EXERCISE- 6 (A)

Question 1:

Name three factors on which the deviation produces by a prism depends and state how does it depend on the factors stated by you.

Solution 1:

The deviation produced by the prism depends on the following four factors:

(a) The angle of incidence - As the angle of incidence increases, first the angle of deviation decreases and reaches to a minimum value for a certain angle of incidence. By further increasing the angle of incidence, the angle of deviation is found to increase.

(b) The material of prism (i.e., on refractive index) - For a given angle of incidence, the prism with a higher refractive index produces a greater deviation than the prism which has a lower refractive index.

(c) Angle of prism- Angle of deviation increases with the increase in the angle of prism.

(d) The colour or wavelength of light used- Angle of deviation increases with the decrease in wavelength of light.

Question 2:

How does the deviation produced by a triangular prism depend on the colours (or wavelengths) of light incident on it?

Solution 2:

The deviation caused by a prism increases with the decrease in the wavelength of light incident on it.

Question 3:

Which colour of white light is deviated by a glass prism the most and which the least?

Solution 3:

A glass prism deviates the violet light most and the red light least.

Question 4:

Define the term dispersion of light.

Solution 4:

The phenomenon of splitting of white light by a prism into its constituent colours is known as dispersion of light.

Question 5:

Explain the cause of dispersion of white light through a prism.

Solution 5:

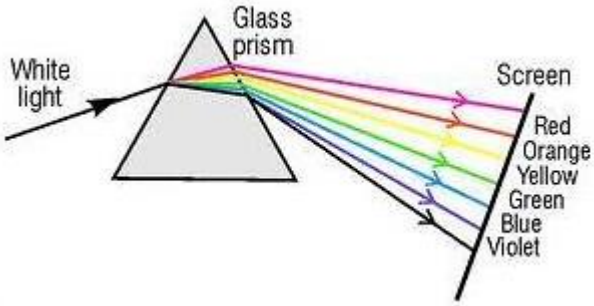
When white light is incident on the first surface of a prism and enters in glass, light of different colours due to different speeds in glass, is refracted or deviated through different angles. Thus the dispersion of white light into its constituent colours takes place at the first surface of prism. Thus the cause of dispersion is the change in speed of light with wavelength or frequency.

Question 6:

Explain briefly, with the help of a neat labelled diagram, how white light gets dispersed by a prism.

Solution 6:

When white light is incident on the first surface of a prism and enters in glass, light of different colours due to different speeds in glass, is refracted or deviated through different angles. Thus the dispersion of white light into its constituent colours takes place at the first surface of prism.



On the second surface, only refraction takes place and different colours are deviated through different angles. As a result, the colours get further separated on refraction at the second surface (violet being deviated the most and red the least).

Question 7:

The diagram shown below in Fig. 6.11 shows the path taken by a narrow beam of yellow monochromatic light passing through an equiangular glass prism. Now the yellow light is replaced by a narrow beam of white light incident at the same angle. Draw another diagram to show the passage of white light through the prism and label it to show the effect of prism on the white light.

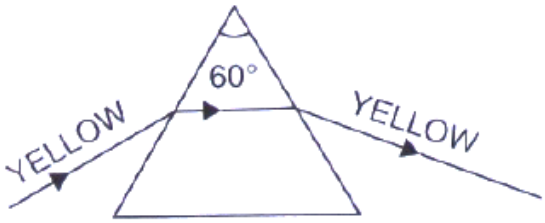
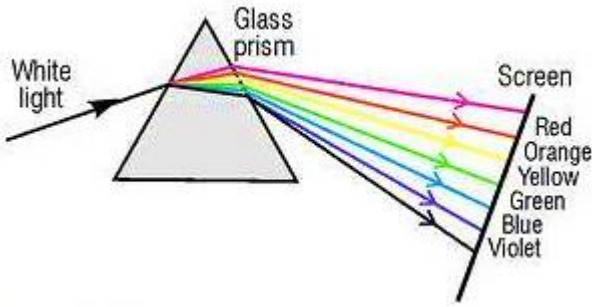


Fig. 6.11

Solution 7:



Question 8:

How does the speed of light in glass change on increasing the wavelength of light?

Solution 8:

Speed of light increases with increase in the wavelength.

Question 9:

Which colour of white light travels (a) fastest (b) slowest, in glass?

Solution 9:

Red colour travels fastest and Blue colour travels slowest in glass.

