CLASS 10TH WORKSHEET CHAPTER - SPECTRUM

Exercise 6(A) — Multiple Choice Type

Question 1

When a white light ray falls on a prism, the ray at its first surface suffers —

1. no refraction
2. only dispersion
3. only deviation
4. both deviation and dispersion

Answer

both deviation and dispersion

Reason — When a white light enters the first surface of a prism, light of different colours due to their different speeds in glass, gets **deviated** through different angles towards the base of the prism i.e., **dispersion** of white light into its constituent colours takes place at the first surface of prism. Hence, both deviation and dispersion takes place at the first surface.

Question 2

When a ray of white light falls on a prism, which of the following statements are correct ?

1. The dispersion of white light occurs at the first surface of the prism.
2. The deviation of light rays occurs at both the surfaces of the prism.
3. The prism does not produce colours, but it only splits the various colours present in the white light.
4. All of the above.

Answer

All of the above.

Reason —

- The dispersion of white light occurs at the first surface of the prism, where white light separates into its constituent colors due to differences in their refractive indices.
- The deviation of light rays occurs at both surfaces of the prism, where each color of light bends or deviates as it enters and exits the prism due to changes in refractive index.
- The prism does not produce colors but only splits the various colors present in white light.

Hence, all the statements are true.

Question 3

The correct arrangement of colours in an increasing order of their wavelengths is:

1. Violet < Green < Red
2. Red < Green < Violet
3. Green < Violet < Red
4. Green < Red < Violet

Answer

Violet < Green < Red

Reason — The above sequence represents the order of increasing wavelengths of light, with red having the longest wavelength, green in the middle, and violet having the shortest wavelength.

Question 4

Out of red, blue and violet, which colour has the greatest speed in vacuum?

1. red
2. blue
3. violet
4. all have the same speed

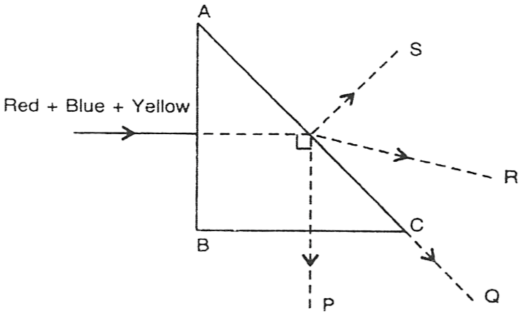
Answer

all have the same speed

Reason — All electromagnetic waves, including light, travel at the same speed in a vacuum, which is the speed of light denoted by 'c'. Therefore, regardless of their colour, red, blue, and violet light all travel at the same speed in vacuum.

Question 5

A beam consisting of red, blue and yellow colours is incident normally on the face AB of an isosceles right-angled prism ABC as shown in the figure given below. Critical angle of glass-air interface for yellow colour is 45°.



Out of the four emergent rays P, Q, R and S, which one is for the yellow colour:

1. P
2. Q
3. R
4. S

Answer

Q

Reason — As the critical angle for yellow colour is 45°, so it suffers refraction along the line AC of the prism.

Question 6

The frequency of violet light is 7.5 x 10^{14} Hz. Its wavelength in nm is:

1. 7500 nm
2. 4000 nm
3. 400 nm
4. 750 nm

Answer

400 nm

Reason — As we know,

Speed of light (c) = Frequency (f) x Wavelength (λ)

and

C = 3 x 10^8 m s^{-1}

Frequency range = 7.5 × 10^{14} Hz

Substituting the values in the formula,

$$3 \times 10^8 = 7.5 \times 10^{14} \times \lambda\lambda = \frac{3 \times 10^8}{7.5 \times 10^{14}} \Rightarrow \lambda = 0.4 \times 10^{-6}\text{m} \Rightarrow \lambda = 400 \times 10^{-9}\text{m}$$

Therefore,

λ = 400 nm

Question 7

The correct order of angle of deviation of indigo, green, yellow and red colours is :

1. $\delta_I > \delta_G > \delta_Y > \delta_R$
2. $\delta_G > \delta_I > \delta_Y > \delta_R$
3. $\delta_R > \delta_G > \delta_Y > \delta_I$
4. $\delta_R > \delta_Y > \delta_G > \delta_I$

Answer

$\delta_I > \delta_G > \delta_Y > \delta_R$

Reason — The order of deviation is: $\delta_I > \delta_G > \delta_Y > \delta_R$ as red light deviates the least and indigo the most. A

Question 8

Assertion (A): When a ray of light is refracted through a rectangular glass slab, there is no dispersion of light.
Reason (R): Dispersion of light is the phenomenon of splitting of white light into its constituent colours.

1. Both A and R are true and R is the correct explanation of A
2. Both A and R are true and R is not the correct explanation of A
3. assertion is false but reason is true
4. assertion is true but reason is false.

Answer
Both A and R are true and R is not the correct explanation of A.
Explanation
Assertion (A) is true. When a ray of light passes through a rectangular glass slab, there is no dispersion of light. After refraction at two parallel faces of a glass slab, the ray of light emerges in a direction parallel to the incident ray. As rays of all colours emerge in the same direction as incident ray, hence there is no dispersion, but only lateral displacement
Reason (R) is true. Dispersion of light is the phenomenon of splitting of white light into its constituent colors but this does not justify assertion.
Question 9
Assertion (A): A beam of white light gives a spectrum on passing through a hollow prism.
Reason (R): The speed of light outside the prism is same as the speed of light inside the prism.

1. Both A and R are true and R is the correct explanation of A
2. Both A and R are true and R is not the correct explanation of A
3. assertion is false but reason is true
4. assertion is true but reason is false.

