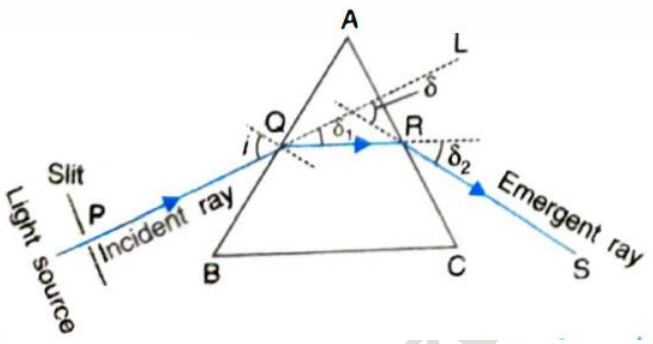
Spectrum

1. **What happen when a white light is passing through a Prism?**
Ans. When a light ray PQ of a single colour enters a triangular prism ABC it gets deviated, say, by an angle δ_1 towards the base BC at the first surface AB of the prism and travels straight as QR inside the prism. The angle of deviation δ_1 depends on the angle of incidence and the refractive index of glass with respect to air. On striking the second surface AC, the ray QR gets further deviated, say, by an angle δ_2 towards the base BC and travels straight as RS outside the prism. The angle of deviation δ_2 depends on the angle of incidence at the second surface (which depends on the angle of the prism A) and the refractive index of air with respect to glass. For the emergent ray RS, the total deviation δ with respect to the incident ray PQ (i.e., the angle between the emergent ray RS and the direction PL of the incident ray PQ) is given as



$$\delta = \delta_1 + \delta_2$$

2. **Name three factors on which the deviation produced by a prism depends?**
Ans. The total angle of deviation δ depend upon the following three factors
   a. the angle of incidence at the first surface.
   b. the angle of the prism. and
   c. the refractive index of the material of the prism (μ). Since the refractive index depend on the colour (or wavelength A) of the light used, so the angle of deviation depend al o on the colour (or wavelength A) of the incident light.

3. **How does the deviation produced by a triangular prism depend on the colour (or wavelength) of light incident on it?**
Ans. The deviation caused by a prism increases with the decrease in the wavelength of light incident on it.
Light of different colours have the same speed in air but different speeds in a medium other than air. If a mixed colour light enters in a prism, then the emergent beam too has different colours arranged in a definite order. It is because the speed of the light in a transparent medium decrease with the decrease in the wavelength of light. Since the refractive index of glass increases with the decrease in the wave length of light, therefore the deviation caused by the prism also increase with the decrease in the wavelength of light.

4. **Name the seven prominent colours present in white light spectrum in order of their increasing wavelength.**
Ans. Seven prominent colours of the white light spectrum in order of their increasing frequencies: Red, Orange, Yellow, Green, Blue, Indigo, Violet

5. **What is Dispersion?**
Ans. The phenomenon due to which a polychromatic light (white light) splits into component of colours, when it passed through a prism is called Dispersion.

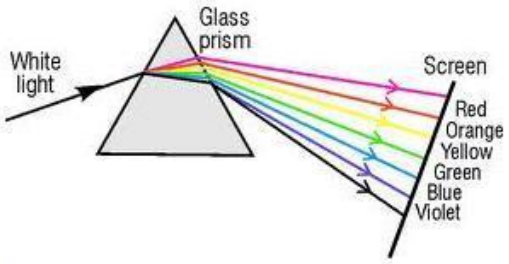
6. **What are the causes of Dispersion?**
   Ans. When white light is incident on the first surface of a prism and enters in glass, light of different colours due to different speeds in glass, is refracted or deviated through different angles. Thus, the dispersion of white light into its constituent 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.

7. **What is Spectrum?**
   Ans. The band of colour obtained on the screen when a polychromatic light splits into component colours is called Spectrum.

8. **What is Impure Spectrum?**
   Ans. A spectrum in which various band of colours have no sharp well-defined boundaries, but merge in each other is called Impure Spectrum.

9. **What is Pure Spectrum?**
   Ans. A spectrum in which various band of colours have sharp well-defined boundaries and do not merge in each other is called Pure Spectrum.