Question 10:

Fig 6.12 shows a thin beam of white light from a source S striking on one face of a prism.

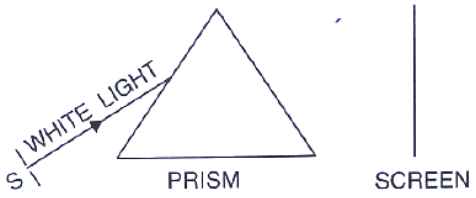


Fig. 6.12

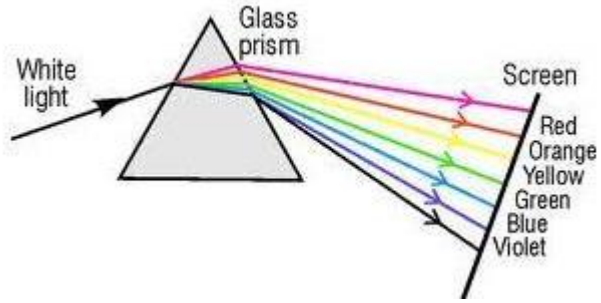
(a) Complete the diagram to show effect of prism on the beam and to show what is seen on the screen.

(b) A slit is placed in between the prism and the screen to pass only the light of green colour. What will you then observe on the screen?

(c) What conclusion do you draw from the observation in part (b) above?

Solution 10:

(a) Constituent colours of white light are seen on the screen after dispersion through the prism.



(b) When a slit is introduced in between the prism and screen to pass only the light of green colour, only green light is observed on the screen.

(c) From the observation, we conclude that prism itself produces no colour.

Question 11:

(a) If a monochromatic beam of light undergoes minimum deviation through an equiangular prism, how does the beam pass through the prism, with respect to its base?

(b) If white light is used in same way as in part (a) above, what change is expected in the emergent beam?

(c) what conclusion do you draw about the nature of white light in part (b)?

Solution 11:

(a) If a monochromatic beam of light undergoes minimum deviation through an equi-angular prism,
then the beam passes parallel to the base of prism.

(b) White light splits into its constituent colours i.e., spectrum is formed.
(c) We conclude that white light is polychromatic.

Question 12:

What do you understand by the term spectrum?

Solution 12:

The colour band obtained on a screen on passing white light through a prism is called the spectrum.

Question 13:

A ray of white light is passed through a glass prism and spectrum is obtained on a screen.
(a) Name the seven colours of the spectrum in order.
(b) Dow the colours have the same width in the spectrum?
(c) which of the colour of the spectrum of white light deviates (i) the most, (ii) the least?

Solution 13:

(a) Violet, Indigo, Blue, Green, Yellow, Orange, Red.
(b) No, different colours have different widths in the spectrum.
(c) (i) Violet colour is deviated the most. (ii) Red colour is deviated the least.

Question 14:

The wavelengths for the light of red and blue colours are roughly 7.8×10^{-7} m and 4.8×10^{-7} m respectively.
(a) Which colour has the greater speed in vacuum?
(b) Which colour has the greater speed in vacuum?

Solution 14:

(a) In vacuum, both have the same speeds.
(b) In glass, red light has a greater speed.

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Question 15:

(i) Draw a diagram to show the splitting of white light by a prism into its constituent colour.
(ii) Draw another diagram to show how the colours of spectrum of white light can be combined to give the effect of white light.

Solution 15:

Color of light is related to its wavelength.

Question 16:

Complete the ray diagram given below to show the nature of light produced on the screen.

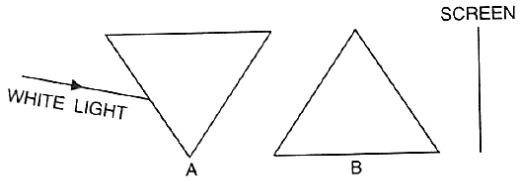

Fig. 6.13

Solution 16:

i. $4000\overset{0}{A}$ to $8000\overset{0}{A}$
ii. 400 nm to 800 nm

Question 17:

Name the subjective property of light related to its wavelength.

Solution 17:

(i) For blue light, approximate wavelength=4800 Å
(ii) For red light, approximate wavelength=8000 Å

Question 18:

What is the range of wavelength of the spectrum of white light in (i) Å, (ii) nm?

