Solutions
of
Optics &
Modern Physics

Lesson 26th to 30th

By DC Pandey

26. Reflection of Light

Introductory Exercise 26.1

1. Since $c \quad \frac{1}{\sqrt{\quad_0 \quad_0}}$ where c is the speed of light in vacuum hence unit of $\frac{1}{\sqrt{\quad_0 \quad_0}}$ is m/s.

2. Hence

$B_y \quad 2 \quad 10^{\quad 7}$ T sin [$500x \quad 1.5 \quad 10^{11}t$]

Comparing this equation with the standard wave eqution $B_y \quad B_0$ sin [$kx \qquad t$]

$$k \quad 500\,\text{m}^{\quad 1} \quad k \quad \frac{2}{\quad}$$

$$\frac{2}{k}\,\text{m}$$

$$\frac{2}{500}\,\text{m} \quad \frac{\quad}{250}\,\text{metre}$$

$$1.5 \quad 10^{11}\ \text{rad/s}$$

$$2 \quad n \quad 1.5 \quad 10^{11}$$

$$n \quad \frac{1.5}{2} \quad 10^{11}\ \text{Hz}$$

Speed of the wave $v \quad \frac{\quad}{k} \quad \frac{1.5 \quad 10^{11}}{500}$

$$3 \quad 10^8\ \text{m/s}$$

Let E_0 be the amplitude of electric field.

Then $E_0 \quad cB_0 \quad 3 \quad 10^8 \quad 2 \quad 10^{\quad 7}$

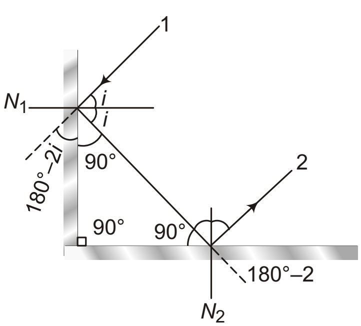
$$60\ \text{V/m}$$

Since wave is propagating along x-axis and B along y-axis, hence E must be along z-axis

$$E \quad 60\ \text{V/m}\ \sin\,[500x \quad 1.5 \quad 10^{11}t]$$

Introductory Exercise 26.2

1. Total deviation produced



$$180 \quad 2i \quad 180 \quad 2$$

$$360 \quad 2(i \qquad)$$

From figure

$$90 \quad i$$

$$360 \quad 2\,[i \quad 90 \quad i]$$

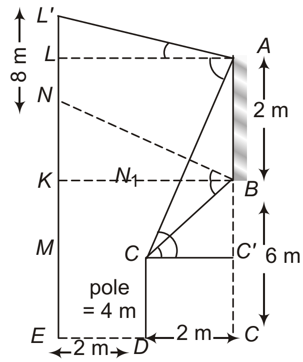
$$180$$

Hence rays 1 and 2 are parallel (anti-parallel).

2. $v_0 \quad 2$ m/s for plane mirror $v_i \quad 2$ m/s.

Velocity of approach $\quad v_0 \quad v_i \quad 4$ m/s.

3. In figure, AB is mirror, G is ground, CD is pole and M is the man. The minimum height to see the image of top of pole is $\quad EN$



$EK \quad KN \quad 6 \quad KN$

Now in NKB,

$$\frac{NK}{KB} \quad \tan \qquad NK \quad KB \tan$$

$$4 \tan$$

In $BC\ C$ we get,

$$\tan \quad \frac{BC}{CC} \quad \frac{2}{2} \quad 1$$

$$45$$

So, $NK \quad 4 \quad \tan 45 \quad 4$ m

Hence in minimum height

6 m 4 m 10 m

In $AC\ C$

$$\tan \quad \frac{4}{2} \quad 2$$

In $L\ LA$ we get,

$$\frac{LL}{LA} \quad \tan$$

$$\frac{LL}{4} \quad 2$$

$$LL \quad 8 \text{ m}$$

Maximum height $CA \quad LL \quad 8 \quad 8 \quad 16$ m

Introductory Exercise 26.3

1. Here f 10 cm (concave mirror)

(a) u 25 cm

Using mirror formula,

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$$

$$\frac{1}{v} \quad \frac{1}{f} \quad \frac{1}{u} \qquad \frac{1}{10} \quad \frac{1}{25}$$

$$\frac{1}{v} \quad \frac{5 \quad 2}{50}$$

$$v \quad \frac{50}{3} \qquad 16.7 \text{ cm}$$

Hence image is real, inverted and less height of the object.

(b) Since u 10 cm,

Hence object is situated on focus of the image formed at .

(c) $u \quad 5, f \quad 10$

$$\frac{1}{v} \quad \frac{1}{f} \quad \frac{1}{u} \qquad \frac{1}{10} \quad \frac{1}{5}$$

$$\frac{1}{v} \quad \frac{1 \quad 2}{10}$$

$$v \quad 10 \text{ cm}$$

Hence, image is virtual, erect and two time of the object.

2. Here $u \quad 3$ m, $f \quad \frac{1}{2}$ m,

we have,

(a) $\frac{1}{v} \quad \frac{1}{f} \quad \frac{1}{u}$

$$\frac{1}{v} \quad 2 \quad \frac{1}{3}$$

$$v \quad 0.6 \text{ m}$$

As ball moves towards focus the image moves towards   and image is real as the distance decreases by focal length image become virtual which moves from   to zero.

(b) The image of the ball coincide with ball, when $u \quad R \quad 1$ m

Using $h \quad ut \quad \frac{1}{2}gt^2$

$$t \quad \sqrt{\frac{2h}{g}} \quad \sqrt{\frac{2 \quad 2}{9.8}}$$

$$0.639 \text{ s}$$

Similarly again images match at $t \quad 0.78$ s.

3. Since image is magnified, hence the mirror is concave.

Here, $$m \quad \frac{v}{u} \quad \frac{v}{u} \quad 5$$

$$v \quad 5u \qquad \text{...(i)}$$

Let distance between mirror and object is x.

Since image is formed at a distance 5 m from mirror

$$v \quad (5 \quad x) \qquad \text{...(ii)}$$

From Eqs.(i) and (ii), we get

$$(5 \quad x) \quad 5x$$

$$4x \quad 5$$

$$x \quad 1.25$$

Hence mirror is placed at 1.25 m on right side of the object by mirror formula

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f},$$

we have

$$\frac{1}{f} \quad \frac{1}{6.25} \quad \frac{1}{1.25}$$

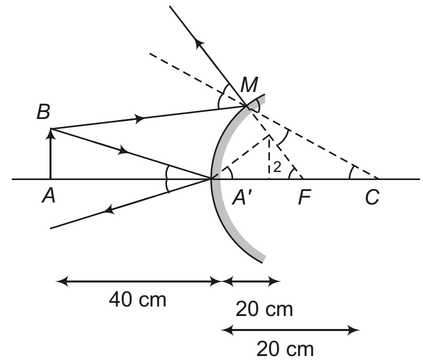
$$f \quad \frac{6.25}{6},$$

Hence $R \quad 2f \quad R \quad \frac{6.25}{3} \quad 2.08$ m

Thus mirror is concave mirror of radius of curvature 2.08 m.

4. Since the incident rays and reflected rays are parallel to each other therefore mirror is plane mirror.

5. Let us solve the first case :



By applying the geometry we can prove that,

$$PA \quad v \quad \frac{40}{3} \text{ cm}$$

Further, in triangles ABP and $PA \; B$ we have,

$$\frac{AB}{40} \quad \frac{A \; B}{(40/3)}$$

$$A \; B \quad \frac{AB}{3} \quad \frac{2}{3} \text{ cm}$$

Similary, we can solve other parts also.

6. Simply apply :

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$$

and $m \quad \frac{I}{o} \quad \frac{v}{u}$ for lateral magnification. If magnitfication is positive, image will be virtual. If magnification is negative, image will be real.

AIEEE Corner

■ Subjective Questions (Level 1)

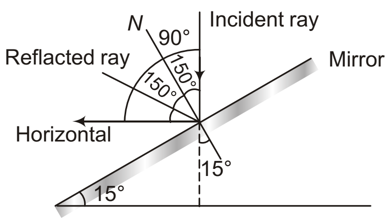
1. Here v 39.2 cm, hence v 39.2 cm

and magnification m 1

$$h_i \quad h_o \quad 4.85$$

Hence image is formed at 39.2 cm behind the mirror and height of image is 4.85 cm.

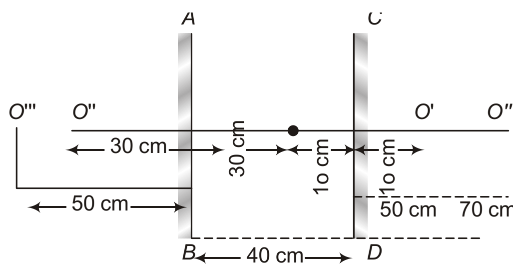
2. From figure, angle of incident 15



Let reflected ray makes an angle with the horizontal, then

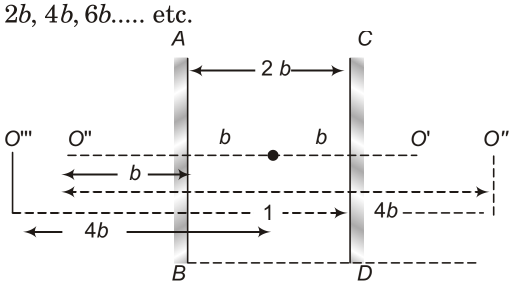
$$15 \quad 15 \quad 90 \qquad 60$$

3.



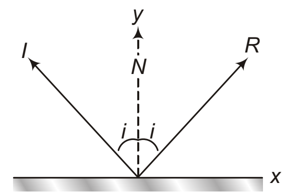
Since mirror are parallel to each other image are formed the distance of five closet to object are 20 cm, 60 cm, 80 cm, 100 cm and 140 cm.

4. The distance of the object from images are $2b$, $4b$, $6b$..... etc.

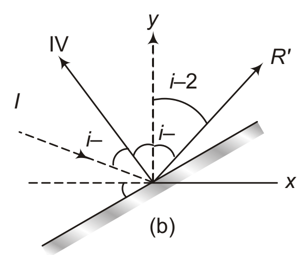


Hence the images distance are $2nb$, where n 1, 2, ... Ans.

5. Suppose mirror is rotated at angle about its axis perpendicular to both the incident ray and normal as shown in figure



(a)



(b)

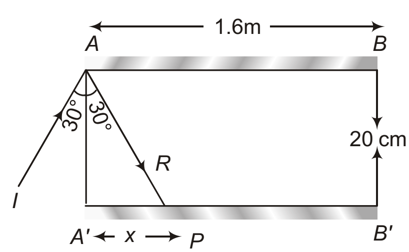
In figure (b) I remain unchanged N and R shift to N and R.

From figure (a) angle of rotation i,

From figure (b) it is i 2

Thus, reflected ray has been rotated by angle 2 .

6. I is incident ray i 30 r



From $PA\ A$, we get

$\frac{x}{20}$ tan 30 x 20 tan 30

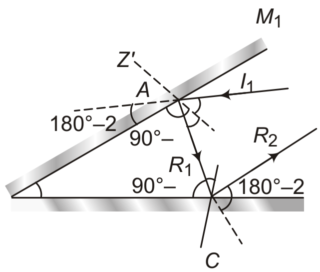
No. of reflection $\frac{AB}{x}$ $\frac{160\text{ cm}}{20\text{ cm} \quad \tan 30}$

$8\sqrt{3}$ 14

Hence the reflected ray reach other end after 14 reflections.

7. The deviation produced by mirror M_1 is

180 2



and the deviation produced by mirror M_2 is

180 2

Hence total deviation

180 2   180 2

360 2(   )

In ABC we get,

90   90   180

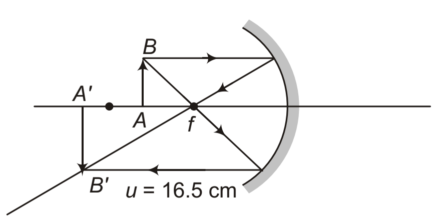
Hence deviation produces 180 2 .

8. Here f $\frac{R}{2}$ $\frac{22}{2}$ 11 cm

Object height h_0 6 mm

u 16.5 cm

(a) The ray diagram is shown in figure



Using mirror formula, $\frac{1}{v}$ $\frac{1}{u}$ $\frac{1}{f}$

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

$\frac{1}{v}$ $\frac{1}{11}$ $\frac{1}{16.5}$ $\frac{165 \quad 11}{16.5 \quad 11}$

v $\frac{16.5 \quad 11}{5.5}$ 33 cm

Hence the image is formed at 33 cm from the pole (vertex) of mirror on the object side the image is real, inverted and magnified. The absolute magnification

$|m|$ $\frac{v}{u}$ $\frac{33}{16.5}$ 2

Hence size of image is h_i 2 h_0

2 6 12 mm.

9. Here u 12 cm, f $\frac{R}{2}$ 10 cm

Using mirror formula

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

we get

$\frac{1}{v}$ $\frac{1}{f}$ $\frac{1}{u}$ $\frac{1}{10}$ $\frac{1}{12}$

$\frac{6 \quad 5}{60}$

v $\frac{60}{11}$ cm 5.46 cm

The image is formed on right side of the vertex at a distance $\frac{60}{11}$ cm. the image is virtual and erect the absolute magnification is given by $|m|$ $\frac{v}{u}$

$|m|$ $\frac{60}{11 \quad (\quad 12)}$ $\frac{5}{11}$

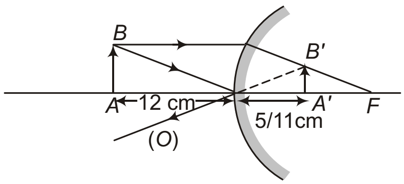
∵ m 1

Hence image is de-magnified.

Height of image h_i $|m|$ h_0

$$h_i \quad \frac{5}{11} \quad 9 \quad \frac{45}{11} \quad 4.09 \text{ mm}$$

The ray diagram is shown in figure



10. Here $f \quad 18$ cm

Let distance of object from vertex of concave mirror is u. Since image is real hence image and object lie left side of the vertex.

Magnification $m \quad \frac{v}{u} \quad \frac{1}{9}$

$$v \quad \frac{u}{9}$$

By mirror formula, $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$, we have

$$\frac{1}{u/9} \quad \frac{1}{u} \quad \frac{1}{18} \qquad \frac{10}{u} \quad \frac{1}{18}$$

$u \quad 180$ cm (left side of the vertex).

11. Here $u \quad 30$ cm, since image is inverted.

Hence the mirror is concave.

$$m \quad \frac{1}{2} \quad \frac{v}{u} \qquad v \quad \frac{u}{2}$$

Using mirror formula, $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$, we get

$$\frac{2}{u} \quad \frac{1}{u} \quad \frac{1}{f} \qquad \frac{3}{u} \quad \frac{1}{f}$$

$$f \quad \frac{u}{3} \quad \frac{30}{3} \qquad 10 \text{ cm}$$

Hence mirror is concave of focal length 10 cm.

12. Here $f \quad \frac{24}{2}$ cm $\quad 12$ cm

(a) Since image is virtual

$$m \quad \frac{v}{u} \qquad v \quad mu$$

$$v \quad 3 \quad u$$

$v \quad 3u$ and v is +ve

By mirror formula,

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f} \qquad \frac{1}{3u} \quad \frac{1}{u} \quad \frac{1}{12}$$

$$\frac{1 \quad 3}{3u} \qquad \frac{1}{12} \qquad u \quad 8 \text{ cm}$$

(b) Since image is real

$$m \quad \frac{v}{u} \quad 3 \quad v \qquad 3u$$

By using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$, we get

$$\frac{1}{e} \quad \frac{1}{u} \qquad \frac{1}{12} \qquad \frac{4}{3u} \qquad \frac{1}{12}$$

$$u \quad 16 \text{ cm}$$

(c) Here $m \quad \frac{v}{m} \quad \frac{1}{3} \quad v \quad \frac{u}{3}$

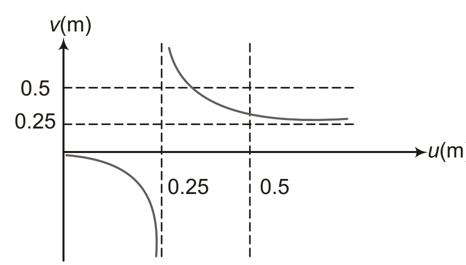
$$\frac{1}{u/3} \quad \frac{1}{u} \qquad \frac{1}{12}$$

$$\frac{4}{u} \qquad \frac{1}{12} \qquad u \quad 48 \text{ cm}$$

13. We have $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$

$$v \quad \frac{uf}{u \quad f} \quad \text{at } u \quad f, v$$

The variation is shown in figure



Hence focal length if assymtote of the curve.

When $u \quad f$, Image is virtual. It means v is negative.

When $\quad u \quad 2f$

$v \quad 2f$

$u \quad 0, v \quad 0$

14. Here $f \quad 21$ cm $\quad R \quad 2f \quad 42$ cm

Since the object is placed on C. Hence its image by concave mirror is formed on C. This image acts as a virtual objet for plane mirror the distance between plane mirror and virtual object 21 cm.

Hence plane mirror forms its real image in front of plane mirror at 12 cm.

15. Let u is the object distance from vertex, v is the image distance for vertex and f is the focal length then distance between object and focus is $u \quad f$ and distance between image and focus is $v \quad f$ *ie*,

$$(u \quad f)(v \quad f) \quad uv \quad (u \quad v)f \quad f^2 \qquad \ldots\text{(i)}$$

Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$, we get

$$uv \quad (u \quad v)f \qquad \ldots\text{(ii)}$$

Putting the value of uv in RHS of Eq. (i), we get

$$(u \quad f)(u \quad f) \quad (v \quad u)f \quad (v \quad u)f \quad f^2$$

$$(u \quad f)(v \quad f) \quad f^2$$

Hence proved.

16. Let object is placed at a distance x from the convex mirror then for convex mirror

$$u \quad x \text{ and } f \quad \frac{R}{2}$$

Let v be the distance of the image from pole (vertex) of convex mirror.

Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$, we get

$$\frac{1}{v} \quad \frac{1}{x} \quad \frac{2}{12} \qquad v \quad \frac{xR}{2x \quad R}$$

For concave mirror

$$u \qquad 2R \quad \frac{xR}{2x \quad R} \qquad \frac{2R^2 \quad 5xR}{2x \quad R}$$

$$v \qquad (2R \quad x) \text{ and } f \qquad \frac{R}{2}$$

Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$, we get

$$\frac{1}{(2R \quad x)} \quad \frac{(2x \quad R)}{(2R^2 \quad 5xR)} \quad \frac{2}{R}$$

$$4R^3 \quad 2x^2R \quad 8xR^2$$

$$8R^3 \quad 16xR^2 \quad 10x^2R$$

$$4R^3 \quad 8xR^2 \quad 8x^2R \quad 0$$

$$4R[R^2 \quad 2xR \quad 2x^2] \quad 0$$

$$2x^2 \quad 2xR \quad R^2 \quad 0$$

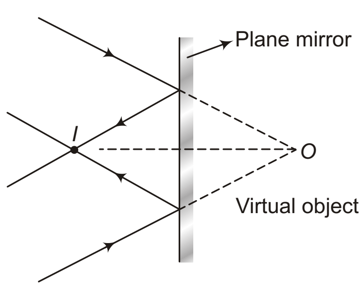
$$\because \qquad R \quad 0$$

$$x \quad \frac{2R \quad 2\sqrt{3}R}{4} \quad \frac{[1 \quad \sqrt{3}]}{2}R$$

$$x \quad \frac{1 \quad \sqrt{3}}{2} \quad R$$

Objective Questions (Level 1)

1. When convergent beam incident on a plane mirror, then mirror forms real image



2. When an object lies at the focus of a concave mirror $u \quad f$ focal length of a concave mirror is negative.

Using mirror formula

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$$

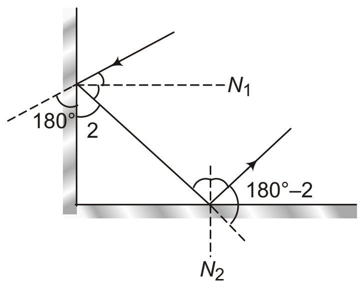
we get,

$$\frac{1}{v} \quad \frac{1}{f} \quad \frac{1}{f} \quad v$$

also magnification $m \quad \frac{v}{u} \quad .$

Hence, correct option is (c) , .

3. Total deviation, $\quad _1 \quad _2$



$180 \quad 2 \qquad 180 \quad 2$

but $\qquad 90$

$180 \quad 2 \qquad 180 \quad 2(90 \qquad)$

180

Hence, option (a) is correct.

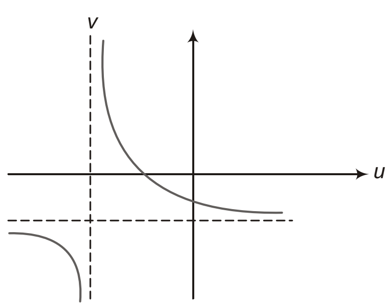
4. A concave mirror cannot from a virtual image of a virtual object.

Hence option (a) is correct.

5. For *a* concave mirror for normal sign convention if $u \quad f \quad v$

and $\qquad$ at $u \qquad , v \qquad f$

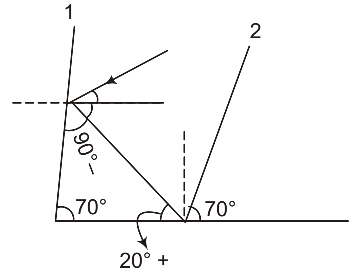
graph between u and v is



The dotted lines are the asymptotes (tangent at) of the curve.

Hence correct option is (b).

6. From figure



$20 \qquad 70$

$70 \quad 20$

50

Here (1) and (2) are paralledl 11 to each other.

Hence the correct option is (a) $\quad 50$.

7. The radius of curvature of convex mirror

$R \qquad 60 \text{ cm}.$

Its focal length $f \quad \frac{R}{2} \qquad 30 \text{ cm}$

Magnification $m \quad \frac{v}{u} \quad \frac{1}{2}$

$v \quad \frac{u}{2}$

Using mirror formula, $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f},$

we get, $\quad \frac{1}{u/2} \quad \frac{1}{u} \quad \frac{1}{30}$

$\frac{3}{u} \quad \frac{1}{30}$

$u \qquad 90 \text{ cm}$

$v \quad \frac{u}{2} \qquad 45 \text{ cm}$

Hence distance between A and B is

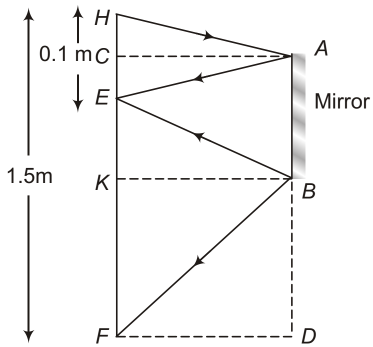
$90 \quad 45$

45 cm

Hence the correct option is (c).

8. Here it is given that height of the boy

$$HF \quad 1.5\,\text{m}$$



Length of mirror $\quad AB \quad 0.75\,\text{m}$

The ray diagram is shown in above figure.

H is the Head of the boy and F is the feet. It also shows the paths of the rays that leaves the head of the man enter his eyes (E). After reflection from the mirror at point A, and the rays that leave his feet and enter his eyes after reflected at point B.

From figure $CE \quad \frac{1}{2}HE \quad 0.05\,\text{m}$

$$CF \quad HF \quad HC \quad HF \quad CE$$
$$1.50 \quad 0.05 \quad 1.45\,\text{m}$$

The distance of the bottom edge of mirror above the floor is

$$BP \quad KF \quad CF \quad KC \quad CD \quad AB$$
$$1.45 \quad 0.75 \quad 0.7\,\text{m}$$

But according to question $BD \quad 0.8$ m (given) which is greater than 0.7 m, the height required to see full image. Hence the boy cannot see his feet.

Option (c) is correct

9. Since the image is magnified hence mirror is concave mirror.

Here $\quad m \quad \frac{v}{u} \quad 3 \quad v \quad 3u$

$$|v| \quad |\ 3u| \quad 3u$$

but $\quad |v \quad u| \quad 80$

$$|3u \quad u| \quad 80 \qquad u \quad 40\,\text{cm}'$$

Using mirror formula, we get

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$$

$$\frac{1}{3u} \quad \frac{1}{u} \quad \frac{1}{f}$$

$$f \quad \frac{3u}{4}$$

$$f \quad \frac{3 \quad 40}{2} \qquad 30\ \text{cm}$$

Mirror is concave and focal length is 30 cm.

Correct option is (a).

10. Here $m \quad \frac{1}{n} \quad \frac{v}{u}$

$$v \quad \frac{u}{n}$$

From mirror formula $\frac{1}{f} \quad \frac{1}{v} \quad \frac{1}{u}$,

we get,

$$\frac{1}{f} \quad \frac{1}{(\ \ u/n)} \quad \frac{1}{u}$$

$$u \qquad (n \quad 1)f$$

Hence the correct option is (d).

11. Differentiating mirror formula, we get

$$\frac{dv}{dt} \quad \frac{v^2}{u^2}\frac{du}{dt} \qquad \left[\because \text{here } \frac{du}{dt} \text{ is} -\text{ve}\right]$$

Using mirror formula

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f},$$

we get $\quad \frac{1}{v} \quad \frac{1}{f} \quad \frac{1}{u}$

Here $\quad u \quad 60\,\text{cm}, \ f \quad 24\,\text{cm}$

Putting these we get, $\ v \quad 40\,\text{cm}$

Hence, $\quad \frac{dv}{dt} \quad \frac{40^2}{60^2} \quad 9 \quad 4\,\text{cm/s}$

Hence the speed of the image is 4 cm/s away from the mirror.

Hence correct option is (c).

12. The wrong statement is (d)

13. Let v_m is the speed of mirror, v_p is the speed of particle and v_p is the speed of the observer, then speed of the image measured by observer is given by

$$v_{op} \quad 2[v_m \quad v_p] \quad v_o$$

$$v_{op} \quad 2[10 \quad 4] \quad 2$$

$$28 \quad 2 \quad 26 \text{ cm/s}$$

Hence correct option is (d).

■ Assertion and Reason

1. Assertion is wrong since when a virtual object is placed at a distance less than the focal length its real image is formed.

Hence answer is (d).

2. Using mirror formula $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$ we get

$$\frac{1}{v} \quad \frac{1}{20} \quad \frac{1}{20} \qquad v \quad 10 \text{ cm}$$

ie image is virtual exect and since $m \quad \frac{v}{u} \quad \frac{1}{2}$.

Hence image is diminished, thus assertion is true.

If u 20 cm for virtual object v hence reason is true but reason is not correct explanation of assertion. Hence answer is (b).

3. Using mirror formula $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$ we get

$$\frac{1}{v} \quad \frac{1}{f} \quad \frac{1}{u}$$

If u is front of mirror u is negative and f is negative for concave mirror.

$$\frac{1}{v} \quad \frac{1}{f} \quad \frac{1}{u} \qquad v \quad \frac{uf}{f \quad u}$$

$$u \quad f \quad v$$

Hence assertion is true also in refractive image and object moves in opposite direction. Hence both assertion and reason are true and reason correctly explain the assertion Correct answer is (a).

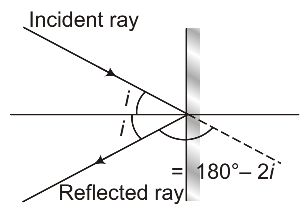
4. Real view mirror of vehicles is convex mirror, hence assertion is true.

It never makes real image of real object reason is also true but convex mirror is used because since its field of view is greatest. Hence both assertion and reason are true but reason is not correct explanation of assertion. Correct answer is (b).

5. Since m 2 hence it is definitely a concave mirror since only concave mirror form magnified image. Since concave mirror form only real image of real object hence reason is also true. Hence it may true but when object is placed between C and F, m 1.

Hence correct answer be (a) or (b).

6.

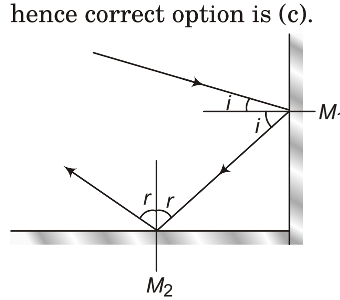


Hence assertion is true.

For normal incidence i 0 hence 180 .

hence assertion is true but reason is false. hence correct option is (c).

7.



Deviation produced by M_1 180 $2i$
Deviation produced by M_2 180 $2r$

Total deviation produced 360 $2(i \quad r)$

But from figure $i \quad r$ 90 , hence deviation 180 for any value of i.

Hence assertion is true but reason is false. Correct option is (c).

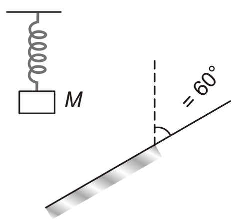
8. The correct option is (b).

9. The correct option is (a, b).

10. The correct option is (b).

■ Objective Questions (Level 2)

1. $v_{max} \quad A$



$$v_{max} \quad \sqrt{\frac{k}{m}} A$$

$\because \quad {}^2 \quad \frac{k}{m}$ for SHM

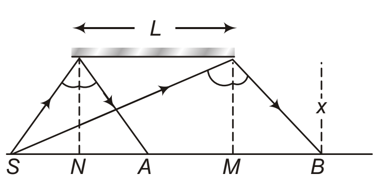
Maximum speed of insect relative to its image

$$2v_{max} \quad 2v_{max} \sin 60$$
$$A\sqrt{3}\sqrt{\frac{k}{m}}$$

Hence correct option is (c).

2. $au^n \quad g$

Height x



Let after time t paperndicular distance between mirror and source is x we have from figure

$$AB \quad AM \quad MB \quad SM \quad SA \quad MB$$

but $SM \quad MB$

$$AB \quad 2MB \quad SA \quad 2x \tan \quad SA$$
$$2x \tan \quad 2x \tan$$
$$AB \quad 2x [\tan \quad \tan \;]$$
$$2x \quad \frac{SM}{x} \quad \frac{SN}{x} \quad 2[SM \quad SN]$$
$$AB \quad 2 \quad L,$$

where $SM \quad SN \quad L$ Length of mirror

$$\frac{d}{dt}[AB] \quad \frac{d}{dt}(2L) \quad 0$$

$\because$ Length of mirror is constant.

Hence the correct option is (d).

3. Here u 10 cm and v 20 cm

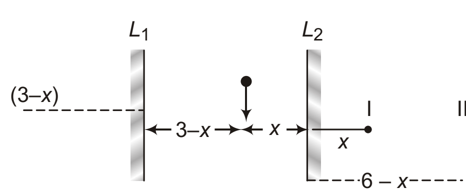
Using mirror formula

$$\frac{1}{u} \quad \frac{1}{v} \quad \frac{1}{f} \text{ we get } \frac{dv}{v^2} \quad \frac{du}{u^2} \quad 0$$
$$\frac{dv}{du} \quad \frac{v^2}{u^2} \quad \frac{20^2}{10^2} \quad 4$$
$$dv \quad 4du$$
$$dv \quad 4 \quad (\quad 0.1), \text{ here } du \quad 0.1$$
$$dv \quad 0.4 \text{ cm},$$

ie, 0.4 cm away from the mirror.

Hence the correct option is (a).

4. The first and second images are shown in figure but according to question

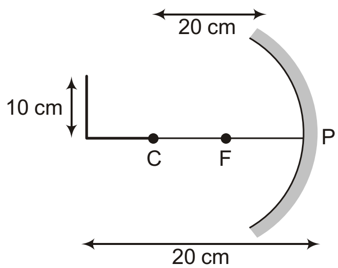


$(6 \quad x) \quad x \quad 4$

$2 \quad 2x \qquad x \quad 1\,\text{m}$

Hence the correct option is (c).

5. For vertical part $\dfrac{1}{20} \quad \dfrac{1}{v} \qquad \dfrac{1}{5}$



$v \qquad \dfrac{20}{3}$

$|m_v| \quad \dfrac{v}{u} \qquad \dfrac{20/3}{20} \quad \dfrac{1}{3}$

$L_v \quad \dfrac{10}{3}\,\text{cm}$

For horizontal part first end is at C hence its image is also at C *ie* at $v \qquad 10\,\text{cm}$, for other end

$$\frac{1}{20} \quad \frac{1}{v} \quad \frac{1}{5} \quad v \qquad \frac{20}{3}$$

$|v| \quad \dfrac{20}{3}$

$L_H \quad |v \quad u| \quad \dfrac{20}{3} \quad 10 \quad \dfrac{10}{3}$

$L_H \quad \dfrac{10}{3}$

The ratio $L_V : L_H \quad 1:1.$

Hence correct option is (c) 1 : 1.

6. Here $u \qquad 15\,\text{cm}, f \qquad 10\,\text{cm}$

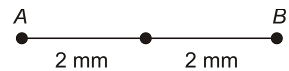
Using $\qquad \dfrac{1}{v} \quad \dfrac{1}{u} \quad \dfrac{1}{f}$

We get, $\quad v \qquad 30\,\text{cm}$

We have $\quad m \quad \dfrac{v}{m} \quad \dfrac{(v_2 \quad v_1)}{u_2 \quad u_1}$

$\dfrac{dv}{du} \quad 2$

$dv \quad 2\,du,$



$AB \quad du \quad 4\,\text{mm}$

$dv \quad 2 \quad 4\,\text{mm} \qquad dv \quad 8\,\text{mm}$

Hence the correct option is (c).

7. If the mirror is rotated by an angle in anticlock, wise direction about an axis to the plane mirror, the new angle of incidence becomes i and angle of reflection also $i \quad 2$.

According to problem

$i \quad i \quad 2 \qquad 45$

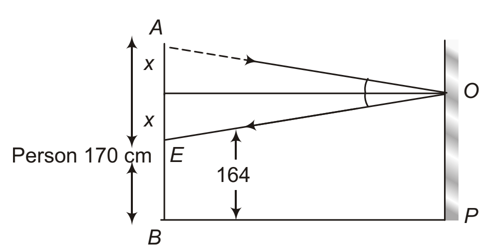
$2i \quad 45 \qquad 2 \qquad 45 \qquad 2 \quad 20 \qquad 85$

But angle of incidence angle of reflection.

Hence the angle between origial incident and reflected ray was 85 . Similarly is the mirror is rotated clockwise the angle became 5 .

Hence correct option is (c) 85 or 5 .

8. The person see his hair if the incident ray statics from point A after reflected by mirror reach his eyes. Let O is point at minimum at a distance x below the point A.



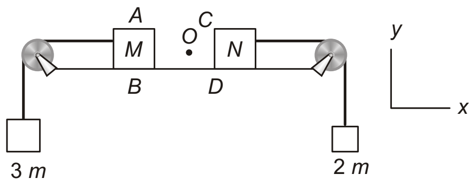
We have $2x \quad 60\,\text{cm} \qquad x \quad 3\,\text{cm}$

The distance of O from P is

$170 \quad 3 \quad 167\,\text{cm}$

Hence correct option is (a).

9. Acceleration of block



$$a_{AB} \quad \frac{3mg}{3m \quad m} \quad \frac{3g}{4}$$

Acceleration of block CD:

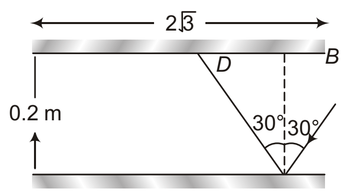
$$a_{CD} \quad \frac{2mg}{2m \quad m} \quad \frac{2g}{3}$$

Since the accelerations are in opposite directions relative acceleration of one image with respect to other is given by

$$a_{AB} \quad a_{CD} \quad \frac{3g}{4} \quad \frac{2g}{13} \quad \frac{17g}{12}$$

Hence the correct option is (c).

10. Here $\frac{BD}{0.2} \quad \tan 30$

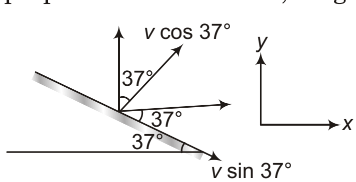


$$BD \quad 0.2 \quad \frac{1}{\sqrt{3}}$$

No. of reflections $\frac{2\sqrt{3}}{0.2/\sqrt{3}} \quad 30$

Hence, the correct option is (b).

11. Resolving velocity along parallel to mirror and perpendicular to mirror, we get



$v_{||} \quad v \sin 37$ and $v \quad v \cos 37$

From figure, we get

$$v_x \quad v\cos 37 \;\; \sin 37 \quad v \sin 37 \;\; \cos 37$$

$$2v \cos 37 \;\; \sin 37$$

$$v_x \quad 2 \quad 5 \quad \frac{4}{5} \quad \frac{3}{5} \quad \frac{24}{5} \quad 4.8$$

$$v_y \quad v\cos 37 \quad \cos 37$$

$$v \sin 37 \quad \sin 37$$

$$v_y \quad v\,[\cos^2 37 \quad \sin^2 37\;]$$

$$5 \quad \frac{4}{5} \quad \frac{3}{5} \quad \frac{4}{5} \quad \frac{3}{5}$$

$$5 \quad \frac{7}{5} \quad \frac{1}{5} \quad \frac{7}{5} \quad 1.4$$

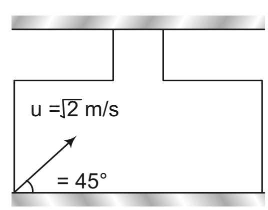
Hence velocity of image is given by

$$\mathbf{v} \quad v_x\,\hat{\mathbf{i}} \quad v_y\,\hat{\mathbf{j}}$$

$$\mathbf{v} \quad 4.8\,\hat{\mathbf{i}} \quad 1.4\,\hat{\mathbf{j}}$$

Hence the correct option is (c).

12. Since elevator start falling freely, the relative acceleration of the particle in elevator frame $\quad g \quad g \quad 0$



Hence, in elevator frame path of the particle is a straight line.

The vertical component of velocity is

$$u \sin 45 \quad \sqrt{2} \quad \frac{1}{\sqrt{2}} \quad 1\text{ m/s}$$

The separation between mirror and particle in 0.5 s is

$$y \quad v_y t \quad 1 \quad 0.5 \quad 0.5\text{ m}$$

The separation between image of particle and particle at this moment

$$2y \quad 2 \quad 0.5\,\text{m} \quad 1\,\text{m}$$

Hence the correct option is (b).

