Chapter-9

Light – Reflection and Refraction

2 MARKS QUESTIONS

1.Define the principle focus of a concave mirror.

Solution :

Principal focus of a concave mirror is the point on its principal axis, where light rays coming parallel to principal axis actually converge after reflection from mirror.

2. The radius of curvature of a spherical mirror is 20 cm. what is its focal length?

Solution :

Focal length (f)= R/2 = 20 cm/2 = 10 cm.

3. Name a mirror that can give an erect and enlarged image of an object.

Solution :

Only a concave mirror can give a erect and enlarged image of an object.

4. Why do we prefer a convex mirror as a rear-view mirror in vehicles?

Solution :

We prefer a convex mirror as a rear-view mirror in vehicles because a convex mirror gives an erect and diminished image. As a result, convex mirror help the driver to have much wider field view.

5. Find the focal length of a convex mirror whose radius of curvature is 32 cm.

Solution :

Radius of curvature of (R) = 32 cm

Focal length(f) = R/2 = 32/2 cm = 16 cm.

6. A concave mirror produces three times magnified real image of an object placed at 10 cm in front of it. Where is the image located?

Solution :

Distance of object from concave mirror (u)= -10 cm.

Magnification (m) = -3

m = -v/u

v = -mu = -(3) x (-10) = -30 cm.

7. A ray of light traveling in air enters obliquely into water. Does the light ray bend towards or away from the normal? Why?

Solution :

The light bends towards the normal on entry into water. It is due to the fact that as compared to air, the water is optically denser medium.

8. Light enters from air to glass having refractive index 1.50. What is the speed of light in glass? The speed of light in vacuum is 3×108 m/s.

Solution :

Speed of light in vacuum (c) = 3×10^8 m/s.

Refractive index = c/v.

Speed of light in glass = 3×10^8 m/s/ 1.50

= 2×10^8 m/s

9. Find out, from Table (10.3), the medium having highest optical density. Also, find the medium with lowest optical density.

Solution :

As per table, diamond has highest optical density (2.42). Medium with lowest optical density is air (1.0003)

10. You are given kerosene, turpentine and water. In which of these does the light travel fastest? Use the information given in table 10.3

Solution :

As the refractive index of water is least out of three substances, hence speed of light is maximum in water. So, light travels fastest in water.

11. The refractive index of diamond is 2.42. What is the meaning of this statement?

Solution :

It means that speed of light in diamond is 2.42 times slower than speed of light in air.

12. Define 1 dioptre of power of lens.

Solution :

One dioptre of is defined as the power of lens having a focal length of 1 m.

4 MARKS QUESTIONS

1.Name the type of mirror used in the following situations:

(a) Headlights of a car

(b) Side/rear-view mirror of a vehicle.

(c) Solar furnace.

Support your answer with reason.

Solution :

(a) Headlights of a car- concave mirror to give parallel beam of light after reflection from concave mirror.

(b) Side/rear-view mirror of vehicle- convex mirror as it forms virtual erect and diminished image to give wider view field.

(c) Solar furnace- concave mirror to concentrate sunlight to produce heat in solar furnace.

2.An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of image.

Solution :

f = +15 cm, u = -10 cm.

1/f = 1/v +1/u

1/v = 1/15 +1/10

1/v = 5/30

v = + 30 cm.

The image is formed 6 cm behind the mirror, it is a virtual and erect image.

3.n object 5.0 cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position of the image, its nature and size.

Solution :

Radius of curvature (R) = 30 cm

f = R/2 = 30/2 = 15 cm

u = –20 cm, h= 5 cm.

1/v +1/u = 1/f

1/v = 1/15+ 1/20 = 7/60

v = 60/7 = 8.6 cm.

image is virtual and erect and formed behind the mirror.

h_i/h_0= v/u

h_i/5= 8.6/20

h_i = 2.2 cm.

Size of image is 2.2 cm.

4. An object of size 7.0 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed, so that a sharp focused image can be obtained? Find the size and the nature of the image.

Solution :

u = – 27 cm, f = – 18 cm. h_o= 7.0 cm

1/v = 1/f- 1/u

1/v = -1/18 + 1/27 = -1/54

V = – 54 cm.