Answer
assertion is false but reason is true
Explanation
Assertion (A) is false. A beam of white light does give a spectrum when passing through a prism, but it is not a "hollow" prism that causes this dispersion. A hollow prism contains air in it, so when a beam of white light is passed through it, it does not give a spectrum. Because light is passed to air through air, so no spectrum will be produced.
Reason (R) is true. The speed of light inside a medium, such as a glass prism, is generally slower than the speed of light in vacuum but here prism is hollow so refractive indices of air and hollow is are same . So the speed of light outside the prism is same as the speed of light inside the glass prism.
Exercise 6(A) — Very Short Questions
Question 1
How does the speed of light in glass change on increasing the wavelength of light?
Answer
On increasing the wavelength of light in glass, the **speed of light will also increase**.
For example — In visible light, the speed of **violet colour (wavelength λ = 4000 Å) is least and red colour (wavelength λ = 8000 Å) is most.**
Question 2
Which colour of white light travels (a) fastest (b) slowest, in glass?
Answer
(a) **Red colour of white light travels fastest** in glass as it has longest wavelength i.e., λ = 8000 Å.
(b) **Violet colour of white light travels slowest** in glass as it has shortest wavelength i.e., λ = 4000 Å.
Question 3
Name the subjective property of light related to its wavelength.
Answer
Colour of light is the subjective property of light related to its wavelength.
Different colours differ in their wavelength. In fact, wavelength is the characteristic of colour, irrespective of its origin i.e., **the light of the same colour, obtained from different sources will have same wavelength.**

Question 4
What is the range of wavelength of the spectrum of white light in —
(i) Å, and
(ii) nm?
Answer
(i) The range of wavelength in Å is **4000 Å to 8000 Å.**
(ii) The range of wavelength in nm is **400 nm to 800 nm.**
Question 5
Name four colours of the spectrum of white light which have wavelength longer than blue light.
Answer
The four colours of the spectrum of white light which have wavelength longer than blue light are **green, yellow, orange and red.**
Question 6
How will the dispersion of light through a prism change if the prism is made of diamond instead of glass ?
Answer
If the prism is made of diamond instead of glass, the dispersion of light will increase. This is because diamond has a much higher refractive index than glass. A higher refractive index causes light of different colours to bend more and spread out more, leading to greater separation of colours in the spectrum.
Exercise 6(A) — Short Questions
Question 1
Name three factors on which the deviation produced by a prism depends and state how does it depend on the factors stated by you.
Answer
The three factors on which the deviation produced by a prism depends are as follows —
1. **The angle of incidence (i)** — As the angle of incidence increases, the angle of deviation first decreases, reaches to a minimum value for a certain angle of incidence and then on further increasing the angle of incidence, the angle of deviation begins to increase.
2. **The angle of prism (A)** — Angle of deviation increases with increase in the angle of prism (A).
3. **Refractive index of the material of prism** — 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.
   For example — **A flint glass prism produces more deviation than a crown glass prism for same refracting angle since $\mu_{flint} > \mu_{crown}$**

Question 2
How does the deviation produced by a triangular prism depend on the colour (or wavelength) of light incident on it?
Answer
Speed of light in a transparent medium decreases with the decrease in wavelength of light. Therefore, the refractive index of glass (material of prism) increases with the decrease in wavelength of light.
Hence, the **deviation produced by a prism also increases with the decrease in the wavelength of light incident on it.**
For example — In visible light, **violet colour (wavelength λ = 4000 Å) is deviated the most and red colour (wavelength λ = 8000 Å) is deviated the least.**
Question 3
(a) Write the approximate wavelengths for (i) blue and (ii) red light.
(b) The wavelength of violet and red light are 4000 Å and 8000 Å respectively.
Which of the two has higher frequency?
Answer
(a) The approximate wavelengths for **blue light is 4800 Å** and **red light is 8000 Å.**
(b) The colour of **light with shortest wavelength has the highest frequency.**
When we compare the wavelength of **violet colours (4000 Å) and red (8000 Å),** we observe that the

wavelength of violet colour is shorter than that of red.
Hence, **Violet light of 4000 Å has higher frequency**.

Question 4

Write the seven prominent colours present in white light in the order of increasing wavelength.

Answer

The seven prominent colours present in white light in the order of increasing wavelength are as follows —

1. Violet
2. Indigo
3. Blue
4. Green
5. Yellow
6. Orange
7. Red

Question 5

Name the seven prominent colours of the white light spectrum in order of their increasing frequencies.

Answer

The seven prominent colours of the white light spectrum in order of their increasing frequencies are —

1. Red
2. Orange
3. Yellow
4. Green
5. Blue
6. Indigo
7. Violet

Question 6

The wavelengths for the light of red and blue colours are nearly 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 greater speed in glass?

Answer

(a) In vacuum, both have the same speed.
(b) As speed of light increases with increase in wavelength of light. When we observe the given values, we find that the wavelength of red colour (7.8×10^{-7} m) is more than that of blue colour (4.8×10^{-7} m). Hence, in glass, red light has greater speed.

Question 7

Define the term dispersion of light.

Answer

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

Question 8

What do you understand by the term spectrum?

Answer

On passing white light through a prism, the band of colours seen on a screen is called the spectrum.

Question 9

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

Answer

(a) The seven colours of the spectrum in order are **Violet, Indigo, Blue, Green, Yellow, Orange and Red.**
(b) No, all the seven colours have **different widths** in the spectrum.
(c) **Violet colour of the white light is deviated the most**, as it's wavelength is least i.e., 4000 Å and **Red colour of the white light is deviated the least**, as it's wavelength is the longest i.e., 8000 Å.

Question 10

How would the dispersion of light change if the prism is submerged in water instead of air? Will the spread of the constituent colours remain the same?