13. Here velocity of mirror

$$\mathbf{v}_m \quad 4\,\hat{\mathbf{i}} \quad 4\,\hat{\mathbf{j}} \quad 8\,\hat{\mathbf{k}}$$

and velocity of object

$$\mathbf{v}_o \quad 3\,\hat{\mathbf{i}} \quad 4\,\hat{\mathbf{j}} \quad 5\,\hat{\mathbf{k}}$$

Since $\hat{\mathbf{k}}$ is normal to the mirror hence $\hat{\mathbf{i}}$ and $\hat{\mathbf{j}}$ components of image velocity remain unchanged *ie*, velocity of image can be written as

$$\mathbf{v}_i \quad 3\,\hat{\mathbf{i}} \quad 4\,\hat{\mathbf{j}} \quad v_{iz}\,\hat{\mathbf{k}}$$

but $\quad v_{iz} \quad 2u_{mz} \quad v_{oz} \quad 2 \quad 8 \quad 5 \quad 11$

Hence, we get

$$\mathbf{v}_i \quad 3\,\hat{\mathbf{i}} \quad 4\,\hat{\mathbf{j}} \quad 11\,\hat{\mathbf{k}} \text{ (\textit{wrt} ground)}$$

Hence, the correct option is (b).

$$3\hat{\mathbf{i}} \quad 4\hat{\mathbf{j}} \quad 11\hat{\mathbf{k}}$$

14. Only option (b) satisfy the given condition.

Here $X_0 \quad 2, X_i \quad 10$

Using $\dfrac{1}{X_0} \quad \dfrac{1}{X_i} \quad \dfrac{1}{f}$

we get

$$\frac{1}{10} \quad \frac{1}{2} \quad \frac{1}{f}$$

$$f \quad 2.5\,\text{cm}$$

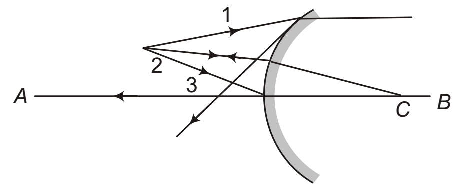
Hence, the mirror is concave.

We know that $y_i \quad \dfrac{fy_0}{f \quad x_0}$

$$\frac{2.5 \quad 1}{2.5 \quad 2} \quad 5\,\text{cm}$$

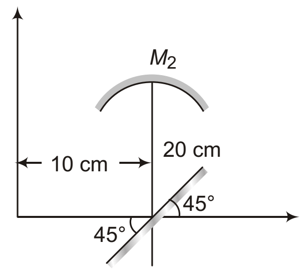
Hence, the correct option is (b).

16. There are two mistakes one in ray (1) and other in ray (3).



Hence correct option is (b).

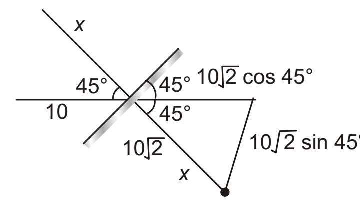
17. The image formation by plane mirror is shown as



$$\frac{10}{x} \quad \sin 45 \qquad x \quad 10\sqrt{2}$$

The x-coordinate is $10\sqrt{2}\cos 45 \quad 10$

and y-coordinate is $\quad 10\sqrt{2}\sin 45 \quad 10$



Hence, the convert option if (c), (10, 10).

18. $x_i \quad \dfrac{fx_0}{x_0 \quad f} \quad \dfrac{10 \quad 10}{10 \quad 10} \quad 5\,\text{cm}$

For concave mirror $f \quad 10\,\text{cm}$.

$$y_i \quad \frac{fy_0}{f \quad x_0} \quad \frac{10 \quad 20}{10 \quad 10}\,\text{cm}$$

$$10\,\text{cm}$$

Hence the coordinates of image are (5, 10).

Therefore, the correct option is (d).

19. For convex mirror $f \quad 10$ cm

$$x_i \quad \frac{fx_0}{x_0 \quad f} \quad \frac{10 \quad 10}{10 \quad 10}$$

$$y_i \quad \frac{fy_0}{f \quad y_0} \quad \frac{10 \quad\quad 20}{10 \quad 10}$$

Hence the correct option is (d).

20. It concave mirror is replaced by plane mirror the coordinates are (0, 40).

Hence the correct option is (d).

■ More than one options are correct

1. Here $f \quad 20$ cm

Case 1. (if image is real) u, v and f all are –ve.

Here $m \quad 2 \quad v \quad 2u$

using mirror formula

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$$

we get, $$\frac{1}{2u} \quad \frac{1}{u} \quad\quad \frac{1}{20}$$

$$\frac{3}{2u} \quad \frac{1}{20} \quad\quad u \quad\quad 30 \text{ cm}$$

Case 2. (if image is virtual)

u and f are ve, while v is +ve

$$\frac{1}{2u} \quad \frac{1}{u} \quad\quad \frac{1}{20}$$

$$u \quad\quad 10 \text{ cm}$$

Hence possible values of u are 10 cm, 30 cm.

The correct options are (a) and (b).

2. Magnitude of focal length spherical mirror is f and linear magnification is $\frac{1}{2}$

Since concave mirror fro inverted real image and magnification is less than unity, therefore $u \quad 2f$.

Hence option (a) is correct.'

If image is erect than it is a convex mirror.

Let mirror is concave hence focal length

f.

Here $m \quad \frac{1}{2} \quad\quad \frac{v}{u}$

$$v \quad\quad \frac{u}{2}$$

Using mirror formula $\frac{1}{u} \quad \frac{1}{v} \quad \frac{1}{f}$, we get

$$\frac{1}{u/2} \quad \frac{1}{u} \quad\quad \frac{1}{f}$$

$$\frac{3}{u} \quad\quad \frac{1}{f}$$

$$u \quad\quad 3f$$

Hence, if the mirror is concave the object distance will be $3f$.

Let mirror is convex, then

$$m \quad \frac{v}{u} \quad \frac{1}{2} \quad\quad u \quad \frac{v}{2}$$

Using mirror formula, we get

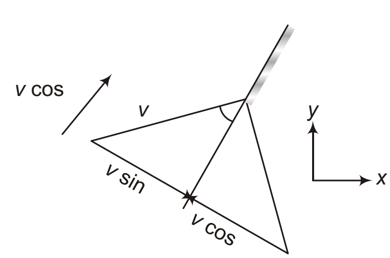
$$\frac{1}{u/2} \quad \frac{1}{u} \quad \frac{1}{f} \quad\quad u \quad f$$

Hence, if mirror is convex the object distance will be f.

Hence correct options are (a), (b), (c) and (d).

3. Since by a plane mirror

speed of image speed of object



Hence speed of image also v.

Horizontal component (along mirror)

$$v \cos$$

Vertical component (to mirror)

$$v \sin$$

Hence image velocity also make an angle with the mirror.

Resolving velocity along (y-axis *ie*, parallel to mirror) and (x-axis *ie* perpendicular to mirror).

$$\mathbf{v}_0 \quad v \sin \hat{\mathbf{i}} \quad v \cos \hat{\mathbf{j}}$$

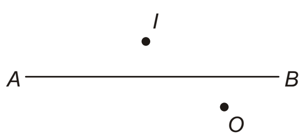
$$\mathbf{v}_i \quad v \sin \hat{\mathbf{i}} \quad v \cos \hat{\mathbf{j}}$$

Relative velocity of object w.r.t. image is

$$\mathbf{v}_{0i} \quad \mathbf{v}_0 \quad \mathbf{v}_i \quad 2v \sin \quad \hat{\mathbf{i}}$$

Hence, correct options are (a), (b) and (d).

4.



As image is on opposite side of the principle axis (inverter image) hence the mirror is concave because convex mirror always form erect image.

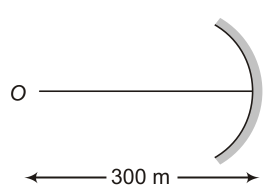
The mirror is lying to the right of O and the O lies between C and F.

If centre of curvature lies to the right hand side of O then $v \quad u$.

Hence, this option is incorrect.

Hence, the correct options are (a), (b) and (d).

5. Here $f \quad 20$ cm, $u \quad 30$ cm



Using mirror formula

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$$

we get,

$$v \quad 60$$

Different this w.r.t. time, we get

$$\frac{1}{v^2}\frac{dv}{dt} \quad \frac{1}{u^2}\frac{du}{dt} \quad 0$$

$$\frac{dv}{dt} \quad \frac{v^2}{u^2} \quad \frac{du}{dt}$$

Hence in event (1),

$$\frac{du}{dt} \quad v$$

$$\frac{dv}{dt} \quad \frac{60^2}{30^2} \quad v \quad 4v$$

Hence, speed of image in event (1) is $4v$.

after time y coordinate of object $y_0 \quad v\,t$

but $x_0 \quad 30$

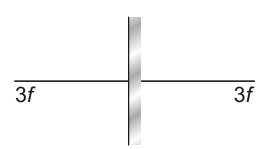
then $\quad y_i \quad \frac{fy_0}{f \quad x_0} \quad \frac{20 \quad v\,t}{20 \quad 30}$

$$y_i \quad | \quad 2vt | \quad 2vt$$

$$\frac{dy_i}{dt} \quad 2v$$

Hence, option (b) and (c) are correct.

6. For plane mirror



$$u \quad 3f \quad v \quad 3f$$

For concave mirror

$$u \quad 3f$$

Using mirror formula

$$\frac{1}{v} \quad \frac{1}{3f} \quad \frac{1}{f} \quad \frac{2}{3f}$$

$$v \quad 1.5f$$

$$|v| \quad 1.5f$$

For convex mirror,

$$\frac{1}{v} \quad \frac{1}{3f} \quad \frac{1}{f} \quad \frac{4}{3f}$$

$$v \quad 0.75f$$

Hence maximum distance in event (1) if image is from plane mirror and minimum distance from convex mirror

When $v \quad 1.5f$, then $v \quad 1.5f$

by plane mirror

For concave mirror

$$\frac{1}{u} \quad \frac{1}{1.5f} \quad \frac{1}{f} \quad \frac{2}{3f} \quad \frac{1}{f}$$

$$\frac{2 \quad 3}{3f} \quad \frac{1}{3f}$$

$$v \quad 3f$$

$$|v| \quad 3f$$

For convex mirror

$$\frac{1}{v} \quad \frac{2}{3f} \quad \frac{1}{f} \quad \frac{5}{3f}$$

$$v \quad 0.6f$$

Hence, in event (2) maximum distance of image from the concave mirror.

Hence, correct options are (a), (b) and (c).

■ Match the Columns

1. (a) $m \quad 2$, since $|m| \quad 2 \quad 1$.

Therefore mirror is concave and $\because m$ is ve.

Hence image is real [for concave mirror m is ve]

Therefore,

(a) q, r

(b) Since $m \quad \frac{1}{2}$, $\because m$ is ve

Hence mirror is concave and image is real.

(b) q, r

(c) $m \quad 2$, $\because m \quad 1$

Hence mirror is concave and $\because m$ is + ve

Hence image is virtual.

(c) q, s

(d) $\because 1\,\text{m} \quad \frac{1}{2} \quad 1$ and + ve

Hence the mirror is convex and image is virtual.

(d) p, s

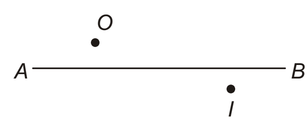
2. Plane mirror (for virtual object) only real image

(a) p

(b) r

(c) p

3. (a) Since object and its image are on opposite side of principle axis.



Hence mirror is concave

(a) r.

(b) Similarly as for option (a).

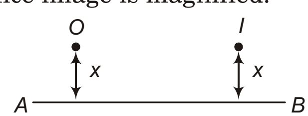
(b) r

(c) Since image and object are of same height from AB.

Hence mirror is plane mirror.

(c) p

(d) Since image is magnified.



Hence mirror is concave [D is. distance between O and mirror is less than the focal length].

Hence

(d) r.

4. (a) For concave mirror M_1 focal length

$$20 \text{ cm}$$

When x 20 cm, Mirror is M_1

v and magnified

(a) p, s

(b) For convex mirror M_2 of focal length 20 cm if X (distance of object from pole) 20

Using mirror formula $\frac{1}{v} \quad \frac{1}{v} \quad \frac{1}{f}$

we get

$$\frac{1}{v} \quad \frac{1}{20} \quad \frac{1}{20} \quad \frac{1}{10}$$

$$v \quad 10 \text{ cm}$$

Hence image is virtual.

(b) r

(c) u 30 cm, f 20 cm

$$\frac{1}{v} \quad \frac{1}{30} \quad \frac{1}{20} \quad \frac{2 \quad 3}{60} \quad \frac{1}{60}$$

$$v \quad 60 \text{ cm}$$

Hence image is real.

$$m \quad \frac{60}{30} \quad 2$$

Hence image is magnified (2 times).

(c) q, s

(d) for mirror M_2 (convex) at X 30 cm

image again virtual.

(d) r

5. (a) For concave mirror f 20 cm

Case I. Image is real.

$$m \quad 2 \quad \frac{v}{u} \quad v \quad 2u$$

Using $\frac{1}{u} \quad \frac{1}{u} \quad \frac{1}{f}$

we get, $\frac{1}{2u} \quad \frac{1}{u} \quad \frac{1}{20}$

$$\frac{3}{2u} \quad \frac{1}{20}$$

$$u \quad 30 \text{ cm}$$

If image is virtual v $2v$

$$\frac{1}{2u} \quad \frac{1}{u} \quad \frac{1}{20}$$

$$u \quad 10 \text{ cm}$$

Hence correct option are as

(a) p, q

(b) Here m $\frac{1}{2}$ 1

Hence image is real.

$$\frac{1}{2} \quad \frac{v}{u} \quad v \quad \frac{u}{2}$$

Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$, we get

$$\frac{1}{u/2} \quad \frac{1}{u} \quad \frac{1}{20}$$

$$\frac{3}{4} \quad \frac{1}{20} \quad u \quad 60 \text{ cm}$$

Hence correct option is none of these.

(b) s

(c) if m 1, than u $2f$

$$u \quad 40 \text{ cm}$$

Hence correct option is none of these.

(c) (s)

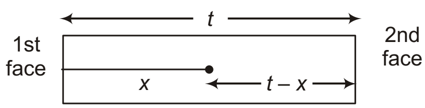
(d) Similarly as in part (b) we see that answer is none of these.

(d) (s)

27 Refraction of Light

Introductory Exercise 27.1

1. Let real depth of dust particle is x and thickness of slab is t



From Ist surface

$$\frac{\text{Real depth}}{\text{App. depth}}$$

$$1.5 \quad \frac{x}{6\,\text{cm}} \qquad x \quad 9\text{ cm} \qquad \ldots\text{(i)}$$

From other face

$$\frac{t \quad x}{4} \qquad t \quad x \quad 4 \quad 1.5$$

$$t \quad x \quad 6 \quad 9 \quad 6 \quad 16\text{ cm}$$

2. $$_{1\ \ 2} \quad \frac{4}{3} \qquad \frac{_2}{_1} \quad \frac{4}{3} \qquad \ldots\text{(i)}$$

$$_{2\ \ 3} \quad \frac{3}{2} \qquad \frac{_3}{_2} \quad \frac{3}{2} \qquad \ldots\text{(ii)}$$

From Eqs. (i) and (ii), we get

$$\frac{_3}{_1} \quad \frac{4}{3} \quad \frac{3}{2} \quad 2$$

3. Frequency remain same.

Let v_1 is velocity in medium (1) and v_2 in Medium (2)

We have

$$_1 \quad \frac{c}{v_1} \text{ and } _2 \quad \frac{c}{v_2}$$

$$\frac{_1}{_2} \quad \frac{v_2}{v_1} \qquad v_2 \quad \frac{_1}{_2} v_1$$

Similarly, wavelength $_2 \quad \frac{_1}{_2} \quad _1$

4. From $v_a \quad n \quad _a$

$$_a \quad \frac{v_a}{n_a} \quad \frac{3 \quad 10^8}{6 \quad 10^{\ \ 14}} \quad 5 \quad 10^{\ \ 7}\text{m}$$

50 nm

$$\frac{_a}{_m} \quad \frac{500}{300} \quad \frac{5}{3} \quad 1.67$$

Introductory Exercise 27.2

1. Since light rays are coming from glass to air applying $\frac{_2}{v} \quad \frac{_1}{u} \quad \frac{_2 \quad _1}{R}$

$$\frac{1}{v} \quad \frac{1.5}{10} \quad \frac{1 \quad 1.5}{1.5}$$

$$\frac{1}{v} \quad \frac{1}{30} \quad \frac{1.5}{10} \quad \frac{1 \quad 4.5}{30}$$

$$v \quad \frac{30}{3.5} \quad 8.57\text{ cm}$$

2. $$\frac{_2}{v} \quad \frac{_1}{u} \quad \frac{_2 \quad _1}{R}$$

(a) $$\frac{1.5}{} \quad \frac{1}{(\ \ 20)} \quad \frac{0.5}{6}$$

On solving $v \quad 45$ cm

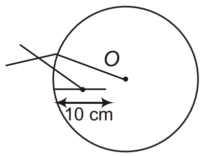
(b) $$\frac{1.5}{v} \quad \frac{1}{(\ \ 10)} \quad \frac{0.5}{6}$$

On solving we get $v \quad 90$ cm

(c) $\frac{1.5}{v} \quad \frac{1}{(\ \ 3)} \quad \frac{0.5}{6}$

On solving $v \quad 6.0\,\text{cm}$

3. Light rays are coming from glass to air



$$\frac{2}{v} \quad \frac{1}{u} \quad \frac{2 \quad 1}{R}$$

$$\frac{1}{v} \quad \frac{4}{3(\ \ 10)} \quad \frac{1 \quad 4/3}{(\ \ 15)}$$

$$\frac{1}{v} \quad \frac{4}{30} \quad \frac{1}{45} \text{ on solving } v \quad 9\text{ cm}$$

4. Applying $\frac{u_2}{v} \quad \frac{1}{u} \quad \frac{2 \quad 1}{R}$

$$\frac{1.44}{v} \quad \frac{1}{} \quad \frac{0.44}{1.25}$$

On solving $v \quad 0.795\,\text{cm}$

5. $\frac{2}{v} \quad \frac{1}{u} \quad \frac{2 \quad 1}{R}$

$$\frac{1.635}{v} \quad \frac{1}{(\ \ 9)} \quad \frac{0.635}{(\ \ 2.50)}$$

on solving $v \quad 6.993$ cm

Lateral magnification $m \quad \frac{v}{u}$

$$\frac{6.993}{9} \quad 0.777$$

Introductory Exercise 27.3

1. We have

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f} \quad (\quad 1) \quad \frac{1}{R_1} \quad \frac{1}{R_2}$$

$$\frac{1}{20} \quad \frac{1}{60} \quad (1.65 \quad 1) \quad \frac{1}{R} \quad \frac{1}{R}$$

$$\frac{3 \quad 1}{60} \quad 0.65 \quad \frac{2}{R}$$

$$R \quad 60 \quad 0.65 \quad 39\text{ cm}$$

2. Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$, we get

$$\frac{1}{50} \quad \frac{1}{x} \quad \frac{1}{30} \qquad \frac{1}{x} \quad \frac{1}{30} \quad \frac{1}{50}$$

On solving $x \quad 18.75\,\text{cm}$

$$m \quad \frac{v}{u} \quad \frac{50}{18.75}$$

Height of filament image $2 \quad \frac{50}{18.75}$

$$5.3\text{ cm}$$

3. $\frac{1}{f} \quad (\quad 1) \quad \frac{1}{R} \quad \frac{1}{R}$

If lens faces becomes opposite three is no change in radius of curvature hence focal length does not change.

4. Using formula $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$ when $u \quad 0_1\, v \quad 0$

when $u \quad f, v$ hence image moves from surface to .

5. $\frac{1}{f} \quad (\quad 1) \quad \frac{1}{R_1} \quad \frac{1}{R_2}$

$$\frac{1}{f} \quad (1.3 \quad 1) \quad \frac{1}{R} \quad \frac{1}{R} \quad 0.3 \quad \frac{2}{20}$$

$$f \quad \frac{100}{3}\text{ cm}$$

(a) When immersed in a liquid of 1.8 refractive index

$$\frac{1}{f_1} \quad \frac{1.3}{1.8} \quad 1 \quad \frac{2}{R} \quad \frac{0.5}{1.8} \quad \frac{2}{20}$$

$f \quad 36\,\text{cm}$

(b) The minimum distance is equal to the focal length $\quad 36$ cm

6. Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$

$$\frac{1}{v} \quad \frac{1}{(\ 20)} \quad \frac{12}{10}$$

On solving $v \quad 20\,\text{cm}$

Magnification $\quad \frac{v}{u} \quad 1$

Hence the image of same size and inverted. Let the distance between second lens is x Since magnification is unity image distance also x using again

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$$

we get

$$\frac{1}{x} \quad \frac{1}{(\ x)} \quad \frac{1}{f} \quad \frac{1}{10} \qquad x \quad 20\,\text{cm}$$

Hence the distance between two lenses

$$20\,\text{cm} \quad 20\,\text{cm} \quad 40\,\text{cm}$$

7. $\frac{1}{v} \quad \frac{1}{f} \quad \frac{1}{u}$ ...(i)

$$\frac{1}{v_1} \quad \frac{1}{f} \quad \frac{1}{u \quad du} \qquad \text{...(ii)}$$

$$\frac{1}{v} \quad \frac{1}{v} \quad \frac{(u \quad du \quad u)}{(u \quad du)u} \text{ on solving, we get}$$

$$\frac{v \quad v}{v} \quad \frac{du}{u(u \quad du)} \text{ thickness } dv \quad \frac{v^2}{u^2}\,du$$

10. Size of image $\quad \sqrt{6 \quad \frac{2}{3}} \quad 2\,\text{cm}.$

11. Let image distance is u

$$|m| \quad 3 \qquad v \quad 3u$$

$$\frac{1}{3u} \quad \frac{1}{u} \quad \frac{1}{12} \qquad v \quad 16\,\text{cm}$$

12. Since image is upright and diminished hence lens is concave. Now

$$u \quad v \quad 20 \qquad \text{...(i)}$$

$$m \quad \frac{v}{u} \quad \frac{1}{2}$$

$$\frac{1}{2} \quad \frac{u \quad 20}{u}$$

$$u \quad 40\,\text{cm and } v \quad 20\,\text{cm}$$

Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$

$$\frac{1}{20} \quad \frac{1}{40} \quad \frac{1}{f} \qquad f \quad 40\,\text{cm}$$

13. The image coincide itself if light falls normally on plane mirror hence object must be on focus *i.e.* 10 cm.

8. $\frac{1}{v} \quad \frac{1}{u} \quad \frac{2(\ _2 \quad _1)}{R_2} \quad \frac{2(\ _2 \quad _1 \quad 1)}{R_1}$

$$\frac{1}{v} \quad \frac{1}{0.2} \quad \frac{2(4/3)}{0.4} \quad \frac{2(4/3 \quad 1)}{0.4}$$

On solving $v \quad 12\,\text{cm}$

9. Since shift in position $\quad t \quad 0.1$ m

Hence real depth $\quad (0.1 \quad 0.2)$ m

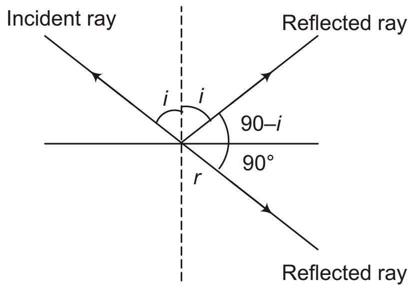
$$0.3\ \text{m}$$

and apparent depth $\quad 0.2$ m

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

$$\frac{0.3}{0.2} \quad 1.5$$

AIEEE Corner

1. 

We have $r \quad 90 \quad i \quad 180 \quad r \quad 90 \quad i$

From Snell's law $1.5 \quad \dfrac{\sin i}{\sin r} \quad \dfrac{\sin i}{\sin (90 \quad i)}$

$$\tan i \quad 1.5$$

$$i \quad \tan^{\ 1}(1.5)$$

2. $n_w \quad \dfrac{v_{\text{air}}}{u_w} \quad \dfrac{343}{1498} \quad 0.229$

Critical angle $\quad \sin^{\ 1}(0.229) \quad 13.2$

3. Sped in glycrine $v_g \quad \dfrac{c}{n_g} \quad \dfrac{3 \quad 10^8}{1.47}$

$$t_1 \quad \frac{20}{v_g} \quad \frac{20 \quad 1.47}{3 \quad 10^8} \quad 9.8 \quad 10^{\ 8}\,\text{s}$$

Speed in glycrine $v_g \quad \dfrac{c}{n_g} \quad \dfrac{3 \quad 10^8}{1.63}$

$$t_2 \quad \frac{20}{v_c} \quad \frac{20 \quad 1.63}{3 \quad 10^8} \sim 10.8 \quad 10^{\ 8}$$

$$t_2 \quad t_1 \quad (10.86 \quad 9.8) \quad 10^{\ 8}$$

$$1.67 \quad 10^{\ 8}\,\text{s}$$

4. (a) $t_1 \quad \dfrac{1 \quad 10^{\ 6}\ \text{m}}{v_1} \quad \dfrac{1 \quad 10^{\ 6}\ \text{m}}{3 \quad 10^8/1.2}$

$$\frac{1.2 \quad 10^{\ 6}}{3 \quad 10^8}$$

$$t_1 \quad 0.4 \quad 10^{\ 14}\,\text{s}$$

$$t_2 \quad \frac{1.5 \quad 10^{\ 6}}{3 \quad 10^8} \quad 0.5 \quad 10^{\ 14}\ \text{s}$$

$$t_3 \quad \frac{1 \quad 10^{\ 6}}{3 \quad 10^8/1.8} \quad \frac{1.8 \quad 10^{\ 6}}{3 \quad 10^8} \quad 0.6 \quad 10^{\ 14}$$

Hence t_1 is least and $t_1 \quad 0.4 \quad 10^{\ 14}$ s

(b) Total number of wavelengths

$$\frac{1 \quad \text{m}}{/n_1} \quad \frac{1.5 \quad \text{m}}{/n_2} \quad \frac{1 \quad \text{m}}{/n_3}$$

$$\frac{1000 \quad 1.2\,\text{nm}}{600\,\text{nm}} \quad \frac{1.5 \quad 100\,\text{nm}}{600\,\text{nm}}$$

$$\frac{1 \quad 1.8 \quad 1000\,\text{nm}}{600\,\text{nm}}$$

$$\frac{4500}{600} \quad 7.5$$

5. The given wave equation is

$$E_x(y, t) \quad E_{ax} \sin \quad \frac{2 \ y}{5 \quad 10^{\ 7}} \quad 3 \quad 10^{14} \quad 2 \ t$$

Comparing with standard equation

$$E_x(y, t) \quad E_0 \sin [ky \qquad t]$$

$$k \quad \frac{2}{5 \quad 10^{\ 7}} \qquad 2 \quad 3 \quad 10^{14}$$

$$v \quad \frac{}{k} \quad \frac{2 \quad 3 \quad 10^{14}}{2 \ /5 \quad 10^{\ 7}} \quad 1.5 \quad 10^8\ \text{m/s}$$

Refractive index $n \quad \dfrac{c}{v} \quad \dfrac{3 \quad 10^8}{1.5 \quad 10^8} \quad 2$

Wavelength in this way $_n \quad \dfrac{2}{k}$

$$_n \quad \frac{2}{25/5 \quad 10^7} \quad 5 \quad 10^{\ 7}\text{m}$$

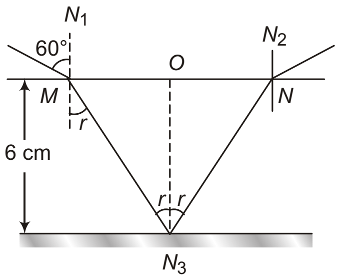
$$_n \quad 500\,\text{nm}$$

If vacuum, wavelength is then

$$_n \quad \frac{}{n}$$

$$n \ _n \quad 2 \quad 500 \quad 1000\,\text{nm}$$

6. Refraction from plane and spherical surfaces



We have $\dfrac{\sin 60}{\sin r} \quad 1.8$

$$\sin r \quad \frac{\sin 60}{1.8}$$

$$\sin r \quad \frac{\sqrt{3}}{2 \quad 1.8} \quad 0.48$$

$$r \quad \sin^{\ 1}(0.48)$$

$$r \sim 28.7$$

Now $\quad \dfrac{MO}{6} \quad \tan r$

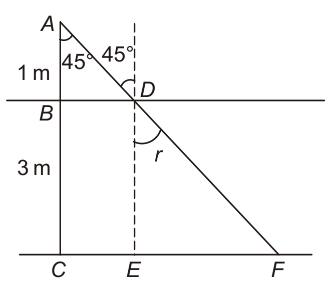
$$MO \quad 6 \tan r$$

Similarly $ON \quad 6 \tan r$

$$MN \quad MO \quad ON \quad 12 \tan r \quad 12 \tan(28.7\ \ )$$

$$MN \quad 6.6 \text{ cm}$$

7. From Snell's law $\dfrac{4}{3} \quad \dfrac{\sin 45}{\sin r}$



Solving we get $r \quad 32$

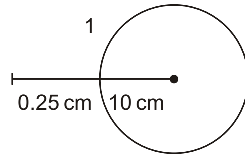
$$EF \quad DE \tan r \quad 3 \tan 32$$

$$1.88 \text{ m}$$

Total length of shadow $\ 1 \quad 1.88$

$$2.88 \text{ m}$$

8. The situation is shown in figure



For first surface $\dfrac{_2}{v} \quad \dfrac{_1}{u} \quad \dfrac{_2 \quad\quad _1}{R}$

$$\frac{1.5}{v} \quad \frac{1}{(\ \ 2.5)} \quad \frac{0.5}{10}$$

$$\frac{1.5}{v} \quad \frac{1}{20} \quad \frac{1}{2.5} \quad\quad \frac{7}{20}$$

$$v \quad \frac{30}{7} \text{ cm}$$

This image acts as a virtual object for 2nd surface

$$u_2 \quad\quad 20 \quad \frac{30}{7} \quad\quad \frac{170}{7} \text{ cm}$$

and $\quad\quad R \quad\quad 10 \text{ cm}$

$$\frac{_2}{v} \quad \frac{_1}{u} \quad \frac{_2 \quad\quad _1}{r}$$

$$\frac{1}{v} \quad \frac{1.5}{170/7} \quad \frac{0.5}{10}$$

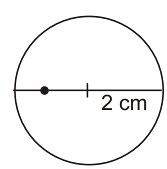
$$\frac{1}{v} \quad \frac{1}{20} \quad \frac{10.5}{170}$$

$$v \quad\quad 85 \text{ cm}$$

Hence final image will produced at $\ \ 65$ cm from Ist surface.

9. Here $v \quad\quad 1$ cm

$$R \quad\quad 2 \text{ cm}$$



Applying $\dfrac{_2}{v} \quad \dfrac{_1}{u} \quad \dfrac{_2 \quad\quad _1}{R}$

$$\frac{1}{1} \quad \frac{1.5}{x} \quad \frac{1 \quad 1.5}{2} \quad \frac{0.5}{2} \quad \frac{1}{4}$$

$$\frac{1.5}{x} \quad \frac{5}{4}$$

$$x \quad \frac{6}{5} \quad\quad 1.2 \text{ cm}$$

10.

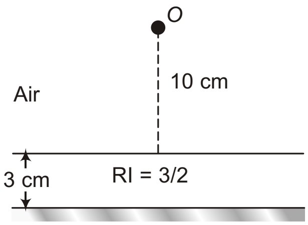


Image formed by refection acts the virtual object for the mirror.

Here shift $t \quad 1 \quad \frac{1}{}$

$$3 \quad 1 \quad \frac{1}{3/2} \quad 1\,\text{cm}$$

Hence object appear to the mirror

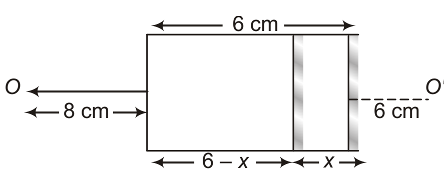
$$(10 \quad 1)\ \text{cm}$$

$$11\,\text{cm}$$

The image formed by mirror $\quad 11\,\text{cm}$

Hence image formed by the mirror at 11 cm behind the mirror.

11.



Step. Let shift in mirror is x then the distance of object.

From the mirror is $\quad 8 \quad (6 \quad x)$.

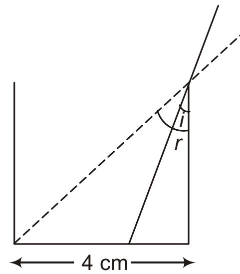
Step II. Plane mirror form image behind the mirror at same distance as the distance object from mirror hence

$$8 \quad (6 \quad x) \quad x \quad 6 \quad x \quad 4\ \text{cm}$$

Step III. $\dfrac{\text{real depth}}{\text{app. depth}} \quad \dfrac{6}{4} \quad 1.5$

hence real position of the bubble inside sphere is 1.2 cm from the surface.

12.



Here $\quad \sin r \quad \dfrac{4}{\sqrt{4^2 \quad n^2}}$

$$\sin i \quad \frac{2}{\sqrt{2^2 \quad n^2}}$$

$$u \quad \frac{\sin i}{\sin r} \quad \frac{4}{3} \quad \frac{4\sqrt{2^2 \quad n^2}}{2\sqrt{4^2 \quad n^2}}$$

$$\frac{4}{9} \quad \frac{4 \quad n^2}{16 \quad n^2} \quad 5n^2 \quad 28$$

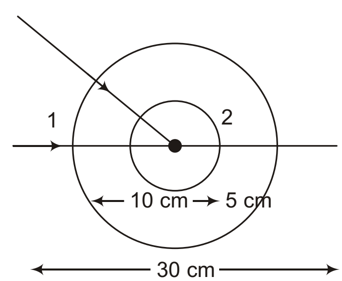
$$n^2 \quad \sqrt{\frac{28}{5}} \quad n \quad 2.4\ \text{cm}$$

13. Using $\dfrac{2}{v} \quad \dfrac{1}{u} \quad \dfrac{2 \quad 1}{R}$

$$\frac{1}{v} \quad \frac{1.5}{} \quad \frac{1 \quad 1.5}{5}$$

$$\frac{1}{v} \quad \frac{1}{10} \quad v \quad 10\,\text{cm}$$

14. For first surface $\dfrac{2}{v} \quad \dfrac{1}{u} \quad \dfrac{2 \quad 1}{R}$



$$\frac{1.5}{v} \quad \frac{1}{} \quad \frac{0.5}{10} \quad v \quad 30\,\text{cm}$$

For 2nd surface

$$\frac{1}{v} \quad \frac{1.5}{(\ 15)} \quad \frac{0.5}{5}$$

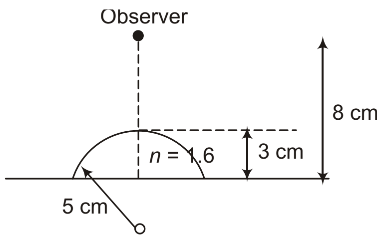
$$\frac{1}{v} \quad \frac{1}{10} \quad \frac{1}{10} \quad v \quad 5\,\text{cm}$$

Hence the distance from first face is

$$(10 \quad 5)\,\text{cm}$$

$$15\,\text{cm}$$

15. Since rays goes from paper weight (n 1.6) to air hence



$$\frac{1}{v} \quad \frac{1.6}{(\ 3)} \quad \frac{1 \quad 1.6}{5}$$

$$\frac{1}{v} \quad \frac{0.6}{5} \quad \frac{1.6}{3}$$

On solving we get $v \quad 0.58 \quad |v| \quad 0.58$ cm

Hence the distance between observer and table top is $(8 \quad 0.58)$ cm 7.42 cm.

16. Let real velocity of bird v_B cm/s

Velocity of bird w.r.t. fish 16 cm/s

Velocity of bird w.r.t. water v_B

But $v_B \quad v_f \quad 16$ cm/s

Here $v_f \quad 4$ cm/s

$$\frac{4}{3}v_B \quad 4 \quad 16$$

$$\frac{4}{3}v_B \quad 12\,\text{cm/s}$$

$$v_B \quad 9\,\text{cm/s}$$

17. Let the distance between the object and screen is d and let distance between object and lens is x

Using lens formula $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$ we get

$$\frac{1}{d \quad x} \quad \frac{1}{(\ x)} \quad \frac{1}{16}$$

$$x^2 \quad xd \quad 16d \quad 0$$

$$x \quad \frac{d \quad \sqrt{d^2 \quad 64d}}{2}$$

Let $\quad x_1 \quad \frac{d \quad \sqrt{d^2 \quad 64d}}{2}$

and $\quad x_2 \quad \frac{d \quad \sqrt{d^2 \quad 64d}}{2}$

$$x_1 \quad x_2 \quad \sqrt{d^2 \quad 64d}$$

But $x_1 \quad x_2 \quad 60 \quad d^2 \quad 64d \quad 3600 \quad 0$

$$(d \quad 100)(d \quad 36) \quad 0$$

$$d \quad 100 \because d \quad 36$$

Hence the distance between object and screen is 100 cm.

18. $\because \frac{1}{f} \quad (n \quad 1)\ \frac{1}{R_1} \quad \frac{1}{R_2}$

For identical double convex lens

$$|R_1| \quad |R_2| \quad R$$

but $\quad R_1 \quad R$ and $R_2 \quad R$

$$\frac{1}{f} \quad (n \quad 1)\ \frac{1}{R} \quad \frac{1}{R} \quad (n \quad 1)\frac{2}{R}$$

$$f \quad \frac{R}{2(n \quad 1)} \text{ hence } f_1 \quad \frac{R}{2(1.5 \quad 1)} \quad R$$

and $f_2 \quad \frac{R}{2(1.7 \quad 1)} \quad \frac{R}{1.4}$

(a) $\frac{f_1}{f_2} \quad 1.4 \quad f_1 : f_2 \quad 1.4 : 1$

(b) For first lens

$$f_i \quad \frac{R}{2\ \frac{1.5}{1.6} \quad 1} \quad \frac{1.6R}{2 \quad 1} \quad 8R$$

hence first lens become concave (diverging)

For 2nd lens

$$f_2 \quad \frac{R}{2\left(\frac{1.7}{1.6} \quad 1\right)} \quad \frac{1.6R}{2 \quad 0.1} \quad 8R$$

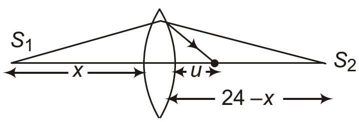
Hence 2nd lens remain **convex.**

19. Here u 10 cm acts the virtual object for the lens v 15 cm using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$

$$\frac{1}{15} \quad \frac{1}{10} \quad \frac{1}{f}$$

On solving we get f 30 cm.

