

Student's Learning Outcomes (SLOs)

After studying this chapter, students will be able to:

- explain thermal conduction in all solids (in terms of atomic or molecular lattice vibrations and also in terms of the movement of free (delocalized) electrons in metallic conductors.
- analyze everyday applications of conduction, convection, and radiation, (a) Heating objects such as kitchen pans (b) Heating a room by convection (c) Measuring temperature using an infrared thermometer (d) Using thermal insulation to maintain the temperature of a liquid and to reduce thermal energy transfer in buildings (e) The mechanism of a household hot-water system.
- explain convection in liquids and gases [in terms of density changes]. Justify experiments to illustrate convection.
- explain convection in seawater to support marine life.
- describe the role of land breezes and sea breezes in maintaining moderate coastal climates.
- explain how birds are able to fly for hours without flapping their wings and gliders are able to rise by riding on thermal currents.
- describe the process of thermal energy transfer by radiation [and know that it does not require a medium],
- describe the effect of surface colour and texture on the emission, absorption, and reflection of infrared radiation.
- justify qualitatively how the rate of emission of radiation depends on the surface temperature and surface area of an object.
- analyze the consequence of heat radiation in the greenhouse effect and its effect on global warming.

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

Introduction

Q.1: What is the Importance of heat and how does transfer of heat occur?

Ans. Heat: Heat is an important form of energy that is essential for life. It plays a pivotal role in cooking, maintaining our body temperature, and supporting various industrial processes.

Understanding how heat flow is important for protecting ourselves from extreme temperatures.

Heat transfer: When two objects with different temperatures come into contact, thermal energy flows from the hotter object to the cooler one, a process known as heat transfer. This is a natural occurrence that continues as long as there is a temperature difference between the objects.

Examples: Thermal energy constantly transfers from one object to another until thermal equilibrium is reached. Whether it is the Sun warming the Earth, a hot cup of coffee, or a metal rod heating when placed in a flame, heat transfer is a fundamental part of daily life.

Types of heat transfer: The three primary types of heat transfer conduction, convection, and radiation.

Understanding of these processes is important not just in nature, but also in the fields like engineering, meteorology, and technology.

11.1 Conduction

Q.2: Write a note on conduction in detail.

OR Define conduction and explain why are metals generally better conductors than non-metals?

Ans. Conduction:

"Conduction is the process of heat transfer through a material via direct contact between particles."

or "Conduction is the process by which heat is transferred through direct contact between particles in a material, without any actual movement of the material."

Explanation: It happens when fast-moving (hotter) particles collide with slow-moving (cooler) particles, transferring their kinetic energy. This method of heat transfer is most efficient in solids, especially in metals, as their particles are densely packed, and freely moving electrons facilitate the quick transfer of energy.

Q.3: Explain thermal conduction in solids in detail.

OR Why does heat travel more quickly in metals than in non-metals?

Ans. Conduction:

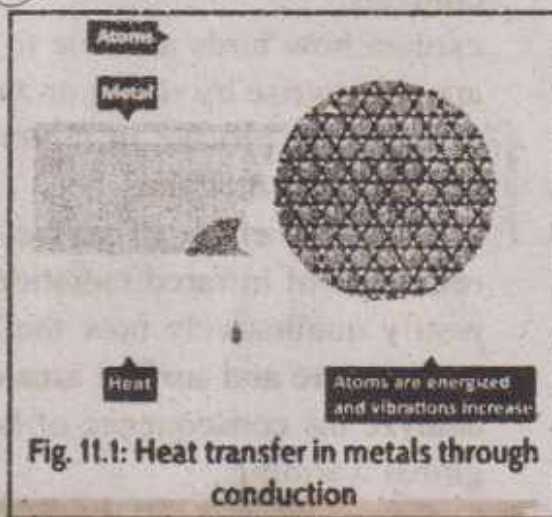
"Conduction is the process of transfer of heat from the hotter part of a substance to the colder part without the movement of the particles, and it occurs mainly in solids."

Thermal conduction in solids:

- **The microscopic mechanism:**

1. **Vibration:**

In solids, the atoms and molecules are tightly packed and constantly vibrate around



their mean positions

2. Collisions:

When one end of the solid is heated, the particles at that end begin to vibrate more vigorously.

3. Energy-Transfer:

These vibrating particles collide with nearby atoms or molecules, transferring some of their energy to them. This process causes the neighbouring particles to vibrate more rapidly and, in turn, pass some of their energy to other surrounding particles.