Answer

When a prism is submerged in water instead of air, the dispersion of light decreases. This is because dispersion depends on the difference in refractive index between the prism material and the surrounding medium.

In air, the difference is large, so light bends more at the surfaces of the prism, causing greater dispersion. In water, the difference is smaller, so light bends less as it enters and exits the prism. As a result, the spread of the constituent colours is reduced.

Exercise 6(A) — Long Questions

Question 1

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

Answer

The **cause of dispersion of white light is the change in speed of light with wavelength.**

When white light enters the first surface of a prism, light of different colours due to their different speeds in glass, gets **deviated** through different angles towards the base of the prism i.e., the **dispersion (or splitting) of white light into its constituent colours takes place at the first surface of prism.**

Violet colour is deviated the most and red colour the least.

Therefore, light of different colours present in white light follows different paths inside the glass prism and then strikes the second surface of prism

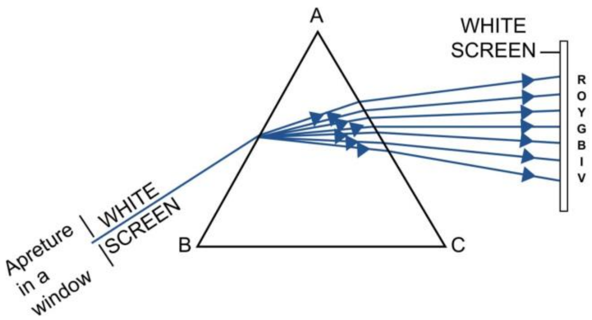
On the second surface of prism, only refraction takes place (from glass to air) and different colours are deviated through different angles i.e., **violet is deviated the most and red the least.** As a result colours get further separated on refraction at the second surface.

The light emerging out of prism, thus has different colours that spread out to form a spectrum on the screen.

Question 2

Explain briefly, with the help of a neat labelled diagram, how does white light gets dispersed by a prism. On which surface of the prism, there is both the dispersion and deviation of light, and on which surface of the prism, there is only the deviation of light?

Answer



When white light enters the first surface of a prism, light of different colours due to their different speeds in glass, gets deviated through different angles towards base of the prism i.e., the **dispersion of white light into its constituent colours takes place at the first surface of prism.**

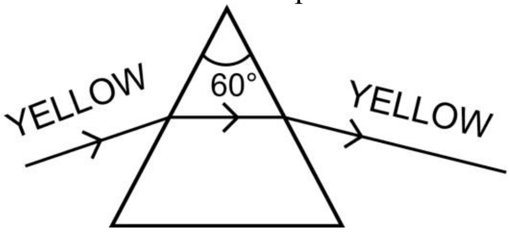
On the second surface of the prism, only refraction takes place and different colours are deviated through different angles i.e., violet colour is deviated the most and red colour the least. Hence, the **colours get further separated on refraction at the second surface.**

(i) On the first surface, there is both the dispersion and deviation of light.

(ii) On the second surface, there is only the deviation of light.

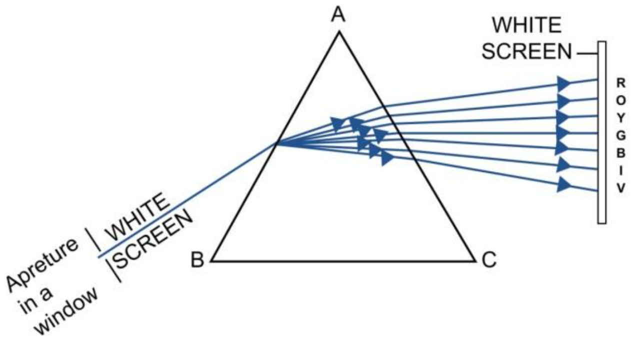
Question 3

The diagram shown below, shows the path taken by a narrow beam of yellow monochromatic light passing through an equiangular glass prism. If 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 the white light through the prism and label it to show the effect of the prism on the white light.



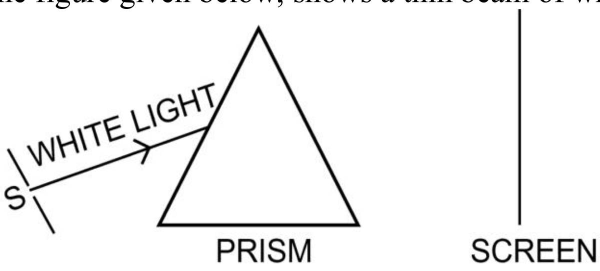
Answer

Below diagram shows the effect of the prism on the white light:



Question 4

The figure given below, shows a thin beam of white light from a source S striking on one face of a prism.



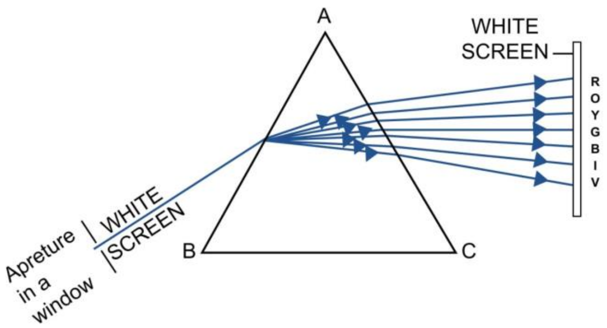
(a) Complete the diagram to show the effect of the prism on the beam and to show what is seen on the screen.

(b) If 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?

Answer

(a) Below diagram shows the effect of the prism on the beam and the spectrum seen on the screen:



A coloured patch like a rainbow is seen on the screen. This is called the **spectrum.**

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

(c) With the help of the above experiment we can say that the **prism does not produce colours, but it only splits** the various colours present in the light incident on it.

