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CHAPTER NOTES

Earth as a System: Energy, Matter, and Life Class 9 Notes | CBSE Science Chapter 10

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Hi, I am **Ira**. I teach this syllabus all day, so **Earth as a System: Energy, Matter, and Life** is very much my home ground.

Ask me anything from this chapter. A concept, a numerical, or that one doubt you did not want to raise in class. Pick one to start:

Explain Earth as a System: Energy, Matter, and Life simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

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Earth as a System: Energy, Matter, and Life

Class 9 Notes | CBSE Science Chapter 13

Earth as a System: Energy, Matter, and Life is Chapter 13 of CBSE Class 9 Science (2026-27 NCERT textbook). It treats the Earth as one system made of five interacting spheres: the geosphere, hydrosphere, cryosphere, atmosphere and biosphere. The chapter explains how sunlight reaches the Earth, why different places heat up unevenly, how the atmosphere keeps the planet warm, how uneven heating sets winds and ocean currents moving, and how water, carbon, nitrogen and oxygen cycle between living and non-living parts of the Earth.

For exams, the chapter tests both facts and reasoning. You need definitions (insolation, solar constant, albedo, biogeochemical cycle, eutrophication), the numbers the textbook gives (solar constant about 1.4 kW m^{-2} , troposphere about 12 km high, nitrogen 78% and oxygen 21% of air), the steps of the nitrogen cycle with the bacteria involved, and the ability to explain how a change in one sphere spreads to the others.

Quick Answer - Earth as a System

The Earth has five linked spheres, so a main energy source; its radiation arrive infrared. The solar constant is about 1.4 surface albedo make heating uneven, a valley and mountain breezes, planetary re-radiated heat. Water, carbon, nitrogen parts of the Earth, and human activity is



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All Key Terms at a Glance

Term	Meaning	Key fact from the chapter
Earth's spheres	Geosphere, hydrosphere, cryosphere, atmosphere, biosphere	A disturbance in one sphere changes the others
Insolation	Sun's radiation that reaches the Earth's surface	Maximum about 1 kW m^{-2} under clear sky
Solar constant	Solar energy per unit time per unit area, perpendicular to the rays, at the top of the atmosphere	About $1.4 \text{ kW m}^{-2} = 1400 \text{ J s}^{-1} \text{ m}^{-2}$
Albedo	Fraction of solar radiation reflected by a surface	Snow 0.80 to 0.90; ice 0.50 to 0.70; crushed rock 0.25 to
Troposphere	Lowest layer of the atmosphere	
Stratosphere	Layer above the troposphere, containing the ozone layer	
Greenhouse effect	Trapping of re-radiated heat by gases	
Planetary winds	Large-scale winds driven by pressure belts	
Gyres	Large circular patterns of ocean currents	
Biogeochemical cycle	Cyclic movement of matter and energy between a system and its components	



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Term	Meaning	Key fact from the chapter
Eutrophication	Algal bloom caused by excess nutrients in water	Depletes oxygen and kills fish

Key Concepts

1. The Earth as One System: Five Interacting Spheres

Life on Earth runs on a constant flow of energy and matter. The Sun is the main source of energy; the Earth’s hot interior and chemical reactions in air, water and rocks also drive this flow. This chapter joins ideas you met separately in earlier classes into one **Earth system** of five interacting spheres.

Sphere	What it contains
Geosphere	Solid rocks, soil, landforms and the Earth’s interior
Hydrosphere	Liquid water: oceans, rivers, lakes and groundwater
Cryosphere	Solid water: ice and snow
Atmosphere	The air surrounding the Earth that we breathe
Biosphere	All living organisms and their habitats

Solar heating, movement of air and water, delicate balance. The key idea: **a disturbance**

Activity 13.1 in words: a mountain scene with grazing sheep. Snowmelt (cryosphere) feeds rivers (hydrosphere) growing on soil (geosphere). If there is a forest fire, less grass grows and the sheep have less to eat.



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A large-scale chain from the chapter:

1. Warmer Arabian Sea water leads to more evaporation from the sea.
2. This causes fluctuations in the southwest monsoon, so rainfall becomes variable: floods in some regions of India and drought in others. The hydrosphere is disrupted.
3. A rise in atmospheric temperature can speed up the melting of glaciers and polar ice (cryosphere).
4. Melting can flood low-lying regions and, in the long run, raise sea levels that threaten coastal cities.
5. Ecosystems in the biosphere are disturbed because habitats are lost.

In "interrelationship" answers, start in one sphere, name the change, then name each sphere it passes into.

2. Solar Radiation, Insolation and

Solar radiation is the main source of energy for Earth. **Waves**, which travel through a vacuum at the speed of light, are of two different types: they are mechanical waves and electromagnetic waves. The empty space between the Sun and the Earth is filled with electromagnetic waves.

