# CHAPTER 21 — SPACE AND ENVIRONMENT

*Class 10 Physics — Complete Notes with Diagrams*

*Key concepts: Sun and planetary data · Global warming and geothermal activity · Radiation exposure*

## 1. Nature of the Sun

### Q.1 Explain nature of Sun.

The Sun is the greatest source of light, heat, and other forms of electromagnetic (E.M) waves.

- The gravitational pull of the Sun keeps planets, including the Earth, orbiting around it.
- The Sun is located at the centre of our solar system.
- The Sun contains 74% hydrogen and 24% helium, along with a few other elements.
- Nuclear fusion takes place at the core of the Sun, where hydrogen atoms fuse together to form helium, causing a tremendous rise in temperature (in millions of degrees Celsius).
- This releases a massive amount of energy which reaches the Earth as light and heat.
- This energy travels through space as various types of radiation — infrared, heat, sunlight, and ultraviolet radiation.
- These radiations considerably affect people and other forms of life on Earth.
- The Sun's energy plays an essential role in shaping weather patterns, changing the climate, and supporting ecosystems.

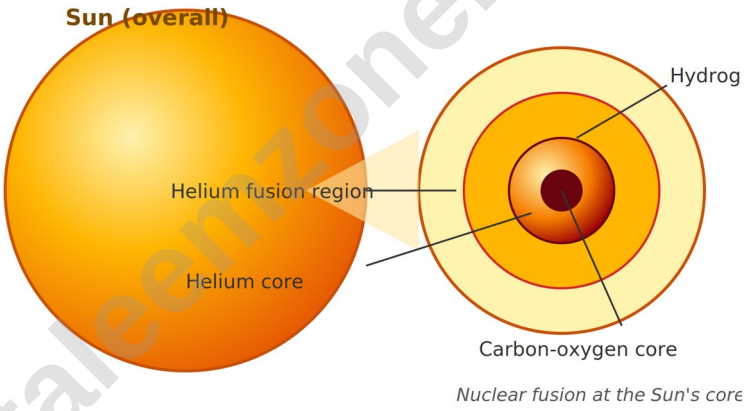



*Fig 21.1: Schematic diagram of nuclear fusion at the Sun's core*

> **Tidbit:** Even though it looks like a burning ball, the Sun does not burn like wood or coal. It fuses hydrogen into helium in its core, releasing immense energy through nuclear fusion, not combustion.

### Q.2 Explain key differences in planetary characteristics across the solar system.

For the study of planets, it is necessary to focus on different factors such as orbital distance, orbital period, density, surface temperature, and gravitational field strength — which make each planet unique.

> Do You Know? Planets have different orbital periods around the Sun. Mercury completes one orbit in 88 days. Earth takes 365.25 days. Neptune has the longest period of 165 Earth years. Closer planets have shorter orbital times due to smaller orbital distances.

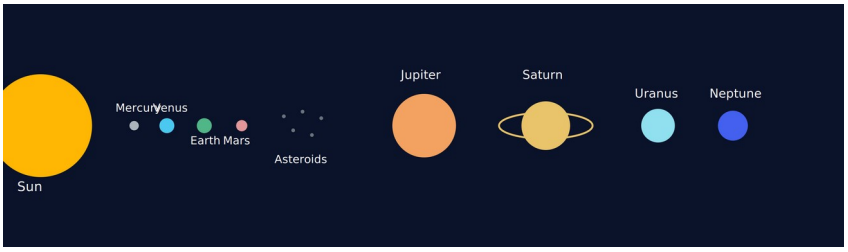



*Fig 21.2: The solar system — Sun, planets, and the asteroid belt*

### 1. Orbital Distance

- Planets closer to the Sun have smaller orbital distances; those farther away have larger orbital distances.
- Orbital distance plays a vital role in determining the amount of solar energy received by each planet.

### 2. Orbital Period

- This is the time a planet takes to complete one orbit around the Sun.
- Planets closer to the Sun have shorter orbital periods.

### 3. Density

- Density reflects a planet's composition.
- Rocky planets like Earth and Mars have higher densities due to their solid, metallic cores, while gas giants like Jupiter and Saturn have lower densities because they are composed mostly of hydrogen and helium.