Question 5

(a) A beam of monochromatic 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 the same way as in part (a) above, what change do you expect in the emergent beam?

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

Answer

(a) When a beam of monochromatic light undergoes minimum deviation through an equiangular prism, then the beam passes **parallel to the base** of the prism.

(b) If white light is used instead of a monochromatic light, then the **white light splits into its constituent colours i.e., spectrum is formed.**

(c) With the help of the experiment given above, we conclude that the **white light is polychromatic in nature.**

Exercise 6(A) — Numericals

Question 1

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

Answer

As we know,

Speed of light (c) = Frequency (f) x Wavelength (λ)

Given,

λ = 550 nm

$= 550 \times 10^{-9}$ m

$= 0.55 \times 10^{-6}$ m

$C = 3 \times 10^8$ m s^{-1}

Substituting the values in the formula, we get,

$$3 \times 10^8 = f \times 0.55 \times 10^{-6} f = \frac{3 \times 10^8}{0.55 \times 10^{-6}} \Rightarrow f = 5.45 \times 10^{14} \text{Hz}$$

Hence, we get,

Frequency = 5.4×10^{14} Hz

Question 2

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

Answer

As we know,

Speed of light (c) = Frequency (f) x Wavelength (λ)

Given,

$C = 3 \times 10^8$ m s^{-1}

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

Let, $f_1 = 3.75 \times 10^{14}$ Hz

Substituting the values in the formula,

$$3 \times 10^8 = 3.75 \times 10^{14} \times \lambda\lambda = \frac{3 \times 10^8}{3.75 \times 10^{14}} \Rightarrow \lambda = 0.8 \times 10^{-6} \text{m} \Rightarrow \lambda = 8000 \times 10^{-10} \text{m}$$

As, 1 Å = 10^{-10} m

Therefore,

λ_1 = 8000 Å

Let, $f_2 = 7.5 \times 10^{14}$ Hz

Substituting the values in the formula,

$$3 \times 10^8 = 7.5 \times 10^{14} \times \lambda\lambda = \frac{3 \times 10^8}{7.5 \times 10^{14}} \Rightarrow \lambda = 0.4 \times 10^{-6} \text{m} \Rightarrow \lambda = 4000 \times 10^{-10} \text{m}$$

As, 1 Å = 10^{-10} m

Therefore,
λ_2 = 4000 Å
Therefore, the **wavelength range is 4000 Å to 8000 Å.**
Exercise 6(B) — Multiple Choice Type
Question 1
When an electromagnetic wave passes from one medium to the other, which property remains unchanged ?
1. speed
2. wavelength
3. direction of travel
4. frequency

Answer
frequency
Reason — When an electromagnetic wave passes from one medium to another, the frequency of the wave remains unchanged. This is a fundamental property of electromagnetic waves.
Question 2
Two waves A and B have wavelengths 0.01 Å and 9000 Å respectively. The waves A and B are:
1. Gamma wave and ultraviolet wave respectively.
2. Microwave and infrared wave respectively.
3. Radiowave and gamma wave respectively.
4. Gamma wave and infrared wave respectively.

Answer
Gamma wave and infrared wave respectively
Reason — Wave A with a very short wavelength is characteristic of gamma rays and wave B with a much longer wavelength falls into the infrared range.
Question 3
The correct arrangement of the following radiations in an increasing order of their wavelengths is :
X-rays, infrared rays, gamma rays, microwaves.
1. gamma rays, infrared rays, X-rays, microwaves
2. gamma rays, X-rays, microwaves, infrared rays
3. gamma rays, X-rays, infrared rays, microwaves
4. X-rays, gamma rays, infrared rays, microwaves

Answer
gamma rays, X-rays, infrared rays, microwaves
Reason — The arrangement of radiations in increasing order of their wavelengths is
- Gamma rays,
- X-rays,
- Ultraviolet,
- Visible light,
- Infrared rays,
- Microwaves and
- Radio waves.

Question 4
A radiation P is focused by a proper device on the bulb of a thermometer. Mercury in the thermometer shows a rapid increase. The radiation P is —
1. infrared radiation
2. visible light
3. ultraviolet radiation
4. X-rays

Answer
infrared radiation

Reason — Mercury in the thermometer shows a rapid increase due to the heating effect of the radiation. Hence, we can say that the radiation P is the infrared radiation.

Question 5

The most energetic electromagnetic radiations are —

1. microwaves
2. ultraviolet waves
3. X-rays
4. gamma rays

Answer

gamma rays

Reason — Gamma rays are the most energetic electromagnetic radiations of wavelength shorter than 0.01 nm and frequency above 10^{19} Hz.

Question 6

Column X shows the kinds of electromagnetic waves and column Y shows their applications.

Column X	Column Y
(A) Infrared rays	(i) in remote-controlled gadgets
(B) Radio waves	(ii) for transmission
(C) X-rays	(iii) for detection of bone fractures
(D) Ultraviolet rays	(iv) absorption by atmospheric ozone layer

Choose the correct pairing:

1. A - (i), B - (ii), C - (iii), D - (iv)
2. A - (iv), B - (iii), C - (ii), D - (i)
3. A - (i), B - (ii), C - (iv), D - (iii)
4. A - (iii), B - (ii), C - (i), D - (iv)

Answer

A - (i), B - (ii), C - (iii), D - (iv)

Reason — The correct pairing is :

Column X	Column Y
(A) Infrared rays	(i) in remote-controlled gadgets
(B) Radio waves	(ii) for transmission
(C) X-rays	(iii) for detection of bone fractures
(D) Ultraviolet rays	(iv) absorption by atmospheric ozone layer

Exercise 6(B) — Very Short Question

Question 1

(a) Arrange the following radiations in the order of their increasing wavelength:
X-rays, infrared rays, radio waves, gamma rays and micro waves.
(b) Name the radiation which is used for satellite communication?

