (2)

Q.23 (2)

Shift in the fringe pattern $x = \frac{(\mu-1)t.D}{d}$

$= \frac{(1.5-1)\times 2.5\times 10^{-5}\times 100\times 10^{-2}}{0.5\times 10^{-3}} = 2.5\text{ cm}$

Q.24 (4)
In the presence of thin glass plate, the fringe pattern shifts, but no change in fringe width.

Q.25 (2)

Q.26 (4)
If shift is equivalent to n fringes then

$n = \frac{(\mu-1)t}{\lambda} \Rightarrow n \propto t \Rightarrow \frac{t_2}{t_1} = \frac{n_2}{n_1} \Rightarrow t_2 = \frac{n_2}{n_1}\times t$

$t_2 = \frac{20}{30}\times 4.8 = 3.2\text{ mm}$

Q.27 (1)
According to given condition

$(\mu - 1)t = n\lambda$ t, n =1

So, $(\mu - 1)\, t_{min} = \lambda$

$t_{min} = \frac{\lambda}{\mu-1} = \frac{\lambda}{1.5-1} = 2\lambda$

Q.28 (3)
It is caused due to turning of light around corners.

Q.29 (2)
Diffraction is obtained when the slit width is of the order of wavelength of EM waves (or light). Here wavelength of X-rays (1-100 Å) is very-very lesser than slit width (0.6 mm). Therefore no diffraction pattern will be observed.

Q.30 (1)

$2\theta = \frac{2\lambda}{d}$ (where d = slit width) As d decreases, θ increases.

Q.31 (2)
Polariser produced prolarised light.

Q.32 (4)
Ultrasonic waves are longitudinal waves.

Q.33 (1)
When unpolarised light is made incident at polarising angle, the reflected light is plane polarised in a direction perpendicular to the plane of incidence. Therefore $\vec{E}$ in reflected light will vibrate in vertical plane with respect to plane of incidence.

EXERCISE-II (NEET LEVEL)

Q.1 (3)
Contrast indicates the ratio of maximum possible intensity on screen to the minimum possible intensity.

As $\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2}{\left(\sqrt{I_1}-\sqrt{I_2}\right)^2}$

so it only depends on the source intensity.

Q.2 (3)
Amplitude depends upon intensity and phase difference.

Q.3 (4)
In interferene there should be two coherent sources and propagation of waves should be simultaneously and in same direction.

Q.4 (3)
In transverse and longitudinal waves.

Q.5 (2)
Wave nature

Q.6 (2)
Given $I_1 : I_2 = 100 : 1$

$\frac{\sqrt{I_1}}{\sqrt{I_2}} = 10 : 1$

$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = (10 + 1)^2 = 121$

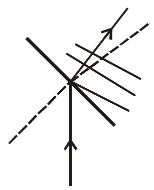
$I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = (10 - 1)^2 = 81$

$\frac{I_{max}}{I_{min}} = 121 : 81$

Q.7 (4)
In coherent sources initial phase remains constant.

Q.8 (2)
Phase difference changes with time.

Q.9 (1)



Wave front.

Q.10 (3)
Frequency remains constant wave length decreases.

Q.11 (1)

$\frac{13\lambda}{2} = 0.13$

$\Rightarrow \lambda = \frac{2}{100}$ m

$\because f = \frac{v}{\lambda}$

$\Rightarrow f = \frac{3\times10^8\times100}{2} = 1.5\times10^{10}$ Hz

Q.12 (1)

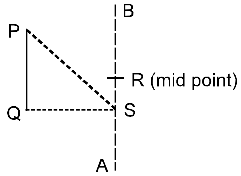
we know that $\beta = \frac{\lambda D}{d}$ & $\lambda_{yellow} > \lambda_{blue}$.

$\Rightarrow$ as λ decreases, so β also decreases.

Q.13 (2)

Q.14 (1)

Q.15 (3)
Lets take any general point S on the line AB.



Clearly: for any position of S on line AB; we have for Δ PQS:
PQ + QS > PS{in any triangle sum of 2 sides is more then the third side}
$\Rightarrow$ PS – QS < 3λ.

As PS – QS represents the path difference at any point on AB $\Rightarrow$ it can never be more than 3λ. Now minimas occur at.

$\frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$ only.

so 3 minimas below R (mid point of AB) and 3 also above R.

Q.16 (3)

$\Delta x = (24-1)\frac{\lambda}{2} = \frac{dy}{D}$

$y = (2x-1)\frac{D\lambda}{2d}$

Q.17 (3)

$\beta = \frac{\lambda D}{d}$

$\lambda\downarrow \beta\downarrow$

Q.18 (2)

$\beta = \frac{\lambda D}{d}$

Q.19 (1)

$\beta = x = \frac{\lambda D}{d}$ D =

$\lambda = \frac{xd}{L}$

Q.20 (3)
$4I_0 = I$
$I_0 = I/4$

Q.21 (3)

$I' = 4I\cos^2\frac{\Delta\phi}{2}$

$\Rightarrow \cos^2\frac{\Delta\phi}{2} = \frac{1}{4} \Rightarrow \cos\frac{\Delta\phi}{2} = \pm\frac{1}{2}$

$\Rightarrow \Delta\phi = \frac{2x}{\lambda}\frac{dy}{D} \Rightarrow \cos\frac{\pi.dy}{\lambda D} = +\frac{1}{2}$

$\Rightarrow \frac{\pi.dy}{\lambda D} = \frac{\pi}{3} \Rightarrow y = \frac{\lambda D}{3d}$

Q.22 (1)

$$\Delta\phi = \frac{d.y}{D} \times \frac{2\pi}{\lambda}$$

$$\because \ y = \frac{\lambda D}{d} \times \frac{1}{4}$$

$$\therefore \ \Delta\phi = \frac{\pi}{2} \qquad \Rightarrow I' = 4I\cos^2\frac{\Delta\phi}{2} = 2I$$

Q.23 (3)

$I_0 = 4I$

Intensity due to one

$$\Delta\phi = \frac{d.y}{D} \times \frac{2\pi}{\lambda}$$

$$= \frac{0.25 \times 10^{-2} \times 4 \times 10^{-5}}{100 \times 10^{-2}} \times \frac{2\pi}{6000 \times 10^{-10}}$$

$\Delta\phi = \pi/3$

$$I' = I_0 \cos^2\frac{\frac{\pi}{3}}{2} = \frac{3I_0}{4}$$

Q.24 (3)

$0.3 \times 10^{-3} \times \sin 30^o = n \times 500 \times 10^{-9} \Rightarrow n = 300$

$\therefore \ 299 + 299 + 1 = 599$

Q.25 (1)

Q.26 (2)

For strong reflection.

$$2\mu t = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2} \ ......$$

$$\Rightarrow \lambda = 4\mu t, \frac{4\mu t}{3}, \frac{4\mu t}{5}, \frac{4\mu t}{7} \ ......$$

$\Rightarrow$ 3000 nm. 1000 nm, 600 nm, 430 nm,333 nm.

$\Rightarrow$ only option is 600 nm.

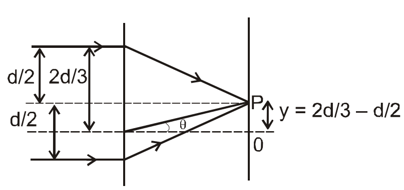
Q.27 (2)

$$\frac{n\lambda_R D}{d} = (n+1)\frac{\lambda_B D}{d}$$

$\Rightarrow n. 7800 = (n + 1)\ 5200$

$\Rightarrow n = 2.$

Q.28 (4)



we know that P will be the central maxima (at which path difference is zero)

$$\text{Now } OP = \frac{d}{2} - \frac{d}{3} = \frac{d}{6}$$

Q.29 (3)

Fourth maxima will be at $y = 4\beta$.

$$\Rightarrow y = \frac{4\lambda D}{d}$$

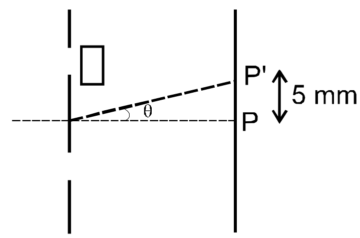
as $\lambda_{Green} > \lambda_{blue}$.

$\Rightarrow \beta_{Green} > \beta_{blue}$

$\Rightarrow X_{Green} > X_{blue}$

$$\text{Also get } \frac{X(\text{blue})}{X(\text{green})} = \frac{4360}{5460}$$

Q.30 (1)



Clearly the central maxima at P(initially) shifts to P' where PP' = 5 mm.

So now, path difference at P' must be zero.

$\Rightarrow d\sin\theta = (\mu - 1)t$

$\Rightarrow d\tan\theta = (\mu - 1)t$

$$\mu = 1 + \frac{d.(PP')}{Dt}\text{; get } \mu = 1.2$$

Q.31 (4)

$$\beta = \frac{\lambda D}{d}$$

In water $\lambda\downarrow$ so $\beta\downarrow$

Q.32 (3)

$$2I = 4I\cos^2\frac{\Delta\phi}{2}$$

$$\Rightarrow \cos\frac{\Delta\phi}{2} = \frac{1}{\sqrt{2}} \ \Rightarrow \ \frac{\Delta\phi}{2} = \frac{\pi}{4}$$

$$\Rightarrow \frac{2\pi}{\lambda} \times \frac{\left(\frac{3}{2} - 1\right)t}{2} = \frac{\pi}{4} \ \Rightarrow t = \lambda/2$$

Q.33 (4)

$$\Delta x = (2n+1)\,\frac{\lambda}{2}$$

$$\Delta x = (\ell_1 + \ell_3) - (\ell_2 + \ell_4) = (2n+1)\,\frac{\lambda}{2}$$

EXERCISE-III (JEE MAIN LEVEL)

Q.1 (3)

$$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{I} + \sqrt{4I}\right)^2 = 9I$$

$$I_{min} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{I} + \sqrt{4I}\right)^2 = I$$

Q.2 (3)

Contrast indicates the ratio of maximum possible intensity on screen to the minimum possible intensity.

$$\text{As } \frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2}$$

so it only depends on the source intensity.

Q.3 (2)

$y_1 = A_1 \sin 3\omega t,\ f_1 = 0$

$$y_2 = A_2 \cos\left(3\omega t + \frac{\pi}{6}\right)$$

$$y_2 = A_2 \sin\left(\frac{\pi}{2} + 3\omega t + \frac{\pi}{6}\right),\quad f_2 = \frac{\pi}{2} + \frac{\pi}{6}$$

$D\,f = f_2 - f_1$

$$\Delta\phi = \frac{\pi}{2} + \frac{\pi}{6} = \frac{3\pi + \pi}{6} = \frac{4\pi}{6} = \frac{2\pi}{3}$$

Q.4 (2)

Given $I_1 : I_2 = 100 : 1$

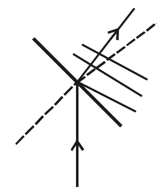
$$\frac{\sqrt{I_1}}{\sqrt{I_2}} = 10 : 1$$

$$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = (10+1)^2 = 121$$

$$I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = (10-1)^2 = 81$$

$$\frac{I_{max}}{I_{min}} = 121 : 81$$

Q.5 (1)



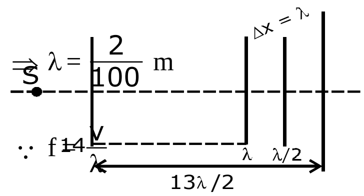
Wave front.

Q.6 (1)

$$\frac{13\lambda}{2} = 0.13$$

$$\Rightarrow \lambda = \frac{2}{100}\ \text{m}$$

$$\because f = \frac{v}{\lambda}$$



$$\Rightarrow f = \frac{3 \times 10^8 \times 100}{2} = 1.5 \times 10^{10}\ \text{Hz}$$

Q.7 (2)

As $\lambda << d$; we can we $\quad \beta = \frac{\lambda D}{d}$

$$\text{we get } \beta = \frac{500 \times 10^{-9} \times 1}{10^{-3}} = 0.5\ \text{mm}.$$

As β is not very small; hence it might so happen that till 1000th maxima, we no longer can apply $y' = 1000 \times \beta$.

Lets see if we can apply:

At 1000th maxima. Path difference is $1000\,\lambda$.

$$\Rightarrow 1000\,\lambda = d \sin\theta = \frac{d \times y}{\sqrt{D^2 + y^2}}$$

$$\Rightarrow (5 \times 10^{-4})^2 = \frac{(10^{-3}\ \text{m})^2 \times y^2}{D^2 + y^2}$$

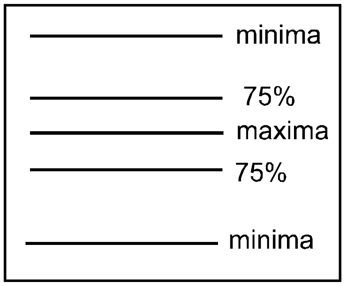
$$\Rightarrow 0.25\,D^2 = y^2(1 - 0.25) \Rightarrow y = \left(\frac{0.25}{0.75}\right)^{\frac{1}{2}} \times D$$

$$y = \frac{D}{\sqrt{3}} = 0.577\ \text{m}.$$

As 0.577 m. and 0.5 m. are quite distant, so we could not use $y' = 1000\,\beta$ for such a high maxima.

Q.8 (4)

Lets look at the screen.



as we know that 75% intensity will correspond to a point where intensity is $3I_0$.

$\{\because I_{max} = 4I_0\}$

$I = I_0 + I_0 + 2\sqrt{I_0}\sqrt{I_0}\cos(\Delta\phi)$

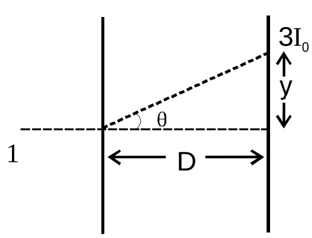
$3I_0 = 2I_0(1 + \cos\Delta\phi)$

$\cos(\Delta\phi) = \frac{1}{2}$

$\Delta\phi = \frac{\pi}{3}, 2\pi - \frac{\pi}{3}, 2\pi + \frac{\pi}{3}, ...$

$\Delta p = \frac{\lambda}{6}, \lambda - \frac{\lambda}{6}, \lambda + \frac{\lambda}{6}, ...$

$\Delta p = \frac{yd}{D}$



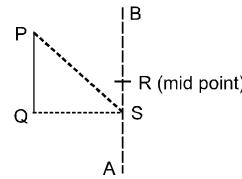
$\frac{yd}{D} = \frac{\lambda}{6} \Rightarrow y = \frac{D}{d} \times \frac{\lambda}{6}, ...$

$y = \frac{\beta}{6}, \beta - \frac{\beta}{6}, \beta + \frac{\beta}{6}$

$y = \frac{\lambda}{6} \times \frac{D}{d} = \frac{6000 \times 10^{-10} \times 1}{3 \times 10^{-3}} = 0.2$ mm

Q.9 (3)

Lets take any general point S on the line AB.



Clearly: for any position of S on line AB; we have for Δ PQS:

PQ + QS > PS {in any triangle sum of 2 sides is more then the third side}

$\Rightarrow$ PS – QS < 3λ.

As PS – QS represents the path difference at any point on AB $\Rightarrow$ it can never be more than 3λ. Now minimas occur at.

$\frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$ only.

so 3 minimas below R (mid point of AB) and 3 also above R.

Q.10 (3)

$I' = 4I\cos^2\frac{\Delta\phi}{2}$

$\Rightarrow \cos^2\frac{\Delta\phi}{2} = \frac{1}{4} \Rightarrow \cos\frac{\Delta\phi}{2} = \pm\frac{1}{2}$

$\Rightarrow \Delta\phi = \frac{2x}{\lambda}\frac{dy}{D} \Rightarrow \cos\frac{\pi.dy}{\lambda D} = +\frac{1}{2}$

$\Rightarrow \frac{\pi.dy}{\lambda D} = \frac{\pi}{3} \Rightarrow y = \frac{\lambda D}{3d}$

Q.11 (3)

$I_0 = 4I$

Intensity due to one

$\Delta\phi = \frac{d.y}{D} \times \frac{2\pi}{\lambda}$

$= \frac{0.25 \times 10^{-2} \times 4 \times 10^{-5}}{100 \times 10^{-2}} \times \frac{2\pi}{6000 \times 10^{-10}}$

$\Delta\phi = \pi/3$

$I' = I_0\cos^2\frac{\frac{\pi}{3}}{2} = \frac{3I_0}{4}$

Q.12 (3)

$\frac{dy}{D} \times \frac{2\pi}{\lambda} = \Delta\phi$

$$\Rightarrow 2I = 4I\cos^2\frac{\Delta\phi}{2} \Rightarrow \cos\frac{\Delta\phi}{2} = \frac{1}{\sqrt{2}}$$

$$\Rightarrow \frac{\Delta\phi}{2} = \frac{\pi}{4} \Rightarrow \frac{d.y}{D}.\frac{2\pi}{\lambda} = \frac{\pi}{2}$$

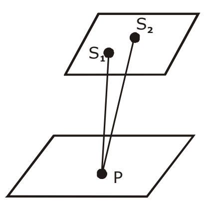
$$\Rightarrow \frac{1\times10^{-3}\times y}{1\times500\times10^{-1}} = \frac{1}{4} \Rightarrow y = 1.25\times10^{-4}\,m$$

Q.13 (3)

$0.3\times10^{-3}\times\sin30^o = n\times500\times10^{-9} \Rightarrow n = 300$

$\therefore\ 299+299+1 = 599$

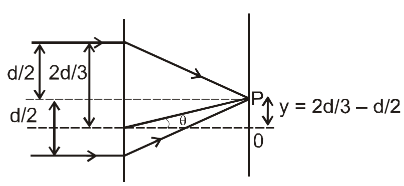
Q.14 (2)



$S_2P - S_1P = n\lambda = \text{const.}$

$\Rightarrow$ equation of hyperbola

Q.15 (4)



we know that P will be the central maxima (at which path difference is zero)

$$\text{Now OP} = \frac{d}{2} - \frac{d}{3} = \frac{d}{6}$$

Q.16 (3)

Fourth maxima will be at $y = 4\beta$.

$$\Rightarrow y = \frac{4\lambda D}{d}$$

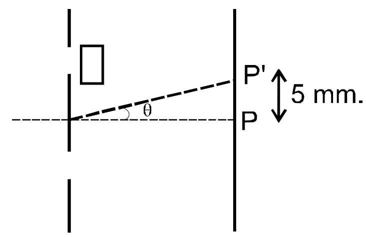
as $\lambda_{Green} > \lambda_{blue}$.

$\Rightarrow \beta_{Green} > \beta_{blue}$

$\Rightarrow X_{Green} > X_{blue}$

$$\text{Also get } \frac{X(blue)}{X(green)} = \frac{4360}{5460}$$

Q.17 (1)



Clearly the central maxima at P(initially) shifts to P' where PP' = 5 mm.

So now, path difference at P' must be zero.

$\Rightarrow d\sin\theta = (\mu - 1)t$

$\Rightarrow d\tan\theta = (\mu - 1)t$

$$\mu = 1 + \frac{d.(PP')}{Dt};\ \text{get } \mu = 1.2$$

Q.18 (4)

As we know, at the point of 75% intensity

$$\cos\phi = \frac{1}{2}$$

$$\Rightarrow \frac{2\pi}{\lambda}\times\Delta P = \frac{\pi}{3}, \frac{5\pi}{3}, \frac{7\pi}{3}, \frac{11\pi}{3}, \frac{13\pi}{3}$$

$$\Rightarrow (\mu-1)\,t = \frac{\lambda}{6}, \frac{5\lambda}{6}, \frac{7\lambda}{6}, \frac{11\lambda}{6}, \frac{13\lambda}{6}$$

$$\Rightarrow t = \frac{\lambda}{6(\mu-1)}, \frac{5\lambda}{6(\mu-1)}, \frac{7\lambda}{6(\mu-1)}, \frac{11\lambda}{6(\mu-1)}, \frac{13\lambda}{6(\mu-1)}$$

$= 0.2\ \mu m; 1\ \mu m, 1.4\ \mu m, 2.6\ \mu m.......$

Hence only 1.6 μm is not possible.

Q.19 (3)

$$2I = 4I\cos^2\frac{\Delta\phi}{2}$$

$$\Rightarrow \cos\frac{\Delta\phi}{2} = \frac{1}{\sqrt{2}} \Rightarrow \frac{\Delta\phi}{2} = \frac{\pi}{4}$$

$$\Rightarrow \frac{2\pi}{\lambda}\times\frac{\left(\frac{3}{2}-1\right)t}{2} = \frac{\pi}{4} \Rightarrow t = \lambda/2$$

Q.20 (2)

$$\left|(2\mu-1)\,t - (\mu-1).2t\right| = \frac{d.y}{D}$$

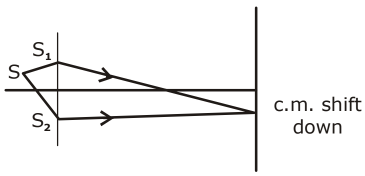
$$t = \frac{d.y}{D} \Rightarrow y = \frac{t\,D}{d}$$

Q.21 (4)

$$\Delta x = (2n+1)\frac{\lambda}{2}$$

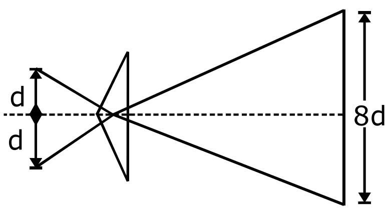
$$\Delta x = (\ell_1 + \ell_3) - (\ell_2 + \ell_4) = (2n+1)\frac{\lambda}{2}$$

Q.22 (4)



$$\beta = \frac{\lambda D}{d} = \text{remain same.}$$

Q.23 (2)



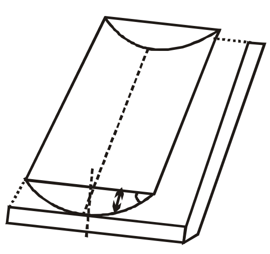
$d = (\mu - 1)A \times 1$

$$\text{no. of fringes} = \frac{8d^2.2}{\lambda D}$$

$$= \frac{16d^2}{\lambda D} = \frac{16[(\mu-1)A.1]^2}{6000 \times 10^{-10} \times 5} s$$

$= 5.33$

Q.24 (3)



t changes more rapidly when we go outwards.

