

Chapter - 10

The Human Eye and The Colourful World

Human eye : The sense organ that helps us to see.

- Located in eye sockets in skull.
- Diameter of eye ball is 2.3 cm

Parts of Human Eye

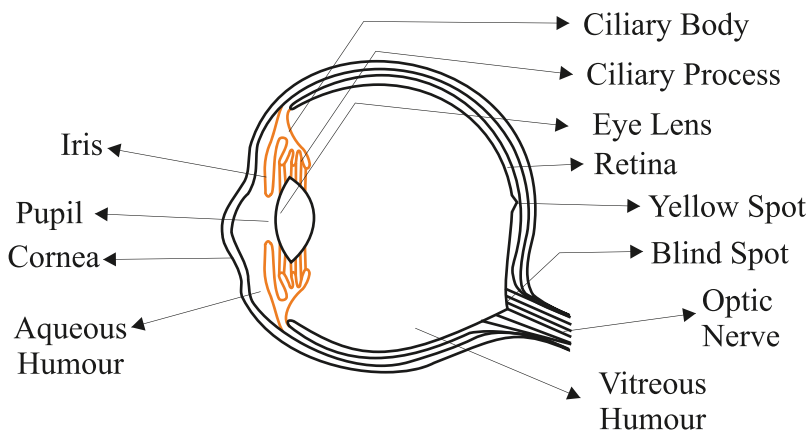
Cornea : It is the outermost, transparent part. It provides most of the refraction of light.

Lens : It is composed of a fibrous, jelly like material. Provides the focused real and inverted image of the object on the retina. This is convex lens that converges light at retina.

Iris : It is a dark muscular diaphragm that controls the size of the pupil.

Pupil : It is the window of the eye. It is the central aperture in iris. It regulates and controls the amount of light entering the eye.

Retina : It is a delicate membrane having enormous number of light sensitive cells.



The Structure of human eye

Far point : The maximum distance at which object can be seen clearly is far point of the eye. For a normal adult eye, its value is infinity.

Near point or Least distance of distinct vision:

The minimum distance at which objects can be seen most distinctively without strain.

- For a normal adult eye, its value is 25 cm.
- Range of human vision – 25 cm to infinity.

Accommodation : The ability of the eye lens to adjust its focal length is called accommodation. Focal length can be changed with the help of ciliary muscles.

Myopia (Near sightedness)

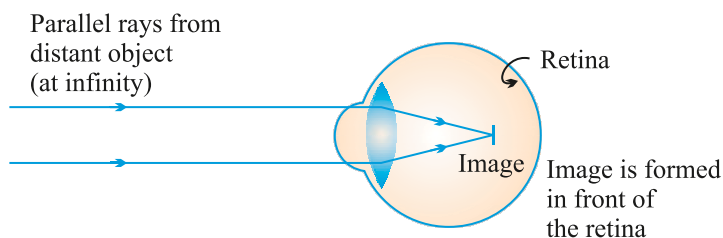
- A myopic person can see nearby objects clearly but cannot see distant objects clearly.
- Image is formed in front of retina.
- The far point (F) of a myopic lens is less than infinity.

Causes of Myopia

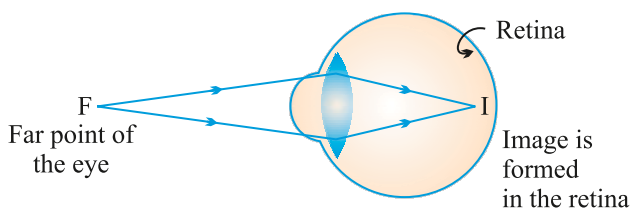
- Excessive curvature of eye lens
- Elongation of eye ball

Correction

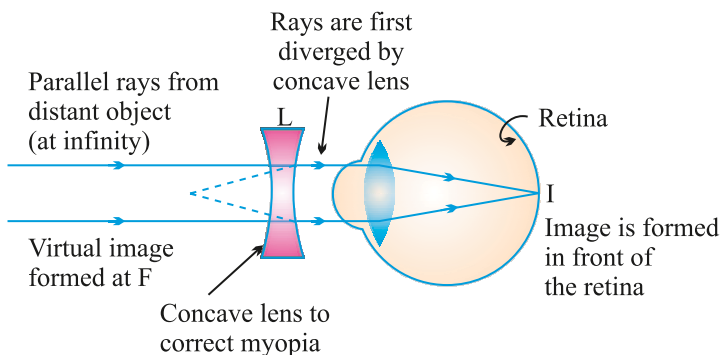
Use of concave lens of appropriate power.



