



7. The electromagnetic waves used in radar systems are  
 (a) Infrared waves      (b) Ultraviolet rays      (c) Microwaves      (d) X-rays
8. In the process of charging of a capacitor, the current produced between the plates of the capacitor is (where symbols have their usual meanings)  
 (a)  $\mu_0 \frac{d\phi_E}{dt}$       (b)  $\frac{1}{\mu_0} \frac{d\phi_E}{dt}$       (c)  $\varepsilon_0 \frac{d\phi_E}{dt}$       (d)  $\frac{1}{\varepsilon_0} \frac{d\phi_E}{dt}$

**In the following questions 9 and 10, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:**

- (a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).  
 (b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).  
 (c) Assertion (A) is true but reason (R) is false.  
 (d) Assertion (A) is false but reason (R) is true.

**9. Assertion (A):** When a charged particle moves in a circular path, it produces electromagnetic wave.

**Reason (R):** Charged particle has acceleration.

**10. Assertion (A):** In an electromagnetic wave, electric field vector and magnetic field vector are mutually perpendicular.

**Reason (R):** Electromagnetic waves are transverse.

## SECTION – B

**Questions 11 to 14 carry 2 marks each.**

11. Consider an induced magnetic field due to changing electric field and an induced electric field due to changing magnetic field. Which one is more easily observed? Justify your answer.
12. (a) Explain briefly the fact that electromagnetic waves carry energy.  
 (b) Why do we not, feel the pressure due to sunshine?
13. (i) How are infrared waves produced? Write their one important use.  
 (ii) The thin ozone layer on top of the stratosphere is crucial for human survival. Why?

**OR**

How are X-rays produced? Give any two uses of these.

14. (i) Which segment of electromagnetic waves has highest frequency? How are these waves produced? Give one use of these waves.  
 (ii) Which EM waves lie near the high frequency end of visible part of EM spectrum? Give its one use. In what way this component of light has harmful effects on humans?

## SECTION – C

**Questions 15 to 17 carry 3 marks each.**

15. (a) Write the following radiations in a descending order of frequencies: red light, X-rays, microwaves, radio waves  
 (b) What is the nature of waves used in radar?  
 (c) What is the role of ozone layer in the atmosphere?
16. (a) How are electromagnetic waves produced by oscillating charges?  
 (b) State clearly how a microwave oven works to heat up a food item containing water molecules.  
 (c) Why are microwaves found useful for the radar systems in aircraft navigation?



17. Electromagnetic waves of wavelengths  $\lambda_1$ ,  $\lambda_2$  and  $\lambda_3$  are used in radar systems, in water purifiers and in remote switches of TV, respectively.
- (a) Identify the electromagnetic waves, and  
 (b) Sketch a schematic diagram depicting oscillating electric and magnetic fields of an em wave propagating along + z-direction.

OR

- (a) Name the e.m. waves which are suitable for radar systems used in aircraft navigation. Write the range of frequency of these waves.  
 (b) If the Earth did not have atmosphere, would its average surface temperature be higher or lower than what it is now? Explain.  
 (c) An e.m. wave exerts pressure on the surface on which it is incident. Justify.

### SECTION – D

Questions 18 carry 5 marks.

18. How does Ampere-Maxwell law explain the flow of current through a capacitor when it is being charged by a battery? Write the expression for the displacement current in terms of the rate of change of electric flux.