Screen must be placed at a distance of 54 cm from the mirror in front of it.

h_i/h_0= v/u

h_i/h_0= v/u

h_i/7 = +54/-27

h_i = -2 x 7 = -14 cm.

Thus, the image is of 14 cm length and is inverted image.

4. A ray of light travelling in air enters obliquely into water. Does the light ray bend towards the normal or away from the normal? Why?

Answer-

The light ray bends towards the normal. When a light ray enters from an optically rarer medium (which has a low refractive index) to an optically denser medium (which has a high refractive index), its speed slows down and bends towards the normal. As water is optically denser than air, a ray of light entering from air into water will bend towards the normal.

5. Light enters from air to glass, having a refractive index 1.50. What is the speed of light in the glass? The speed of light in vacuum is 3 x 10^8 ms^{-1}.

Answer-

Refractive index of a medium (nm) = Speed of light in vacuum/Speed of light in the medium

Speed of light in vacuum (c) = 3 × 10^8 m/s

Refractive index of glass (ng) = 1.50

Speed of light in the glass (v) = Speed of light in vacuum/ Refractive index of glass

= c/ng

=3 × 10^8/1.50 = 2x 10^8 ms^{-1}.

6.You are given kerosene, turpentine and water. In which of these does the light travel fastest? Use the information given in the table.

Material medium	**Refractive index**	**Material medium**	**Refractive index**
Air	1.0003	Canada Balsam	1.53
Ice	1.31	–	–
Water	1.33	Rock salt	1.54
Alcohol	1.36	–	–
Kerosene	1.44	Carbon disulphide	1.63
Fused quartz	1.46	Dense flint glass	1.65
Turpentine oil	1.47	Ruby	1.71
Benzene	1.50	Sapphire	1.77
Crown	1.52	Diamond	2.42

glass			

Answer-

Light travels faster in water as compared to kerosene & turpentine, as the refractive index of water is lower than that of kerosene and turpentine. The speed of light is inversely proportional to the refractive index.

7. The refractive index of diamond is 2.42. What is the meaning of this statement?

Answer-

A diamond has a refractive index of 2.42, which means that the speed of light in a diamond will reduce by a factor of 2.42 as compared to its speed in the air.

In other words, the speed of light in a diamond is 1/2.42 times the speed of light in a vacuum.

8. A convex lens forms a real and inverted image of a needle at a distance of 50 cm from it. Where is the needle placed in front of the convex lens if the image is equal to the size of the object? Also, find the power of the lens.

Answer-

The position of the image should be at 2F since the image is real and the same size.

It is given that the image of the needle is formed at a distance of 50 cm from the convex lens. Therefore, the needle is placed in front of the lens at a distance of 50 cm.

Object distance (u) = – 50 cm

Image distance, (v) = 50 cm

Focal length = f

According to the lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{f} = \frac{1}{50} - \frac{1}{-50}$$
$$= \frac{1}{50} + \frac{1}{50} = \frac{1}{25}$$

$$f = 25cm = 0.25m$$

$$Power\ of\ lens,\ P = \frac{1}{f(in\ metres)} = \frac{1}{0.25} = +4D$$

9.One-half of a convex lens is covered with black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations.

Answer-

Yes, it will produce a complete image of the object, as shown in the figure. This can be verified experimentally by observing the image of a distant object, like a tree on a screen, when the lower half of the lens is covered with black paper. However, the intensity or brightness of the image will reduce.

10.An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.

Answer-

Focal length of convex mirror (f) = +15 cm

Object distance (u) = – 10 cm

According to the mirror formula,

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

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

$$v = \frac{5}{30} = 6cm$$

$$Magnification = \frac{-v}{u} = \frac{-6}{-10} = 0.6$$

The image is located at a distance of 6 cm from the mirror on the other side of the mirror.

The positive and a value of less than 1 magnification indicates that the image formed is virtual, erect, and diminished.

7 MARKS QUESTIONS

1.A concave mirror produces three times magnified (enlarged) real image of an object placed at 10 cm in front of it. Where is the image located?