- (a) In a myopic eye, image of distant object is formed in front of the retina (and not on the retina)



(b) The far point (F) of a myopic eye is less than infinity



(c) Correction of myopia. The concave lens placed in front of the eye forms a virtual image of distant object at far point (F) of the myopic eye.

Hypermetropia (Far sightedness)

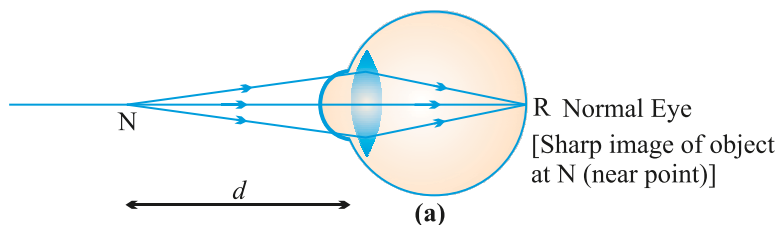
- Affected person can see far objects clearly but cannot see nearby objects clearly.
- The near point of the eye moves away from near point (25 cm)
- Image is formed behind the retina.

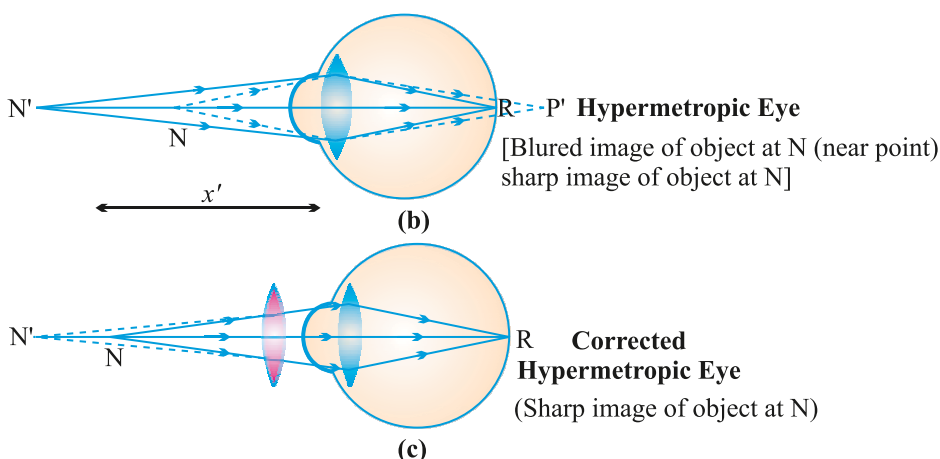
Causes of Hypermetropia

- Focal length of the eye lens becomes too long.
- Eye ball becomes too small.

Correction

Use of convex lens of suitable power can correct the defect.





Presbyopia (Old age Hypermetropia)

It is the defect of vision due to which an old person cannot see the nearby objects clearly due to loss of power of accommodation of the eye.

- The near-point of the old person having presbyopia gradually recedes and becomes much more than 25 cm away.

Causes

- Gradual weakening of ciliary muscles.
- Diminishing flexibility of eye lens.

Correction

- Use of both concave and convex lens of suitable power.
- Sometimes a person may suffer from both myopia and hypermetropia.
- Such people require bifocal lens for correction.

Advantage of the eyes in front of the face

- It gives a wider field of view.
- It enhances the ability to detect faint objects.
- It provides three dimensional view.