OR

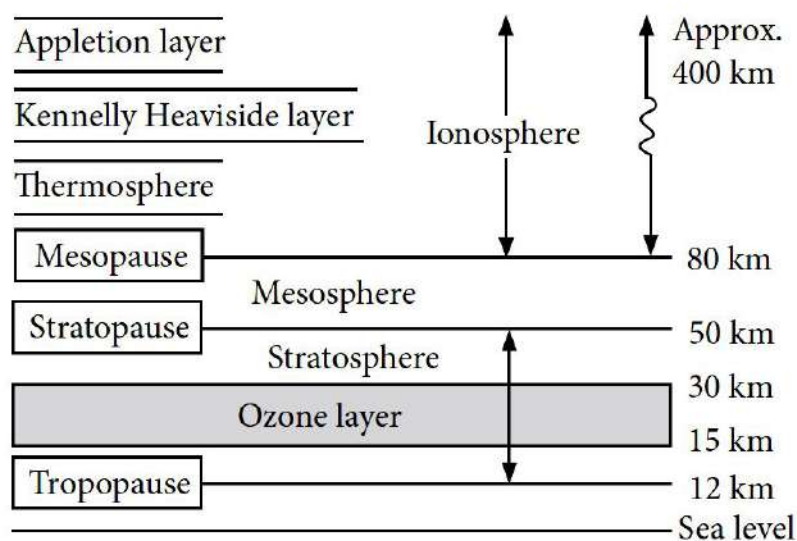
- (a) Name the EM waves which are produced during radioactive decay of a nucleus. Write their frequency range.  
 (b) Welders wear special glass goggles while working. Why? Explain.  
 (c) Why are infrared waves often called as heat waves? Give their one application.  
 (d) Thin ozone layer on top of stratosphere is crucial for human survival. Why?  
 (e) Why is the amount of the momentum transferred by the em waves incident on the surface so small?

### SECTION – E (Case Study Based Questions)

Questions 19 to 20 carry 4 marks each.

#### 19. Sources of Electromagnetic Waves

Radio waves are produced by the accelerated motion of charges in conducting wires. Microwaves are produced by special vacuum tubes. Infrared waves are produced by hot bodies and molecules also known as heat waves. UV rays are produced by special lamps and very hot bodies like Sun.



- (i) Solar radiation is
- (a) transverse electromagnetic wave  
 (b) longitudinal electromagnetic waves  
 (c) both longitudinal and transverse electromagnetic waves



(d) none of these.

(ii) What is the cause of greenhouse effect?

- (a) Infrared rays                      (b) Ultraviolet rays                      (c) X-rays                      (d) Radiowaves

(iii) Biological importance of ozone layer is

- (a) it stops ultraviolet rays                      (b) It layer reduces greenhouse effect  
(c) it reflects radiowaves                      (d) none of these.

(iv) Ozone is found in

- (a) stratosphere                      (b) ionosphere                      (c) mesosphere                      (d) troposphere

**OR**

(iv) Earth's atmosphere is richest in

- (a) ultraviolet                      (b) infrared                      (c) X-rays                      (d) microwaves

## 20. Electromagnetic Spectrum

All the known radiations from a big family of electromagnetic waves which stretch over a large range of wavelengths. Electromagnetic wave include radio waves, microwaves, visible light waves, infrared rays, UV rays, X-rays and gamma rays. The orderly distribution of the electromagnetic waves in accordance with their wavelength or frequency into distinct groups having widely differing properties is electromagnetic spectrum.

(i) Which wavelength of the Sun is used finally as electric energy?

- (a) radio waves                      (b) infrared waves                      (c) visible light                      (d) microwaves

(ii) Which of the following electromagnetic radiations have the longest wavelength?

- (a) X-rays                      (b)  $\gamma$ -rays                      (c) microwaves                      (d) radiowaves

(iii) Which one of the following is not electromagnetic in nature?

- (a) X-rays                      (b) gamma rays                      (c) cathode rays                      (d) infrared rays

(iv) Which of the following has minimum wavelength ?

- (a) X-rays                      (b) ultraviolet rays                      (c)  $\gamma$ -rays                      (d) cosmic rays

**OR**

(iv) The decreasing order of wavelength of infrared, microwave, ultraviolet and gamma rays is

- (a) microwave, infrared, ultraviolet, gamma rays  
(b) gamma rays, ultraviolet, infrared, microwave  
(c) microwave, gamma rays, infrared, ultraviolet  
(d) infrared, microwave, ultraviolet, gamma rays.

.....





- (a) very intense visible light                      (b) infrared radiation  
(c) ultraviolet rays                                      (d) microwaves

Ans. (c) ultraviolet rays

6. Displacement current exists only when

- (a) electric field is changing.                      (b) magnetic field is changing.  
(c) electric field is not changing.                      (d) magnetic field is not changing.

Ans. (a) electric field is changing.