The electromagnetic spectrum

The full range of EM radiation is called the electromagnetic spectrum. It ranges from high frequency (short wavelength) to low frequency (long wavelength).

Gamma rays → X-rays → Ultraviolet (UV) waves

Gamma rays and X-rays carry very high energy and are absorbed in the upper atmosphere. Microwaves and radio waves carry low energy. About 47 per cent of the Sun's energy falls in the **UV, visible light and infrared** region.

Short wavelength UV is mostly absorbed by the ozone layer. **Visible light** reaches the surface and powers photosynthesis. **Infrared** warms the surface, which re-radiates energy as long wavelength radiation.

Ready to Go Beyond box: UV rays lie between visible light and X-rays. They have more energy than visible light. Long exposure to UV rays can damage eyes and skin and cause cancer.



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is also used to kill germs in water purifiers.

Insolation and the solar constant

Insolation is the amount of the Sun’s radiation that reaches the Earth’s surface. It warms the Earth’s surface and its atmosphere.

The **solar constant** is the average amount of solar energy received per unit time per unit area that is perpendicular to the Sun’s rays at the **top of the Earth’s atmosphere**. Its value is about **1.4 kW m⁻²**, or about **1400 J s⁻¹ m⁻²**. It is the Sun’s energy available before any absorption, scattering or reflection by the atmosphere.

Gases, clouds and dust absorb and scatter some of this energy on the way down. So the **maximum insolation at the surface is lower**, about **1 kW m⁻²** under clear sky conditions.

Quantity	Where it is measured	Approximate value
Solar constant	Top of the atmosphere perpendicular to the Sun’s rays	1.4 kW m ⁻²
Maximum insolation	Earth’s surface, clear sky	1 kW m ⁻²

The solar constant helps scientists understand the climate of India, in the tropical and sub-tropical regions. It drives the southwest monsoon and gives India its high temperature.

Energy from insolation: E = intensity × area × time in s, E is in joules.

Anna Mani, India’s pioneering atmospheric physicist, and S. Rangarajan, published *Solar Radiation Over India* in 1954.

3. Why the Earth Heats Unevenly:

Land heats up faster than water. **Dark surfaces absorb more** and stay **hot** in summer.



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Albedo

The **fraction of solar radiation reflected by a surface** is called its **albedo**. The word comes from Latin and means whiteness. Albedo is a fraction, so it has no unit and lies between 0 and 1.

- **High albedo** surfaces reflect more light and stay cool.
- **Low albedo** surfaces reflect less, absorb more and heat up quickly.

Material (NCERT Table 13.1)	Albedo given in the textbook	Meaning
Snow	0.80 to 0.90	Reflects 80 to 90% of incoming sunlight
Ice	0.50 to 0.70	Reflects 50 to 70%
Crushed rock	0.25 to 0.30	

The textbook leaves the rows for light-coloured surfaces (Activity 13.2). It states the pattern: **snow** is very cold, while **black soil and ocean water** have low albedo.

All objects also radiate heat. A concrete house re-radiates the heat it absorbed in the day. That's why houses stay cool in hot summers because they reflect more light.

Urban heat island effect

Cities are warmer than surrounding rural areas. Concrete, brick and asphalt absorb solar radiation and re-radiate it. This raises the demand for air conditioning. Vegetation reduces transpiration. Human land use can change the local climate.

Latitude and the Earth's shape

The Earth is spherical, so the Sun's rays strike the surface at different angles.

- Near the **equator**, the radiation is concentrated. Equatorial regions get more energy. Equatorial regions are warmer.
- Near the **poles**, the same radiation is spread over a larger area. Polar regions are much colder.



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The spherical shape and the **tilt of the Earth's axis** also cause seasons and changing day length. The chapter summary names the **shape of the Earth, latitude and tilt of the axis** as mainly responsible for uneven heating, which drives global winds and ocean currents.

4. The Atmosphere: Layers, Ozone and the Greenhouse Effect

The **atmosphere** is the air surrounding the Earth, held in place by the Earth's gravity. It consists mainly of **nitrogen (78%)** and **oxygen (21%)**, with small amounts of argon, carbon dioxide, water vapour and other gases.

Layers of the atmosphere

The atmosphere is layered. From the ground up: **troposphere, stratosphere, mesosphere, thermosphere, exosphere.**

Layer	Approximate altitude
Troposphere	0 to 12 km (average height about 5 km)
Stratosphere	12 to 50 km
Mesosphere, thermosphere, exosphere	Above 50 km

- **Troposphere:** nearly all weather phenomena occur here. Warm air near the surface rises and drives convection cells. Warmest at the equator and coldest at the poles.
- **Stratosphere:** ozone absorbs UV rays and warms the air. Warmer air sitting above cooler air does not rise, and confines weather to the troposphere.
- At about **100 km** above the Earth begins the thermosphere, where temperature increases with altitude.