$\Rightarrow$ path diff. changes more rapidly

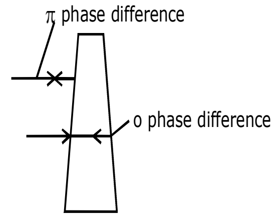
$\Rightarrow$ fringe width $\downarrow$

Q.25 (3)

$$\Delta\phi = \pi + (2\mu t).\frac{2\pi}{\lambda}$$

at top

$t \to 0$



$\Delta\phi = \pi$

Minima for all the

wave length.

Top position will appear dark.

$\Rightarrow$ As we move down violet Maxima will appear first.

first colour will be violet.

EXERCISE-IV

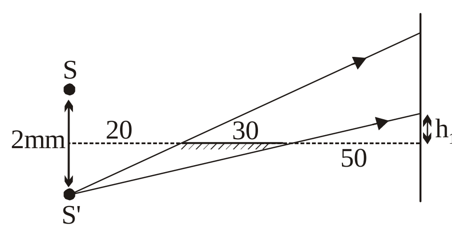
Q.1 0005

$2\mu t = n\lambda = \lambda$

$$t = \frac{\lambda}{2\mu} = \frac{500 \times 10^{-9}}{2 \times 1.25} = 2 \times 10^{-7}\ m^2$$

$$A = \frac{v}{t} = \frac{1}{2 \times 10^{-7}} = 5 \times 10^6\ m^2 = 5\ km^2$$

Q.2 0012



$$\frac{0.1}{h_1} = \frac{50}{50} \Rightarrow h_1 = 1mm$$

$$\frac{L + h_1}{0.1} = \frac{80}{20} \Rightarrow L + h_1 = 4\ mm \Rightarrow L = 3\ mm$$

$$B = \frac{\lambda D}{d} = \frac{5 \times 10^{-7} \times 1}{2 \times 10^{-3}} = 2.5 \times 10^{-4}\ m$$

$$N = \frac{L}{B} = \frac{3 \times 10^{-3}}{2.5 \times 10^{-4}} = \frac{300}{25} = 12$$

Q.3 0007

$$P_A = \frac{10}{\pi} \times p \times (10^{-3})^2 \times 0.1 = 10^{-6}\,W$$

$$P_B = \frac{10}{\pi} \times \pi \times (2 \times 10^{-3})^2 \times 0.1 = 4 \times 10^{-6}\,W$$

$$P = P_A + P_B + 2\sqrt{P_A \times P_B}\cos\Delta\phi$$

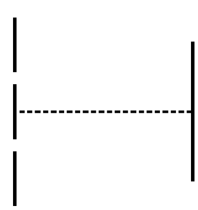
$$\Delta\phi = \frac{2\pi}{\lambda} \times (n-1)\,t$$

$$= \frac{2\pi}{6\times10^{-7}} \times 0.5 \times 2 \times 10^{-7} = \frac{\pi}{3}$$

$$= 4 \times 10^{-6} + 10^{-6} + 4 \times 10^{-6} \times \frac{1}{2} = 7 \times 10^{-6}\,W = 7\,\mu W$$

Q.4 0007

$I_1 = I_0,\ I_2 = 4I_0$

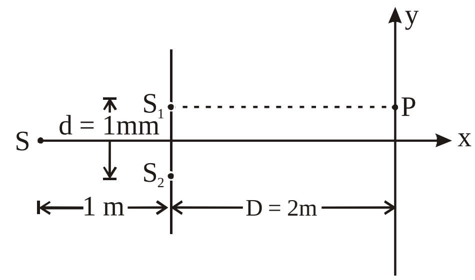


$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\left(\frac{2\pi}{\lambda} \times \frac{dy}{D}\right)$$

$$= I_0 + 4I_0 + 2\sqrt{4I_0^2}\cos\left(\frac{2\pi}{6\times10^{-7}} \times \frac{10^{-3}}{5} \times \frac{10^{-3}}{2}\right)$$

$$= 5I_0 + 4I_0\cos\left(\frac{10\pi}{30}\right) = 5I_0 + 4I_0\cos\left(\frac{\pi}{3}\right) = 7I_0$$

Q.5 In a modified YDSE the source S of wavelength 5000Å oscillates about axis of setup according to the equation $y = 0.5\sin\left(\frac{\pi}{6}\right)t$, where y is in millimeter and t in second. At what time t will the intensity at P, a point exactly in front of slit S_1, be maximum for the first time?



Ans. 0001

Sol. The path difference at point P,

$$\Delta x = (SS_2 - SS_1) + (S_2P - S_1P)$$

$$= \frac{dy}{D_1} + \frac{d(d/2)}{D_2}$$

For constructive interference,

$$\Delta x = \frac{dy}{D_1} + \frac{d^2}{2D_2} = n\lambda$$

$$\frac{(10^{-3})(0.5\sin\pi\ t)\times10^{-3}}{1} + \frac{(10^{-3})^2}{2\times2} = n\lambda$$

$$(0.5\sin\left(\frac{\pi}{6}\right)t) \times 10^{-6} + 0.25 \times 10^{-6}$$

$$= (5000 \times 10^{-10})n = 0.5 \times 10^{-6}n$$

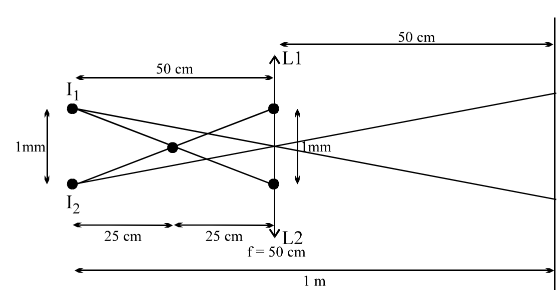
$$\sin\left(\frac{\pi}{6}\right)t = \frac{0.5n - 0.25}{0.5}$$

For the minimum value of t, $n = 1$.

$$\sin\left(\frac{\pi}{6}\right)t = \frac{1}{2} \Rightarrow \left(\frac{\pi}{6}\right)t = \frac{\pi}{6} \quad \text{or}$$

t = 1 sec.

Q.6 0.6mm



$u = -25$

$$\frac{1}{v} - \frac{1}{-25} = \frac{1}{50} \Rightarrow \frac{1}{v} = -\frac{1}{50}$$

$\Rightarrow\ v = -50$

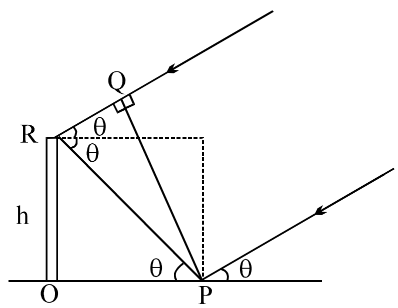
$$\beta = \frac{6\times10^{-7}\times1}{10^{-3}} = 6\times10^{-4} = 0.6\text{ mm}$$

Q.7 0.16 m

$$PR = \frac{h}{\sin\theta} \quad ; QR = PR\cos 2\theta = \frac{h\cos 2\theta}{\sin\theta}$$

$$\Delta X = PR - RQ + \frac{h}{2}$$

$$\Delta X = \frac{h}{\sin\theta}(1-\cos2\theta) + \frac{h}{2} = 2h\sin\theta + \frac{h}{2}$$



$$\Delta X \cong 2h\theta + \frac{h}{2}$$

$\sin\theta = \theta$

Maximum to maximum

$\lambda = 2h(\theta_2 - \theta_1) + 0$

$\lambda = 2(4)[0.03 - 0.01] = 2(4)(0.02) = 0.16$ m

Q.8 0001

Reflected ray from upper surface would shift by $\lambda/2$ only while reflected from lower surface would not have any shift.

$2\mu t = n_1\lambda_1 = n_2\lambda_2 \Rightarrow (n_1 = n_2 + 1)$

as there is no minima in between these two wavelengths

$(n+1)(512) = (n)(640)$

$n_2(640 - 512) = 512$

$n_2 = 4$

So $2\times1.28\,t = (4)(640)$

$$t = \frac{4\times640}{2\times1.28} = 1000\text{ nm} = 1\mu\text{m}$$

Q.9 2311

$$I = 4I_0\cos^2\frac{\phi}{2}$$

Case - 1, $\phi = 0 \Rightarrow I = 4I_0$

Case - 2, $I = \frac{3I}{4} = 4I_0\cos^2\frac{\phi}{2}$

$$\Rightarrow \cos^2\frac{\phi}{2} = \frac{3}{4}$$

$$\cos\frac{\phi}{2} = \frac{\pm\sqrt{3}}{2} \Rightarrow \frac{\phi}{2} = \frac{\pi}{6} \qquad \phi = \frac{\pi}{3}$$

Now, $\phi = \frac{(\mu-1)t\times2\pi}{\lambda}$

$$\frac{\pi}{3} = \frac{(\mu-1)t-2\pi}{\lambda}$$

$$t = \frac{\lambda}{6(\mu-1)}$$

$$t = \frac{6933}{3} = 2311\text{ Å}$$

Q.10 209

$$I = I_0\cos^2\left(\frac{\phi}{2}\right),\text{ here } I = \frac{I_0}{4}$$

$$\cos\left(\frac{\theta}{2}\right) = \frac{1}{2} \qquad \Rightarrow \frac{\theta}{2} = \frac{\pi}{3}$$

$$\Rightarrow \phi = \frac{2\pi}{3}$$

$$\frac{\Delta L}{\lambda}\times2\pi = \frac{2\pi}{3} \Rightarrow \Delta L = \frac{627}{3}\text{ nm}$$

$\Delta L = 209$ nm.

Q. 11 (2) **Q. 12** (1) **Q. 13** (3) **Q. 14** (1) **Q.15** (1) **Q.16** (1)

PREVIOUS YEAR'S

MHT CET

Q.1 (3)	**Q.2** (1)	**Q.3** (1)	**Q.4** (2)	**Q.5** (4)
Q.6 (2)	**Q.7** (4)	**Q.8** (1)	**Q.9** (3)	**Q.10** (3)
Q.11 (4)	**Q.12** (3)	**Q.13** (2)	**Q.14** (2)	**Q.15** (4)
Q.16 (2)	**Q.17** (3)	**Q.18** (1)	**Q.19** (Bonus)	
Q.20 (Bouns)	**Q.21** (2)	**Q.22** (2)	**Q.23** (3)	**Q.24** (2)
Q.25 (4)	**Q.26** (1)	**Q.27** (Bonus)	**Q.28** (3)	**Q.29** (2)
Q.30 (3)	**Q.31** (3)	**Q.32** (3)	**Q.33** (2)	**Q.34** (2)
Q.35 (2)				

Q.36 **(3)**

Given, wavelength of used light, λ = 6000 Å

initial angular separation, $\beta_1 = \beta$

Final angular separation, $\beta_2 = \beta$ - 30° of β

$\beta_2 = \beta - 0.3° \beta = 0.7\beta$

We know that, $\beta \propto \lambda$

$$\Rightarrow \frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}$$

$$\Rightarrow \lambda_2 = \frac{\beta_2 \times \lambda_1}{\beta_1} = \frac{0.7\beta \times 6000}{\beta} = 4200Å$$

Q.37 **(4)**

We know that, fringe width,

$$\beta = \frac{D\lambda}{d}$$

$\Rightarrow \beta \propto D$

Hence, graph (4) is the correct.

Q.38 **(1)**

For monochromatic light the resultant intensity is

$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\theta = 2I + 2I\cos\theta$ ($\because I_1 = I_2 = 1$)...(i)

For maximum intensity, $\theta = 0°$

$I_R = 2I + 2I\cos 0° = 4I$ ($\because \cos 0° = 1$)

or K = 4I

or $I = \frac{K}{4}$ ...(ii)

For path difference $\lambda/3$, phase difference,

$$\phi = 2\pi \times \frac{\text{Path difference}}{\lambda} = 2\pi \times \frac{\lambda/3}{\lambda} = \frac{2\pi}{3}$$

$\therefore I_R = 2I + 2I\cos\frac{2\pi}{3}$ [From Eq. (i)]

$$= 2I + 2I\left(-\frac{1}{2}\right) = 2I - I = I$$

$= \frac{K}{4}$ [using Eq.(ii)]

Q.39 **(1)**

For minima in YDSE, the phase difference as superimposing waves should be odd integral multiple of π.

i.e., $\Phi = (2n-1)\pi$ (where, n = 1, 2, 3.......)

Q.40 **(4)**

For the first minima, $\sin\theta = \frac{\lambda}{a}$

$$\Rightarrow \frac{\lambda}{a} = \sin 45° = \frac{1}{\sqrt{2}}$$

$$\Rightarrow \frac{\lambda}{a} = \frac{1}{\sqrt{2}} \quad \text{....(i)}$$

For first secondary maximum, $\sin\theta = \frac{3\lambda}{2a} = \frac{3}{2} \times \frac{1}{\sqrt{2}}$

[From Eq. (i)]

$$\Rightarrow \theta = \sin^{-1}\left(\frac{3}{2\sqrt{2}}\right)$$

Q.41 **(4)**

Distance between the first dark fringes on either side of the central bright fringe

= width of central maxima

$$\Rightarrow 2y = \frac{2\lambda D}{d}$$

Here, λ = 6000 nm = 600×10^{-9}m

d = 1mm = 1×10^{-3} m

d = 2 m

$$\Rightarrow 2y = \frac{2 \times 600 \times 10^{-9} \times 2}{1 \times 10^{-3}} = 24 \times 10^{-4}\,\text{m} = 2.4\text{mm}$$

Q.42 **(3)**

According to given situation,

$a_1 = a_2 = a = a_R$

$$a_R = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$$

$$a = \sqrt{a^2 + a^2 + 2a^2\cos\phi}$$

$\Rightarrow 1 + \cos\phi = 1/2$

$$\Rightarrow \cos\phi = -\frac{1}{2} \Rightarrow \phi = \frac{2\pi}{3}$$

Q.43 (3)

Since, phase difference, $\phi = \frac{2\pi}{\lambda} \times$ path difference $= \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = \frac{\pi}{2}$

$\therefore$ Intensity, $I = I_0\cos^2\left(\frac{\phi}{2}\right)$

$$\Rightarrow \frac{I_0}{I} = \frac{1}{\cos^2\left(\frac{\pi}{4}\right)} = \frac{1}{\left(1/\sqrt{2}\right)^2} = 2:1$$

Q.44 (1)

According to question,

Position of first dark fringe = d/2

For n^{th} dark fringe, $x_n = (2n-1)\dfrac{D\lambda}{2d}$

Here, n = 1

$\therefore \quad x_1 = d/2$

$$(2\times1-1)\frac{D\lambda}{2d} = \frac{d}{2} \Rightarrow \lambda = \frac{d^2}{D}$$

Q.45 (4)

Since, the path difference between two interfering waves is of type $(2n-1)\left(\dfrac{\lambda}{2}\right)$

So, it forms dark band.

$$\Rightarrow \quad \left(\frac{2n-1}{2}\right)\lambda = \left(\frac{87}{2}\right)\lambda \Rightarrow 2n-1 = 87$$

$$\Rightarrow \quad n = \frac{88}{2} = 44$$

Q.46 (3)

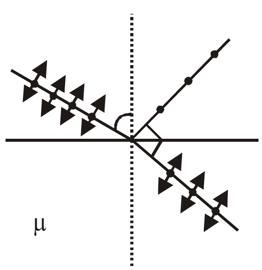
The general condition for Fraunhoffer diffraction is

$$\frac{b^2}{L\lambda} << 1$$

NEET/AIPMT

Q.1 (2)

When reflected light rays and refracted rays are perpendicular, reflected light is polarised with electric field vector perpendicular to the plane of incidence.



Also, tan i = m (Brewster angle)

Q.2 (2)

$$\text{Angular width} = \frac{\lambda}{d}$$

$$0.20^\circ = \frac{\lambda}{2mm} \qquad \text{........(i)}$$

$$0.21^\circ = \frac{\lambda}{d} \qquad \text{........(ii)}$$

Dividing we get, $\dfrac{0.20}{0.21} = \dfrac{d}{2\,mm}$

$\therefore \quad d = 1.9\,mm$

Q.3 (2)

For double slit experiment

Angular width for first minima $= \dfrac{\lambda}{2d} \propto \lambda$

$$\frac{\theta'}{\theta} = \frac{\lambda}{\lambda'} = \frac{\lambda}{(\mu)} = \mu$$

$$\theta' = \frac{\theta}{\mu} = \frac{0.2^\circ}{\left(\frac{4}{3}\right)} = 0.15^\circ$$

Q.4 (2)

Q.5 (2)

Q.6 (4)

Q.7 (3)

$$y = (n\lambda)\left(\frac{D}{d}\right)$$

$n_1\lambda_1 = n_2\lambda_2$

$(8)(600\,nm) = n_2(400)$

$n_2 = 12$

JEE MAIN

Q.1 (3)

$$R.P = \frac{d}{1.22\lambda}$$

$$= \frac{2.44\times10^{-2}}{1.22\times2.440\times10^{-10}}$$

$R.P = 8.2\times10^5$

Q.2 [3]

For first minima,

$$a\sin\theta = \frac{3\lambda}{2}$$

$$a\tan\theta = \frac{ay}{D} \quad (\text{for small angle } \tan\theta = \sin\theta)$$

$$y = \frac{3D\lambda}{2a}$$

$$\Delta y = \frac{3D}{2a}(\lambda_1 - \lambda_2)$$

$$= \frac{3D}{2a}\,(655-650)\,nm$$

$$= \frac{3}{2}\times\frac{D}{a}\times5\,nm$$

$$= \frac{3}{2}\times\frac{2}{0.5}\times\frac{5\times10^{-9}}{10^{-3}}$$

$= 3\times10^{-5}$

Ans. is 3

Q.3 (4)

$$\frac{I_{max}}{I_{min}}=\frac{(\sqrt{I_1}+\sqrt{I_2})^2}{(\sqrt{I_1}-\sqrt{I_2})^2}=\left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2=\frac{\left(\sqrt{\frac{9}{4}}+1\right)^2}{\left(\sqrt{\frac{9}{4}}-1\right)^2}=\frac{\left(\frac{3}{2}+1\right)}{\left(\frac{3}{2}-1\right)}=\frac{\frac{25}{4}}{\frac{1}{4}}$$

$$=\frac{25}{1}=25:1$$

Q.4 (2)

Using $I_{res}=I_1+I_2+2\sqrt{I_1I_2}\cos\Delta\phi$

$I_p=I+9I+2\sqrt{I\times 9I}\cos\frac{\pi}{2}$

$I_p=10\,I$

$I_Q=I+9I+2\sqrt{I\times 9I}\cos\pi$

$I_Q=10I-6I=4I$

$\therefore\ I_P-I_Q=10I-4I=6I$

Q.5 (2)

$\frac{I_2}{I_1}=\frac{4}{1}$ let suppose $I_1=I_0$ then

$I_2=4I_0$

$I_{max}=(\sqrt{I_2}+\sqrt{I_1})^2=(\sqrt{4I_0}+\sqrt{I_0})^2=(3\sqrt{I_0})^2=9I_0$

$I_{min}=(\sqrt{I_2}-\sqrt{I_1})^2=(2\sqrt{I_0}-\sqrt{I_0})^2=I_0$

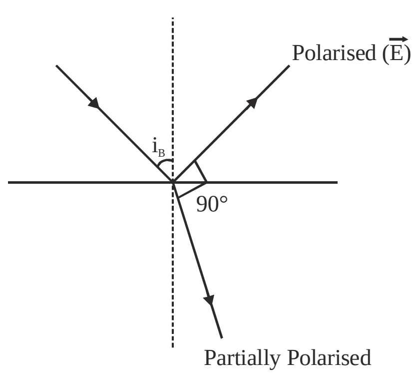
So,

$$\frac{I_{max}+I_{min}}{I_{max}-I_{min}}=\frac{9I_0+I_0}{9I_0-I_0}=\frac{10I_0}{8I_0}=\frac{5}{4}$$

$$\frac{5}{4}=\frac{5}{x}\Rightarrow\boxed{x=4}$$

Q.6 (4)

When unpolarised light is incidence on the denser medium from rarer medium then reflected part of light is pure polarised with electric field component only and refracted light is partially polarised.



When electric field vector is removed then only refraction take place.

