6	Spectrum	Book: Selina

Exercise A

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.**

   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 μflint > μcrown

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

   If the light entering the prism is not of single colour, i.e., it is a mixture of seven colours, then the emergent beam also has different colours arranged in a definite order. It is because the light of different colours have different speed in a medium. The speed of light in a transport medium decreases with the decrease in the wavelength of light. Therefore, the refractive index of glass (the material of prism) increases with the decrease in the wavelength of light and so the deviation caused by a prism also increases with the decrease in the wavelength of light. In visible light, violet (wavelength λ 4000 A°) is deviated^ the most and red (wavelength λ = 8000 A°) is deviated the least because in glass, the speed of violet light is the least and that of the red light is the most.

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

   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.

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

   Most – violet and least – Red

5. **Name the subjective property of light related to its wavelength.**

   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.

6. **What is the range of wavelength of the spectrum of white light in — (i) Å, and (ii) nm?**

   (i) The range of wavelength in Å is 4000 Å to 8000 Å.

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(ii) The range of wavelength in nm is 400 nm to 800 nm.

7. (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?

(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.

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

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

Violet, Indigo, Blue, Green, Yellow, Orange, Red

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

Red, orange, yellow, green, blue, indigo, violet

10. Name four colours of the spectrum of white light which have wavelength longer than blue light.

Green, yellow, orange and red

11. Which colour of the white light is deviated by a glass prism (i) the most and, (ii) the least?

(i) Violet colour (wavelength = 4000 Å) is deviated the most.

(ii) Red colour (wavelength = 8000 Å) is deviated the least.

12. The wavelengths for 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?

In vacuum, both have the same speed.

(b) Which colour has greater speed in glass?

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 x 10-7 m) is more than that of blue colour (4.8 x 10-7 m). Hence, in glass, red light has greater speed.

13. Define the term dispersion of light.

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

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

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, gets 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 of colours in speed of light with wavelength (or frequency).

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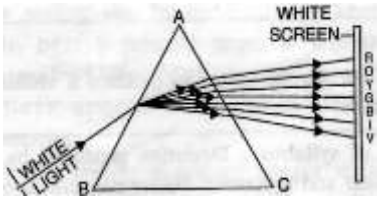
15. Explain briefly, with the help of a neat labeled diagram, how white light gets dispersed by a prism?



The refractive index of glass is different for different colours of light. When white light is incident on the surface of a prism, different colours are deviated by different amounts as the deviation depends upon refractive index which is different for different colours. Of these, violet is deviated the most and red is deviated the least. Thus, all the colours come out of the prism from different points

16. What do you understand by the term spectrum?

The band of colours obtained on a screen on passing white light through a prism, is called the j spectrum.

17. 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.

Violet, Indigo, Blue, Green, Yellow, Orange, Red

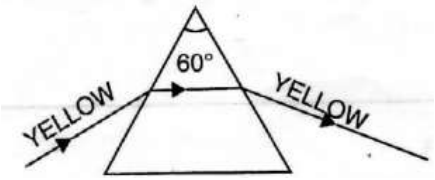
(b) Do the colours have the same width in the spectrum?

No, different colours have different width.

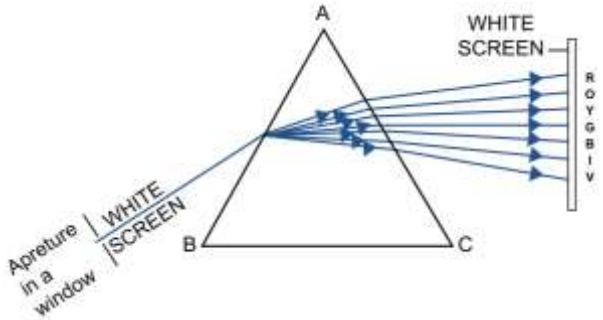
(c) Which of the colour of the spectrum of white light deviates (i) the most, (ii) the least?