Two protective roles of the atmosphere



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1. **It partly absorbs incoming solar radiation.** The ozone layer blocks harmful UV rays. Clouds and other gases absorb some sunlight before it reaches the surface.
2. **It traps outgoing heat.** The surface absorbs sunlight and re-radiates it as infrared. Greenhouse gases such as CO₂, CH₄ and water vapour absorb this re-radiated heat and stop it escaping into space.

Without the atmosphere, the Earth would be too cold for life. The trapping of heat by greenhouse gases is the **greenhouse effect**.

Excess CO₂ from human activities **enhances** the greenhouse effect and causes **global warming**, which if left unchecked could make the Earth uninhabitable. Venus is hotter than Mercury, even though Mercury is closer to the Sun, because Venus has an atmosphere that has led to an uncontrolled greenhouse effect.

Ozone layer and the ozone hole

The ozone layer is a protective shield that absorbs harmful UV radiation. If ozone molecules are destroyed faster than they form, the layer thins. **Chlorofluorocarbons (CFCs)**, used in refrigerators and air conditioners, are major culprits. The most significant depletion is over Antarctica, known as the **ozone hole**. More UV radiation reaches the surface, harming ecosystems. A global agreement, the **Montreal Protocol**, has reduced CFCs. The ozone layer is now slowly recovering.

5. Uneven Heating Drives Winds and Air Pressure

Wind is the movement of air from a region of high pressure to a region of low pressure. Pressure differences come mainly from uneven heating. This explains land and sea breezes and much local weather.

Local winds: valley and mountain breezes

In mountains, the slopes and the valley floor heat up differently during the day. This causes air to move up and down the slopes, creating local winds.



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Feature	Valley breeze	Mountain breeze
When	Daytime	After sunset (night)
Which part is warmer	Sun-facing slopes heat faster than the valley floor	Valley floor stays warmer; slopes lose heat faster
What the air does	Warm air over the slopes rises, making low pressure; cooler valley air moves up the slopes	Cool, denser air over the slopes flows down into the valley
Direction	Up the slope	Down the slope

Such daily wind changes are common in Shimla, Dehradun and other Himalayan valleys, and they help regulate temperature and moisture for soil and crops.

Planetary winds and pressure belts

Uneven heating between the equator and the poles creates large-scale pressure differences move air from high pressure to low pressure areas.

Latitude	Pressure belt
0° (equator)	Equatorial low pressure belt
About 30° N and S	Sub-tropical high pressure belts
About 60° N and S	Sub-polar low pressure belts
About 90° N and S (poles)	Polar high pressure belts

The **rotation of the Earth** deflects these winds into curved paths. Winds turn to the **right in the Northern Hemisphere** and to the **left in the Southern Hemisphere**.

Ocean currents



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Ocean currents are the continuous movement of large masses of ocean water. Factors that drive and shape them:

- **Winds:** strong planetary winds drag surface water through friction, setting surface currents in motion.
- **Temperature:** warm equatorial water travels over the surface towards the poles; colder, denser water slowly flows back towards the equator at deeper levels.
- **Salinity:** lower-salinity water is less dense and stays near the surface; higher-salinity, denser water sinks and moves at depth.
- **Earth's rotation:** deflects moving water into large circular patterns called **gyres**, clockwise in the Northern Hemisphere and counter clockwise in the Southern Hemisphere.
- **Land masses:** continents block and redirect currents.

Why currents matter: they carry heat from the equator towards the poles and reduce temperature differences. The warm **North Atlantic Drift**, an extension of the **Gulf Stream**, keeps many ports on the northwestern coast of Europe open. Ocean currents also carry nutrients that support marine ecosystems.



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6. Biogeochemical Cycles: Water, Carbon, Nitrogen, and Oxygen

Living organisms constantly exchange matter and energy with their environment. The **cyclic movement of matter and energy between the biotic and abiotic components** is called a **biogeochemical cycle**. Carbon, nitrogen and oxygen are recycled and reused in the ecosystem.

a) Water cycle

Water evaporates from water bodies and returns as rain, hail or snow. It runs off to the sea or infiltrates the ground. The way it dissolves minerals and carries them is called the water cycle.

How climate change affects the water cycle

- A warmer atmosphere holds more moisture (leading to intensified monsoons) and droughts elsewhere.
- Melting glaciers add water to rivers and seas, raising sea levels and threatening coastal cities such as Mumbai and Chennai.

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- Sudden bursts of intense rain cause more runoff, which erodes soil. Less water infiltrates, so groundwater recharge falls and farming in dry months becomes harder.

b) Carbon cycle

Carbon forms the backbone of life: every protein, carbohydrate, fat and DNA molecule contains carbon. Carbon circulates between the atmosphere (CO_2), biosphere (plants and animals), geosphere (carbonate rocks and fossil fuels such as coal and oil) and hydrosphere (dissolved CO_2 and marine shells).