Q.7 (450)

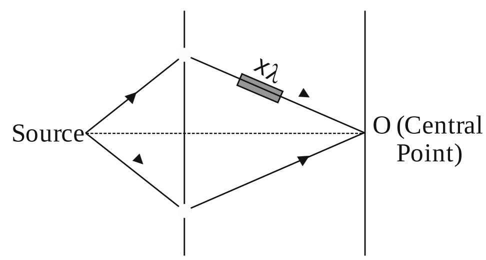
$d=0.6\times10^{-3}$

$D=80\times10^{-2}$

1^{st} Dark fringe $=\frac{D\lambda}{2d}=\frac{d}{2},\ \lambda=\frac{d^2}{D}$

$=450\times10^{-9}$ m

Q.8 (2)



Path difference at $O=(\mu-1)t$

If the intensity at O remains (maximum) unchanged,path difference must be $n\lambda$.

$\Rightarrow(\mu-1)t=n\lambda$

$(1.5-1)x\lambda=n\lambda$

$\Rightarrow x=2n$

or $n=1,\ x=2$

Q.9 (4)

$$\beta=\frac{0.35\times5}{7}=0.25$$

$$\frac{1}{\alpha}=\frac{25}{100}$$

$$\alpha=4$$

Q.10 (4)

$\beta=\frac{\lambda D}{d}$ — d = dist. Between slits

$\lambda_1=5000$ Å — β = fringe width

$\lambda_2=6000$ Å — D = Distance between centre of slits and screen

$\beta_1=0.05$ m

$d_2=2d_1$

$$\therefore\ \frac{\beta_1}{\beta_2}=\frac{\lambda_1}{\lambda_2}\times\frac{d_2}{d_1}=\frac{5}{6}\times2=\frac{10}{6}$$

$$\frac{0.5}{\beta_2}=\frac{5}{6}\times2\qquad \beta_2=\frac{30}{100}=0.3\text{ mm}$$

$\beta_2=0.3$ mm

Q.11 (2)

$$\underset{(air)}{B} = \frac{D\lambda}{d} = 12mm$$

In water

$$B_{water} = \frac{D\lambda_{water}}{d} = \frac{D\lambda_{air}}{d\mu_{water}}$$

$$\frac{\lambda_{air}}{\lambda_{water}} = \frac{\mu_{water}}{\mu_{air}}$$

$$\frac{\lambda_{air}}{\lambda_{water}} = \frac{\mu_{water}}{1}$$

$$\lambda_{water} = \frac{\lambda_{air}}{\mu_{water}}$$

$$\frac{12}{\frac{4}{3}} = 9mm$$

Q.12 [2]

$I_1 = I$ and $I_2 = 4I$

at point $A \rightarrow \phi = \frac{\pi}{2}$

at point $B \rightarrow \phi = \frac{\pi}{3}$

$$I_A = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$$

$$I_A = I + 4I + 2\sqrt{I}\sqrt{4I}\cos(\frac{\pi}{2})$$

$=5I + 0$

$I_A = 5I$ ....(1)

Now

$$I_B = I + 4I + 2\sqrt{I}\sqrt{4I}\cos(\frac{\pi}{3})$$

$$5I + 4I.\frac{1}{2} = 7I$$

$I_B = 71$ ......(2)

Difference between two intensities will be $= |I_B - I_A|$

$= |7I - 5I|$

$= 2I$

So $x = 2$

Q.13 (2)

$$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = (1+2)^2 = 9$$

$$I_{min}\left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = (1-2)^2 = 1$$

Now $\frac{10}{8} = \frac{2\alpha+1}{\beta+3}$

$5\beta + 15 = 8\alpha + 4$

$$\frac{2(2)+1}{1+3} = \frac{2\alpha+1}{\beta+3}$$

$\alpha = 2, \beta = 1$

Hence $\frac{\alpha}{\beta} = 2$

Q.14 (630)

$\beta \propto \lambda$

$$\lambda_2 = \frac{9}{8}\lambda_1$$

$$\therefore \beta_2 = \frac{9}{8}\beta_1 = \frac{9}{8}\times 500 = 630nm$$

Q.15 (24)

$$I_{net} = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$$

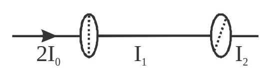
I_{max} for $\phi = 0$ & I_{min} for $\phi = \pi$

$$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{9I} + \sqrt{4I}\right)^2 = 25I$$

$$I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = \left(\sqrt{9I} - \sqrt{4I}\right)^2 = I$$

$I_{max} - I_{min} = 25I - I = 24\,I$

Q.16 (3)



$$I_1 = \frac{1}{2} = (2I_0) = I_0$$

$I_2 = I_1 \cos^2 30^o$

$$= I_0.\frac{3}{4} = \frac{3I_0}{4}$$

DUAL NATURE OF MATTER AND RADIATION

EXERCISE-I (MHT CET LEVEL)

Q.1 (4)

$$\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi$$

$$\frac{1}{2}m' = \frac{hc}{(3\lambda/4)} - \phi = \frac{4hc}{3\lambda} - \phi$$

Clearly, v’ $> \sqrt{\frac{4}{3}v}$

Q.2 (1)

Q.3 (4)

Momentum of a photo $\propto \frac{E}{c}$

$= 5.33 \times 10^{-27}\, kg\, ms^{-1}$

Q.4 (1)

$$K_{max} = h\nu - h\nu_0 = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

$$1.24 \times 10^{-6}\left(\frac{10^8}{18} - \frac{10^8}{23}\right) = 1.49\text{eV}$$

Q.5 (4)	**Q.6** (2)	**Q.7** (3)	**Q.8** (4)	**Q.9** (1)
Q.10 (3)	**Q.11 (1)**	**Q.12 (2)**	**Q.13 (1)**	**Q.14 (2)**
Q.15 (3)	**Q.16** (3)	**Q.17 (3)**	**Q.18 (3)**	**Q.19 (2)**
Q.20 (3)				

EXERCISE-II (NEET LEVEL)

Q.1 (4)

$$p = \frac{hv}{c} \Rightarrow v = \frac{pc}{h} = \frac{3.3 \times 10^{-29} \times 3 \times 10^8}{6.6 \times 10^{-34}}$$

$= 1.5 \times 10^{13}$ Hz

Q.2 (1)

Q.3 (2)

$$p = \frac{E}{c} = \frac{hv}{c} \Rightarrow v = \frac{pc}{h}$$

Q.4 (2)

If v_{max} is the speed of the fastest electron emitted from the metal surface, then

$$\frac{he}{\lambda} = W_0 + \frac{1}{2}mv_{max}^2$$

$$\frac{\left(6.63 \times 10^{-14}\right) \times \left(3 \times 10^3\right)}{\left(180 \times 10^{-9}\right)}$$

$$= 2 \times \left(1.6 \times 10^{-19}\right) + \frac{1}{2}\left(9.1 \times 10^{-34}\right)v_{max}^2$$

$$\therefore v = 1.31 \times 10^6\, m/s$$

The radius of the electron is given by

$$r = \frac{mv}{qB}$$

$$= \frac{\left(9.1 \times 10^{-31}\right) \times \left(1.31 \times 10^6\right)}{\left(1.6 \times 10^{-19}\right) \times \left(5 \times 10^{-9}\right)} - 0.149m$$

Q.5 (1)

We have $E = W_0 + K$

or $\frac{hc}{400 \times 10^{-9}} = W_0 + \frac{1}{2}mv^2$ ....(i)

and $\frac{hc}{250 \times 10^{-9}} = W_0 + \frac{1}{2}m(v)^2$ ....(ii)

On simplifying above equations, we get $W_0 = 2hv \times 10^6$J.

Q.6 (4)

$E \propto \frac{1}{\lambda}$; also $\lambda_{infrared} > \lambda_{visible}$ so $E_{infrared} > E_{visible}$

Q.7 (3)

$$E = nh\nu \Rightarrow \nu \propto \frac{1}{n} \Rightarrow \frac{n_1}{n_2} = \frac{\gamma_2}{\gamma_1}$$

Q.8 (3)

According to Einstein’s photoelectric equation

Q.9 (4)
In this case, for photoelectric emission the wavelength of incident radiations must be less then 5200 Å. Wavelength of ultraviolet radiations is less then this value (5200 Å) but wavelength of infrared radiations is higher than this value.

Q.10 (1)

Frequency of light of wavelength ($\lambda = 4000$Å) is $v = \frac{c}{\lambda}$

$= \frac{3\times10^8}{4000\times10^{-10}} = 0.75\times10^{15}$ which is less than the given threshold frequency. Hence no photoelectric emisssion takes place.

Q.11 (2)
$K_{max} = (hv - W_0)$; v = frequency of incident light.

Q.12 (4)
Intensity $\propto$ (No. of photons) $\propto$ (No. of photoelectrons)

Q.13 (4)

$E = W_0 + K_{max}$; $E = \frac{12375}{3000} = 4.125$ eV

$\Rightarrow K_{max} = E - W_0 = 4.125 \text{ eV} - 1\text{eV} = 3.125$ eV

$\Rightarrow \frac{1}{2}mv^2_{max} = 3.125 \times 1.6 \times 10^{-19}$ J

$\Rightarrow v_{max} = \sqrt{\frac{2\times3.125\times1.6\times10^{-19}}{9.1\times10^{-31}}} = 1 \times 10^6$ m/s

Q.14 (3)

$K_{max} = \frac{hc}{\lambda} - W_0 = \frac{6.4\times10^{-34}\times3\times10^8}{6400\times10^{-10}} - 1.6\times10^{-19}$

$= 1.4 \times 10^{-19}$ J

Q.15 (3)
Energy of incident radiations (in eV)

$= \frac{12375}{4100} = 3.01$ eV

Work function of metal A and B are less then 3.01 eV, so A and B will emit photo electrons.

Q.16 (3)

Energy of incident light $E(eV) = \frac{12375}{3320} = 3.72$ eV

(332 nm = 3320 Å)

According to the relation $E = W_0 + eV_0$

$\Rightarrow V_0 = \frac{(E - W_0)}{e} = \frac{3.72\text{eV} - 1.07\text{eV}}{e} = 2.65$ Volt.

Q.17 (4)
Intensity $\propto$ (No. of photons) $\propto$ (No. of photoelectrons)

Q.18 (4)
Number of ejected electrons $\propto$ (intensity)

$\propto \frac{1}{(\text{Distance})^2}$

Therefore an increment of distance two times will reduce the number of ejected electrons to $\frac{1}{4}$th of the previous one.

Q.19 (2)
As we know, threshold wavelength

$(\lambda_0) = \frac{hc}{\phi}$

$$\Rightarrow \lambda_0 = \frac{(6.63\times10^{-34})\times3\times10^8}{2.3\times(1.6\times10^{-19})} = 5.404\times10^{-7}\,m.$$

$\Rightarrow \lambda_0 = 5404$Å

Hence, wavelength 4144 Å and 4972 Å will emit electron from the metal surface. For each wavelength energy incident on the surface per unit time

$= \frac{3.6\times10^{-3}}{\cdot 3}\times(1\text{cm})^2 = 1.2\times10^{-7}$

Therefore, energy incident on the surface for each wavelength in 2s

$E = (1.2 \times 10^{-7}) \times 2 = 2.4 \times 10^{-7}$J

Number of photons n_1 due to wavelength 4144 Å

$$n_1 = \frac{(2.4\times10^{-7})(4144\times10^{-10})}{(6.63\times10^{-34})(3\times10^8)} = 0.5\times10^{12}$$

Number of photons n_2 due to the wavelenth 4972 Å

$$n_2 = \frac{(2.4\times10^{-7})(4972\times10^{-10})}{(6.63\times10^{-34})(3\times10^8)} = 0.572\times10^{12}$$

Therfore total number of photoelectrins liberated in 2s,

$N = n_1 + n_2$

$= 0.5\times10^{12} + 0.575\times10^{12}$

$= 1.075\times10^{12}$

Q.20 (1)

P_{in} 25W λ =6600 A =6600 × 10^{-10}m nhv = p

$\Rightarrow$ Number of photons emitted/sec,

$$n = \frac{p}{\frac{hc}{\lambda}} = \frac{p\lambda}{hc} = \frac{25\times 6600\times 10^{-10}}{6.64\times 10^{-34}\times 3\times 10^{8}}$$

$$= 8.28\times 10^{19} = \frac{25}{3}\times 10^{19}$$

3% of emitted photons are producing current

$$\therefore I = \frac{3}{100}\times ne$$

$$= \frac{3}{100}\times\frac{25}{3}\times 10^{19}\times 1.6\times 10^{-19} = 0.4A$$

Q.21 (1)

Q.22 (4)
According to Einstein's photoelectric equation

$$E = W_0 + K_{max} \Rightarrow V_0 = \frac{hc}{e}\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$$

Hence if λ decreases V_0 increases.

Q.23 (3)

Q.24 (2)

Q.25 (2)

Stopping potential $V_0 = \frac{hc}{e}\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$. As λ decreases so V_0 increases.

Q.26 (1)
Intensity increases means more photons of same energy will emit more electrons of same energy, hence only photoelectric current increases.

Q.27 (2)
$K_{max} = (|V_s|)eV \Rightarrow |V_s| = 4V$

EXERCISE-III (JEE MAIN LEVEL)

1. Photoelectric effect

Q.1 (3)

$$E = \frac{12400 (eV)}{(\lambda \text{ in Å})}$$

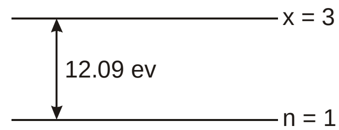
$$\text{No. of Photon} = \frac{IAt\lambda}{hc}$$

$$\text{No. of Photon} = \frac{Pt\lambda}{hc} = \frac{E\lambda}{hc}$$

if E is constant no. of photon is $\propto$ l

Q.2 (1)

hf = 1.7 + 10.4 = 12.1 eV = energy in H-atom



Q.3 (4)
Frequency of light does not change with medium.

Q.4 (3)
Einstein's formula
$k_{max\,1} = eV_1 + f$
if frequency is doubled,
$k_{max\,2} = ev_2 + f > 2\,K_{max\,1}$

Q.5 (1)
The number of photo electron depends on the number of photons

Number of photon = $\frac{I}{hc/\lambda} = \frac{\lambda \cdot I}{hc}$ μ l

Ratio of no. of photo electrons = $\frac{\lambda_A}{\lambda_B}$

Q.6 (1)
A Photon can interact with only a single electron.

Q.7 (2)

$C = l \cdot n = \frac{h}{p} \cdot \frac{E}{h} = \frac{E}{p}$

Q.8 (1)

Applying $p = \frac{h}{\lambda}$ and $E = \frac{hc}{\lambda}$

If l decreases E and p increases.

Q.9 (1)

$$2\phi = \phi + K_1 \quad\Rightarrow\quad K_1 = \phi = \frac{1}{2}mv_1^2$$

$$5\phi = \phi + K_2 \quad\Rightarrow\quad K_2 = 4\phi = \frac{1}{2}mv_2^2$$

$$v_1 : v_2 = 1 : 2$$

Q.10 (2)
no. of Photons $\propto$ I
I -, no. of photon e^- ejection -

Q.11 (4)

$\frac{h}{\lambda} = 10^{12} h$

Q.12 (2)
Since frequency of light solurce is double, the energy carried by each photon will be doubled.
Hence intensity will be doubled even if number of photons remains constant. Hence saturation current is constant. Since frequency is doubled, maximum KE increases but it is not doubled.

Q.13 (2)
The threshold frequency for Al must be greater as it has higher work function.

Q.14 (2)
Stopping potential = maximum kinetic energy of e = 4V.

Q.15 (3)

$hf = \phi + ev_S$

Q.16 (2)

$$\text{No. of Photons} = \frac{10^{-3}}{\frac{12400}{5000} \times 1.6 \times 10^{-13}}$$

$$= 0.25 \times 10^{16}$$

$$\text{No. of } e^- \text{ reaching} = \frac{0.16 \times 10^{-6}}{1.6 \times 10^{-19}} = 10^{+12}$$

$$\% = \frac{10^{12}}{0.25 \times 10^{16}} \times 100 = 0.04\%$$

Q.17 (1)
Experimental obervation.

Q.18 (2)

$$\frac{hC}{\lambda} = \phi + eV \quad ....(i)$$

$$\frac{hC}{2\lambda} = \phi + \frac{eV}{3} \quad ....(ii)$$

$3 \cdot II - I$

$$\Rightarrow \left(\frac{3}{2} - 1\right)\frac{hc}{\lambda} = 2\phi \qquad \Rightarrow \phi = \frac{hc}{4\lambda}$$

$\therefore \lambda_{th} = 4\lambda$

Q.19 (4)
As distance $\uparrow$ ses.

$I \downarrow$ ses.

$\therefore i \downarrow$

$$I = \frac{P}{4\pi r^2}$$

Q.20 (1)
Greater work function means greater cut off frequency.

Slope Remains same
$f_y > f_x$
Intercept of y > Intercept of x
and must be parallel to each

Q.21 (2)
Diameter is same so light falling will be same so photoelectric current will be same.

Q.22 (1)
The energy of x–ray is more that of U.V. light. Hence, the K.E. of emitted photoelectron is more and hence stopping potential required is also more.

EXERCISE-IV

Q.1 (2)	**Q.2** (3)	**Q.3** (1)	**Q.4** (1)	**Q.5** (1)
Q.6 (3)				

PREVIOUS YEAR'S

MHT CET

Q.1 (4)	**Q.2** (1)	**Q.3** (4)	**Q.4** (2)	**Q.5** (3)
Q.6 (4)	**Q.7** (2)	**Q.8** (4)	**Q.9** (2)	**Q.10** (1)
Q.11 (3)	**Q.12** (1)	**Q.13** (4)	**Q.14** (4)	**Q.15** (3)
Q.16 (1)	**Q.17** (4)	**Q.18** (3)	**Q.19** (2)	**Q.20** (1)
Q.21 (2)	**Q.22** (1)	**Q.23** (2)	**Q.24** (4)	**Q.25** (2)
Q.26 (2)	**Q.27** (2)	**Q.28** (3)	**Q.29** (2)	**Q.30** (2)
Q.31 (3)	**Q.32** (3)			

Q.33 **(2)**

For electron, $\lambda_e = \frac{h}{\sqrt{2mE_e}}$

$$\Rightarrow E_e = \frac{h^2}{(2m)\lambda_e^2}$$

for photon, $\lambda_p = \frac{hc}{E_p}$

$$\Rightarrow E_p = \frac{hc}{\lambda_p} = \frac{hc}{2\lambda_e} \quad (\because \lambda_p = 2\lambda_e)$$

$$\Rightarrow \frac{E_p}{E_c} = \frac{hc}{2\lambda_p} \times \frac{2m\lambda_e^2}{h^2} = mc \times \frac{\lambda_e}{h}$$

Also, $\lambda_e = \frac{h}{mv_e} \Rightarrow \frac{\lambda_e}{h} = \frac{1}{mv_e}$

$$\Rightarrow \frac{E_p}{E_e} = mc \times \frac{1}{mv_c} = \frac{c}{v_e} \quad \left(\because v_e = \frac{c}{c/100}\right)$$

$$= \frac{c}{c/100}$$

$= 100 = 10^2$

Q.34 **(1)**

Given, work function of metal $\Phi = 3.6$ eV

Threshold wavelength, $\lambda_1 = 3000$ Å

Work function for another metal $\Phi_2 = 1.8$ eV

Threshold wavelength $\lambda_2 = ?$

According to Einstein's photoelectric equation,

$$\frac{hc}{\lambda_0} = \phi_0$$

Therefore, $\frac{\frac{hc}{\lambda_1}}{\frac{hc}{\lambda_2}} = \frac{\phi_1}{\phi_2} = \frac{3.6}{1.8}$

$\Rightarrow \lambda_2 = 2 \times \lambda_1$

$\Rightarrow \lambda_2 = 6000$Å

Q.35 **(3)**

Accroding to Einstein's photoelectric equation, maximum energy of emitted electrons is given by

$$K_{max} = \frac{1}{2}mv^2_{max} = h\nu - h\nu_0$$

$$\frac{1}{2}mv^2_{max} = h(\nu - \nu_0) \quad \text{.......(i)}$$

When, frequency of incident radiation, becomes 2v, then velocity of emitted electron is v_1, hence from Eq. (i), we get

$$\frac{1}{2}mv_1^2 = h(2\nu - \nu_0)$$

$$\frac{1}{2}mv_1^2 = h\nu_0 \quad \text{....(ii)}$$

Again, when frequency becomes 5 ν_0, the velocity of emitted electron is v_2.

$\therefore$ From Eq. (i), we have

$$\frac{1}{2}mv_2^2 = h(5\nu - \nu)$$

$$\Rightarrow \frac{1}{2}mv_2^2 = \frac{h\nu}{4h\nu} \quad \text{...(iii)}$$

Dividing Eq. (ii) by Eq. (iii), we get

$$\frac{\frac{1}{2}mv_1^2}{\frac{1}{2}mv_2^2} = \frac{h\nu}{4h\nu}$$

$$\Rightarrow \left(\frac{v_1}{v_2}\right)^2 = \left(\frac{1}{2}\right)^2 \quad \Rightarrow v_1 : v_2 = 1:2$$

Q.36 **(2)**

Since, photoelectric current (I) does not depend on the frequency (ν) of incident radiation. Hence, graph showing in option (2) is correct.

Q.37 (2)

From Einstein's photoelectric equation

$$K_{max} = h\nu - \phi_0$$

$$\Rightarrow eV_0 = h\nu - h\nu_0 = V_0 = \frac{h}{e}(\nu - \nu_0)$$

So, graph showing the variation stopping potential and frequency is correctly shown in Fig. A.