### 4. Surface Temperature

- This depends on factors like distance from the Sun, atmospheric composition, and greenhouse effects.
- Venus has an extremely high surface temperature due to its thick, heat-trapping atmosphere.
- Mars is much colder due to its thin atmosphere and greater distance from the Sun.

### 5. Gravitational Field Strength

- For a planet, the gravitational field strength at its surface depends on its mass, and is nearly uniform across its surface.
- The strength of the gravitational field decreases as the distance from the planet increases.
- Smaller planets (like Mars) have weaker gravitational force, while larger planets (such as Jupiter) have stronger gravitational pull relative to Earth.

> **Tidbit:** Even after 4.5 billion years, the Earth's core remains molten, partly due to radioactive decay and the heat left over from planetary formation.

## 2. Formation of Cyclones

### Q.3 Explain how cyclones are formed using the idea of convection.

- Cyclones refer to heavy storms containing fast and spinning winds forming around a low air pressure area.
- The phenomenon of convection is responsible for developing these cyclones.
- Convection takes place due to the rise of warm air (being lighter) compared to the heavier cool air, which moves down.
- As the warm air rises, more air rushes in to take its place, which creates the spinning effect.
- The cyclone grows stronger and bigger due to this continued movement of air.

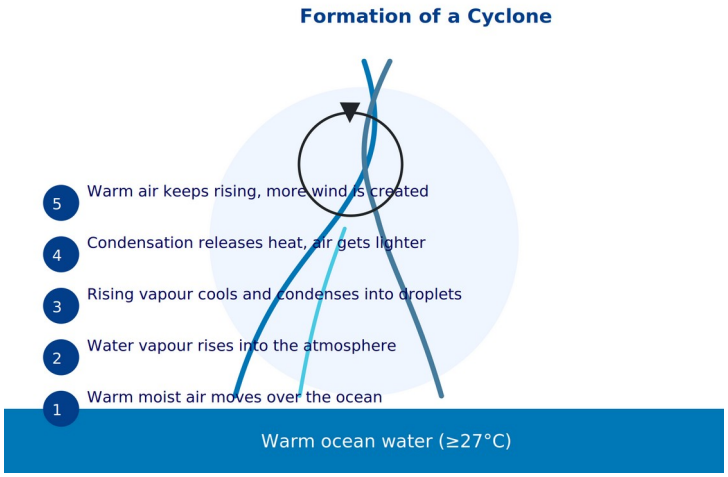



*Fig 21.4: Formation of a cyclone through convection*

### 1. Warm Ocean Waters

- Cyclones form over warm oceans where the sea surface temperature is very high (27°C or 300 K).
- The air above the warm water is heated, becomes less dense, and rises rapidly.

- This upward movement of warm air creates an area of low pressure at the surface.

### 2. Rising Air and Condensation

- The rising warm air moves to low-pressure areas, causing the air to expand.
- Clouds form due to the moisture in the air; as a result, heat is released into the surrounding air.
- This heat makes the air even warmer, so it rises even faster.
- As this continues, the warm air keeps rising, forming more clouds and releasing more heat.

### 3. Formation of a Low-pressure Centre

- As warm air keeps rising, it leaves behind empty space near the surface, like a small vacuum.
- Warmer, moist air from surrounding areas rushes in to fill this space.
- Because the Earth is spinning, this moving air does not go in a straight line — it starts to spin around the low-pressure area. This is called the Coriolis effect.
- In the northern hemisphere, the air spins anticlockwise; in the southern hemisphere, it spins clockwise.

### 4. Development of a Cyclonic System

- As more warm air is pulled into the storm, the rising and spinning of air becomes even stronger.
- The cyclone keeps growing as long as it has warm, moist air from the ocean.
- In the middle of the cyclone, a calm and clear area called the eye forms, where the air moves downward.
- Just outside this calm centre is the eye wall — the most dangerous part, with extremely strong winds and heavy rain.