	Fast carbon cycle	Slow carbon cycle
Time scale	Days to years	Millions of years
Processes	Photosynthesis takes CO_2 into glucose; respiration releases CO_2 ; plants or other animals; carbon of dead organisms returns to air	Dead plants and animals are

Burning fossil fuels returns carbon stored over long time scale. Ocean water absorbs CO_2 to form bicarbonate ions. Phytoplankton for photosynthesis and by sea animals.

Carbon numbers from the chapter: carbon cycle. 71% of global carbon is in the oceans, and the atmosphere holds only about 1% of global carbon.

Rising CO_2 : burning fossil fuels and deforestation have increased CO_2 in the atmosphere by 420 ppm since 1960 (ppm = parts per million). This is unprecedented in human history. This record is from Northern Hemisphere plant growth and is a sign of the greenhouse effect, causing global warming. For India this may mean more intense monsoons.

c) Nitrogen cycle

Nitrogen is essential for making **proteins** and **nucleic acids**. It is in the atmosphere, but N_2 gas is rather non-reactive. It must first be converted into soluble compounds.



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Step	Change	Done by
Nitrogen fixation	Atmospheric $N_2 \rightarrow$ ammonia (NH_3)	Nitrogen-fixing bacteria: <i>Rhizobium</i> in root nodules of legumes, <i>Azotobacter</i> in soil
Nitrification (step 1)	Ammonia (NH_3) $\rightarrow$ nitrite (NO_2^-)	<i>Nitrosomonas</i>
Nitrification (step 2)	Nitrite (NO_2^-) $\rightarrow$ nitrate (NO_3^-)	<i>Nitrobacter</i>
Assimilation	Plants absorb nitrogen compounds from soil; animals get nitrogen by eating plants or other animals	Plants, animals
Ammonification	Dead organisms and ammonia returned	
Denitrification	Some nitrates $\rightarrow$ nitrate	

Denitrification completes the cycle and keeps a tiny amount of atmospheric nitrogen

Haber-Bosch process (Ready to Go Beyond) process, which makes ammonia from atmospheric nitrogen. It is a key part of the Green Revolution. It uses about 1 to 2% of the world's energy from coal, natural gas, and water.

d) Oxygen cycle

About **21%** of the atmosphere is free oxygen. It is used by plants and animals to make carbohydrates, proteins, nucleic acids, fats, and minerals in the crust, and carbon dioxide is released.

- **Removal of O_2 :** respiration by plants and animals (releases CO_2), and oxide formation.
- **Restoration of O_2 :** photosynthesis, in which plants take up CO_2 and release O_2 .



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The balance between consumption (respiration and combustion) and production (photosynthesis) circulates oxygen between the atmosphere, land, oceans and living organisms. The oxygen and carbon cycles are linked: photosynthesis takes in CO₂ and gives out O₂, while respiration and combustion do the reverse.

7. Human Impact on the Earth’s Processes

Human actions disturb the biogeochemical cycles across all the spheres.

Human activity	Cycle or sphere affected	Result
Burning fossil fuels	Carbon cycle, atmosphere	Excess CO ₂ , stronger greenhouse warming; natural sinks (forests, oceans) become saturated
Excess CO ₂ absorbed by oceans	Hydrosphere, biosphere	
Warming of oceans	Carbon cycle	
Overuse of fertilisers	Nitrogen cycle, hydrosphere	
Deforestation	Carbon, oxygen and water cycles; geosphere; biosphere	
Vehicular emissions	Atmosphere	
CFCs (past use)	Atmosphere	

The Montreal Protocol has started the record of CFCs, while the Kyoto Protocol and the Paris Agreement



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Restoring the balance: conserve energy, switch to renewables such as solar and wind, plant trees, save water, practise sustainable farming, and reduce, reuse and recycle.

Mission LiFE (Lifestyle for Environment), an India-led initiative introduced at the United Nations Climate Change Conference in 2021, encourages eco-friendly lifestyles.



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Formula and Reaction Sheet

Item	Formula, reaction or value	Note
Energy received from sunlight	$E = \text{intensity} \times \text{area} \times \text{time}$	Intensity in $\text{J s}^{-1} \text{m}^{-2}$, area in m^2 , time in s gives E in J
Solar constant	About $1.4 \text{ kW m}^{-2} = 1400 \text{ J s}^{-1} \text{m}^{-2}$	Top of the atmosphere, perpendicular to the rays
Maximum surface insolation	About 1 kW m^{-2}	Clear sky
Unit conversion	$1 \text{ kW} = 1000 \text{ W} = 1000 \text{ J s}^{-1}$; $1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$	1 kWh is one unit on an electricity bill
Albedo	Albedo = $\frac{\text{reflected radiation}}{\text{incoming radiation}}$	
Troposphere temperature fall	About $6.5^\circ \text{C km}^{-1}$	
Photosynthesis	$\text{Carbon dioxide} + \text{glucose} + \text{oxygen} + \text{sunlight}$	
Respiration	$\text{Glucose} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{energy}$	
Combustion of fuels	$\text{Fuel} + \text{oxygen} \rightarrow \text{dioxide} + \text{heat}$	
Nitrogen fixation	$\text{N}_2 \rightarrow \text{NH}_3$	
Nitrification	$\text{NH}_3 \rightarrow \text{NO}_2^- \rightarrow \text{NO}_3^-$	
Denitrification	$\text{NO}_3^- \rightarrow \text{N}_2$	