Q.38 (2)

Energy of photon, $E_{photon} = KE + \phi$

where, KE = kinetic energy and ϕ = work function.

Energy of photon1, $E_{photon_1} = 1.3$eV

$$E_{photon_1} = \frac{1}{2}mv_1^2 + 0.8$$

$$\frac{1}{2}mv_1^2 = 1.3 - 0.8 \Rightarrow \frac{1}{2}mv_1^2 = 0.5$$

Energy of photon 2, $E_{photon_2} = 2.8$ eV

$$\therefore \quad \frac{1}{2}mv_2^2 = 2.8 - 0.8 = 2\text{eV}$$

Now, ratio of maximum speeds = $\frac{v_1^2}{v_2^2} = \frac{0.5}{2} = \frac{1}{4}$

$$\therefore \quad \frac{v_1}{v_2} = \frac{1}{2}$$

Q.39 (2)

From Einstein equation

$$KE_{max} = h\nu - h\nu_0$$

$$\Rightarrow KE_{max1} = h\nu_1 - h\nu_0 \quad \text{...........(i)}$$

and $KE_{max2} = h\nu_2 - h\nu_0$ ....(ii)

Dividing Eq. (i) by Eq. (ii), we get

$$\frac{KE_{max1}}{KE_{max2}} = \frac{h(v_1 - v_0)}{h(v_2 - v_0)} \Rightarrow \frac{2}{K} = \frac{v_1 - v_0}{v_2 - v_0}$$

$$\Rightarrow 2v_2 - 2v_0 = Kv_1 - Kv_0 \Rightarrow (K-2)v_0 = Kv_1 - 2v_2$$

or $v_0 = \frac{Kv_1 - 2v_2}{K-2}$

Q.40 (1)

$$\text{Efficiency} = \frac{\text{Output power}(P_0)}{\text{Input power}(P_i)}$$

$$\Rightarrow \quad 20\% = \frac{P_0}{P_1} \Rightarrow 0.2 = \frac{P_0}{1}$$

$[P_i = 1]$

$\Rightarrow P_0 = 0.2$

Number of photons emitted per second is given as

$$n = \frac{\text{Output power}}{\text{Energy of one photon}} = \frac{P_0}{\frac{hc}{\lambda}} = \frac{P_0\lambda}{hc}$$

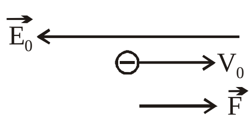
$$= \frac{0.2 \times 4000 \times 10^{-10}}{6.6 \times 10^{-34} \times 3 \times 10^8} = 0.04 \times 10^{19} = 4 \times 10^{17}$$

NEET/AIPMT

Q.1 (3)

Initial de-Broglie wavelength

$$\lambda_0 = \frac{h}{mV_0}$$



Acceleration of electron

$$a = \frac{eE_0}{m}$$

Velocity after time 't'

$$V = \left(V_0 + \frac{eE_0}{m}t\right)$$

$$\text{So, } \lambda = \frac{h}{mV} = \frac{h}{m\left(V_0 + \frac{eE_0}{m}t\right)}$$

$$= \frac{h}{mV_0\left[1 + \frac{eE_0}{mV_0}t\right]}$$

$$= \frac{\lambda_0}{\left[1 + \frac{eE_0}{mV_0}t\right]}$$

Q.2 (3)

$$E = W_0 + \frac{1}{2}mv^2$$

$$h(2v_0) = hv_0 + \frac{1}{2}mv_1^2$$

$$hv_0 = \frac{1}{2}mv_1^2 \qquad \text{......(i)}$$

$$h(5v_0) = hv_0 + \frac{1}{2}mv_2^2$$

$$4hv_0 = \frac{1}{2}mv_2^2 \qquad \text{......(ii)}$$

Divide (i) by (ii),

$$\frac{1}{4} = \frac{v_1^2}{v_2^2}$$

$$\frac{v_1}{v_2} = \frac{1}{2}$$

Q.3 **(2)**

Q.4 **(3)**

Q.5 **(2)**

Q.6 (3)

Q.7 (2)

Q.8 (2)

Q.9 (Bouns)

Using the equation

$eV = h\upsilon - \phi$

or $eV = h\upsilon - h\upsilon_{Th}$

$$\frac{eV_S}{2} = \frac{h\upsilon}{2} - h\upsilon_{Th} \qquad \text{....(1)}$$

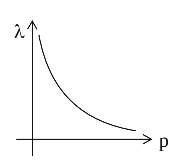
$$eV_s = h\upsilon - h\upsilon_{Th} \qquad \text{.......(2)}$$

Date Incorrect

Q.10 **(3)**

$$\lambda = \frac{h}{p}$$

Graph will be hyperbolic



JEE MAIN

Q.1 **(2)**

Let threshold frequency = f_0
incident frequency = $2f_0$

$hf = h f_0 + K.E.$

$h(2f_0) = hf_0 + \frac{1}{2}mv_1^2$

$hf_0 = \frac{1}{2}mv_1^2$ ....(1)

When incident frequency $f' = 5f_0$

$hf' = hf_0 + K.E.$

$h(5f_0) = hf_0 + \frac{1}{2}mv_2^2$

$4hf_0 = \frac{1}{2}mv_2^2$ ....(2)

Equation (1)/(2)

$\frac{v_1^2}{v_2^2} = \frac{1}{4} \Rightarrow v_2 = 2v_1$ $x = 2$

Q.2 (2)

$KE_{max} == h\nu - \phi$

$$\frac{KE\,max_1}{Ke\,max_2} = \frac{3.8-0.6}{1.4-0.6} = \frac{3.2}{0.8} = \frac{4}{1}$$

$$\therefore \frac{\frac{1}{2}mv_1^2}{\frac{1}{2}mv_2^2} = \frac{V_{1max}}{V_{2max}} = \sqrt{\frac{4}{1}} = \frac{2}{1}$$

Q.3 **(1)**

In Davisson-Germer experiment the electrons exihibit diffraction there by proving that electrons have wave nature. Hence both statement are correct.

Q.4 (2)

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2m(K.E)}}$$

$$\lambda \propto \frac{1}{\sqrt{m}}$$

$m_e < m_p < m_n < m_\alpha$

$$\boxed{\lambda_\alpha < \lambda_n < \lambda_p < \lambda_e}$$

Q.5 (2)

Q.6 **(1)**

$\lambda = 4500$ Å

$B = 2mT, R = 2mm$

$$R\frac{\sqrt{2Km}}{qB}$$

$$\frac{(qBR)^2}{2m} = K$$

$$\frac{(1.6\times10^{-19}\times2\times10^{-3}\times2\times10^{-3})^2}{2\times9.1\times10^{-31}} = K$$

$$\frac{(6.4)^2}{2\times9.1}\times\frac{10^{-50}}{10^{-31}} = K$$

$K = 2.25\times10^{-19}$ J

$$= \frac{2.25\times10^{-19}}{1.6\times10^{-19}}eV = 1.40eV$$

$$E = \frac{12400}{4500} = 2.76eV$$

$\phi = E - K = (2.76 - 1.40)\,eV = 1.36\,eV$

Q.7 **[35]**

Stopping potential $V_0 = 0.42$ V

$\lambda = 6630$ Å

$E = \phi = +eV_0$

E : energy of incident photon

V_0 : Stopping potential

$\phi = E - eV_0$

$$E = \frac{12400}{6630}eV = 1.87\,eV$$

$\phi = (1.87 - 0.42) = 1.45\,eV$

$\phi = h\nu_0 : \nu_0$: threshold frequency

$1.45\times1.6\times10^{-19} = 6.63\times10^{-34}\times\nu_0$

$\nu_0 = 0.35\times10^{15}$

$= 35\times10^{13}\,sec^{-1} \Rightarrow x = 35$

Q.8 (2)

$$k = \frac{P^2}{2m} \Rightarrow P\alpha\sqrt{m}$$

$$\text{Now } \lambda = \frac{h}{P}$$

$$\text{So}, \lambda \propto \frac{1}{P} \Rightarrow \lambda \propto \frac{1}{\sqrt{m}}$$

$$\frac{\lambda_\alpha}{\lambda_{C12}} = \frac{\sqrt{3}}{1}$$

Q.9 (1)

De Broglie wavelength

$$\lambda_e = \frac{h}{\sqrt{2Mk}} \text{ For Electron}$$

$$K_e = \frac{h^2}{2M_e\lambda_e^2}$$

For Photon

$E_p = \frac{hc}{\lambda_p}$

$\frac{h^2}{2M_e\lambda_e^2} = \frac{hC}{\lambda_p} \Rightarrow \lambda_e^2 \propto \lambda_p$

Q.10 (2)

$\frac{hc}{\lambda_1} - \phi = K_1$

$\frac{hc}{\lambda_2} - \phi = K_2$

$\lambda_1 = 3\lambda_2$

$3K_1 = \frac{3hc}{\lambda_1} - 3\phi$

$3K_1 = \frac{hc}{\lambda_2} - 3\phi$

$3K_1 = K_2 - 2\phi$

$3K_1 < K_2$

$K_1 < \frac{K_2}{3}$

Q.11 (1)

R is not correct explanation of A because R is not considering when energy of incident radiation is less than work function of metal, then also kinetic energy of photoelectrons is zero.

Q.12 (4)

$E = 200\,[\sin(6 \times 10^{15})\,t + \sin(9 \times 10^{15})t]V_m^{-1}$

Kinetic energy will be maximum corresponding to the maximum frequency maximum angular frequency $= 9 \times 10^{15}$

$\Rightarrow$ Maximum frequency $= \frac{\omega_{max}}{2\pi}$

$(\therefore \omega = 2\pi f)$

$\Rightarrow f_{max} = \frac{9 \times 10^{15}}{2\pi}$

$= 1.43 \times 10^{15}$ Hz

Using Einsteins equation

$h\nu = K_{max} + \phi$

$\Rightarrow 4.14 \times 10^{-15} \times 1.43 \times 10^{15} = k_{max} + 2.5$

$\Rightarrow K_{max} = 5.92 - 2.50 \quad = 3.42$ eV

Q.13 **(600)**

$\therefore$ Fringe width is $= \beta$

$B = \frac{\lambda D}{d}$

Let initially fringe width $= \beta$

$= \frac{\lambda D_1}{d}$

Final width $= \beta_2$

$= \frac{\lambda D_2}{d}$

$\beta_2 - \beta_1 = \frac{\lambda}{d}(D_2 - D_1)$

Change in $\beta = 3 \times 10^{-3}$ cm $= 3 \times 10^{-5}$ m

Chagne in $D = 5 \times 10^{-2}$ m

$\Rightarrow 3 \times 10^{-5} = \frac{\lambda}{10^{-3}} \times 5 \times 10^{-2}$

$\Rightarrow \lambda = \frac{3 \times 10^{-8}}{15 \times 10^{-2}} = 0.6 + 10^{-6}$ m

$= 600$ nm

Q.14 (3)

$KE_{Max_1} = \frac{hc}{\lambda_1} - \phi$

$KE_{Max_2} = \frac{hc}{\lambda_2} - \phi$

$K.E_{Max_2} = 2\,k.E_{Max_1} \qquad \{\lambda_1 = 800\,nm, \lambda_2 = 500\,nm\}$

$\frac{hc}{\lambda_2} - \phi = 2\left(\frac{hc}{\lambda_1} - \phi\right)$

$\phi = hc\left(\frac{2}{\lambda_1} - \frac{1}{\lambda_2}\right)$

$\phi = 1230\left(\frac{2}{800} - \frac{1}{500}\right)$

$\phi = 0.615$ eV

Q.15 (4)

$eV_p = \frac{p^2}{2m} = \frac{h^2}{2m_p\lambda_p^2}$ ...(1)

$eV_d = \frac{h^2}{2m_p\lambda_d^2}$ ...(2)

Q.16 (4)

$\vec{V} = V_0\hat{i}$ and $\vec{E} = -E_0\hat{i} = \frac{-e\vec{E}}{m} = \frac{eEo}{m}\hat{i}$

at t = 0 wavelength is $\lambda_0 = \dfrac{h}{mv_0}$

at time 't'

$$\vec{V} = \vec{u} + \vec{a}t$$

$$\vec{V} = V_0\hat{i} + \frac{eE_0}{m}\hat{i}\,t$$

$$\therefore V = \left(V_0 + \frac{eE_0}{m}t\right)$$

Now

$$\lambda = \frac{h}{mv} = \frac{h}{m\left(V_0 + \frac{eE_0}{m}t\right)} = \frac{h}{mV_0\left(1 + \frac{eE_0}{mV_0}t\right)}$$

$$\boxed{\lambda = \frac{\lambda_0}{(1 + \frac{eE_0}{mV_0}t)}}$$

Q.17 (2)

By Theory

Q.18 (4)

$$\lambda = \frac{h}{mv} \text{ (de-Broglie's wavelength)}$$

$$\lambda = \frac{h}{\sqrt{2m(K.E.)}}$$

$$h = \frac{h}{\sqrt{2mqV}}$$

Putting the values of m ; q

We get $\lambda = \dfrac{1.22}{\sqrt{V}}$ nm

Q.19 (3)

$E = KE + F$ — E – Energy of photon; KE – KE of e^-; ϕ = work function

Case I

$E_1 = 5\phi$

$E_1 = 10\phi$

$$\frac{1}{2}mv_1^2 = (KE)_1 = E_1 - \phi = 5\phi - \phi = 4\phi$$

$$\frac{1}{2}mv_2^2 = (KE)_2 = E_2 - \phi = 10\phi - \phi = 9\phi$$

So, $\dfrac{v_1}{v_2} = \sqrt{\dfrac{4\phi}{9\phi}} = \dfrac{2}{3}$

Q.20 (2)

$$E = \frac{hc}{\lambda} - \phi \quad \text{... (1)}$$

$$2E = \frac{hc}{\lambda'} - \phi \quad \text{... (2)}$$

(2) - (1)

$$E = hc\left(\frac{1}{\lambda'} - \frac{1}{\lambda}\right)$$

$$\Rightarrow \lambda' = \frac{hc\lambda}{E\lambda + hc}$$

Q.21 (2)

$$p = \sqrt{2mE} = \sqrt{2mqV}$$

$$\frac{p_0}{p_p} = \sqrt{\frac{m_\alpha q_\alpha}{m_p q_p}} = \sqrt{\frac{4}{1} \times \frac{2}{1}}$$

$$= \frac{2\sqrt{2}}{1}$$

ATOMS

EXERCISE-I (MHT CET LEVEL)

Q.1 (4)

$\frac{1}{\lambda} = R\left[\frac{1}{n^2{}_1} - \frac{1}{n^2{}_2}\right]$.For first wavelength, n_1

$= 2, n_2 = 3$

$\Rightarrow \lambda_1 = 6563$ For first wavelength, n_1

$2, n_2 = 4 \Rightarrow \lambda_2 = 4861A$

Q.2 (4)

Q.3 (3)

Q.4 (4)

Radius of the orbit, $r_n \;\alpha\; n^2$

$\frac{r_{nbig}}{r_{nsmall}} = \frac{n^2{}_{big}}{n^2{}_{small}} = \frac{4}{1}$ (Given)

$\Rightarrow \quad \frac{n_{big}}{n_{small}} = 2$

$\Rightarrow \quad \frac{n_{big}}{n_{small}} = \frac{1}{2}$

Velocity of electron in n^{th} orbit

$$v_n \alpha \frac{1}{n}$$

$\frac{v_{n\,big}}{v_{n\,small}} = \frac{n_{small}}{n_{big}} = \frac{1}{2}$

$\Rightarrow v_{n\,small} = 2(v_{n\,big}) = 2V$

Q.5 (3)

$\frac{1}{\lambda} = R\frac{1}{\frac{2}{n}\\1} - \frac{1}{\frac{2}{n}\\2}$

For limiting wavelength of Lyman series

$n_1 = 1, n_2 = \infty \frac{1}{\lambda L} = R$

For limiting wavelength of Balmer series

$n_1 = 2, n_2 = \infty$

$\frac{1}{\lambda_B} = R\left(\frac{1}{4}\right) \Rightarrow \lambda_B \frac{4}{R}$

$\therefore \lambda_B = 4\lambda_L = 4 \times 912 Å$

Q.6 **(4)**

Angular speed of electron in the n the orbit of Bohr H–atom is inversely proportional to n^3

$\omega_n \propto \frac{1}{n^3}$

Q.7 (1)

Q.8 (4)

Q.9 (4)

Q.10 (2)

Q.11 (2)

Q.12 (1)

Q.13 (2)

Q.14 (1)

Q.15 (3)

Q.16 (1)

Q.17 (1)

Q.18 (2)

Q.19 (4)

Q.20 (4)

Q.21 **(1)**

Q.22 (4)

Q.23 (1)

Q.24 (3)

Q.25 (2)

Q.26 **(3)**

Q.27 (4)

Q.28 **(3)**

Q.29 **(1)**

Q.30 (4)

Q.31 (3)

Q.32 **(2)**

Q.33 (3)

Q.34 (1)

The maximum kinetic energy of an electron accelerated through a potential difference of V volt is

$$\frac{1}{2}mv^2 = eV$$

$\therefore$ maximum velocity $v = \sqrt{\frac{2eV}{m}}$

$$v = \sqrt{\frac{2\times1.6\times10^{-19}\times15000}{9.1\times10^{-31}}}$$

$$v = 7.26\times10^{7}\,m/s$$

Q.35 (1)

$$\lambda = \frac{h}{m_1v_1} = \frac{h}{m_2v_2}$$

$$\therefore \frac{v_1}{v_2} = \frac{m_2}{m_1} = \frac{4}{1}$$

Q.36 (4)

$$\frac{h}{\sqrt{2mE}} = \frac{6.6\times10^{-34}}{\sqrt{2\times9\times10^{-31}\times80\times1.6\times10^{-19}}} = 1.4\text{ Å}$$

Q.37 (1)

EXERCISE-II (NEET LEVEL)

Q.1 (4)

Bohr radius $r = \frac{\varepsilon_0 n^2h^2}{\pi Zme^2}$; $\therefore r \propto n^2$

Q.2 (3)

Lyman series lies in the UV region

Q.3 (2)

The size of the atom is of the order of 1Å = 10^{-10}m.

Q.4 (2)

Balmer series lies in the visible region.

Q.5 (2)

For 2nd line of Balmer series in hydrogen spectrum

$$\frac{1}{\lambda} = R(1)\left(\frac{1}{2^2}-\frac{1}{4^2}\right) = \frac{3}{16}R$$

For Li^{2+} $\left[\frac{1}{\lambda} = R\times9\left(\frac{1}{x^2}-\frac{1}{12^2}\right) = \frac{3R}{16}\right]$

which is satisfied by n = 12 $\rightarrow$ n = 6.

Q.6 (4)

Q.7 (1)

$Z_1 = 1, Z_2 = 1, Z_3 = 2$ and $Z_4 = 3$.

$$\frac{1}{\lambda}RZ^2\left(\frac{1}{1^2}-\frac{1}{2^2}\right)$$

or $\lambda = \frac{4}{3RZ^2}$

or λZ^2 = constant

So $\lambda_1(1)^2 = \lambda_2(1)^2 = \lambda_3(2)^2 = \lambda a(3^2)$

or $\lambda_1(1)^2 = \lambda_2(1)^2 = \lambda_3(2)^2 = \lambda a(3^2)$

or $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$.

Q.8 (3)

For third line of Balmer series

$n_1 = 2, n_2 = 5$

$$\therefore \frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right] \text{ given } Z^2 = \left[\frac{n_1^2n_2^2}{\left(n_2^2-n_1^2\right)\lambda R}\right]$$

On putting values Z = 2

From

$$E = -\frac{13.6Z^2}{n^2} = \frac{-13.6(2)^2}{(1)^2} = -54.4eV$$

Q.9 (1)

Q.10 (1)

Q.11 (4)

Q.12 **(1)**

Q.13 (4)

$$2E - E = \frac{hc}{\lambda} \Rightarrow E = \frac{hc}{\lambda}$$

$$\frac{4E}{3} - E = \frac{hc}{\lambda} \Rightarrow \frac{E}{3} = \frac{hc}{\lambda'} \therefore \frac{\lambda'}{\lambda} = 3 \Rightarrow \lambda' = 3\lambda$$

Q.14 (4)

If E is the energy radiated in transition then $E_{R\to G} > E_{Q\to S} > E_{R\to S} > E_{Q\to R} > E_{P\to Q}$

For getting blue line energy radiated should be maximum $\left(E \propto \frac{1}{\lambda}\right)$. Hence (4) is the correct option.

Q.15 (3)

$mvr = \frac{nh}{2\pi}$, for n =1 it is $\frac{h}{2\pi}$

Q.16 (4)

By using

$$N_E = \frac{n(n-1)}{2}$$

$$\Rightarrow N_E = \frac{4(4-1)}{2} = 6$$

Q.17 (3)

For third line of Balmer series $n_1 = 2$, $n_2 = 5$

$$\therefore \frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \text{gives } Z^2 = \frac{n_1^2 n_2^2}{(n_2^2 - n_1^2)\lambda R}$$

On putting values $Z = 2$

From $E = -\frac{13.6Z^2}{n^2}$

$$= \frac{-13.6(2)^2}{(1)^2} = -54.4 \text{ eV}$$

Q.18 (4)

$r \propto n^2$. For ground state n =1 and for first excited state n = 2.