CHECK YOUR KNOWLEDGE

VERY SHORT ANSWER TYPE QUESTIONS

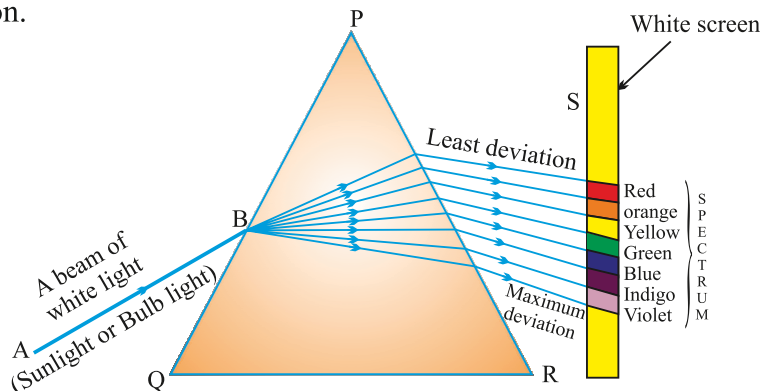
1. What type of lens is used to correct (a) Hypermetropia, (b) Myopia ?
2. Name the defect of vision in which the eye-lens loses its power of accommodation due to old age.
3. What is the far point of a person suffering from myopia ?
4. What is the other name of old age hypermetropia ?
5. You friend can read a book perfectly well but cannot read the writing on black-board unless she sits on the front row in class. Is she short-sighted or long-sighted ?

SHORT ANSWER TYPE QUESTIONS

1. Differentiate between Hypermetropia and Myopia.
2. What is presbyopia ? Write two causes of this defect. Name the type of lens which can be used to correct presbyopia.
3. The near point of a person suffering from hypermetropia is at 50 cm from his eye. What is the nature and power of the lens needed to correct this defect ?
4. How is the amount of light entering the eye controlled ?
5. (a) What happens to the size of pupil of our eye in (i) dim light, (ii) bright light ?
(b) Name the cells on the retina sensitive to (i) bright light, (ii) dim light.
6. (a) Draw a simple diagram of the human eye and label clearly the cornea, iris, pupil, ciliary muscles, eye lens, retina and optic nerve.
(b) Describe the working of the human eye with the help of the above diagram.
7. What is short sightedness ? State the two causes of short-sightedness. With the help of ray diagrams, show :
(a) the eye defect short sightedness.
(b) correction of short sightedness by using a lens.

Dispersion of Light by Glass Prism

When white light is passed through a glass prism, it splits into its seven constituent colours to form a band of seven colours. This phenomenon is called dispersion.



Spectrum : The band of seven colours formed due to dispersion of white light is called spectrum.

Acronym : It is a group of alphabets that represent sequential colours in spectrum.

V I B G Y O R

$$\text{Angle of deviation} \propto \frac{1}{\text{wavelength}}$$

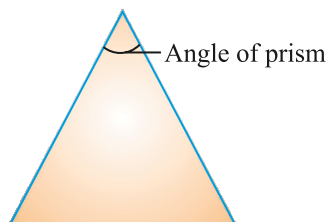
- Red is the **least deviated** colour as it has largest/longest wavelength.
- Violet is the **most deviated** colour as it has smallest wavelength in visible spectrum.

Q. Why spectrum is formed when white light is passed through a glass prism ?

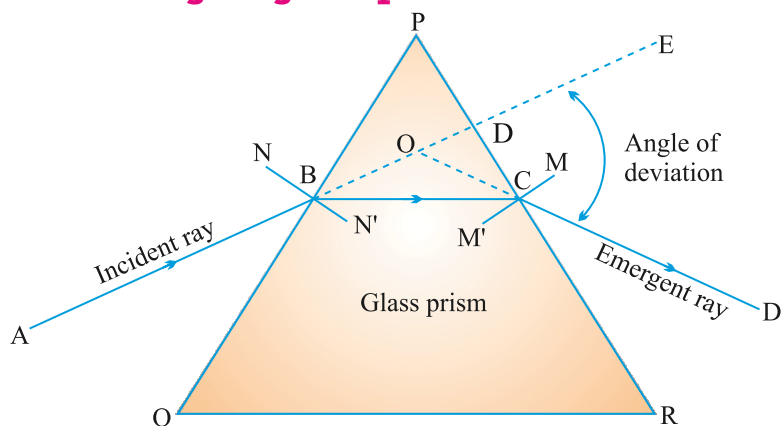
Ans. Each colour has a definite wavelength and for each wavelength the angle of deviation differs. Red is the least deviated and violet is the most deviated colour so different colours deviate at different angles to form spectrum.

Prism : It is a pyramidal piece of glass with two triangular bases and three rectangular lateral surfaces.

Angle of Prism : The angle between two adjoining lateral surfaces.