Solution 18:

Seven prominent colours of the white light spectrum in order of their increasing frequencies:
Red, Orange, Yellow, Green, Blue, Indigo, Violet

Question 19:
Write the approximate wavelengths for (i) blue and (ii) red light.

Solution 19:
Green, Yellow orange and red have wavelength longer than blue light.

MULTIPLE CHOICE TYPE:

Question 1:
When a white light ray falls on a prism, the ray at its first surface suffers.
(a) no refraction
(b) only dispersion
(c) only deviation
(d) both deviation and dispersion

Solution 1:
Both deviation and dispersion.
Hint: When a white light ray falls on the first surface of a prism, light rays of different colours due to their different speeds in glass get refracted (or deviated) through different angles. Thus, the dispersion of white light into its constituent colours takes place at the first surface of prism.

Question 2:
In the spectrum of white light by a prism, the colour at the extreme end opposite to the base of prism is:
(a) violet (b) yellow
(c) red (d) blue

Solution 2:
The colour of the extreme end opposite to the base of the prism is red.
Hint: The angle of deviation decreases with the increase in wavelength of light for a given angle of incidence. Since the red light has greatest wavelength, it gets deviated the least and is seen on the extreme end opposite to the base of prism.

NUMERICALS:

Question 1:

Calculate the frequency of yellow light of wavelength 550nm. The speed of light is 3×10^8 m/s^{-1}

Solution 1:

Given, wavelength $\lambda = 550$ nm $= 550 \times 10^{-9}$ m

Speed of light, $c = 3 \times 10^8$ m/s

We know that,

Frequency = $\frac{Speed\ of\ light}{wave\ length}$

Or, frequency = $\frac{3 \times 10^8}{550 \times 10^{-9}} = 5.4 \times 10^{14}$ HZ

Question 2:

The frequency range of visible light is from 3.75 x 10^{14} Hz to 7.5 x 10^{14} Hz. Calculate its wavelength range. Take speed of light = 3 x 10^8m/s^{-1}

Solution 2:

Speed of light, c = 3 x 10^8m/s

Frequency range = 3.75 x 10^{14} Hz to 7.5 x 10^{14} Hz.

Speed of light = frequency x wavelength

For frequency = 3.75 x 10^{14}Hz

$$\Lambda = \frac{c}{\nu} = \frac{3\times10^8 m/s}{3.75\times10^{14} Hz} = 8\times10^{-7} m = 8000\,Å$$

For frequency =7.5 x 10^{14}Hz

$$\Lambda = \frac{c}{\nu} = \frac{3\times10^8 m/s}{7.5\times10^{14} Hz} = 4\times10^{-7} m = 4000\,Å$$

Wavelength range = 4000 Å to 8000 Å

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EXERCISE. 6 B

Question 1:

(a) Give a list of at least five radiations, in order of their increasing frequencies, which make up the complete electromagnetic spectrum.

(b) Which of the radiation mentioned in answer to part (a) has the highest penetrating power?

Solution 1:

(a) Five radiations, in the order of their increasing frequencies are:
Infrared waves, Visible light, Ultraviolet, X-rays and Gamma rays.

(b) Gamma rays have the highest penetrating power.

Question 2:

(a) Arrange the following radiations in the order of their increasing wavelength:
X-rays, infrared rays, ratio waves, gamma ray and micro waves?

(b) Which radiation is used for satellite communication?

Solution 2:

(a) Gamma rays, X-rays, infrared rays, micro waves, radio waves.

(b) Microwave is used for satellite communication.

Question 3:

A wave has a wavelength of 0.01 Å. (a) Name the wave. (b) State its one property different from light.

Solution 3:

(a) Gamma ray.

(b) Gamma rays have strong penetrating power.

Question 4:

(a) Name the high energetic invisible electro-magnetic wave which helps in the study of structure of crystals.

(b) State one more use of the wave named in part (a).

Solution 4:

(a) X-rays are used in the study of crystals.

(b) It is also used to detect fracture in bones.

Question 5:

What is the range of the wavelength of the following electromagnetic waves?
(a) Gamma rays, (b) X-rays, (c) Ultraviolet (d) Visible, (e) Infrared, (f) Micro waves and (g) Radio waves.