Violet deviates most and Red deviates least

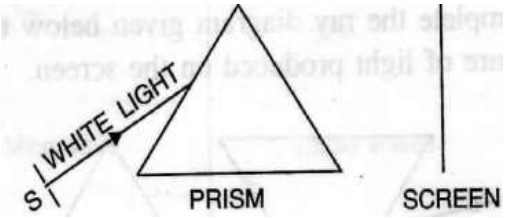
18. The diagram shown below in Fig. shows the path taken by a narrow beam of yellow monochromatic light passing through an equiangular glass prism. Now the yellow light is replaced by a narrow beam of white light incident at the same angle. Draw another diagram to show the passage of the beam through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



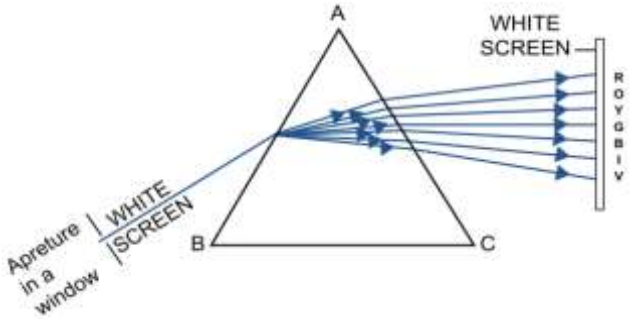
Ans. Below diagram shows the effect of the prism on the white light:



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



(a) Complete diagram to show the 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?

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

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.

20. Answer the following

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

parallel to the base,

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

white light splits into its constituent colours i.e., spectrum is formed

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

white light is polychromatic

21. MULTIPLE CHOICE TYPE

(1) When a white light ray falls on a prism, the ray at its first surface suffers <u>both deviation and dispersion</u>.

(2) In spectrum of white light by a prism, the colour at the extreme end opposite to the base of prism is <u>red</u>.

(3) The wavelength range of white light is — <u>400 nm to 800 nm</u>

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Exercise B

1. **Answer the following**

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

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

   Gamma rays of the electromagnetic spectrum has the highest penetrating power.

2. **(a) Arrange the following in the order of their increasing wavelength**

   X rays, infrared rays, radio waves, gamma rays and micro waves.

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

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

   (b) The radiation used for satellite communication is micro waves.

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

   (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.

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

   (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 x 108 ms^{-1} in vacuum. Hence, the speed of x-ray in vacuum is also equal to 3 x 108 ms-1.

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

5. **(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).**

   (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.

6. **State the name and the range of wavelength of the invisible electromagnetic waves beyond the red end of visible spectrum.**

   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.

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

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

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

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.

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

(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.

10. What do you understand by the invisible spectrum?

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

11. Name the radiation which can be detected by (a) a thermopile (b) a solution of silver chloride.

(a) Infrared (b) Ultraviolet

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

(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 106 nm.

13. Name the radiations of wavelength just (a) longer than 8×10^{-7} m, (b) shorter than 4×10^{-7} m

(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.

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

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

(a) Ultraviolet radiations ($\lambda = 100$ to 400 nm) and

(b) X-rays ($\lambda = 0.01$ 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.

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

(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).

16. 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

(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.

17. 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.

(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 107 Å).

(b) All electromagnetic waves travel with the speed of light (i.e., 3 x 10 8) in vacuum. Thus, ratio of speeds of these waves in vacuum is 1 : 1.

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

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.

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

The electromagnetic waves of wavelength λ = 8000 Å to 107 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.

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

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.

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

Three properties of ultraviolet radiations which are similar to the visible light are as follows —

(a) Ultraviolet radiations travel in a straight line like visible light, with a speed of 3 x 108 m s-1 in air or vacuum.

(b) They obey the laws of reflection and refraction.

(c) They affect the photographic plate.

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

The properties of ultraviolet radiations which differ from the visible light are as follows —

(a) They are usually scattered by the dust particles present in the earth's atmosphere.

(b) They produce fluorescence on striking a zinc-sulphide screen.

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

Three properties of infrared radiations which are similar to the visible light are as follows —

(a) Infrared radiations travel in a straight line like visible light, with a speed of 3 x 108 m s-1 in air or vacuum.

(b) They obey the laws of reflection and refraction.

(c) They do not produce fluorescence.

24. Give two properties of infrared radiations which differ from visible light.

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

(a) They do not pass through glass as they are absorbed by glass.