Q.19 (3)

According to de-Broglie hypothesis.

Q.20 (2)

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}}, \ \lambda \propto \frac{h}{\sqrt{E}} \ \text{(h and m = constant)}$$

Q.21 (2)

By using $\lambda \propto \frac{1}{\sqrt{V}}$

$$\Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}} \Rightarrow \frac{10^{-10}}{\lambda_2} = \sqrt{\frac{600}{150}} = 2$$

$$\Rightarrow \lambda_2 = 0.5 \text{ Å}$$

Q.22 (1)

$$\lambda_{neutron} \propto \frac{1}{\sqrt{T}} \Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{T_2}{T_1}}$$

$$\Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{(273+927)}{(273+27)}} = \sqrt{\frac{1200}{300}} = 2 \Rightarrow \lambda_2 = \frac{\lambda}{2}$$

Q.23 (3)

The voltage applied across the X-ray tube is of the range of 10 kV – 80 kV.

Q.24 (2)

$\lambda_{min} = \frac{hc}{eV}$ where h, c and e are constants. Hence

$$\lambda_{min} \propto \frac{1}{V}$$

Q.25 (3)

Range of X-rays is 0.1Å to 100 Å.

Q.26 (4)

The production of X-rays is an atomic property whereas the production of γ-rays is a nuclear property

Q.27 (3)

Q.28 (3)

$$v \propto (Z-b)^2 \Rightarrow v = a(Z-b)^2$$

Z = atomic number of element (a, b are constant).

Q.29 (4)

Nucleus of heavy atom captures electron of *k*-orbit. This is a radioactive process, so vacancy of this electron is filled by an outer electron and *x*-rays are produces.

Q.30 (3)

Q.31 (3)

$$\lambda \propto \frac{1}{(Z-1)^2} \Rightarrow \frac{\lambda_2}{\lambda_1} = \left(\frac{Z_1-1}{Z_2-1}\right)^2$$

$$\Rightarrow \frac{\lambda_2}{1} = \left(\frac{43-1}{29-1}\right)^2 = \left(\frac{42}{28}\right)^2$$

$$\Rightarrow l_2 = \frac{9}{4}\lambda$$

EXERCISE-III (JEE MAIN LEVEL)

Q.1 (2)

$r = a_0 \frac{n^2}{Z} = a_0 . \frac{2^2}{4} = a_0$

Q.2 (3)

$E_n (Li^{2+}) = E_1 (H)$

$\Rightarrow -13.6 \frac{3^2}{n^2} = -13.6 \times \frac{1}{1}$

$\Rightarrow n = 3$

Q.3 (4)

$r \propto n^2$

$\therefore r_{10} = 10^2 \times 1.06$ Å $= 106$ Å.

Q.4 (2)

Since speed reduces to half, KE reduced to

$\frac{1}{4}$ th $\Rightarrow n = 2$

$mvr = \frac{nh}{2\pi}$

$mv_0 r = 1. \frac{h}{2\pi}$ I

$m \frac{v_0}{2} r` = 2 \cdot \frac{h}{2\pi}$ II

from I and II

$r' = 4r$

Q.5 (1)

According to the Bohr model

P.E. = – 2 K.E. = 2 T. E.

$\Rightarrow$ K.E. = – T.E.

Where T.E. = $\frac{-me^4}{8 \epsilon_0^2 n^2h^2}$

K. E.= $-\frac{-me^4}{8 \epsilon_0^2 n^2h^2}$

$\Rightarrow \frac{K.E.}{T.E.} = -1$

Q.6 (4)

All the transition energies in option(A),(B) and (C) are greater than corresponding to n = 4 to n = 3. Hence, option (D).

Q.7 (3)

12.1 eV radiation will excite a hydrogen atom in ground state to n = 3

state number of possible transition = ${}^nC_2 = {}^3C_2 = 3$.

Q.8 (4)

$0.529\left[(n-1)^2 - n^2\right] = 0.529(n-1)^2$

$\Rightarrow \quad 2n+1 = n^2 + 1 - 2n$

$\Rightarrow \quad n = 0, 4$

Q.9 (3)

$E = 13.6\left(\frac{Z^2}{n^2}\right)$

$D\,E_H = \frac{13.6(1)^2}{(1)^2} - \frac{13.6(1)^2}{(2)^2} = 10.2$ eV = hn

$DE_{Li} = \frac{13.6(3)^2}{(1)^2} - \frac{13.6(3)^2}{(2)^2} = 91.80$ eV = h (9 n)

Q.10 (3)

n - 1 = 5

n = 6

No. of briught lines = $\frac{n(n-1)}{2} = \frac{6 \times 5}{2} = 15$

Q.11 (3)

$P = \frac{E}{C}$ $n_1 = 1, n_2 = 5$

$= \frac{\left(\frac{13.6}{1^2} - \frac{13.6}{5^2}\right)}{3 \times 10^8} \times 1.6 \times 10^{-19}$

$= \frac{13.056}{3} \times 1.6 \times 10^{-27}$

$mv = 6.96 \times 10^{-27}$

v = 4.2 m/s

Q.12 (4)

$\Delta E = Rcz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = \frac{hc}{\lambda}$

$\frac{1}{\lambda} \propto z^2$

For z = 3 $\quad Li^{+2}$

λ will be minimum

Q.13 (2)

$r = 0.529 \times \frac{n^2}{Z}$

$0.529 \times \frac{2^2}{2}$

$r = 1.06\,A^0$

Q.14 (1)
E = -3.4 ev (for n = 2)

———————— n = 2

angular momentum = $\frac{2h}{2\pi} = \frac{h}{\pi}$

Q.15 (4)

$l_d = \frac{h}{mv}$

E_1 = energy of photon = $\frac{hc}{\lambda}$ and energy of $e^- = \frac{p^2}{2m} = \frac{hv}{2\lambda}$

The required ratio = $\frac{\frac{hv}{2\lambda}}{\frac{hc}{\lambda}} = \frac{1}{4}$.

Q.16 (3)

K.E. of neutron E = $\frac{3}{2}kT$

$\lambda_d = \frac{h}{p} = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2m \times \frac{3}{2}kT}}$; $\lambda_2 = \lambda\sqrt{\frac{(927+273)}{27+273}} = 2\lambda$.

Q.17 (4)

$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2meV}}$

Q.18 (1)

$KE = 100 + 50 = 150\,eV$

$v = 150\,volt$

$\lambda = \sqrt{\frac{150}{V}}$

$\lambda = 1\,\overset{0}{A}$

Q.19 (1)
The contineous x-ray comes out because the striking electron lose its kinetic energy

Q.20 (3)
The cut off wavelength depends on the accelerating potential difference which is unchanged. Hence, the wavelength will remain unchanged.

Q.21 (3)

0.1 to $10\,\overset{0}{A}$ (x-ray range)

Q.22 (4)
When freqency is increased energy increases i.e. penetrating power increases

Q.23 (3)
K_α : transition from $2 \to 1$
Similarly for $K_\beta : 3 \to 1$, $K_\gamma : 4 \to 1$; L_α 0: $3 \to 2$: $M_\alpha : 4 \to 3$
Now we can compare energy and λ .

Q.24 (2)
The characteristic x-rays are obtained due to the transition of electron from inner orbits.

Q.25 (2)
When ever the energy of photon is doubled then work function increases must more than by 2 times.

EXERCISE-IV

Q.1 [3.4]	**Q.2** [914]	**Q.3** [8.65]	**Q.4** [4.2]	**Q.5** [5.4]
Q.6 [0.8]	**Q.7** [3.05]	**Q.8** [58.46]	**Q.9** [1]	**Q.10** [6.25]
Q.11 (2)	**Q.12** (2)	**Q.13** (1)	**Q.14** (1)	**Q.15** (1)
Q.16 (2)				

PREVIOUS YEAR'S

MHT CET

Q.1 (2)	**Q.2** (2)	**Q.3** (3)	**Q.4** (2)	**Q.5** (4)
Q.6 (3)	**Q.7** (1)	**Q.8** (1)	**Q.9** (2)	**Q.10** (4)
Q.11 (1)	**Q.12** (4)	**Q.13** (1)	**Q.14** (4)	**Q.15** (2)
Q.16 (4)	**Q.17** (1)	**Q.18** (4)	**Q.19** (1)	**Q.20** (4)
Q.21 (4)	**Q.22** (1)	**Q.23** (1)	**Q.24** (3)	**Q.25** (1)
Q.26 (3)	**Q.27** (2)	**Q.28** (2)	**Q.29** (4)	**Q.30** (4)
Q.31 (2)	**Q.32** (3)	**Q.33** (2)	**Q.34** (3)	**Q.35** (1)

Q.36 (4)
We known that, wavelength of spectrum in hydrogen atom is given as

$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For the series limit of Balmer series, $n_1 = 2$ and $n_2 = \infty$

$\therefore \frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right]$

$\Rightarrow \frac{1}{\lambda} = \frac{R}{4} \Rightarrow \lambda = \frac{4}{R} \Rightarrow \frac{c}{f} = \frac{4}{R}$ [$\because c = f\lambda$]

$f = \frac{R_c}{4}$

Q.37 **(4)**
Accroding to bohr's model, the kinetic energy of moving electron in nth orbit is given as

$$K = \frac{Rhc}{n^2}$$

where, R = Rydberg constant, h = Planck's constant and c = speed of light.

Similarly, potential energy of electron moving in nth orbit,

$$P = -2\frac{Rhc}{n^2} \quad ...(i)$$

From Eqs. (i) and (ii), we have

P = -2K

Total energy of electron moving in nth orbit

E = K + P = K - 2K

E = -K

$\Rightarrow$ K = - E=-(-3.4 eV)

[given, E = -3.4 eV]

$\Rightarrow$ K = 3.4 eV

From Eq. (iii), we have

P = -2K = -2(3.4)= -6.8 eV

$\because$ P - K = -6.8-3.4=-10.2 eV

and K - P = 3.4 - (-6.8)= 10.2 eV

Q.38 **(3)**

Given, E_1 = 13.6 eV

Energy of H-atom in nth excited state is

$$E_n = -\frac{13.6}{n^2} eV$$

For n = 2, $E_2 = -\frac{13.6}{2^2} = -3.4$ eV

So, energy required to excite H- atom from ground state to next higher state is

E = E_2 - E_1 = -3.4 - (13.6) = 10.2 eV

Q.39 **(2)**

Energy of electron in nth orbit in H-atom,

$$E_n \frac{-13.6}{n^2} eV$$

For third excited state, n= 4

$$\therefore\ E_4 = \frac{-13.6}{4^2} = -0.85eV$$

For ground state, n= 1

$$\therefore E_1 = \frac{-13.6^2}{1^2} = -13.6eV$$

If ν be the frequency of emitted photon, then

hν = E_4 - E_1

= - 0.85 (-13.6)

= - 0.85 + 13.6 = 12.75 eV

$$v = \frac{12.75\times1.6\times10^{-19}}{h}$$

$$= = \frac{12.75\times1.6\times10^{-19}}{6.63\times10^{-34}} = 3\times10^{15} Hz$$

Q.40 **(3)**

Wavelength of spectral line in hydrogen atom (Z=1) given as

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \quad ....(i)\ [\because Z=1]$$

For last line of Lyman series,

n_1 = 1 and $n_2 = \infty$

$\therefore$ From Eq. (i), we have

$$\frac{1}{\lambda_L} = R\left(\frac{1}{1^2} - \frac{1}{\infty}\right) = \frac{R}{4} \Rightarrow \lambda_L = \frac{R}{4}$$

Similary, for last line of Balmer series, n_1 = 2 and $n_2 = \infty$

$\therefore$ From Eq. (i), we get

$$\frac{1}{\lambda_B} = R\left(\frac{1}{2^2} - \frac{1}{\infty}\right) = \frac{R}{4}$$

$$\Rightarrow \quad \lambda_B = \frac{4}{R}$$

Hence, from Eq. (i) and Eq. (ii), we get

$$\frac{\lambda_L}{\lambda_B} = \frac{1/R}{4/R} = \frac{1}{4}$$

or $\lambda_L : \lambda_B = 1 : 4$

$\Rightarrow \lambda_B : \lambda_L = 4 : 1$

Q.41 (4)

The magnetic moment of a revolving electron in a orbit around nucleus is given by

$$M_{orb} = \frac{neh}{4\pi m_e}$$

$$\Rightarrow \quad m_{orb} \propto n$$

Q.42 (4)

In hydorgen spectrum Paschen series, Brackett series and Pfund series lies in infrared region of spectrum. So, the possible transitions are

n = 6 to n = 5; n = 6 to n = 4; n = 6 to n = 3

n = 5 to n = 4; n = 5 to n = 3; n = 4 to n = 3

Q.43 (4)

The radius of atomic orbit is given by

$$r_n = 0.059\frac{n^2}{Z}$$

For Be^{3+}, Z = 4

According to question,

$$\frac{r_0}{Z_1^2} = \frac{r_n}{Z_2^2}$$

$$\Rightarrow \quad \frac{(1)^2}{1} = \frac{n^2}{4} \Rightarrow n = 2$$

Q.44 (2)

As, time period, $T \propto n^3$

$$\Rightarrow \quad \frac{1}{\text{Frequency}(f)} \propto n^3 \qquad \left[\because T = \frac{1}{f}\right]$$

$$\Rightarrow \quad f \propto n^{-3}$$

Thus, f decreases with increase in n or vice-versa.

NEET/AIPMT

Q.1 (2)

KE = – (total energy)

So, Kinetic energy : total energy = 1 : –1

Q.2 (3)

Total energy = –3.4 eV

K.E. = – (T.E.) = 3.4 eV

P.E. = 2 (T.E.) = 2 × (–3.4eV) = –6.8 eV

Q.3 (2)

de Broglie wave length of electron $(\lambda_e) = \frac{12.27}{\sqrt{v}} A^\circ$

v = accelerating voltage

$$\lambda_e = \frac{12.27}{\sqrt{10000}} \times 10^{-10} m$$

$$\lambda_e = 12.2 \times 10^{-12} m$$

Q.4 (3)

Q.5 **(3)**

First excited state ⇒ n = 2

$$T_1 = -13.6 \frac{z^2}{n^2} = -\frac{13.6}{4} eV$$

Second excited state ⇒ n = 3

$$T_2 = -13.6 \frac{z^2}{n^2} = -\frac{13.6}{9} eV$$

$$T_1 : T_2 = \frac{1}{4} : \frac{1}{9} = 9 : 4$$

JEE MAIN

Q.1 (3)

According to electromagnetic theory accelerated charge liberate radiation. So electron eventually moves in smaller radius and may collapsed with nucleus.

Q.2 (2)

$$TE = \frac{-13.6Z^2}{n^2}, KE = \frac{13.6z^2}{n^2}, PE = \frac{-13.6z^2}{2n^2}$$

n ↑|TE| ↓But TE is (–ve) so↑

n↑|KE = | TE|↓So KE↑

$$TE = \frac{PE}{2} \text{ So } PE \uparrow$$

Q.3 **(4)**

Orbital velocity of electron

$$v \propto \frac{z}{n} \propto Z \text{ (n = same for both atoms)}$$

$$\Rightarrow \frac{v_{He^+}}{v_H} = \frac{z_{He^+}}{z_H} = \frac{2}{1}$$

Q.4 (2)

$$13.6\left(\frac{1}{1^2} - \frac{1}{n^2}\right) = 10.2$$

n = 12

$$L_i = \frac{h}{2\pi} \times 1$$

$$L_F = \frac{2h}{2\pi}$$

$$\Delta L = L_F - L_i = \frac{h}{2\pi} = \frac{6.6 \times 10^{-34}}{2 \times \frac{22}{7}}$$

$= 1.05 \times 10^{-34}$ J –s

Q.5 **(114)**

Z = 3

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$n_1 = 1, n_2 = 3,$

$$\frac{1}{\lambda} = R(9)\left(\frac{1}{1} - \frac{1}{9}\right) = 8R$$

$$\lambda = \frac{1}{8R} = 114 \times 10^{-10} m$$

Q.6 (4)

When electron jump from lower to higher energy level, energy absorbed so statement-I incorrect.

When electron jump from higher to lower energy level, energy of emitted photon

$E = E_2 - E_1$

$$hf = E_2 - E_1 \Rightarrow f = \frac{E_2 - E_1}{h}$$

So statement-II is correct.

Q.7 (3)

$$\boxed{\text{Impact parameters} \propto \cot\left(\frac{\theta}{2}\right)}$$

Where $\sqrt{d_1}, \sqrt{d_2}$ are impact parameters

$\theta_1 = 60°,\ \theta_2 = 90°$

$$\frac{d_1}{d_2}=\frac{\cot^2 30°}{\cot^2 45°}$$

$\Rightarrow d_1 = 3d_2$

Q.8 (1)

From Bohar II[nd] postulate

$$mvr=\frac{nh}{2\pi}$$

$$mvr=\frac{nh}{2\pi r}$$

Q.9 (2)

$$\overrightarrow{\mu_L}=\frac{q}{2m}\vec{L}\{q=\text{as per sign}\}$$

$$\vec{\mu}_L=\frac{-e}{2m}\vec{L}$$

Q.10 (2)

$n_2 = n, n_1 = 1$

$$\frac{1}{\lambda}=Rz^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$$

$$\frac{1}{\lambda}=R(1)\left(\frac{1}{1}-\frac{1}{n^2}\right)$$

$$\frac{1}{\lambda}=R\left[\frac{n^2-1}{n^2}\right]$$

$\Rightarrow n^2 = \lambda Rn^2 - \lambda R$

$\lambda R = n^2(\lambda R - 1)$

$$n=\sqrt{\frac{\lambda R}{\lambda R-1}}$$

Q.11 [5]

$$E=-13.6\times\frac{z^2}{n^2}$$

____________	h = 3	= –1.51 eV
____________	h = 2	= –3.4 eV
____________	h = 1	= –13.6 eV

$E_3 - E_2 = 1.51 + 3.4 = 1.89$ eV

$E_\infty - E_2 = 0 + 3.4 = 3.4$ eV

$$\frac{E_3-E_2}{E_\infty-E_2}=\frac{1.89}{3.4}=\frac{x}{x+4}$$

$\Rightarrow 1.89x + 7.56 = 3.4x$

$7.56 = 1.51x$

$x = 5$

Q.12 [5]

For Lyman seres I line

$$\frac{1}{\lambda}=R\left(\frac{1}{1^2}-\frac{1}{2^2}\right)=\frac{3R}{4}$$

$$\boxed{\lambda=\frac{4}{3R}}\rightarrow R=\frac{4}{3\lambda}$$

For Pashchen 3[rd] transition

$$\frac{1}{\lambda_3}=R\left(\frac{1}{3^2}-\frac{1}{(6)^2}\right)=R\left(\frac{1}{9}-\frac{1}{36}\right)=R\left(\frac{4-1}{36}\right)$$

$$\boxed{\lambda_3=\frac{12}{R}}=\frac{12\lambda}{\frac{4}{3\lambda}}=9\lambda$$

For Balmer 2nd line

$$\frac{1}{\lambda_2}=R\left(\frac{1}{(2)^2}-\frac{1}{(4)^2}\right)=R\left(\frac{1}{4}-\frac{1}{16}\right)=R\left(\frac{4-1}{16}\right)$$

$$\lambda_2=\frac{16}{3R}=\frac{16}{\frac{3\times4}{3\lambda}}=4\lambda$$

$|\lambda_3-\lambda_2|=a\lambda$

$9\lambda-4\lambda=a\lambda$

$5\lambda=a\lambda$

$\boxed{a=5}$

Q.13 (1)

$$E_n=\frac{-13.6}{n^2}eV$$

$$\Rightarrow\frac{E_2-E_1}{E_\infty-E_1}=\frac{13.6\left(1-\frac{1}{4}\right)}{13.6}=\frac{3}{4}$$

NUCLEI

EXERCISE-I (MHT CET LEVEL)

Q.1 **(1)**
Isotones means equal number of neutrons
i.e.,(A–Z)= 74–34= 71–31=40

Q.2 (1)

Q.3 (3)

Q.4 (3)

Q.5 (2)

Q.6 (3)

Q.7 (3)

Q.8 (2)

Q.9 (4)

Q.10 **(2)**

Q.11 **(1)**

Q.12 **(2)**

Q.13 (2)
Nuclear energy is relased is fission because BE/nuclear is larger for fission fragments than for parents nucleus.

Q.14 (1)

$$B.E_H = \frac{2.22}{2} = 1.11$$

$$B.E_{He} = \frac{28.3}{4} = 7.08$$

$$B.E_{Fe} = \frac{492}{56} = 8.78 = \text{maximum}$$

$$B.E_U = \frac{1786}{235} = 7.6$$

$^{56}_{26}Fe$ is most stable as it has maximum binding energy per nucleon.