Solution 5:

(a) Gamma rays-wavelength shorter than 0.1 Å
(b) X-rays-wavelength range 0.1 Å to 100 Å
(c) Ultraviolet rays-wavelength range 100 Å to 4000 Å
(d) Visible light-wavelength range 4000 Å to 8000 Å
(e) Infrared radiations-wavelength range 8000 Å to 10^7 Å
(f) Microwaves-wavelength range 10^7 Å to 10^{11} Å
(g) Radio waves-wavelength above 10^{11}Å

Question 6:

Give the range of wavelength of the electromagnetic waves visible to us.

Solution 6:

4000 Å to 8000 Å .

Question 7:

Name the region beyond (i) the red end and (ii) the violet end, of the spectrum.

Solution 7:

(i) Infrared
(ii) Ultraviolet

Question 8:

What do you understand by the invisible spectrum? How will you investigate the existence of radiation beyond the red and violet ends of the spectrum?

Solution 8:

The part of spectrum beyond the red and the violet ends is called the invisible spectrum as our eyes do not respond to the spectrum beyond the red and the violet extremes.

If the different radiations from the red part of the spectrum to the violet end and beyond it, are made incident on the silver-chloride solution, it is observed that from the red to the violet end, the solution remains unaffected. However just beyond the violet end, it turns violet and finally it becomes dark brown. Thus there exist certain radiations beyond the violet end of the spectrum, which are chemically more active than the visible light, called ultraviolet radiations. Now, if a thermometer with a blackened bulb is moved from the violet end towards the red end, it is observed that there is a slow rise in temperature, but when it is moved beyond the red region, a rapid rise in temperature is noticed. It means that the portion of spectrum beyond the red end has certain radiations which produce a strong heating effect, but they are not visible. These radiations are called the infrared radiations.

Question 9:

State the approximate range of wavelength associated with (i) the ultraviolet rays, (ii) the visible light and (iii) infrared rays.

Solution 9:

(i)Ultraviolet rays-wavelength range 100 Å to 4000 Å
(ii)Visible light-wavelength range 4000 Å to 8000 Å
(iii)Infrared radiations-wavelength range 8000 Å to 10^7 Å

Question 10:

Name the radiations of wavelength just (i) longer than 8×10^{-7}m, (ii) Shorter than 4×10^{-7} m.

Solution 10:

(i)Infrared radiations are longer than 8×10^{-7}m.
(ii) ultraviolet radiations are shorter than 4×10^{-7} m.

Question 11:

Name two electromagnetic waves of frequency greater than that of violet light. State one use of each.

Solution 11:

X-rays and ultraviolet rays are electromagnetic waves of frequency greater than that of violet light.

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Uses:
X-rays are used for studying atomic arrangement in crystals.
Ultraviolet rays are used for detecting the purity of gems, eggs, ghee etc.

Question 12:

Give one use each of (i) microwaves, (ii) ultraviolet radiations, (iii) infrared radiations, and (iv) gamma rays.

Solution 12:

(i) Microwaves are used for satellite communication.
(ii)Ultraviolet radiations are used for detecting the purity of gems, eggs, ghee etc.
(iii)Infrared radiations are used in remote control of television and other gadgets.
(iv)Gamma rays are used in medical science to kill cancer cells.

Question 13:

Name the rays or waves (i) of highest frequency, (ii) used for taking photographs in dark, (iii) produced by the changes in the nucleus of an atom, (iv) of wavelength nearly 0.1 nm.

Solution 13:

(i)Gamma rays are of highest frequency.
(ii)Infrared rays are used for taking photographs in dark.
(iii)Gamma rays are produced by the changes in the nucleus of an atom.
(iv)X-Rays are of wavelength nearly 0.1 nm.

Question 14:

Two waves A and B have wavelength 0.01 Å and 9000 Å respectively.
(a) Name the two waves.
(b) Compare the speeds of these waves when they travel in vacuum.

Solution 14:

(a) A- Gamma rays, B-infrared radiations
(b) Ratio of speeds of these waves in vacuum is 1:1 as all electromagnetic waves travel with the speed of light in vacuum.

Question 15:

Name two sources, each of infrared radiations and ultraviolet radiations.

Solution 15:

All heated bodies such as a heated iron ball, flame, fire etc., are the sources of infrared radiations. The electric arc and sparks give ultraviolet radiations.

Question 16:

What are infrared radiations? How are they detected? State one use of these radiations.