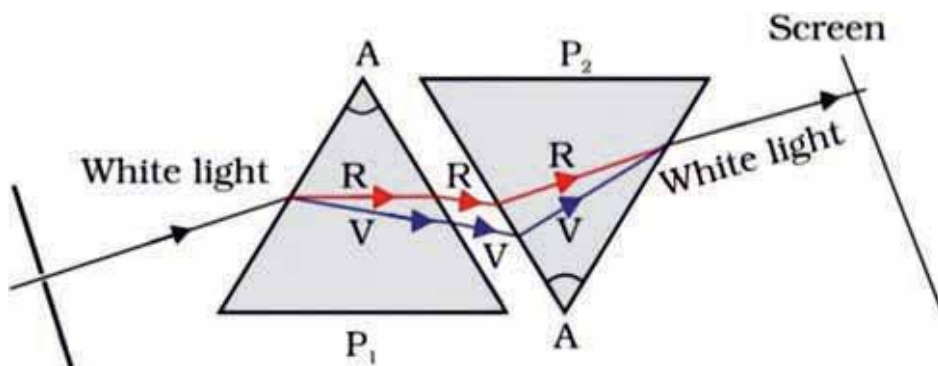
Refraction through a glass prism



Angle of deviation (d) : It is the angle between incident ray and emergent ray.

Issac Newton was the first person who proved that sunlight is made up of seven colours :

- He passed sunlight through a glass prism to form a band of seven colours.
- He tried to split the colours further by putting another prism ahead of the prism forming spectrum but he failed to obtain more colours.
- He formed a spectrum from sunlight and placed an identical but inverted prism in front of prism forming the spectrum. All the seven colours combined by the inverted prism and emerged as white light.

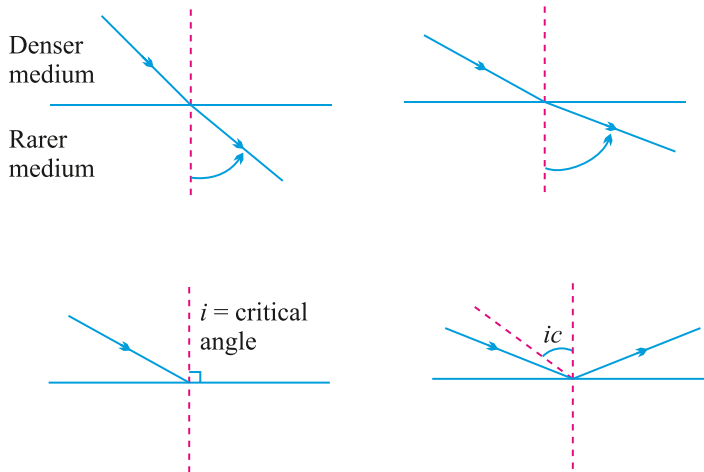


Q. What is referred as white light ?

Ans. Any light that forms a spectrum similar to that of sunlight is referred as white light.

Total Internal Reflection

When light enters obliquely from a denser medium to a rarer medium and the angle of incidence exceeds critical angle, the light reflects in the denser medium. This is called internal reflection.



Conditions necessary for Internal Reflection

- (i) Light should enter obliquely from a denser to a rarer medium.
- (ii) The angle of incidence should exceed critical angle, the light reflects in the denser medium.

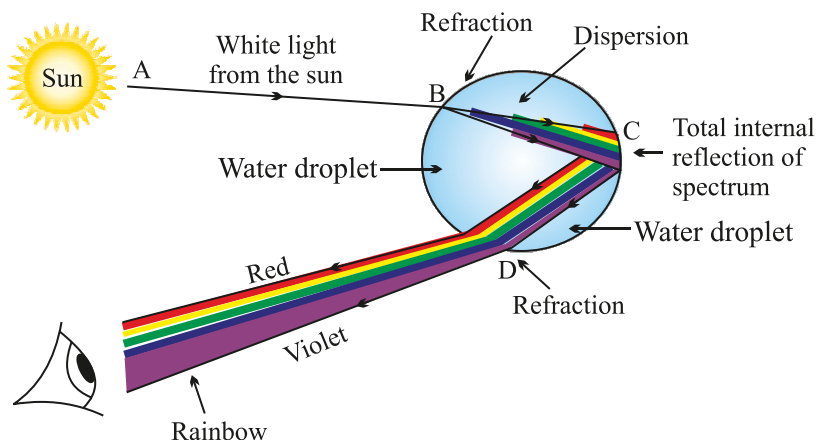
Critical angle : The angle of incidence for which the angle of refraction is 90° .