7. The electromagnetic waves used in radar systems are

- (a) Infrared waves                      (b) Ultraviolet rays                      (c) Microwaves                      (d) X-rays

Ans. (c) Microwaves

8. In the process of charging of a capacitor, the current produced between the plates of the capacitor is (where symbols have their usual meanings)

- (a)  $\mu_0 \frac{d\phi_E}{dt}$                       (b)  $\frac{1}{\mu_0} \frac{d\phi_E}{dt}$                       (c)  $\varepsilon_0 \frac{d\phi_E}{dt}$                       (d)  $\frac{1}{\varepsilon_0} \frac{d\phi_E}{dt}$

Ans. (c)  $\varepsilon_0 \frac{d\phi_E}{dt}$

**In the following questions 9 and 10, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:**

- (a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).  
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(d) Assertion (A) is false but reason (R) is true.

9. **Assertion (A):** When a charged particle moves in a circular path, it produces electromagnetic wave.

**Reason (R):** Charged particle has acceleration.

Ans. (a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).

10. **Assertion (A):** In an electromagnetic wave, electric field vector and magnetic field vector are mutually perpendicular.

**Reason (R):** Electromagnetic waves are transverse.

Ans. (b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).

## SECTION – B

**Questions 11 to 14 carry 2 marks each.**

11. Consider an induced magnetic field due to changing electric field and an induced electric field due to changing magnetic field. Which one is more easily observed? Justify your answer.

Ans. Electric field which is easily observed because an a.c. circuit displacement current can be increased by increasing the angular frequency of current. The electric field increase due to changing magnetic field can be increased by taking more no. of turns of the coil. But magnetic field set up due to this displacement current is very small so it can easily observed.

12. (a) Explain briefly the fact that electromagnetic waves carry energy.

(b) Why do we not, feel the pressure due to sunshine?

Ans. (a) Consider a plane perpendicular to the direction of propagation of the electromagnetic wave. If there are, on this plane, electric charges, they will be set and sustained in motion by the





electric and magnetic fields of the electromagnetic wave. The charges thus acquire energy and momentum from the waves.

(b) When the sun shines on your hand, you feel the energy being absorbed from the electromagnetic waves (your hands get warm). Electromagnetic waves also transfer momentum to your hand but because  $c$  is very large, the amount of momentum transferred is extremely small and you do not feel the pressure.

13. (i) How are infrared waves produced? Write their one important use.

(ii) The thin ozone layer on top of the stratosphere is crucial for human survival. Why?

Ans. (i) Infrared waves are produced by hot bodies and molecules.

Important use: (a) To treat muscular strains (b) To reveal the secret writings on the ancient walls

(c) For producing dehydrated fruits (d) Solar heater (e) Solar cooker (Any one)

(ii) Ozone layer protects us from harmful UV rays.

**OR**

How are X-rays produced? Give any two uses of these.

Ans. When fast moving electrons strike a heavy target like tungsten, X-rays are produced.

Uses: (i) Used as a diagnostic tool in medicine.

(ii) Treatment for certain forms of cancer.

(iii) To study crystal structure.

14. (i) Which segment of electromagnetic waves has highest frequency? How are these waves produced? Give one use of these waves.

(ii) Which EM waves lie near the high frequency end of visible part of EM spectrum? Give its one use. In what way this component of light has harmful effects on humans?

Ans. (i) Gamma rays have the highest frequency. These are produced during nuclear reactions and also emitted by radioactive nuclei. They are used in medicine to destroy cancer cells.

(ii) Ultraviolet rays lie near the high frequency end of visible part of EM spectrum. They are used to sterilise drinking water and surgical instruments. Exposure to UV radiation induces the production of more melanin, causing tanning of the skin.

## **SECTION – C**

**Questions 15 to 17 carry 3 marks each.**

15. (a) Write the following radiations in a descending order of frequencies: red light, X-rays, microwaves, radio waves

(b) What is the nature of waves used in radar?

(c) What is the role of ozone layer in the atmosphere?

Ans. (a) X-rays > Visible rays (red light) > microwaves > radio waves

(b) Radio waves are used in RADAR system. They are electromagnetic waves and Transverse in nature.

(c) The ozone layer in the stratosphere absorbs a portion of the radiation from the sun, preventing it from reaching the planet's surface. Most importantly, it absorbs the portion of UV light called UVB. UVB is a kind of ultraviolet light from the sun (and sun lamps) that has several harmful effects.

16. (a) How are electromagnetic waves produced by oscillating charges?

(b) State clearly how a microwave oven works to heat up a food item containing water molecules.