Answer-

Magnification produced by a spherical mirror:

$$m = \frac{Height\ of\ the\ image}{Height\ of\ the\ object} = -\frac{Image\ Distance}{Object\ Distance}$$

$$m = \frac{h_1}{h_0} = -\frac{u}{v}$$

$$Let\ the\ height\ of\ the\ object, h_0 = h$$

$$Then,\ height\ of\ the\ image\ h_1 = -3h\ (Image\ formed\ is\ real)$$

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

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

Object distance (u) = – 10 cm

v = 3 × (- 10) = – 30 cm

Therefore, the negative sign indicates that an inverted image is formed in front of the given concave mirror at a distance of 30 cm.

2.Light enters from air to glass, having a refractive index 1.50. What is the speed of light in the glass? The speed of light in vacuum is 3 x 10^8 ms^{-1}.

Answer-

Refractive index of a medium (nm) = Speed of light in vacuum/Speed of light in the medium

Speed of light in vacuum (c) = 3×10^8 m/s

Refractive index of glass (ng) = 1.50

Speed of light in the glass (v) = Speed of light in vacuum/ Refractive index of glass

= c/ng

=$3 \times 10^8/1.50 = 2x\ 10^8$ ms^{-1}.

3. Find out, from the table, the medium having the highest optical density. Also, find the medium with the lowest optical density.

Material medium	**Refractive index**	**Material medium**	**Refractive index**
Air	1.0003	Canada Balsam	1.53
Ice	1.31	–	–
Water	1.33	Rock salt	1.54
Alcohol	1.36	–	–
Kerosene	1.44	Carbon disulphide	1.63
Fused quartz	1.46	Dense flint glass	1.65
Turpentine oil	1.47	Ruby	1.71
Benzene	1.50	Sapphire	1.77
Crown	1.52	Diamond	2.42

glass			

Answer-

Lowest optical density = Air

Highest optical density = Diamond

The optical density of a medium is directly related to its refractive index. A medium with the highest refractive index will have the highest optical density and vice-versa.

It can be observed from the table that air and diamond, respectively have the lowest and highest refractive index. Hence, air has the lowest optical density and diamond has the highest optical density.

4. A convex lens forms a real and inverted image of a needle at a distance of 50 cm from it. Where is the needle placed in front of the convex lens if the image is equal to the size of the object? Also, find the power of the lens.

Answer-

The position of the image should be at 2F since the image is real and the same size.

It is given that the image of the needle is formed at a distance of 50 cm from the convex lens. Therefore, the needle is placed in front of the lens at a distance of 50 cm.

Object distance (u) = – 50 cm

Image distance, (v) = 50 cm

Focal length = f

According to the lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{f} = \frac{1}{50} - \frac{1}{-50}$$
$$= \frac{1}{50} + \frac{1}{50} = \frac{1}{25}$$
$$f = 25cm = 0.25m$$
$$Power\ of\ lens,\ P = \frac{1}{f(in\ metres)} = \frac{1}{0.25} = +4D$$

5. An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Draw the ray diagram and find the position, size and nature of the image formed.

Answer-

Height of the object, h_0 = 5 cm

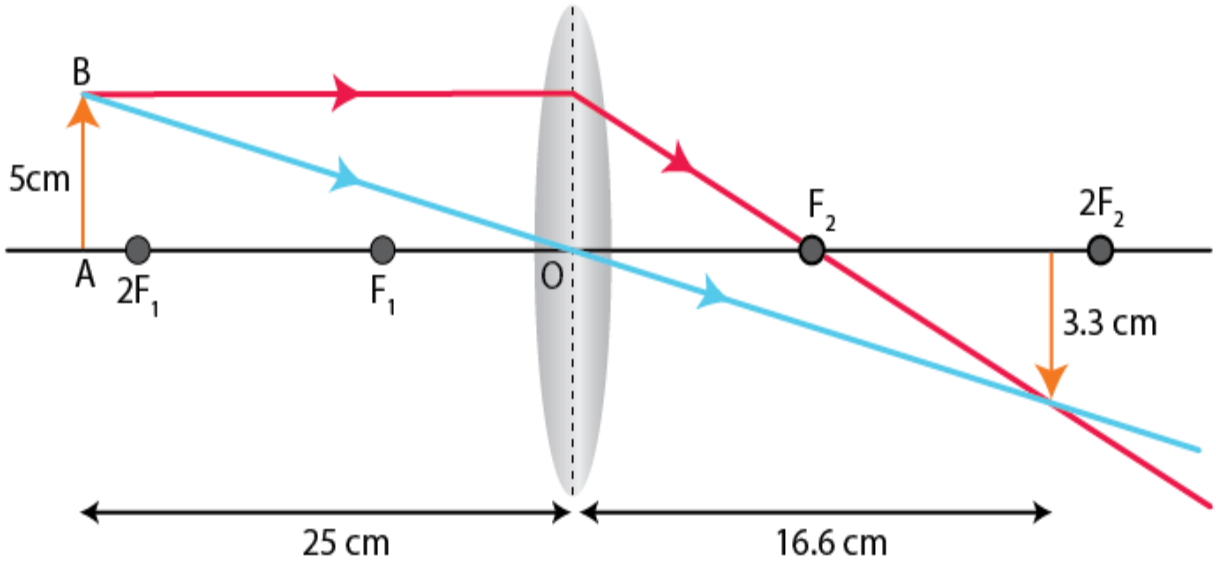
Distance of the object from converging lens, u = -25 cm