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



11. **What is Invisible Spectrum?**
    Ans. The region of the spectrum which do not excite the retina, and hence are not visible are collectively called Invisible Spectrum.

12. **What is Infrared Spectrum?**
    Ans. The electromagnetic radiations beyond red light of the visible spectrum are called Infrared radiation and the spectrum is called Infrared Spectrum.

13. **Write the names of waves of wavelength longer than the red part of the Visible Spectrum?**
    Ans. The names of waves of wavelength longer than the red part of the Visible Spectrum in increasing order of wavelength are
    a. Infrared Radiations
    b. Microwave
    c. Radio Wave

14. Write the names of waves of wavelength shorter than the violet part of the Visible Spectrum?

Ans. The names of waves of wavelength longer than the red part of the Visible Spectrum in increasing order of wavelength are

a. Ultraviolet Rays
b. X Rays
c. Gamma Rays.

15. What are the sources of Different Electromagnetic Spectrum?

Ans.

Rays	Sources
Infrared Radiations	Excitation of outer electronic shell to a very order.
Microwave	Electronic devices such as crystal oscillators
Radio Wave	TV and radio transmitters
Ultraviolet Rays	Sunlight, arc-lamp. spark
X Rays	From a heavy metal target of high melting point when highly energetic electrons are stopped by it.
Gamma Rays	in cosmic rays. from radioactive substances.

Approximate Ranges of Wavelength and Frequency

Rays	Wave length (Å)	Frequency (Hz)
Gamma	0.1	10^{19}
X Rays	0.1 to 100	3×10^{19} to 3×10^{16}
Ultraviolet	100 to 4000	3×10^{16} to 7.5×10^{14}
Visible Light	4000 to 8000	7.5×10^{14} to 3.75×10^{14}
Infrared Light	8000 to 10^{7}	3.75×10^{14} to 3×10^{11}

16. What are the properties of Infrared Spectrum?

Ans. The properties of Infrared Spectrum are

a. Electromagnetic waves do not require any material medium for their propagation.
b. They all travel with the same speed vacuum and air (the Speed is 3×10^{8}m/s) and with different speeds in different medium.
c. They exhibit the properties of reflection and refraction. In refraction, when an electromagnetic wave passes from one medium to the other, there is change in its direction of travel, speed and wavelength, but its frequency remains unchanged.
d. These waves are not deflected by electric and magnetic fields.
e. These waves are transverse in nature.

17. What are the sources of Gamma Rays?

Ans. The sources of Gamma Rays are Radioactive emotions, when the nucleus of radioactive atoms pass from the excited state to the ground state.

18. What are the properties of Gamma Rays?

Ans. They cause fluorescence when they strike the fluorescent materials like Zinc Sulphide. They can easily penetrate through thick metallic sheets. Gamma Radiations easily pass-through human body and cause immediate biological damage.

19. **What are the uses of Gamma Rays?**
Ans. They are used in medical science to kill cancer cells (i.e., radio therapy) and in industry to check welding.

20. **What are the properties of X-Ray?**
Ans. X-rays are chemically more active than ultraviolet radiations. They strongly affect a photographic plate. Like gamma rays, they cause fluorescence in certain materials such as zinc sulphide, etc. They can penetrate through human flesh, but are stopped by the bones.

21. **What are uses of X-Rays?**
Ans. They are used for the detection of fracture in bones, teeth, etc. (i.e., radiography), and for diagnostic purposes such as CAT scan in -medical science. X-rays are also used for studying atomic arrangement in crystals as well as in complex molecules. X-rays are used by detective agencies to detect concealed precious metals.

22. **What are the sources of Ultraviolet Radiations?**
Ans. The electric arc and sparks give ultraviolet radiations. A mercury vapour lamp emits radiation, a part of which has ultraviolet radiations along with the visible light. Sun is also a source of ultraviolet radiations, but a large fraction of it is ab orbed by the ozone layer present in the earth' upper atmosphere which protects us from its harmful effects.