Q.15 (4)
$M(_8O^{16}) = M(_7N^{15}) + 1m_p$
binding energy of last proton
$= M(N^{15}) + m_p - M(_1O^{16})$
= 15.00011 + 1.00783 - 15399492
= 0.01302 amu = 12.13 MeV

Q.16 (1)
Q.17 (1)
Q.18 **(2)**
Q.19 (3)
Let N_0 be the number of atoms of X at time t = 0
Then at t = 4 hrs (two half lives)

$$N_x = \frac{N_0}{4} and N_y = \frac{3N_0}{4}$$

$\therefore N_x/N_y = 1/3$
and at t = 6 hrs (three half lives)

$$N_x \frac{N_0}{8} \text{ and } N_y \frac{7N_0}{8}$$

$$or \frac{N_x}{N_y} = \frac{1}{7}$$

The given ratio $\frac{1}{4}$ lies between $\frac{1}{3}$ and $\frac{1}{7}$

Therefore,t lies between 4 hrs and 6 hrs.

Q.20 (2)

Q.21 (4)

Q.22 (4)

Q.23 (2)

Q.24 **(Bouns)**

Q.25 **(2)**

Q.26 $$N = N_0\left(\frac{1}{2}\right)^n$$

or $$\frac{N_0}{16} = N_0\left(\frac{1}{2}\right)^n$$

or n = 4

Halflife $$t_{1/2} = \frac{t}{n} = \frac{2}{4} = \frac{1}{2}h$$

Q.27 (1)

Q.28 (1)

Q.29 (1)

Q.30 (4)

Q.31 (4)

Q.32 **(3)**

Q.33 **(4)**

Q.34 **(3)**

Q.35 **(4)**

Q.36 **(1)**

Q.37 **(4)**

Q.38 **(1)**

Q.39 **(4)**

Q.40 **(1)**

Q.41 **(3)**

Q.42 (4)
In an explosion a body breaks up into two pieces of unequal masses both part. will have numerically equal momentum and lighter part will have more velocity.
$U \longrightarrow Th + He$

$$KE_{Th} = \frac{P^2}{2m_{Th}}, \quad KE_{He} = \frac{P^2}{2m_{He}}$$

Since m_{He} is less so KE_{He} will be more.

Q.43 (4)
Mass of uranium changed into energy

$$= \frac{0.1}{100} \times 1 = 10^{-3} kg$$

The energy released = mC^2
$= 10^{-3} \times (3 \times 10^8)^2$ 7= 9×10^{13} J.

Q.44 **(3)**

Q.45 **(2)**

EXERCISE-II (NEET LEVEL)

Q.1 (1)
Radius of $O_5^{189} = r_0 \; A_{O5}^{1/3}$

Radius of that nucleus = $\frac{1}{3} \times r_0 \left(A_{O_5}\right)^{\frac{1}{3}} = r_0 \left(\frac{189}{27}\right)^{\frac{1}{3}} = r_0$ $7^{1/3}$

$\therefore$ **A for that nucleus = 7**

Q.2 (4)
$r = r_0(A)^{1/3}$
r increase with increasing A mass number So, $r_A < r_B$ as mass number of A is smaller
E_{bn} decrease with increasing A for A > 56, ^{56}Fe has highest E_{bn} value.
so, E_{bn} for nucleus with A = 125
$E_{bnA} > E_{bnB}$

Q.3 (2)
The order of magnitude of mass and volume of uranium nucleus will be
mC"A(1.67×10^{-27} kg) (A is atomic number)

$$V = \frac{4}{3}\pi r^3 \simeq \frac{4}{3}\pi \, [(1.25 \times 10^{-15} m)A^{1/3}]^3$$

$\simeq (8.2 \times 10^{-45} m^3)A$

Hence, $\rho = \frac{m}{v} = \frac{A(1.67 \times 10^{-27} kg)}{(8.2 \times 10^{-45} m^3)A}$

$\simeq 2.0 \times 10^{17} kg/m^3$

Q.4 (3)
Nucleus does not contains electron.

Q.5 (1)
B.E.= $\Delta mc^2 = [2(1.0087 + 1.0073(-4.0015] = 28.4$ MeV

Q.6 (4)
Energy / day = $200 \times 10^6 \times 24 \times 3600$
$= 2 \times 2.4 \times 3.6 \times 10^{12} = 1728 \times 10^{10}$ J

Q.7 (3)
Energy released while forming a nucleus is known as binding energy (by definition).

Q.8 (3)
Out side the Nucleus, neutron is unstable (life ≈ 932 sec).

Q.9 (2)

Q.10 (3)
$_{85}X^{297} \rightarrow {}_{77}Y^{281} + 4({}_2He^4)$

Q.11 **(2)**

Q.12 (2)

x+1= 24 + 4 ⇒ x = 27.

Q.13 (4)

$_6C^{11} \rightarrow {}_5B^{11} + \beta^+ + \gamma$ because $\beta^+ = {}_1e^0$

Q.14 **(1)**

$$N = \frac{N_0}{2^4} = \frac{N_0}{16},$$

% amount remaining $= \frac{N \times 100}{N_0} = \frac{N_0}{16} \times \frac{100}{N_0} = 6.25\%$

Q.15 **(4)**

For stable product $\frac{dN}{dt} = -\lambda N \Rightarrow 0 = -\lambda N \Rightarrow \lambda = 0$

Q.16 (1)

$$E_n = -3.4eV$$

The kinetic energy is equal to the magnitude of total energy in this case.

$$\therefore K.E. = +3.4eV$$

The de Broglie wavelength of electron

$$\lambda = \frac{h}{\sqrt{2mK}}$$

$$= \frac{6.64 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 3.4 \times 1.6 \times 10^{-19}}} \text{eV}$$

$$= 0.66 \times 10^{-9} m$$

Q.17 (3)

Let the initial mass of uranium be M_0 Final mass of uranium after time t, $M = \frac{3}{4} M_0$

According to the law of radioactive disintegration.

$$\frac{M}{M_0} = \left(\frac{1}{2}\right)^{t/T} \Rightarrow \frac{M_0}{M} = (2)^{t/T}$$

$$\therefore \log_{10}\left(\frac{M_0}{M}\right) = \frac{t}{T} \log_{10}(2)$$

$$t = T\frac{\log_{10}\left(\frac{M_0}{M}\right)}{\log_{10}(2)} = \frac{T\log_{10}\left(\frac{4}{3}\right)}{\log_{10}(2)}$$

$$= \frac{T\log_{10}(1.333)}{\log_{10}(2)} = 4.5 \times 10^9 \left(\frac{0.1249}{0.3010}\right)$$

$$\Rightarrow t = 1.867 \times 10^9 \text{ yr.}$$

Q.18 (4)

$$\frac{dN}{dt} = 50 - \frac{N}{0.5} \cdot \int_0^N \frac{dN}{50 - 2N} = \int_0^t dt$$

$$N = \left(100\left(1 - e^{-\frac{t}{2}}\right)\right) = 25$$

$$t = 2\ln\left(\frac{4}{3}\right)$$

Q.19 (2)

Specific activity of 1 gm radium is 1 Curie.

Q.20 **(3)**

$T_{avg.} = \frac{1}{\lambda} \Rightarrow T_{1/2} = \frac{\ln 2}{\lambda} < T_{avg.}$

So more than half the nuclei decay.

Q.21 (3)

γ-rays are highly penetrating.

Q.22 (3)

Fraction remains after n half lives $\frac{N}{N_0} = \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^{t/T}$

$$\therefore \frac{N}{N_0} = \left(\frac{1}{2}\right)^{\frac{T/2}{T}} = \left(\frac{1}{2}\right)^{1/2} = \frac{1}{\sqrt{2}}$$

Q.23 (1)

Number of half lives in 20 min = n = $\frac{20}{5} = 4$

Fraction of material remains after four half lives = $\frac{1}{16}$

Hence fraction that decays = $1 - \frac{1}{16} = \frac{15}{16} = 93.75\%$

Q.24 (4)

By using $A = A_0\left(\frac{1}{2}\right)^{1/T_{1/2}} \Rightarrow \frac{A}{A_0} = \left(\frac{1}{2}\right)^{9/3} = \frac{1}{8}$

Q.25 (4)

$$n_\alpha = \frac{A - A'}{4} = \frac{235 - 207}{4} = 7$$

$n_\beta = (2n_\alpha - Z + Z') = (2 \times 7 - 92 + 82) = 4$

Q.26 **(3)**

Q.27 **(1)**

Q.28 (1)

Q.29 (2)

Q.30 (2)

Q.31 (2)

Q.32 **(2)**

Q.33 **(2)**
Q.34 **(2)**
Q.35 (3)

Q.36 (4)

Q.37 (1)
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

EXERCISE-III (JEE MAIN LEVEL)

Q.1 (4)

Q.2 (4) the binding energy per nucleon in a nucleus varies in a way that depends on the actual value of A.

Q.3 (1)
$Q = (2BE_{He} - BE_{Li})$
$= (2 \times 7.06 \times 4 - 5.60 \times 7)$ Mev
= 17.28 Mev.

Q.4 (3)

1 a.m.u. = $\frac{1}{12}$ [mass of one $_6c^{12}$]

For $C \Rightarrow A = 12$

Q.5 (2)

$^AX + {^AX} \rightarrow {^{2A}Y}$

$E_2 - 2E_1 = Q$

Q.6 (3)

$3B \rightarrow A + e$

$\downarrow \quad \downarrow$

$E_b \quad E_a$

$e = E_a - 3E_b \Rightarrow 3E_b = E_a - e$

Q.7 (3)
BE/ Nucleon $\Rightarrow$

$^4_2He \Rightarrow \frac{28}{4} = 7\,MeV$

$^7_3Li \Rightarrow \frac{52}{7} = 7.4\,MeV$

$^{12}_6C \Rightarrow \frac{90}{12} = 7.5\,MeV$

$^{14}_7N \Rightarrow \frac{98}{14} = 7\,MeV$

Elements with more BE/nucleon is more stable.

Q.8 (3)
Energy released = $[(80 \times 7) + (120 \times 8)] - [200 \times 6.5]$
= 220 MeV **Ans.**

Q.9 (2)
$^4_2He + {^{14}_7N} \rightarrow {^{17}_8O} + {^1_1H}$

Q.10 (2)

$n \rightarrow p + e^- + \bar{\upsilon}$

4. **Statistical law of radioactive decay**

Q.11 (4)
Energy of γ photon
= Difference in energies of α particles = 0.4 MeV

Q.12 (1)
The weight will not change appreciably as the process is b - decay.

Q.13 (4)

Q.14 (3)
$A = \lambda N$

$A_1 = \frac{0.693}{2} N_0 e^{-\frac{0.693}{2}t}$

$A_2 = \frac{0.693}{4} N_0\, e^{\frac{-0.693}{4}t}$ $\quad \frac{A_1}{A_2} = 2e^{\frac{0.693}{4}t - \frac{0.693}{2}t}$

$= 2e^{\frac{-0.693}{2}}$

Q.18 (2)
$0.9N_0 = N_0 e^{-\lambda t}$

$N = N_0 e^{-2\lambda t}$ $N = N_0 0.9 \times 0.9$
$N = 0.81\, N_0$

Q.16 (1)

$\lambda_1 : \lambda_2 = 1 : 2$

$\lambda_1 A_0 = \lambda_2 B_0 \quad A_0 = 2B_0$

Q.17 (1)

$f_1 = 1 - e^{-\lambda \frac{1}{\lambda}} = 0.634$

$f_2 = 1 - e^{-\lambda \frac{Ln2}{\lambda}} = 1 - e^{\ln 2^{-1}} = \left(1 - \frac{1}{2}\right) = \frac{1}{2}$

Q.18 (2)

Initial = N_o

Total decayed in 10 years

$\frac{N_o}{2} + \frac{N_o}{2^2} = \frac{3}{4} N_o$

Prob = $= \frac{\frac{3}{4} N_o}{N_o}$ Prob = 75%

Q.19 (1)

Prob of decay by $l_1 \Rightarrow \frac{dN_1}{N_1} = \lambda_1 t$

$\lambda_2 \Rightarrow \frac{dN_2}{N_2} = \lambda_2 t$

$\text{Total Prob} = \frac{dN}{N} = \lambda dt$

$\lambda dt = \lambda_1 dt + \lambda_2 dt$

$\lambda = \lambda_1 + \lambda_2$

Q.20 (3)

No effect of concentration on activity.

Q.21 (2)

$\text{time} = \frac{3200 \times 10^3}{2000}$

$1600 \rightarrow 1600 \text{ sec.}$

Remaining after two half time

$\frac{N_o}{4} = \frac{10^8}{4} = 25 \times 10^6$

Q.22 (1)

(1) no of moles of $_1H^2$ consumed

$= \frac{1MW \times (24 \times 3600) \text{sec/day}}{(20 \text{ MeV} \times 6.023 \times 10^{23})} = 0.05$

$\therefore \quad m = 0.1$ g

Q.23 (4)

Fusion reaction is possible at high temperature because kinetic energy is high enough to overcome repulsion between nuclei.

Q.24 (3)

$Q = (BE_x + BE_y - Be_u)$

$= (2 \times 117 \times 8.5 - 236 \times 7.6)$ MeV = 195 MeV » **200 MeV.**

Q.25 (4)

No. of nuclear spliting per second is

$N = \frac{100MW}{200MeV} = \frac{100}{200 \times 1.6 \times 10^{-19}} \; S^{-1}$

No. of neutrons Liberated = $\frac{100}{200} \times \frac{1}{1.6 \times 10^{-19}} \times 2.5$

S^{-1}

$= \frac{125}{16}$ **× 10^{18} S^{-1}**

EXERCISE-IV

Q.1 0026

$\lambda_{th} = \frac{hc}{eV_a}$

$\frac{1}{\lambda_{K\alpha}} = R(z-1)^2 \left(\frac{1}{1^2} - \frac{1}{2^2}\right)$

$\frac{13}{10}(\lambda_{K\alpha} - \lambda_{th}) = \left(\lambda_{K\alpha} - \frac{\lambda_{th}}{2}\right)$

$\frac{3}{10}\lambda_{K\alpha} = \left(\frac{13}{10} - \frac{1}{2}\right)\lambda_{th}$

$\frac{3}{10}\left(\frac{4 \times 10^{-7}}{3(z_7)^2}\right) = \left(\frac{8}{10}\right)\frac{12.4 \times 10^{-7}}{15.5 \times 10^3}$

$\Rightarrow \frac{5000}{8} = (z-1)^2$

$625 = (z-1)^2 \qquad \Rightarrow z = 26$

Q.2 0003

	A	**B**
t = 0	N_0	N_0
t_0 = 3 days	2N	N

$2N = N_0 (0.5)\, t_0/\tau_1$

$N = N_0 (0.5) t_0/\tau_2$

$$2 = (0.5)\,t_0\left(\frac{1}{\tau_1} - \frac{1}{\tau_2}\right)$$

$$\Rightarrow 0.5^{-1} = (0.5)\left(\frac{3}{\tau_1} - 2\right)$$

$$\Rightarrow -1 = \frac{3}{\tau_1} - 2 \quad \therefore\ \tau_1 = 3 \text{ days}$$

Q.3 0653

Reaction Energy = Δmc^2

= (63.9297642–63.9279660– 2 × 0.0005486) ×931.5 = 653 KeV]

Q.4 0136

$7.2 = 1.2\,A^{1/3}$

$A = 6^3 = 216$

$1.28 \times 10^{-17} = Z \times 1.6 \times 10^{-19}$

$$\frac{128}{1.6} = Z = 80$$

$N = A - Z = 136$

Q.5 0001

Evaporations and reaction has rate similar to first order reaction rate

Hence

$$\frac{1}{t_{1/2}} = \frac{1}{(t_{1/2})_{evoparation}} + \frac{1}{(t_{1/2})_{suction}} \quad \Rightarrow$$

$$\frac{1}{t_{1/2}} = 6 \text{ hrs}$$

$$\text{Hence water left} = \frac{16}{2^4} = 1\text{kg}$$

Q.6 1880

$$\text{Energy available} = \frac{1}{2}\mu v_{rel}^2. = \text{Q value.}$$

$$= \frac{1}{2} \times \frac{7\times1}{7+1} \times v_{rel}^2 = \text{Q value.}$$

$$\Rightarrow \frac{1}{2} \times v_{rel}^2 = Q \times \frac{8}{7}$$

$$K_i = 1645 \times \frac{8}{7} = 1880 \text{ keV}$$

Q.7 0020

$^4He_2 \longrightarrow {}^1H_1 + {}^3H_1$

$$\Delta m = m\left({}^4_2He\right) - m\left({}^1H_1\right) - m\left({}^3H_1\right) = -0.021271$$

$\therefore \quad E = \Delta mc^2$

$\quad = -19.81$ MeV

–ve sign shows that energy is supplied.

Q.8 (1)
Q.9 (1)
Q.10 (1)
Q.11 (2)
Q.12 (3)
Q.13 (1)

PREVIOUS YEAR'S

MHT CET

Q.1 (3)
Q.2 (1)
Q.3 (2)
Q.4 (2)
Q.5 (4)
Q.6 (2)
Q.7 (2)
Q.8 **(4)**

If A_1 and A_2 are the mass number of two parts. The radius of nucelus is given by

$R = R_0\,(A)^{1/3}$

So, $R_1 = R_0(A_1)^{1/3}$ and $R_2 = R_0\,(A_2)^{1/3}$

$$\Rightarrow \frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3}$$

$$\Rightarrow \frac{A_1}{A_2} = \left(\frac{R_1}{R_2}\right)^3 = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$$

$$\therefore \text{ Ratio of masses, } \frac{m_1}{m_2} = \frac{A_1}{A_2} = \frac{1}{8}$$

From conservation of momentum,

$m_1v_1 = m_2v_2$

$$\Rightarrow \frac{v_1}{v_2} = \frac{m_2}{m_1} = \frac{8}{1} \text{ or } 8:1$$

Q.9 (1)

The initial amount of substance = N_0

and remaining amount = N

According to first order decay, $N = N_0e^{-\lambda t}$

$$\text{Fraction of substance remaining} = \frac{N}{N_0} = e^{-\lambda.t}$$

Here, $t = \tau = \frac{1}{\lambda}$

$$\therefore \frac{N}{N_0} = e^{-\lambda.\frac{1}{\lambda}} = e^{-1} = \frac{1}{e} \Rightarrow \frac{N}{N_0} = \frac{1}{2.71}$$

$\therefore$ Fraction of substance disintegrate $= 1 - \frac{N}{N_0}$

$$= 1 - \frac{1}{2.71} = \frac{1.71}{2.71} \approx \frac{2}{3}$$

$\therefore$ Fraction of disintegrated initial quantity will be $\left(\frac{2}{3}\right)N_0$.

NEET / AIPMT

Q.1 (3)

Number of nuclei remaining = 600 – 450 = 150

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$$

$$\frac{150}{600} = \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$$

$$\left(\frac{1}{2}\right)^2 = \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$$

$t = 2t_{1/2} = 2 \times 10$
$= 20$ minute

Q.2 (1)

Q.3 (4)

Q.4 (2)

Q.5 (1)

Q.6 (3)

Q.7 (2)

Nuclear Radius:

$R = R_0 (A)^{1/3}$

$$\frac{R(125)}{R(64)} = \frac{R_0(125)^{1/3}}{R_0(64)^{1/3}} = \frac{5}{4}$$

Q.8 (2)

$${}^{22}_{11}Na \longrightarrow X + e^+ + \nu$$

This is β^+ - decay

$${}^{22}_{11}Na \longrightarrow {}^{22}_{10}Ne + e^+ + \nu$$

JEE MAIN

Q.1 (4)

$x + p \rightarrow \gamma + b$

$Q = k\gamma + k_b - k_p$

$Q + k_p = k\gamma + kb$

$Q + kp > 0$

Q.2 (4)

$A \rightarrow B + C$

Mass No. of A = 220, $\frac{(B.A)_A}{220} = 5.6$ MeV

Mass No. of B = 105, $\frac{(B.A)_B}{105} = 6.4$ MeV

Mass No. of C = 115, $\frac{(B.A)_C}{115} = 6.4$ MeV

$Q = [(B.E)_{product} - (B.E)_{reactant}]$

$Q = [(B.E)_B + (B.E)_C - (B.E)_A]$

$Q = [(5.4) \times 105 + (6.4) \times 115 - (5.6) \times 220]$ MeV

$Q = 176$ MeV

Q.3 (25)

$$\frac{m_A}{m_B} = \frac{m_0\left(\frac{1}{2}\right)^{nA}}{m_0\left(\frac{1}{2}\right)^{nB}}$$

$$\frac{m_A}{m_B} = \left(\frac{1}{2}\right)^{n_A - n_B}$$

$t = n \times T_h$

$16 = n_A \times 4$

$n_A = 4$

$16 = n_B \times 8$

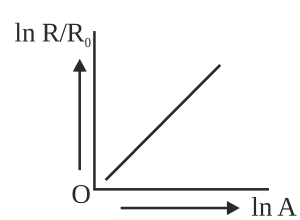
$n_B = 2$

$$\frac{m_A}{m_B} = \left(\frac{1}{2}\right)^{4-2} = \left(\frac{1}{2}\right)^2 = \frac{1}{4} \Rightarrow \frac{x}{100} = \frac{1}{4}, x = 25$$

Q.4 (2)

$$R = R_0 A^{\frac{1}{3}}$$

$$\frac{R}{R_0} A^{1/3} \Rightarrow \ell n\left(\frac{R}{R_0}\right) = \frac{1}{3}\ell n(A)$$



Q.5 (4)

Q.6 (3)

$\lambda_{emitted} = 670nm$
$\lambda_{obs} = 670.7\,nm$
$v = ?$
$c = 3 \times 10^8$ m/s
If v <<c

$$\frac{\lambda_{obs} - \lambda_{emitted}}{\lambda_{emitted}} = \frac{v}{c} \quad \Rightarrow \frac{670.7 - 670}{670} = \frac{v}{3\times10^8}$$

$V = 3.13 \times 10^5$ m/s

Q.7 (4)

$\lambda_{eq} = \lambda_1 + \lambda_2$

$$\frac{\ln 2}{(t_{1/2})_{eq}} = \frac{\ln 2}{(t_{1/2})_1} + \frac{\ln 2}{(t_{1/2})_2} \quad \Rightarrow (t_{1/2})_{eq} = \frac{(t_{1/2})_1 \times (t_{1/2})_2}{(t_{1/2})_1 (t_{1/2})_2}$$

$$\frac{3\times4.5}{3+4.5} = \frac{3\times4.5}{7.5} = \frac{3\times3}{5} = 1.8\,hr$$

Q.8 (3)

Q.9 (2)

$A_0 = 2.56 \times 10^{-3}$
$A = 2 \times 10^{-5}$
Half life = 5 day
Total times = ?
$\therefore A = A_0 e^{-\lambda t}$
$2.56 \times 10^{-3} e^{-\lambda t} = 2 \times 10^{-5}$

$$\frac{\text{In}\,2}{5}(t) = \text{In}(128)$$

$$t = \frac{5\,\text{In}(128)}{\text{In}(2)} = 5 \times \log_3 128 = 5 \times 7 = 35 \text{ days}$$

Q.10 (1)

$$D \xrightarrow{\alpha} D_1 \xrightarrow{\beta^-} D_2 \xrightarrow{\alpha} D_3 \xrightarrow{\gamma} D_4$$

During α decay atomic number decrease by 2 and mass number decreases by 4. ${}^{182}_{72}D \xrightarrow{\alpha} {}^{178}_{72}D_1$

During β^- decay, neutron converts into proton. Atomic number increase by one and mass number remains same. ${}^{178}_{72}D_1 \xrightarrow{\beta^{-1}} {}^{178}_{72}D_2$

${}^{178}_{73}D_2 \xrightarrow{\alpha} {}^{174}_{71}D_2$

During γ decay, photon is emitted, no change in mass number or atomic number.