Answer

(a) The radiations in the order of their increasing wavelength are follows —
gamma rays, x-rays, infrared rays, micro waves, radio waves.
(b) The radiation used for satellite communication is **micro waves.**

Question 2

A wave has a wavelength of 10^{-3} nm. (a) Name the wave. (b) State it's one property different from light.

Answer
(a) The wave which has a wavelength of 10^{-3} nm is **gamma rays.**
(b) The property of gamma rays different from light is that, it has **strong penetrating power.** Hence, gamma rays can pass through human body and can cause immense damage.
Question 3
(a) Name the high energetic invisible electromagnetic wave which helps in the study of the structure of crystals.
(b) State one more use of the wave named in part (a).
Answer
(a) **X-rays** are used in the study of atomic arrangement in crystals as well as in complex molecules.
(b) As X-rays can penetrate through human flesh, but they are stopped by bones. Hence, they are also used **to detect fracture in bones.**
Question 4
State the name and the range of wavelength of the invisible electromagnetic waves beyond the red end of visible spectrum.
Answer
The invisible electromagnetic waves beyond the red end of visible spectrum are called the **infrared (or heat) radiations.**
Range of wavelength of infrared radiations is **8000 Å to 10^7 Å.**
Question 5
Give the range of wavelength of the electromagnetic waves visible to us.
Answer
The range of wavelength of the electromagnetic waves visible to us is **4000 Å to 8000 Å.**
They are called the visible radiations (or visible light) because in the presence of these radiations, other objects are seen by us.
Question 6
Name the region just beyond (i) the red end and (ii) the violet end, of the spectrum.
Answer
(i) The region just beyond the red end of the spectrum is known as the **infrared.**
(ii) The region just beyond the violet end of the spectrum is known as the **ultraviolet.**
Question 7
Name the radiation which can be detected by (a) a thermopile (b) a solution of silver chloride.
Answer
(a) Infrared
(b) Ultraviolet
Question 8
Name the radiations of wavelength just (a) longer than 8×10^{-7} m, (b) shorter than 4×10^{-7} m
Answer
(i) The radiations of wavelength just longer than 8×10^{-7} m are **infrared** radiation.
(ii) The radiations of wavelength just shorter than 4×10^{-7} m are **Ultraviolet** radiations.
Question 9
Name the material of prism required for obtaining the spectrum of (a) ultraviolet light, (b) infrared radiations.
Answer
(a) Ultraviolet radiations are absorbed through glass, but can pass through quartz. Therefore, to obtain the ultraviolet spectrum from its source, a **quartz prism** is used.
Question 10
Name the radiations which are absorbed by the green house gases in the earth's atmosphere.
Answer
The green house gases such as carbon dioxide, present in the earth's atmosphere absorb the low energy **infrared radiations** and keep the earth's surface warm.

Exercise 6(B) — Short Question

Question 1

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

(b) Name the radiation mentioned by you in part (a) which has the highest penetrating power.

Answer

The list of radiations of electromagnetic spectrum in increasing order of their wavelength is as follows —

(i) Gamma rays

(ii) X – rays

(iii) Ultraviolet rays

(iv) Visible light

(v) Infrared radiations

(b) **Gamma rays** of the electromagnetic spectrum has the highest penetrating power.

Question 2

A wave has wavelength 50 Å. (a) Name the wave. (b) State it's speed in vacuum. (c) State it's one use.

Answer

(a) Wavelength of X-ray waves is in the range of 0.1 Å to 100 Å. Hence, the electromagnetic wave having wavelength 50 Å is **X-ray.**

(b) As all the waves move with the speed of 3×10^8 ms^{-1} in vacuum. Hence, the speed of x-ray in vacuum is also equal to **3×10^8 ms^{-1}.**

(c) X-ray waves are used for the **detection of fracture in bones**, teeth etc (i.e., radiography).

Question 3

Name three radiations and their wavelength range which are invisible and beyond the violet end of the visible spectrum.

Answer

The three radiations which are invisible and beyond the violet end of the visible spectrum, (in decreasing order of wavelength) are as follows —

Radiation	**Wavelength (nm)**
(i) Ultraviolet rays	10 – 400
(ii) X-rays	0.01 – 10
(iii) Gamma rays	below 0.01

Question 4

What do you understand by the invisible spectrum?

Answer

The part of spectrum **beyond the red extreme and the violet extreme** to which our eyes do not respond is called the invisible spectrum.

Question 5

State the approximate range of wavelength associated with (a) ultraviolet rays, (b) visible light, and (c) infrared rays.

Answer

(a) Ultraviolet rays — wavelength range 10 to 400 nm

(b) Visible light — wavelength range 400 to 800 nm

(c) Infrared radiations — wavelength range 800 to 10^6 nm.

Question 6

Name two electromagnetic waves of wavelength smaller than that of violet light. State one use of each.

Answer

Two electromagnetic waves of wavelength smaller than that of violet light ($\lambda = 400$ nm) are —

(a) **Ultraviolet radiations** (λ = 100 to 400 nm) and
(b) **X-rays** (λ = 0.01 to 10 nm)
Ultraviolet radiations are used for **sterilizing purposes.**
X-rays are used for **detection of fracture in bones, teeth, etc. (i.e., radiography) and for diagnostic purposes such as CAT scan in medical science.**

Question 7

Give one use each of (a) microwaves, (b) ultraviolet radiations, (c) infrared radiations, and (d) gamma rays.

Answer

(a) Microwaves are used for analysis of atomic and molecular structure.
(b) Ultraviolet radiations are used for sterilizing purposes.
(c) Infrared radiations are used for therapeutic purposes by doctors.
(d) Gamma rays are used in medical science to kill cancer cells (i.e., radio therapy).