### 5. Energy Dissipation

- Cyclones weaken when they move over land or colder water because they lose their warm, moist-air fuel supply.
- Over the ocean, warm air keeps the cyclone strong by helping the air rise and spin.
- Without this energy, the storm loses strength, winds weaken, and the cyclone slowly fades away.

> **Tidbit:** Earth-observing satellites can detect heat patterns, water vapour, and storm movement, helping scientists predict cyclones and track climate change with astonishing precision.

> Do You Know? Survival times without spacesuits vary greatly across planets. Mercury and Mars allow less than 2 minutes due to thin atmospheres. Venus, Jupiter, Saturn, Uranus, and Neptune provide less than 1 second survival due to extreme conditions. Earth uniquely supports life for about 80 years.

## 3. Global Warming and Geothermal Activity

### Q.4 Explain how global warming contributes to extreme weather.

- Global warming is a long-term increase in the average surface temperature of the Earth due to burning of fossil fuels, release of gases like methane, carbon dioxide, nitrous oxide, deforestation, and certain industrial and farming methods.
- These gases trap heat coming from the Sun, causing an increase in temperature.
- Global warming greatly impacts weather, sea level, and ecosystems. Similarly, the Earth's inner heat (Geothermal Activity) causes volcanic eruptions, geysers, hot springs, and the movement of tectonic plates.
- Geothermal energy is considered a renewable resource because it is sustainable as long as the Earth's internal heat remains active.

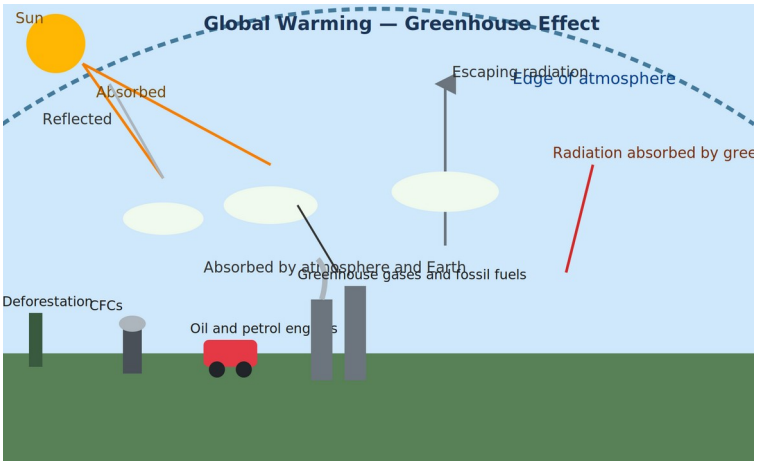



*Fig 21.5: Illustration of global warming (greenhouse effect)*

### 1. Hurricanes

Rising temperatures mean more heat is absorbed by the ocean, fuelling hurricanes and making them stronger and more destructive. Warmer ocean waters increase wind speeds and rainfall, causing greater damage. Melting ice and expanding seawater also raise sea levels, leading to stronger storm surges and more frequent coastal flooding.

### 2. Heat Waves

Rising global temperatures produce heat waves. Heat is trapped by atmospheric gases, leading to extended periods of extreme heat. Buildings and roads absorb and retain heat, causing cities to become much hotter than surrounding areas.

### 3. Flooding

- Heavier rainfall occurs in a warmer atmosphere because it can hold more moisture, resulting in intense flooding.
- As global warming changes weather patterns, storms become stronger, increasing the risk of inland and coastal floods.
- Sea levels rise due to melting glaciers and ice sheets, resulting in more flooding in coastal regions.

### 4. Wildfires

- Wildfires often result from high temperatures and long periods of dryness.
- Reduced moisture makes forests and grasslands more susceptible to ignition.
- The wildfire season is lasting longer due to earlier snowmelt and extended dry periods.

> For Your Information: Thanks to water's high specific heat capacity, oceans absorb and release heat slowly, helping to regulate global climate and reduce the intensity of heatwaves — until global warming upsets the balance.

### 5. Droughts

- Increased temperature causes more water to evaporate from the land, drying out the soil.
- This reduces water available for plants, animals, and people, causing droughts to last longer and become more intense.
- Changes in rainfall patterns lead to extended dry periods, making it harder to grow crops and provide drinking water.