Solution 16:

Infrared radiations are the electromagnetic waves of wavelength in the range of 8000Å to 10^7Å.
Detection: If a thermometer with a blackened bulb is moved from the violet end towards the red end, it is observed that there is a slow rise in temperature, but when it is moved beyond the red region, a rapid rise in temperature is noticed. It means that the portion of spectrum beyond the red end has certain radiations which produce a strong heating effect, but they are not visible. These radiations are called the infrared radiations.
Use: The infrared radiations are used for therapeutic purposes by doctors.

Question 17:

What are ultraviolet radiations? How are they detected? State one use of these radiations.

Solution 17:

The electromagnetic radiations of wavelength from 100Å to 4000Å are called the ultraviolet radiations.
Detection: If the different radiations from the red part of the spectrum to the violet end and beyond it, are made incident on the silver-chloride solution, it is observed that from the red to the violet end, the solution remains unaffected. However just beyond the violet end, it first turns violet and finally it becomes dark brown. Thus there exist certain radiations beyond the violet end of the spectrum, which are chemically more active than visible light, called ultraviolet radiations.
Use: Ultraviolet radiations are used for sterilizing purposes.

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Question 18:

Name three properties of ultraviolet radiations which are similar to visible light.

Solution 18:

(a) Ultraviolet radiations travel in a straight line with a speed of 3×10^8 m in air (or vacuum).
(b) They obey the laws of reflection and refraction.
(c) They affect the photographic plate.

Question 19:

Give two properties of ultraviolet radiations which differ from the visible light.

Solution 19:

(a) Ultraviolet radiations produce fluorescence on striking a zinc sulphide screen.
(b) They cause health hazards like cancer on the body.

Question 20:

Mention three properties of infrared radiations similar to the visible light.

Solution 20:

(a) Infrared radiations travel in straight line as light does, with a speed equal to 3×10^8m/s in vacuum.
(b) They obey the laws of reflection and refraction.
(c) They do not cause fluorescence on zinc sulphide screen.

Question 21:

Give two such properties of infrared radiations which are not true for visible light.

Solution 21:

(a) Infrared radiations are invisible.
(b) They do not affect the ordinary photographic film.

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Question 22:

Explain the following:

(i) Infrared radiations are used for photography in fog.
(ii) Infrared radiations are used as signals during war
(iii) the photographic darkrooms are provided with infrared lamps.
(iv) A rock salt prism is used instead of a glass prism to obtain the infrared spectrum.
(v) A quartz is required for obtaining the spectrum of the ultraviolet light.
(vi) Ultraviolet bulbs have a quartz envelope instead of glass

Solution 22:

(i) Infrared radiations are used in photography in fog because they are not much scattered by the atmosphere, so they can penetrate appreciably through it.
(ii) Infrared radiations are used as signals during the war as they are not visible and they are not absorbed much in the medium.
(iii) Infrared lamps are used in dark rooms for developing photographs since they do not affect the photographic film chemically, but they provide some visibility.
(iv) Infrared spectrum can be obtained only with the help of a rock-salt prism since the rock-salt prism does not absorb infrared radiations whereas a glass prism absorbs them.
(v) A quartz prism is used to obtain the spectrum of the ultraviolet radiations as they are not absorbed by quartz, whereas ordinary glass absorbs the ultraviolet light.
(vi) Ultraviolet bulbs have a quartz envelope instead of glass as they are not absorbed by quartz, whereas ordinary glad absorbs the ultraviolet light.

MULTIPLE CHOICE TYPE:

Question 1:

The most energetic electromagnetic radiations are:
(a) Microwaves (b) ultraviolet waves
(c) X-rays (d) gamma rays

Solution 1:

Gamma rays

Question 2:

The source of ultraviolet light is:

(a) electric bulb (b) red hot iron ball

(c) sodium vapour lamp (d) carbon arc-lamp

Solution 2:

Carbon arc-lamp

Question 3:

A radiations A is focused by a proper device on the bulb of a thermometer. Mercury in the thermometer shows a rapid increase. The radiations A is:

(a) infrared radiation

(b) visible light

(c) ultraviolet radiation

(d) X-rays

Solution 3:

Infrared radiation

Hint: Infrared radiations produce strong heating effect.

NUMERICALS

Question 1:

An electromagnetic wave has a frequency of 500 MHz and a wavelength of 60 cm.

(a) Calculate the velocity of the wave.

(b) name the medium through which it is travelling

Solution 1:

(a) Frequency = 500MHz = 500 x 10^6Hz

Wavelength = 60 cm = 0.6 m

Velocity of wave = frequency x wavelength

= 500x 10^6 x 0.6 = 3 x 10^8m/s

(b) Electromagnetic wave is travelling through air.