Q.11 (20)

Let initially M_0 is no. of nuclei in the sample then

$$M_0 \xrightarrow{t_1/2} \frac{M_0}{2} \xrightarrow{t_{1/2}} \frac{M_0}{4} \xrightarrow{t_{1/2}} \frac{M_0}{8} \xrightarrow{t_{1/2}} \frac{M_0}{16}$$

$100 \to 50 \to 25 \to 12.5 \to 6.25\%$
After 4 half lives 6.25% of initial sample remains
Total time = 4 × 5 = 20 years.

Q.12 (3)

$$R_1 = \frac{dN_0}{dt} = -\lambda N_0 = 4250$$

$R_2 = -\lambda N = 2250$

$$\frac{N}{N_0} = \frac{2250}{4250}$$

$$\frac{N_0}{N} = 1.88 \qquad \text{...(1)}$$

$N = N_0 e^{-\lambda(10)}$

$$\frac{N}{N_0} = e^{-\lambda(10)}$$

$1.88 = e^{10\lambda}$
$\text{Log}_{10}(1.88) = 10\lambda \log_{10} e$
$0.274 = 10 \times .4343\lambda$

$$\lambda = \frac{0.274}{4.343}$$

$\lambda = 0.063$

Q.13 (3)

Radius of nucleus is given by $R=(1.3\times10^{-15})A^{1/3}$m, where A is mass number.
So, we can say that radius of nucleus is directly proportional to $A^{1/3}$.
i.e.,

$$R \,\alpha\, A^{\frac{1}{3}}$$

$$\therefore \frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{\frac{1}{3}} \Rightarrow \frac{R_1}{R_2} = \left(\frac{4}{3}\right)^{\frac{1}{3}}$$

$$\left(\frac{R_1}{R_2}\right)^3 = \left(\frac{4}{3}\right) \qquad \therefore \frac{p_1}{p_2} = \frac{1}{1}$$

Q.14 [26]

E = -(2×1.1+2×1.1) - (-(4×7.6)) = -4.4 +30.4 = 26 MeV

Q.15 (3)

$$A = \frac{A_0}{16}\text{(given)} \qquad t = 30 \text{ year (given)}$$

Now

$$A = \frac{A_0}{2^n} \text{ where } n = \frac{t}{T} \qquad T \to \text{Half life}$$

So

$$\frac{A_0}{16} = \frac{A_0}{2^n} \Rightarrow \boxed{n = 4}$$

and $4 = \frac{30}{T} \Rightarrow \boxed{T = \frac{30}{4} = 7.5\,\text{year}}$

Q.16 (4)

$$A = \frac{A_0}{2^n}$$

$$2^n = \frac{A_0}{A} = \frac{64\times10^{-4}}{5\times10^{-4}} = 128 = 2^7$$

N = 7 half lifes

So 7×5 = 35 days

Q.17 (3)

7/8 disintegrates means 1/8 remains

or $\left(\frac{1}{2}\right)^3 \therefore$ 3 half lives = 180 days

Q.18 (15)

$$A = A_0 \times 2^{-t/T}$$

$$\frac{A_0}{64} = A_0 \times 2^{-t/T}$$

$\therefore$ t = 6T = 6 × 2.5 = 15 hours

Q.19 (1)

$N = \frac{7}{8}N_0$ in t = 15 min

(N = No. of nuclei which decayed)

$N = N_0(1 - e^{-\lambda t})$

$\frac{7}{8}N_0 = N_0(1 - e^{-\lambda t}) \Rightarrow \frac{7}{8} = 1 - e^{-\lambda t}$

$$e^{-\lambda t} = 1 - \frac{7}{8} = \frac{1}{8}$$

$e^{\lambda t} = 8$

$\lambda t = \ln 8$

t = 15 min & w.KT $t_{1/2} = \frac{\ln(2)}{\lambda}$

So, $t = \frac{\ln(2^3)}{\lambda} = \frac{3\ln 2}{\lambda} = 3t_{1/2}$

$$t_{1/2} = \frac{t}{3} = \frac{15}{3} = 5 \text{ min}$$

Q.20 (2)

$R \propto A^{1/3}$

$$V = \frac{4}{3}\pi R^3 \propto A$$

Mass $\propto$ A

So density in independent of A

Q.21 (9)

$N = N_0 e^{-\lambda t}$

$$\frac{N_B}{N_A} = \frac{e^{-\lambda_2 t}}{e^{-\lambda_1 t}} = e^{-\lambda_2 t}.e^{-\lambda_1 t}$$

$$e^1 = e^{(\lambda_1 - \lambda_2)t}$$

$(\lambda_1 - \lambda_2)\,t = 1$

$$t = \frac{1}{\lambda_1 - \lambda_2} = \frac{1}{25\lambda - 16\lambda} = \frac{1}{9\lambda}$$

SEMICONDUCTOR ELECTRONICS- MATERIALS, DEVICES AND SIMPLE CIRCUITS

EXERCISE-I (MHT CET LEVEL)

Q.1 (3)

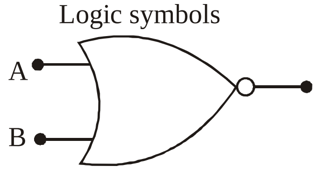
$$I=\frac{V}{R}=\frac{20}{2\times10^{3}}=10\times10^{-3}A=10mA$$

Q.2 (2)

The given gate is a NOR gate. The output is high, when all inputs are low.

A	B	Y
0	0	1
1	0	0
0	1	0
1	1	0

Logic symbols



Q.3 (3)

Q.4 (Bonus)

Q.5 (2)

$$\left(\overline{A+B}\right)=NOR \text{ gate}$$

When both inputs of NAND gate are connected, it behaves as NOT gate

OR + NOT = NOR

Q.6 (4)

Q.7 (1)

A positive feedback from output to input in as amplifier provides oscillations of constant amplitude.

Q.8 (2)

$\text{I} \rightarrow \text{ON}$

$\text{II} \rightarrow \text{OFF}$

In IInd state it is used as a amplifier it is active region.

Q.9 (1)

The output ac voltage is 2.0V. so, the ac collector current $i_c = 2.0/2000 = 1.0$ mA.

The signal current through the base is, therfore given by, $i_B = i_c/\beta = 1.0\text{mA}/100 = 0.010\text{mA}$.

The dc base current has to be $10\times0.010 = 0.10\text{mA}$

$R_B = (V_{BB}\text{-}V_{BE})/I_B$

Assuming $V_{BE} = 0.6V$, $R_B = (2.0.06)/0.10 = 14\Omega$

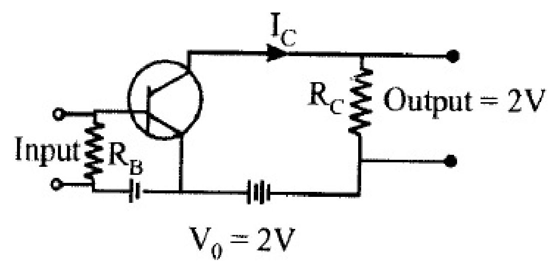
Q.10 (1)

The final boolean expression is,

$$X = \overline{(\overline{A}.\overline{B})} = \overline{\overline{A}}+\overline{\overline{B}} = A+B \Rightarrow \text{OR gate}$$

Q.11 (3)

Given : Voltage across the collector $V_0 = 2$ V; collector resstance resistance, $R_c = 2\times10^3\Omega$; Base resistance $R_B = 1\times10^3\ \Omega$; Input signal voltage, $V_i = ?$



$$V_0 = I_C R_C = 2$$

$$\Rightarrow I_C = \frac{2}{2\times10^3}10^{-3}A$$

Current gain $\alpha = \dfrac{I_C}{I_B} = 100$

$$\Rightarrow I_B = \frac{I_C}{100} = \frac{10^{-3}}{100} = 10^{-5}A$$

$$V_i = R_B I_B \Rightarrow V_i = 1\times10^3\times10^{-5}$$

$$\Rightarrow V_i = 10^{-2}V \Rightarrow V_i = 10mV$$

Q.12 (4)

During the operation, either of D_1 and D_2 be in forward bias. Also R_1 and R_2 are different, so output across R will have different peaks.

Q.13 **(2)**

Voltage gain, $A_V = \beta\dfrac{R_L}{R_i} = 0.6\times\dfrac{24}{3} = 4.8$

Q.14 **(2)**
forward bias opposes the potential barrier and if the applied voltage is more than knee voltage if cancals the potential barrier..

Q.15 (1)	**Q.16** (2)	**Q.17** (4)	**Q.18** (2)	**Q.19** (3)
Q.20 (4)	**Q.21** (3)	**Q.22** (3)	**Q.23** (3)	**Q.24** (1)
Q.25 (2)	**Q.26** (4)	**Q.27** (3)	**Q.28** (3)	**Q.29** (4)
Q.30 (3)	**Q.31** (1)	**Q.32** (4)	**Q.33** (2)	**Q.34** (4)
Q.35 (4)	**Q.36** (4)	**Q.37** (2)	**Q.38** (4)	**Q.39** (2)
Q.40 (1)	**Q.41** (4)	**Q.42** (1)	**Q.43** (2)	**Q.44** (1)
Q.45 (4)	**Q.46** (1)	**Q.47** (4)	**Q.48** (1)	**Q.49** (3)
Q.50 (2)	**Q.51** (1)	**Q.52** (4)	**Q.53** (3)	**Q.54** (3)
Q.55 (4)	**Q.56** (2)	**Q.57** (2)	**Q.58** (1)	**Q.59** (2)

EXERCISE-II (NEET/JEE MAIN LEVEL)

Q.1 (2)	**Q.2** (2)	**Q.3** (1)	**Q.4** (1)	**Q.5** (1)
Q.6 (3)	**Q.7** (1)	**Q.8** (2)	**Q.9** (2)	**Q.10** (1)
Q.11 (2)	**Q.12** (1)	**Q.13** (1)	**Q.14** (3)	**Q.15** (2)
Q.16 (1)	**Q.17** (3)			

EXERCISE-III

Q.1 (2)	**Q.2** (3)	**Q.3** (1)	**Q.4** (3)	**Q.5** (1)
Q.6 (1)				

PREVIOUS YEAR'S

MHT CET

Q.1 (2)	**Q.2** (3)	**Q.3** (1)	**Q.4** (2)	**Q.5** (3)
Q.6 (4)	**Q.7** (3)	**Q.8** (3)	**Q.9** (1)	**Q.10** (2)
Q.11 (2)	**Q.12** (2)	**Q.13** (1)	**Q.14** (1)	**Q.15** (3)
Q.16 (2)	**Q.17** (4)	**Q.18** (3)	**Q.19** (3)	**Q.20** (2)
Q.21 (1)	**Q.22** (1)	**Q.23** (2)	**Q.24** (3)	**Q.25** (2)
Q.26 (2)	**Q.27** (2)	**Q.28** (2)	**Q.29** (3)	**Q.30** (2)
Q.31 (1)	**Q.32** (2)	**Q.33** (2)	**Q.34** (3)	**Q.35** (4)
Q.36 (1)				

Q.37 **(4)**
According to given situation, truth table can be given as

Input		Output	
A	B	AB	(Y) = $\overline{AB}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

Hence, the given logic gate is NAND gate.

Q.38 **(2)**
Given, voltage gain = 40, Rin = 100Ω.
$R_{out} = 400\Omega$

Since, voltage gain = $\beta\left(\frac{R_{out}}{R_{in}}\right)$

$\Rightarrow \beta = \text{voltage gain} \times \frac{R_{in}}{R_{out}}$

$= 40 \times \frac{100}{400} = 10$

Power gain = β× voltage gain
$= 10 \times 40 = 400$

Q.39 **(3)**
For CE n-p-n transistor, DC current gain

$\beta_{DC} = \frac{I_c}{I_B}$

At saturation state, V_{CE} becomes zero,
$\therefore$ Vcc - $I_C R_C$ = 0

$I_c \approx \frac{V_{cc}}{R_c} = \frac{20}{4000} = \frac{1}{200}\text{A}$

Hence, saturation base current

$I_B = \frac{I_C}{\beta_{DC}} = \frac{1}{200 \times 300} = \frac{1}{60000}\text{A} = 16.66\mu\text{A}$

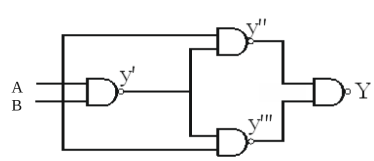
Q.40 **(4)**

Potential drop across silicon diode in forward bias is around 0.7 V.
In the given circuit, potential drop across 300Ω resistor is
$\Delta V = IR$

$\Rightarrow \quad I = \frac{\Delta V}{R} = \frac{5 - 0.7}{300} = 0.01433\text{A}$

or I = 14.33 mA

Q.41 **(3)**
The respective output of each logic gate is shown below



Here, $Y' = \overline{A.B} = \overline{A} + \overline{B}$

$Y'' = \overline{A.(\overline{A} + \overline{B})} = \overline{A} + \overline{(\overline{A} + \overline{B})}$

[By de morgan's theorem]

$$=\overline{A}+\left(\overline{\overline{A}}.\overline{\overline{B}}\right)=\overline{A}+(A.B)$$

$$Y'''=\overline{B.\left(\overline{A}+\overline{B}\right)}=\overline{B}+\left(\overline{\overline{A}+\overline{B}}\right)=\overline{B}+\left(\overline{\overline{A}}.\overline{\overline{B}}\right)$$

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

$$Y=\overline{Y''.Y'''}=\overline{\overline{A}+(A.B).\left[\overline{B}+(A.B)\right]}$$

$$=\left[\overline{\overline{A}+A.B}\right]+\left[\overline{\overline{B}+(A.B)}\right]$$

$$=\overline{\overline{A}}.\left(\overline{A.B}\right)+\overline{\overline{B}}.\left(\overline{A.B}\right)$$

$$=A\left(\overline{AB}\right)+B\left(\overline{AB}\right)$$

$$=(A+B)\left(\overline{A.B}\right)=(A+B)\left(\overline{A}+\overline{B}\right)$$

$$=A\overline{A}+A\overline{B}+B\overline{A}+B\overline{B}$$

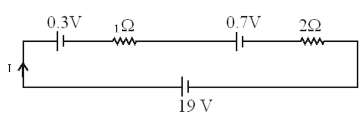
$$=0+A\overline{B}+B\overline{A}+0$$

$$=\overline{A}.B+A.\overline{B}$$

Q.42 **(1)**

We know that, barrier potential of Ge, V_{B1} = 0.3 V and barrier potential of Si, V_{B2} = 0.7 V

Redrawing the above figure as



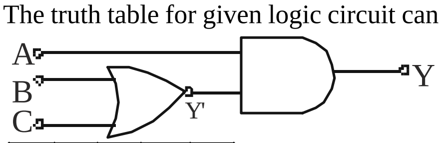
Applying KVL, we get

$-19+0.3+1.I+0.7+2I=0$

$\Rightarrow 3I=18 \Rightarrow I=6A$

Q.43 (4)

The truth table for given logic circuit can be given as



A	B	C	Y'	Y
0	0	0	1	0
0	0	1	0	0
0	1	0	0	0
0	1	1	0	0
1	0	0	1	1
1	0	1	0	0
1	1	0	0	0
1	1	1	0	0

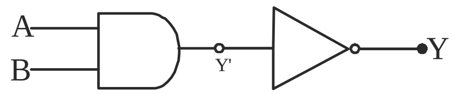
Thus, Y is 'High' when A = 1, B = 0 and C = 0

Q.44 (2)

In a forward bias arrangement of a p-n junction diode, the p-region is connected to the positive terminal and n- region is connected to the negative terminal of the battery. The direction of conventional current is from p-region to n-region of the diode.

Q.45 (4)

The truth table for a NAND gate is shown below



A	B	Y'	Y
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

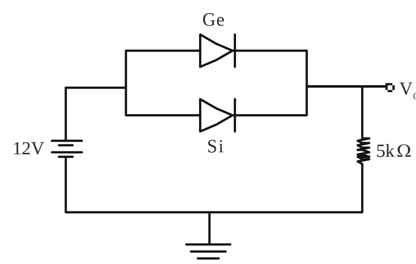
It is correctly shown in S.

Q.46 (4)

For an insulator, E_g > 3eV, i.e. why electron transition from valence band to conduction band is not possible. For semiconductor, E_g is near about 1 eV while for metals E_g = 0 eV.

Q.47 (3)

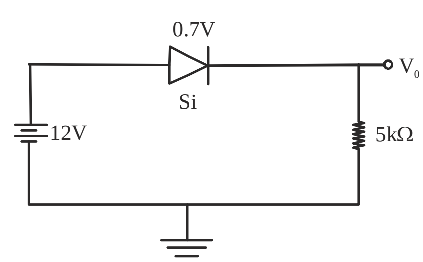
Initially Ge and Si are both forward biased, so current will effectively pass through Ge diode with a voltage drop of 0.3V.



$\therefore$ Initial output voltage, $V_0 = 12 - 0.3 = 11.7$ V

When ends of diode Ge is overturned, i.e it becomes in reverse bias, hence only Si diode will work. In this condition, output voltage,

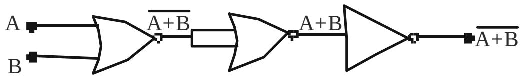
$$V_0 = 12 - 0.7 = 11.3\text{ V}$$



$\therefore$ Change in output voltage = 11.7 – 11.3 = 0.4 V

Q.48 (3)

Truth table for given network is



$\therefore$ Output, $Y = \overline{A+B}$

= Output of NOR gate

Output Y of network matches with that of NOR gate, so the given electrical network is equivalent to NOR gate.

NEET/AIPMT

Q.1 (2)

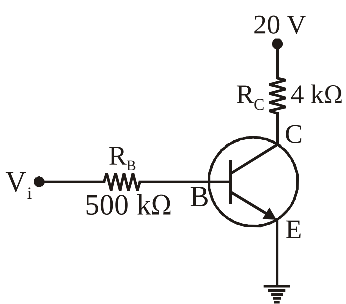
Q.2 (4)

Q.3 (4)

$V_{BE} = 0$

$V_{CE} = 0$

$V_{b=0}$



$$I_c = \frac{(20-0)}{4\times10^3}$$

$$I_c = 5\times10^{-3} = 5mA$$

$$V_i = V_{BE} + I_B R_B$$

$$V_i = 0 + I_B R_B$$

$$20 = I_B \times 500\times10^3$$

$$I_B = \frac{20}{500\times10^3} = 40\mu A$$

$$\beta = \frac{I_c}{I_b} = \frac{25\times10^{-3}}{40\times10^{-6}} = 125$$

Q.4 (4)

Due to heating, number of electron-hole pairs will increase, so overall resistance of diode will change. Due to which forward biasing and reversed biasing both are changed.

Q.5 (2)

Q.6 (3)

Q.7 (4)

Due to heating, number of electron-hole pairs will increase, so overall resistance of diode will change. Due to which forward biasing and reversed biasing both are changed.