### 6. Winter Storms

- Global warming can also make winter storms stronger.
- Warmer air holds more moisture, meaning heavier snowfall when temperatures are cold enough.
- This leads to extreme winter storms, including heavy snow, ice storms, and longer freezing periods in unexpected places.

> **Tidbit:** Global warming heats up the oceans, and warm ocean water acts like fuel for hurricanes. The hotter the water, the more energy the storm gets, leading to stronger winds, heavier rainfall, and longer-lasting storms.

# 4. Radiation Exposure

## Q.5 What is meant by background radiations? Explain their sources.

Definition: The radiation that exists around us all the time is known as background radiation.

### 1. Explanation

- Radiation exposure happens when someone comes into contact with radiation, a type of energy. This energy can come from natural sources like the Sun and the ground, or from man-made sources like X-ray machines and nuclear power plants.
- A small amount of radiation is usually safe, but too much exposure can harm the body by damaging cells — hence the use of safety measures like protective wear and limited exposure.
- It is the constant, low-level ionizing radiation present in the environment from both natural and human-made sources.
- It includes cosmic rays from space, radioactive materials in the Earth's crust (like uranium and radon), and even tiny amounts of radiation in our food and bodies.
- Human activities such as medical procedures (X-rays, CT scans), nuclear power plants, and past nuclear testing also contribute to it.
- Background radiation is usually harmless at normal levels, but it is an ever-present part of our environment.

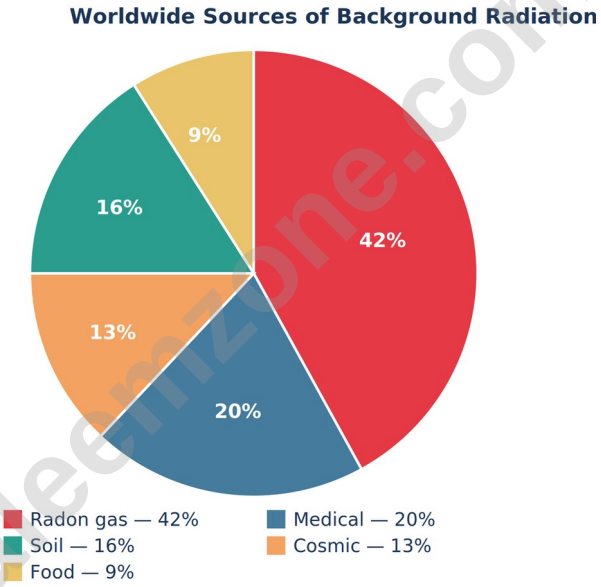



*Fig 21.9: Worldwide sources of background radiation*

### 2. Sources of Radiation

#### a. Radon gas (in the air)

1. Radon gas is an alpha emitter.
2. It is particularly dangerous if inhaled into the lungs in large quantities.
3. The gas is tasteless, colourless, and odourless, but it is not generally a health issue unless levels are significantly high.

> **Tidbit:** Radon gas seeps from the ground into homes, especially basements, contributing to background radiation. It is invisible, odourless, and radioactive, making detection difficult. Inhalation poses health risks through internal exposure.

#### b. Rocks and buildings

4. Natural radioactivity can be found in building materials, including decorative rocks, stones, and bricks.
5. Heavy radioactive elements such as uranium and thorium occur naturally in rocks in the ground.
6. Uranium decays into radon gas.