Focal length of a converging lens, f = 10 cm

Using the lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} - \frac{1}{25} = \frac{15}{250}$$
$$v = \frac{250}{15} = 16.66cm$$
$$Also,\ for\ a\ converging\ lens,\ \frac{h_i}{h_0} = \frac{v}{u}$$
$$h_i = \frac{v}{u} \times h_0 = \frac{50 \times 5}{3 \times (-25)} = \frac{10}{-3} = -3.3cm$$

Thus, the image is inverted and formed at a distance of 16.7 cm behind the lens and measures 3.3 cm. The ray diagram is shown below.



6. A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram.

Answer-

Focal length of concave lens (OF_1), f = – 15 cm

Image distance, v= – 10 cm

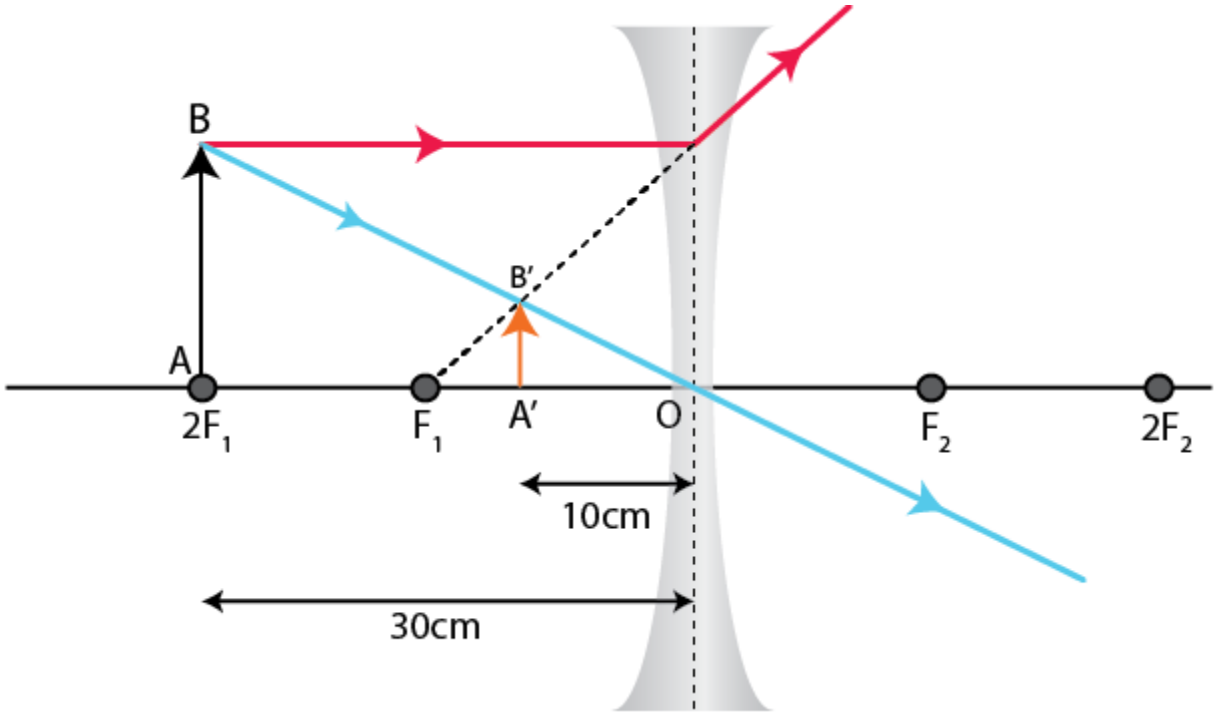
According to the lens formula,

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

$$\frac{1}{u} = \frac{1}{v} - \frac{1}{f} = -\frac{1}{10} - \frac{1}{-15} = -\frac{1}{10} + \frac{1}{15}$$

$$v = -\frac{5}{150} = -30cm$$

The negative value of u indicates that the object is placed 30 cm in front of the lens. This is shown in the following ray diagram.