4. Spreading of heat:

Gradually, heat spreads throughout the solid, but the transfer is slow, with only a small amount of heat moving from the hotter to the cooler parts. In conduction, heat transfers through a solid medium due to a temperature difference.

Conduction in Metals vs Non-metals:

While both can conduct heat, metals are typically much better at it than non metals.

1. Metals:

Metals have free electrons that can move freely within the material. These electrons carry energy rapidly from hot areas to cooler areas, facilitating a much quicker transfer of energy. This is why heat moves more rapidly through metals than non-metals.

2. Non-Metals:

These materials lack free electrons and rely solely on particle to particle vibration, making the process much slower.

11.2

Convection in liquids and Gases

Q.4: Define convection? Explain convection in liquids and gasses?

OR What is convection and how it works in liquids and gases? Explain with an experiment.

Ans. Convection:

Convection is the transfer of heat through the actual movement of molecules from a hot area to a cold area.

or "Convection in the transfer of heat through liquids and gasses by the actual movement of molecules from a hotter region to a colder region."

Explanation: Liquids and gases are not very efficient in conducting heat. However, heat can still be transferred through these fluids (liquids or gasses) by a process called convection.

Process: When a liquid or gas is heated, it becomes less dense (lighter) and expands. The heated liquid or gas rises above the heat source, and cooler fluid from the surrounding area moves in to take its place. This colder fluid then gets heated as well.

Conclusion: In this way, heat is transferred through fluids by the movement of heated molecules from the hotter parts to the colder parts of the fluid.

Experiment: (For Liquid Convection)

Fill a beaker two-thirds with water and heat it by placing a burner underneath. Now drop two or three potassium permanganate crystals into the water. We will notice coloured streaks moving upward above the flame, then flowing downward along the sides, as shown in Fig. 11.2. These coloured streaks reveal the movement of currents within the liquid. But these currents stop when the burner is removed. As the water at the bottom of the beaker heats up, it expands, becoming lighter and rising. Meanwhile, the cooler, denser water sinks to replace it.

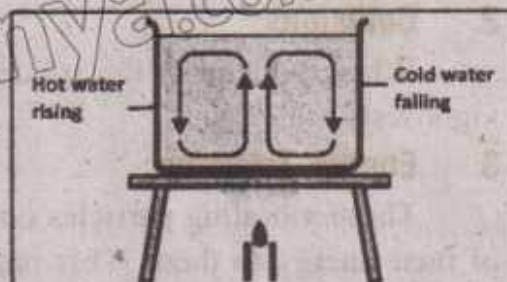


Fig. 11.2: Convection currents circulate heat as hot water rises and cold water sinks

Q.5: Write a note on convection currents in air. Explain process.

OR Explain the formation and importance of convection currents in the atmosphere?

Ans. Convection Currents:

"Convection currents are the continuous circular movements of fluid that transfer heat from hotter regions to cooler regions until the temperature becomes uniform."

Examples:

- Heating of water in a vessel.
- Sea breeze and Land breeze.
- Warm air rising from heaters.
- Hot air escaping through ventilators.

Explanation: When gasses get heated, they expand, and this creates convection currents due to the differences in air density at various points in the atmosphere.

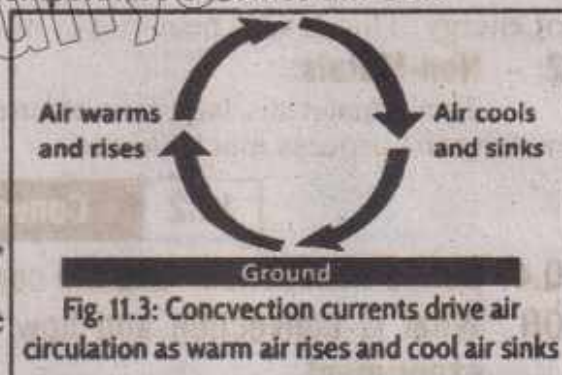


Fig. 11.3: Convection currents drive air circulation as warm air rises and cool air sinks

Process: The formation of a convection current follows a continuous cycle.

1. Heating:

The sun heats the Earth's surface. The air directly above the ground absorbs this heat through conduction.

2. Expansion and Rising:

As the air warms up, its molecules move faster and spread apart. This makes the air lighter and less dense, causing it to rise upward.

3. Cooling and Sinking:

As the warm air reaches higher altitudes, it cools down. Cooling causes the air to become denser and heavier, which makes it sink back toward the Earth's surface.

4. Replacement:

The cooler, denser air moves in to replace the rising warm air near the ground. This air is then heated, and the cycle repeats.