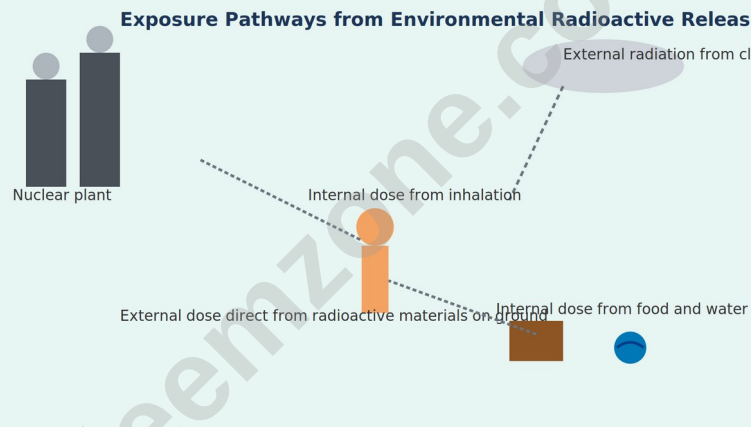
#### c. Food and Drink

7. Food and water contain small amounts of naturally occurring radioactive isotopes, such as potassium-40 and carbon-14.

8. These isotopes are absorbed by plants and animals and enter the human body through consumption.
9. The contribution from food and drink is generally small but consistent.

### d. Cosmic rays from space

10. The Sun and other stars emit an enormous number of cosmic rays, including protons, every second.
11. Some of these enter the Earth's atmosphere at high speeds.
12. When they collide with molecules in the air, they produce gamma radiation.
13. High exposure to radiation in a short time can cause radiation sickness, with symptoms like nausea, vomiting, fatigue, and organ damage.
14. Long-term exposure to low levels of radiation increases the risk of cancer, especially in organs like the lungs, thyroid, and bones.
15. Radiation can damage DNA, leading to genetic mutations that may affect future generations.
16. Radioactive materials can contaminate air, water, soil, and food, spreading radiation to the environment.
17. Inhaling radioactive dust or drinking contaminated water can cause internal exposure, where radioactive particles stay in the body and keep emitting radiation.
18. Accidents such as leaks, spills, or explosions can occur if radioactive materials are not stored or handled safely.
19. Nuclear power plant accidents or improper waste management can lead to large-scale disasters, harming communities and ecosystems.
20. Radioactive materials can be misused in "dirty bombs," which spread radiation using conventional explosives, causing panic and long-term contamination.




*Exposure pathways to humans from environmental release of radioactive materials*

> Brain Teaser: Which type of radiation comes from space and can affect airline pilots, but never passes through walls? — Cosmic rays come from space and affect airline pilots at high altitudes. These rays consist of protons from the Sun and stars entering the Earth's atmosphere. They produce gamma radiation upon collision but cannot pass through solid walls due to their particle nature.

## Multiple Choice Questions

- 1. What process generates energy in the Sun? (b) Nuclear fusion
- 2. The factor which primarily determines a planet's surface temperature: (b) its orbital distance from the Sun
- 3. What is the primary reason cyclones form over warm ocean waters? (c) The rising of warm, moist air creating low pressure
- 4. Which gas contributes most to global warming? (b) Carbon dioxide
- 5. How does the Coriolis effect influence cyclones? (a) It causes cyclones to spin in opposite directions in different hemispheres
- 6. A major cause of rising sea levels is: (c) melting glaciers and ice sheets
- 7. A significant source of background radiation is: (b) cosmic rays from space
- 8. What is the primary composition percentage of hydrogen in the Sun? (b) 74%
- 9. Planets closer to the Sun have: (b) Shorter orbital periods
- 10. Why do rocky planets like Earth have higher densities? (b) Solid metallic cores
- 11. Gravitational field strength at a planet's surface depends mainly on: (b) Mass

- 12. Minimum sea surface temperature for cyclone formation is: (b) 27°C
- 13. What creates the initial low pressure area in cyclone formation? (b) Warm air rising
- 14. Condensation in cyclones releases: (b) Heat
- 15. The Coriolis effect causes cyclones to spin: (b) Anticlockwise in northern hemisphere
- 16. What weakens cyclones over land? (b) Lack of warm ocean air
- 17. Global warming primarily increases: (b) Extreme weather events
- 18. Warmer oceans make hurricanes: (b) More intense
- 19. Heat waves are worsened in areas with: (b) Buildings and roads
- 20. Rising sea levels result from: (a) Melting glaciers
- 21. Wildfires increase due to global warming because of: (b) Dryness and high temperatures
- 22. Background radiation is: (b) Constant low-level
- 23. Largest contributor to background radiation: (a) Radon gas
- 24. Radon gas is dangerous because it is: (b) Inhaled into lungs
- 25. Cosmic rays produce background radiation by colliding with: (a) Air molecules
- 26. Cosmic rays' contribution to background radiation is: (c) 13%
- 27. Convection currents primarily drive: (b) Tectonic plate motion
- 28. Satellites help protect Earth by collecting: (a) Environmental data
- 29. Geothermal energy is considered: (b) Renewable
- 30. Droughts worsen due to global warming by: (a) More evaporation
- 31. Eye wall of cyclone has: (b) Strongest winds