7. An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.

Answer-

Focal length of convex mirror (f) = +15 cm

Object distance (u) = – 10 cm

According to the mirror formula,

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$
$$\frac{1}{v} = \frac{1}{15} - \frac{1}{-10} = \frac{2+3}{30}$$
$$v = \frac{5}{30} = 6cm$$
$$Magnification = \frac{-v}{u} = \frac{-6}{-10} = 0.6$$

The image is located at a distance of 6 cm from the mirror on the other side of the mirror.

The positive and a value of less than 1 magnification indicates that the image formed is virtual, erect, and diminished.

8.An object 5 cm is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position, nature and size of the image.

Answer-

Object distance (u) = – 20 cm

Object height (h) = 5 cm

Radius of curvature (R) = 30 cm

Radius of curvature = 2 × Focal length

R = 2f

f = 15 cm

According to the mirror formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$$
$$= \frac{1}{15} + \frac{1}{20} = \frac{4+3}{60} = \frac{7}{60}$$

$$v = 8.57cm$$

$$The\ positive\ value\ of\ v\ indicates\ that\ the\ image\ is\ formed\ behind\ the\ mirror$$

$$Magnification, m = -\frac{Image\ Distance}{Object\ Distance} = \frac{-8.57}{-20} = 0.428$$

$$The\ positive\ value\ of\ magnification\ indicates\ that\ the\ image\ formed\ is\ virtual$$

$$Magnification, m = \frac{Height\ of\ the\ image}{Height\ of\ the\ object} = \frac{h^1}{h}$$

$$h^1 = m \times h = 0.428 \times 5 = 2.14cm$$

The positive value of image height indicates that the image formed is erect.

Hence, the image formed is erect, virtual, and smaller in size.

9.An object of size 7.0 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed so that a sharply focused image can be obtained? Find the size and nature of the image.

Answer-

Object distance (u) = – 27 cm

Object height (h) = 7 cm

Focal length (f) = – 18 cm

According to the mirror formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$$
$$= -\frac{1}{18} + \frac{1}{27} = -\frac{1}{54}$$

$$v = -54cm$$

$The\ screen\ should\ be\ placed\ at\ a\ distance\ of\ 54cm\ in\ front\ of\ the\ given\ mirror$

$$Magnification, m = -\frac{Image\ Distance}{Object\ Distance} = \frac{-54}{27} = -2$$

$The\ negative\ value\ of\ magnification\ indicates\ that\ the\ image\ formed\ is\ real$

$$Magnification, m = \frac{Height\ of\ the\ image}{Height\ of\ the\ object} = \frac{h^1}{h}$$

$$h^1 = m \times h = 7 \times -2 = -14cm$$

The negative value of image height indicates that the image formed is inverted.

MULTIPLE CHOICE QUESTIONS

1) When a plane mirror is rotated through a certain angle, the reflected ray turns through twice as much and the size of the image:

(a) is doubled

(b) is halved

(c) becomes infinite

(d) remains the same

Correct Answer: Option (d)

2) If an object is placed symmetrically between two plane mirrors, inclined at an angle of 72 degrees, then the total no. of images formed is:

(a) 5

(b) 4

(c) 2

(d) infinite

Correct Answer: Option (b)

3) Which statement is true for the reflection of light?

(a) The angle of incidence and reflection are equal.

(b) The reflected light is less bright than the incident light.

(c) The sum of the angle of incidence and reflection is always greater than 90^0.

(d) The beams of the incident light, after reflection, diverge at unequal angles.

