ICSE CLASS 10 · PHYSICS

Chapter 6 : SPECTRUM

STEP-BY-STEP SOLUTIONS & MARKING SCHEME (40 MARKS)

Maximum Marks: 40 · Section A (20) compulsory · Section B: any two of three questions (2 × 10 = 20) · $c = f\lambda$ · $c = 3 \times 10^8$ m s^{-1} · VIBGYOR: violet, indigo, blue, green, yellow, orange, red

Marks for each step are shown in square brackets on the right. Parts added in the solution diagrams are drawn in red or in the colour of the light.

SECTION A (20 Marks)

Question 1 — Multiple choice [8 marks, 1 mark each]

No.	Answer	Reason
(i)	**(d)** red	Deviation increases as wavelength decreases; red has the longest wavelength of visible light, so it is deviated the least (violet the most).
(ii)	**(b)** infrared rays	Order of increasing wavelength: gamma rays, X-rays, ultraviolet, visible, infrared, microwaves, radio waves. Of the options, infrared is longest.
(iii)	**(a)** 500 nm	$\lambda = c \div f = (3 \times 10^8) \div (6 \times 10^{14}) = 5 \times 10^{-7}$ m = 500 nm.
(iv)	**(b)** scattering of sunlight	Air molecules scatter short-wavelength blue light much more than red ($I \propto 1 \div \lambda^4$), so scattered blue light reaches the eye from all directions.
(v)	**(c)** Both (A) and (R) are true, and (R) is the correct explanation for (A).	Both are true: red has the longest wavelength, so it is scattered least and can be seen from far away even in fog; (R) explains (A).
(vi)	**(b)** X-rays	X-rays penetrate flesh but are stopped by bones, so they are used in radiography to detect fractures.
(vii)	**(c)** quartz	Glass absorbs ultraviolet radiation, whereas quartz transmits it.
(viii)	**(c)** frequency	Frequency is a property of the source and does not change on refraction; speed and wavelength change, and the direction changes unless incidence is normal.

Question 2 [6 marks]

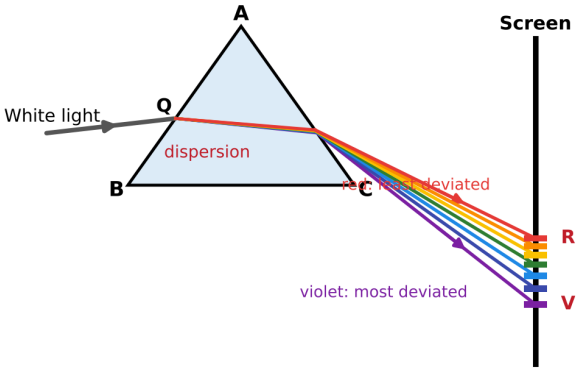
(a) (i) **Dispersion**: the splitting of white light into its constituent colours when it passes through a prism (or any refracting medium). [1] **[2]**

(ii) **Spectrum**: the band of colours (VIBGYOR) obtained on a screen when white light passes through a prism. [1]

(b) (i) The ray bends towards the base at face AB, the colours separate (violet most, red least), and they bend further towards the base at face AC; a band of colours falls on the screen. [1] **[3]**

(ii) The end nearest the base of the prism is **violet (V)** and the end farthest from the base is **red (R)**. [1]

(iii) **Dispersion** of light (caused by the different speeds of different colours in glass, so $\mu_{violet} > \mu_{red}$). [1]



Solution to Q2(b)

(c) (i) Most scattered: **violet (blue)**; (ii) least scattered: **red**, since the intensity of scattered light $I \propto 1 \div \lambda^4$. [½ + ½] **[1]**

Question 3 [6 marks]

(a) Given: $\lambda = 6000$ Å, $c = 3 \times 10^8$ m s^{-1}, v (glass) $= 2 \times 10^8$ m s^{-1}. **[3]**

(i) $\lambda = 6000 \times 10^{-10}$ m = **6×10^{-7} m**. [1]