(c) Why are microwaves found useful for the radar systems in aircraft navigation?

Ans. (a) If a charge particle oscillates with some frequency, produces an oscillating electric field in space, which produces an oscillating magnetic field, which in turn, is a source of electric field, and so on. Thus oscillating electric fields and magnetic fields regenerate each other, and an electromagnetic wave propagates in the space.



(b) In microwave oven, the frequency of the microwaves is selected to match the resonant frequency of water molecules so that energy from the waves get transferred efficiently to the kinetic energy of the molecules. This kinetic energy raises the temperature of any food containing water.

(c) Microwaves are short wavelength radio waves, with frequency of order of few GHz. Due to short wavelength, they have high penetrating power with respect to atmosphere and less diffraction in the atmospheric layers. So these waves are suitable for the radar systems used in aircraft navigation.

17. Electromagnetic waves of wavelengths  $\lambda_1$ ,  $\lambda_2$  and  $\lambda_3$  are used in radar systems, in water purifiers and in remote switches of TV, respectively.

(a) Identify the electromagnetic waves, and

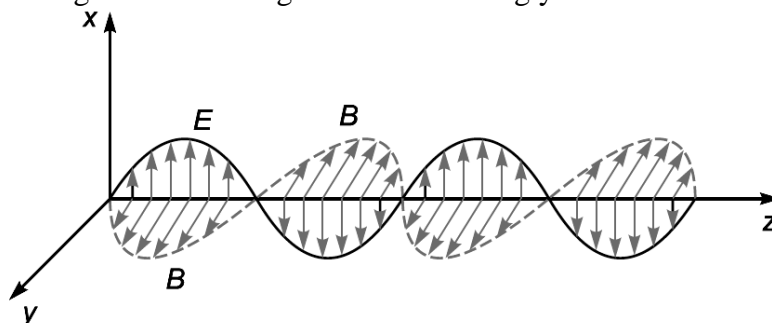
(b) Sketch a schematic diagram depicting oscillating electric and magnetic fields of an em wave propagating along + z-direction.

Ans. (a) (i) Radar Systems – Microwave

(ii) Water purifiers – Ultra Violet (UV)

(iii) Remote switches of TV–Infrared (IR)

(b) Electric field is along x-axis and magnetic field is along y-axis.



OR

(a) Name the e.m. waves which are suitable for radar systems used in aircraft navigation. Write the range of frequency of these waves.

(b) If the Earth did not have atmosphere, would its average surface temperature be higher or lower than what it is now? Explain.

(c) An e.m. wave exerts pressure on the surface on which it is incident. Justify.

Ans. (a) Microwaves are suitable for the radar system used in aircraft navigation.

Range of frequency of microwaves is 10<sup>8</sup> Hz to 10<sup>11</sup> Hz.

(b) If the Earth did not have atmosphere, then there would be absence of greenhouse effect of the atmosphere. Due to this reason, the temperature of the earth would be lower than what it is now.

(c) An e.m. wave carries momentum with itself and given by

$$P = \text{Energy of wave (U)} / \text{Speed of the wave (c)} = U/c$$

when it is incident upon a surface it exerts pressure on it.

## SECTION – D

**Questions 18 carry 5 marks.**

18. How does Ampere-Maxwell law explain the flow of current through a capacitor when it is being charged by a battery? Write the expression for the displacement current in terms of the rate of change of electric flux.

Ans. Consider charging of a parallel plate capacitor by a time varying current  $I(t)$ .