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Important Definitions

- **Earth system:** the Earth viewed as one system of five interacting spheres (geosphere, hydrosphere, cryosphere, atmosphere, biosphere) connected by flows of energy and matter.
- **Insolation:** the amount of the Sun's radiation that reaches the Earth's surface.
- **Solar constant:** the average amount of solar energy received per unit time per unit area perpendicular to the Sun's rays at the top of the Earth's atmosphere; about 1.4 kW m^{-2} .
- **Albedo:** the fraction of solar radiation reflected by a surface.
- **Greenhouse gases:** gases such as CO_2 , CH_4 and water vapour that absorb heat re-radiated by the Earth's surface.
- **Planetary winds:** large-scale winds set up by pressure belts formed through uneven heating between the equator and the poles.
- **Ocean current:** continuous movement of large masses of ocean water.
- **Gyre:** a large circular pattern of ocean currents.
- **Biogeochemical cycle:** the cyclic movement of chemical elements between the abiotic components of the Earth.
- **Nitrogen fixation:** conversion of atmospheric nitrogen into a form usable by plants.
- **Nitrification:** conversion of ammonia into nitrate.
- **Ammonification:** return of nitrogen compounds to the soil as ammonia by decomposers breaking down dead matter.
- **Denitrification:** conversion of some nitrate back into atmospheric nitrogen.
- **Eutrophication:** excess nutrients (nitrate, phosphate) leading to algal blooms that deplete oxygen and kill fish.



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Solved Examples (NCERT)

Example 1: Solar energy on 1 m^2 in

How much solar energy will be received by 1 m^2 of the surface of the Earth were 1 kW m^{-2} ?

Solution: $E = \text{intensity} \times \text{area} \times \text{time}$.

Intensity = $1 \text{ kW m}^{-2} = 1000 \text{ J s}^{-1} \text{ m}^{-2}$; area = 1 m^2 ; time = $1 \text{ h} = 3600 \text{ s}$.

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$$E = 1000 \times 1 \times 3600 = 3600000 \text{ J} = \mathbf{3.6 \times 10^6 \text{ J}}.$$

The textbook notes that this equals one unit of household electricity, and is roughly the energy needed to melt 5 kg of ice and heat the water to 100 °C.

Example 2: Energy at the top of the atmosphere

Using the solar constant, find the solar energy received in one minute by a 2 m² panel held perpendicular to the Sun's rays at the top of the atmosphere.

Solution: Solar constant = 1400 J s⁻¹ m⁻²; area = 2 m²; time = 60 s.

$$E = 1400 \times 2 \times 60 = \mathbf{168000 \text{ J} = 1.68 \times 10^5 \text{ J}}.$$

Example 3: Rooftop sunlight in a day

A flat roof of 10 m² receives an average insolation of 1 kW m⁻² for 5 hours. Find the solar energy falling on it in kWh and in joules.

Solution: Power falling on the roof = 1 kW

$$\text{Energy} = \text{power} \times \text{time} = 10 \text{ kW} \times 5 \text{ h} = \mathbf{50 \text{ kWh}}$$

Solar panels convert only a fraction of this

Example 4: Albedo and absorbed

Sunlight of 1000 W falls on each square m of crushed rock with albedo 0.25. How much surface warms faster?

Solution: Reflected = albedo × incoming.

$$\text{Snow: reflected} = 0.80 \times 1000 = 800 \text{ W; absorbed} = 1000 - 800 = 200 \text{ W}$$

$$\text{Crushed rock: reflected} = 0.25 \times 1000 = 250 \text{ W; absorbed} = 1000 - 250 = 750 \text{ W}$$

The rock absorbs almost four times as much energy as the snow, so it gets much more absorption and more heating, which is why



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Example 5: Temperature on a hill

On a summer afternoon the temperature at a plain near sea level is 30 °C. Estimate the temperature at a hill station 2 km higher, using the textbook's rate of fall in the troposphere.

Solution: Temperature falls about 6.5 °C per km in the troposphere.

Fall over 2 km = $6.5 \times 2 = 13$ °C. Estimated temperature = $30 - 13 = 17$ °C.

This is an estimate, since 6.5 °C per km is an average rate.

Example 6: Reading the CO₂ record

Atmospheric CO₂ rose from 315 ppm to 420 ppm since 1960. Find the increase in ppm and as a percentage of the 1960 value.

Solution: Increase = $420 - 315 = 105$ ppm.