Question 8

Name the waves (a) of lowest wavelength, (b) used for taking photographs in dark, (c) produced by the changes in the nucleus of an atom, (d) of wavelength nearly 0.1 nm

Answer

(a) The waves of lowest wavelength are **gamma rays** (λ = below 0.01 nm).
(b) The waves used for taking photographs in dark are **infrared rays.**
(c) The waves produced by the changes in the nucleus of an atom are **gamma rays.**
(d) The waves having wavelength nearly 0.1 nm are **X-rays.**

Question 9

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.

Answer

(a) Wave A is Gamma rays (as the wavelength range of gamma rays is shorter than 0.1 Å). Wave B is Infrared radiations (as the wavelength range of infrared radiations is 8000 Å to 10^7 Å).
(b) All electromagnetic waves travel with the speed of light (i.e., 3×10^8) in vacuum. Thus, ratio of speeds of these waves in vacuum is **1 : 1.**

Question 10

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

Answer

All **red hot bodies** such as a heated iron ball, flame, fire, etc. are the sources of infrared radiations.
The **Sun** is the natural source of infrared radiations.
The **electric arc and sparks** give ultraviolet radiations. A **mercury vapour** lamp emits radiations, a part of which has ultraviolet radiations along with the visible light.

Question 11

Name two properties of ultraviolet radiations which are similar to the visible light and two which differ from visible light.

Answer

Two properties of ultraviolet radiations which are similar to the visible light are as follows:

1. Ultraviolet radiations travel in a straight line like visible light, with a speed of 3×10^8 m s^{-1} in air or vacuum.
2. They obey the laws of reflection and refraction like visible light.

Two properties of ultraviolet radiations which differ from the visible light are as follows:

1. Ultraviolet radiations have wavelength in the range of 100 Å to 4000 Å whereas wavelength of visible light is the range of 4000 Å to 8000 Å.
2. Ultraviolet radiations cause fluorescence on striking a zinc-sulphide screen whereas visible light does not cause such fluorescence.

Question 12

Mention two properties of infrared radiations which are similar to the visible light and two which differ from visible light.

Answer

Two properties of infrared radiations which are similar to the visible light are as follows:

1. Infrared radiations travel in a straight line like visible light, with a speed of 3×10^8 m s^{-1} in air or vacuum.
2. They obey the laws of reflection and refraction like visible light.

Two properties of infrared radiations which differ from the visible light are as follows:

1. Infrared radiations have wavelength in the range of 8000 Å to 10^7 Å whereas wavelength of visible light is the range of 4000 Å to 8000 Å.
2. Infrared radiations do not affect ordinary photographic plate whereas visible light affects photographic plate.

Question 13

State one harmful effect each of the (a) ultraviolet and (b) infrared radiations.

Answer

Harmful effects of the given radiations are as follows —

(a) **Ultraviolet** radiations cause health hazards like **skin cancer if human body is exposed to them for a long period.**

(b) **Infrared** radiations causes **skin burns.**

Question 14

Give reason for the following:

(i) Infrared radiations are used for photography in fog.
(ii) Infrared radiations are used for signals during the 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 prism is required for obtaining the spectrum of the ultraviolet light.
(vi) Ultraviolet bulbs have a quartz envelope instead of glass.

Answer

(i) Infrared radiations are used for photography in fog because they are **not much scattered, and so they can penetrate appreciably through it.**

(ii) Infrared radiations are used for signals during the war because they are **not visible and they are not absorbed much in the medium.**

(iii) The photographic darkrooms are provided with infrared lamps because they **provide some visibility without affecting the photographic film.**

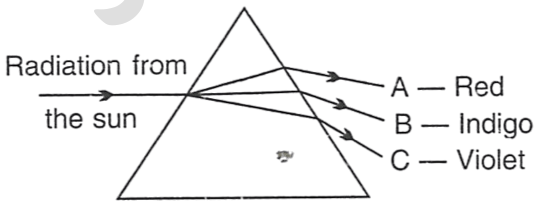
(iv) A rock salt prism is used instead of a glass prism to obtain the infrared spectrum because the **rock salt prism does not absorb the infrared radiations, whereas a glass prism absorbs them.**

(v) A quartz prism is required for obtaining the spectrum of the ultraviolet light because ultraviolet radiations can **pass through quartz whereas ordinary glass absorbs them.**

(vi) Ultraviolet bulbs have a quartz envelope instead of glass because ultraviolet radiations are **not absorbed by quartz whereas ordinary glass absorbs the ultraviolet light.**

Question 15

Radiations from the sun fall on a prism and suffer dispersion. Three thermometers are kept on which the radiations after dispersion are made to fall as shown in the figure given below. Which thermometer would show a higher reading? Give a reason for your answer.



Answer

Thermometer A (with red light) would show a higher reading.

Reason — Red light has the longest wavelength and the lowest frequency among the three. Hence, it carries more heat energy compared to violet or indigo light. As a result, it causes a greater rise in temperature, making thermometer A show a higher reading.

Exercise 6(B) — Long Question

Question 1

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

Answer

The electromagnetic waves of **wavelength λ = 8000 Å to 10^7 Å are called infrared radiations.**

For the detection of infrared radiations —

If a thermometer having it's bulb blackened is moved from the violet end towards the red end of the spectrum of visible light, it is observed that there is a very slow rise in temperature. But when this thermometer is moved beyond the red extreme, a rapid rise in temperature is noticed.