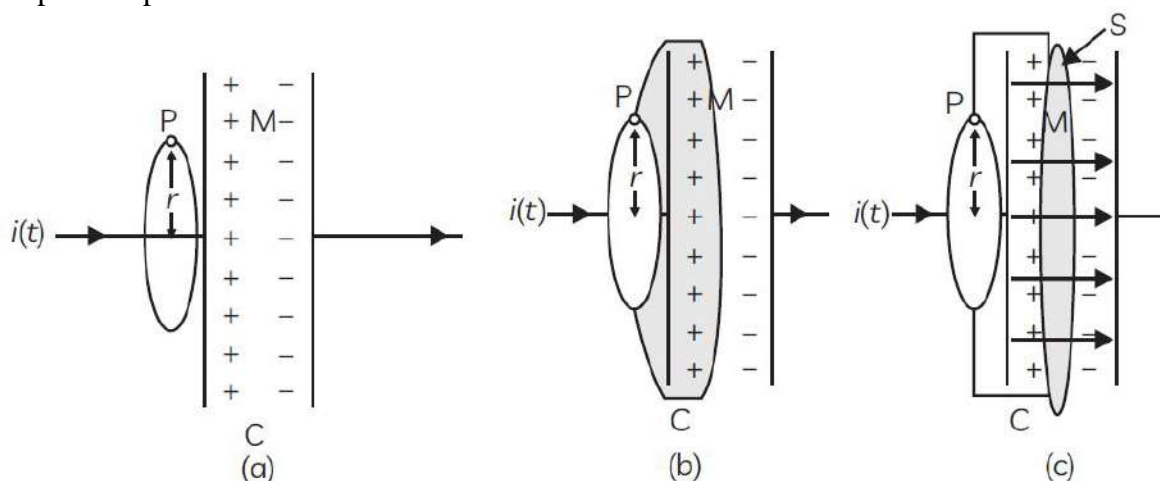
Let us find the magnetic field at a point P in a region outside the capacitor. For this we consider a plane circular loop of radius  $r$  whose plane is perpendicular to the direction of the current carrying wire and which is centred symmetrically with respect to the wire Fig (a). Using symmetry condition and applying Ampere's circuital law, we have

$$B(2\pi r) = \mu_0(0) = 0$$





It is because no current passes through the surface of fig(b) and (c). It causes a contradiction because we get a finite value of magnetic field B by doing calculation in one way and zero value of B by doing calculation in another way. To remove this contradiction Maxwell introduced the concept of displacement current.



$I_D = \epsilon_0 \frac{d\phi_E}{dt}$ , where  $\frac{d\phi_E}{dt}$  is the rate of change of electric flux between the plates of given capacitor.

Now, the Ampere Maxwell's circuital law is expressed as:  $\oint \vec{B} \cdot d\vec{l} = \mu_0 [I(t) + I_D]$

Thus, Ampere-Maxwell law successfully explains the flow of current through a capacitor when it is being charged (or discharged) by a battery.

**OR**

- (a) Name the EM waves which are produced during radioactive decay of a nucleus. Write their frequency range.
- (b) Welders wear special glass goggles while working. Why? Explain.
- (c) Why are infrared waves often called as heat waves? Give their one application.
- (d) Thin ozone layer on top of stratosphere is crucial for human survival. Why?
- (e) Why is the amount of the momentum transferred by the em waves incident on the surface so small?

Ans. (a) EM waves :  $\gamma$ -rays

Range :  $10^{19}$  Hz to  $10^{23}$  Hz

(b) This is because the special glass goggles protect the eyes from large amount of UV radiations produced by welding arcs.

(c) Infrared waves are called heat waves because water molecules present in the materials readily absorb the infrared rays and get heated up.

Application: They are used in green houses to warm the plants.

(b) Ozone layer absorbs the ultraviolet radiations from the sun and prevents it from reaching the earth's surface.

(c) Momentum transferred,  $p = U/c$

where  $U$  = energy transferred, and  $c$  = speed of light

Due to the large value of speed of light ( $c$ ), the amount of momentum transferred by the em waves incident on the surface is small.

## SECTION – E (Case Study Based Questions)

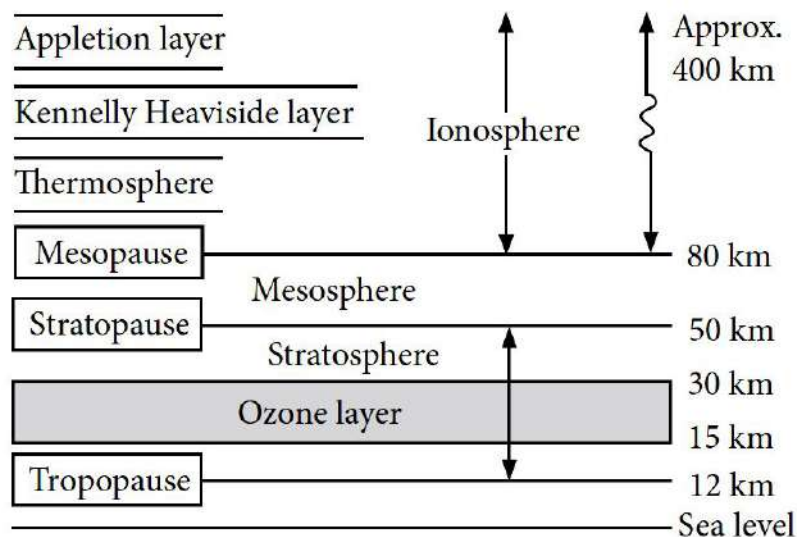
Questions 19 to 20 carry 4 marks each.