Q.8 **(4)**

Q.9 (1)

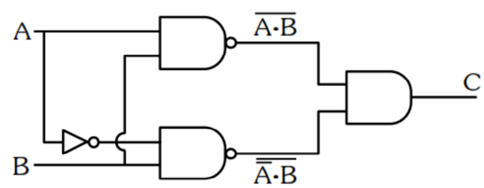
Q.10 (3)

Q.11 (4)

Q.12 (2)

Q.13 (3)

Q.14 (2)



$C = \overline{A\cdot B}.\overline{\bar{A}\cdot B}$

using De-Morgan Theorem

$C = \overline{A\cdot B + \bar{A}\cdot B}$

$C = \overline{B(A+\bar{A})} = \bar{B}$

There fore

A	B	C
0	0	1
0	1	0
1	0	1
1	1	0

Q.15 **(2)**

In half wave rectification

$f_{in} = f_{out}$

Þ $f_{out} = 60$ Hz

JEE MAIN

Q.1 **(4)**

Due to photon incident in depletion layer electron-hole pairs are generated which increases the minority charge carrier and hence reverse bias current increases.

Q.2 (750)

Current gain, $\beta = \frac{\Delta I_C}{\Delta I_B}$

$= \frac{1.5\text{mA}}{10\mu\text{A}} = \frac{1.5\times10^{-3}}{10\times10^{-6}}$

$= 1.5\times10^{-3+5}$

$= 150$

$R_{input} = \frac{V}{I} = \frac{10\text{mV}}{10\mu\text{A}}$

$= \frac{10\times10^{-3}}{10\times10^{-6}} = 10^3\,\Omega$

$\therefore$ Voltage gain

$= \beta\times\frac{R_L}{R_{in}}$

$= 150\times\frac{5\times10^3}{10^3}$

$= 150\times5$

$= 750$

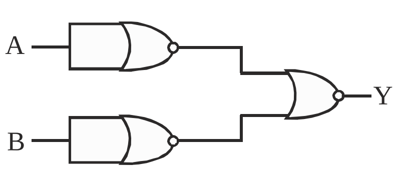
Q.3 **(5mA)**

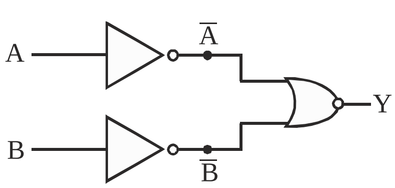
$V = \frac{10\times1}{1.8} = 5.55\,\text{volt} > V_z\,(5\,\text{volt})$

So zener diode is ON & voltage across R_L = 1 kΩ is $V_z = 5$ Volt

$\therefore \frac{V_L}{R_L} = \frac{5\,\text{volt}}{1\text{k}\Omega} = 5\text{mA}$

Q.4 (1)





$Y = \overline{(\overline{A}+\overline{B})} = \overline{\overline{(A.B)}}$

$\boxed{Y = A.B}$

Q.5 (15)

Q.6 (2)

Q.7 (1)

Q.8 **(2)**

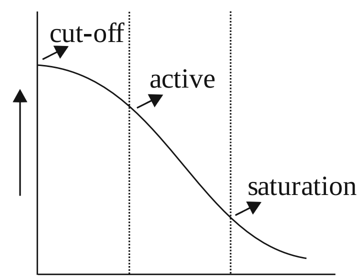
When the amplifier connects with positive feedback, it acts as the oscillator the feedback here is positive feedback which means some amount of voltage is given to the input

Q.9 **(2)**

A	B	Y
1	1	0
0	0	1
0	1	1
1	0	1
1	1	0
0	0	1
0	1	1
1	0	1
NAND Gate		

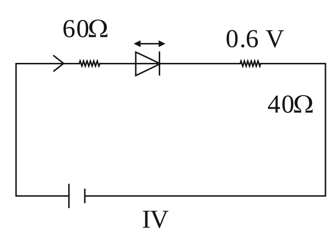
$Y = \overline{A.B}$

Q.10 (4)



When operated in cut-off mode there is no emitter, base or collector current and thus it behaves as open switch. When operated in saturation mode emitter base junction is forward biased and there is current in all parts of the circuit thus it behaves as a closed switch.

Q.11 (4)



$1 - I(60) - 0.6\,I(40) = 0$

$\frac{0.4}{100} = I$

$I = 4\,\text{mA}$

Q.12 (3)

This NAND gate

A	B	Y
0	0	1
1	0	1
0	1	1
1	1	0

Q.13 (2)

Diode is two terminal devices which conduct current is only one direction.

Q.14 (1)

Both A & R true & R is correct Explanation.

Q.15 (4)

In +ve half cycle

$$D_1 \rightarrow F.B.; D_2 \rightarrow R.B.$$

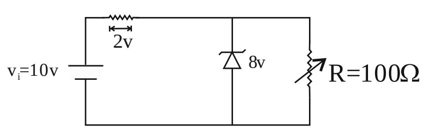
0 - 0.6V

V_{out} same as V_{in}

In -ve half cycle

$$D_2 \rightarrow F.B.; D_1 \rightarrow R.B.$$

Q.16 (2)



I_{ZM}=10 mA

$$I = \frac{2}{100} = 20mA$$

$V_L = I_L R_L$

$$8 = 10 \times 10^{-3} \times R_{L_{max}}$$

$$\frac{4}{5} \times 10^3 = R_{L_{max}}$$

$$800 = R_{L_{max}}$$

$I = I_Z + I_L$

$I_L = 10$ mA

If $I_Z = 0$

$$I_{L_{max}} = 20mA$$

$$V_L = I_{L_{max}} \times R_{L_{min}}$$

$$\frac{8}{20} \times 10^3 = R_{L_{min}}$$

$$400 = R_{L_{min}}$$

$$\frac{R_{L_{max}}}{R_{L_{min}}} = \frac{800}{400} = 2$$

Q.17 (2)

Δi_b = change in base current = 100 μA

Δi_c = change in collector current = 10 mA

R_L = load resistance = 2 kΩ

R_i = 1KΩ

$$\beta = \frac{\Delta i_c}{\Delta i_b} = \frac{10 \times 10^{-3}}{100 \times 10^{-6}} = 100$$

$$R_g = \frac{R_L}{R_i} = \frac{2k}{1k} = 2$$

$P_{gain} = \beta^2 (R_g) = (100)^2 \times 2 = 2 \times 2 \times 10^4$

$P_a = 2 \times 10^4$

$\therefore$ $\boxed{x = 2}$

Q.18 x = 16

Barrier potential

= 0.4 V

Speed of e^-

$= 6 \times 10^5\ ms^{-1}$

$Me = 9 \times 10^{-31}$ and $e = 1.6 \times 10^{-19}$

As the electron passes from n to p region, its kinetic energy will decrease by same amount as the work done by electric field because negative charge experiences force in the direction opposite to electric field.

$Kf = Ki - W_E$

$W_E = qV = 1.6 \times 10^{-19} \times 0.4$

$= 64 \times 10^{-21}$ J

$$KE_i = \frac{1}{2} \times 9 \times 10^{-31} \times 36 \times 10^{10}$$

$= 162 \times 10^{-21}$ J

$KE_f = 162 \times 10^{-21} - 64 \times 10^{-21}$

$= 98 \times 10^{-21}$

$$= \frac{1}{2} mV_f^2 \qquad (V_f \rightarrow \text{final speed})$$

$$\Rightarrow \frac{1}{2} \times 9 \times 10^{-31} V_f^2 = 98 \times 10^{-2}$$

$$\Rightarrow V_f^2 = \frac{196}{9} \times 10^{10}$$

$$\Rightarrow V_f = \frac{16}{3} \times 10^5\ ms^{-1}$$

x = 16

Q.19 (1)

Given circuit is of And gate

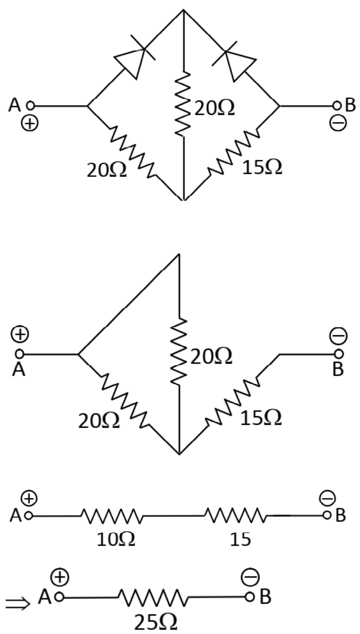
y = A. B

A	B	Y
0	0	0
1	0	0
0	1	0
1	1	1

Q.20 [3]

$$\Delta Eg = \frac{hc}{\lambda} \qquad \Delta E_g = \frac{12400}{4000} \qquad \Delta E_g = 3.1eV$$

Q.21 [25]



Q.22 [9]

At 100 volt

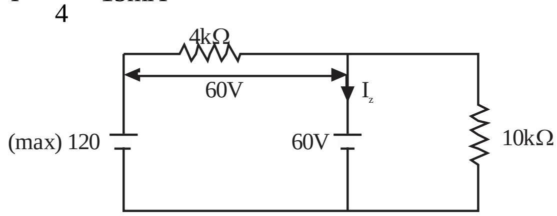
$$V_{across}10\Omega = \frac{100\times10}{10+4} = \frac{1000}{14} = 71.42$$

$71.42 > V_z (60)$

So diode will be ON

If V = 120 then diode also ON

$$I = \frac{60}{4} = 15mA$$



$$I_z = \frac{60}{10k\Omega} = 6mA$$

$$I = \frac{60}{4} = 15mA$$

$$I_{z\,(max)} = I - I_L = 15mA - 6mA = 9mA$$

Q.23 [200]

$$\beta_{AC} = \frac{\Delta_{ic}}{\Delta_{iB}} = 50$$

voltage gain $= 50\times\frac{R_{out}}{R_{in}} = 200$

Q.24 (1)

A	B	Y
0	0	0
1	1	1
0	1	0
1	0	0
0	0	0

And gate

Q.25 (2)

$$\text{Current gain } \beta = \frac{\Delta I_C}{\Delta I_B} = \frac{2mA}{5\mu A} = 400$$

Q.26 conceptual / theory

Q.27 (2)

Current gain $\beta = 100$

$$\text{Voltage gain } = \beta\frac{R_0}{R_i}$$

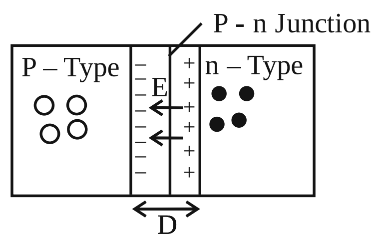
$$= 100\times\frac{10}{1} = 1000$$

$$\text{voltage gain} = \frac{v_0}{v_1} = 1000$$

$v_0 = 1000\times 1\times10^{-3}$

= 1 volt

Q.28 (1)



$$E = \frac{V}{d} = \frac{\text{Potential barrier Across Junction}}{\text{width of Depletion layer}}$$

$$= \frac{0.6V}{6\times10^{-6}m} = 1\times10^5 V/m$$

$= 1\times10^5$ N/C

Q.29 (480)

$\varepsilon - IR - V_z = 0$

$20 - IR - 6 = 0$

$IR = 12$

$25\times10^{-3}R = 12$

$$R = \frac{12}{25\times10^{-3}} = 480\Omega$$

COMMUNICATION SYSTEMS

EXERCISE-I (MHT CET LEVEL)

Q.1 (4)
Q.2 (2)
Q.3 (4)
Q.4 (1)
Q.5 (3)
Q.6 (2)
Q.7 (1)
Q.8 (2)

EXERCISE-II (JEE MAIN LEVEL)

Q.1 (3)	**Q.2** (4)	**Q.3** (1)	**Q.4** (4)	**Q.5** (1)
Q.6 (2)	**Q.7** (4)	**Q.8** (1)	**Q.9** (3)	**Q.10** (1)
Q.11 (3)	**Q.12** (2)	**Q.13** (4)	**Q.14** (3)	**Q.15** (1)
Q.16 (2)	**Q.17** (3)	**Q.18** (1)	**Q.19** (1)	**Q.20** (4)

PREVIOUS YEAR'S

MHT CET

Q.1 (4)	**Q.2** (1)	**Q.3** (3)	**Q.4** (3)	**Q.5** (4)
Q.6 (1)	**Q.7** (2)	**Q.8** (2)	**Q.9** (3)	

JEE-MAIN

Q.1 (c)

Size of antenna $=\frac{\lambda}{4}$

$$=\frac{3\times10^8}{3.5\times10^9\times4}=\frac{3}{140}\text{m}$$

$$=\frac{3}{140}\times1000\,\text{mm}$$

$$=\frac{150}{7}=21.4\,\text{mm}$$

Q.2 (6)

$\lambda=4\times5=20\,\text{mm}=20\times10^{-3}$ ...[$\because$ height of antenna $=\lambda/4$]

$$\upsilon=\frac{c}{\sqrt{\mu_r\varepsilon_r}}$$

$$=\frac{3\times10^8}{\sqrt{1\times6.25}}=\frac{3}{2.5}\times10^8$$

$$v=\frac{6}{5}\times10^8$$

$$f=\frac{v}{\lambda}=\frac{6\times10^8}{5\times20\times10^{-3}}=6\times10^9$$

$f=6\,\text{GHz}$

Q.3 **(2)**

Optical fibre frequency range is 1 THz to 1000 THz.

Q.4 (b)

(B) Guided media channel $\rightarrow$ Optical fiber (IV)
(C) digital signal $\rightarrow$ Rectangular wave (III)
(D) Frequecy modulation $\rightarrow$ Local Broad Cast (II)
(A) Facsimile $\rightarrow$ Static Document Image (I)

Q.5 (C)

Q.6 **(4)**

$y(t)=40\sin(10\times10^6\,\pi t)$
$x(t)=20\sin(1000\,\pi t)$
$\Rightarrow\omega_c=10^7\,\pi$
$\omega_m=10^3\pi$
$A_C=40$
$A_m=20$

Equation of modulated wave $=(A_C+A_m\sin\omega_m t)\sin\omega_c t$

$$=A_C\left(\frac{A_m}{A_c}\ \ w_m t\right)\omega_c t$$

$$=A_C\left(1+m\sin\omega_m t\right)\sin\omega_c t,\quad \mu=\frac{A_m}{A_C}$$

$$=A_C\sin\omega_c t+\frac{\mu A_C}{2}\left[\cos(\omega_c-\omega_m)t-\cos\left(\omega_c+\omega_m\right)t\right]$$

Amplitude of minimum frequency

$$=\frac{\mu A_C}{2}=\frac{A_m}{A_C}\times\frac{A_C}{2}=\frac{A_m}{2}=10$$

Q.7 (192)

$$\text{LOS}=\sqrt{2Rh_T}+\sqrt{2Rh_R}$$

$$=\sqrt{2R}\left(\sqrt{h_T}+\sqrt{h_R}\right)$$

$$=\sqrt{2\times64\times10^5}\,(\sqrt{25}+\sqrt{49})$$

$$=192\sqrt{5}\times10^2\,\text{m}.$$

$K=192$

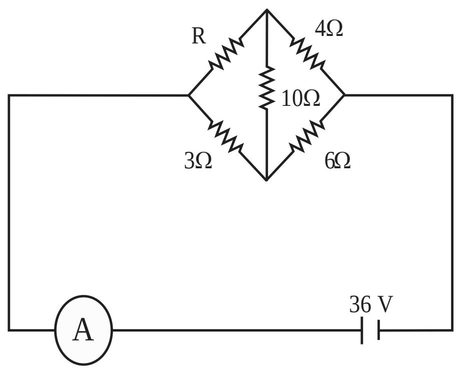
Q. 8 (C)

(a) For low frequency or high wave length size of

antenna required is high.
(b) E P R is low for longer wavelength.
(c) Yes we want to avoid mixing up signals transmitted by different transmitter simultaneously.
(d) Low frequency signals sent to long distance by superimposing with high frequency.

Q.9 (C)
Theory based

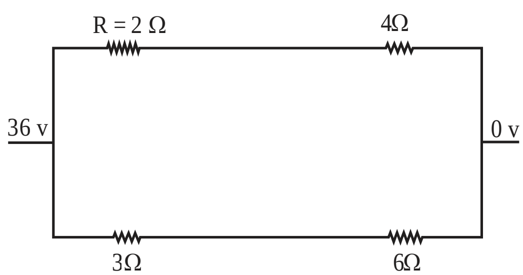
Q.10 (10)



If I = 0 In 10Ω then

$$\frac{R}{3}=\frac{4}{6}$$

R = 2Ω



$$Req=\frac{6\times9}{15}=\frac{54}{15}$$

From Ohm's Law V = IReq

$$I=\frac{V}{R}$$

$$I=\frac{36}{54}\times15=\frac{540}{54}$$

I = 10 A

Q.11 (C)
Bandwidth= $2f_m$
$= 2\times10^4$ Hz $= 20\times10^3$ Hz
=20 kHz

Q.12 (B)
$\lambda = 1000$ nm 2% of source frequency available
$c = 3\times10^8$ m/s Bandwidth of each channel = 8KHz

$$\therefore f=\frac{c}{\lambda}=\frac{3\times10^8}{10\times10^{-7}}$$

$$=\frac{3}{10}\times10^{15}=3\times10^{14}\text{ Hz}$$

$$\therefore 2\%\text{ of } f=\frac{2}{100}\times3\times10^{14}\text{ Hz}$$

$= 6\times10^{12}$ Hz

$$\text{No. of channel}=\frac{\text{Bandwidth}}{\text{frequency of channel}}=\frac{6\times10^{12}}{8\times10^3}=\frac{3}{4}\times10^9$$

$= 0.75\times10^9 = 75\times10^7$

Q.13 (C)
We know that range of an antenna of height as given by $d=\sqrt{2RH}$
Where R is Radius of Earth.
Using this

$$d_1=d=\sqrt{2\times R\times125}$$

$$d_2=2d=\sqrt{2\times R\times H'}$$

where H' is new height of antenna.

$$\Rightarrow\frac{d}{2d}=\frac{\sqrt{2\times R\times125}}{\sqrt{2\times R\times H'}}$$

$$\Rightarrow\frac{1}{2}=\sqrt{\frac{125}{H'}}$$

$\Rightarrow H' = 500$ m
Increase in height
= H' – 125
= 375 m

Q.14 [150]
Coverage radius $d=\sqrt{2Rh}$
Area $A=\pi d^2$
$100\times\pi d^2=6.03\times10^5$
$100\times\pi(2Rh)=6.03\times10^5$

$$h=\frac{6.03\times10^5}{100\times2\times3.14\times6400}$$

h = 0. 15 km
h = 150 m

Q.15 (4)

$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{max}}$$

$$= \frac{6-2}{6+2} = \frac{4}{8} = \frac{1}{2} \times 100\% = 50\%$$

Q.16 (2)

$$\lambda_1 = \frac{C}{f_1} = \frac{3\times10^8}{6\times10^6} = 50\text{cm}$$

$$\lambda_2 = \frac{C}{f_2} = \frac{3\times10^8}{10\times10^6} = 30\text{cm}$$

$\lambda_1 - \lambda_2 = 50 - 30 = 20\ \text{m}$

Q.17 (2)

Modulation index, $\mu = \dfrac{A_{max} - A_{min}}{A_{max} + A_{min}} \times 100$

$$= \frac{60-20}{60+20} \times 100 = \frac{40}{80} \times 100 = 50$$

Q.18 (4)

$h_1 = 100\ \text{m}$

Range become triple than new height is h_2 than

$D = \sqrt{2Rh}$

$\downarrow$

Range

$D \propto \sqrt{h}$

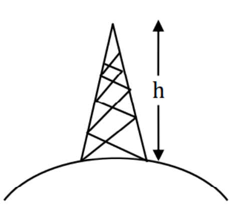
$$\frac{D_2}{D_1} = \sqrt{\frac{h_2}{h_1}}$$

$$\frac{3D_1}{D_1} = \sqrt{\frac{h_2}{h_1}}$$

$$9 = \frac{h_2}{h_1} \Rightarrow \boxed{h_2 = 9h_1}$$

$h_2 = 9 \times 100$

$\boxed{h_2 = 900\ \text{m}}$



Q.19 (1)

$$\mu = \frac{A_m}{A_c} = \frac{1}{5} = 0.2$$

Q.20 (A)

$$\mu = \frac{A_m}{A_C}$$

$\mu \le 1$ to avoid distortion

because $\mu > 1$ will result in interference between career frequency and message frequency.

Q.21 (4)

Given

FM broadcast

Modulating frequency = 20 kHz = f

Deviation ratio = $\dfrac{\text{Frequency deviation}}{\text{modulating Frequency}} = \dfrac{\Delta f}{f}$

$\Rightarrow$ Frequency deviation – $\Delta f = f \times 10$

$\Rightarrow 20\ \text{kHz} \times 10 = 200\ \text{kHz}$

$\Rightarrow$ Bandwidth $= 2(f + \Delta f)$

$= 2\,(20 + 200)\ \text{kHz}$

$= 440\ \text{kHz}$

Q.22 (1)

Modulation index : $m = \dfrac{A_m}{A_C}$

Given $2A_m = 8$

$A_m + A_C = 9 \Rightarrow A_C = 5$

$$\therefore\ m = \frac{4}{5} = 0.8$$

Q.23 (2)

Frequencies present in output of square law device

$2f_c, f_c + f_m, f_c, f_c - f_m, 2f_m, f_m$

After passing through band pass filter.

$f_c + f_m, f_c, f_c - f_m$

Band width = $2f_m$

$$= \frac{2\omega_m}{2\pi} = \frac{6.28\times10^6}{3.14} = 2\text{MHz}$$