It means that the part of spectrum beyond the red extreme of the visible light has certain radiations which produce a strong heating effect, but they are not visible. **These radiations are called the infrared radiations.**

The infrared radiations are **used for therapeutic purposes by doctors.**

Question 2

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

Answer

The electromagnetic radiations of **wavelength λ = 100 Å to 4000 Å are called the ultraviolet radiations.**

For the detection of ultra violet radiations —

If silver chloride solution is exposed to the electromagnetic waves starting from the red to the violet end and then beyond it, it is observed that from the red end to the violet end, the solution remains almost unaffected. But just beyond the violet end, the solution first turns violet and then finally it becomes dark brown (or black).

It shows that there exists certain radiations beyond the violet extreme of the visible part, which are chemically more active than the visible light. These radiations are called the ultra violet radiations (or actinic rays).

Ultraviolet radiations are **used for sterilizing purposes.** Type

Exercise 6(B) — Numericals

Question 1

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

(a) Calculate the speed of the wave.

(b) Name the medium through which it is travelling.

Answer

(a) As we know,

Velocity of wave (c) = frequency (f) x wavelength (λ)

Given,

f = 500 MHz

Hence, f = 500 x 10^6 Hz or

f = 5 x 10^8 Hz

λ = 60 cm

As 100 cm = 1m

Therefore,

60 cm = $\frac{60}{100}$ m

Hence, **λ = 0.6 m**

Substituting the values in the formula above we get,

$$c = (5 \times 10^8) \times 0.6 \Rightarrow c = 3 \times 10^8$$

Hence,

Speed of the electromagnetic wave = 3 x 10^8 ms^{-1}

(b) The electromagnetic wave is travelling through **air.**

Question 2

The wavelength of X-rays is 0.01 Å . Calculate it's frequency. State the assumption made, if any.

Answer

Assumption — Speed of X-rays = 3×10^8 ms^{-1}

As we know,

Speed of wave (c) = frequency (f) x wavelength (λ)

Given,

c = 3×10^8 ms^{-1}

λ = 0.01 Å

As 1 Å = 10^{-10} m

Hence,

λ = 0.01 Å = 0.01×10^{-10} m

Substituting the values in the formula above we get,

$$3 \times 10^8 = f \times (0.01 \times 10^{-10}) \Rightarrow f = \frac{3 \times 10^8}{0.01 \times 10^{-10}} \Rightarrow f = \frac{3 \times 10^8}{1 \times 10^{-12}} \Rightarrow f = 3 \times 10^{20} Hz$$

Hence,

Frequency of x - rays = 3×10^{20} Hz

Exercise 6(C) — Multiple Choice Type

Question 1

For scattering of light, the necessary condition is that the size of air molecules should be .... the wavelength of incident light.

1. smaller than
2. greater than
3. equal to
4. both (b) and (c)

Answer

smaller than

Reason — Scattering of light occurs when the size of the particles or molecules in the medium through which light travels is smaller than the wavelength of the light. This condition allows the incident light to interact with the particles, causing it to scatter in various directions.

Question 2

The intensity of scattered light is related to its wavelength as:

1. $I \propto \lambda^4$
2. $I \propto \lambda^2$
3. $I \propto \frac{1}{\lambda^4}$
4. $I \propto \frac{1}{\lambda^2}$

Answer

$I \propto \frac{1}{\lambda^4}$

Reason — Intensity of scattered light is found to be inversely proportional to the fourth power of the wavelength of light.

(i.e., $I \propto \frac{1}{\lambda^4}$).

Question 3

In the white light of Sun, maximum scattering by the air molecules present in the earth's atmosphere is for —

1. red colour
2. yellow colour
3. green colour
4. blue colour

Answer
blue colour
Reason — Intensity of scattered light is found to be inversely proportional to the fourth power of the wavelength of light.
(i.e., I ∝ $\frac{1}{\lambda^4}$).
As blue light has lowest wavelength, hence, the **blue** light is scattered the most.
Question 4
Violet light is scattered nearly .... times more than the red light.

1. 4
2. 8
3. 16
4. 9

Answer
16
Reason — According to Rayleigh scattering, the amount of scattering is inversely proportional to the fourth power of the wavelength of the light.
We know,
λ_{violet} = 4000 Å and
λ_{red} = 8000 Å.
According to Rayleigh scattering,
$\frac{\text{Intensity of scattering of violet}}{\text{Intensity of scattering of red}} = (\frac{\lambda_{red}}{\lambda_{violet}})^4$
So,
$\frac{\text{Intensity of scattering of violet}}{\text{Intensity of scattering of red}} = (\frac{8000}{4000})^4 = 2^4$
= 16
Hence, Intensity of scattering of violet = 16 time Intensity of scattering of red.
Question 5
To an astronaut in a space-ship, the earth appears —

1. white
2. red
3. blue
4. black

Answer
blue
Reason — When an astronaut goes above the atmosphere of the earth in a rocket, he sees the sky black, but to him the earth appears blue due to the blue colour of sunlight scattered by the earth's atmosphere reaching him.
Question 6
The red colour of the sun at sunrise and sunset is due to which of the following phenomenon?

1. deviation
2. dispersion
3. both deviation and dispersion
4. scattering

Answer
scattering
Reason — During sunrise and sunset, the sun is positioned at a lower angle in the sky. This causes sunlight to travel through a thicker layer of Earth's atmosphere, which scatters shorter wavelengths of light (such as blue and green) more strongly than longer wavelengths (such as red and orange). As a result, the shorter wavelengths are scattered out of the line of sight, leaving predominantly red and orange hues to be observed.
Question 7

The sky in a direction other than that of the sun appears .... to an observer on the moon.

1. red
2. blue
3. orange
4. black

Answer

black

Reason — Unlike earth, which has an atmosphere that scatters sunlight in various directions, the moon lacks an atmosphere. As a result, there is no scattering of sunlight to create the blue sky that we see on earth. Hence, the sky in a direction other than that of the sun appears black to an observer on the moon.