20. Situation is shown in figure.



For Ist source direction left to right is ve

Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$, we get

$$\frac{1}{v} \quad \frac{1}{(\ x)} \quad \frac{1}{9} \quad \frac{1}{v} \quad \frac{1}{x} \quad \frac{1}{9} \qquad \text{...(i)}$$

For 2nd source direction right to left is ve

hence $\frac{1}{v} \quad \frac{1}{24 \quad x} \quad \frac{1}{9}$ ...(ii)

On adding Eqs. (i) and (ii) we set

$$\frac{1}{x} \quad \frac{1}{24 \quad x} \quad \frac{2}{9} \quad x^2 \quad 24x \quad 108 \quad 0$$

$$x \quad 6, 18$$

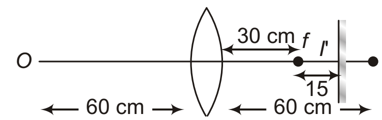
hence lens can be placed at a distance of 6 cm from any source.

21. Since the object is placed at c of first lens hence image also form at c and of same magnification *i.e.* v $2f$. Since two lens are separated by distance f hence the distance between 2nd lens and image is f. This image acts a virtual object for this lens using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$, we get $\frac{1}{v} \quad \frac{1}{f} \quad v \quad \frac{f}{2}$

and magnification $m_2 \quad \frac{v}{u} \quad \frac{f/2}{f} \quad \frac{1}{2}$

Hence image is formed at $\frac{f}{2}$ right of 2nd lens.

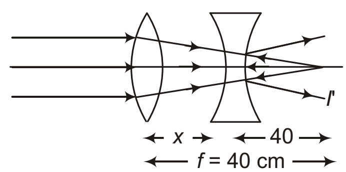
22. Since the object is placed at $2f$ hence image also form $2f$ by lens *i.e.*, at 60 cm. The mirror must be placed at that place that it made the final image at focus of lens. The difference is shown below.



Hence the distance between lens and mirror

40 cm 15 cm 45 cm

23. The diagram is shown in figure.

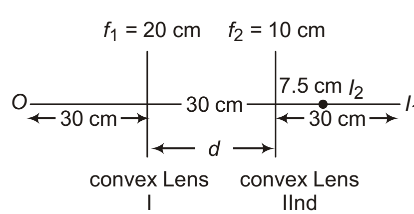


The parallel ray after refraction on convergent lens meet at focus 40 cm. Let distance between two lenses is x then using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$ for diverging lens

$$\frac{1}{} \quad \frac{1}{(40 \quad x)} \quad \frac{1}{15}$$

$$x \quad 25\text{ cm}$$

24. Here f_1 20 cm f_2 10 cm and d 30 cm



For first lens using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$ we get

$$\frac{1}{v} \quad \frac{1}{30} \quad \frac{1}{20} \quad \frac{1}{v} \quad \frac{1}{20} \quad \frac{1}{30} \quad v \quad 60\text{ cm}$$

For 2nd lens

$$\frac{1}{v} \quad \frac{1}{30} \quad \frac{1}{10}$$

$$\frac{1}{v} \quad \frac{1}{30} \quad \frac{1}{10}$$

$$\frac{1}{v} \quad \frac{4}{30}$$

$$v \quad 7.5\,\text{cm}$$

Hence image formed at 7.5 cm from 2nd lens.

25. For lens u 40 cm f 20 cm using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$

$$\frac{1}{v} \quad \frac{1}{f} \quad \frac{1}{u}$$

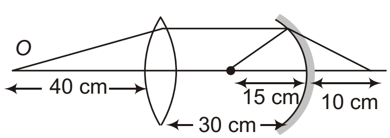
$$\frac{1}{v} \quad \frac{1}{20} \quad \frac{1}{40} \quad \frac{2 \quad 1}{40} \quad \frac{1}{40}$$

$$v \quad 40\,\text{cm}$$

Hence the image is at 40 cm right from the lens. Since distance between mirror and lens is 30 cm. Hence for mirror v 10 cm, f 10 cm.

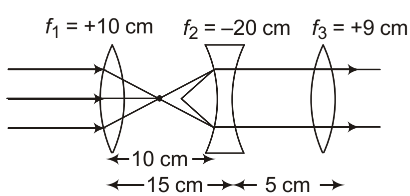
Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f} \quad \frac{1}{v} \quad \frac{1}{f} \quad \frac{1}{u}$

$$\frac{1}{v} \quad \frac{1}{10} \quad \frac{1}{10} \quad v \quad 5\,\text{cm}$$



Hence image is formed at 5 cm from the mirror toward lens.

26.



For first lens v 10 cm

For 2nd lens u 5 cm, f 20 cm

Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$

$$\frac{1}{v} \quad \frac{1}{20} \quad \frac{1}{5}$$

$$v \quad 4\,\text{cm}$$

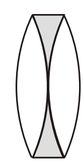
For third lens v 9 cm and f 9 cm

$$\frac{1}{v} \quad \frac{1}{(\ 9)} \quad \frac{1}{9}$$

$$v$$

Hence the image formed at or rays become parallel.

27. Situation is shown in figure when space between two convex lenses is filled with refractive index 1.3 it become a concave lens of radii R_1 30 cm and R_2 70 cm hence it focal length is



$$\frac{1}{f} \quad (n \quad 1) \quad \frac{1}{R_1} \quad \frac{1}{R_2}$$

$$\frac{1}{f} \quad (1.3 \quad 1) \quad \frac{1}{30} \quad \frac{1}{70}$$

$$f \quad 70\,\text{cm}$$

Hence the equivalent focal length of combination $\frac{1}{F} \quad \frac{1}{30} \quad \frac{1}{70} \quad \frac{1}{70}$

F 30 cm if

u 90 cm then using

$$\frac{1}{F} \quad \frac{1}{v} \quad \frac{1}{u}$$

we get $\frac{1}{30} \quad \frac{1}{v} \quad \frac{1}{90}$

$$\frac{1}{v} \quad \frac{1}{30} \quad \frac{1}{90} \quad \frac{2}{90} \quad \frac{1}{45}$$

$$v \quad 45\,\text{cm}$$

28. $n_{\text{ice}} \quad \dfrac{c}{v} \quad \dfrac{3 \quad 10^8}{2.3 \quad 10^8} \quad 1.30$

$$_c \quad \sin^{\ 1} \frac{1}{n_{\text{ice}}} \quad \sin^{\ 1} \frac{1}{1.30}$$

$$\sin^{\ 1}(0.77)$$

29. (a) Let angle of refraction in material 2 is r

then $\quad \dfrac{\sin}{\sin r} \quad \dfrac{1.8}{1.6} \quad \dfrac{18}{16}$ ...(i)

For (2) to (3) interface

$$\frac{\sin r}{\sin 90} \quad \frac{1.3}{1.8} \quad \frac{13}{18}$$

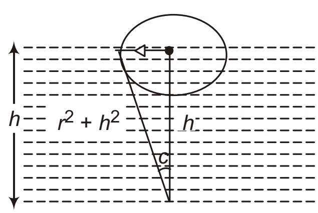
$\sin r \quad \dfrac{13}{18}$ ...(ii)

From (i) and (ii) $\sin \quad \dfrac{18}{16} \quad \dfrac{13}{18}$

$$\sin^{\ 1} \frac{13}{16}$$

(b) Yes, if decreases r also decreases and become less than the critical angle and hence light goes into material 3.

30. Let maximum height of liquid is h. From figure for critical angle C



$\dfrac{1}{\sin C} \quad \dfrac{\sqrt{r^2 \quad h^2}}{r}$ ...(i)

Here $r \quad 1\,\text{cm}$ and $\quad \dfrac{4}{3}$ putting these values in Eq. (i). Solving we get $h \quad \dfrac{4}{3}$ cm

Here $\quad \sin \ _c \quad \dfrac{1}{_g} \quad \dfrac{2}{3}$

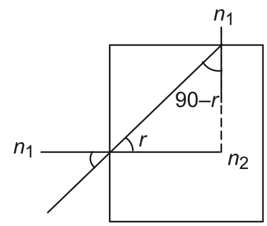
Now if water film is poured on the glass air surface. Let emergent angle at glass water surface is r, then

$$\frac{\sin \ _c}{\sin r} \quad \frac{_w}{_g} \quad \frac{4}{3} \quad \frac{2}{3}$$

$$\sin r \quad \frac{9}{8} \sin \ _c \quad \frac{9}{8} \quad \frac{2}{3} \quad \frac{3}{4}$$

$$r \quad \sin^{\ 1} \frac{3}{4}$$

32. For total internal reflection at top surface



$$\frac{\sin (90 \quad r)}{\sin 90} \quad \frac{n_1}{n_2}$$

$$\cos r \quad \frac{n_1}{n_2}$$

and $\quad \dfrac{\sin}{\sin r} \quad \dfrac{n_2}{n_1}$

$$\sin \quad \frac{n_2}{n_1} \sin r$$

$$\sin \quad \frac{n_2}{n_1} \sqrt{1 \quad \cos^2 r}$$

$$\frac{n_2}{n_1} \sqrt{1 \quad \frac{n_1}{n_2}^{\,2}}$$

$$\sin \quad \sqrt{\frac{n_2^2 \quad n_1^2}{n_1^2}}$$

$$\sin^{\ 1} \sqrt{\frac{n_2}{n_1}^{\,2} \quad 1}$$

33. The deviation angle vary from 0° to where
$90 \quad c$ ...(i)

where C is the critical angle

Now, $\quad \sin c \quad \dfrac{_w}{_g} \quad \dfrac{4/3}{3/2} \quad \dfrac{8}{9}$

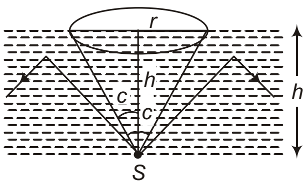
From Eq. (i) $\cos \quad \sin C$

$$\cos \quad \frac{8}{9}$$

$$\cos^{\ 1}\frac{8}{9}$$

Hence deviation angle vary from 0° to $\cos^{\ 1}\frac{8}{9}$.

34.



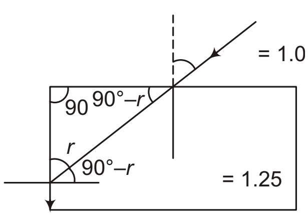
(a) Only circular patch light escapes because only those rays which are incident within a cone of semivertex angle C [Critical angle] are refracted out of the water surface. All other rays are totally internally reflected as shown in figures

(b) Now $\quad \frac{1}{\sin C} \quad \frac{\sqrt{r^2 \quad h^2}}{r}$

or $\quad C \quad \sin^{\ 1}\frac{1}{\ }$

$$\sin^{\ 1}\frac{r}{\sqrt{r^2 \quad h^2}}$$

35.



For maximum angle the angle $90 \quad r$ at left surface must be equal to critical angle

$$\sin(90 \quad r) \quad \frac{1}{1.25} \quad \frac{100}{125} \quad \frac{4}{5}$$

$$\cos r \quad \frac{4}{5}$$

$$\sin r \quad \frac{3}{5}$$

Now, $\quad \frac{\sin}{\sin r} \quad 1.25 \quad \frac{5}{4}$

$$\sin \quad \frac{5}{4}\sin r \quad \frac{5}{4} \quad \frac{3}{5}$$

$$\sin^{\ 1}\frac{3}{4}$$

36. $\dfrac{\sin\dfrac{A \quad m}{2}}{\sin\dfrac{A}{2}}$

$$\sqrt{3} \quad \frac{\sin\dfrac{A \quad \sin}{2}}{\sin\dfrac{A}{2}} \quad \frac{2\sin\dfrac{A}{2}\cos\dfrac{A}{2}}{\sin\dfrac{A}{2}}$$

$$\cos\frac{A}{2} \quad \frac{\sqrt{3}}{2} \quad \frac{A}{2} \quad 30$$

$$A \quad 60$$

37. Here $i_1 \quad r_1 \quad 0$.

Now, let other face angle of incidence is r_2

$\because \quad r_1 \quad r_2 \quad A \quad 0 \quad r_2 \quad A$

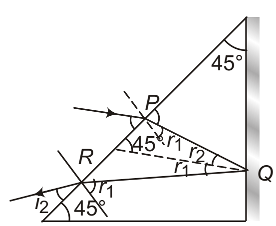
$$r_2 \quad A \quad 30$$

$$\frac{\sin r_2}{\sin i_2} \quad \frac{1}{1.5} \quad \sin i_2 \quad 1.4\sin r_2$$

$$\sin i_2 \quad 1.5 \quad \sin 30$$

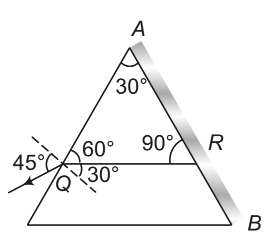
$$i_2 \quad \sin^{\ 1}(0.75) \quad 19$$

38. From figure sin $\quad OQP \quad OQR$



Hence the ray retrace its path.

39.



The ray retrace its path from ref. by surface AB hence AR 90 from geometry it is clear that r 30

$$\frac{\sin i}{\sin r}$$

$$\frac{\sin 45}{\sin 30} \quad \frac{1/\sqrt{2}}{1/2} \quad \sqrt{2}$$

40. Depends on formula.

41. The maximum angle will be A $2C$ where C is the critical angle

Now, C $\sin^{1}\frac{1}{1.5}$ 41.81

Hence A $2C$ 2 41.81 83.62

42. $$\frac{\sin \frac{A \quad m}{2}}{\sin \frac{A}{2}}$$ here A 60

$$1.5 \quad \frac{\sin \frac{60 \quad m}{2}}{\sin 30}$$

$$0.75 \quad \sin \frac{60 \quad m}{2}$$

$$60 \quad m \quad 2\sin^{1}(0.75)$$

$$m \quad 22.8$$

and not deviation 180 22.8 157.2

(b) If the system is placed in water

$$\frac{1.5}{4/3} \quad \frac{4.5}{4}$$

$$60 \quad m \quad 2\sin^{1}(1.125 \quad \sin 30\ )$$

$$m \quad 2\sin^{1}\frac{1.125}{2} \quad 60$$

Net deviation 180 m 128.4

43. $$\frac{V \quad R}{Y \quad 1}$$

$$0.0305 \quad \frac{1.665 \quad 1.645}{y \quad 1}$$

On solving we get y 1.656

44. $\frac{1}{f_1} \quad \frac{2}{f_2} \quad 0$

$$\frac{0.18}{20} \quad \frac{2}{30} \quad 2 \quad \frac{0.18 \quad 30}{20}$$

$$2 \quad 0.27$$

Now, $$\frac{1}{F} \quad \frac{1}{f_1} \quad \frac{1}{f_2} \quad \frac{1}{F} \quad \frac{1}{20} \quad \frac{1}{30}$$

$$F \quad 60\,\text{cm}$$

45. $\frac{1}{f_1} \quad \frac{2}{f_2} \quad 0$

$$\frac{1}{2} \quad \frac{f_1}{f_2}$$

$$\frac{3}{2} \quad \frac{f_1}{f_2}$$

$$f_1 \quad \frac{3}{2}f_2$$

Now, $$\frac{1}{F} \quad \frac{1}{f_1} \quad \frac{1}{f_2}$$

$$\frac{1}{150} \quad \frac{1}{f_2} \quad \frac{2}{3f_2}$$

f_2 50 cm and f_1 75 cm

46. Applying $\frac{\sin i_1}{\sin r_1}$

Find angle r_1 for two different refraction indices. Because i_1 65 from both the cases.

Then again apply

$\frac{\sin i_2}{\sin r_2}$ and find i_2. Because r_2 A r_1.

Then apply :

$$(i_1 \quad i_2) \quad A$$

for two refraction indices. Then difference in deviations is :

$$1 \quad 2$$

Objective Questions (Level-1)

1. Endoscope is bases on total internal refraction Hence, correct option is (c)

2. Here $A \quad \frac{B}{^2}$

$\because$ is dimensionless.

$\frac{B}{^2}$ dimension of

$B \quad ^2 \quad B$ has dimension of Area

Hence, correct option is (d).

3. Shift $1 \quad \frac{1}{}$

$\because$ $_R$ is minimum. than other visible colour. Red colour least raised.

correct option is (c)

4. Critical angle $_C \quad \sin^{1} \frac{1}{}$

$\because$ $_0$ is maximum for violet colour hence $_c$ for violet colour is least.

Hence correct option is (d)

5. We have $P \quad \frac{1}{f(\text{metre})}$

$$\frac{100}{f(\text{cm})} \quad 100 \quad (n \quad 1) \quad \frac{1}{R} \quad \frac{1}{r}$$

$$P \quad \frac{100 \quad 0.6 \quad 2}{10} \quad 12$$

Hence, correct option is (a).

6. Speed of light in water $\frac{c}{_w}$

$$v_w \quad \frac{3 \quad 10^8}{4/3} \quad 2.25 \quad 10^8 \text{ m/s}$$

Hence correct option os (c).

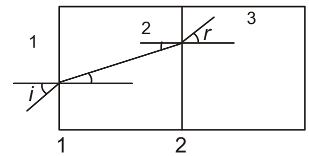
7. Due to TIR emergent beam will turn into black.

Hence correct option is (c).

8. $\because v \quad n$ but frequency n remain constant and v decreases hence decreases.

Hence correct option is (b).

9. Using Snell's law



On first and 2nd interface

$$\frac{\sin i}{\sin} \quad \frac{_2}{_1} \qquad \ldots(i)$$

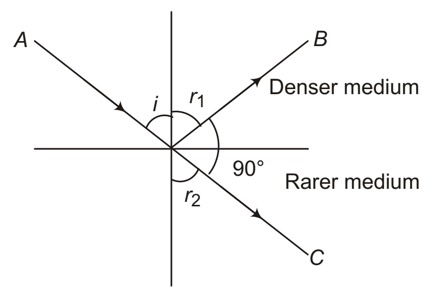
and $$\frac{\sin}{\sin r} \quad \frac{_3}{_2} \qquad \ldots(ii)$$

Multiplying (i) and (ii), we get

$$\frac{\sin i}{\sin r} \quad \frac{_3}{_1}$$

Hence correct option is (b).

10. We have $i \quad r_1$ and $r_2 \quad 90 \quad i$



Now $$\frac{\sin i}{\sin r_2} \quad \frac{1}{}$$

$$\frac{\sin i}{\sin (90 \quad i)} \quad \frac{1}{}$$

$$\tan i \quad \frac{1}{} \qquad \ldots(i)$$

If C is the critical angle then $C \quad \sin^{1} \frac{1}{}$

$$C \quad \sin^{1}(\tan i)$$

Hence correct option is (a).

11. Let angle of minimum deviation is $_m$ we know that

$$\frac{\sin \frac{A \quad _m}{2}}{\sin \frac{A}{2}}$$

$$\sqrt{2} \quad \frac{\sin \frac{(60 \quad _m)}{2}}{\sin 30}$$

$$\frac{1}{\sqrt{2}} \quad \sin \frac{60 \quad _m}{2}$$

$$\frac{60 \quad _m}{2} \quad 45 \qquad _m \quad 30$$

Hence correct option is (a).

12. We know that

$$\frac{1}{f} \quad (n \quad 1) \frac{1}{R_1} \quad \frac{1}{R_2}$$

$$\frac{1}{a^2} \quad (1.5 \quad 1) \frac{1}{R_1} \quad \frac{1}{R_2}$$

$$\frac{1}{0.2} \quad (0.5 \quad 1) \frac{1}{R_1} \quad \frac{1}{R_2} \qquad \text{...(i)}$$

Let refractive index of the liquid s n_l

$$\frac{1}{f_{cm}} \quad \frac{n}{n_l} \quad 1 \quad \frac{1}{R_1} \quad \frac{1}{R_2}$$

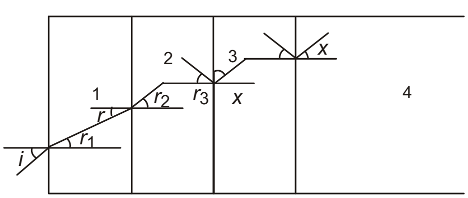
$$\frac{1}{0.5} \quad \frac{1.5}{n_l} \quad 1 \quad 10$$

$$\frac{1}{5} \quad \frac{1.5}{n_l} \quad 1$$

$$\frac{1.5}{n_l} \quad \frac{4}{5} \quad \frac{5 \quad 1.5}{4} \quad n_l \qquad n_l \quad \frac{15}{8}$$

Hence correct option is (b).

13.



We have, $\frac{\sin i}{\sin r_1} \quad \frac{}{1}$ ...(i)

$$\frac{\sin r_1}{\sin r_2} \quad \frac{2}{1} \qquad \text{...(ii)}$$

and $\frac{\sin r_2}{\sin r_3} \quad \frac{3}{2}$ ...(iii)

$$\frac{\sin r_3}{\sin x} \quad \frac{4}{3} \qquad \text{...(iv)}$$

Multiplying (i), (ii), (iii) and (iv), we get

$$\frac{\sin i}{\sin x} \quad \frac{4}{} \qquad \sin x \quad \frac{}{4} \sin i$$

Hence correct option is (b)

14. Let radius of curvature of the lens is R

then $\frac{1}{f} \quad (n \quad 1) \frac{1}{R} \quad \frac{1}{R} \qquad f \quad \frac{R}{2(x \quad 1)}$

Let focal length of one part is f

then $\frac{1}{f} \quad (n \quad 1) \frac{1}{R} \quad \frac{1}{}$

$$f \quad \frac{R}{(n \quad 1)} \quad 2f$$

The focal length of the combination is

$$\frac{1}{F} \quad \frac{1}{2f} \quad \frac{1}{2f} \quad \frac{1}{2f} \quad \frac{1}{2f} \qquad F \quad \frac{f}{2}$$

Hence correct option is (b).

15. Here $P \quad 5\text{D} \quad f \quad 20\,\text{cm}$

$$\frac{1}{20} \quad (1.5 \quad 1) \frac{1}{R_1} \quad \frac{1}{R_2} \qquad \text{...(i)}$$

and $\frac{1}{100} \quad \frac{1.5}{n_e} \quad 1 \quad \frac{1}{R_1} \quad \frac{1}{R_2}$ ...(ii)

Dividing Eq. (ii) by (i) $\frac{1}{5} \quad \frac{\frac{1.5}{n_l} \quad 1}{0.5}$

$$\frac{1}{10} \quad 1 \quad \frac{1.5}{n_l}$$

$$n_l \quad \frac{5}{3}$$

Hence correct option is (b).

16. We know that

$$\frac{1}{F} \quad \frac{1}{f_1} \quad \frac{1}{f_2} \quad \frac{d}{f_1 f_2}$$

$\because$ whole system is concave $\quad F \quad 0$

$$\frac{d}{f_1 f_2} \quad \frac{1}{f_1} \quad \frac{1}{f_2} \quad d \quad f_1 \quad f_2$$

$$d \quad (10 \quad 20)\,\text{cm} \qquad d \quad 30\,\text{cm}$$

Hence only possible value of the given values is 40 cm.

Hence correct option is (d).

17. Since when $A \quad 2\ _c$ total light is reflect (TIR) take place hence maximum value of A is $2\ _c$.

Hence correct option is (c).

18. $\because$ emergent ray is to the surface

$$i_2 \quad r_2 \quad 0$$

$\because \qquad r_1 \quad r_2 \quad A \quad r_1 \quad A$

Now $\qquad \dfrac{\sin i}{\sin A}$

Since i and A are small

$$\sin i \sim i \text{ and } \sin A \sim A$$

$$\frac{i}{A} \quad i \quad A$$

Hence correct option is (c).

19. $\dfrac{\sin \dfrac{A \quad _m}{2}}{\sin \dfrac{A}{2}}$

$$\cot \frac{A}{2} \quad \frac{\sin \dfrac{A \quad _m}{2}}{\sin \dfrac{A}{2}}$$

$$\frac{A \quad _m}{2} \quad 90 \quad \frac{A}{2}$$

$$A \quad _m \quad 180 \quad A$$

$$_m \quad 180 \quad 2A$$

Hence correct option is (d).

20. Minimum deviation condition

$$r_1 \quad r_2 \quad r \quad 90 \quad r \quad 90 \quad r \quad A \quad 180$$

$$A \quad 2r$$

$$r \quad \frac{A}{2} \quad 30$$

Now $\qquad \dfrac{\sin i}{\sin r}$

$$\sqrt{2} \quad \frac{\sin i}{\sin 30}$$

$$\sin i \quad \frac{1}{\sqrt{2}}$$

$$i \quad 45$$

Hence correct option is (a).

21. $\dfrac{1}{F} \quad \dfrac{1}{f_1} \quad \dfrac{1}{f_1} \quad \dfrac{d}{f_1 f_2}$ ...(i)

$$\frac{1}{2F} \quad \frac{1}{f_1} \quad \frac{1}{f_2} \quad \frac{2d}{f_1 f_2} \qquad \text{...(ii)}$$

$$\frac{1}{F} \quad \frac{1}{f_1} \quad \frac{1}{f_2} \quad \frac{4d}{f_1 f_2} \qquad \text{...(iii)}$$

On solving (i) , (ii) and (iii) we get $F \quad 2F$.

Correct option is (a).

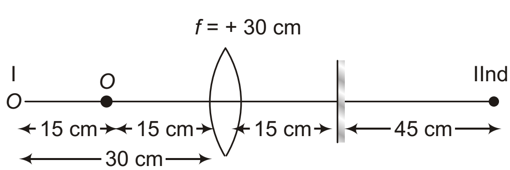
22. $\left|\dfrac{1}{f}\right| \quad (n \quad 1)\left|\dfrac{1}{R_1} \quad \dfrac{1}{R_2}\right|$

$$\frac{1}{24} \quad (1.5 \quad 1)\left|\frac{1}{R} \quad \frac{1}{2R}\right|$$

$$\frac{1}{24} \quad \frac{0.5}{2R} \quad R \quad 6 \text{ and } 2R \quad 12$$

Hence correct option is (a).

23. The system is shown in figure.



Using $\qquad \dfrac{1}{v} \quad \dfrac{1}{u} \quad \dfrac{1}{f}$

$$\frac{1}{v} \quad \frac{1}{(\ \ 15)} \quad \frac{1}{30} \quad v \quad 30\,\text{cm}$$

This image I_1 act as a virtual object for mirror since plane mirror form image at same distance as object. Hence the distance between object and image is $(30 \quad 45)\,\text{cm} \quad 75\,\text{cm}$.

Hence correct option is (c).

24. $\dfrac{\sin 45}{\sin r_1} \quad \sqrt{3}$ ...(i)

$$\frac{\sin r_1}{\sin r_2} \quad \sqrt{\frac{2}{3}}$$

Multiplying Eq. (i) and (ii)

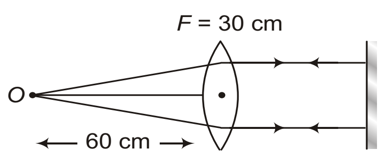
$$\frac{\sin 45}{\sin r_2} \quad \sqrt{2}$$

$$\sin r_2 \quad \frac{1}{2}$$

$$r_2 \quad 30$$

Hence correct option is (a).

25. For small angle prism



$_{\min} \quad (\quad 1)\, A$ if increases

$_{\min}$ increases

Hence correct option is (a)

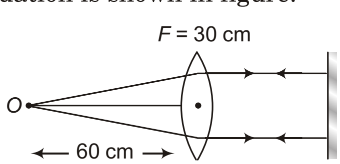
26. $\dfrac{\sin i}{\sin r} \quad \dfrac{n_2}{n_1} \quad \dfrac{\sin i}{\sin \dfrac{i}{2}} \quad n$

$\because r \quad \dfrac{i}{2}$

$$2\cos\frac{i}{2} \quad n \qquad i \quad 2\cos^{\ 1}\frac{n}{2}$$

Hence correct option is (c).

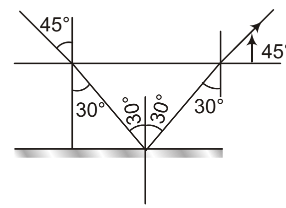
27. Situation is shown in figure.



Since image after reflection form on object itself hence the object must be placed at focus of the lens. The rays after refraction by lens becomes parallel to optic axis. Hence reflection rays follow the same path and final image form on x itself. Hence $x \quad 30\,\text{cm}$.

Correct option is (b).

28. $\dfrac{\sin 45}{\sin r} \quad \sqrt{2} \quad \sin r \quad \dfrac{1}{2} \quad r \quad 30$



hence total deflection $45 \quad (\quad 45\ ) \quad 90$

Hence correct option is (a).

29. $$\frac{\sin \dfrac{A \qquad _m}{2}}{\sin \dfrac{A}{2}}$$

$$\sqrt{\frac{3}{2}} \quad \frac{\sin \dfrac{90 \qquad _{m,}}{2}}{\sin 45}$$

$$\sin \frac{90 \quad _m}{2} \quad \frac{\sqrt{3}}{2} \quad \sin 60$$

$$_m \quad 30$$

Hence correct option is (c)

30. $\dfrac{1}{f} \quad (n \quad 1)\ \dfrac{1}{R_1} \quad \dfrac{1}{R_2}$

here $\quad n \quad \dfrac{n_{\text{air}}}{n_{\text{glass}}} \quad \dfrac{1}{1.5}$

$$\frac{1}{f} \quad \frac{1}{1.5} \quad 1 \quad \frac{1}{10} \quad \frac{1}{10}$$

$f \qquad 15\,\text{cm}$. Hence lens is concave

Correct option is (a).

31. For lens $u \quad 12$ cm and $F \quad 10$ cm

We have $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$

$$\frac{1}{v} \quad \frac{1}{12} \quad \frac{1}{10}$$

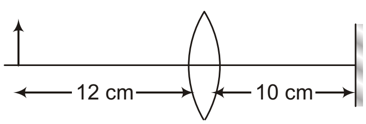
$$v \quad 60 \text{ cm}$$

Since the distance between lens and mirror is 10 cm. Hence the image formed 50 cm from convex mirror. The rays retrace its path if image is formed at the centre of curvature of the mirror *i.e.,*

$$R_{\text{convex}} \quad 50 \text{ cm} \quad F \quad \frac{R}{2} \quad 25 \text{ cm}$$

Hence the correct option is (b)

32.



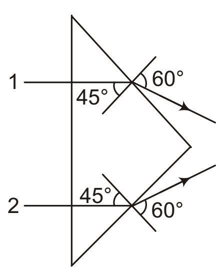
Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f} \quad \frac{1}{v} \quad \frac{1}{(\;12)} \quad \frac{1}{20}$

$$v \quad 30 \text{ cm}$$

Hence the distance between mirror and this image is 40 cm. Therefore second image formed 40 cm behind the mirror.

Hence correct option is (c).

33. We have $\frac{\sin i}{\sin r}$



$$\frac{\sqrt{2}}{\sqrt{3}} \quad \frac{\sin 45}{\sin r}$$

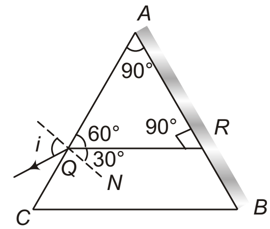
$$\sin r \quad \frac{\sqrt{3}}{2} \quad r \quad 60 \text{ (on both faces)}$$

Hence the angle between emergent ray

$$90 \quad (30 \quad 30\;) \quad 30$$

Hence correct option is (b).

34.



Since the ray retrace its path hence $ARQ \quad 90 \qquad RQN \qquad r \quad 30$

$$\frac{\sin i}{\sin r} \quad \sin i \quad \sin r \quad \sqrt{2} \quad \sin 30$$

$$\sin i \quad \frac{1}{\sqrt{2}} \quad i \quad 45$$

Hence correct option is (c).

35. $f \quad 10$ cm

the focal length of $\frac{1}{F} \quad \frac{1}{10} \quad \frac{1}{10}$

$$F \quad 5 \text{ cm}$$

Here $u \quad 7.5$ cm, $F \quad 5$ cm

$$\frac{1}{v} \quad \frac{1}{7.5} \quad \frac{1}{5} \quad \frac{1}{v} \quad \frac{7.5 \quad 5}{7.5 \quad 5}$$

$$v \quad 15 \text{ cm}$$

Hence $|m| \quad \left|\frac{v}{u}\right| \quad \frac{\text{height of image}}{\text{height of object}} \quad \frac{15}{7.5}$

Height of image $\quad 2 \quad 1$ cm $\quad 2$ cm

Hence correct option is (a).

36. $\frac{n_2}{v} \quad \frac{n_1}{u} \quad \frac{n_2 \quad n_1}{R}$

$$\frac{1}{v} \quad \frac{3}{2}\frac{1}{(\;)} \quad \frac{(3/2 \quad 1)}{20}$$

$$v \quad 40 \text{ cm}$$

Hence correct option is (a).

37. $\frac{1}{f} \quad \frac{n_g}{n_L} \quad 1 \quad \frac{1}{R_1} \quad \frac{1}{R_2}$

Here $R_1 \quad 30$ cm and $R_2 \quad 50$ cm

$$\frac{1}{f} \quad \frac{1.5}{1.4} \quad 1 \quad \frac{1}{30} \quad \frac{1}{50}$$

On solving

$$f \quad 1050\,\text{cm}$$

Hence correct option is (d).

38. From the figure, it is clear that $\quad_1 \quad_3 \quad_2$

Hence correct option is (b).

39. Here $A \quad 60$, $\quad_m \quad 60$

$$\frac{\sin \dfrac{A \qquad_m}{2}}{\sin \dfrac{A}{2}} \quad \frac{\sin 60}{\sin 30}$$

$$\frac{\sqrt{3}/2}{1/2} \quad \sqrt{3}$$

Hence correct option is (a).

JEE Corner

Assertion and Reason

1. Due to shifting of image on refraction Shayam appear nearer to Ram and light suffer two refraction. Hence, both (a) and (b) are correct but reason does not explain the assertion.

Correct option is (b).

2. Applying lens formula

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$$

Let u object distance from lens

$v \quad d \quad u$ distance of image from lens.

$\because \quad v \quad u \quad d$

$$\frac{1}{d \quad u} \quad \frac{1}{u} \quad \frac{1}{f}$$

$$u^2 \quad du \quad df \quad 0$$

$$u \quad \frac{d \quad \sqrt{d \quad 4f}}{2}$$

$\because u$ is real hence $d \quad 4f$

Thus mean distance $v \quad 4f$, if $u \quad 2f, v \quad 2f$. Hence both assertion and reason are true, and reason explain or may not explain assertion. Hence correct option is (a, b)

3. Correct option is (b).

4. Correct option is (c).

5. Since both assertion and reason are true built reason is not explain assertion Hence correct option is (b).

6. Using mirror formula.

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$$

Here $\quad u$

$$f \quad f \text{ (concave lens)}$$

$$\frac{1}{v} \quad \frac{1}{\quad} \quad \frac{1}{f}$$

$$v \quad f$$

Hence image is formed at principle focus thus assertion is false but reason is true. Hence correct option is (d).

7.
$$\frac{\sin \dfrac{A \qquad_m}{2}}{\sin A / 2}$$

Here $\quad A \quad 60$, $\quad \sqrt{2}$

$$\sqrt{2} \quad \frac{\sin \dfrac{60 \qquad_m}{2}}{\sin 30}$$

$$\frac{60 \qquad_m}{2} \quad 450 \qquad_m \quad 30$$

Hence both assertion and reason are true and reason explain assertion correctly.

Correct option is (a).

8. Focal length of combination

$$\frac{1}{F} \quad \frac{1}{F_{\text{convex}}} \quad \frac{1}{F_{\text{convex}}} \quad \frac{1}{f_1} \quad \frac{1}{f_2}$$

if $\qquad f_1 \quad f_2$

$$\frac{1}{f_1} \quad \frac{1}{f_2}$$

$F \qquad$ negative

Hence assertion is true. Since power is a measure of converging or divergence of a lens. Hence reason is not true. Correct option is (c).

9. Since glass slab produced a net shift. Hence v is increased. Thus magnified image is obtained but image may be real or virtual depending on the position of slab.

Correct option is (b)

10. In this case image distance of O_1 and O_2 are same from the lens.

$\because \ \frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$ and reason is trure.

Hence correct option is (d).

11. Assertion is false since only ray energe if refractve index of the colour less than the prism and angle of incidence is less than critical angle but reason is true. Correct option is (a).

12. If two object is placed between pole and focus image is real hence assertion is true. Also reason is correct.

Hence correct option is (b)

13. Since both assertion and reason are true and reason explanation is correct.

Hence correct option is (a).

Objective Questions (Level 2)

Single option correct

1. We have $\dfrac{\text{Real depth}}{\text{App. depth}}$

$$\frac{4}{3} \quad \frac{1}{\text{App. depth}}$$

$$\text{App. depth} \quad \frac{3}{4}$$

Hence the distance between bird and mirror

$$2 \quad \frac{3}{4} \quad \frac{11}{4}\,\text{m}$$

Since plane mirror form image behind the mirror (for real object) at same distance as object hence the distance between bird and its image

$$\frac{11}{4} \quad \frac{11}{4} \quad \frac{11}{2}\,\text{m}$$

Correct option is (d).

2. $\dfrac{{}_2}{v} \quad \dfrac{{}_1}{u} \quad \dfrac{{}_2 \quad {}_1}{R}$

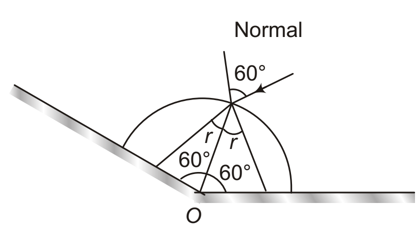
Here $\qquad u_1 \quad 1$

and $\qquad {}_2 \quad 1.5$

$$\frac{1.5}{v} \quad \frac{1}{} \quad \frac{0.5}{R} \qquad v \quad 3R$$

Hence correct option is (b).

3. From figure, $r \quad 30$



$\because \ r \qquad 90 \quad 120 \quad 90$

Hence $\frac{\sin 60}{\sin 30} \quad \sqrt{3}$

The correct option is (d).

4. The lens become diverging if

$$\begin{matrix} 1 & 2 & 2 & 3 \\ 1 & 3 & 2 & 2 \end{matrix}$$

or $\quad 2_2 \quad 1 \quad 3$

Hence correct option is (b).