23. **What are the properties of Ultraviolet Rays?**
Ans. The properties of Ultraviolet Rays are:
    a. Ultraviolet radiations can pass through quartz, but they are absorbed by glass Therefore, to obtain the ultra violet spectrum from its source, a quartz prism is used instead of a glass prism. For the same reason ultraviolet bulb have an envelope made of quartz instead of glass.
    b. These radiations travel in a straight line with a speed of 3×10^8 m s^{-1} in air (or vacuum).
    c. They are usually scattered by du t particles present in the earth's atmosphere.
    d. They obey the law of reflection and refraction.
    e. They strongly affect a photographic plate as they are chemically more active than visible light.
    f. They produce fluorescence on striking a zinc-sulphide screen.

24. **What are the harmful effects of Ultraviolet Rays?**
Ans. Ultraviolet radiation, cause health hazards like skin an r if human body is exposed to them for a long period.

25. **What are the uses of Ultraviolet Rays?**
Ans. Uses of Ultraviolet Rays are:
    a. For sterilising air, surgical equipment, etc.
    b. For detecting the purity of gems, eggs, ghee, etc.
    c. In producing vitamin D in food of plants and animals.

26. **What are the sources of Visible Light?**
Ans. The sources are Sun, electric bulb, flame and white bot bodies are the main sources of visible light.

27. What are the uses of Visible Light?

Ans. The visible light is used in photography, in photosynthesis and to see the objects around us.

28. What are the sources of Infrared Radiations?

Ans. All red-hot bodies such as a heated iron ball, flame, fire etc. are sources of infrared radiations. The Sun is the natural source if Infrared radiations.

29. What are the properties of Infrared Radiations?

Ans. The properties are

a. They travel in straight lines like light, With a speed equal to 3×10^8 m s^{-1}vacumm.
b. They obey the laws of reflection and refraction.
c. They do not affect the ordinary photographic film. However, the a specially treat ed photographic film is affected by them.
d. They are absorbed by glass, but they pass through rock-salt.
e. They are detected by their heating property using a blackened bulb thermometer or a thermopile.
f. They are scattered less by the earth's atmosphere because of their long wavelength. Hence, they can penetrate deep inside the atmosphere even in fog.
g. The greenhouse gases such as carbon di oxide, present in the earth's atmosphere absorb the low energy infected radiations and keep the earth's surface worm.

30. What are the uses of Infrared Radiation?

Ans. The uses of Infrared Radiations are:

a. Infrared radiation is used for therapeutic purposes by doctor.
b. They are used in photography at night and also in mist and fog because they are not much scattered so they can penetrate appreciably through it
c. Infrared lamps are used in dark rooms for developing photographs as they provide some visibility without affecting the photographic film.
d. They are used as signals during war as they are not visible and they are not absorbed much in the medium.
e. They are used in remote control of television and other gadgets.

31. What are the sources of Micro wave?

Ans. These waves are produced by electronic devices such as Chrystal oscillation.

32. What are the uses of Microwaves?

Ans. They are used for satellite communication, for analysis of atomic and molecular structure, for cooking in microwave oven and in radar communication.

33. What are the uses of Radio Waves?

Ans. These waves are used mainly in radar communication and also in radio and television transmission.

34. Distinction between ultraviolet, visible and infrared radiations

Ans.

Issue	IR	VL	UV
Wavelength	760 nm-1mm	360-760 nm	10-400 nm
Communication distance	• Short and medium ranges in LiFi and OCC • Ultra-short, short, medium, long, and ultra-long ranges in FSOC • Short, medium, long, and ultra-long ranges in LiDAR	• Short and medium ranges in VLC, LiFi, and OCC • Ultra-short, short, medium, long, and ultra-long ranges in FSOC • Short , medium, long, and ultra-long ranges in LiDAR	• Short and medium ranges in LiFi • Ultra-short, short, medium, long, and ultra-long ranges in FSOC
Advantage	Not visible for human eye considering the cases where illumination is not important	• Safe for human • It can be used for illumination and communication purposes simultaneously	• Not visible for human eye considering the cases where illumination is not important • High data rate NLOS communication is possible
Limitation	• Not always safe for human • LOS communication and very limited low data rate NLOS communication using reflection of IR	• LOS communication and very limited low data rate NLOS communication using reflection of light • Visibility of light when illumination is not required	Not safe for human
Communication Technologies	LiFi, OCC, FSO, and LiDAR	VLC, LiFi, OCC, FSO, and LiDAR	LiFi and FSO
Illumination	No	Communication with and without illumination	No

35. What is Scattering of Light?

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

36. What are the applications of Scattering?

Ans. Some effect of scattering of sunlight by the earth's atmosphere are:

a. Red Colour of sun at Sunrise and Sunset
b. White colour of sky at noon
c. Blue colour of sky
d. Black colour of sky in the absence of atmosphere
e. White colour of cloud
f. Use of Red Light for the Danger Signal

37. Why red coloured Sun is seen at the time of Sunrise and Sunset?

Ans. At the time of sunrise and sunset. light from the 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 red light reaches us. As a result, the Sun and the region nearby it, is seen red.