## Key Short Questions (Exercise + Board)

### 21.1 What are the two main elements that make up the Sun?

The Sun mainly consists of hydrogen and helium. Hydrogen makes up about 74% of the Sun's mass, and helium contributes about 24%. Nuclear fusion takes place at the core, where hydrogen atoms fuse together to form helium.

### 21.2 What factors are used to compare planets in terms of their characteristics?

Factors used to compare planets include orbital distance, orbital period, density, surface temperature, and gravitational field strength. Orbital distance determines solar energy received; density reflects planet composition; gravitational field strength depends on mass.

### 21.3 Explain how global warming increases the intensity of hurricanes.

Global warming increases ocean temperature. Warm ocean water provides extra energy to hurricanes, leading to stronger winds and heavier rainfall — making hurricanes more destructive.

### 21.4 What is background radiation, and what are its natural sources?

Background radiation is the constant, low-level ionizing radiation present in the environment from natural and human-made sources. Natural sources include radon gas (in the air), rocks and buildings, food and drink, and cosmic rays.

### 21.5 Name three safety measures used to handle radioactive materials safely.

Protective clothing is used to reduce exposure. Exposure time is kept as short as possible. Radioactive materials are stored in shielded containers, and strict safety rules are followed during handling.

### 21.6 Why do cyclones weaken when they move over land?

Cyclones need warm, moist air for energy. Land surfaces do not provide this moisture. Without warm ocean water, air stops rising as much and spinning slows, so the storm loses strength and winds become weaker.

### 21.7 How does the Coriolis Effect influence the movement of cyclones?

The Coriolis Effect is caused by Earth's rotation, which makes moving air curve instead of flowing straight. Cyclones spin anticlockwise in the northern hemisphere and clockwise in the southern hemisphere, shaping the cyclone structure.

### 21.8 What is the primary cause of rising sea levels due to global warming?

The primary cause is the melting of glaciers and ice sheets. Rising temperature melts polar ice, and seawater also expands when heated. Both processes increase sea level.

### Q.1 Define nuclear fusion and explain its role in the Sun.

Nuclear fusion is the process in which hydrogen atoms combine to form helium and release energy. It occurs in the core of the Sun at extremely high temperatures, releasing a huge amount of energy as heat and light, which reaches the Earth and supports life and climate.

### Q.2 How does orbital distance affect the characteristics of planets?

Planets closer to the Sun have smaller orbital distances and receive more solar energy. Those farther away have larger orbital distances and receive less energy. This distance plays a vital role in determining surface temperature and energy received by each planet.

### Q.3 Why do rocky planets have higher densities compared to gas giants?

Rocky planets like Earth and Mars have higher densities due to their solid, metallic cores. Gas giants like Jupiter and Saturn have lower densities because they consist mostly of hydrogen and helium gases. Density reflects the composition and internal structure of planets.

### Q.4 What conditions are necessary for cyclone formation over oceans?

Cyclones form over warm ocean waters where sea surface temperature is 27°C or higher. Warm water heats the air above it, making it less dense so it rises rapidly. This creates low pressure at the surface, drawing in more warm moist air to continue the process.

### Q.5 Define convection and explain how it occurs in air.

The transfer of heat by the movement of fluids like air or liquid is called convection. Warm air becomes lighter and rises upward; cool air is heavier and moves downward. This continuous movement creates convection currents.

### Q.6 What is the eye and eye wall of a cyclone?

The eye is the calm centre where air moves downward, creating clear conditions. The eye wall surrounds it and contains the most dangerous part, with extremely strong winds and heavy rain — where the cyclone's maximum power is concentrated.