5. $\frac{1}{v_1} \quad \frac{1}{16} \quad \frac{1}{f} \qquad v_1 \quad \frac{16f}{16 \quad f}$

$$m_1 \quad \frac{v_1}{16} \quad \frac{16f}{16(16 \quad f)} \quad \frac{f}{(16 \quad f)} \qquad \ldots\text{(i)}$$

and $\quad \frac{1}{v_2} \quad \frac{1}{6} \quad \frac{1}{f} \qquad v_2 \quad \frac{6f}{6 \quad f}$

$$_2 \quad \frac{v_2}{6} \qquad (\because \text{image is virtual})$$

$$m_2 \quad \frac{6f}{6(6 \quad f)} \quad \frac{f}{6 \quad f} \qquad \ldots\text{(ii)}$$

But $\quad m_1 \quad m_2 \quad \frac{f}{16 \quad f} \quad \frac{f}{6 \quad f}$

$$6 \quad f \quad 16 \quad f \qquad 2f \quad 22$$

$$f \quad 11\,\text{cm}$$

Hence correct option is (d).

6. Let real depth at any instant t of the water is h then volume of water $V \quad R^2 h$

$$\frac{dV}{dt} \quad R^2 \frac{dh}{dt} \qquad \ldots\text{(i)}$$

Let apparent depth at this instant is h

$$\because \quad \frac{\text{Real depth}}{\text{Apparent depth}}$$

$$\frac{n_2}{n_1} \quad \frac{h}{h_1} \qquad h_1 \quad \frac{n_1}{n_2} h$$

Now $\quad \frac{dh}{dt} \quad x \quad \frac{n_1}{n_2} \frac{dh}{dt}$

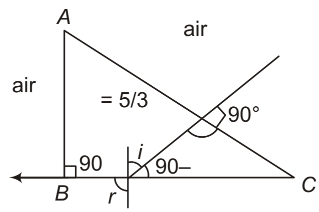
$$\frac{dh}{dt} \quad \frac{xn_2}{n_1} \qquad \ldots\text{(ii)}$$

From Eq. (i) and (ii), we get

$$\frac{dV}{dt} \quad \frac{R^2 xn_2}{n_1}$$

Hence correct option is (b).

7.



$\because \quad 37 \qquad i \quad [90 \quad (90 \quad)] \qquad 37$

Applying Snell's law on face BC.

$$\frac{\sin 37}{\sin r} \quad \frac{_2}{_1} \quad \frac{3}{5}$$

$$\sin r \quad \frac{4}{3} \sin 37 \quad \frac{5}{3} \quad \frac{3}{5} \quad 1$$

$$r \quad 90$$

Hence deviation $\quad 90 \quad 37 \quad 127$

Correct option is (b).

8. Let refractive index of liquid is

For position of fish w.r.t. bird is

$$\frac{\text{Real depth}}{\text{App. depth}} \qquad \frac{x}{h_1} \qquad \ldots\text{(i)}$$

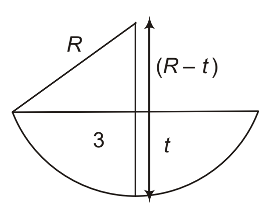
For position of bird w.r.t. fish is

$$\frac{1}{} \quad \frac{y}{h_2} \qquad \ldots(2)$$

From Eq. (i) and (ii) we get $u \quad \frac{h_2}{h_1}$

Hence correct option is (a).

9.



$$(R \quad t)^2 \quad 3^2 \quad R^2$$

$$2Rt \sim 9 \quad \because R \qquad T$$

$$2R \quad \frac{900\,\text{mm}}{3\,\text{mm}} \quad 300\,\text{mm}$$

$$R \quad 150\,\text{mm} \quad 15\,\text{cm}$$

Hence correct option is (a).

10. $\frac{1}{v_1} \quad \frac{1}{v_1} \quad \frac{1}{f} \qquad v_1 \quad \frac{fv_1}{v_1 \quad f}$

$$m_1 \quad \frac{v_1}{v_1} \quad \frac{f}{(v_1 \quad f)} \qquad \ldots\text{(i)}$$

$$\frac{1}{v_2} \quad \frac{1}{v_2} \quad \frac{1}{f} \qquad v_2 \quad \frac{fv_2}{v_2 \quad f}$$

$$m_2 \quad \frac{v_2}{v_2} \quad \frac{f}{{}_2 \quad f} \qquad \ldots\text{(ii)}$$

$\because \quad m_1 \quad m_2$

$$\frac{f}{v_1 \quad f} \quad \frac{f}{v_2 f} \qquad f \quad \frac{v_1 \quad v_2}{2}$$

Hence the correct option is (d).

11. $\frac{1}{F} \quad \frac{1}{f_1} \quad \frac{1}{f_2} \quad \frac{d}{f_1 f_2}$

$$F \quad \frac{f_1 f_2}{f_1 \quad f_2 \quad d}$$

as d increases $f_1 \quad f_2 \quad d$ decreases hence F increases. Hence image move to right.

Correct option is (b).

12. In this case, minimum deviation of ray 1 is same as ray 2.

Hence correct option is (c).

13. For critical angle at glass air surface

$$\sin \ _c \quad \frac{1}{_g} \quad \frac{2}{3} \qquad \ldots\text{(i)}$$

Now for glass water surface.

$$\frac{_w}{_g} \quad \frac{\sin \ _c}{\sin r} \quad \frac{4/3}{3/2} \quad \frac{2}{3 \quad \sin r}$$

$$\sin r \quad \frac{4}{3}$$

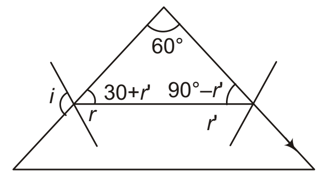
Now for water air surface

$$\frac{_w}{_a} \quad \frac{\sin r}{\sin r} \quad \frac{4}{3} \quad \frac{4}{3} \quad \frac{1}{\sin r}$$

$$\sin r \quad 1 \quad r \quad 90$$

Hence correct option is (d).

14. For limiting angle of incident emergent ray become parallel to the 2nd face



$\because \qquad \frac{\sin r}{\sin 90} \quad \sqrt{\frac{3}{7}} \qquad r \quad \sin^{1}\sqrt{\frac{3}{7}}$

Now $r \quad 30 \quad r \quad 90$

$$r \quad 60 \quad r$$

$$r \quad (60 \quad \sin^{1}\sqrt{3/7})$$

Now $\quad \frac{\sin i}{\sin r}$

$$\sqrt{\frac{7}{3}} \quad \frac{\sin i}{\sin[60 \quad \sin^{1}\sqrt{3/7}]}$$

$$i \quad \sin^{1}\{\sqrt{7/3} \quad \sin(60 \quad \sin^{1}\sqrt{3/7}\}$$

$$\sin^{1}\sqrt{\frac{7}{3}} \quad \sin(60 \quad 21\ )$$

$$\sin^{1}\{\sqrt{7/3} \quad \sin 19\ \}$$

$$\sin^{1}\{0.49\} \sim 30$$

Hence correct option is (a).

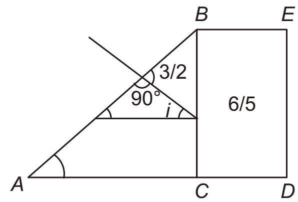
15. The image form the object itself if the rays incident parallel to optical axis on the mirror *i.e.,* image of refraction is formed at . It is possible when O is placed at focus *i.e.,* $d \quad 10\,\text{cm}$

Hence correct option is (c).

16. The dot will appear at c for all values of .
Since position does not in same medium.

Hence correct option is (b).

17. We have for total internal reflection



$$\frac{\sin i}{\sin 90} \quad \frac{6/5}{3/2}$$

$$\sin i \quad \frac{4}{5} \qquad i \quad \sin^{1} \frac{4}{5} \qquad 53$$

Hence the ray will not cross BC if $i \quad 53$

$$90 \qquad i \quad 180$$

$$90 \quad i \because i \quad 53$$

$$37$$

Hence correct option is (a).

18. For reflection at curved surface

$$\frac{1}{v} \quad \frac{1}{(\ \ x)} \quad \frac{3}{2} \quad 1 \quad \frac{1}{10}$$

$$v \quad \frac{20x}{x \quad 20}$$

This image act as virtual object for plane-glass-water surface

$$\frac{\ \ _g}{} \quad \frac{_w(x \quad 20)}{20x} \quad \frac{_g \qquad _w}{}$$

$$x \quad 20\,\text{cm}$$

Hence answer is (c).

19. The ratio of focal length in the situation II and III is 1 : 1.

Hence correct option is (c).

20. We have $\frac{1}{OB} \quad \frac{1}{(\ \ OA)} \quad \frac{1}{f}$

$$\frac{1}{OB} \quad \frac{1}{OA} \quad \frac{1}{f}$$

$$f \quad \frac{OB.OA}{OA \quad OB} \because OB \quad OA \quad AB$$

$$f \quad \frac{OB.OA}{AB} \qquad \text{...(i)}$$

Now $AB^2 \quad AC^2 \quad BC^2$

$$(OA \quad OB)^2 \quad OC^2 \quad OA^2 \quad OB^2 \quad OC^2$$

$$OA^2 \quad OB^2 \quad 2OAOB \quad 20C^2 \quad OA^2 \quad OB^2$$

$$OC^2 \quad OA\,OB \qquad \text{...(ii)}$$

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

$$f \quad \frac{OC^2}{AB}$$

Hence correct option is (c).

21. The shift produce

$$t \quad t\ 1 \quad \frac{2}{_w \quad _g}$$

$$36\ 1 \quad \frac{1}{9/8} \because {_w} \quad {_g} \quad \frac{3/2}{4/3} \quad \frac{9}{8}$$

$$\frac{36 \quad 1}{9} \quad 4\text{ cm}$$

Hence correct option is (b).

22. $\frac{\text{Real depth}}{\text{App. depth}}$

$$\frac{4}{3} \quad \frac{\text{real depth}}{10.5\,\text{cm}}$$

$$\text{Real depth} \quad \frac{4}{3} \quad 10.5\,\text{cm} \quad 14\text{ cm}$$

Hence correct option is (d).

23. $\because y_0 \quad 1\,\text{cm and } y_i \quad 2\,\text{cm}$

$$m \quad \frac{v}{u} \quad 2 \quad \frac{v}{u}$$

Now let x be the position of lens then $v \quad 50 \quad x$ and $v \quad (40 \quad x)$.

$$2 \quad \frac{50 \quad x}{40 \quad x}$$

$$80 \quad 2x \quad 50 \quad x$$

$$3x \quad 30 \quad x \quad 10\,\text{cm}$$

Hence correct option is (c).

24. If the plane surface of plano-convex lens is silvered it behave the concave mirror of focal length $f_m/2$

$\because \quad f_m \quad 10\,\text{cm}$

$f_e \quad 5\,\text{cm hence } R \quad 10\,\text{cm}$

Correct option is (c).

25. Since lens made real and magnified image, hence it is a convex lens when lens dipped in water its focal length.

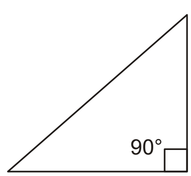
$$\frac{1}{f} \quad \frac{w}{g} \quad 1 \quad \frac{1}{R_1} \quad \frac{1}{R_2}$$

$$\frac{4/3}{3/2} \quad 1 \quad \frac{1}{R_1} \quad \frac{1}{R_2} \qquad \frac{1}{9} \quad \frac{1}{R_1} \quad \frac{1}{R_2}$$

$\because f$ is ve lens behave as concave, hence the image is virtual and magnified.

Correct option is (c).

26. The prism transmit the light for which angle of incidence(c), $2c \quad 90 \quad c \quad 45$



Hence $\quad \frac{1}{\sin C} \quad \frac{1}{\sin 45} \quad \sqrt{2} \quad 1.414$

Correct option is (b).

27. $\frac{1}{v} \quad \frac{1}{(\ \ 16)} \quad \frac{1}{f} \because |m| \quad \left|\frac{v}{u}\right| \quad 3$

For convex lens $v \quad 3u$

$\frac{1}{48} \quad \frac{1}{16} \quad \frac{1}{f} \quad f \quad 12\,\text{cm}$ (for real image)

Similarly when distance is 6 cm, 3 times virtual image is formed hence mirror is convex with focal length 12 cm.

Correct option is (c).

28. $v_g \quad n \;_g \quad \frac{c}{g} \quad n \;_g$ ...(i)

and $\quad \frac{c}{w} \quad n \;_w$ ...(ii)

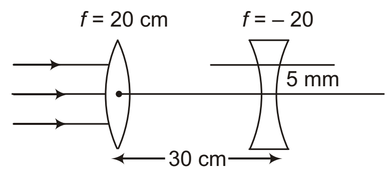
Dividing (i) and (ii)

$$\frac{w}{g} \quad \frac{g}{w} \quad \frac{4}{3\ g} \quad \frac{4}{5}$$

$$_g \quad \frac{5}{3}$$

Hence correct option is (a).

29. $x \quad \frac{f_1 f_2 \quad d(f_1 \quad d)}{f_1 \quad f_2 \quad d}$ and $y \quad \frac{(f_1 \quad d)}{f_1 \quad f_2 \quad d}$



Here $f_1 \quad f_2 \quad 20\,\text{cm}, d \quad 30\,\text{cm}$

and $\quad 55\text{m} \quad 0.5\,\text{cm}$

Putting these values we get

$x \quad 25\,\text{cm}$ and $y \quad 0.25\,\text{cm}$

Correct option is (b).

30. Since for each angle of incidence at glass-air boundry remains 0° hence there will never be total internal reflection.

Correct option is (d).

31. Diameter $\qquad$ Original diameter

$$\frac{4}{3} \quad 1\,\text{cm} \quad \frac{4}{3}\,\text{cm}$$

Hence correct option is (a).

32. $\frac{1}{f_1} \quad (1.5 \quad 1) \quad \frac{1}{20} \quad \frac{1}{20}$

$f_1 \quad 20\,\text{cm}$

Here $u_1 \quad 30\,\text{cm}$

$$\frac{1}{v} \quad \frac{1}{u_1} \quad \frac{1}{f_1} \quad \frac{1}{v_1} \quad \frac{1}{20} \quad \frac{1}{30} \quad v_1 \quad 60\,\text{cm}$$

Magnification $|m_1| \quad \left|\frac{v}{u}\right| \quad \frac{60}{30} \quad 2$

(Inverted image)

For second lens. $\frac{1}{v_2} \quad \frac{1}{60} \quad \frac{1}{20} \quad v_2 \quad\quad 30\,\text{cm}$

Magnification $|m_2| \quad \left|\frac{30}{60}\right| \quad \frac{1}{2}$

Total magnification $\quad m_1 \quad m_2 \quad 1$

Hence object size remains 3mm and it is formed at $(120 \quad 30)$ cm $\quad$ 50 cm from first lens.

Hence correct option is (b).

33. From left hand side refraction occur from $n_2 \quad 2$ to $n_1 \quad 1$.

$$n \quad \frac{n_1}{n_2} \quad \frac{1}{2} \quad 0.5$$

$$\frac{n}{v} \quad \frac{1}{u} \quad \frac{n \quad 1}{R}$$

$$\frac{0.5}{v} \quad \frac{1}{10} \quad \frac{0.5}{10} \quad \frac{1}{10} \quad \frac{0.5}{10}$$

$$v \quad 10\,\text{cm}$$

Hence correct option is (a).

34. For lens $v \quad\quad 20\,\text{cm},\ f \quad\quad 10\,\text{cm}$

Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$ we get $v \quad 20\,\text{cm}$

This image acts virtual object for convex mirror. For mirror $v \quad\quad (x \quad 20)$

and $v \quad\quad (20 \quad x)$ and $f \quad\quad 60\,\text{cm}$

Using $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$

$$\frac{1}{(20 \quad x)} \quad \frac{1}{(x \quad 20)} \quad \frac{1}{60}$$

After solving we get $x \quad 20\,\text{cm}$.

Hence correct option is (c).

35. In this case system behave as concave mirror or focal length $\quad\quad f_e$

$$1.5 \quad 20 \quad 30\,\text{cm}$$

Now using mirror formula

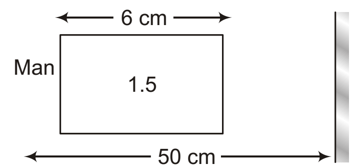
$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f} \text{ we get}$$

$$\frac{1}{v} \quad \frac{1}{20} \quad\quad \frac{1}{30}$$

$$\frac{1}{v} \quad \frac{1}{20} \quad \frac{1}{30} \quad v \quad\quad 60\,\text{cm}$$

Hence correct option is (d).

36. Shift in mirror $\quad 6 \quad 1 \quad \frac{1}{1.5} \quad\quad 2\,\text{cm}$



Hence man lie at 48 cm from mirror. The distance of image from observer $\quad 2 \quad 48$

$$96\,\text{cm}$$

Hence correct option is (b).

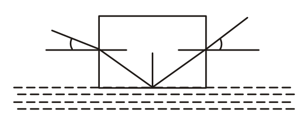
37. Using lens formula $\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$

$$\frac{1}{(f \quad 40)} \quad \frac{1}{(f \quad 10)} \quad \frac{1}{f}$$

On solving we get $f \quad 20\,\text{cm}$

Hence correct option is (c).

38.



$$\frac{\sin}{\sin(90 \quad\ _c)} \quad n_1$$

$$\frac{\sin}{\cos\ _c} \quad n_1$$

Now $\quad\quad \cos\ _c \quad \sqrt{\frac{n_1^2 \quad n_2^2}{n_1}}$

$$\sin \quad \sqrt{\frac{n_1^2 \quad n_2^2}{n_1}} \quad n_1$$

$$\sin \quad\quad \sqrt{n_1^2 \quad n_2^2}$$

Hence correct option is (a).

39. For mirror $u \quad 1\,\text{cm}$ (taking upward direction ve)

$$f \quad 2\,\text{cm}$$

$$\frac{1}{v} \quad \frac{1}{f} \quad \frac{1}{u}$$

$$\frac{1}{v} \quad \frac{1}{2} \quad 1 \quad \frac{1}{2}$$

$$v \quad 2\,\text{cm}$$

Hence mirror form virtual image behind mirror at 2 cm from pole. This image acts as virtual object for slab on see below the slab the shift is

$$t \quad 1 \quad \frac{1}{3/2} \quad 9 \quad 3\,\text{cm}$$

Hence virtual image form on object thus correct option is (a).

40. We have $\frac{2}{v} \quad \frac{1}{u} \quad \frac{2 \quad 1}{R}$

For real object u is ve

$$\frac{2}{v} \quad \frac{(\ 2 \quad 1)}{R} \quad \frac{1}{u}$$

$\because$ R is ve and $_1 \quad _2$

$$\frac{2}{v} \quad \text{ve} \quad \frac{1}{u}$$

$$v \quad \text{ve}$$

Hence, if $_1 \quad _2$ then these cannot be real image of real object.

Hence, correct option is (a).

41. At oil-concave surface

$$\frac{1}{f_1} \quad (1.6 \quad 1) \frac{1}{\ } \quad \frac{1}{10} \qquad \frac{1}{f_1} \quad \frac{0.6}{10}$$

At other surface light goes from oil to glass

$$\frac{1}{f_2} \quad \frac{1.5}{1.6} \quad 1 \quad \frac{1}{10} \quad \frac{1}{20}$$

$$\frac{1}{f_2} \quad \frac{0.3}{20 \quad 1.6}$$

Let focal length of combination is F

$$\frac{1}{F} \quad \frac{1}{f_1} \quad \frac{1}{f_2} \quad \frac{0.6}{10} \quad \frac{0.3}{20 \quad 1.6}$$

$$F \quad 28.57\,\text{cm}$$

Hence correct option is (d).

42. Using formula

$$\frac{2}{v} \quad \frac{1}{u} \quad \frac{2 \quad 1}{R}$$

For real image is ve

$$\frac{2}{v} \quad \frac{1}{u} \quad \frac{2 \quad 1}{R}$$

$$\frac{1.5}{v} \quad \frac{0.5}{R} \quad \frac{1}{u}$$

$$\frac{1.5}{v} \quad \frac{1}{2R} \quad \frac{1}{u}\ v \text{ is} \quad \text{ve if}\ u \quad 2R$$

Hence correct option is (b).

43. $v \quad \frac{fu}{f \quad u}$ when $u \quad f$

u lend to lens

if $\quad u \quad 0, v \quad 0$

Hence correct option is (d).

44. Since image formed by diverging lens is always virtual.

Hence correct option is (a)

45. If the object place at first focus the image forms at $\ $ *ie*, rays incident the plane surface normally and retrace its path.

Now $x \quad f_1 \quad \frac{_1 R}{_2 \quad _1} \quad \frac{60}{0.5} \quad 120\,\text{cm}$

Hence correct option is (a).

46. $\frac{2}{v_1} \quad \frac{1}{u_1} \quad \frac{2 \quad 1}{R}$ for $_2 \quad 1.6$

$$\frac{1.6}{v_1} \quad \frac{1}{(\ 2)} \quad \frac{1.6 \quad 1}{1} \quad \frac{6}{10}$$

$$\frac{1.6}{v_1} \quad \frac{6}{10} \quad \frac{1}{2} \quad \frac{1}{10}$$

$$v_1 \quad 16\,\text{m}$$

For $\quad _2 \quad 2$

$$\frac{2}{v_2} \quad \frac{1}{(\ \ 2)} \quad \frac{2\ \ 1}{1} \quad 1$$

$$\frac{2}{v_2} \quad 1 \quad \frac{1}{2} \quad \frac{1}{2} \quad v_2 \quad 4\text{ m}$$

Hence separation between images $\quad v_1 \quad v_2$

$(16 \quad 4)$ cm

12 cm

Hence correct option is (a).

47. System behave a a concave mirror

Here $u \quad 10, v \quad 40$ cm

Using mirror formula

$$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f} \text{ we get}$$

$$\frac{1}{40} \quad \frac{1}{10} \quad \frac{1}{f}$$

$f \quad 8$ cm

Hence correct option is (a).

48. The focal length of lens combination is $2f$

Hence $\frac{1}{2f} \quad \frac{(1.8 \quad 1.2)}{(1.2 \quad 1)} \quad \frac{1}{\ } \quad \frac{1}{R}$

$$\frac{1}{16} \quad \frac{0.6}{0.2R}$$

$R \quad 48$ cm

Hence correct option is (a).

49. If plane surface is silvered the system acts a concave mirror having focal length

$$\frac{R}{2} \quad 24\text{ cm}$$

Hence correct option is (c).

■ More than one options correct

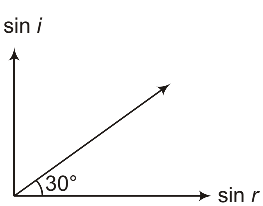
1. Since prism are identical hence if a right prism produce deviation inverted prism produce deviation .

if $n \quad 2m$ deviation becomes zero.

if $n \quad 2m \quad 1$ deviation produce is

Hence correct options are (a) and (b).

2.



$\because$ sin i $\quad$ sin r

tan 30 $\quad \sqrt{3}$

if speed of light in medium x is v

then speed of light; in medium $y \quad \frac{v}{\ } \quad \frac{v}{\sqrt{3}}$

Since y is denser w.r.t. x hence total internal reflection take place when incidence in y.

The correct options are (b) and (d).

3. The correct options are (b) and (c).

4. The lens form real image if $D \quad 4F$ (displacement method)

and $\quad f \quad \frac{D^2 \quad x^2}{4D}$

and the magnification $m_1 m_2 \quad 1$

Hence correct options are (b), (c) and (d).

5. Deviation produced by prism

$(\quad 1)A \quad (1.5 \quad 1)\,4 \quad 2$

if the mirror is rotated 2 ray become horizontal after reflection from mirror.

Again if mirror is rotated by 1° reflection ray deviated by 2° from horizontal and after passing through prism again ray become horizontal.

Hence correct option are (a) and (b).

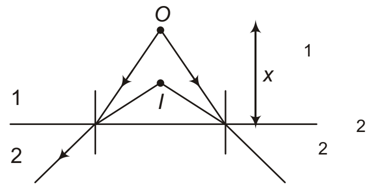
Match the Columns

1. Correct match is

(a) q, r (b) p, s
(c) p, r (d) p, r

2. (a) p, r (b) q, s
(c) q, r (d) q, r

3.



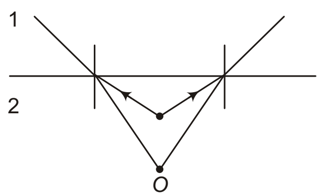
Hence image distance is less than x and virtual.

(a) q, s

Similarly as in (a) the correct match for

(b) q, r

(c)



(c) p, s

(d) p, r

4. (a) $q,$

(b) r

(c) r

(d) p

5. Since $\frac{1}{f} \quad (n \quad 1) \frac{1}{R_1} \quad \frac{1}{R_2}$

here n 1.5 for (a) n 1.4

$$\frac{1}{f} \quad \frac{1.5}{1.4} \quad 1 \quad \frac{1}{R_1} \quad \frac{1}{R_2}$$

f is ve

hence

(a) $p, s \because f$ increases, power decreases

(b) $q, s \because f$ is ve and increase in magnification

Similarly

(c) q, s and

(d) p, s

6. For real object at $2c$ convex lens form image at $2c$ similarly for virtual object concave lens does.

(a) q, s (b) q, r
(c) q, r (d) q, r

28 Interference and Diffraction of Light

Introductory Exercise 28.1

1. Because they are incoherent *ie*, does not remain constant.

2. Since laser is highly coherent and monochromatic source of light

3. $I \quad I_0 \cos^2 \quad /2$

$$\frac{3I_0}{4} \quad I_0 \cos^2 \quad /2$$

$$\cos \quad /2 \quad \frac{\sqrt{3}}{2}$$

$$\overline{2} \quad \overline{6}$$

$$\overline{3}$$

$$x \quad \frac{}{2} \qquad \frac{}{2} \quad \overline{3} \quad \overline{6}$$

But $\quad x \quad \frac{yd}{D}$

$$y \quad \frac{D \quad x}{d} \quad \frac{D}{d} \quad \overline{6}$$

$$y \quad \frac{1.2 \quad 600 \quad 10^{\ 9}}{0.25 \quad 10^{\ 2} \quad 6} \quad 48 \quad \text{m}$$

4. $2 \quad t \quad n \quad \frac{1}{2}$ for minimum thickness $n \quad 1$

$$t \quad \frac{}{4} \quad \frac{3}{4 \quad 1.5} \quad 0.5\,\text{cm}$$

5. Here $a_1 \quad 3\,a$ and $a_2 \quad a$

$$R^2 \quad (3a)^2 \quad (a)^2 \quad 2 \quad 3a \quad a \quad \cos$$

$$I \quad 9I_0 \quad I_0 \quad 6I_0 \cos$$

$$I \quad [10 \quad 6\cos \quad]I_0$$

$$I \quad 10 \quad 6 \quad 2\cos^2 \overline{2} \quad 1 \quad I_0$$

$$10 \quad 12\cos^2 \overline{2} \quad 6 \quad I_0$$

$$4 \quad 12\cos^2 \overline{2} \quad I_0$$

$$4I_0 \quad 1 \quad 3\cos^2 \overline{2}$$

Now, $I_{\max} \quad \frac{I_0}{9}$

$$I \quad \frac{4}{9} I_{\max} \quad 1 \quad 3\cos^2 \overline{2}$$

6. $x \quad \frac{yd}{D} \quad (\quad 1)\,t$

if $\quad t \quad \frac{}{2(\quad 1)}$

$$x \quad \frac{yd}{D} \quad \overline{2}$$

For maxima $\quad x \quad n$

$$\frac{yd}{D} \quad 2n \quad \frac{1}{2}$$

This become minima.

For minima $\quad x \quad n \quad \frac{1}{2}$

$$\frac{yd}{} \quad \overline{2} \quad n \quad \overline{2}$$

$$\frac{yd}{D} \quad n$$ this become maxima.

Hence maxima and minima are interchanged.

7. For two slit experiment

$$d \sin \quad n$$

$$\sin \quad \frac{n}{d}$$

But $\quad \sin \quad 1 \quad \frac{n}{} \quad 1$

$$n \quad \frac{d}{} \qquad n \quad \frac{4 \quad 10^{6}}{6 \quad 10^{7}} \quad 6.67$$

$$n \quad 6$$

8. Since amplitude of each wave is equal. The amplitude of resultant wave is zero if waves are equally displaced in phase

ie, $\quad \frac{360}{8} \quad 45$

Hence phase difference must be 45°

AIEEE Corner

Subjective Question (Level-1)

1. $R^2 \quad a_1^2 \quad a_2^2 \quad 2a_1a_2 \cos$

(i) $R \quad 2a, a_1 \quad a_2 \quad a$

$$4a^2 \quad a^2 \quad a^2 \quad 2a^2 \cos$$

$$\cos \quad 1 \qquad 0$$

(ii) $2a^2 \quad 2a^2 \quad 2a^2 \cos$

$$90$$

(iii) $a^2 \quad 2a^2 \quad 2a^2 \cos$

$$\cos \quad \frac{1}{2} \qquad 120$$

(iv) $0 \quad 2a^2 \quad 2a^2 \cos \qquad 180$

2. $\dfrac{I_{\max}}{I_{\min}} \quad \dfrac{(a_1 \quad a_2)^2}{(a_1 \quad a_2)^2} \quad \dfrac{\left(\frac{a_1}{a_2} \quad 1\right)^2}{\left(\frac{a_1}{a_2} \quad 1\right)^2}$

$$\frac{I_{\max}}{I_{\min}} \quad \frac{\left(\frac{5}{3} \quad 1\right)^2}{\left(\frac{5}{3} \quad 1\right)^2} \quad \frac{8^2}{2^2} \quad 16$$

$$I_{\max} : I_{\min} \quad 16:1$$

3. $I \quad I_{\max} \cos^2 \frac{}{2}$

$$\frac{I_{\max}}{2} \quad I_{\max} \cos^2 \frac{}{2}$$

$$\cos \frac{}{2} \quad \cos \frac{}{4}$$

$$\frac{}{2}$$

Now, $\quad \frac{2}{} \qquad x$

$$\frac{}{2} \quad \frac{2}{} \qquad x$$

$$x \quad \frac{}{4}$$

But $\quad x \quad \frac{yd}{D}$

$$y \quad \frac{D \quad x}{d}$$

$$y \quad \frac{1\text{m}}{4 \quad 1\text{mm}} \quad \frac{1 \quad 500 \quad 10^{9}}{4 \quad 10^{3}}$$

$$y \quad 1.25 \quad 10^{4} \text{ m}$$

4. $I \quad I_{\max} \cos^2 \frac{}{2}$

(a) $\dfrac{I_{\max}}{2} \quad I_{\max} \cos^2 \dfrac{}{2} \qquad \dfrac{}{2}$

Now $\quad \frac{2}{} \qquad x$

$$x \quad \frac{}{4} \text{ and } x \quad \frac{yd}{D} \qquad \frac{D}{4d}$$

(b) $\dfrac{1}{4} I_{\max} \quad I_{\max} \cos^2 \dfrac{}{2}$

$$\cos \frac{}{2} \quad \cos \frac{}{3} \qquad \frac{2}{3}$$

$$\frac{2}{} \qquad x$$

$\frac{2}{3} \quad \frac{2}{} \quad x \quad x \quad \frac{}{3}$

Now $x \quad \frac{yd}{D} \quad y \quad \frac{D}{3d}$

5. (a) $I \quad I_{max} \cos^2 \frac{}{2}$

$I_{max} \quad I_0$ and $\quad 60$

$I \quad I_0 \cos^2 30 \quad \frac{3}{4} I_0 \quad 0.75 I_0$

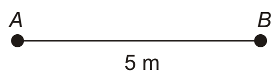
(b) $\frac{2}{} \quad x$

$\frac{}{3} \quad \frac{2}{} \quad x$

$x \quad \frac{}{6} \quad \frac{480}{6}$ nm

$x \quad 80$ nm

6. $_A \quad _B \quad 6$m



For constructive interference difference wavelength $0, \quad , 2$

$\because \quad 6 \quad d_{AB} \quad 5$

Hence only constructive interference occur at $\quad 0$

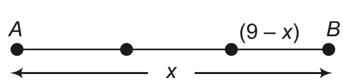
$x \quad \frac{5}{2}$m $\quad 2.5$ m

For destructive interference $\quad , \frac{3}{2}$

Only possibility at $\quad 6$

Which occur at $x \quad 1$ m and $x \quad 4$ m from A.

7. The wavelength $\quad \frac{c}{n} \quad \frac{3 \quad 10^8}{120 \quad 10^6} \quad 2.5$ m



For constructive interference

$x \quad (9 \quad x) \quad n$, where $n \quad 0, 1, 2 \ldots$

$x \quad 4.5, 5.75, 7, 8.25$

The other points are $3.25, 2, .75$

8. In Young's double slit experiment

$w \quad \frac{D}{d}$

$2.82 \quad 10^{\ 3}$m $\quad \frac{2.2}{.460 \quad 10^{\ 3}}$

590 nm

9. x_n for bright fringe is given by

$x_n \quad \frac{nD}{d}$

$x_1 \quad \frac{D}{d}$ and $x_2 \quad \frac{2D}{d}$

$x \quad \frac{D}{d}$ the angular separation

$\sin(\quad) \quad \frac{x}{D} \quad \frac{}{d} \quad \frac{5 \quad 10^{\ 7}}{2 \quad 10^{\ 3}} \quad 2.5 \quad 10^{\ 4}$

$(\quad) \quad \sin^{\ 1}[0.00025]$

0.014

10. When whole appratus is immersed in water

$n_w \quad \frac{4}{3} \quad 700 \quad 10^{\ 9}$m

$w \quad \frac{D}{d} \quad \frac{48 \quad 10^{\ 2} \quad 4 \quad 7 \quad 10^{\ 7}}{3 \quad 25 \quad 10^{\ 5}} \quad 0.90$ mm

11. $w_1 \quad \frac{D_1}{d}$ and $w_2 \quad \frac{D_2}{d}$

$w_1 \quad w_2 \quad \frac{(D_1 \quad D_2)}{d}$

$3 \quad 10^{\ 5} \quad \frac{1.5 \quad 10^{\ 2}}{10^{\ 3}}$

$\frac{3}{1.5} \quad \frac{10^{\ 8}}{10^{\ 2}} \quad 2 \quad 10^{\ 6}$m $\quad 2 \quad$ m

12. For bright fringe $x_n \quad \frac{Dn}{d}$

For first light ($\quad$ 480 nm) the third order

Bright fringe is $x_3 \quad \frac{1 \quad 3 \quad 480 \quad 10^{\ 9}}{5 \quad 10^{\ 3}}$

For second light ($\quad$ 600 nm)

$x_3 \quad \frac{1 \quad 3 \quad 600 \quad 10^{\ 9}}{5 \quad 10^{\ 3}}$

$$x \quad x_3 \quad x_3 \quad \frac{3 \quad 10^{\ 9} \quad (600 \quad 480)}{5 \quad 10^{\ 3}}$$

$$\frac{3 \quad 120}{5} \quad 10^{\ 6}$$

$$x \quad 72 \quad 10^{\ 6}, \quad x \quad 72 \quad \text{m}$$

13. Fringe width :

$$\frac{D}{d}$$

$$\frac{(500 \quad 10^{\ 9})(75 \quad 10^{\ 2})}{(0.45 \quad 10^{\ 3})} \text{m}$$

$$0.83 \quad 10^{\ 3}\,\text{m} \quad 0.83\,\text{mm}$$

Distance between second and third dark line one fringe width 0.83 mm.

14. For first order bright fringe

$$x \quad \frac{D}{d}$$

$$4.94 \quad 10^{\ 3} \quad \frac{3 \quad 600 \quad 10^{\ 9}}{d}$$

$$d \quad \frac{18 \quad 10^{\ 7}}{4.94 \quad 10^{\ 3}} \quad \frac{18}{5.94} \quad 10^{\ 4}\text{m}$$

Let for wavelength first dark fringe is obtained at this point for first dark fringe

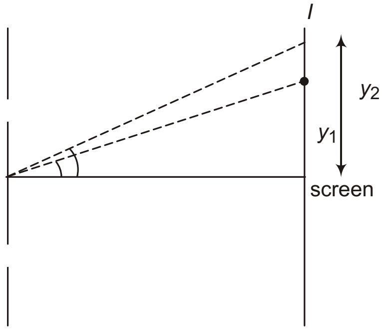
$$x \quad \frac{D}{2d}$$

$$4.94 \quad 10^{\ 3} \quad \frac{3 \qquad 4.94}{2 \quad 18 \quad 10^{\ 4}}$$

$$2 \quad 18 \quad 10^{\ 7} \quad 3$$

$$12 \quad 10^{\ 7}\text{m} \qquad 1200\ \text{nm}$$

15.



For dark fringe

$$d\sin \qquad (2n \quad 1)\frac{}{2}$$

For first dark fringe n 1 and for 2nd, n 2

$$d\sin \qquad \frac{}{2}$$

$$d\sin \qquad \frac{3}{2} \qquad \sin \qquad \frac{}{2d}$$

$$\frac{y_1}{\sqrt{D^2 \quad y_1^2}} \quad \frac{}{2d}$$

and $\dfrac{y_2}{\sqrt{D^2 \quad y_1^2}} \quad \dfrac{3}{2d}$

$$\frac{y_1}{\sqrt{(35 \quad 10^{\ 2})^2 \quad y_1^2}} \quad \frac{550 \quad 10^{\ 9}}{2 \quad 1.8 \quad 10^{\ 6}} \qquad \ldots\text{(i)}$$

and $\dfrac{y_2}{\sqrt{(35 \quad 10^{\ 2})^2 \quad y_2^2}} \quad \dfrac{3 \quad 550 \quad 10^{\ 9}}{2 \quad 1.8 \quad 10^{\ 6}}$

On solving $y_2 \quad y_1$ 12.6 cm

16. Wavelength of source $\quad \sqrt{2meV}$

$$\frac{6.62 \quad 10^{\ 34}}{\sqrt{2 \quad 9.1 \quad 10^{\ 31} \quad 100 \quad 1.6 \quad 10^{\ 19}}}$$

$$1.24 \quad 10^{\ 10}\text{m}$$

$$w \quad \frac{D}{d} \quad \frac{3 \quad 1.24 \quad 10^{\ 10}}{10 \quad 10^{\ 10}}\text{m} \quad 36.6\,\text{cm}$$

17. Given 546 nm 5.46 $10^{\ 7}$m, D 1m

d 0.3 mm 0.3 $10^{\ 3}$m

(a) At distance y 10 mm 10 $10^{\ 3}$m from the central fringe path difference will be

$$y \quad \frac{y.d}{D} \quad \frac{10 \quad 10^{\ 3} \quad 0.3 \quad 10^{\ 3}}{1}$$

$$3 \quad 10^{\ 6}\ \text{m}$$

Corresponding phase difference

$$\frac{2}{} \qquad x \quad \frac{2}{5.46 \quad 10^{\ 7}} \quad 3 \quad 10^{\ 6}\ \text{rad}$$

1978

$I \quad I_0 \cos^2 \frac{}{2}$

$I_0 \cos^2 \frac{1978}{2} \qquad I_0 \cos^2 989$

$I \quad 3 \quad 10^{\ 4} I_0$

(b) Fringe width $w \quad \frac{D}{d}$

$w \quad \frac{5.46 \quad 10^{\ 7} \quad 1}{0.3 \quad 10^{\ 3}} \quad 1.82\,\text{mm}$

Number of fringes $\frac{10\,\text{mm}}{1.82\,\text{mm}} \quad 5.49$

Hence the number of fringe is five.