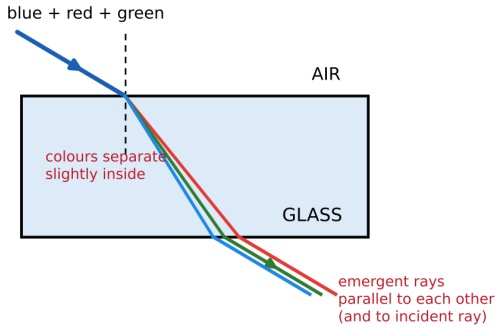
(ii) $f = c \div \lambda = (3 \times 10^8) \div (6 \times 10^{-7}) =$ **5×10^{14} Hz**. [1]

(iii) The frequency does not change in glass, so $\lambda' = v \div f = (2 \times 10^8) \div (5 \times 10^{14}) =$ **4×10^{-7} m (400 nm)**. [1]

(b) (i) The colours enter at the same point O and bend towards the normal by different amounts (blue most, red least). On leaving the slab each emerges parallel to the incident beam, so the three emergent rays are parallel to each other. [1] **[3]**

(ii) The emergent light is **almost white** (blue + red + green = white), displaced sideways from the original path. [1]

(iii) The emergent rays are parallel and so close together that they overlap; the second surface is parallel to the first, so it undoes the deviation of each colour instead of increasing it as in a prism. [1]



Solution to Q3(b)

SECTION B (20 Marks) — any two questions

Question 4 [10 marks]

(a) Given: $f = 6 \times 10^{18}$ Hz, $c = 3 \times 10^{8}$ m s^{-1}. **[3]**

(i) $\lambda = c \div f = (3 \times 10^{8}) \div (6 \times 10^{18}) =$ **5×10^{-11} m**. [1]

(ii) 1 Å = 10^{-10} m, so $\lambda = 5 \times 10^{-11} \div 10^{-10} =$ **0.5 Å**. [1]

(iii) **Assumption**: the speed of X-rays in air/vacuum is 3×10^{8} m s^{-1} (same as light). [1]

(b) (i) Infrared radiations have long wavelength and are scattered very little by fog and mist, so they penetrate it. [1] **[3]**

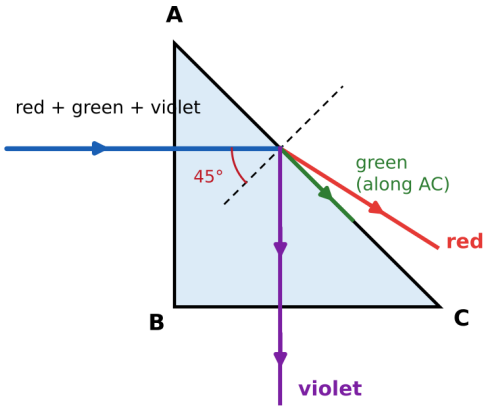
(ii) Glass absorbs infrared radiation, but rock salt does not absorb it, so infrared passes through the rock-salt prism. [1]

(iii) Glass absorbs ultraviolet radiation; quartz transmits it, so the UV from the lamp can come out. [1]

(c) (i) The beam passes undeviated through AB (normal incidence) and meets AC at an angle of incidence of **45°**. **Violet**: the critical angle is less than 45°, so it is totally reflected and goes down normally to BC. **Green**: the angle of incidence equals its critical angle, so it just grazes along face AC. **Red**: the critical angle is more than 45°, so it is refracted out of AC, bending away from the normal towards the base. [2] **[4]**

(ii) **Violet** emerges from BC (undeviated, since it falls normally); the phenomenon is **total internal reflection**. [1]

(iii) For red light μ is least, so its critical angle is more than 45°; the angle of incidence 45° is less than the critical angle and refraction takes place. [1]



Solution to Q4(c)

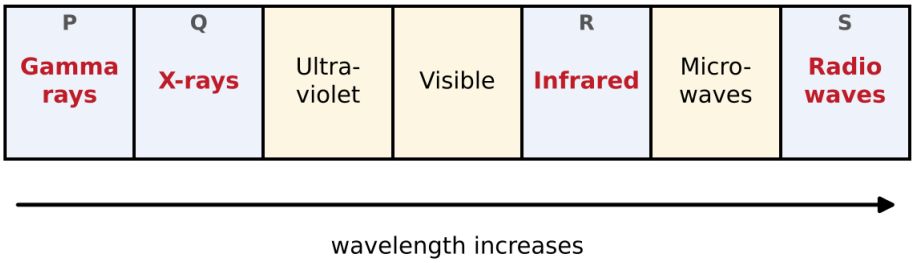
Question 5 [10 marks]

(a) Any three (1 mark each): **[3]**

- They need no material medium and can travel in vacuum.
- They all travel with the same speed in vacuum (3×10^{8} m s^{-1}).
- They show reflection and refraction (and obey the relation $c = f\lambda$).
- They are not deflected by electric or magnetic fields.
- They are transverse waves.