Rainbow : It is a natural spectrum appearing in the sky after rain showers.

- Rainbow is observed in the direction opposite to the sun.
- Three phenomenon which are involved in rainbow formation are :
 - (a) Dispersion
 - (b) Refraction
 - (c) Internal reflection

Formation of Rainbow :

Some water droplets remain suspended in air after rain. These droplets behave as glass prism. When light enters the rain drop, it first refracts and disperses. Then it reflects internally and again refracts as it comes out of the drop and the seven colours reach the eye of observer in form of rainbow.



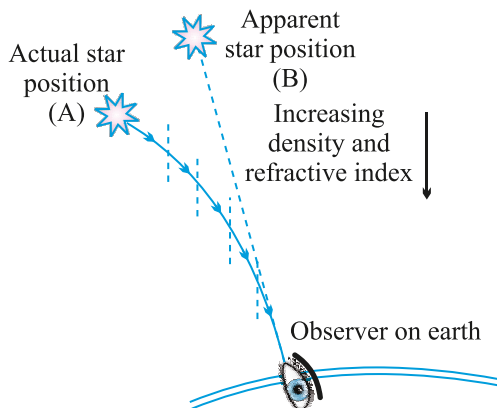
Atmospheric Refraction : The refraction by different layers of atmosphere is called atmospheric refraction.

- (i) Apparent flickering of objects placed behind a hot object or fire.
 - (ii) Stars near the horizon appear slightly higher than their actual position.
 - (iii) Advanced sunrise and delayed sunset.
 - (iv) Twinkling of stars.
- (i) *An object placed behind the fire or a hot surface appears to flicker when seen through the air .*

The air above hot surface becomes hot and rises. The space is occupied by cool air. The refractive index of hot air is less than that of cool air. So, the physical condition of the medium are not constant. Due to changing Refractive Index (RI) of medium, the light appears to come from different directions.

It results in fluctuation in apparent position of object.

- (ii) Stars when seen near the horizon appear slightly higher than their actual position due to atmospheric refraction.

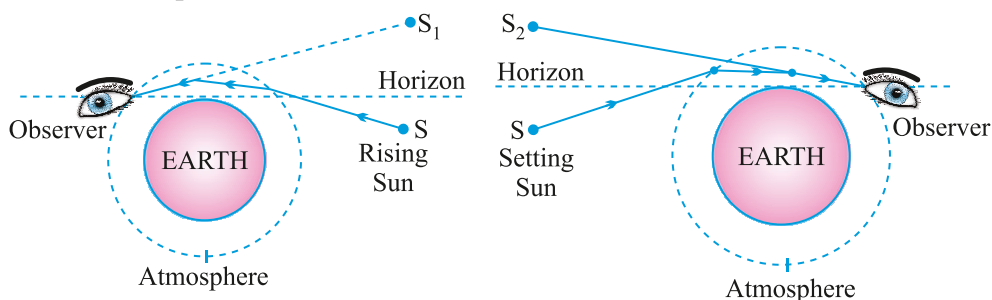


The refractive index of earth's atmosphere in general increases from top to bottom. So, the light coming from a star near the horizon has to travel from rarer to denser medium and it bends towards the normal. As a result the star appears higher.

(iii) Advanced sunrise

The sun appears about two minutes earlier than actual sunrise and the sun remains visible for about two minutes after actual sunset.

When the sun is below horizon, the rays have to pass from rarer to denser medium. So rays bend towards the normal. As a result the sun appears higher than its actual position.



(iv) Twinkling of stars

Stars are very far from us, so they behave as point source of light. Since the physical conditions of the earth's atmosphere are not constant the light from stars appears to come from different directions. This results in fluctuation of apparent position of star.

The amount of light coming from stars also vary due to changing Refractive Index of atmosphere.

The star appears bright when more light from star reaches our eyes and the same star appears dull when less amount of light reaches our eyes.

Both these effects are responsible for twinkling of stars.

Scattering effect : Spreading of light in various directions by colloid particles.

$$\text{Law of Rayleigh} \quad \text{Scattering} \propto \frac{1}{(\text{wavelength})^4}$$

Tyndall effect : When light passes through a colloid its path becomes visible. This is called **Tyndall effect**.