18. Shift due to sheet of thickness 10 and refractive index 1.6 is

$x_1 \quad \frac{(\quad 1)\,tD}{d}$

$x_1 \quad (1.6 \quad 1) \quad \frac{10 \quad 10^{\ 6} \quad 1.5}{1.5 \quad 10^{\ 3}}$

$x_1 \quad 0.6 \quad 10 \quad 10^{\ 3} \quad 6 \quad 10^{\ 3}\text{m}$

Shift due to sheet of thickness 15 and refractive index 1.2 is

$x_2 \quad \frac{(1.2 \quad 1) \quad 15 \quad 10^{\ 6} \quad 1.5}{1.5 \quad 10^{\ 3}}$

$x_2 \quad 3 \quad 10^{\ 3}\text{m}$

Since these shifts are in opposite direction of central maxima hence net shift

$x \quad x_1 \quad x_2 \quad 6 \quad 10^{\ 3}\text{m} \quad 3 \quad 10^{\ 3}\text{m}$

$3 \quad 10^{\ 3}\text{m} \quad 3\ \text{mm}$

19. Let is the wavelength of light D is screen distance from source and d is the separation between slits (all are in metres)

Shift $\quad x \quad \frac{(\quad 1)\,tD}{d}$

$x \quad \frac{(1.6 \quad 1) \quad 1.964 \quad 10^{\ 6} \quad D}{d}$

$x \quad \frac{1.1784\,D}{d} \quad 10^{\ 6}\text{m}$

Now when t is removed and D is doubled the distance between successive maximum (or minima) *i.e.*, fringe width

$w \quad \frac{2D}{d}$

but according to question $\ x \quad w$

$\frac{1.178 \quad 10^{\ 6} D}{d} \quad \frac{2D}{d}$

$0.589 \quad 10^{\ 6}\text{m} \quad 589\ \text{nm}$

20. Let n bright fringe (5500 Å) concide with 10th

bright fringe of 6000 Å

$n \quad 5500\ \text{Å} \quad 6000\ \text{Å} \quad 10$

$n \sim 11$

Similarly first bright fringe concide with 1st fringe. Now fringe width

$w \quad \frac{14.74 \quad 12.5}{10} \quad 0.224\ \text{mm}$

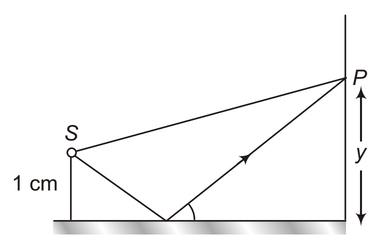
Hence position of 10th bright fringe

$14.74 \quad 0.224 \sim 14.55\,\text{mm}$

Position of zero order bright fringe

$12.75 \quad 0.224 \sim 12.25\,\text{mm}$

21. Here $d \sim 1\,\text{cm}$



$D \quad 100\,\text{m}$

$500\ \text{nm}$

For first dark fringe

$$y \quad \frac{}{2d} \quad \frac{100 \quad 500 \quad 10^{\;9}}{2 \quad 10^{\;2}}$$

$$y \quad 2.5\,\text{mm}$$

22. The destructive interference will be $2 \;\; t \quad n$

for thinnest $n \quad 1$

$$2 \;\; t$$

$$t \quad \frac{}{2} \quad \frac{650 \quad 10^{\;9}}{2 \quad 1.42}$$

$$t \quad 114 \text{ nm}$$

23. Here $t \quad 0.485 \quad \text{m}, t \quad 485\,\text{nm}, n \quad 1.53$

(a) Condition for constructive interference in refractive system

$$2 \;\; t \quad n \;\; \frac{1}{2} \qquad \text{where, } n \quad 1, 2$$

For $\quad n \quad 1, \;_1 \quad 4 \;\; t \quad 4 \quad 1.53 \quad 485$

$$2968.2\,\text{mm}$$

which does not lie in visible region put

$n \quad 2, 3, \ldots\ldots$

we get $\quad 424$ nm, 594 nm, ...

(b) For structive interference in transmitted system

$2 \;\; t \quad n$, putting $n \quad 1, 2,$

only $\quad 495$ nm is lie in visible region.

24. For constructive interference

$$2 \;\; t \quad n \;\; \frac{1}{2} \quad \text{for } t \text{ to be minimum } n \quad 1$$

$$t \quad \frac{}{4} \quad \frac{6000}{4 \quad 1.3} \quad 1154 \text{ Å}$$

25. For destructive interference

$2 \;\; t \quad n$ for t to be minimum

$n \quad 1$

$$t \quad \frac{}{2} \quad \frac{800}{2} \qquad \ldots\text{(i)}$$

For constructive interference

$$2 \;\; t \quad (2n \quad 1)\frac{}{2}$$

$$2 \quad \frac{800}{2} \quad (2n \quad 1)\frac{}{2}$$

$$1600 \quad (2n \quad 1)$$

For $n \quad 1, \quad 600$ nm which does not lie in visible region

For $\qquad n \quad 2$

$$1600 \quad 3$$

$$\frac{1600}{3} \qquad 533 \text{ nm}$$

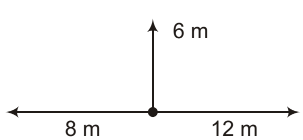
for $n \quad 3, \quad \dfrac{1600}{5} \quad 320$ nm which does lie in visible

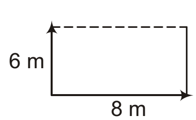
Hence $\quad 533$ nm

Objective Questions (Level-1)

■ (Single option correct)

1. Using phasor method





$$R \quad \sqrt{8^2 \quad 6^2} \quad 10\,\text{m}$$

Hence correct option is (b).

2. Here $\dfrac{I_1}{I_2} \quad B^2$

$$I_{\max} \quad [\sqrt{I_1} \quad \sqrt{I_1}]^2$$

$$I_{\min} \quad [\sqrt{I_1} \quad \sqrt{I_2}]$$

$$\frac{I_{\min}}{I_{\max}} \quad \left(\frac{\sqrt{\frac{I_1}{I_2}} \quad 1}{\sqrt{\frac{I_1}{I_2}} \quad 1}\right)^2 \qquad \left(\frac{1}{1}\right)^2$$

$$\frac{(I_{\max} \quad I_{\min})}{(I_{\max} \quad I_{\min})} \quad \left(\frac{1 \qquad 1}{2}\right)^2$$

$$\frac{I_{\max} \quad I_{\min}}{I_{\max} \quad I_{\min}} \quad \frac{1}{2}$$

Hence, correct option is (d).

3. For nth dark fringe

$$x_n \quad (2n \quad 1)\frac{D}{2d}$$

For 1st dark fringe $n \quad 1$

$$x_1 \quad \frac{D}{2d}$$

Angular position $\quad \sin^{\ 1}\frac{x_1}{D}$

$$\sin^{\ 1}\frac{\quad}{2a}$$

$$\sin^{\ 1}\frac{5460 \quad 10^{\ 10}}{2 \quad 0.1 \quad 10^{\ 3}}$$

$$\sin^{\ 1}[273 \quad 10^{\ 5}]$$

$$\sin^{\ 1}[0.00273]$$

$$0.16$$

Hence correct option is (b)

4. For 10th bright fringe $x_{10} \quad \frac{10D}{d}$

For 6th dark fringe $x_6 \quad (2 \quad 6 \quad 1)\frac{D}{2d}$

But $\qquad x_6 \quad x_{10}$

$$\frac{11}{2a}D \qquad \frac{10D}{d}$$

$$\text{—} \quad \frac{20}{11}$$

But $\qquad \text{—} \quad \frac{20}{11} \quad 1.8$

Hence correct option is (a).

5. Shift $\frac{(\quad 1)\,tD}{d}$

$$\frac{(1.5 \quad 1) \quad 10 \quad 10^{\ 6} \quad 100 \quad 10^{\ 2}}{2.5 \quad 10^{\ 3}}$$

$$\frac{5 \quad 10^{\ 6}}{2.5 \quad 10^{\ 3}} \quad 2 \quad 10^{\ 3}\text{m} \quad 2\text{mm}$$

Hence correct option is (a).

6. $x_n \quad \frac{Dn}{d}$ for nth bright fringe

$$x_n \quad \frac{D}{2d}(2n \quad 1) \text{ for } n\text{th dark fringe}$$

$$x \quad x_n \quad x_n \quad \frac{D}{2d}[2n \quad 2n \quad 1]$$

$$x \quad \frac{D}{2d}$$

Hence correct option is (c).

7. Since at centre path difference for all colour is always zero hence centre will be white.

Hence correct option is (a).

8. $n_1 \quad {}_1 \quad n_2 \quad {}_2$

$$60 \quad 4000 \quad n_2 \quad 6000 \quad n_2 \quad 40$$

Hence correct option is (a).

9. Initial fringe width $w_1 \quad \frac{D}{d}$

Final fringe width $w_2 \quad \frac{(D \quad 5 \quad 10^{\ 2})}{d}$

$$| \quad w| \quad |w_2 \quad w_1| \quad \frac{\quad}{d} \quad 5 \quad 10^{\ 2}$$

$$3 \quad 10^{\ 5} \quad \frac{\quad}{10^{\ 3}} \quad 5 \quad 10^{\ 2}$$

$$\frac{3 \quad 10^{\ 6}}{5} \qquad 6000\ \text{Å}$$

Hence correct option is (a).

10. $\frac{I_{max}}{I_{min}} \quad \frac{49}{9}$

Now $\frac{I_{max}}{I_{min}} \quad \frac{\sqrt{I_1} \quad \sqrt{I_2}}{\sqrt{I_1} \quad \sqrt{I_2}}^{2} \quad \frac{\sqrt{\frac{I_1}{I_2}} \quad 1}{\sqrt{\frac{I_1}{I_2}} \quad 1}^{2}$

$$\frac{I_{max}}{I_{min}} \quad \frac{\sqrt{\frac{49}{9}} \quad 1}{\sqrt{\frac{49}{9}} \quad 1}^{2} \quad \frac{\frac{7}{3} \quad 1}{\frac{7}{3} \quad 1}^{2} \quad \frac{100}{16}$$

$$\frac{I_{max}}{I_{min}} \quad \frac{25}{4}$$

Hence correct option is (a)

11. $x_n \quad \frac{Dn}{d}$

$$x_3 \quad \frac{3D}{d} \quad 7.5 \quad 10^{3}\text{m}$$

$$\frac{7.5 \quad 10^{3} \quad 0.2 \quad 10^{3}}{3 \quad 1}$$

$$0.5 \quad 10^{6} \quad 500\text{ nm}$$

Hence correct option is (b).

12. Let nth fringe of 6500 Å concide with n th fringe of 5200 Å.

$$x_n \quad \frac{Dn \quad 6500\text{ Å}}{d} \quad \frac{Dn}{d} \quad 5200\text{ Å}$$

$$\frac{n}{n} \quad \frac{5200}{6500} \quad \frac{4}{5}$$

It means 4th fringe of 6500 Å coincide with 5th fringe of 5200 Å hence the distance

$$x \quad \frac{4 \quad 120 \quad 10^{2} \quad 6500 \quad 10^{10}}{2 \quad 10^{3}}$$

$$x \quad 0.156\text{ cm}$$

Hence correct option is (a).

13. Since number of minima does not depends on orientation hence $n_1 \quad n_2$

Hence correct option is (a).

■ Assertion and Reason

1. We have $I \quad 4I_0 \cos^2 \frac{}{2}$ if $\quad \frac{2}{3}$

we get $I \quad I_0$

Hence assertion is true.

Now path difference $\frac{}{2}$ phase difference

Path difference $\frac{}{2} \quad \frac{2}{3} \quad \frac{}{3}$

Hence reason is true.

But reason is not the explanation of assertion. Hence correct option is (b).

2. Here assertion and reason are both true but reason is not correct explanation of assertion. Correct option is (b).

3. Assertion is wrong since fringes are symmetrical *ie*, fringes obtained both above and below point O. Reason is true.

Correct option is (a).

4. Here both assertion and reason are true and reason correctly explain assertion. Hence correct option is (a).

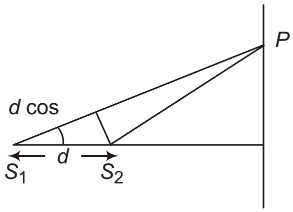
5. Both assertion and reason are true and reason correctly explain the assertion.

Hence correct option is (a).

6. Assertion is true since locus of all fringes is circle. But reason is wrong since fringes may have any shape.

Correct option is (c).

7.



Path difference at point P is $x \quad d\cos$

The path difference decreases as increases.
∵ as increases, cos decreases

Hence order of fringe $n \quad \frac{d\cos}{\quad}$ decreases as we go above P. Hence assertion is wrong (false).

For 11th order maxima path differenc is more hence reason is true but assertion is false correct option is (d).

8. Here assertion is true and reason is false and reason does not correctly explain assertion. Correct option is (c).

9. ∵ $d\sin \quad n$

$$\sin \quad \frac{n}{d} \text{ but } \frac{d}{\quad} \quad 4$$

$$\sin \quad \frac{n}{4}$$

Now if 30

$$n \quad 4\sin 30 \quad 2$$

Hence assertion is true.

Also reason is true and does not correctly explain assertion correct option is (b).

10. Here assertion is false. Since shift $\frac{(\quad 1)tD}{d}$ is independent of .

Hence shift of red colour shift of violet colour.

and reason is true

∵ $\quad _V \quad _R$

Hence correct option is (d)

Objective Questions (Level 2)

1. $I \quad 4I_0\cos^2 \frac{x}{\quad}$

$$I_0 \quad 4I_0\cos^2 \frac{x_1}{\quad}$$

$$x_1 \quad \frac{\quad}{3} \qquad \ldots\text{(i)}$$

and $$2I_0 \quad 4I_0\cos^2 \frac{x_2}{\quad}$$

$$x_2 \quad \frac{\quad}{4} \qquad \ldots\text{(ii)}$$

$$x \quad x_1 \quad x_2 \quad \frac{\quad}{3} \quad \frac{\quad}{4} \quad \frac{\quad}{12}$$

Hence correct option is (c).

2. $I \quad 4I_0\cos^2 \frac{x}{\quad} \quad k\cos^2 \frac{x}{\quad}$

$$I \quad k\cos^2 - \quad k \qquad \ldots\text{(i)}$$

$$\frac{I}{4} \quad k\cos^2 \frac{x}{\quad}$$

$$\frac{k}{4} \quad k\cos^2 \frac{x}{\quad}$$

$$\cos\frac{x}{\quad} \quad \frac{1}{2}$$

$$\frac{x}{\quad} \quad \cos^{1} \frac{1}{2}$$

$$\frac{x}{\quad} \quad \frac{\quad}{3} \text{ or } \frac{x}{\quad} \quad \frac{2}{3}$$

$$x \quad \frac{\quad}{3} \text{ or } x \quad \frac{2}{3}$$

Hence correct option is (b).

3. Light of wavelength is strongly reflected if

$$2ut \quad n \quad \frac{1}{2} \qquad n \quad 0, 1, 2 \qquad \ldots\text{(i)}$$

$$2ut \quad 2 \quad 1.5 \quad 5 \quad 10^{\ 7}\text{m} \quad 1.5 \quad 10^{\ 6}\text{m}$$

Putting 400 nm in eq. (1) and using eq. (ii)

$$1.5 \quad 10^{6}\ \text{m} \quad n \quad \frac{1}{2} \quad 4 \quad 10^{7}\ \text{m}$$

$$n \quad 3.25$$

Putting $\quad 700$

$$1.5 \quad 10^{6}\ \text{m} \quad n \quad \frac{1}{2} \quad 7 \quad 10^{7}$$

$$n \quad 1.66$$

Hence n can take values 2 and 3.

From (i) if $n \quad 2$, $\quad \dfrac{4ut}{2 \quad 2 \quad 1} \quad 600$ nm

if $\quad n \quad 3 \quad 429$ nm

only $\quad 600$ is given in the options.

Hence correct option is (b).

4. $x_n \quad \dfrac{D \ n}{d} \quad \dfrac{100 \quad 10^{2}}{0.01 \quad 10^{3}} \quad n$

$$x_n \quad \frac{n}{10^{5}} \qquad \text{For} \quad 4000\ \text{Å}$$

$$x_n \quad \frac{n \quad 4000 \quad 10^{10}\text{m}}{10^{5}} \quad 4 \quad 10^{5} \quad n$$

$$0.04 \quad n$$

$x_n \quad 4n$ mm

Similarly for $\quad 7000$ Å

$x_n \quad 7n$ mm $n \quad 5, 6$

hence only $x \quad 5$

Passes through hole $\quad 5000$ Å

Hence correct option is (b).

5. $I \quad 4I_0 \cos^2 \dfrac{x}{} \quad$ where $\quad \dfrac{}{d}$

$$\frac{1 \quad 6000 \quad 10^{10}}{1 \quad 10^{3}} \quad (6 \quad 10^{4})$$

$$75\%\ I_0 \quad I_0 \cos^2 \frac{x}{}$$

$$\frac{3}{16} \quad \cos^2 \frac{x}{}$$

$$\frac{\sqrt{3}}{4} \quad \cos \frac{x}{}$$

$$x \quad \cos^{1} \sqrt{\frac{3}{4}} \qquad x \quad -\cos^{1} \sqrt{\frac{3}{4}}$$

$$x \quad 0.20\ \text{mm}$$

Hence correct option is (d).

6. Number of fringes shifted $\quad \dfrac{(\quad 1)\,t}{}$

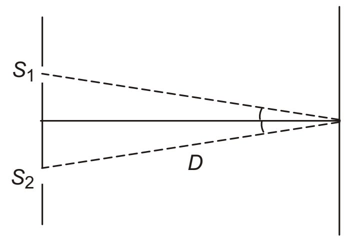
$$4 \quad \frac{(1.5 \quad 1) \quad t}{6000\ \text{Å}}$$

$$\frac{4}{0.5} \quad 6 \quad 10^{7}\text{m} \quad t$$

$$t \quad 4.8 \quad \text{m}$$

Hence correct option is (a).

7. For nth order minima



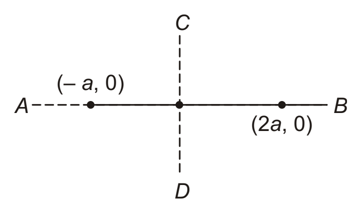
$$y_n \quad \frac{(2n \quad 1)\,D}{2d} \ \text{for 3rd minima } n \quad 3$$

$$y_3 \quad \frac{5D}{2d} \quad \frac{5}{2}$$

$$\because \quad \sim \tan \quad \frac{d}{D}$$

Hence correct option is (b).

8. $AB \quad d \quad 3a \quad \dfrac{3a \quad 5}{5}$



$$AB \quad 15$$

Hence total maxima $\quad 14 \quad 4 \quad 4$

$$60$$

Hence correct option is (a).

9. $I \quad 4I_0 \cos^2 \frac{x}{}$

$I \quad 4I_0 \cos^2 - \quad \frac{}{4}$

$I \quad 4I_0 \cos^2 \frac{}{4}$

$\frac{4I_0}{2} \quad 2I_0$

$\frac{I_0}{I} \quad \frac{1}{2}$

Hence correct option is (b).

10. $I \quad I_0 \cos^2 -(\quad 1)\,t$

at $\quad I \qquad I \quad I_0$

Hence correct variation is (c)

11. $I \quad I_0 \cos^2 \frac{x}{}$

$\frac{3}{4} I_0 \quad I_0 \cos^2 \frac{x}{}$

$\frac{x}{} \quad \frac{}{6}$

$x \quad \frac{}{6}$ but $x \quad (\quad 1)\,t$

$(1.5 \quad 1) \quad t \quad \frac{}{6}$

$t \quad \frac{}{3} \quad \frac{6000}{3}$ Å

$t \quad 2000$ Å $\quad 0.2 \quad$ m

Hence correct option is (a).

12. Net shift $(\;_1 \quad 1)\,t \quad (\;_2 \quad 1)\,t$

$(\;_1 \quad \;_2)\,t \quad (1.52 \quad 1.40) \quad t$

Net shift $\quad 0.12 \quad 10.4 \quad$ m

$12 \quad 104 \quad 10^{\;9}$ m

$1248 \quad 10^{\;9}$ m

1248 nm

Net shift $\quad n$

where n is $\quad$ ve integer

$n \quad 1248$

Now, for 416 $\quad n \quad 3$

For 624 $\quad , n \quad 2$

Hence correct option is (c).

13. $w \quad \frac{D}{d \quad n} \quad \frac{6300 \text{ Å} \quad 1.33 \text{ m}}{1 \text{ mm} \quad 1.33}$

$\frac{63 \quad 10^{\;8} \quad 1.33 \text{ m}}{10^{\;3} \quad 1.33}$

0.63 mm

Hence correct option is (a).

14. $x \quad \frac{7D}{nd} \quad \frac{3D}{nd} \quad 4 \; \frac{D}{nd}$

$x \quad 4 \quad 0.63$ mm $\quad 2.52$ mm

Correct option is (a).

15. $x \quad 2$ of fridge width

$(\quad 1)\,t \quad \frac{2 \quad 0.63 \text{ mm}}{2}$

$t \quad \frac{2 \quad 0.63}{0.53} \quad 1.57$ mm

Hence correct option is (b).

16. Since on introducing thin glass sheet fringe width does not change hence fringe width 0.63 mm.

The correct option is (a).

More than one options correct

1. At centre path difference between all colours is zero hence cnetre is white since violet has least wavelength hence next to central will be violet and since intensity is different for different for colours hence there will be not a completely dark fringe

Hence correct options, are (b), (c) and (d).

2. Correct options are (a), (c) and (d).

3. $\because I \quad 4I_0 \cos^2 \frac{}{2}$ at centre $\quad 0 \quad I \quad 4I_0$

and at distance 4 mm above o is again maxima hence its intensity is also $4I_0$.

Hence correct options are (a) and (c).

4. The correct options, are (a), (c) and (d)

Since phase difference constant

Light should be monochromatic.

5. Since in this case fringe pattern shift upward hence the correct options are (a), (b) and (c).

6. $\because n_{1\ 1} \quad n_{2\ 2}$ for maxima

Using this option (a) is satisfied and $(2n_1 \quad 1)_{\ 1} \quad (2n_2 \quad 1)_{\ 2}$ for minima

Using this 3rd option is satified

Hence correct options are (a) and (c).

Match the Columns

1. $\because I \quad 4I_0 \cos^2 \frac{}{2}$

if $\quad 60 \quad I \quad 3I_0$

if $\quad 90 \quad I \quad 2I_0$

if $\quad 0 \quad I \quad 4I_0$

if $\quad 120 \quad I \quad I_0$

Hence correct match is

(a) s; (b) q; (c) p; (d) r

2. $x \quad \frac{}{2}$

$\frac{2}{} \quad x$ if $x \quad \frac{}{3}$

$\frac{2}{3} \quad 120$

if $\quad x \quad \frac{}{6}$

60 if $x \quad \frac{}{4}, \quad 90$

Using $I \quad 4I_0 \cos^2 \frac{}{2}$

The correct match are

(a) q; (b) p; (c) r; (d) s

3. Distance between third order maxima and central maxima $\frac{3D}{d} \quad 3w$

Distance between 3rd order minima and central

Maxima $\quad 3 \quad \frac{1}{2} \frac{D}{d} \quad 2.5\frac{D}{d} \quad 2.5w$

Distance between first minima and forth order

maxima $\frac{4D}{d} \quad \frac{D}{2d} \quad 2.5w$

Distance between first minima and forth order

maxima $\frac{4D}{d} \quad \frac{D}{2d} \quad 3.5w$

Distance between 2nd order maxima and fifth order minima $\quad 4.5w \quad 2w \quad 2.5w$

hence correct match is

(a) q; (b) p; (c) r; (d) p

4. Since fringe shift in the division of sheet placed soure hence

(a) p

Similarly for other the correct match

(b) r, s; (c) p; (d) p

5. When $y \quad \frac{D}{2d}$ there will a dark fringe at 0.

hence (a) q

when $y \quad \frac{D}{6d} \quad 3 \quad \frac{D}{2d}$

The intensity becomes $3I$

(b) p

when $y \quad \frac{D}{4d}$ Intensity $2I$

(c) s

when $y \quad \frac{D}{3d}$ Intensity I

(d) r

6. When a thin plate (transparent) is placed in front of S_1 zero order fringe shift above from O hence

(a) r

When S_1 is closed interference disappear and uniform illuminance is obtained on screen hence

(b) p, q

Similarly (c) r, s and

When s is removed and two real sources s_1 and s_2 emitting light of same wavelength are placed interference disappear. Since sources become non-cohrrent hence (d) p, q

29. Modern Physics I

Introductory Exercise 29.1

1. The positron has same mass m as the electron. The reduced mass of electron positron atom is

$$\frac{m \quad m}{m \quad m} \quad \frac{1}{2}\text{m}$$

$$R_H \quad \frac{me^4}{8\ {}_0^2ch^3}$$

$$R_P \quad \frac{R_H}{2}$$

$$\frac{1}{_H} \quad R_H \quad \frac{1}{2^2} \quad \frac{1}{3^2}$$

$$\frac{1}{_P} \quad R_P \quad \frac{1}{2^2} \quad \frac{1}{3^2}$$

$$\frac{_P}{_H} \quad \frac{R_H}{R_P} \quad 2$$

$$_p \quad 2 \ _H \quad 2 \quad 6563 \text{ Å} \quad 13126 \text{ Å}$$

$$1.31 \quad \text{m}$$

$$\frac{1}{_{\text{He}}} \quad R_H \quad \frac{1}{2^2} \quad \frac{1}{3^2} \quad z^2$$

$$\frac{1}{_{\text{He}}} \quad \frac{1}{_{\text{H}}} \quad z^2 \qquad _{\text{He}} \quad \frac{_{\text{H}}}{2^2} \quad \frac{6563 \text{ Å}}{2^2}$$

$$_{\text{He}} \quad 164 \text{ nm}$$

2. $\frac{1}{} \quad R \quad \frac{1}{2^2} \quad \frac{1}{n^2}$ for largest wavelength $n \quad 3$

$$\frac{1}{} \quad R \quad \frac{1}{4} \quad \frac{1}{9}$$

$$\frac{36}{5R} \quad \frac{36}{5 \quad 1.097 \quad 10^7}$$

656 nm

3. For H-atom $r_n \quad \frac{_0 n^2h^2}{me^2}$

$$u_n \quad \frac{e^2}{2\ _0nh}$$

$$T_n \quad \frac{2\ r_n}{u_n} \quad 2 \quad \frac{n^2h^2 \quad 2\ _0nh}{me^2 \quad e^2}$$

$$\frac{4\ _0n^3h^3}{me^4}$$

$$r_n \quad \frac{1}{T_n} \quad \frac{me^4}{4\ {}_0^2n^3h^3}$$

$$r_1 \quad \frac{me^4}{4\ {}_0^2h^3}$$

$$_1 \quad \frac{9.1 \quad 10^{\ 31} \quad (1.6 \quad 10^{\ 19})^4}{4 \quad (8.85 \quad 10^{\ 12})^2 \quad (6.6 \quad 10^{\ 34})^3}$$

$$_1 \quad 6.58 \quad 10^{15} \text{ Hz}$$

$$_2 \quad \frac{_1}{2^3} \quad \frac{_1}{8} \quad \frac{6.58 \quad 10^{15}}{8}$$

$$0.823 \quad 10^{15} \text{ Hz}$$

(b) $\frac{1}{} \quad R \quad \frac{1}{1^2} \quad \frac{1}{2^2}$

$$\frac{c}{} \quad 3 \quad 10^8 \quad R \quad \frac{3}{4}$$

$$\frac{9 \quad 10^8 \quad 1.097 \quad 10^7}{4}$$

$$2.46 \quad 10^{15} \text{ Hz}$$

(c) Number of revolutions

$$v_2 \quad T \quad 0.823 \quad 10^{15} \quad 1 \quad 10^{\ 8}$$

$$8.23 \quad 10^6 \text{ revolution}$$

4. Reduce mass $\dfrac{m\ m_p}{m\quad m_p} \quad \dfrac{207\,\text{m} \quad 1836\,\text{m}}{(207\,\text{m} \quad 1836\,\text{m})} \quad 186\,\text{m}$

$$r_1 \quad 4 \quad {}_0 \frac{h^2}{4\ {}^2\ e^2} \quad 4 \quad {}_0 \frac{h^2}{4\ {}^2 (186m)\, e^2}$$

Putting the value we get

$$r_1 \quad 2.55 \quad 10^{\ 13}\text{m}$$

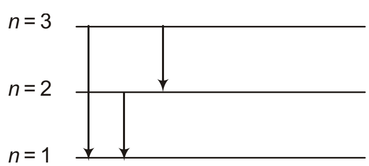
$$E_1 \quad \frac{e^4}{8\ {}_0^2 h^2} \quad 2810\,\text{eV}$$

Ionization energy $\quad E_1 \quad 2.81$ keV

5. (a) $\dfrac{h}{mv} \quad \dfrac{6.6 \quad 10^{\ 34}}{46 \quad 10^{\ 3} \quad 30} \quad 4.8 \quad 10^{\ 34}\text{m}$

(b) $\dfrac{6.6 \quad 10^{\ 34}}{9.1 \quad 10^{\ 31} \quad 10^7} \quad 7.3 \quad 10^{\ 11}\text{m}$

6. (a) After absorbing 12.3 eV the atom excited to $n \quad 3$ state



$$\frac{1}{{}_L} \quad R\ 1 \quad \frac{1}{n^2}$$

$$\frac{1}{{}_{L_1}} \quad R\ 1 \quad \frac{1}{9} \quad \frac{8R}{9}$$

$${}_{L_1} \quad \frac{9}{8R} \quad \frac{9}{8 \quad 1.097 \quad 10^7} \quad 102\text{ nm}$$

$$\frac{1}{{}_{L_2}} \quad R\ 1 \quad \frac{1}{4}$$

$${}_{L_2} \quad \frac{4}{3R} \quad \frac{4}{3 \quad 1.097 \quad 10^7} \quad 122\text{ nm}$$

$$\frac{1}{{}_B} \quad R \quad \frac{1}{2^2} \quad \frac{1}{3^2} \quad \frac{5R}{36}$$

$${}_B \quad \frac{36}{5R}$$

$${}_B \quad \frac{36}{5 \quad 1.097 \quad 10^7} \quad 653\text{ nm}$$

7. $\ {}_K \quad {}_K \quad {}_L \quad {}_L \quad \dfrac{{}_K \quad {}_K}{{}_K \quad {}_K}$

$$\frac{c}{{}_K} \quad \frac{c}{{}_K} \quad \frac{c}{{}_L} \quad {}_L \quad \frac{0.71 \quad 0.63}{0.71 \quad 0.63}$$

$$\frac{1}{{}_L} \quad \frac{1}{{}_K} \quad \frac{1}{{}_K} \quad {}_L \quad 5.59\text{ nm}$$

8. $\ \dfrac{hc}{E}$

$${}_K \quad \frac{6.6 \quad 10^{\ 34} \quad 3 \quad 10^8}{(E_1 \quad 2870) \quad 1.6 \quad 10^{\ 19}}$$

$$0.71 \quad 10^{\ 9} \quad \frac{6.6 \quad 10^{\ 34} \quad 3 \quad 10^8}{(E_1 \quad 2870) \quad 1.6 \quad 10^{\ 19}}$$

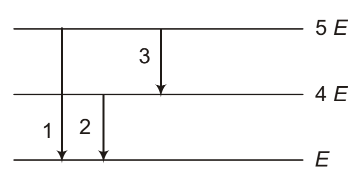
Solving this we get

$$E_1 \quad 4613\text{ eV}$$

$${}_{K_B} \quad \frac{6.6 \quad 10^{\ 34} \quad 3 \quad 10^8}{(4613 \quad E_3) \quad 1.6 \quad 10^{\ 19}} \quad 0.63$$

Solving this we get $E_3 \quad 2650$ eV

9. $\ {}_{31} \quad \dfrac{4E}{h} \quad f$ ...(i)



$${}_{21} \quad \frac{3E}{h} \quad \frac{3}{4} \quad \frac{4E}{h} \quad \frac{3f}{4}$$

$${}_{32} \quad \frac{E}{h} \quad \frac{f}{4}$$

Introductory Exercise 29.2

1. $eV_0 \quad \frac{hc}{\ } \quad W$

$$eV_0 \quad \frac{6.6 \quad 10^{\ 34} \quad 3 \quad 10^8}{2 \quad 10^{\ 7} \quad 1.6 \quad 10^{\ 19}} \quad 4.3\text{ eV}$$

$$eV_0 \quad 6.2\text{eV} \quad 4.3\text{ eV} \quad 1.9\text{ eV}$$

$$V_0 \quad 1.9\text{ volt}$$

2. $P \quad 1.5\text{mW} \quad 1.5 \quad 10^{\ 3}\text{ W}$

Energy of each photon

$$\frac{6.62 \quad 10^{\ 34} \quad 3 \quad 10^8}{4 \quad 10^{\ 7}}$$

$$4.96 \quad 10^{\ 19}\text{ J}$$

Number of photons incident per second

$$\frac{P}{\text{Energy of each photon}} \quad \frac{1.5 \quad 10^{\ 3}}{4.96 \quad 10^{\ 19}}$$

$$\sim 3 \quad 10^{15}$$

The number of photoelectrons produce

$$0.1\% \quad 3 \quad 10^{15} \quad 3 \quad 10^{12}$$

Current $i \quad 3 \quad 10^{12} \quad 1.6 \quad 10^{\ 19}$ A

$$4.8 \quad 10^{\ 7}\text{ A} \quad 0.48 \quad \text{A}$$

3. $K_{\max} \quad hf \quad W \quad hf \quad hf_0$

$$K_{\max} \quad (f \quad f_0)$$

4. $K_{\max} \quad \frac{hc}{\ } \quad W$

$$\frac{6.62 \quad 10^{\ 34} \quad 3 \quad 10^8}{2 \quad 10^{\ 7} \quad 1.6 \quad 10^{\ 19}} \quad 3 \quad \text{eV}$$

$$[6.20 \quad 3]\text{eV} \quad 3.20\text{ eV}$$

The minimum kinetic energy 0.

5. $K_{\max} \quad h[f \quad f_0]$

$$1.2\text{ eV} \quad h[f \quad f_0] \qquad \text{...(i)}$$

$$4.2\text{ eV} \quad h[1.5f \quad f_0] \qquad \text{...(ii)}$$

Dividing Eq. (i) and Eq. (ii)

$$\frac{124}{42} \quad \frac{f \quad f_0}{1.5f \quad f_0}$$

$$3f \quad 2f_0 \quad 7f \quad 7f_0$$

$$5f_0 \quad 4f$$

$$f_0 \quad \frac{4}{5}f \quad 0.8f$$

$$1.2 \quad 1.6 \quad 10^{\ 19} \quad 6.62 \quad 10^{\ 34} \quad \frac{f_0}{0.8} \quad f_0$$

$$\frac{1.2 \quad 1.6 \quad 10^{\ 19}}{6.62 \quad 10^{\ 34}} \quad \frac{2f_0}{8} \quad \frac{f_0}{4}$$

$$f_0 \quad 1.16 \quad 10^{15}\text{Hz}$$

Subjective Questions (Level I)

1. Here $\quad 280\text{ nm} \quad 28 \quad 10^{\ 8}$ m

$$E \quad \frac{hc}{\ } \quad \frac{6.6 \quad 10^{\ 34} \quad 3 \quad 10^8}{28 \quad 10^{\ 8}}\text{ J}$$

$$E \quad \frac{19.8 \quad 10^{\ 34} \quad 10^{16}}{28}\text{ J} \quad \frac{198 \quad 10^{\ 19}}{28}\text{ J}$$

$$E \quad \frac{198 \quad 10^{\ 19}}{28 \quad 1.6 \quad 10^{\ 19}}\text{ eV} \quad \frac{198}{28 \quad 1.6} \sim 4.6\text{ eV}$$

We have $E \quad mc^2 \quad m \quad \frac{E}{c^2} \quad \frac{198 \quad 10^{\ 19}}{28 \quad 9 \quad 10^{16}}$

$$m \quad 8.2 \quad 10^{\ 36}\text{ kg}$$

Momentum $p \quad mc \quad 8.2 \quad 10^{\ 36} \quad 3 \quad 10^8$

$$2.46 \quad 10^{\ 27}\text{ kg-m/s}$$

2. Intensity of light at a distance 2 m

From the source $\quad \frac{1}{4 \quad (2)^2} \quad \frac{1}{16}\text{ W/m}^2$

Let plate area is A

Energy incident on unit time is

$$E_1 \quad \frac{1}{16} A$$

Energy of each photon

$$\frac{6.6 \quad 10^{34} \quad 3 \quad 10^{8}}{4.8 \quad 10^{7}}$$

Number of photons striking per unit area

$$n \quad \frac{\frac{1}{16} \quad A \quad 4.8 \quad 10^{7}}{A \quad 6.6 \quad 10^{34} \quad 3 \quad 10^{8} \quad A}$$

$4.82 \quad 10^{16}$ per m^2 s

3. Here $p \quad 8.24 \quad 10^{28}$ kg-m/s

(a) Energy of photon $E \quad pc$

$$E \quad 8.24 \quad 10^{28} \quad 3 \quad 10^{8}$$

$$E \quad 2.47 \quad 10^{19}\,\text{J}$$

Energy in eV $\dfrac{E \text{ in joule}}{1.6 \quad 10^{19}}$

$$\frac{2.47 \quad 10^{19}}{1.6 \quad 10^{19}}$$

Energy (in eV) 1.54 eV

(b) Wavelength

$$\frac{h}{p} \quad \frac{6.6 \quad 10^{34}}{8.24 \quad 10^{28}} \quad 804 \text{ nm}$$

This wavelength in Infrared region.