Percentage increase = $(105 / 315) \times 100 =$

These two rounded readings give about 33%. You can quote 35% for a direct question and show this rise unprecedented in the history of h

Example 7: Grass-covered and bare

How are mountain and valley breezes formed with grass and another covered with bare rocks? How would the breezes be different? If so, how?

Solution: By day, sun-facing slopes heat faster, creating low pressure, and cooler valley breezes rise. At sunset the slopes lose heat faster than the valley, so the air flows down into the valley: the valley breeze.

The two mountain breezes would likely differ. The grassy mountain radiating heat after sunset, warming the air through transpiration. So the grassy mountain breeze.



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Example 8: Tracing a carbon atom (NCERT Exercise 9)

Explain with suitable diagram the path that carbon takes to go back to the atmosphere. You may start from plants using CO_2 from the atmosphere.

Solution: Draw “ CO_2 in atmosphere” at the top with arrows to and from plants, animals, decomposers, fossil fuels and the ocean:

1. Plants take in CO_2 and make glucose by photosynthesis.
2. Path A: plants respire and release CO_2 back to the air.
3. Path B: animals eat plants, respire and release CO_2 .
4. Path C: plants and animals die; decomposers break down their bodies and release CO_2 .
5. Path D (slow): buried remains become coal, oil and gas over millions of years; burning these fuels releases CO_2 .
6. Path E: oceans absorb CO_2 and exchange it with the atmosphere; CO_2 is also found in shells and on the ocean floor.

Competency-Based Questions

1. Case-based: The shrinking lake

A village in a high valley depends on a lake for water. The lake is shrinking. The farmers and shepherds graze sheep. For three winters,

(a) Name the spheres involved in this change. (soil of the pasture), biosphere (grass, sheep)

(b) Predict the effect on the sheep. Less food, less water for grass and so less food for sheep.

(c) Which idea of the chapter does this case study illustrate? Changes in the spheres affect changes in the others.

2. Case-based: Heat in the city

A student records night temperatures in a city and a village over several summer nights. The city is warmer every night. The city has many roads; the village has fields and trees.



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(a) Name the effect. The urban heat island effect.

(b) Explain why the city stays warmer at night. Concrete, brick and asphalt absorb solar radiation by day and retain it. At night they re-radiate the stored heat and keep the city air warm. Vegetation in the village cools the air through shade and transpiration.

3. Assertion-Reason

Options for Q3 to Q5: (a) Both A and R are true and R is the correct explanation of A. (b) Both A and R are true but R is not the correct explanation of A. (c) A is true but R is false. (d) A is false but R is true.

Assertion (A): Weather phenomena are confined mainly to the troposphere. **Reason (R):** In the stratosphere, temperature increases with height, so there is little vertical mixing of air.

Answer: (a). The warm-over-cool arrangement in the stratosphere keeps it calm and holds weather in the troposphere.

4. Assertion-Reason

Assertion (A): Polar regions are very cold

Answer: (c). A is true. R is false: snow and most sunlight and keep the poles cold. The latitudes also contributes.

5. Assertion-Reason

Assertion (A): Plants cannot directly use a non-reactive and must first be converted i

Answer: (a). Both true, and R explains A.

6. Data reasoning: The Keeling cur

The textbook's graph of atmospheric CO₂ wiggle every year. It starts near 315 ppm a

(a) What causes the overall rise? Burning

(b) What causes the yearly dips in the sa
each year absorbs CO₂ through photosynthesis.



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(c) Give two effects of this rise named in the chapter. Any two of: global warming from a stronger greenhouse effect, melting of glaciers and Arctic sea ice, rising sea level, more extreme weather, more acidic sea water.

7. Competency MCQ: Planetary winds

Air sinks around 30° N. Which statement is correct?

(i) It forms a low pressure belt and all of it flows to the pole. (ii) It forms a high pressure belt; part flows to the equator and part towards the poles along the surface. (iii) It forms a high pressure belt and all of it rises again at the equator without moving. (iv) It forms a low pressure belt deflected to the left.

Answer: (ii). Sinking air makes the sub-tropical high pressure belt. Part returns to the equator; part moves poleward and rises near 60° N.

8. Case-based: A green lake

Farmers near a lake apply large amounts of fertilisers and many fish die.

(a) Name the process. Eutrophication.

(b) Explain the chain from field to dead fish. Fertilisers from the field enter the lake, causing a rapid increase in algal growth (algal bloom). The bloom eventually dies and decomposes, depleting oxygen and causing fish deaths.

(c) Which cycle has been disturbed, and how? The nitrogen cycle has been disturbed because of the excessive use of fertilisers in the right amount and practise.

Important Questions for

1-Mark Questions

Q1. Choose the most appropriate option to complete the sentence. (i) To provide food directly to the consumers. (ii) To provide food indirectly to the consumers. (iii) To remove pollutants and toxins from the ecosystem. (iv) To provide food directly to the producers.