E.g.,

- (i) Path of light becomes visible when light enters a dark and dusty room through a slit or ventilator.
- (ii) Path of light becomes visible when light passes through dense canopy of trees in a forest.

The colour of scattered light depends on the size of scattering particles

- (i) If particles are very fine, they scatter mainly the blue colour of light (shorter wavelength).
 - (ii) Medium sized particles scatter mainly the red colour (longer wavelength).
 - (iii) Even larger particles scatter all the colours of light that is why it appears white.
- Wavelength of red light is about 1.8 times to that of blue light.

Q. *Why danger signs are made of red colour ?*

Ans. Red is the least scattered colour. It is least scattered by fog and smoke and can be seen in the same colour over a long distance. So, danger signs are made in red colour.

Q. *Why the colour of sky appears blue on a clear day ?*

Ans. The upper layer of atmosphere contains very fine particles of water vapours and gases. These particles are more effective in scattering of light of shorter wavelength mainly blue than larger wavelength. So, the sky appears blue.

Q. *How does the sky appear to an astronaut in the space or to a passenger of jet plane flying at high altitude ?*

Ans. The sky would appear dark to an astronaut in the space as scattering is not very prominent at such high altitude due to absence of particles.

Q. *Why clouds appear white ?*

Ans. Clouds are formed by water vapours. Water vapours condense to form water droplets due to larger size of droplets, all colours of light are scattered and clouds appear white.

Q. *Why colour of sun appear red during sunrise and sunset ?*

Ans. While sunset and sunrise, the colour of the sun and its surrounding appear red. During sunset and sunrise, the sun is near horizon and therefore the sunlight has to travel larger distance in atmosphere. Due to this most of the blue light (shorter wavelength) are scattered away by the particles. The light of longer wavelength (red colour) will reach our eye. This is why sun appear red in colour.

Q. *Why do planets not twinkle ?*

Ans. The planets are much closer to the earth and are thus seen as extended source. If we consider a planet as a collection of a large number of point-sized sources of light, the total variation in the amount of light entering our eye from all individual point sized sources will average out to zero and will nullify the twinkling effect.

QUESTIONS

1 MARKER OBJECTIVE QUESTIONS

I. MULTIPLE CHOICE QUESTIONS

- The image formed retina of human eye is
 - Virtual and erect
 - Real and inverted
 - Virtual and inverted
 - Real and erect
- The change in the focal length of human eye is caused due to
 - Ciliary muscles
 - Pupil
 - Cornea
 - Iris
- The least distance of distinct vision for a young adult with normal vision is
 - 25 m
 - 20 m
 - 25 cm
 - 20 cm
- The persistence of vision for human eye is
 - 1/10th of a second
 - 1/16th of a second
 - 1/6th of the second
 - 1/18th of a second
- The light sensitive cells of retina which are sensitive to the intensity of light are—
 - Cones
 - Rods
 - Both rods and cones
 - None of these
- A person cannot see distinctly objects kept beyond 2 m. This defect can be corrected by using lens of power-
 - +0.5 D
 - 0.5 D
 - +0.2 D
 - 0.2 D
- A student sitting on the last bench can read the letters written on the blackboard but is not able to read / the letters written in his textbook. Which of the following statements is correct?
 - The near point of his eyes has receded away.
 - The near point of his eyes has come closer to him.

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VERY SHORT ANSWER TYPE QUESTIONS

1. Which of the two is scattered more easily – light of shorter wavelength or light of longer wavelength ?
2. What is the near and far point of a normal eye ?
3. State two effects produced by the scattering of light by the atmosphere.
4. What is tyndall effect ?
5. Which light has longer wavelength – red light or blue light ?
6. What do you understand by dispersion of light ?
7. As light rays pass from air into a glass prism, are they refracted towards or away from the normal ?
8. Assertion (A): Some persons have the difficulty to see the objects in dim light during night.
Reason (R): Cones respond less to the illumination.
 - (a) (A) is incorrect and (R) is correct.
 - (b) (A) is correct and (R) is incorrect.
 - (c) Both (A) and (R) are correct but (R) is not the correct explanation of (A).
 - (d) Both (A) and (R) are correct but (R) is the correct explanation of (A).
9. Assertion (A): The colour of the clear sky appears blue.
Reason (R): The sky of the moon appears dark.
 - (a) (A) is incorrect and (R) is correct.
 - (b) (A) is correct and (R) is incorrect.
 - (c) Both (A) and (R) are correct but (R) is not the correct explanation of (A).
 - (d) Both (A) and (R) are correct but (R) is the correct explanation of (A).
10. Assertion (A): The human eye has more field of view.
Reason (R): For a normal eye, the farthest point upto which the eye can see objects clearly is infinity.
 - (a) (A) is incorrect and (R) is correct.
 - (b) (A) is correct and (R) is incorrect.
 - (c) Both (A) and (R) are correct but (R) is not the correct explanation of (A).
 - (d) Both (A) and (R) are correct but (R) is the correct explanation of (A).