4. We have $c \quad f \qquad f \quad \dfrac{c}{} \quad \dfrac{3 \quad 10^{8}\,\text{m/s}}{6 \quad 10^{7}\,\text{m}}$

$$f \quad 5 \quad 10^{14}\,\text{Hz}$$

We have $p \quad \dfrac{E}{t} \qquad E \quad pt$ power per sec energy

$$P \quad E$$

$$75 \quad (h \quad v) \quad n$$

$$\frac{75}{6.6 \quad 10^{34} \quad 5 \quad 10^{14}}$$

$n \quad 2.3 \quad 10^{20}$ photons/sec

5. (a) $E \quad 2.45\,\text{MeV} \quad 2.45 \quad 1.6 \quad 10^{19} \quad 10^{6}\,\text{J}$

$$E \quad h \qquad \frac{E}{h} \quad \frac{3.92 \quad 10^{13}}{6.6 \quad 10^{34}}$$

$$5.92 \quad 10^{20}\ \text{Hz}$$

(b) We have $c \qquad \dfrac{c}{}$

$$\frac{3 \quad 10^{8}}{5.92 \quad 10^{20}} \quad 5.06 \quad 10^{13}\ \text{m}$$

6. We have $p \quad \sqrt{2mK}$

$p_1 \quad \sqrt{2mK_1}$ and $p_2 \quad \sqrt{2mK_2}$

$$\frac{p_1}{p_2} \quad \sqrt{\frac{K_1}{K_2}}$$

$$\frac{1}{2} \quad \sqrt{\frac{K_1}{K_2}} \qquad [\because p_2 \quad 2p_1]$$

$$K_2 \quad 4K_1$$

(b) $E_1 \quad p_1 c$ and $E_2 \quad p_2 c \quad E_2 \quad 2p_1 c$

$$E_2 \quad 2E_1$$

7. (a) Since power energy per unit line

let n be the number of photons

$$P \quad nE \quad 10 \quad n \quad \frac{nc}{}$$

$$n \quad \frac{10}{hc} \quad \frac{10 \quad 500 \quad 10^{9}}{6.6 \quad 10^{34} \quad 3 \quad 10^{8}}$$

$$n \quad 2.52 \quad 10^{19}$$

(b) Force exerted on that surface

$$F \quad \frac{P}{c} \quad \frac{10}{3 \quad 10^{8}} \quad 3.33 \quad 10^{8}\ \text{N}$$

8. Absorbing (power) light 70% of incident light

P_a 70% of 10 W 7 W

Refractive power 30% of 10 W

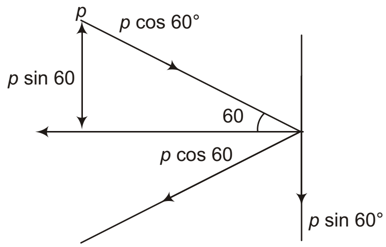
P_R 3 W

The force exerted $\dfrac{P_a}{c} \quad \dfrac{2P_R}{c}$

$$\frac{7 \quad 2 \quad 3}{c} \quad \frac{13}{3 \quad 10^{8}}$$

$4.3 \quad 10^{8}$ N

9. Force rate of change of momentum



$$F \quad \frac{p}{t} \text{ here } t \quad 1\,\text{s}$$

$$F \quad 2p\cos 60$$

$$F \quad p$$

$$F \quad \frac{nh}{}$$

where n is number of photons striking per second

$$F \quad \frac{1 \quad 10^{19} \quad 6.63 \quad 10^{\ 34}}{663 \quad 10^{\ 9}} \quad 10^{\ 8}\,\text{N}$$

10. Here output energy 60 W/s

$$\text{Pressure } p \quad \frac{2 \quad 60}{3 \quad 10^{8}} \quad 4 \quad 10^{\ 7}\ \text{N}$$

de-Broglie wavelength

11. Here m 5 g m 5 $10^{\ 3}$kg, v 340 m/s

by de-Broglie hypothesis wavelength

$$\frac{h}{mv} \quad \frac{6.62 \quad 10^{\ 34}}{5 \quad 10^{\ 3} \quad 340}$$

$$3.9 \quad 10^{\ 34}\ \text{m}$$

Since is too small. No wave like property is exhibit.

12.(a) $$_{e} \quad \frac{h}{m_e v} \quad \frac{6.6 \quad 10^{\ 34}}{9.1 \quad 10^{\ 31} \quad 4.7 \quad 10^{6}}$$

$$1.55 \quad 10^{\ 10}\ \text{m}$$

(b) $$_{p} \quad \frac{6.6 \quad 10^{\ 34}}{1836 \quad 9.1 \quad 10^{\ 31} \quad 4.7 \quad 10^{\ 6}}$$

$$8.44 \quad 10^{\ 14}\,\text{m}$$

13. (a) $$\frac{h}{p} \quad p \quad \frac{h}{} \quad \frac{6.6 \quad 10^{\ 34}}{2.8 \quad 10^{\ 10}}$$

$$p \quad 2.37 \quad 10^{\ 24}\,\text{kg-m/s}$$

(b) $\because p^2 \quad 2m_e K \quad K \quad \dfrac{p^2}{2m_e}$

$$K \quad \frac{(2.37 \quad 10^{\ 24})^2}{2 \quad 9.1 \quad 10^{\ 31}}$$

$$K \quad 3.07 \quad 10^{\ 18}\ \text{J}$$

$$K\,(\text{in eV}) \quad \frac{K \text{ in J}}{1.6 \quad 10^{\ 19}} \quad \frac{3.07 \quad 10^{\ 18}}{1.6 \quad 10^{\ 19}}$$

$$K \quad 19.2\ \text{eV}$$

14. Here T 273 20 293 K

$$v_{\text{rms}} \quad \sqrt{\frac{3RT}{M}} \qquad \frac{h}{Mv_{\text{rms}}}$$

$$\frac{h}{\sqrt{3\,MRT}}$$

$$\frac{6.6 \quad 10^{\ 34}}{\sqrt{3 \quad 1836 \quad 9.1 \quad 10^{\ 31} \quad 8.31 \quad 293}}$$

$$1.04\ \text{Å}$$

15. For hydrogen like atom

$$E \quad K \text{ Here } E \quad 3.4\ \text{eV}$$

$$K \quad 3.4\ \text{eV} \quad 3.4 \quad 1.6 \quad 10^{\ 19}\ \text{J}$$

$$\frac{h}{p} \quad \frac{h}{\sqrt{2m_e K}}$$

$$\frac{6.6 \quad 10^{\ 34}}{\sqrt{2 \quad 9.1 \quad 10^{\ 31} \quad 3.4 \quad 1.6 \quad 10^{\ 19}}}$$

$$6.663\ \text{Å}$$

16. In Bohr model the velocity of electron in nth orbit is given by

$$U_n \quad \frac{e^2}{2 \ _0 nh}$$

Putting the values of e, $_0$, h and n 1, we get

$$U_1 \quad 2.19 \quad 10^{7}\,\text{m/s and } U_4 \quad \frac{2.19 \quad 10^{6}}{4}\,\text{m/s}$$

$$_1 \quad \frac{h}{m_e v_1} \text{ and } _4 \quad \frac{h}{m_e u_4} \quad \frac{h}{m_e \dfrac{u_1}{4}} \quad 4 \quad _1$$

$$_1 \quad \frac{6.6 \quad 10^{\;34}}{9.1 \quad 10^{\;31} \quad 2.19 \quad 10^6}$$

$$3.32 \quad 10^{\;10}\text{m}$$

$$_4 \quad 4 \;_1 \quad 4 \quad 3.332 \quad 10^{\;10}\text{m}$$

$$13.28 \quad 10^{\;10} \text{ m}$$

$$1.33 \quad 10^{\;9}\text{m}$$

The radius of first Bohr orbit

$$r_1 \quad 0.529 \quad 10^{\;10}$$

The radius of fourth Bohr orbit

$$r_4 \quad 16 \quad 0.529 \quad 10^{\;10}$$

$$2 \; r_1 \quad 2 \quad 3.14 \quad 0.529 \quad 10^{\;10}$$

$$3.32 \quad 10^{\;10}\text{m} \quad _1$$

Bohr Atomic Model and Emission Spectrum

17. For hydrogen like atom we can write

$$e_n \quad \frac{z^2}{n^2}(13.6\,\text{eV})$$

For lithium atom $z \quad 3$ we get

$$E_n \quad \frac{9}{n^2}(13.6\,\text{eV}) \quad \frac{122.4}{n^2}\text{eV}$$

The ground state energy is for $n \quad 1$

$$E_1 \quad \frac{122.4}{1^2}\text{eV} \qquad 122.4 \text{ eV}$$

Ionization potential $\quad E_1 \quad 122.4$ eV

18. For hydrogen atom we can write

(a) $E \quad K \quad K \quad 3.4$ eV

(b) PE $\quad 2K \quad 2 \quad 3.4 \quad 6.8$ eV

Since potential energy depends upon refrence hence it will changed.

19. Binding energy of an electron in He-atom is $E_0 \quad 24.6$ eV. *ie*, the energy required to remove one electron from He-atom $\quad 24.6$ eV

Now, He-atom becomes He and energy of He ion is given by

$$E_n \quad \frac{z^2(13.6)}{n^2} \text{ for He } \quad z \quad 2\text{, we get}$$

$$E_1 \quad 4 \quad 13.6 \quad 54.4 \text{ eV.}$$

Hence energy required to remove this electron $\quad 54.4$ eV, thus total energy $\quad 24.6 \quad 54.4 \quad 79$ eV

20. For hydrogen atom $E_n \quad \dfrac{13.6\,\text{eV}}{n^2}$

Putting $n \quad 3$, we get

$$E_3 \quad \frac{13.6\,\text{eV}}{9} \qquad 1.51\,\text{eV}$$

Hence hydrogen atom is in third excited state the angular momentum

$$L \quad \frac{nh}{2} \quad \frac{3h}{2} \quad \frac{3 \quad 6.62 \quad 10^{\;34}}{2 \quad 3.14}$$

$$L \quad 3.16 \quad 10^{\;34}\text{kg-m}^2/\text{s}$$

21. We have $\quad \dfrac{hc}{E} \quad \dfrac{6.6 \quad 10^{\;34} \quad 3 \quad 10^8}{E}$

$$E \quad \frac{6.6 \quad 10^{\;34} \quad 3 \quad 10^8}{1023 \quad 10^{\;10}} \text{(in Joule)}$$

$$E \quad \frac{6.6 \quad 10^{\;34} \quad 3 \quad 10^8}{1023 \quad 10^{\;10} \quad 1.6 \quad 10^{\;19}} \text{(in eV)}$$

$$\sim 12.1\,\text{eV}$$

$$E_n \quad E_1 \quad 12.1\,\text{eV But } E_1 \quad 13.6\,\text{eV}$$

$$E_n \sim \quad 1.51\,\text{eV}$$

For H-atom $E_n \quad \dfrac{13.6}{n^2} \qquad 1.51 \qquad \dfrac{13.6}{n^2}$

$$n \quad 3$$

Hence atom goes to 3rd excited state. The possible transition are (3 2, 3 1, and 2 1) *ie*, 3 transitions are possible and the largest wavelength 1023 Å

(From 3 1)

22. For hydrogen like atom

$$E_n \quad \frac{z^2}{n^2}(13.6)\text{ eV}$$

For Li $\quad z \quad 3$

$$E_n \quad \frac{122.4}{n^2}\text{eV} \quad E_1 \quad 122.4\text{ eV}$$

$$E_3 \quad \frac{122.4}{9}\text{eV} \quad 13.6\text{ eV}$$

$$E \quad E_3 \quad E_1 \quad (122.4 \quad 13.6)\text{ eV} \quad 108.8\text{ eV}$$

$$\frac{hc}{E} \quad \frac{6.6 \quad 10^{\ 34} \quad 3 \quad 10^8}{108.8 \quad 1.6 \quad 10^{\ 19}} \quad 113.74\text{ Å}$$

23. The excited state energy He atom will be equal to the sum of energies of the photons having wavelength 108.5 nm and 30.4 nm.

$$E_n \quad E_1 \quad \frac{hc}{_1} \quad \frac{hc}{_2}$$

$$\frac{6.63 \quad 10^{\ 34} \quad 3 \quad 10^8}{10^{\ 10}} \quad \frac{1}{1085} \quad \frac{1}{304}$$

$$E_n \quad E_1 \quad 83.7 \quad 10^{\ 19}\text{ J}$$

$$\frac{83.7 \quad 10^{\ 19}\text{ J}}{1.6 \quad 10^{\ 19}\text{ J/eV}} \quad 52.3\text{ eV} \quad \text{...(i)}$$

For He atom $E_n \quad \frac{z^2(13.6)}{n^2}\text{eV}$

For He $\quad z \quad 2$

$$E_n \quad \frac{54.4}{n^2}\text{ eV}$$

$$E_1 \quad 54.4\text{ eV}$$

$$E_n \quad E_1 \quad 54.4 \ 1 \quad \frac{1}{n^2} \quad \text{eV} \quad \text{...(ii)}$$

From Eqs. (i) and (ii), we get

$$52.3 \quad 54.4 \ 1 \quad \frac{1}{n^2}$$

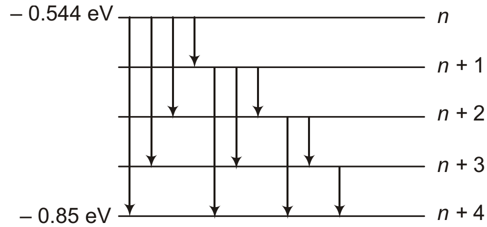
$$1 \quad \frac{1}{n^2} \quad 0.96$$

$$n \quad 5$$

24. For hydrogen like atom

$$E_n \quad \frac{z^2}{n^2}(13.6)\text{ eV}$$

Let for ten transitions quantum numbers of energy levels are n, $n \quad 1$, $n \quad 2$, $n \quad 3$ and $n \quad 4$



$$\frac{z^2(13.6)\text{ eV}}{n^2} \quad 0.85\text{ eV} \quad \text{...(i)}$$

$$\frac{z^2(13.6)\text{ eV}}{(n \quad 4)^2} \quad 0.544\text{ eV} \quad \text{...(ii)}$$

Dividing Eq. (i) and Eq. (ii)

$$\frac{(n \quad 4)^2}{n^2} \quad \frac{0.85}{0.544} \quad 1.5625$$

$$\frac{n \quad 4}{n} \quad 1.25$$

$$1 \quad \frac{4}{n} \quad 1.25$$

$$\frac{4}{n} \quad 0.25$$

$$n \quad \frac{4}{0.25} \quad 16$$

Putting this value of n in Eq. (i)

$$\frac{z^2(13.6)}{(16)^2} \quad 0.85$$

$$z^2 \quad \frac{256 \quad 0.85}{13.6}$$

$$z^2 \quad 16 \quad z \quad 4$$

Hence atom no. of atom is 4

We know that $E \quad \frac{hc}{}$

$\frac{hc}{E}$ for smallest wavelength E is maximum

$$\frac{6.6 \quad 10^{\ 34} \quad 3 \quad 10^8}{[\ 0.544 \quad (\ 0.85)] \quad 1.6 \quad 10^{\ 19}}$$

40441 Å

25. Here $E_1 \quad 15.6\,\text{eV}$

(a) Hence ionization potential

$E_1 \quad 15.6\,\text{eV}$

(b) We have $\quad \frac{hc}{E}$ for short wavelength

E is maximum

$$\frac{6.6 \quad 10^{\quad 34} \quad 3 \quad 10^{8}}{0 \quad (\quad 5.3) \quad 1.6 \quad 10^{\quad 19}} \sim 2335\ \text{Å}$$

(c) Excitation potential for $n \quad 3$ state is

$E_3 \quad E_1 \qquad 3.08 \quad 15.6 \quad 12.52\ \text{V}$

(d) From $n \quad 3$ to $n \quad 1$

$E \quad E_3 \quad E_1 \qquad 3.08 \quad 15.6 \quad 12.52\,\text{eV}$

We know $\quad \frac{hc}{E}$

$$\frac{1}{\ } \quad \frac{E}{hc} \quad \frac{12.52 \quad 1.6 \quad 10^{\quad 19}}{6.6 \quad 10^{\quad 34} \quad 3 \quad 10^{8}}$$

$1.01 \quad 10^{7}\ (\text{m}^{\quad 1})$

26. (a) $E_1 \qquad 6.52\,\text{eV}$

$860\ \text{nm} \quad 8600\ \text{Å}$

Energy of this photon

$$\frac{12375\,(\text{eV})}{8600} \quad 1.44\ \text{eV}$$

hence internal energy of atom after absorbing this photon is given by

$E_i \quad E_1 \quad 1.44\ \text{eV} \qquad 6.52 \quad 1.44$

$5.08\ \text{eV}$

(b) $\ _2 \quad \frac{12375\,(\text{eV})}{4200} \quad 2.95\ \text{eV}$

hence internal energy of the atom after emission of this photon is given by

$E_i \quad E_1 \quad 2.95\,\text{eV} \quad (\quad 2.68 \quad 2.95)\,\text{eV}$

$E_i \qquad 5.63\ \text{eV}$

27. Heve $U \quad \frac{1}{2} m \quad {}^{2} r^{2} \qquad F \quad \left|\frac{dU}{dr}\right| \quad m^{2} \quad {}^{2} r$

But $\qquad \frac{mv^{2}}{r} \quad m^{2} \quad {}^{2} r$

$v^{2} \quad m \quad {}^{2} r^{2}$

But by Bohr's postulate $mvr \quad \frac{nh}{2}$

$$m^{2} v^{2} r^{2} \quad \frac{n^{2} h^{2}}{4 \quad ^{2}}$$

$$m^{3} \quad {}^{2} r^{4} \quad \frac{n^{2} h^{2}}{4 \quad ^{2}}$$

$$r^{4} \quad \frac{n^{2} h^{2}}{4 \quad {}^{2} m^{3} \quad ^{2}}$$

$$r \quad \sqrt{n}$$

28. $\frac{1}{\ _K} \quad R(z \quad 1)^{2} \ 1 \quad \frac{1}{2^{2}} \qquad \frac{1}{\ _0}$

$$\frac{1}{\ _K} \quad R(z \quad 1)^{2} \ 1 \quad \frac{1}{3^{2}}$$

$$\frac{\ _K}{\ _K} \quad \frac{3}{4} \frac{9}{8} \quad \frac{27}{32}$$

$$_K \quad \frac{27}{32} \ _K \qquad \frac{27}{32} \ _0$$

29. $\ _0 \quad \frac{hc}{eV}$

$$_{0_1} \quad \frac{6.6 \quad 10^{\quad 34} \quad 3 \quad 10^{8}}{1.6 \quad 10^{\quad 19} \quad 25 \quad 10^{3}}$$

$_{0_1} \quad 49.5\ \text{pm}$

$_{0_2} \quad 2 \ _{0_1} \quad 2 \quad 49.5\ \text{pm} \quad 99\ \text{pm}$

$[1\ \text{pm} \quad 10^{\quad 12}\ \text{m}]$

30. $f_K \quad (2.48 \quad 10^{15})\ \text{Hz}\ (z \quad 1)^{2}$

$$\frac{3 \quad 10^{8}}{\ _K} \quad 2.48 \quad 10^{15}(2 \quad 1)^{2}$$

$$\frac{3 \quad 10^{8}}{0.76 \quad 10^{\quad 10} \quad 2.58 \quad 10^{15}} \quad (z \quad 1)^{2}$$

$z \quad 1) \sim 40 \qquad z \quad 41$

31. $\ _i \quad \frac{hc}{eV} \qquad 26\ \text{pm}$ when $V_f \quad 1.5\ \text{V}$

$_f \quad (\ _i \quad 26)\ \text{pm}$

$$_f \quad \frac{hc}{e \quad 1.5\ V} \quad \frac{1}{1.5} \frac{hc}{eV} \quad \frac{12}{1.5} \quad \frac{1}{1.5} \ _i$$

$$(\ _i \quad 26) \quad \frac{2}{3}\ _i$$

$$3\ _i \quad 26 \quad 3 \quad 2\ _i$$

$$_i \quad 78\text{ pm}$$

$$78 \quad 10^{\ 12} \quad \frac{6.6 \quad 10^{\ 34} \quad 3 \quad 10^{8}}{1.6 \quad 10^{\ 19} \quad V}$$

$$V \quad \frac{6.6 \quad 3 \quad 10^{\ 26}}{1.6 \quad 78 \quad 10^{\ 12} \quad 10^{\ 19}}$$

$$V \quad 15865\text{ volt}$$

32. $\sqrt{V} \quad a(z \quad b)$

$$\frac{c}{\ } \quad a^2(z \quad b)^2$$

$$\frac{1}{\ } \quad \frac{a^2}{c}(z \quad b)^2$$

$$\frac{1}{887\text{ pm}} \quad \frac{a^2}{c}(13 \quad b)^2 \qquad \text{...(i)}$$

and $$\frac{1}{146\text{ pm}} \quad \frac{a^2}{z}(30 \quad b)^2 \qquad \text{...(ii)}$$

Dividing Eq. (i) and Eq. (ii)

$$\frac{146}{887} \quad \frac{(13 \quad b)}{(30 \quad b)}^{2}$$

$$2.5 \quad \frac{30 \quad b}{13 \quad b}$$

$$32.5 \quad 2.5b \quad 30 \quad b$$

$$2.5 \quad 1.5b$$

$$b \quad \frac{5}{3}$$

$$\frac{1}{\ _{26}} \quad \frac{a^2}{c} \quad 26 \quad \frac{5}{3}^{\ 2}$$

$$\frac{1}{\ _{26}} \quad \frac{26 \quad \frac{5}{3}^{\ 2}}{887\text{ pm} \quad 13 \quad \frac{5}{3}^{\ 2}}$$

$$_{26} \quad \frac{887\text{ pm} \quad 13 \quad \frac{5}{3}^{\ 2}}{26 \quad \frac{5}{3}^{\ 2}}$$

$$887\text{ pm} \quad \frac{34^2}{(73)^2}$$

$$\sim 198\text{ pm}$$

33. $\sqrt{f} \quad \sqrt{\frac{3RC}{4}}(z \quad 1)$

$$\sqrt{4.2 \quad 10^{18}} \quad \sqrt{\frac{3 \quad 1.1 \quad 10^{7} \quad 3 \quad 10^{8}}{4}}(z \quad 1)^2$$

$$\frac{4.2 \quad 10^{18} \quad 4}{9 \quad 1.1 \quad 10^{15}} \quad (z \quad 1)^2$$

$$(z \quad 1) \quad 41 \quad z \quad 42$$

34. $P \quad Vi \quad 40\text{ kW} \quad 10\text{ mA} \quad 400\text{ W}$

$$\%\text{ of } P \quad \frac{400 \quad 1}{100} \quad 4\text{ W}$$

(a) Total power of X-rays $\quad 4$ W

(b) Heat produced per second

$$400 \quad 4 \quad 396\text{ J/s}$$

Photoelectric effect

35. Einstein photo electric equation is

$$K_{\max} \quad h \quad W$$

$$eV_0 \quad \frac{hc}{\ } \quad W \because K_{\max} \quad eV_0$$

$$10.4\text{ eV} \quad \frac{12375}{(\text{Å})} \quad 1.7\text{ eV}$$

$$(\text{Å}) \quad \frac{12375}{12.1} \quad 1022\text{ Å}$$

For H-atom $\quad \frac{hc}{E} \quad E \quad \frac{12375}{1022} \quad 12.1\text{ eV}$

This difference equal to $n \quad 3 \qquad n \quad 1$ transition.

36. $K_{max} \quad h \qquad W$

$$K_{max} \quad \frac{6.6 \quad 10^{\ 34} \quad 1.5 \quad 10^{15}}{1.6 \quad 10^{\ 19}} \quad 3.7$$

$$K_{max} \quad 6.18 \quad 3.7 \quad 2.48 \text{ eV}$$

37. Here work function

$$W(\text{in eV}) \quad \frac{12375}{5000 \text{ Å}} \quad 2.475 \text{ eV}$$

$$K_{max} \quad eV_0 \quad 3 \text{ eV}$$

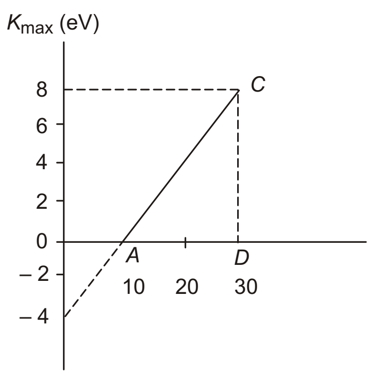
$$K_{max} \quad \frac{hc}{} \quad W$$

$$3 \quad \frac{12375}{(\text{in Å})} \quad 2.475$$

$$\frac{12375}{5.475} \quad 2260 \text{ Å}$$

38. Comparing the given graph with

$$K_{max} \quad h \qquad W$$



$$f \quad 1 \quad 10^{14} \text{ Hz}$$

(a) $_o$ threshold frequency $\quad 10 \quad 10^{14}$ Hz

10^{15} Hz

(b) $W \quad 4$ eV

(c) h slope of the graph

$$\frac{CD}{AD} \quad \frac{8 \text{ eV}}{20 \quad 10^{14} \text{Hz}}$$

$$h \quad \frac{8 \quad 1.6 \quad 10^{\ 19}}{2 \quad 10^{15}} \quad 6.4 \quad 10^{\ 34} \text{ J-s}$$

39. Here $\frac{v_{1(\max)}}{u_{2(\max)}} \quad \frac{3}{1}$

Using Einstein equation, $K_{max} \quad \frac{hc}{} \quad W$, we get

$$\frac{1}{2}mv^2_{max} \quad \frac{hc}{} \quad W$$

where m is the mass of photoelectron

$$\frac{1}{2}m[v_{1(\max)}]^2 \quad \frac{hc}{_1} \quad W \qquad \ldots\text{(i)}$$

and

$$\frac{1}{2}m[v_{2(\max)}]^2 \quad \frac{hc}{_2} \quad W \qquad \ldots\text{(ii)}$$

Dividing Eq. (i) and Eq. (ii), we get

$$\frac{v_{1\ max}}{v_{2\ max}}^{2} \quad \frac{\frac{hc}{_1} \quad W}{\frac{hc}{_2} \quad W} \quad (3)^2 \quad \frac{\frac{hc}{_1} \quad W}{\frac{hc}{_2} \quad W}$$

$$\frac{9hc}{_2} \quad \frac{hc}{_1} \quad 8W$$

$$hc \quad \frac{9}{6000} \quad \frac{1}{3000} \quad 8W$$

$$\frac{6.6 \quad 10^{\ 34} \quad 3 \quad 10^8 \quad 7}{6000 \quad 10^{\ 10} \quad 1.6 \quad 10^{\ 19}} \quad 8W$$

$$W \quad 1.81 \text{ eV}$$

Putting the value of W in Eq. (i)

$$\frac{1}{2}m(u_{1\ max})^2 \quad \frac{hc}{3000 \quad 10^{\ 10}}$$

$$1.81 \quad 1.6 \quad 10^{\ 19}$$

$$\frac{1}{2}m(u_{1\ max})^2 \quad \frac{6.62 \quad 10^{\ 34} \quad 3 \quad 10^8}{3 \quad 10^7}$$

$$2.896 \quad 10^{\ 19}$$

$$\frac{1}{2}m(u_{1\ max})^2 \quad 6.62 \quad 10^{\ 19} \quad 2.896 \quad 10^{\ 19}$$

$$\frac{1}{2}m(u_{1\ max})^2 \quad 3.724 \quad 10^{\ 19}$$

$$(u_{1\,max})^2 \quad \frac{3.724 \quad 10^{19} \quad 2}{9.1 \quad 10^{31}}$$

$$1.81 \quad 1.6 \quad 10^{19} \because \quad m_e \quad 9.1 \quad 10^{31}$$

$$u_{1\,max} \quad 9 \quad 10^5 \text{ m/s}$$

and $v_{2\,max} \quad \frac{1}{3} v_{1\,max} \quad 3 \quad 10^5$ m/s

40. Here intensity $I \quad 2$ W/m^2 and

Area $A \quad 1 \quad 10^{4}$m^2

Energy incident per unit time on the metal surface

$$E \quad IA \quad 2 \quad 10^{4} \text{ W}$$

$$2 \quad 10^{4} \text{ J/s} \quad \frac{2 \quad 10^{4}}{1.6 \quad 10^{19}} \frac{\text{eV}}{\text{s}}$$

$$\frac{2 \quad 10^{15}}{1.6} \text{ eV/s}$$

Energy of each photon $\quad$ 10.6 eV

Number of photons incident on surface

$$\frac{2 \quad 10^{15}}{1.6 \quad 10.6}$$

Number of photoelectrons emitted

$$\frac{0.53}{100} \quad \frac{2 \quad 10^{15}}{1.6 \quad 10.6}$$

$$6.25 \quad 10^{11} \text{ per second}$$

Minimum KE $\quad$ 0

Maximum KE $\quad$ (10.6 $\quad$ 5.6) eV $\quad$ 5 eV

41. $K_{max} \quad \frac{hc}{} \quad W$

$$K_{max} \quad \frac{6.6 \quad 10^{34} \quad 3 \quad 10^8}{180 \quad 10^{9}} \quad 2 \quad 1.6 \quad 10^{19}$$

$$\frac{1}{2} m_e v_{max}^2 \quad \frac{6.6 \quad 3 \quad 10^{18}}{18} \quad 2 \quad 1.6 \quad 10^{19}$$

$$\frac{1}{2} m_e v_{max}^2 \quad 11 \quad 10^{19} \quad 3.2 \quad 10^{19}$$

$$7.2 \quad 10^{19} \text{ J}$$

$$v_{max} \quad \sqrt{\frac{2 \quad 7.2 \quad 10^{19}}{9.1 \quad 10^{31}}} \quad 1.25 \quad 10^6 \text{ m/s}$$

$$r \quad \frac{mv_{max}}{eB} \quad \frac{9.1 \quad 10^{31} \quad 1.25 \quad 10^6}{1.6 \quad 10^{19} \quad 5 \quad 10^{5}}$$

$$r \quad 0.148 \text{ m}$$

42. The given equation is

$$E \quad (100 \text{ v / m}) [\sin ((5 \quad 10^{15}) t \quad \sin (8 \quad 10^{15}) t]$$

Light consist of two different frequencies.

Maximum frequency

$$\frac{8 \quad 10^{15}}{2} \quad 1.27 \quad 10^{15} \text{ Hz}$$

For maximum KE we will use Einstein's equation

$$(\text{KE})_{max} \quad h \quad W$$

$$\frac{1.27 \quad 10^{15} \quad 6.62 \quad 10^{34}}{1.6 \quad 10^{19}} \quad 2$$

$$(\text{KE})_{max} \quad 3.27 \text{ eV}$$

43. Here $E \quad E_0 \sin 1.57 \quad 10^7 (x \quad ct)$ frequency of the wave

$$\frac{1.57 \quad 3 \quad 10^{15}}{2 \quad 3.14} \quad 0.75 \quad 10^{15}$$

We have

$$eV_0 \quad \frac{6.6 \quad 10^{34} \quad 0.75 \quad 10^{15}}{1.8 \quad 10^{19}} \quad 1.9 \text{ eV}$$

$$V_0 \quad 1.2 \text{ V}$$

Objective Questions (Level-1)

1. Einstein photo electric equation is

$$K_{max} \quad h \quad W$$

its slope $\quad h \quad$ planck constant which is same for all metals and independent of intensity of radiation.

Hence correct option is (d).

2. Since current is directly proportional to intensity therefore as current is increased intensity is increased since $_{\min}$ $\frac{1}{V}$, if V is decreased $_{\min}$ is increased.

Hence correct option is (c).

3. For hydrogen atom (Bohr's model) nth orbital speed $v_n \quad \frac{e^2}{2 \ {}_0 nh}$

For first orbit $n \quad 1$

$$v_1 \quad \frac{e^2}{2 \ {}_0 \quad h}$$

$$\frac{(1.6 \quad 10^{\ 19})^2}{2 \quad 8.85 \quad 10^{\ 12} \quad 6.62 \quad 10^{\ 34}}$$

$$v \sim \frac{1}{137} \quad 3 \quad 10^8 \quad \frac{c}{137}$$

Hence correct option is (c).

4. ${}_{86}A^{22} \quad {}_{3} \quad {}_{80}X^{210} \quad {}^{4} \quad {}_{84}B^{210}$

Hence correct option is (b)

5. $_{\min}(\text{in Å}) \quad \frac{12375}{V\,(\text{in volt})} \quad \frac{12375}{20 \quad 1000} \sim 0.62$ Å

Hence correct option is (c).

6. We have $\frac{1}{2} m_e v_{\max}^2 \quad$ eV

$$v_{\max} \quad \sqrt{\frac{2eV}{m}}$$

$$\sqrt{\frac{2 \quad 1.6 \quad 10^{\ 19} \quad 18 \quad 1000}{9.1 \quad 10^{\ 31}}}$$

$$v_{\max} \sim 8 \quad 10^7 \text{ m/s}$$

Hence correct option is (a).

7. For hydrogen atom $v_n \quad \frac{e^2}{2 \ {}_0 nh}$

$$v_2 \quad \frac{e^2}{2 \ {}_0 \quad 2h}, v_3 \quad \frac{e^2}{2 \ {}_0 \quad 3h}$$

$$\frac{v_2}{v_3} \quad \frac{3}{2}$$

Let $_2$ and $_3$ are the de-Broglie wavelengths

$$\frac{_2}{_3} \quad \frac{\frac{h}{mv_2}}{\frac{n}{mv_3}} \quad \frac{v_3}{v_2}$$

$$\frac{_2}{_3} \quad \frac{2}{3}$$

Hence correct option is (a).

8. For hydrogen like atom

$$E_n \quad \frac{z^2}{n^2}(13.6 \text{ eV})$$

For ground state $n \quad 1$

$$E_1 \quad z^2 \quad 13.6 \text{ eV}$$

But $\quad E_1 \quad 122.4$ eV

$$122.4 \text{ eV} \quad z^2 \quad 13.6 \text{ eV}$$

$$z^2 \quad 9$$

$$z \quad 3$$

Hence it is Li^2

The correct option is (c).

9. $_{\min} \quad \frac{hc}{eV} \quad \frac{_{\min}}{_{\min}} \quad 100 \quad \frac{V}{V} \quad 100$

Percentage change in $_{\min} \quad 2\%$

Hence $_{\min}$ is decreased by 2%

correct option is (c)

10. $E_n \quad \frac{z^2}{n^2}(13.6 \text{ eV})$ for first excited state $n \quad 2$

$$E_2 \quad \frac{z^2}{4}(13.6) \text{ eV}$$

$$13.6 \text{ eV} \quad \frac{z^2}{4} \quad 13.6 \text{ eV}$$

$$z \quad 2$$

Hence it is He

Correct option is (a).

11. $_{\min}(\text{in Å}) \quad \frac{12375}{V\,(\text{in volt})}$

$$V \quad \frac{12375}{1} \quad 12.375 \quad 10^3 \text{ V}$$

$$V \quad 12.4 \text{ eV}$$

Hence correct option is (c).

12. We have $\dfrac{h}{p}$

$$p \quad \frac{h}{} \quad \frac{6.62 \quad 10^{\quad 34}}{0.5 \quad 10^{\quad 10}}$$

$$13.26 \quad 10^{\quad 24} \text{ kg-m/s}$$

Hence correct option is (c).

13. $W \quad \dfrac{hc}{_0} \quad _0 \quad \dfrac{6.6 \quad 10^{\quad 34} \quad 3 \quad 10^8}{1.6 \quad 10^{\quad 19} \quad 1.6}$

$$_0 \quad 7750 \text{ Å}$$

Hence correct option is (a).

14. For H-like atom Balmer series is $\dfrac{1}{} \quad z^2 R \; \dfrac{1}{2^2} \quad \dfrac{1}{n^2}$

For third Balmer line $n \quad 5$

$$\frac{1}{1085 \quad 10^{\quad 10}} \quad z^2 \quad 1.09 \quad 10^7 \; \frac{1}{4} \quad \frac{1}{5^2}$$

$$z^2 \quad \frac{100 \quad 1000}{1085 \quad 1.097 \quad 21} \quad 4$$

$$z \quad 2$$

Binding energy $\quad (13.6) \quad z^2 \text{eV} \quad 13.6 \quad 4 \text{ eV}$

$$54.4 \text{ eV}$$

Hence correct option is (a).

15. If $V_1 \quad 0$ then total energy KE

$$\text{KE} \quad 13.6 \text{ eV}$$

and the energy difference between two states $\quad 10.2$ eV

Hence total energy in this state

$$13.6 \quad 10.2$$

$$23.8 \text{ eV}$$

The correct option is (c).

16. $eV_0 \quad \dfrac{hc}{3300} \quad W$ ...(i)

$$2eV_0 \quad \frac{hc}{2200} \qquad \text{...(ii)}$$

Substracted Eq. (i) from Eq. (ii), we get

$$eV_0 \quad hc \; \frac{3300 \quad 2200}{3300 \quad 2200}$$

$$\frac{hc}{3 \quad 2200 \quad 10^{\quad 10}}$$

$$V_0 \quad \frac{6.6 \quad 10^{\quad 34} \quad 3 \quad 10^8}{3 \quad 2200 \quad 1.6 \quad 10^{\quad 19} \quad 10^{\quad 10}}$$

$$\frac{30}{16} \quad \frac{15}{8}$$

$$V_0 \quad \frac{15}{8} \text{V}$$

Hence the correct option is (c).

17. $E \quad \dfrac{hc}{} \quad W$ ...(i)

$$4E \quad \frac{hc}{3} \quad W$$

$$4E \quad \frac{3hc}{} \quad W \qquad \text{...(ii)}$$

From Eqs. (i) and (ii)

$$4 \quad \frac{hc}{} \quad W \quad \frac{3hc}{} \quad W$$

$$\frac{hc}{} \quad 3W$$

$$W \quad \frac{hc}{3}$$

Hence correct option is (b).

18. By Moseley's law

$\sqrt{f} \quad a(z \quad b)$ for K line $b \quad 1$

$$\sqrt{f} \quad a(z \quad 1)$$

$$\sqrt{f} \quad a(31 \quad 1) \quad a \quad 30 \qquad \text{...(i)}$$

and $\quad \sqrt{f} \quad a(51 \quad 1) \quad 9 \quad 50$

$$\sqrt{\frac{f}{f}} \quad \frac{3}{5}$$

$$f \quad \frac{25f}{9}$$

Hence correct option is (a).