Question 8

The danger signal is red because its wavelength is the .... and therefore it gets .... the least.

1. least, deviated
2. longest, scattered
3. longest, dispersed
4. least, scattered

Answer

longest, scattered

Reason — When light passes through a medium, shorter wavelengths (such as blue and violet) are scattered more strongly than longer wavelengths (such as red and orange). Hence, red light is often used for danger signals to ensure visibility over longer distances.

Exercise 6(C) — Very Short Questions

Question 1

When sunlight enters the earth's atmosphere, state which colour of light is scattered (i) the most, and (ii) the least.

Answer

(i) Violet is scattered the most.

(ii) Red is scattered the least.

Question 2

A beam of blue, green and yellow light passes through the the earth's atmosphere. Name the colour which is scattered (a) the least, (b) the most.

Answer

(a) **Yellow** light is scattered the least as it has the highest wavelength.

(b) **Blue** light is scattered the most as it has the lowest wavelength.

Exercise 6(C) — Short Questions

Question 1

What is meant by scattering of light?

Answer

Scattering is the process of absorption and then re-emission of light energy by the dust particles and air molecules present in the atmosphere.

Question 2

How does the intensity of scattered light depend on the wavelength of incident light? State the condition when this dependence hold.

Answer

The scattering of light is not same for all wavelengths of incident light.

The intensity of scattered light is found to be **inversely proportional to the fourth power of the wavelength of light**

(i.e., $I \propto \frac{1}{\lambda^4}$).

The **above relation holds true, when the air molecules are smaller in size than the wavelength of incident light.**

The air molecules of size bigger than the wavelength of incident light, scatter the light of all wavelengths of white light to the same extent.

For example — The wavelength of violet is least (λ = 4000 Å) and that of red light is most (λ = 8000 Å), therefore, from the incident white light, **violet light is scattered most and the red light is scattered the least.** (violet light is scattered nearly 16 times more than the red light).

Question 3

Which colour of white light is scattered the least? Give reason.

Answer

Red colour of white light is scattered the least because wavelength of red light (λ = 8000 Å) is longest and intensity of scattered light (I) $\propto \frac{1}{\lambda^4}$.

Question 4

The danger signal is red. Why?

Answer

In the visible light, the wavelength of red light is longest, therefore the light of red colour is scattered least by the air molecules of the atmosphere.

Hence, the light of red colour as compared to the light of other colours can penetrate to a longer distance without becoming weak.

Thus, red light can be seen from the farthest distance in comparison to the light of other colours having the same intensity.

Hence red light is used for danger signal, so that the signal may be visible from the far distance even in fog, etc.

Question 5

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

Answer

When seen from the space (or moon), the sky would appear black in colour.

As there is no atmosphere on moon, therefore, no scattered Sun light reaches the moon's surface. Hence, to an observer on the surface of moon, no light reaches his eyes, except the light reaching directly from the Sun.

Thus, the sky in direction other than the that of the Sun will appear black.

Similarly, when an astronaut goes above the atmosphere of the earth in a rocket, he sees the earth black.

Question 6

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

Answer

The characteristic property of light responsible for the blue colour of sky is **scattering**.

Question 7

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

Answer

The light from the Sun has to travel a long distance of the earth's atmosphere before reaching us. As light travels through the atmosphere, it gets scattered in different directions by the air molecules present in it's path.

The **blue (or violet) light due to its short wavelength is scattered more as compared to the red light of longer wavelength.**

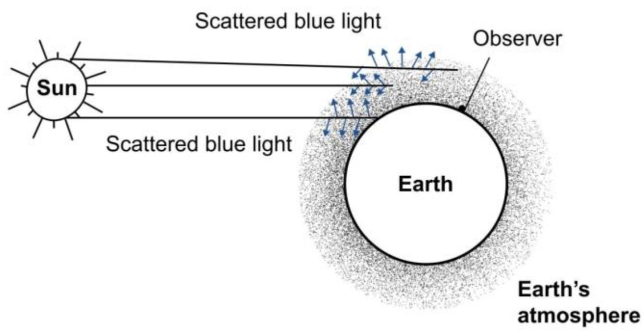
Thus, the light reaching our eye directly from Sun is rich in red colour, while the light reaching our eye from all other directions is the scattered blue light.

Therefore, the **sky in the direction, other than the direction of Sun, is seen blue.**

Question 8

Why does the Sun appear red at sunrise and sunset?

Answer



At the time of sunrise and sunset, the light from Sun has to travel the longest distance of atmosphere to reach the observer.

Since, the blue light of short wavelength is scattered more, much of it is lost, while the red light of long wavelength is scattered a little, so it is not much lost.

Thus, blue light is almost absent in sunlight reaching the observer and only the red (white - blue = red) light reaches us.

As a result, the Sun and the region near by it, is seen red.

Question 9

The sky at noon appears white. Give reason.

Answer

At noon, the Sun is directly above our head, so we get the **light rays directly from the Sun after travelling the shortest distance, without much scattering of any particular colour. Hence, the sky is seen white.**

Question 10

The clouds are seen white. Explain.

Answer

The clouds are nearer the earth surface and they contain dust particles and aggregates of water molecules of size bigger than the wavelength of visible light.

Therefore, the dust particles and tiny ice particles present in clouds scatter all colours of incident white light from Sun to the same extent and hence when the scattered light reaches our eyes, the clouds are seen white.

Question 11

Give reason why the smoke from a fire looks white.

Answer

The smoke from a fire looks white because the molecules of smoke are bigger than the wavelength of light, so they scatter lights of all colours equally and the scattered light appears white.