Question 2:
The wavelength of X-rays is 0.01 Å. Calculate its frequency.
Solution 2:
Wavelength = 0.01Å = 0.01 x 10^{-10} m
Speed of X-rays = 3 x 10^{8}m/s
Speed of light = frequency x wavelength
C = $\nu\lambda$
$\nu = \frac{c}{\lambda} = \frac{3 \times 10^{a} m/s}{0.01 \times 10^{-10}\, m}$ = 3 × 10^{20} Hz

EXERCISE. 6 (C)

Question 1:
What is meant by scattering of light?
Solution 1:
When white light from sun enters the earth's atmosphere, the light gets scattered i.e., the light spreads in all directions by the dust particles, free water molecules and the molecules of the gases present in the atmosphere. This phenomenon is called scattering of light.

Question 2:
How does the intensity of scattered light depends on the wavelength of incident light? State conditions when this dependence holds.
Solution 2:
The intensity of scattered light is found to be inversely proportional to the fourth power of wavelength of light. This relation holds when the size of air molecules is much smaller than the wavelength of the light incident.

Question 3:
When sunlight enters the earth’s atmosphere, state which colour of light is scattered the most and which the least.
Solution 3:
Violet colour is scattered the most and red the least as the intensity of scattered light is found to be inversely proportional to the fourth power of wavelength of light.

Question 4:

The danger signal is red. Why?

Solution 4:

Since the wavelength of red light is the longest in the visible light, the light of red colour is scattered the least by the air molecules of the atmosphere and therefore the light of red colour can penetrate to a longer distance. Thus red light can be seen from the farthest distance as compared to other colours of same intensity. Hence it is used for danger signal so that the signal may be visible from the far distance.

Question 5:

How would the sky appear when seen from the space (or moon)? Give reason for your answer.

Solution 5:

On the moon, since there is no atmosphere, therefore there is no scattering of sun light incident on the moon surface. Hence to an observer on the surface of moon (space), no light reaches the eye of the observer except the light directly from the sun. Thus the sky will have no colour and will appear black to an observer on the moon surface.

Question 6:

What characteristic property of light is responsible for the blue colour of the sky?

Solution 6:

Scattering property of light is responsible for the blue colour of the sky as the blue colour is scattered the most due to its short wavelength.

Question 7:

The colour of sky, in direction other than of the sun, is blue. Explain.

Solution 7:

As the light travels through the atmosphere, it gets scattered in different directions by the air molecules present in its path. The blue light due to its short wavelength is scattered more as compared to the red light of long wavelength. Thus the light reaching our eye directly from sun is rich in red colour, while the light reaching our eye from all other directions is the scattered blue light. Therefore, the sky in direction other than in the direction of sun is seen blue.

Question 8:
Why does the sun appear red at sunrises and sunset?

Solution 8:
At the time of sunrise and sunset, the light from sun has to travel the longest distance of atmosphere to reach the observer. The light travelling from the sun loses blue light of short wavelength due to scattering, while the red light of long wavelength is scattered a little, so is not lost much. Thus blue light is almost absent in sunlight reaching the observer, while it is rich in red colour.

Question 9:
The sky at noon appears white. Give reason.

Solution 9:
At noon, the sun is above our head, so we get light rays directly from the sun without much scattering of any particular colour. Further, light has to travel less depth of atmosphere; hence the sky is seen white.

Question 10:
The clouds are seen white. Explain

Solution 10:
The clouds are nearer the earth surface and they contain dust particles and aggregates of water molecules of sizes bigger than the wavelength of visible light. Therefore, the dust particles and water molecules present in clouds scatter all colours of incident white light from sun to the same extent and hence when the scattered light reaches our eye, the clouds are seen white.

MULTIPLE CHOICE TYPE:

Question 1:
In white light of sun, maximum scattering by the air molecular present in the earth's atmosphere is for:
(a) red colour (b) yellow colour
(c) green colour (d) blue colour

Solution 1:
Blue colour
Hint: When light of certain frequency falls on that atom or molecule, this atom or molecule responds to the light, whenever the size of the atom or molecule comparable to the wavelength of light. The sizes of nitrogen and oxygen molecules in atmosphere are comparable to the wavelength of blue light. These molecules act as scattering centers for scattering of blue light. This is also the reason that we see the sky as blue.