Correct Answer: Option (a)

4) The focal length of a plane mirror is

(a) 0

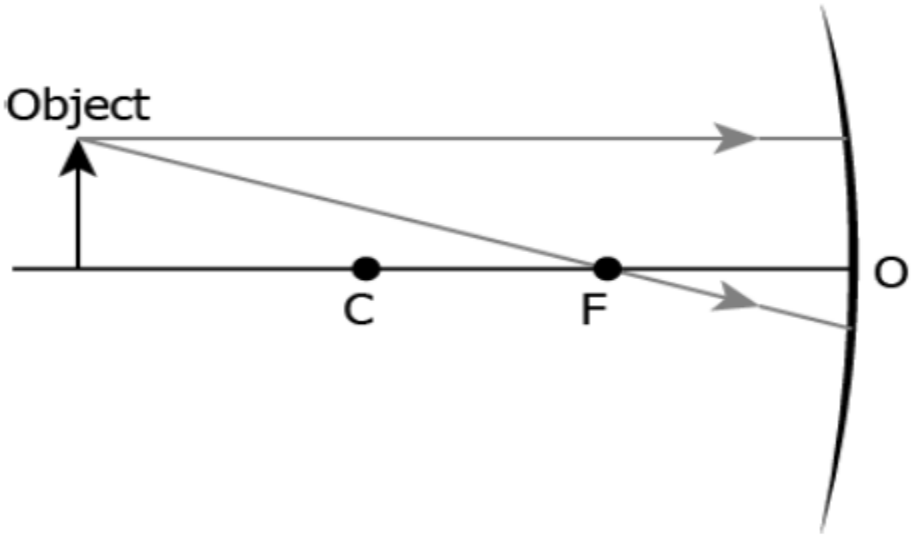
(b) infinite

(c) 25 cm

(d) -25 cm

Correct Answer: Option (b)

5) The image shows the path of incident rays to a concave mirror.



Where would the reflected rays meet for the image formation to take place?

(a) Behind the mirror

(b) Between F and O

(c) Between C and F

(d) Beyond C

Correct Answer: Option (c)

6) A beam of light incident on a plane mirror forms a real image on reflection. The incident beam is:

(a) parallel

(b) convergent

(c) divergent

(d) not certain

Correct Answer: Option (b)

7) An object is placed at a distance of 40cm in front of a concave mirror of a focal length of 20 cm.

The image produced is:

(a) virtual and inverted

(b) real and erect

(c) real, inverted and of the opposite size as that of the object

(d) real, inverted and of the same size as that of the object

Correct Answer: Option (d)

8) A student conducts an experiment using a convex lens. He places the object at a distance of 60 cm in front of the lens and observes that the image is formed at a distance of 30 cm behind the lens. What is the power of the lens?

(a) 0.005 dioptre

(b) 0.05 dioptre

(c) 5 dioptre

(d) 50 dioptre

Correct Answer: Option (c)

9) An image of an object produced on a screen which is about 36 cm using a convex lens. The image produced is about 3 times the size of the object. What is the size of the object?

(a) 12 cm

(b) 33 cm

(c) 39 cm

(d) 108 cm

Correct Answer: Option (a)

10) Image formed by a convex spherical mirror is:

(a) virtual

(b) real

(c) enlarged

(d) inverted

Correct Answer: Option (a)

11) A student studies that a convex lens always forms a virtual image irrespective of its position. What causes the convex mirror to always form a virtual image?

(a) Because the reflected ray never intersects

(b) Because the reflected ray converges at a single point

(c) Because the incident ray traces its path back along the principal axis

(d) Because the incident ray of a convex mirror gets absorbed in the mirror

Correct Answer: Option (a)

FILL IN THE BLANKS

1.The bouncing back of light from a surface is known as **reflection.**

2.The point where light rays meet or appear to meet after reflection or refraction is called **the focus.**

3.The angle of incidence is always equal to the angle of **reflection.**

4.The change in the direction of light when it passes from one medium to another is called **refraction.**

5.The type of mirror that always forms a virtual and erect image is a **convex** mirror.

6.A lens that is thicker at the center than at the edges is called a **convex lens.**

7.The phenomenon that causes the dispersion of light into its component colors is called **dispersion.**

8.The distance between the optical center of a lens or mirror and its focal point is known as **focal length.**

9.The bending of light as it passes through a prism is an example of **dispersion.**

10.The process of vision in the human eye involves the formation of an image on the **retina.**