19. $\sqrt{f} \quad \sqrt{(RC)}\,(z \quad 1)\sqrt{\dfrac{1}{1^2} \quad \dfrac{1}{n^2}}$

for $K \;, n \quad 2$

K , n 3

$$\sqrt{f} \quad \sqrt{RC}\,(z \quad 1)\sqrt{1 \quad \frac{1}{2^2}} \quad \sqrt{RC}\,(z \quad 1) \quad \sqrt{\frac{3}{4}}$$

$$\sqrt{f} \quad \sqrt{RC}\,(z \quad 1)\sqrt{1 \quad \frac{1}{9}} \quad \sqrt{RC}\,(z \quad 1) \quad \sqrt{\frac{8}{9}}$$

$$\frac{\sqrt{f}}{\sqrt{f}} \quad \sqrt{\frac{8 \quad 4}{9 \quad 3}} \quad \sqrt{\frac{32}{27}},$$

Correct option is (a).

20. $\frac{1}{\quad} \quad R \; \frac{1}{2^2} \quad \frac{1}{n^2}$ here n 3

$$\frac{1}{\quad} \quad R \; \frac{1}{2^2} \quad \frac{1}{3^2} \qquad \frac{9 \quad 4}{9 \quad 4} \; R \quad \frac{5R}{36}$$

$$\frac{36}{5R}$$

Hence correct option is (c)

21. $_D \quad \frac{h}{\sqrt{2\,meV}}$ and $_{\min} \quad \frac{hc}{eV}$

$$\frac{_D}{_{\min}} \quad \frac{1}{c}\sqrt{\frac{eV}{2m}}$$

$$\frac{1}{3 \quad 10^8}\sqrt{\frac{1.8 \quad 10^{11} \quad 10000}{2}}$$

$$\frac{_D}{_{\min}} \quad \frac{3 \quad 10^7}{3 \quad 10^8} \quad \frac{1}{10}$$

Hence correct option is (c).

22. $5\,eV_0 \quad \frac{hc}{\quad} \quad W$ …(i)

$eV_0 \quad \frac{hc}{3} \quad W$ …(ii)

From Eqs. (i) and (ii)

$$\frac{5hc}{3} \quad 5W \quad \frac{hc}{\quad} \quad W$$

$$\frac{5hc}{3} \quad \frac{hc}{\quad} \quad 4\,W$$

$$\frac{hc}{\quad}\frac{(5 \quad 3)}{3} \quad 4\,W$$

$$\frac{2hc}{3} \quad 4\,W$$

$$W \quad \frac{hc}{6}$$

Hence correct option is (a).

23. $eV_0 \quad h[2V_0 \quad V_0] \quad hV_0$ …(i)

$eV \quad h[3V_0 \quad V_0] \quad h \quad 2V_0 \quad 2hV_0$ …(ii)

From Eqs. (i) and (ii)

$eV \quad 2 \quad eV_0 \quad V \quad 2V_0$

Hence correct option is (b).

24. For H-atom Lyman series is

$$\frac{1}{\quad} \quad R \; \frac{1}{1^2} \quad \frac{1}{n^2}$$

$$v \quad \frac{c}{\quad} \quad RC \; \frac{1}{1^2} \quad \frac{1}{n^2}$$

For H-like atom

$$RC \; \frac{1}{12} \quad \frac{1}{n^2} \qquad z^2$$

For Li , n 3 $\qquad 3^2 \quad 9\,v$

Hence correct option is (c).

25. Ground state energy of H-atom 13.6 eV

For Li atom $E_n \quad \frac{(\;13.6)\,eV}{n^2} \quad z^2$

$$13.6\,\text{eV} \qquad \frac{13.6\,\text{eV} \quad 9}{n^2}$$

$$n \quad 3$$

Hence correct option is (c).

26. $\frac{1}{2}mv_1^2 \quad h \;_1 \quad W$ …(i)

$\frac{1}{2}mv_2^2 \quad h \;_2 \quad W$ …(ii)

$$\frac{1}{2}m\,[v_1^2 \quad v_2^2] \quad h\,[\;_1 \qquad _2]$$

$$v_1^2 \quad v_2^2 \quad \frac{2h}{m}[\;_1 \qquad _2]$$

Hence correct option is (b).

27. For Lyman series

$$\frac{1}{\quad} \quad R \; \frac{1}{1^2} \quad \frac{1}{n^2}$$

For largest wavelength $n \quad 2$

$$\frac{1}{} \quad R \; \frac{1}{1^2} \quad \frac{1}{2^2}$$

$$\frac{1}{} \quad R \; 1 \quad \frac{1}{4}$$

$$\frac{4}{3R}$$

For He atom

$$\frac{1}{_{\text{He}}} \quad R\,(z)^2 \; \frac{1}{2^2} \quad \frac{1}{n^2} \qquad 4R \; \frac{1}{4} \quad \frac{1}{n^2}$$

$$\frac{3R}{4} \quad 4R \; \frac{1}{4} \quad \frac{1}{n^2}$$

$$\frac{3}{16} \quad \frac{1}{4} \quad \frac{1}{n^2}$$

$$\frac{1}{n^2} \quad \frac{1}{4} \quad \frac{3}{16} \quad \frac{4 \quad 3}{16}$$

$$\frac{1}{n^2} \quad \frac{1}{16}$$

$$n \quad 4$$

Hence correct option is (b).

28. We have $\sqrt{\frac{1}{}} \quad \sqrt{\frac{3R}{4}} \quad (z \quad 1)$

$$\sqrt{\frac{1}{}} \quad \sqrt{\frac{3 \quad 1.0973 \quad 10^7}{4}} \quad (92 \quad 1)$$

$$\frac{4}{3 \quad 91 \quad 91 \quad 1.0973 \quad 10^7} \quad 0.15\ \text{Å}$$

Hence correct option is (c).

29. For K , K and L of X-rays

$$\underset{Y_2}{K} \quad \underset{Y_1}{K} \quad \underset{Y_3}{L}$$

Hence correct option is (b).

30. We have $\dfrac{h}{\sqrt{2mqV}}$

$$_p \; \frac{h}{\sqrt{2m_p eV}} \text{ and } \frac{h}{\sqrt{2m \quad _{e)}V}}$$

$$\frac{_p}{} \quad \sqrt{\frac{2m}{m_p}} \quad \sqrt{\frac{2 \quad 4m_p}{m_p}} \quad \sqrt{8} \quad 2\sqrt{2}$$

Hence correct option is (c).

31. We have, $_e \; \dfrac{h}{\sqrt{2m_e E_1}} \qquad \dfrac{h}{\sqrt{2m \;\; E_2}}$

$$_p \; \frac{h}{\sqrt{2m_p E_3}} \because m \quad m_p \quad m_e$$

and $\quad _e \qquad _p \; \because E_1 \quad E_3 \quad E_2$

Hence correct option is (a).

32. KE in ground state $\quad 13.6\,\text{eV}$

Total energy in $n \qquad$ KE Energy difference between $n \qquad$ to $n \quad 1$

Total energy

$$13.6\,\text{eV} \quad 13.6\,\text{eV}$$

$$27.2\,\text{eV}$$

Hence correct option is (b).

33. Here $P \quad 1000$ W, $\quad 880$ kHz $\quad 880 \quad 10^3$Hz

Let n is the number of photon p emitted per second

$$n \quad \frac{P}{h} \quad \frac{1000}{6.62 \quad 10^{\;34} \quad 880 \quad 10^3}$$

$$1.7 \quad 10^{30}$$

Correct option is (b).

34. Here $\quad 3000$ Å $\quad 3 \quad 10^{\;7}$m

Energy of incident radiation $E \quad \dfrac{hc}{}$ joule

$$E \quad \frac{hc}{1.6 \quad 10^{\;19}} \text{(in eV)}$$

$$E \quad \frac{6.62 \quad 3 \quad 10^{\;26}}{3 \quad 1.6 \quad 10^{\;26}} \quad 4.125\,\text{eV}$$

$\because E \quad$ work function hence no emission of electrons it means sphere remain natured.

Hence correct option is (c).

35. $\because E_n \quad \dfrac{13.6\,\text{eV}}{n^2}$ for $n \quad 5$

$$E_5 \quad \frac{13.6\,\text{eV}}{5^2} \qquad 0.54\,\text{eV}$$

Hence correct option is (a).

36. $K_{\text{max}} \quad E \quad W \quad (6.2 \quad 4.2)\,\text{eV} \quad 2\,\text{eV}$

$$K_{\text{max}} \quad 2 \quad 1.6 \quad 10^{\;19}\,\text{J}$$
$$3.2 \quad 10^{\;19}\,\text{J}$$

Hence correct option is (b).

37. $$\frac{6.62 \quad 10^{\;34}}{5200 \quad 10^{\;10}} \quad 9.1 \quad 10^{\;31} \quad v$$

$$v \quad \frac{6.625 \quad 10^{\;27}}{5.2 \quad 9.1 \quad 10^{\;31}} \sim 1400\,\text{m/s}$$

Hence correct option is (c).

38. $$K_{\text{max}} \quad \frac{6.62 \quad 10^{\;34} \quad 3 \quad 10^{8}}{3000 \quad 10^{\;10} \quad 1.6 \quad 10^{\;19}} \quad 1 \;\; \text{eV}$$

$$K_{\text{max}} \quad 3.14\,\text{eV} \quad 3.14 \quad 1.6 \quad 10^{\;19}\,\text{J}$$

$$\frac{1}{2} m_e v_{\text{max}}^2 \quad 3.14 \quad 1.6 \quad 10^{\;19}$$

$$v_{\text{max}} \quad \sqrt{\frac{3.14 \quad 3.2 \quad 10^{\;19}}{9.1 \quad 10^{\;31}}} \sim 10^{6}\,\text{m/s}$$

Hence correct option is (d).

JEE Corner

1. Here both assertion and reason are true and reason explain correctly assertion. Correct option is (a).

2. For photon $E \quad \frac{hc}{}$ and $p \quad \frac{E}{c}$

If is doubled, E and p are reduced to half. Hence assertion is true. Since speed of photon is always c. Hence reason is false. Hence correct option is (c).

3. If frequency is increased keeping intensity constant photoelectron emitted the plate reach other plate in less time hence saturation current can be increased. Reason can be true or not hence correct option is (a, b).

4. Here both assertion and reason is true and reason correctly explain assertion. Hence correct option is (a).

5. Here assertion is true since possible transition are 6 3, 6 4, 6 5, 5 3, 5 4, and 4 3. According to reason total $\frac{n(n \quad 1)}{2}$ transition has $n \quad 3 \quad \frac{6 \quad (3 \quad 1)}{2} \quad 6$ it may explain or may not explain assertion

Hence correct option is (a, b)

6. We have

$$eV_0 \quad h[\qquad _0]$$

$$V_0 \quad \frac{h}{e} \;\; _0 \quad \frac{h}{e} \;\; _0 \qquad \text{...(i)}$$

if 2 $_0$ $_0$ does not become double hence assertion is false but reason is true. Hence correct option is (d).

7. Here both assertion and reason are true and reason may or may not explain assertion correct option is (a, b).

8. Here assertion and reason are both true.

$\because \quad _{\text{min}} \quad \frac{hc}{eV}$ if V increases

$_{\text{min}}$ decreases

but reason is not correct explanation of assertion hence correct option is (b).

9. $\because \quad E_n \quad \frac{13.6}{n_2}$

$$E_2 \quad E_1$$

Hence assertion is true and $E \quad K \quad \frac{v}{2}$

v is more in $n \quad 2$

Here reason is also true but it is not correct explanation of assertion hence correct option is (b).

10. Here assertion is false but reason is true. Hence correct option is (a).

Objective Questions (Level 2)

1. $F_a \quad F_c \quad \frac{GmM}{r^2} \quad \frac{mv^2}{r}$ ...(i)

and $\quad mvr \quad \frac{nh}{2}$ ...(ii)

From Eq. (ii)

$$v \quad \frac{nh}{2 \ mr}$$

Putting this value in Eq. (i)

$$\frac{GM}{r} \quad \frac{h^2h^2}{4 \ {}^2m^2r^2}$$

$$r \quad \frac{n^2h^2}{4 \ {}^2m^2GM}$$

$$\text{KE} \quad \frac{1}{2}mv^2 \quad \frac{1}{2}\frac{m \quad GM}{r} \quad \frac{GMm}{2r}$$

$$\text{PE} \quad \frac{GMm}{r}$$

$$E \quad \text{KE} \quad \text{PE}$$

$$E \quad \frac{GMm}{2r} \quad \frac{GMm \quad 4 \ {}^2m^2GM}{2n^2h^2}$$

$$E \quad \frac{2 \ {}^2G^2M^2m^3}{n^2h^2} \text{ for ground state } n \quad 1$$

$$E \quad \frac{2 \ {}^2G^2M^2m^3}{n^2}$$

Hence correct option is (b).

2. We have $\ _n \quad i_nA_n \quad \frac{e}{T_n} \quad r_n^2$

$$_n \quad \frac{e \qquad r_n^2 \quad u_n}{2 \ r_n} \quad \frac{e\,u_nr_n}{2}$$

$$_n \quad e \quad \frac{v_1}{n} \quad \frac{r_1 \quad n^2}{2} \quad \frac{e\,v_1r_1}{2} \quad n$$

$$_2 \quad \frac{ev_1r_1 \quad 2}{2}$$

and $\quad _1 \quad \frac{e\,v_1r_1}{2} \quad 1$

$$_1 \quad \frac{_2}{2}$$

Hence magnetic moment decreases two times correct option is (b).

3. For H-like atom $E_n \quad \frac{(13.6)Z^2\text{eV}}{n^2}$

Here $E_2 \quad \frac{(13.6)z^2}{4}$ and $E_1 \quad 13.6\ z^2$

$$E_2 \quad E_1 \quad 40.8 \text{ eV}$$

$$13.6Z^2 \quad 1 \quad \frac{1}{4} \quad 40.8$$

$$Z^2 \quad \frac{40.8 \quad 4}{13.6 \quad 3} \quad Z^2 \quad 4$$

$$Z \quad 2$$

Energy needed to remove the electron from ground state is

$$E_1 \quad (13.6) \quad Z^2 \quad 13.6 \quad 4 \quad 54.4 \text{ eV}$$

Hence correct option is (a).

$$i_n \quad \frac{e}{T_n} \quad \frac{e}{\frac{2 \ r_n}{u_n}} \quad \frac{ev_n}{2 \ r_n}$$

$$\because \quad u_n \quad \frac{1}{n} \text{ and } r_n \quad \frac{1}{n^2}$$

$$i_n \quad \frac{1}{n^3} \quad \frac{i_2}{i_1} \quad \frac{1}{2^3}$$

$$i_1 \quad 8i_2$$

Hence current increases 8 times correct option is (c).

5. Since five dark lines are possible hence atom is excited to $n \quad 6$ state.

The number of transition in emission line $\frac{n(n \quad 1)}{2}$

Number of emission transition $\frac{6 \quad 5}{2} \quad 15$

Hence correct option is (c).

6. $A_n \quad r_n^2$ for hydrozen atom $r_n \quad kn^2$

where k is constant.

$$A_n \quad k^2n^4$$

$$A_1 \quad k^2 \quad \frac{A_n}{A_1} \quad n^4$$

Taking log both sides log $\frac{A_n}{A_1} \quad 4 \log_n$

Hence it is a straight line with slope 4

Correct option is (b)

7. For hydrogen atom $i_n \quad \frac{1}{n^3}$ and

$$B_n \quad \frac{i_n}{r_n} \quad B_n \quad k\frac{1}{n^5} \qquad [\because r_n \quad n^2]$$

$$B_2 \quad \frac{k}{2^5} \text{ and } B_1 \quad k$$

$$\frac{B_2}{B_1} \quad \frac{1}{2^5} \quad \frac{1}{32}$$

$$B_1 \quad 32\,B_2$$

Hence magnatic field increases 32 times.

The correct option is (d).

8. For H-atom Lyman series is given by

$$\frac{1}{\ } \quad R \quad \frac{1}{1^2} \quad \frac{1}{n^2} \quad \text{for first line } n \quad 2$$

$$\frac{1}{\ } \quad R \;\; 1 \quad \frac{1}{2^2}$$

$$\frac{1}{\ } \quad \frac{3R}{4}$$

Momentum of photon $P_p \quad \frac{h}{\ }$

Let momentum of atom p_A

$\because$ Initial momentum was zero. Hence using momentum conservation law, we get

$$p_A \quad p_B \quad Mv \quad \frac{h}{\ } \quad \frac{3hR}{4}$$

$$v \quad \frac{3hR}{4M}$$

Hence the correct option is (a).

9. Light wave equation is

$$200\,\text{V/m}\,\sin(1.5 \quad 10^{15}\,\text{sec}^{\ 1})\,t$$

$$\cos(0.5 \quad 10^{15}\,\text{sec}^{\ 1})\,t$$

Here maximum frequency $\frac{1.5 \quad 10^{15}}{2}$

Maxmum incident energy

$$\frac{1.5 \quad 10^{15}}{2} \quad \frac{6.6 \quad 10^{\ 34}}{1.6 \quad 10^{\ 19}}$$

$$0.98\,\text{eV}$$

Since work function 2 eV maximum energy hence no emission of electrons.

Thus correct option is (d).

10. Since in Balmer series of H-like atom wavelengths (in visible region) are found same or smaller hence the gas was initially in second excited state.

Correct option is (c).

11. For H-atom $T_H \quad 2 \;\; n^3$

and for H-like atom

$$T_x \quad \frac{2 \;\; n^3}{z^2}$$

For H-atom in ground state $T_H \quad 2$

For H-like atom in first excited state

$$T_x \quad \frac{(2 \;\;) \quad 2^3}{z^2} \quad \frac{2 \quad 8}{z^2}$$

But $T_H \quad 2T_x \quad 2 \quad \frac{2 \;\; 2 \quad 8}{z^2}$

$$z^2 \quad 16$$

$$z \quad 4$$

Hence correct option is (c).

12. For K line of X-ray

$$\frac{1}{\ } \quad \frac{a^2}{c}(z \quad 1)^2$$

$\because z$ (atomic No.) for Pb^{204}, Pb^{206}, Pb^{208}

are same hence $_1 \quad _2 \quad _3$.

Hence correct option is (c).

13. The correct option is (d).

14. Since $E_n \quad \frac{13.6\,\text{eV}}{n^2}$

$$E_1 \quad 13.6\,\text{eV}$$

and first excited state $E_2 \quad \frac{13.6}{4}\,\text{eV}$

$$E_2 \quad 3.4\,\text{eV}$$

$$E \quad E_2 \quad E_1 \quad 10.2 \text{ if } K \quad 10.2\,\text{eV}$$

The electron collide elastically with H-atom in ground state.

The correct option is (c).

15. For Lyman series $\frac{1}{\ } \quad R \quad \frac{1}{1^2} \quad \frac{1}{n^2}$ here $n \quad 3$

$$\frac{1}{\ } \quad R \;\; 1 \quad \frac{1}{9}$$

$$\frac{1}{\ } \quad \frac{8R}{9}$$

$$P_{\text{photon}} \quad \frac{h}{\ } \quad \frac{8Rh}{9}$$

But $\quad P_{\text{Photon}} \quad P_{\text{H-atom}}$

$$\frac{8Rh}{9} \quad M_p \quad v$$

$$v \quad \frac{8 \quad 1.097 \quad 10^7 \quad 6.6 \quad 10^{\ \ 34}}{9 \quad 1837 \quad 9.1 \quad 10^{\ \ 31}}$$

$$v \quad 4\text{ m/s}$$

Hence correct option is (a).

16. Power $\quad VI \quad 150 \quad 10^3 \quad 10 \quad 10^{\ \ 3} \quad 1500$ W

The 99% power heated the target hence

Heating power $\quad \frac{99}{100} \quad 1500 \quad 15 \quad 99$ W

The rate at which target is heated per sec. (in cal)

$$\frac{15 \quad 99}{4.2} \sim 355 \qquad \because 1\text{J} \quad \frac{1}{4.2}\text{cal}$$

Hence correct option is (c).

17. $E_n \quad \frac{13.6\,\text{eV} \quad z^2}{n^2}$

$$E_3 \quad \frac{13.6\,\text{eV}}{9} z^2 \text{ and } E_4 \quad \frac{13.6\,\text{eV}}{16} z^2$$

$$E \quad E_4 \quad E_3 \quad (13.6)\,\text{eV} \quad z^2 \; \frac{1}{9} \quad \frac{1}{16}$$

$$E \quad \frac{13.6(\text{eV}) \quad 2^2 \quad 7}{16 \quad 9} \quad 32.4\text{ eV}$$

$$z^2 \quad \frac{16 \quad 32.4 \quad 9}{13.6 \quad 7} \quad 49$$

$$z \quad 7$$

Hence correct option is (d).

18. $\frac{h}{p} \quad \frac{h}{\sqrt{2m_p K}} \quad \frac{h}{\sqrt{2m_p eV}}$

$$10^{\ \ 13} \quad \frac{6.6 \quad 10^{\ \ 34}}{\sqrt{2 \quad 1836 \quad 9.1 \quad 10^{\ \ 31} \quad 1.6 \quad 10^{\ \ 19} \quad V}}$$

$$V \quad 8.15 \quad 10^4 \text{ volt}$$

Hence correct option is (b).

19. Since $E_n \quad \frac{1}{n^2}$ and $L_n \quad n$

Hence $\quad E_n \quad \frac{1}{L_{n^2}}$

The correct option is (d).

20. Since $\ _n \quad \frac{e u_n r_n}{2} \because u_n \quad \frac{1}{n}$ and $r_n \quad n^2$

$$_n \quad kn$$

Where k is constant for H-atom

For ground state $\ _1 \quad k \quad 1 \quad k$ ...(i)

For third excited state $n \quad 4$

$$_2 \quad k \quad 4 \quad 4k \qquad \text{...(ii)}$$

From Eqs. (i) and (ii) we get $\ _2 \quad 4 \ _1$

Hence correct option is (d).

21. By conservation of momentum

$$M_H v \quad (M_H \quad M_H) v \quad v \quad \frac{v}{2}$$

Let initial KE of H-atom $\quad K$

Final KE of each-H-atom $\quad \frac{K}{2}$

For excitation $\frac{K}{2} \quad E_2 \quad E_1 \quad \frac{13.6}{4} \quad 13.6$

$$\frac{K}{2} \quad 10.2\,\text{eV}$$

$$K \quad 20.4\text{ eV}$$

Hence correct option is (a).

22. We know that for H-like atom

$$E_n \quad K_n \quad K_n \quad 3.4\ \text{eV}$$

$$\frac{h}{p} \quad \frac{h}{\sqrt{2m_e K}}$$

$$\frac{6.6 \quad 10^{\ 34}}{\sqrt{2 \quad 9.1 \quad 10^{\ 31} \quad 3.4 \quad 1.6 \quad 10^{\ 19}}}$$

$$6.6\ \text{Å}$$

Hence both options (a) and (b) are correct.

Hence answer is (c) both are correct.

23-25. $0.6e \quad \frac{hc}{4950 \quad 10^{\ 10}} \quad W$ ...(i)

$1.1\,e \quad \frac{hc}{_2} \quad W$ ...(ii)

Subtracting Eq. (i) from Eq. (ii) we get

$$0.5\,e \quad hc \quad \frac{1}{_2} \quad \frac{1}{4950 \quad 10^{\ 10}}$$

$$\frac{0.5 \quad 1.6 \quad 10^{\ 19}}{6.62 \quad 10^{\ 34} \quad 3 \quad 10^{8}} \quad \frac{1}{4950 \quad 10^{\ 10}} \quad \frac{1}{_2}$$

$$_2 \sim 4111\ \text{Å}$$

From Eq. (i)

$$W \quad \frac{6.6 \quad 10^{\ 34} \quad 3 \quad 10^{8}}{4.95 \quad 10^{\ 7} \quad 1.6 \quad 10^{\ 19}} \sim 1.9\ \text{eV}$$

23. $W \quad 1.9\ \text{eV}$

Hence correct option is (c).

24. $\quad 4111\ \text{Å}$

Hence correct option is (c)

25. Since magnatic field does not change the KE of electrons hence retarding potential remain same.

Hence correct option is (c).

26. $(\text{KE})_{\text{max}} \quad 5\ \text{eV} \quad 3\ \text{eV} \quad 2\ \text{eV}$

$$2 \quad 1.6 \qquad 19\ \text{J}$$

$$_{\text{min}} \quad \frac{h}{p} \quad \frac{h}{\sqrt{2m_e K}}$$

$$_{\text{min}} \quad \frac{6.6 \quad 10^{\ 34}}{\sqrt{2 \quad 9.1 \quad 10^{\ 31} \quad 2 \quad 1.6 \quad 10^{\ 19}}}$$

$$8.69\ \text{Å}$$

Hence correct option is (b).

27. Photo emission will stop when potential of sphere becomes stopping potential

$$\frac{1}{4 \quad _0} \frac{q}{r} \quad 2\,\text{V}$$

Since $\qquad (\text{KE})_{\text{max}} \quad eV_0$

hence $\qquad V_0 \quad 2$

$$q \quad 8 \quad _0 r \text{ coulomb}$$

Hence correct option is (b)

28. Let t be the time for photo emission

$$\frac{1}{4 \quad _0} \quad \frac{q}{r} \quad t \quad 2$$

$$t \quad \frac{8 \quad _0 r}{q}$$

Intensity of light at 0.8 from source

$$I \quad \frac{3.2 \quad 10^{\ 3}}{4 \quad (0.8)^2} \sim 4 \quad 10^{\ 4}\ \text{W/m}^2$$

Energy incident on the sphere in unit time

$E_1 \qquad (8 \quad 10^{\ 3})^2 \quad 4 \quad 10^{\ 4} \quad 8.04 \quad 10^{\ 8}\ \text{W}$

Energy of each photon

$$E_2 \quad 5 \quad 1.6 \quad 10^{\ 19} \quad 8 \quad 10^{\ 19}\ \text{J}$$

Total number of photons incident on the sphere per second

$$\frac{E_1}{E_2} \quad \frac{8.04 \quad 10^{\ 8}}{8 \quad 10^{\ 19}} \quad 10^{11}$$

Since 10^6 photons emit one electron.

Hence the total number of photoelectron per sec is $\qquad n_2 \quad \frac{n_1}{10^1} \quad \frac{10^{11}}{10^6} \quad 10^5$

Therefore,

$$q \quad n_2 \quad e \quad t \quad 10^5 \quad 1.6 \quad 10^{\ 19} \quad t$$

$$\frac{9 \quad 10^9 \quad 1.6 \quad 10^{\ 14} \quad t}{r} \quad 2$$

$$t \quad \frac{2 \quad 8 \quad 10^{\ 3}}{9 \quad 1.6 \quad 10^{\ 5}} \qquad t \quad 111\,\text{s}$$

Hence correct option is (c).

More than one options are correct

1. Since $_0 \quad \frac{hc}{eV}$ if v increases $_0$ decreases hence the interval between $_K$ and $_0$ as well as $_K$ and $_0$ increases.

The correct options are (b) and (c).

2. $R \quad n^2, V \quad \frac{1}{n}$ and $E \quad \frac{1}{n^2}$ for Bohr model of H-atom

$$VR \quad n \text{ and } \frac{V}{E} \quad n$$

Hence, the correct options are (a) and (c).

3. For Bohr model of H-atom

$$L \quad n, \quad r \quad n^2 \text{ and } T \quad n^3$$

Hence $\frac{rL}{T}$ is independent of n

$$\frac{L}{T} \quad \frac{1}{n^2} \text{ and } \frac{T}{r} \quad n, L \quad n^3$$

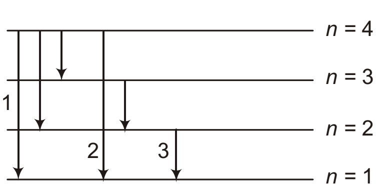
Hence correct options are (a), (b) and (c).

4. $\because \quad \frac{h}{mv}$ and $\frac{h}{\sqrt{2mK}}$

Hence heavy particle has smallest wavelength when speed and KE both particle are same.

The correct options are (a) and (c).

5. Since there are six different wavelength



Hence, final state will be $n \quad 4$.

Since two wavelengths are longer than $_0$ [(From $n \quad 4 \quad 3$ and $n \quad 3 \quad 2$)]

Hence initial state was $n \quad 2$

and there are three transitions shown as (1), (2) and (3) belonging to Lymen series.

Hence correct options are (a), (b) and (d).

6. $\because \sqrt{f} \quad a(z \quad b)$

$\sqrt{f}$ *versus* z is a straight line

$$\because \qquad f \quad \frac{c}{} \quad \sqrt{\frac{1}{}} \quad \frac{a}{\sqrt{c}}(z \quad b)$$

hence $\sqrt{\frac{1}{}}$ *versus* z is a straight line

$$f \quad a^2(z \quad b)$$

$\log f \quad \log a^2 \quad \log(z \quad b)$ which is a straight line

Hence correct options are (a), (b) and (c).

Match the Columns :

1. Lymen series lies in UV region, Balmer series lies in visible region and Paschen and Brackelt series lie in infrared region. Hence

(a)	r
(b)	q
(c)	p
(d)	p

2. For H-atom $E_n \quad \frac{13.6}{n^2}$ eV

$$E_2 \quad \frac{13.6}{2^2}\text{eV} \quad \frac{13.6}{4}\text{eV}$$

Ionization energy from first excited state of H-atom

$$E \quad E_2 \quad \frac{13.6}{4}\text{eV} \qquad \ldots\text{(i)}$$

For He ion

$$E_{H\,(\text{He})} \quad \frac{(13.6)\text{ eV}}{n^2} \quad Z^2 \text{ for He } \ z \quad 2$$

$$E_n(\text{He}) \quad \frac{13.6\text{ eV}}{n^2} \quad 4$$

Ionization energy of He atom from ground state $(13.6)\text{eV} \quad 4 \quad 4E \quad 4$ from Eq. (i)

$16E$

$E_2(\text{He}) \quad \dfrac{(13.6)\,\text{eV} \quad 4}{4} \qquad (13.6)\,\text{eV}$

But $E_2 \quad K_2 \quad K_2 \quad (13.6)$

and $\overline{U} \quad 2K \quad 2 \quad (13.6) \quad 2 \quad 4E \quad 8E$

From Eq. (i)

KE in ground state of He ion

$(13.6)\,\text{eV} \quad 4$

$4E \quad 4 \quad 16E$

Ionisation energy from Ist executive state

$\dfrac{13.6\,\text{eV}}{4} \quad 4 \quad 13.6\,\text{eV} \quad 4E$

Hence correct match are

(a)	*s*
(b)	*r*
(c)	*s*
(d)	*p*

3. $K_{\text{max}} \quad h \quad W$ and $V_0 \quad \dfrac{h}{e} \quad \dfrac{W}{e}$

Slope of line 1 is h, $Y_1 \quad W$

Slope of line 2 is $\dfrac{h}{e}$, $Y_2 \quad \dfrac{W}{e}$

Hence correct match are

(a)	*q*
(b)	*p*
(c)	*r*
(d)	*s*

4. $T \quad \dfrac{2\ r}{v} \because r \quad \dfrac{n^2}{z} \quad U \quad \dfrac{z}{n}$

$T \quad \dfrac{n^3}{z^2}$

(*a*) r

$\because \quad L \quad n$ (b) s

$\because \quad V \quad \dfrac{z}{n}$ (c) s

$\because \quad R \quad \dfrac{n^2}{z}$ (d) q

5. Balmer series is

$\dfrac{1}{_B} \quad R \quad \dfrac{1}{2^2} \quad \dfrac{1}{n^2} \quad n \quad 3, 4, 5 \ldots$

For 2nd line n 4 and $_B$

$\dfrac{1}{} \quad \dfrac{1}{4} \quad \dfrac{1}{16} \quad R$

$\dfrac{16}{3R}$

$\dfrac{1}{_{B_1}} \quad R \quad \dfrac{1}{2^2} \quad \dfrac{1}{3^2}$

$_{B_1} \quad \dfrac{36}{5R} \quad \dfrac{36}{5\ \dfrac{16}{3}} \quad \dfrac{36 \quad 3}{16 \quad 5}$

$_{B_1} \quad \dfrac{27}{20}$

(a) p

$\dfrac{1}{_{B_3}} \quad R \quad \dfrac{1}{2^2} \quad \dfrac{1}{5^2} \qquad \dfrac{R \quad (25 \quad 4)}{25 \quad 4} \quad \dfrac{21R}{100}$

$_{B_3} \quad \dfrac{100}{21R} \quad \dfrac{100}{21\ \dfrac{16}{3}}$

$\dfrac{100 \quad 3}{21 \quad 16} \quad \dfrac{25}{28}$

(b) (s)

For Lyman series

$\dfrac{1}{_L} \quad R \quad \dfrac{1}{1^2} \quad \dfrac{1}{n^2} \quad n \quad 2, 3, 4$

$\dfrac{1}{_{L_1}} \quad R \quad \dfrac{1}{1^2} \quad \dfrac{1}{2^2}$

$_{L_1} \quad \dfrac{4}{3R}$

$_{L_1} \quad \dfrac{5}{16} \quad \dfrac{}{4}$ (c) q

$\dfrac{1}{_{L_2}} \quad R \quad 1 \quad \dfrac{1}{9} \quad \dfrac{8R}{9}$

$_{L_2} \quad \dfrac{9}{8R} \quad \dfrac{9}{8\ \dfrac{16}{3}} \quad \dfrac{9 \quad 3}{16 \quad 8} \quad \dfrac{27}{128}$

(d) s

6. The proper match are

(a) s

$\because$ X-ray is inverse process of photoelectric effect [high energy electrons convert in electromagnetic radiation]

(b) p

$\because$ $_c$ $\frac{1}{V}$ (c) q

$\because$ Wavelength of continuos X-ray depends on voltage

(d) q

7. $\because$ $(KE)_{max}$ f and stopping potential f

(a) p, r

$\because$ stopping potental f hence it remains same

(b) s

$\because$ Current is directly proportional to Intensity. Hence sat current increases but stopping potential does not chase

(c) q, s

$\because$ $(KE)_{max}$ hf W and stopping potential $\frac{hf}{e}$ $\frac{W}{e}$

If W is decreased $(KE)_{max}$ and stopping potential increased

(d) p, r

Modern Physics II

Introductory Exercise 30.1

1. $R_0 \quad N_0 \quad 8000\,\text{Bq}$

$$R_1 \quad N \quad 1000\,\text{Bq}$$

$$\frac{R_1}{R_0} \quad \frac{1}{8} \quad \frac{N}{N_0} \quad e^{\quad t} \qquad \log 8 \quad t$$

$$3\log 2 \quad \frac{\log 2}{T_{1/2}} \quad 9$$

$$T_{1/2} \quad \frac{9}{3} \quad 3 \text{ days}$$

Average, life $\;1.44 \quad T_{1/2} \quad 1.44 \quad 3 \quad 4.33$ days

2. $R_0 \quad N_0$

$$40 \quad 3.7 \quad 10^{10} \quad 10^{\;6} \quad \frac{0.693}{64.8} \quad N_0$$

$$N_0 \quad \frac{40 \quad 64.8 \quad 3.7 \quad 10^4}{0.693}$$

$$13.83 \quad 10^7$$

Now, $\qquad N \quad N_0 e^{\quad t}$

$$N_{10} \quad N_0 e^{\frac{0.693 \quad 10}{64.8}}$$

$$13.83 \quad 10^7 \quad e^{\frac{0.693 \quad 10}{64.8}}$$

$$N_{12} \quad 13.83 \quad 10^7 \quad e^{\frac{0.693 \quad 12}{64.8}}$$

$$N_{10} \quad N_{12} \quad 13.83 \quad 10^7$$

$$e^{\frac{0.693 \quad 10}{64.8}} \quad e^{\frac{0.693 \quad 12}{64.8}}$$

$$9.47 \quad 10^9 \text{ nuclei}$$

3. (a) $\quad R_0 \quad 10\,\text{mCi},\, R \quad 8\,\text{mCi} \quad \frac{R_0}{R} \quad e^{\quad t}$

$$\log \frac{10}{8} \qquad 4 \quad 3600$$

$$\frac{0.223}{4 \quad 3600}$$

$$1.55 \quad 10^{\;5}/\text{s}$$

$$T_{1/2} \quad \frac{0.693}{} \quad \frac{0.693}{1.55 \quad 10^{\;5}} \quad 12.4\,\text{h}$$

(b) $R_0 \quad 10\,\text{mci} \quad 10 \quad 3.7 \quad 10^{10} \quad 10^{\;3}\,\text{Bq}$

$$3.7 \quad 10^8\ \text{Bq}$$

$$R_0 \quad N_0$$

$$N_0 \quad \frac{R_0}{} \quad \frac{3.7 \quad 10^8}{1.55 \quad 10^{\;5}}$$

$$2.39 \quad 10^{13}\,(\text{atoms})$$

(c) $R \quad R_0 e^{\quad t}$

$$10\,\text{mCi} \quad e^{\frac{0.693}{12.4} \quad 30} \quad 1.87\,\text{mCi}$$

4. $R_0 \quad N_0$

$$\frac{R_0}{N_0} \quad \frac{6 \quad 10^{11}\text{Bq}}{10^{15}}$$

$$6 \quad 10^{\;4}/\text{s}$$

$$T_{1/2} \quad \frac{0.693}{} \quad \frac{0.693}{6 \quad 10^{\;4}} \quad 1.16 \quad 10^3\text{s}$$

5. $N_x \quad N_y \quad N_0$

$T_{1/2x} \quad 50$ min and $T_{1/2\,y} \quad 100$ min

$$N_x \quad (N_0)\,\frac{1}{2}^{\,n} \quad N_0\,\frac{1}{2}^{\,4} \quad \frac{N_0}{16}$$

$$N_y \quad N_0\,\frac{1}{2}^{\,n} \quad N_0\,\frac{1}{2}^{\,2} \quad \frac{N_0}{4}$$

$$\frac{N_x}{N_y} \quad \frac{\frac{N_0}{16}}{\frac{N_0}{4}} \quad \frac{1}{4}$$

Introductory Exercise 30.2

1. $E \quad Mc^2$

Here, $P \quad 10^9$ J/s $\quad 10^9 \quad 24 \quad 60$ J/day

$$M \quad \frac{10^9 \quad 24 \quad 60}{(3 \quad 10^8)^2} \quad 9.6 \quad 10^{\ 4}\ \text{kg}$$

2. Number of fission $\dfrac{10^9\ \text{J/s}}{200 \quad 10^6 \quad 1.6 \quad 10^{\ 19}}$

$3.125 \quad 10^{19}$

3. Given reaction is

$${}_{92}U^{238} \qquad {}_{90}Th^{234} \quad {}_2He^4$$

$M \quad (238.050784 \quad 234.043593$

$4.002602)$ u

$M \quad 0.0004589$ u

$E \quad M \quad 931.5$ MeV

$0.0004589 \quad 931.5$

4.27 MeV

4. Complete reactions are

(a) ${}_3Li^6 \quad {}_1H^2 \quad {}_4Be^7 \quad {}_0n^1$

(b) ${}_{17}Cl^{35} \quad {}_1H^1 \quad {}_{16}S^{32} \quad {}_2He^4$

(c) ${}_4Be^9 \quad {}_2He^4 \quad 3({}_2He^4) \quad {}_0n^1$

(d) ${}_{35}Br^{79} \quad {}_1H^2 \quad {}_{36}Kr^{79} \quad 2({}_0n^1)$

AIEEE Corner

Subjective Questions (Level 1)

Radioactivity

1. (a) Initially the rate of distingration is

$$\frac{dN}{dt}_0 \qquad N_0$$

After 5 min $\dfrac{dN}{dt} \qquad N$

$$\frac{N_0}{N} \quad \frac{\frac{dN}{dt}_0}{\frac{dN}{dt}} \quad \frac{4750}{2700} \quad 1.76$$

Now $N \quad N_0\ e^{\ \ t}$ or $\qquad \dfrac{\log \frac{N}{N_0}}{t}$

$$\frac{2.3026}{t}\log_{10}\frac{N_0}{N}$$

$$\frac{2.3026}{5}\log_{10}(1.76)$$

0.113 /min

(b) Half-life $\dfrac{0.693}{} \quad \dfrac{0.693}{0.113} \quad 6.132$ min

2. We have $A \qquad N$

$6 \quad 10^{11} \qquad 1 \quad 10^{15}$

$6 \quad 10^{\ 4}\ s^{\ 1}$

$$T_{1/2} \quad \frac{0.693}{} \quad \frac{0.693}{6 \quad 10^{\ 4}} \quad 1155\ \text{s}$$

19.25 min

3. $A \qquad N$

$A \quad 8$ Ci $\quad 8 \quad 3.7 \quad 10^{10}$ decay/s

$$\frac{0.693}{T_{1/2}} \quad \frac{0.693}{5.3\ \text{yr}}$$

$$\frac{0.693}{5.3 \quad 365 \quad 24 \quad 60 \quad 60\,\text{s}}$$

$$N \quad \frac{A}{}$$

$$\frac{8 \quad 3.7 \quad 10^{10} \quad 5.3 \quad 365 \quad 24 \quad 3600}{0.693}$$

$N \quad 7.2 \quad 10^{19}$

$6.023 \quad 10^{23}$ nuclei $\quad 60$ g

$$1 \quad \frac{60\text{ g}}{6.023 \quad 10^{23}}$$

Hence $7.2 \quad 10^{19}$ nuclei

$$\frac{60 \quad 7.2 \quad 10^{19}}{6.023 \quad 10^{23}} \quad 7.11 \quad 10^{\ 3}\text{ g}$$

4. Number of decay per second

$$\frac{m}{M} \quad N_A \qquad \frac{1}{238} \quad 6 \quad 10^{23} \quad \frac{0.693}{4.5 \quad 10^9 \text{ yr}}$$

$$\frac{6 \quad 10^{23}}{238} \quad \frac{0.693}{4.5 \quad 10^9 \quad 365 \quad 24 \quad 60 \quad 60\text{s}}$$

$1.23 \quad 10^4$ decay/s

5. Probability of decay

$$P \quad (1 \quad e^{\ t}) \quad (1 \quad e^{\ t/T_{\text{mean}}})$$

$$P \quad (1 \quad e^{\ 5/10}) \quad 1 \quad e^{\ 2} \quad 0.39$$

6. Since initially no ^{206}Pb nuclei is present and after time t the ratio of $\frac{N_v}{N_{\text{Pb}}} \quad 3$

It means $\frac{1}{4}$ of original ^{238}U nuclei decays.