11. A student very cautiously traces the path of a ray through a glass slab for different values of the angle of incidence ($\angle i$). He then measures the corresponding values of the angle of incidence. On analysing these measurements of angles, his conclusion would be

(A) $\angle i > \angle r > \angle e$

(B) $\angle i = \angle e > \angle r$

(C) $\angle i < \angle r < \angle e$

(D) $\angle i = \angle e < \angle r$

Sol. (B) $\angle i = \angle e > \angle r$

SHORT ANSWER TYPE QUESTIONS

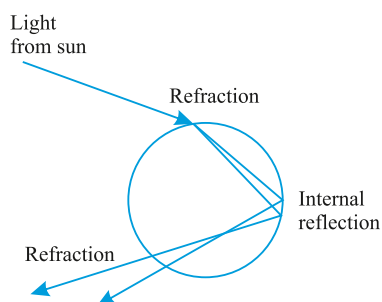
1. Why do stars twinkle at night ?
2. Describe the formation of rainbow in the sky with the help of a diagram.
3. Why the sun appear red while sunset and sunrise ? Explain.
4. Why do stars seem higher than they actually are ? Illustrate your answer with the help of a diagram.
5. What is "dispersion of white light"? Draw a labelled diagram to illustrate the recombination of the spectrum of white light. Why it is essential that the two prisms used for the purpose should be identical and placed in an inverted position with respect to each other? (CBSE 2017)
6. With the help of scattering of light, explain the reason for the difference in colours of the Sun as it appears during sunset/sunrise and noon. (CBSE 2015)
7. Write the importance of ciliary muscles in the human eye. Name the defect of vision that arises due to gradual weakening of the ciliary muscles. What types of lenses are required by the person suffering from this defect to see the objects clearly. (CBSE 2015)
8. (a) A student is unable to see clearly the words written on the black board placed at a distance of approximately 3 m from him. Name the defect of vision the boy is suffering from. State the possible causes of this defect and explain the method of correcting it.
9. (a) Write the function of each of the following parts of human eye:
(i) Cornea (ii) Iris (iii) Crystalline (iv) Ciliary muscles
(b) Why does the sun appear reddish early in the morning? Will this phenomenon be observed by an astronaut on the Moon? Give reason to justify your answer.

- 10 (a) A student suffering from myopia is not able to see distinctly the object placed beyond 5 m. List two possible reasons due to which this defect of vision may have arisen. With the help of ray diagrams explain.
- (i) Why the student is unable to see distinctly the objects placed beyond 5 cm from his eyes.
- (ii) The type of the corrective lens used to restore proper vision and how this defect is correct by the use of this lens
- 10 (b) If, in this case, the numerical value of the focal length of the corrective lens is 5 m, find the power of the lens as per the new Cartesian sign convention.
11. What is atmospheric refraction ? What causes atmospheric refraction ?
12. Draw a neat and labelled diagram of the experimental set-up for observing the scattering of light in a colloidal solution of sulphur to show how the sky appears blue and the sun appears red at sunrise and sunset.

(CBSE 2018)

Competency Based Questions

1. Which natural phenomena is being shown here?



- a) Twinkling of stars
- b) Rainbow formation
- c) reddish appearance of the sun early in the morning
- d) blue colour of sky
2. Which of the following conditions are necessary for this phenomenon?
- a) The Sun should be behind us.
- b) It should have rained and the Sun should be present.

- c) None of A and B
 - d) Both A and B
3. Dispersion of white light by the glass prism shows-
- a) Spectrum
 - b) Tyndall effect
 - c) Twinkling of stars
 - d) Delayed sunset
4. A glass prism is able to produce a spectrum while white light passes through it but a glass slab does not produce any spectrum. Why?
5. Why do different components of white light deviate through a triangular glass prism?