38. **The danger signal is red. Why?**

Ans. The wavelength of red light is longest in the visible light. So, the light of red colour is scattered least by the air molecules of the atmosphere. Hence when compared to other colours the light of red colour can penetrate to a longer distance. 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.

39. Why sky is seen white at noon?

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

40. Why the colour of sky is Blue?

Ans. 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 its path. The blue (or violet) light due to its short wave length is scattered more as compared to the red light of long wavelength. Thus, the light reaching our eye directly from the sun is rich in 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 the direction of the sun, is seen blue. Further for some time after sunset and before sunrise there is no sunlight reaching directly to us. Thus, at these hours the blue scattered light makes the entire sky to appear blue.

41. Why the clouds are seen white?

Ans. The clouds are nearer the earth surface and contain dust particles. The water droplets present in clouds are bigger than the wavelength of all seven colours of light. Hence the water droplets scatter the entire spectrum. Therefore, the clouds appear white.

42. **Give reason why the smoke from a fire looks white.**

Ans. Smoke appears white in colour because the size of the smoke particles are bigger than the wavelength of the light. White light is a mixture of a large number of wavelength but they scatter at the same extent since the condition of scattering is that size of particles should be smaller than the wavelength of light. Hence the scattered light appears white.

43. Why the sky looks black colour in absence of atmosphere?

Ans. The particles in the atmosphere are responsible for the scattering of light. Since blue has the least wavelength, it is scattered the most and the sky appears blue.
In the absence of atmosphere, no scattering will occur and the sky will appear black.
Therefore, both assertion and reason are correct, and the reason is the correct explanation of assertion.

Numerical

1. **Calculate the frequency of yellow light of wavelength 550 nm. The speed of light is $3x10^8$ ms^{-1}.**

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

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

We know that,

$$\text{Frequency} = \frac{\text{Speed of light}}{\text{Wavelength}}$$

$$or,\ \text{Frequency} = \frac{3 \times 10^8}{550 \times 10^{-9}} = 5.4 \times 10^{14}\ Hz$$

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 the speed of light =3×10^8m/s.**

Ans. Speed of light, c= $3x10^8$m/s

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

Speed of light = frequency x wavelength

For frequency=3.75×10^{14}Hz

$$\lambda = \frac{c}{\nu} = \frac{3x10^8 m/s}{3.75x10^{14} Hz} = 8x10^{-7} m = 8000 \text{Å}$$

For frequency =7.5×10^{14}Hz

$$\lambda = \frac{c}{\nu} = \frac{3x10^8 m/s}{7.5x10^{14} Hz} = 4x10^{-7} m = 4000 \text{Å}$$

$$\text{Wavelength range} = 4000 \text{Å}\ \text{ to } 8000 \text{Å}$$

3. **An electromagnetic wave has a frequency of 500MHz and a wavelength of 60cm.**
(a) Calculate the velocity of the wave.
(b) Name the medium through which it is travelling.
Ans. (a) Frequency = 500 MHz
$= 500 \times 10^6$ Hz
Wavelength = 60 cm = 0.6 m
Velocity of wave = frequency × wavelength
$= 500 \times 10^6 \times 0.6 = 3 \times 10^8$ m / s
(b) Electromagnetic wave is travelling through air.

4. **The wavelength of X-rays is 0.01 Å. Calculate its frequency.**
Ans. Wavelength = 0.01Å = 0.01×10^{-10} m
Speed of X-rays = 3×10^8 m / s
Speed of light = frequency × wavelength
$c = v / \lambda$
$v = c\lambda$
$v = (3 \times 10^8\ m / s) / (0.01 \times 10^{-10}\ m)$
$v = 3 \times 10^{20}$ Hz