Hence $\qquad N \quad N_0 e^{\ t}$

$$N_0 \quad \frac{N_0}{4} \quad N_0\, e$$

$$\frac{3}{4} \quad e^{\ t}$$

$$t \quad \frac{\log 4 \quad \log 3}{}$$

$$t \quad \frac{(\log 4 \quad \log 3)}{0.693} \quad 4.5 \quad 10^9 \text{ yr}$$

$$t \quad 1.88 \quad 10^9 \text{ yr}$$

7. $(R_1)_{0\text{P}_{32}} \quad {}_1 4N_0$

$(R_2)_{0\text{P}_{33}} \quad {}_2\, N_0$

$$R_0 \quad (R_1)_{0\text{P}_{32}} \quad (R_2)_{0\text{P}_{33}}$$

$$N_0 (4 \ {}_1 \quad {}_2) \quad 3\text{ mCi}$$

$(R_1)_{t\text{P}_{32}} \quad {}_1 N \quad {}_1 4 N_0\, e^{\ {}_1 t}$

$(R_1)_{t\text{P}_{32}} \quad {}_1 \quad 4N_0\, e^{\frac{\log 2}{14} \ 60 \ 365}$

$(R_2)_{t\text{P}_{33}} \quad {}_2 \quad N_0\, e^{\frac{\log 2}{25} \ 60 \ 365}$

$R \quad (R_1)_{t\text{P}_{32}} \quad (R_2)\, t_{\text{P}_{33}}$

$$N_0 \ 4 \ {}_1 e^{\frac{\log 2}{14} \ 60 \ 365} \qquad {}_2\, e^{\frac{\log 2}{25} \ 60 \ 365}$$

$$\frac{3\text{ mCi}}{(4 \ {}_1 \quad {}_2)}$$

$$4 \ {}_1 e^{\frac{\log 2 \ 60 \ 365}{14}} \qquad {}_2 e^{\frac{\log 2}{25} \ 60 \ 365}$$

$$\frac{3\text{ mCi}}{4 \ \frac{\log 2}{14} \quad \frac{\log 2}{25}}$$

$$\frac{4\log 2}{14} e^{\frac{\log 2 \ 60 \ 365}{14}} \qquad \frac{\log 2}{25} \ e^{\frac{\log 2}{25} \ 60 \ 365}$$

0.205 mCi

8. Complete reactions are

(a) ${}_{88}\text{Ra}^{226} \qquad {}_{86}\text{RN}^{222}$

(b) ${}_8\text{O}^{19} \qquad {}_9\text{F}^{19} \quad e^{\ -}$

(c) ${}_{13}\text{Al}^{25} \qquad {}_{12}\text{Mg}^{25} \quad e$

9. Only reaction (b) is possible.

10. $E \quad (7 \quad 1.000783 \quad 7 \quad 1.00867 \quad 14.00307)$

931.5 MeV

$E \quad 104.72\text{ MeV}$

11. $E \quad [8m_p \quad 8m_n \quad m({}_8 O^{16})] \quad 931.5$

$(8 \quad 1.007825 \quad 8 \quad 1.008665 \quad 15.994915)$

$931.5 \quad 127.6\text{ MeV}$

12. (a) Number of nuclei in kg

$$\frac{6.023 \quad 10^{23}}{235} \quad 1$$

Energy

$$\frac{6.023 \quad 10^{23}}{235} \quad 200 \quad 10^6 \quad 1.6 \quad 10^{\ 19}$$

$8.09 \quad 10^{13}\text{ J}$

(b) Mass $\dfrac{8.09 \quad 10^{13}\,\text{J}}{30 \quad 10^{3}\,\text{J/g}}$

$$\frac{8.09 \quad 10^{13}}{30 \quad 10^{3}}\,\text{g}$$

$$\frac{8.09}{3} \quad 10^{9} \quad \frac{1}{10^{3}}\,\text{kg}$$

$$2.7 \quad 10^{6}\,\text{kg}$$

13. Applying conservation of momentum

$$M \ v \quad M_{\text{Ti}} v_{\text{Ti}}$$

$$v_{\text{Ti}} \quad \frac{M \ v}{M_{\text{Ti}}}$$

$$K \quad \frac{1}{2} M \ v^{2} \quad 6.802\,\text{MeV}$$

$$K_{\text{Ti}} \quad \frac{1}{2} M_{\text{Ti}}\, v_{\text{Ti}}^{2} \quad \frac{1}{2} M_{\text{Ti}} \frac{M^{2} v^{L}}{M_{\text{Ti}}^{2}}$$

$$K_{\text{Ti}} \quad \frac{M}{M_{\text{Ti}}} \quad \frac{1}{2} M \ v^{2}$$

$$\frac{4}{208} \quad 6.802\,\text{MeV}$$

$$\frac{1}{52} \quad 6.802 \quad 0.1308\,\text{MeV}$$

14. Power $100\,\text{MW} \quad 10^{8}\,\text{W} \quad 10^{8}\,\text{J/s}$

$$\frac{10^{8}}{1.6 \quad 10^{\ 13}\,\text{J/MeV}} \quad \frac{10^{21}}{1.6} \frac{\text{MeV}}{\text{s}}$$

Energy per fission $\quad 185\,\text{MeV}$

Hence number of fissions $\dfrac{10^{21}}{1.6 \quad 185}$ / s.

Number of nuclei in 1 kg

$U^{235} \quad \dfrac{6.023 \quad 10^{26}}{235}$

Hence $t \quad \dfrac{6.023 \quad 10^{26} \quad 1.6 \quad 185}{235 \quad 10^{21}}$

8.78 days

15. (a) The given reaction is

$${}_{1}\text{H}^{2} \quad {}_{1}\text{H}^{2} \qquad {}_{1}\text{H}^{3} \quad {}_{1}\text{H}^{1}$$

$$M \quad [2m({}_{1}\text{H}^{2}) \quad m({}_{1}\text{H}^{3}) \quad m({}_{1}\text{H}^{1})]$$

$$[2(2.014102) \quad 3.016049 \quad 1.007825]u$$

$$M \quad 0.000433\,\text{u}$$

$$Q \quad M \quad 931.5 \quad 0.000433 \quad 931.5$$

$$4.05\,\text{MeV}$$

(b) $M \quad (2 \quad 2.014102 \quad 3.016049 \quad 1.008665) \quad 931.5$

$$M \quad 3.25\,\text{MeV}$$

(c) $M \quad (2.014102 \quad 3.016049 \quad 4.002603 \quad 1.008665) \quad 931.5$

$$M \quad 17.57\,\text{MeV}$$

16. The given reaction is

$$\text{He}^{4} \quad \text{He}^{4} \qquad \text{Be}^{8}$$

$$M \quad (2 \quad 4.0026 \quad 8.0053)\,\text{u}$$

$$(8.0052 \quad 8.0053)\,\text{u}$$

$$M \quad (0.0001)\,\text{u}$$

$\because$ M is negative this reaction is not energetically favourable

$$E \quad M \quad 931.5$$

$$1 \quad 10^{\ 4} \quad 931.5\,\text{MeV}$$

$$93.15\,\text{keV}$$

17. Number of nuclei in 1 kg water

$$\frac{6.023 \quad 10^{26}}{18}$$

Heavy water $\dfrac{6.023 \quad 10^{26}}{18} \quad \dfrac{1.5 \quad 10^{\ 2}}{100}$

$$\frac{6.023 \quad 1.5}{18} \quad 10^{22}$$

Energy realesed per fission

$$(2 \quad 2.014102 \quad 3.016049 \quad 1.007825) \quad 931.5$$

$$4.33 \quad 10^{\ 3} \quad 931.5 \quad 10^{6} \quad 1.6 \quad 10^{\ 19}\,\text{J}$$

Hence total energy $\dfrac{6.023 \quad 1.5 \quad 10^{22}}{18}$

$$4.33 \quad 931.5 \quad 1.6 \quad 10^{\ 16}$$

$$3200\,\text{MJ}$$

Objective Questions (Level-1)

1. Since during decay a neutron in the nucleus is transformed into a proton, an electron and an antineutrino as $n \quad P \quad e \quad ^{-}$.

Hence Correct option is (c).

2. Since nuclear force is same for all nucleons. Hence $F_1 \quad F_2 \quad F_3$

Correct option is (a)..

3. Given reaction is ${}_{90}X^{200} \qquad {}_{80}Y^{168}$

Difference in mass number $200 \quad 168 \quad 32$

Hence Number of -particles $\frac{32}{4} \quad 8$

Difference in atomic number 10

hence number of -particles 6

Hence correct option is (d).

4. The reaction is

${}_{92}\mathrm{U}^{235} \quad {}_{0}n^{1} \qquad {}_{54}\mathrm{Xe}^{138} \quad {}_{38}\mathrm{Sr}^{94} \quad 3({}_{0}n^{1})$

The correct option is (b) three neutrons.

5. The reactions are A and $C \quad 2$

After one atomic number reduced by 2 and after 2 atomic number increased by.

Hence A and C are isotopes Correct option is (d).

6. Here $m_p \quad 1.00785\,\mathrm{u}$, $m_n \quad 1.00866\,\mathrm{u}$

and $m \quad 4.00274$ u

$$m \quad 2(m_p \quad m_n) \quad m$$

$$m \quad [2(1.00785 \quad 1.00866) \quad 4.00274]\,\mathrm{u}$$

$$m \quad 0.03028\,\mathrm{u}$$

$$E \quad m \quad 931.5\,\mathrm{MeV}$$

$$0.3028 \quad 931.5 \quad 28.21\,\mathrm{MeV}$$

Hence correct option is (c).

7. $N \quad N_0 \quad \frac{7}{8}N_0 \quad \frac{1}{8}N_0$

But $N \quad N_0 \quad \frac{1}{2}^{n} \quad \frac{1}{8}N_0 \quad N_0 \quad \frac{1}{2}^{n}$

$$n \quad 3$$

$$3 \quad T_{1/2} \quad 8\,\mathrm{s}$$

$$T_{1/2} \quad \frac{8}{3}\,\mathrm{s}$$

Hence correct option is (d).

8. $N \quad N_0\, e^{\quad t}$ for mean life $t \quad \frac{1}{\ }$

$$N \quad N_0\, e^{\frac{1}{\ }} \quad \frac{N_0}{e}$$

Hence the fraction disintegrated

$$\frac{N_0 \quad N}{N_0} \quad 1 \quad \frac{1}{e}$$

Correct option is (b).

9. $N \quad N_0 \quad \frac{7}{8}N_0 \quad \frac{1}{8}N_0$

But $N \quad N_0 \quad \frac{1}{2}^{n}$

$$\frac{1}{8} \quad \frac{1}{2}^{n} \quad n \quad 3$$

Hence half life $T_{1/2} \quad \frac{15\,\mathrm{min}}{3} \quad 5\,\mathrm{min}$

Correct option is (a).

10. Since radioactive substance loses half of its activity in 4 days it means its half life

$$T_{1/2} \quad 4\text{ days}$$

Now $A \quad 5\%$ of A_0

$$A \quad \frac{1}{20}A_0$$

$$\frac{A}{A_0} \quad \frac{1}{20}$$

But $\quad A \quad A_0\, e^{\quad t} \quad \frac{1}{20} \quad e^{\quad t}$

$$\log 20 \quad t \quad t \quad \frac{\log 20}{\ }$$

But $\frac{\log_e 2}{T_{1/2}}$

$$t \quad T_{1/2} \frac{\log_e 20}{\log_e 2} \quad T_{1/2} \frac{\log_{10} 20}{\log_{10} 2} = 4.32 \quad 4$$

$t \quad 17.3$ days

Hence correct option is (c).

11. Total energy released per sec

$$1.6\,\text{MW} \quad 1.6 \quad 10^6\,\text{J/s}$$

Energy released per fission $\;200\,\text{MeV}$

$$200 \quad 10^6 \quad 1.6 \quad 10^{\;19}\,\text{J}$$

$$2 \quad 1.6 \quad 10^{\;11}\,\text{J}$$

Number of fission per second

$$\frac{1.6 \quad 10^6}{2 \quad 1.6 \quad 10^{\;11}} \quad 5 \quad 10^{16}/\text{s}$$

Hence correct option is (a).

12. $\because R \quad R_0\, A^{1/3}$

Volume $\quad \frac{4}{3} \; R^3 \quad \frac{4}{3} \; R_0^3 A$

Mass of nucleus $\quad A \quad 1.67 \quad 10^{\;27}\,\text{kg}$

Density $\quad \frac{\text{mass}}{\text{volume}} \quad \frac{A \quad 1.67 \quad 10^{\;27}\,\text{kg}}{\frac{4}{3} \; R_0^3 A}$

$$\frac{1.67 \quad 10^{\;27}\,\text{kg}}{\frac{4}{3} \; R_0^3}$$

$\because$ is independent of A, hence ratio of densities $\frac{1}{2}$ 1.

Correct option is (d).

13. $N \quad N_0 e^{-\;t} \quad \frac{N}{N_0} \quad e^{-\;t}$

$$\frac{N}{N_0} \quad e^{-\frac{0.693}{6.93}\;10} \quad e^{-1} \quad \frac{1}{e}$$

Fractional change

$$\frac{N_0 \quad N}{N_0} \quad 1 \quad \frac{1}{e} \sim 0.63$$

Hence correct option is (b).

14. Since radioactive substance reduce to about 6% it means $N \quad \frac{N_0}{16}$

We have $\quad N \quad (N_0) \; \frac{1}{2}^{\;n}$

$$\frac{1}{16} \quad \frac{1}{2}^{\;n} \quad n \quad 4$$

$4 \quad T_{1/2} \quad 2\,h \quad T_{1/2} \quad 30\,\text{min}$

Hence correct option is (a).

15. Probability of a nucleus for survival of time t.

$$p_{(\text{survival})} \quad \frac{N}{N_0} \quad \frac{N_0\, e^{\quad t}}{N_0} \quad e^{\quad t}$$

For one mean life $t \;\; \frac{1}{\;}$

$$P_{\text{survival}} \quad e^{\;\frac{1}{\;}} \quad e^{\;1} \quad \frac{1}{e}$$

Hence Correct option is (a).

■ Assertion and Reason

1. Here both assertion and reason are true but reason does not explain assertion. Hence correct option is (b).
2. Here assertion is false but reason is true since for heavier nucleus binding energy per nucleon is least.

   Correct option is (d).
3. Here both assertion and reason are true but reason is not correct explanation of assertion. Hence correct option is (b).
4. Here a ssertion is true but reason is false since electromagnetic waves are produced by accelerating charge particles.

   Correct option is (c).

5. Here assertion is wrong since -decay process is $n \quad p \quad e^- \quad \bar{v}$

but reason is true hence correct option is (d).

6. Here assertion is true but reason is false. Correct option is (c).

7. Here both assertion and reason are true and reason may or may not be true. Correct option is (a, b)

8. Both assertion and reason are true but reason is not correct explanation of assertion. Hence correct option is (b).

9. Here reason is true but assertion is false

$\because$ 1 amu 931.5 MeV

Correct option is (d)

10. Both assertion and reason are true but reason does not correctly explain assertion. Hence correct option is (b).

11. Here both assertion and reason are true and reason may or may not be correct explanation of assertion .

Hence correct options are (a, b).

Objective Questions (Level 2)

■ Single option correct

1. Let initially substance have N_i nuclei then

$$N \quad N_i e^{\quad t}$$

$$\frac{dN}{dt} \qquad N_i e^{\quad t}$$

At $\qquad t \quad t$

we get

$$\left.\frac{dN}{dt}\right|_{t \quad t} \qquad N_i e^{\quad t} \quad N_0 \qquad \ldots\text{(i)}$$

At $\qquad t \quad 4t$

$$\left.\frac{dN}{dt}\right|_{t \quad 4t} \qquad N_i e^{\,4 \quad t} \quad \frac{N_0}{16} \qquad \ldots\text{(ii)}$$

Dividing Eq. (i) and Eq. (ii) we get

$$e^{3 \quad t} \quad 16 \qquad \ldots\text{(iii)}$$

Now at $t \quad \frac{11}{2} \quad t$

$$\left.\frac{dN}{dt}\right|_{t \quad \frac{11t}{2}} \qquad N_i e^{\quad \frac{11}{2} t}$$

$$N_i e^{\quad \frac{8 \quad t}{2}} \quad e^{\quad \frac{3 \quad t}{2}}$$

$$\frac{N_i e^{\,4 \quad t}}{\sqrt{e^{3 \quad t}}} \quad \frac{N_0}{16 \quad \sqrt{16}}$$

From Eqs. (ii) and (iii)

$$\frac{N_0}{64}$$

Hence, correct option is (b).

2. We have $\quad {}_1 \quad {}_2 \quad \frac{\log 2}{30} \quad \frac{\log 2}{60}$

$$\frac{\log 2}{20}$$

Now $\qquad N \quad N_0 e^{\quad t}$

$$\frac{N_0}{4} \quad N_0 e^{\quad \frac{t \log 2}{20}}$$

$$\log 4 \quad \frac{t}{20} \log 2$$

$$2 \log 2 \quad \frac{t}{20} \log 2$$

$$t \quad 40\,\text{yr}$$

Hence correct option is (c).

3. From graph it is clear that number of nucleons in X is N_3 and binding energy per nucleon is E_3 for Y nucleon is N_2 and BE per nucleon is E_2.

Hence $X \quad Y \quad E_3N_3 \quad E_2N_2$

Similerly $W \quad E_1N_1$

The reaction is $W \quad X \quad Y$

The energy released is
$(E_3N_3 \quad E_2N_2 \quad E_1N_1)$

Hence Correct option is (b).

4. Energy $(110 \quad 8.2 \quad 90 \quad 8.2 \quad 200 \quad 7.4)$

$$200 \quad (8.2 \quad 7.4)$$

$$200 \quad 0.8 \quad 160\,\text{MeV}$$

Hence correct option is (d).

5. The reaction is

${}_1H^2 \quad {}_1H^2 \quad {}_2He^4$ energy

Energy $\quad (4 \quad 7 \quad 2 \quad 1.1)\,\text{MeV}$

$\quad (28 \quad 4.4) \quad 23.6\,\text{MeV}$

Hence Correct option is (b).

6. Total energy released per second

$$16 \quad 10^6\,\text{W}$$

$$16 \quad 10^6\,\text{J/s}$$

Energy per fission $\quad 200\,\text{MeV}$

$$200 \quad 10^6 \quad 1.6 \quad 10^{\;19}$$

$$2 \quad 1.6 \quad 10^{\;11}\,\text{J}$$

$\because$ Efficiency $\quad 50\%$

Hence power (energy converted per second)

$$2 \quad 1.6 \quad 10^{\;11} \quad \frac{50}{100} \quad 1.6 \quad 10^{\;11}\,\text{J}$$

Number of fission $\quad \dfrac{16 \quad 10^6}{1.6 \quad 10^{\;11}} \quad 10^{18}/\text{s}$

Hence correct option is (d).

7. $\dfrac{dN}{dt} \quad A \quad N$

$\because$ After time N become

conservation $\quad \dfrac{dN}{dt} \quad 0$

$$N \quad \frac{A}{} \quad \frac{A}{\frac{\log 2}{T}} \quad \frac{AT}{\log 2}$$

Hence correct option is (d).

8. By conservation of momentum

$$M_H\, v \quad (M_H \quad M_H)$$

$$v \quad \frac{v}{2}$$

Let initial KE of H-atom $\quad K$

Final KE of each H-atom $\quad \dfrac{K}{2}$

For excitation

$$\frac{K}{2} \quad E_2 \quad E_1 \quad \frac{13.6}{4} \quad 13.6 \;\; \text{eV}$$

$$\frac{K}{2} \quad 10.2\,\text{eV}$$

$$K \quad 2 \quad 10.2 \quad 1.6 \quad 10^{\;19}$$

$$\frac{1}{2} M_H\, u^2 \quad 2 \quad 10.2 \quad 1.2 \quad 1.6 \quad 10^{\;19}$$

$$u_H \quad \sqrt{\frac{2 \quad 1.2 \quad 10.2 \quad 2 \quad 1.6 \quad 10^{\;19}}{1.673 \quad 10^{27}}}$$

$$6.25 \quad 10^4\,\text{m/s}$$

Hence correct option is (c).

9. Let us suppose just before the death no radioactive atoms were present hence original activity A_0 is given as

$$A_0 \quad N_0 \qquad \text{...(i)}$$

After death the radioactivity decreases exponentially *ie*,

$$A \quad \frac{dN}{dt} \quad N \quad N_0\, e^{\quad t} \qquad \text{...(ii)}$$

Dividing eq. (ii) by eq. (i) we get

$$\frac{A}{A_0} \quad e^{\quad t}$$

or $\; t \quad \log \dfrac{A_0}{A}$ or $t \quad \dfrac{1}{}\log \dfrac{A_0}{A}$

Now $A_0 \quad 15$ decay/min/gram

$$A \quad \frac{375}{200}\,\text{decay/min/g}$$

but $\quad \dfrac{0.693}{5730\text{ yr}}$

$$t \quad \frac{5730}{0.693} \quad \log \frac{15 \quad 200}{375} \quad \frac{5730}{0.693} \quad \log \frac{200}{25}$$

$$t \quad \frac{5730}{0.693} \quad \log 8$$

$$\frac{5730}{0.693} \quad 3 \log 2 \quad 5730 \quad 3$$

$$t \quad 17190\,\text{yr}$$

Hence correct option is (c).

10. $N_P \quad N_0\, e^{\quad (t_1 \quad t)}$ ...(i)

and $\quad N_Q \quad N_0\, e^{\quad t}$

Now $\quad A_P \quad N_P$ and $A_Q \quad N_Q$

$$\frac{A_P}{A_Q} \quad \frac{N_P}{N_Q} \quad e^{\quad t_1}$$

$$t_1 \quad \log \frac{A_Q}{A_P}$$

$$t_1 \quad \frac{1}{\ } \log \frac{A_Q}{A_P} \quad T \log \frac{A_Q}{A_P}$$

Hence correct option is (b).

11. The given reactions are

$${}_1H^2 \quad {}_1H^2 \quad {}_1H^3 \quad p$$

$${}_1H^2 \quad {}_1H^3 \quad {}_2He^4 \quad n$$

$$3\,{}_1H^2 \quad {}_2He^4 \quad n \quad p$$

Mass defect

$$m \quad (3 \quad 2.014 \quad 4.001 \quad 1.007 \quad 1.008)$$

$$m \quad 0.026\,\text{amu}$$

Energy Released

$$0.026 \quad 931\,\text{MeV} \quad 3.87 \quad 10^{\ 12}\,\text{J}$$

This energy produced by the three deutronatoms. Total energy released by 10^{40} deutrons

$$\frac{10^{40}}{3} \quad 3.87 \quad 10^{\ 12}\,\text{J} \quad 1.29 \quad 10^{28}\,\text{J}$$

The average power $P \quad 10^{16}\,\text{W} \quad 10^{16}$ J/s

Therefore total time to exhaust all deutrons of the star will be

$$t \quad \frac{1.29 \quad 10^{28}}{10^{16}}\,\text{s} \quad 10^{12}\,\text{s.}$$

Hence correct option is (c).

12. $N_1 \quad N_0\, e^{\quad {}_1 t} \quad N_0\, e^{\frac{\log 2}{t_1} t}$ ...(i)

$$N_2 \quad N_0\, e^{\quad {}_2 t} \quad N_0\, e^{\frac{\log 2}{t_2} t} \qquad \text{...(ii)}$$

$$R_1 \quad {}_1 N_1 \qquad \text{...(iii)}$$

and $\quad R_2 \quad {}_2 \quad {}_2 N_2$ ...(iv)

Let after time t, $R_1 \quad R_2$ then

$$\frac{R_1}{R_1} \quad 1$$

$$\frac{1}{2} \quad \frac{N_1}{N_2} \quad 1$$

$$\frac{1}{2} \quad \frac{N_2}{N_1} \quad e^{\log 2 \frac{t_2 \quad t_1}{t_1 t_2} \quad t}$$

$$\log \frac{t_2}{t_1} \quad t \quad \log 2 \quad \frac{t_2 \quad t_1}{t_1 t_2}$$

$$t_1 \quad \frac{t_1 t_2}{0.693\,(t_2 \quad t_1)} \quad \log \frac{t_2}{t_1}$$

Hence Correct option is (a).

13. The given reaction is ${}_Z X^{232} \qquad {}_{90} Y^A$

$${}_Z X^{232} \qquad {}_{90} Y^A \quad {}_2 He^4$$

$$Z \quad 92 \text{ and } A \quad 228$$

$\because$ Initially X is in rest hence momentum of -particle after decay will be equal and opposite of Y.

$$M_Y v_Y \quad M \ v$$

$$v_Y \quad \frac{M}{M_Y} v$$

Total kinetic energy

$$K_T \quad \frac{1}{2}(M \ v^2 \quad M_Y v_Y^2)$$

$$K_T \quad \frac{1}{2} \quad M \ v^2 \quad M_y \frac{M^2 v^2}{M_Y^2}$$

$$K_T \quad \frac{1}{2} M \ v^2 \quad 1 \quad \frac{M}{M_Y}$$

$$K_T \quad K \quad 1 \quad \frac{4}{228}$$

$$K \quad \frac{232}{228} K_T$$

Hence Correct option is (b).

14. Energy of emitted photon 7 MeV

$$7 \quad 10^6 \quad 1.6 \quad 10^{\ 19}\,\mathrm{J}$$

$$11.2 \quad 10^{\ 13}\,\mathrm{J}$$

Momentum of photon $\dfrac{11.2 \quad 10^{\ 13}\,\mathrm{J}}{3 \quad 10^8 \ \mathrm{m/s}}$

$$\frac{11.2}{3} \quad 10^{\ 21} \ \text{kg-m/s}$$

$\because$ Initial nucleus is stationary

Applying conservation of momentum principle

$$O \quad \mathbf{P}_{\text{nuc}} \quad \mathbf{P}_{\text{photon}} \quad \mathbf{P}_{\text{nuc}} \quad \mathbf{P}_{\text{photon}}$$

$$|\mathbf{P}_{\text{nuc}}| \quad | \quad \mathbf{P}_{\text{photon}}|$$

$$P_{\text{nuc}} \quad \frac{11.2}{3} \quad 10^{\ 21} \ \text{kg-m/s}$$

Mass of nucleus 24 amu

$$24 \quad 1.66 \quad 10^{\ 27} \ \text{kg}$$

But $P_{\text{nuc}}^2 \quad 2mK_{\text{nuc}}$

$$K_{\text{nuc}} \quad \frac{P_{\text{nuc}}^2}{2m} \quad \frac{11.2 \quad 11.2 \quad 10^{\ 42}}{9 \quad 2 \quad 24 \quad 1.66 \quad 10^{\ 27}} \text{Joule}$$

$$K_{\text{nucc}} \quad \frac{11.2 \quad 11.2 \quad 10^{\ 42}}{18 \quad 24 \quad 1.66 \quad 10^{\ 27} \quad 1.6 \quad 10^{\ 19}} \text{eV}$$

$$1.1 \ \text{keV}$$

Hence correct option is (b).

15. Let time interval between two instants is t_1 then

$$N_1 \quad N_0 \, e^{\ (t \quad t_1)}$$

and $\quad N_2 \quad 2N_0 \, e^{\ t}$

$$A_1 \quad N_1 \quad N_0 \, e^{\ (t \quad t_1)}$$

$$A_2 \quad N_2 \quad (2N_0) \, e^{\ t}$$

$$\frac{A_1}{A_2} \quad \frac{1}{2} \quad e^{\ t_1}$$

$$\frac{2A_1}{A_2} \quad e^{\ t_1}$$

$$\log \frac{A_2}{2A_1} \quad t_1$$

$$t_1 \quad \frac{1}{\ }\log \frac{A_2}{2A_1}$$

$$t_1 \quad \frac{T}{\log 2} \log \frac{A_2}{2A_1}$$

Hence Correct option is (c).

16. The given reaction is

$${}_1\mathrm{H}^2 \quad {}_1\mathrm{H}^2 \quad {}_1\mathrm{H}^3 \quad {}_1\mathrm{H}^1$$

$$M \quad [2m\,({}_1\mathrm{H}^2) \quad m\,({}_1\mathrm{H}^3) \quad m\,({}_1\mathrm{H}^1)]$$

$$(2 \quad 2.014102 \quad 3.016049 \quad 1.007825) \ \text{amu}$$

$$4.33 \quad 10^{\ 3} \text{amu}$$

$$E \quad 4.33 \quad 10^{\ 3} \quad 931.5 \ \text{MeV}$$

$$4 \ \text{MeV}$$

Hence correct option is (c).

17. Number of fusion required to generate 1 kWh

$$\frac{1 \quad 10^3 \quad 3600}{4 \quad 10^6 \quad 1.6 \quad 10^{\ 19}}$$

$$\frac{36 \quad 10^{18}}{6.4} \quad 5.6 \quad 10^{18} \quad 10^{18}$$

Hence correct option is (b).

18. The energy released 4 MeV

This energy produced by two atoms.

Hence energy produced per atom

$$2 \ \text{MeV} \quad 2 \quad 1.6 \quad 10^{\ 13}\,\mathrm{J}$$

Hence number of atom fused to produced 1 kWJ

$$\frac{36 \quad 10^5}{2 \quad 1.6 \quad 10^{\ 13}} \quad \frac{18}{1.6} \quad 10^{18}$$

Mass of deutrium which contain

$$\frac{18}{1.6} \quad 10^{18} \text{ atom}$$

$$\frac{18 \quad 10^{18}}{1.6 \quad 6.02 \quad 10^{23}} \quad 3.7 \quad 10^{\ 5} \text{ kg.}$$

Hence correct option is (c).

■ More Than one Option is Correct

1. $x \quad N_0, y \quad N_0$

$$\frac{x}{y} \quad \frac{N_0}{N_0} \quad \frac{1}{\ }$$

where is decay constant

Hence $\frac{x}{y}$ is constant throught.

$$\because \quad \frac{x}{y} \quad \frac{1}{\ } \quad \frac{1}{\frac{0.693}{T}} \quad \frac{T}{0.693}$$

$$\frac{x}{y} \quad T, \ xy \quad (N_0)^2$$

For one half life $N \quad \frac{N_0}{2}$

$$(xy)_T \quad \left(\frac{N_0}{2}\right)^2 \quad \frac{N_0^2}{4} \quad \frac{xy}{4}$$

Hence correct options are (a), (b) and (d).

2. The correct options are (a), (b), (c) and (d).

3. A nucleus in excited state emits a high energy photon called as -ray. The reaction is

$$X^* \qquad X$$

Hence by gamma radiation atomic number and mass number are not changed. Since after emission of one atomic number reduced by $2({}_2 \ {}^4)$ and after 2 atomic number is increased by (2). Hence correct options are (a), (b) and (c).

4. Here half lives are T and $2T$ and $N_x \quad N_0$, $N_y \quad N_0$ after $4T$ for first substance 4 half lives and after $4T$ the second substance 2 Half lines.

$$N_x \quad N_0 \left(\frac{1}{2}\right)^4 \quad \frac{N_0}{16}$$

$$N_y \quad N_0 \left(\frac{1}{2}\right)^2 \quad \frac{N_0}{4}$$

$$x \quad \frac{N_x}{N_y} \quad \frac{N_0/16}{N_0/4} \quad \frac{1}{4}$$

Let their activity are R_x and R_y.

$$R_x \quad {}_xN_x \text{ and } R_y \quad {}_yN_y$$

$$y \quad \frac{R_x}{R_y} \quad \frac{\ _x}{\ _y} \quad \frac{N_x}{N_y} \quad \frac{\frac{0.693}{T}}{\frac{0.693}{2T}} \quad \frac{1}{4}$$

$$\frac{R_x}{R_y} \quad y \quad \frac{1}{2}$$

Hence correct options are (b) and (c).

5. Since nuclear forces are vary short range charge independent, no electromagnetic and they exchange ($n \quad p$ or $p \quad n$). Hence the correct options are (a), (b), (c) and (d).

6. $\because R \quad R_0 \ A^{1/3}$

$$\frac{M}{4/3 \quad R^3} \quad \frac{A \quad 1.67 \quad 10^{\ 27} \text{ kg}}{\frac{4}{3} \quad R_0^3 A}$$

is independent of A.

$$\text{But} \quad \frac{1.67 \quad 10^{\ 27} \text{ kg}}{\frac{4}{3} \quad 3.14 \quad (1.3 \quad 10^{\ 15})^3}$$

$$1.8 \quad 10^{17} \text{ kg/m}^3$$

Hence correct options are (b) and (c).

Match the Columns

1. Here $N_0 \quad x$, let is the decay constant.

$$N \quad N_0 e^{\ \ t} \quad x e^{\ \ t}$$

$$\left|\frac{dN}{dt}\right| \quad x e^{\ \ t} \text{ but } \left|\frac{dN}{dt}\right|_{t \quad 0} \quad y$$

$$y \quad x e^0 \quad x$$

$$\frac{y}{x}$$

Hence

(a) s

Half life $T_{1/2} \quad \frac{\log 2}{} \quad \frac{\log 2}{\frac{y}{x}} \quad \frac{x}{y}\log 2$

Hence

(b) p

We have activity $R \quad N \quad xe^{\ \ t}$

at $t \quad \frac{1}{}$

$$R \quad x e^{\ \ \frac{1}{}} \quad x e^{\ 1} \quad \frac{x}{e}$$

but $x \quad y$

$$R \quad \frac{y}{e}$$

Hence

(c) r

Number of nuclei after time $t \quad \frac{1}{}$

$$N \quad x e^{\ \ \frac{1}{}} \quad \frac{x}{e}$$

Hence

(d) s

Thus correct match is

(a) s

(b) r

(c) r

(d) s

2. In reaction $P \quad P \quad Q$ energy is released

∵ Binding energy increases when two or more lighter nucleus combine to form haviour nucleus.

Hence correct match is

(a) p

Similerly for reaction

$P \quad P \quad R \quad R$

Correct match is

(b) p

for reaction

$P \quad R \quad 2Q$ from graph BE per nucleon increases.

Hence energy is released.

Correct match is

(c) p

For the reaction

$P \quad Q \quad R$

We will check energy process if BE per nucleon is given. Hence data is not sufficient correct match is

(d) s

3. Since A and B are radioactive nuclei of $(A \quad B)$ decreases with time. Hence correct match is

(a) q

∵ A is converted into B and B is converted into C and decay rate of $A \quad B$ and $B \quad C$ are not known. Hence correct match is

(b) s

Since at time passes A is converted to B and B is converted to C. Hence nuclei of $(B \quad C)$ increases. Correct match is

(c) p

Similerly the correct match for (d) is

(d) s

4. After emission of 1 particle mass no decreased by 4 but after emission of 1 particle atomic number will increase or decrease by 1. Hence for (a)

(a) p, s

(b) p, r

(c) s

(d) q, r

5. For

(a) p

Since BE per nucleon of heavy nuclei is about 7.2 MeV. Hence

(b) s

X-ray photon have wavelength about 1 Å the energy of this wavelength is of order of 10 keV.

(c) r

∵ Visible light energy of order of 2 eV. Hence

(d) q