### Q.7 Define global warming.

The long-term increase in the average surface temperature of the Earth is called global warming. It occurs due to greenhouse gases like carbon dioxide and methane, which trap heat in the atmosphere, leading to climate changes and extreme weather.

### Q.8 How does global warming increase heat waves?

Greenhouse gases trap more heat in the atmosphere, causing prolonged periods of high temperature. Cities become hotter due to heat absorption by buildings, resulting in severe heat waves.

### Q.9 Explain how global warming causes droughts.

Higher temperatures increase evaporation of water. Soil becomes dry and loses moisture, and less water is available for plants and humans, leading to long-lasting drought conditions.

### Q.10 Define radiation exposure.

Contact of living organisms with radiation energy is called radiation exposure. Radiation may come from natural or man-made sources; small exposure is usually safe, but high exposure can damage body cells.

### Q.11 Write a short note on radon gas as a source of radiation.

Radon gas is a natural radioactive gas present in air. It is colourless, tasteless, and odourless. It emits alpha radiation, and high concentrations can be harmful if inhaled.

## Constructed Response Questions (Reasoning)

### 21.1 Why do gas giants like Jupiter, despite their larger size, have lower densities than rocky planets such as Earth and Mars? What does this tell us about their internal structure?

Reason: Rocky planets like Earth and Mars have higher densities due to solid, metallic cores. Gas giants like Jupiter and Saturn have lower densities because they are composed mostly of hydrogen and helium — showing that gas giants have a gaseous composition without dense solid cores.

### 21.2 If two planets receive the same amount of sunlight but have different atmospheric compositions, why might their surface temperatures still differ significantly?

Reason: Different atmospheric compositions trap heat differently. Thick atmospheres cause higher temperatures, while thin atmospheres lose heat easily.

### 21.3 How does the Coriolis effect play a role in creating the spiralling motion of cyclones, and what might happen to cyclone formation if the Earth stopped rotating?

Reason: Earth's rotation bends the path of moving air, causing it to spin around the low-pressure centre — anticlockwise in the north, clockwise in the south. If Earth stopped rotating, air would move straight and cyclones would not spin.

### 21.4 Compare the ways radiation, conduction, and convection each contribute to geothermal activity. Why is convection considered the primary driver of tectonic plate motion?

| Radiation | Conduction | Convection |
|---|---|---|
| Heat transfer by electromagnetic waves from Earth's interior | Heat transfer through direct contact in solid mantle rocks | Heat transfer by movement of molten material in mantle |
| Slow process from core | Limited to solid regions | Causes rising hot material, drives plate movement |
| Minor role in surface activity | Transfers heat gradually | Primary driver of tectonic plates |

Reason: Convection is primary because hot mantle material rises and cooler material sinks, creating currents that push tectonic plates. Radiation and conduction alone cannot generate large-scale motion.

### 21.5 Explain why background radiation is always present in our environment and how cosmic and terrestrial sources balance each other despite fluctuations in human activity.

Reason: Natural sources like cosmic rays (13%), radon gas (42%), rocks/buildings (16%), and food (9%) provide steady radiation. Cosmic rays from space balance terrestrial sources. Even when human activity changes, these natural sources continue emitting radiation, keeping background radiation constant.

## Comprehensive Questions

- 21.1 Describe the process of nuclear fusion in the Sun and explain how it generates energy. (See Q.1 of theory.)
- 21.2 How does a planet's orbital distance affect its surface temperature and the amount of solar energy it receives? (See Q.2 of theory.)
- 21.3 Explain the role of convection in the formation and strengthening of cyclones. (See Q.3 of theory.)
- 21.4 What are the major sources of background radiation, and how does human activity contribute to it? (See Q.5 of theory.)
- 21.5 Explain how radiation exposure can be harmful and describe three key safety measures used to minimize its risks. (See Q.5 of theory.)

## Important Questions of Board Examination

- What is meant by background radiations? Enlist some sources of background radiations.

### Important Short Questions

- What are background radiations? State their two sources.
- Define global warming.

*Compiled from uploaded "Unique Notes — Physics 10, Chapter 21: Space and Environment" (pages 249–264). Diagrams redrawn schematically for clarity.*