Answer: (ii).



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Q2. Which of the following is primarily responsible for warming of the Earth? (i) Solar radiation is immediately absorbed by carbon dioxide, which then releases it as heat. (ii) The atmosphere's tiny particles absorb incoming solar radiation, which directly heats the Earth. (iii) The Earth's surface absorbs solar radiation, which is then re-radiated and trapped by greenhouse gases. (iv) The Earth's environment is heated only by the solar radiation reflected by the clouds. (NCERT Exercise 2)

Answer: (iii).

Q3. What is the approximate value of the solar constant?

Answer: About 1.4 kW m^{-2} ($1400 \text{ J s}^{-1} \text{ m}^{-2}$).

Q4. Name the bacterium that converts nitrite into nitrate.

Answer: *Nitrobacter*.

2-Mark Questions

Q5. Distinguish between insolation and solar constant.

Answer: Insolation is the Sun's radiation that reaches the Earth's surface in kW m^{-2} under clear sky. The solar constant is the amount of solar radiation received per unit area perpendicular to the rays at the top of the atmosphere; it is about 1.4 kW m^{-2} .

Q6. Why is an excess of CO_2 in the atmosphere a concern? (NCERT Exercise 10)

Answer: Plants need CO_2 for photosynthesis. An excess of CO_2 intensifies the greenhouse effect, causing global warming, extreme weather, and it makes sea water more acidic.

Q7. You have witnessed weather phenomena. Which atmospheric layer is mainly responsible for its occurrence? (NCERT Exercise 6)

Answer: The troposphere. It is heated from below. It is the layer closest to the Earth's surface (about $6.5 \text{ }^\circ\text{C}$ per km). Warm air near the ground rises and carries moisture up to form clouds and rain.



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3-Mark Questions

Q8. Describe how albedo affects the Earth's surface temperature and its climate. (NCERT Exercise 4)

Answer: Albedo is the fraction of solar radiation a surface reflects. High-albedo surfaces such as snow (0.80 to 0.90) and ice (0.50 to 0.70) reflect most sunlight and stay cool, which keeps polar regions very cold. Low-albedo surfaces such as black soil and ocean water absorb more and are relatively warmer. Changes in land cover change albedo: deforestation alters surface albedo, and cities of concrete and asphalt absorb and re-radiate heat, forming urban heat islands. So albedo helps set both local temperatures and the global energy balance.

Q9. Explain how climate change affects the water cycle. Illustrate with examples. (NCERT Exercise 3)

Answer: A warmer atmosphere holds more moisture, giving heavier rain in some areas, such as intensified monsoons, and droughts elsewhere. Rising sea levels over time, threatening coastal cities. Increased rainfall increases runoff and soil erosion, and less snow means less farming hard in dry months.

Q10. How is heat lost from the surface of Earth? (NCERT Exercise 11)

Answer: The surface absorbs sunlight and warms the atmosphere. Part of this outgoing heat escapes to space as greenhouse gases (CO₂, CH₄, water vapour). This traps heat, and radiation also explains the urban heat island effect, trapping from excess greenhouse gases causing warming.

Q11. If the Earth were a flat disc instead of a sphere, how would temperature be different? (NCERT Exercise 11)

Answer: On a sphere, rays fall concentrated at the poles, giving warm equatorial and cold polar regions. On a flat disc, rays would strike every part at nearly the same angle. Temperature differences between equator and poles they create would weaken, and planetary winds would be much weaker.



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5-Mark Questions

Q12. Explain the processes involved in the nitrogen cycle. How would life on Earth be affected if nitrogen were not cycled? (NCERT Exercise 7)

Answer: Atmospheric N_2 is the largest reservoir but is non-reactive. (1) Nitrogen fixation: *Rhizobium* in root nodules of legumes and *Azotobacter* in soil convert N_2 into ammonia; lightning also fixes some nitrogen as nitrogen oxides. (2) Nitrification: *Nitrosomonas* converts ammonia to nitrite, and *Nitrobacter* converts nitrite to nitrate. (3) Assimilation: plants absorb these compounds; animals get nitrogen by eating plants or other animals. (4) Ammonification: decomposers (bacteria, fungi) break down dead matter and wastes, returning ammonia to soil. (5) Denitrification: *Pseudomonas* converts some nitrates back to N_2 , completing the cycle.

If nitrogen were not cycled, fixed nitrogen in the soil would run out, plants could not make proteins and nucleic acids, food chains would collapse and dead matter would not return its nutrients.

Q13. What are the impacts of deforestation? What are the other consequences of deforestation?

Answer: Oxygen and carbon cycles: fewer trees removed from the air and less O_2 is released. Forests act as carbon sinks, and deforestation leads to greenhouse warming. Other consequences include soil erosion, loss of biodiversity, and changes in the water cycle; surface albedo changes; without reforestation, biodiversity declines as species are destroyed.