(b) They are invisible.

25. Name the material of prism required for obtaining spectrum of (a) ultraviolet light, (b) infrared radiations.

(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.

(b) Infrared radiations are absorbed by glass, but they can pass through rock salt. Hence, a rock salt prism is used to obtain an infrared spectrum.

26. Name the radiations which are absorbed by the green house gases in the earth's atmosphere.

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.

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

Harmful effects of the given radiations are as follows —

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

(b) Infrared radiations causes skin burns.

28. Give reason for the following:

(1) Infrared radiations are used for photography in fog.

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

(2) Infrared radiations are used for signals during the war.

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

(3) The photographic darkrooms are provided with infrared lamps.

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

(4) A rock salt prism is used instead of a glass prism to obtain the infrared spectrum.

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.

(5) A quartz prism is required for obtaining the spectrum of the ultraviolet light.

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.

(6) Ultraviolet bulbs have a quartz envelope instead of glass.

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

29. Multiple Choice Type

(1) The most energetic electromagnetic radiations are — gamma rays

(2) The source of ultraviolet light is — carbon arc-lamp

(3) 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 — infrared radiation

Exercise C

1. What is meant by scattering of light?

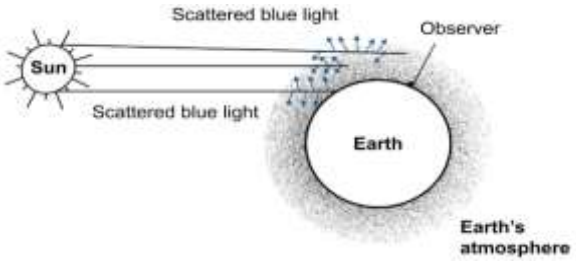
Scattering is the process of absorption and then re-emission of light energy.

2. How does the intensity of scattered light depend on the wavelength of incident light? State conditions when this dependence holds.

The intensity of scattered light is inversely proportional to the fourth power of wavelength of light (i.e., $I \alpha 1/\lambda^4$). The wavelength of violet light is the least (~ 4000 A°) and that of red light is the most (~ 8000 A°), therefore, from the incident white light, violet light is scattered the most and the red

light is scattered the least (violet light is scattered nearly 16 times more than the red light). As a result, light travelling in forward direction and reaching on earth surface has less intensity of the colours of violet end (such as blue, indigo, violet) and more intensity of colours of the red end (such as orange, red). But if the size of air molecules or dust particles is bigger than the wavelength of incident light, the intensity of scattered light is the same for all wavelengths of white light.

3. **When sunlight enters earth's atmosphere, state which colour of light is scattered the most and which the least.**
   Violet is scattered the most and red the least.
4. **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.**
   (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.
5. **Which colour of white light is scattered the least? Give reason**
   Red colour of white light is scattered the least because wavelength of red light ($\lambda = 8000$ Å) is longest and intensity of scattered light (I) $\propto {}^{1}/_{\lambda^4}$
6. **The danger signal is red. Why?**
   The wavelength of red light is the longest in the visible light, the light of red colour is scattered 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 the other colours having the same intensity. Hence it is used for danger signal so that the signal may be visible from the far distance.
7. **How would the sky appear when seen from the space (or moon)? Give reason for your answer.**
   The sky will appear black when seen from the space (or moon) 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, no other light reaches the eye of the observer except the light directly from sun. Thus the sky will have no colour and will appear black to an observer on the moon surface.
8. **What characteristic property of light is responsible for the blue colour of the sky?**
   Scattering
9. **The colour of sky, in direction other than of the sun, is blue. Explain.**
   The light from sun has to travel a long distance of the earth's atmosphere before reaching us. As the 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 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. So, the sky in direction, other than the direction of sun, is seen blue.
10. **Why does the sun appear red at sunrise and sunset?**



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 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 since white- blue = red (nearly). As a result, the sun and the region near by it is seen red

11. The sky at noon appears white. Give reason.

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

12. The clouds are seen white. Explain.

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 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.

13. Give reason why the smoke from a fire looks white.

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.

14. MULTIPLE CHOICE TYPE

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

(2) To an astronaut in a space-ship, the earth appears — blue

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