(b) (i) P = **gamma rays**, Q = **X-rays**, R = **infrared rays**, S = **radio waves**. [½ each = 2] **[3]**

(ii) **P (gamma rays)** has the highest frequency, because the shortest wavelength means the highest frequency (c = fλ). [1]

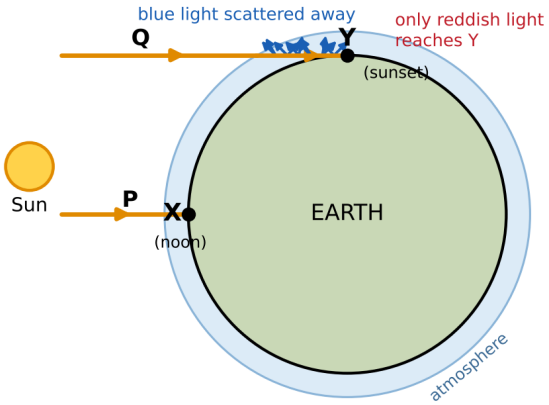


Solution to Q5(b)

(c) (i) Path **Q** (the sunlight reaching Y at sunset travels a much longer path through the atmosphere). [1] **[4]**

(ii) Y sees a **red** sun. The long path scatters away most of the blue light (short wavelength, $I \propto 1 \div \lambda^4$), so mainly red light, which is scattered the least, reaches Y. [2]

(iii) The sky looks **black**, because the moon has no atmosphere, so there is no scattering of sunlight. [1]



Solution to Q5(c)

Question 6 [10 marks]

(a) (i) **Infrared**: used for photography at night or in fog (or for therapy / remote controls). [1] **[3]**

(ii) **Ultraviolet**: used for sterilising / detecting the purity of gems and eggs. [1]

(iii) **Gamma rays** (about 0.01 Å): used to kill cancer cells (radiotherapy) or to check welds. [1]

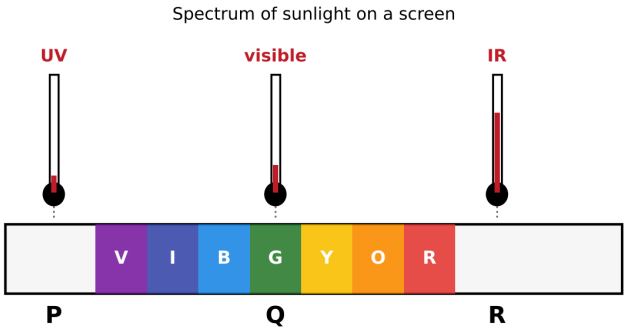
(b) Any three (1 mark each): **[3]**

- Wavelength: UV 100 Å to 4000 Å; IR 8000 Å to 10^7 Å.
- Heating effect: UV produce no heating effect; IR produce a strong heating effect.
- Photographic plate: UV affect an ordinary plate; IR do not affect it.
- UV cause fluorescence on a zinc-sulphide screen; IR do not.
- UV pass through quartz but not glass; IR pass through rock salt but not glass.
- UV cause skin cancer; IR in large dose cause skin burns.

(c) (i) **Thermometer R** shows the fastest rise; the radiation just beyond the red end is **infrared** (heat) radiation, which has a strong heating effect. [1 + 1] **[4]**

(ii) At **P** (just beyond the violet end), where **ultraviolet** radiation is chemically very active and blackens silver chloride. [1]

(iii) **Quartz** (it transmits ultraviolet radiation, whereas glass absorbs it). [1]



Solution to Q6(c)

Marks summary	
Section A: Q1 (8) + Q2 (2 + 3 + 1 = 6) + Q3 (3 + 3 = 6)	**20**
Section B: any two of Q4 – Q6 (10 marks each)	**20**
Total	**40**