### 19. Sources of Electromagnetic Waves

Radio waves are produced by the accelerated motion of charges in conducting wires.

Microwaves are produced by special vacuum tubes. Infrared waves are produced by hot bodies and molecules also known as heat waves. UV rays are produced by special lamps and very hot bodies like Sun.





- (i) Solar radiation is  
 (a) transverse electromagnetic wave  
 (b) longitudinal electromagnetic waves  
 (c) both longitudinal and transverse electromagnetic waves  
 (d) none of these.
- (ii) What is the cause of greenhouse effect?  
 (a) Infrared rays                      (b) Ultraviolet rays                      (c) X-rays                      (d) Radiowaves
- (iii) Biological importance of ozone layer is  
 (a) it stops ultraviolet rays                      (b) It layer reduces greenhouse effect  
 (c) it reflects radiowaves                      (d) none of these.
- (iv) Ozone is found in  
 (a) stratosphere                      (b) ionosphere                      (c) mesosphere                      (d) troposphere
- OR**
- (iv) Earth's atmosphere is richest in  
 (a) ultraviolet                      (b) infrared                      (c) X-rays                      (d) microwaves

Ans. (i) (a) transverse electromagnetic wave

(ii) (a) Infrared rays

Greenhouse effect is due to infrared rays.

(iii) (a) it stops ultraviolet rays

Ozone layer absorbs the harmful ultraviolet radiations coming from the sun.

(iv) (a) stratosphere

Ozone layer lies in stratosphere.

**OR**

(iv) (b) infrared

The atmosphere of earth is richest in infrared radiation.

## 20. Electromagnetic Spectrum

All the known radiations from a big family of electromagnetic waves which stretch over a large range of wavelengths. Electromagnetic wave include radio waves, microwaves, visible light waves, infrared rays, UV rays, X-rays and gamma rays. The orderly distribution of the electromagnetic waves in accordance with their wavelength or frequency into distinct groups having widely differing properties is electromagnetic spectrum.

(i) Which wavelength of the Sun is used finally as electric energy?

- (a) radio waves                      (b) infrared waves                      (c) visible light                      (d) microwaves



(ii) Which of the following electromagnetic radiations have the longest wavelength?  
(a) X-rays                      (b)  $\gamma$ -rays                      (c) microwaves                      (d) radiowaves

(iii) Which one of the following is not electromagnetic in nature?  
(a) X-rays                      (b) gamma rays                      (c) cathode rays                      (d) infrared rays

(iv) Which of the following has minimum wavelength ?  
(a) X-rays                      (b) ultraviolet rays                      (c)  $\gamma$ -rays                      (d) cosmic rays

**OR**

(iv) The decreasing order of wavelength of infrared, microwave, ultraviolet and gamma rays is  
(a) microwave, infrared, ultraviolet, gamma rays  
(b) gamma rays, ultraviolet, infrared, microwave  
(c) microwave, gamma rays, infrared, ultraviolet  
(d) infrared, microwave, ultraviolet, gamma rays.

Ans. (i) (b) infrared waves

Infrared rays can be converted into electric energy as in solar cell.

(ii) (d) radiowaves

Radiowaves have longest wavelength.

(iii) (c) cathode rays

Cathode rays are invisible fast moving streams of electrons emitted by the cathode of a discharge tube which is maintained at a pressure of about 0.01 mm of mercury.

(iv) (c)  $\gamma$ -rays

$\gamma$ -rays have minimum wavelength.

**OR**

(iv) (a) microwave, infrared, ultraviolet, gamma rays

$$\lambda_{\text{micro}} > \lambda_{\text{infra}} > \lambda_{\text{ultra}} > \lambda_{\text{gamma}}$$