Q14. Describe the interrelationship between the spheres of the Earth. Give an example how these spheres function in a system.

Answer: The five spheres (geosphere, hydrosphere, atmosphere, biosphere, and lithosphere) are connected by solar heating, movement of matter, and energy. One change affects the others. Example: warmer temperatures lead to more evaporation, which leads to more rainfall, which leads to more vegetation, which leads to more soil, which leads to more food for grazing sheep.



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Common Mistakes and Examiner Tips

1. **Mixing up insolation and solar constant.** Fix: the solar constant is measured at the top of the atmosphere (about 1.4 kW m^{-2}); insolation is what reaches the surface (maximum about 1 kW m^{-2}).
2. **Saying snow has low albedo because it is cold.** Fix: snow is cold *because* it has high albedo and reflects most sunlight. High albedo means more reflection.
3. **Swapping valley and mountain breezes.** Fix: valley breeze by day, blowing up the slope; mountain breeze at night, blowing down the slope. Each is named after where the air comes from.
4. **Writing that the stratosphere has weather.** Fix: nearly all weather is in the troposphere. The stratosphere is calm because temperature rises with height there.
5. **Treating all ozone as good.** Fix: stratospheric ozone blocks UV; ground-level ozone from vehicle emissions and sunlight is harmful.
6. **Getting the direction of deflection wrong.** Hemisphere and to the left in the South clockwise in the south.
7. **Mixing up Nitrosomonas and Nitrobacter.** *Nitrosomonas* does the first step (ammonia to nitrite).
8. **Confusing ammonification with nitrification.** matter (decomposers); nitrification oxidizes nitrite to nitrate.
9. **Calling the greenhouse effect harmful.** Earth warm enough for life. The problem is too warm.
10. **Forgetting units in energy numericals.** ($\times 3600$) before multiplying. Write the final answer with units.
11. **Listing spheres without linking them.** For each change in sphere A $\rightarrow$ effect in sphere B.

Quick Revision Points

- The Sun is the main source of energy; it drives energy and matter flows.
- About 99% of the Sun's energy is in the form of visible light and infrared radiation.



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- Solar constant about 1.4 kW m^{-2} ; maximum surface insolation about 1 kW m^{-2} .
- 1 m^2 at 1 kW m^{-2} for 1 hour receives $3.6 \times 10^6 \text{ J}$, one unit of electricity.
- Albedo is the fraction of radiation reflected. Snow 0.80 to 0.90, ice 0.50 to 0.70, crushed rock 0.25 to 0.30.
- Rays are concentrated at the equator and spread at the poles; shape, latitude and tilt cause uneven heating.
- Air: nitrogen 78%, oxygen 21%.
- Troposphere 0 to about 12 km, weather, temperature falls about $6.5 \text{ }^\circ\text{C}$ per km; thickest over the equator.
- Stratosphere 12 to 50 km, ozone layer, temperature rises with height.
- Greenhouse gases: CO_2 , CH_4 , water vapour. Venus is hotter than Mercury due to an uncontrolled greenhouse effect.
- CFCs caused the ozone hole; the Montreal Protocol is helping it recover.
- Wind blows from high to low pressure.
- Pressure belts: equatorial low (0°), sub-tropical high (30°), equatorial high (60°), sub-tropical low (90°).
- Winds deflect right in the north, left in the south; clockwise in the north, counter-clockwise in the south.
- Ocean currents are driven by winds, temperature differences. Atlantic Drift keeps European ports ice-free.
- Carbon: fast cycle days to years, slow cycle thousands of years. CO₂ levels have risen since 1960.
- Nitrogen: fixation (*Rhizobium*, *Azotobacter*), nitrification, assimilation, ammonification, denitrification.
- Oxygen is used in respiration, combustion; produced in photosynthesis.



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Weightage and Exam Pattern

Class 9 has no board exam. This chapter is important for internal assessments (half-yearly and annual papers), and the NCERT source is descriptive, with a few simple energy calculations, cause-and-effect chains and short numericals.

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Question type	What this chapter typically supplies
MCQ and one-word	Solar constant value, layer names and heights, albedo meaning, bacteria in the nitrogen cycle, NCERT Exercise 1 and 2
Assertion-Reason	Weather in the troposphere, albedo of snow, non-reactive N ₂ , direction of deflection
Short answer (2 to 3 marks)	Insolation versus solar constant, valley and mountain breezes, effects of excess CO ₂ , climate change and the water cycle
Long answer (5 marks)	Nitrogen cycle with its bacteria, deforestation and the carbon and oxygen cycles, interrelationship of the spheres
Case-based and numerical	Energy from insolation ($E = \text{intensity} \times \text{area} \times \text{time}$), urban heat islands, eutrophication, the Keeling curve

This chapter is the foundation for Class 10 how life sustains itself. Photosynthesis, respiration, and living things are the ideas you carry forward.



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