Natural Phenomena caused by convection: This constant movement of air creates

convection currents, which are responsible for various natural phenomena. Such as winds, sea breezes, and weather patterns. These currents help to distribute heat throughout the atmosphere, playing a vital role in regulating Earth's climate and weather.

Q.6: Discuss the various natural and practical applications of convection currents?

Ans. Atmospheric and House-hold applications:

Convection currents play a fundamental role in regulating both our indoor and outdoor environments and the earth's climate.

Heating System: Convection currents created by electric, gas, or coal heaters are used to warm our homes and offices. Central heating systems also rely on convection to distribute heat throughout the buildings.

Climate regulation: On a larger scale, convection currents occur naturally in the environment. The daily changes in temperature in the atmosphere are caused by the movement of warm or cool air.

1. Land and Sea Breezes:

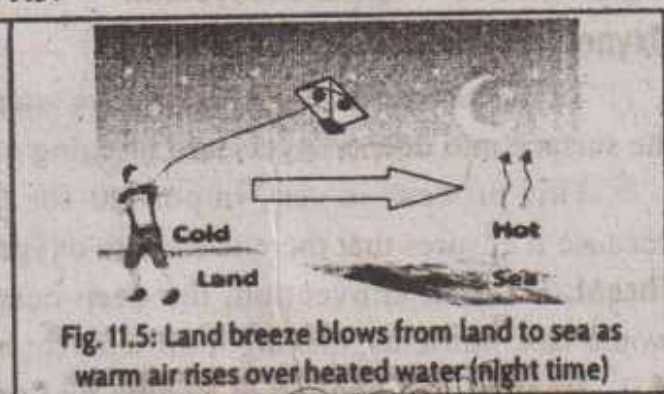
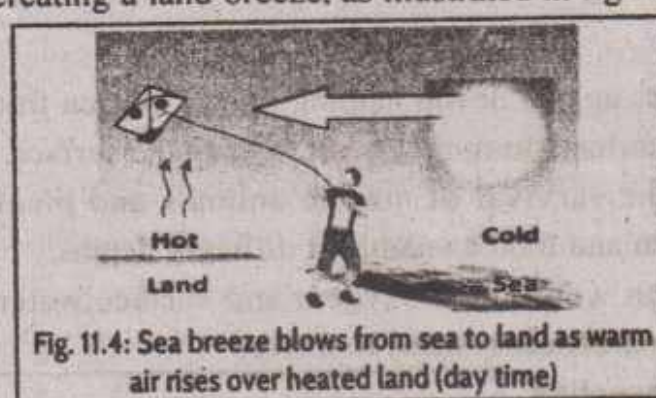
Convection drives the local winds found near coastal areas due to the different heating rates of land and water.

● Sea Breeze (Day time):

During the day, the land heats up faster than the sea due to the land's lower specific heat capacity. The warm air above the land rises, and cooler air from the sea moves in to replace it, creating a sea breeze, as shown in fig. 11.4.

● Land Breeze (Night time):

At night, land cools down more quickly than the sea. As a result, the air above the sea becomes warmer and rises, while cooler air from the land moves toward the sea, creating a land breeze, as illustrated in fig. 11.5.



2. Gliding:

Gliding is the motion of flying without continuous flapping of wings.

Glider: A glider, which is like a small plane without an engine, relies on the upward movement of warm air currents, or thermals, created by convection. (Fig. 11.6)



Gliders take advantage of these rising currents of warm air to stay in the air for

extended periods.

Gliding in birds:

Birds use thermals to stay aloft for hours without flapping their wings. They stretch their wings and circle in the thermals, allowing them to gain altitude as the warm air rises.

Examples: Birds such as eagles, hawks and vultures are especially skilled at using thermals to glide over



Fig. 11.7: Birds flying taking the advantage of thermal air currents

long distances with little effort, barely needing to flap their wings. (Fig. 11.7)

3. Convention in Seawater and Marine Life:

Convention plays an important role in sea water and is important for supporting marine life.

- **Surface Heating:**

Sunlight heats the surface of the ocean.

- **Density changes:**

As the surface water warms up, it becomes lighter (less dense) and remains at the top.

- **Sinking of cold water:**

Conversely, cooler water is denser and heavier, causing it to sink toward the ocean floor.

- **The Cycle:**

This difference in temperature and density creates continuous convection currents that move water up and down throughout the ocean depths.

Importance for Marine ecosystem:

Oxygen distribution:

These currents continuously move water up and down, helping to mix oxygen from the surface into deeper layers and bringing nutrients from the ocean floor to the surface.

This process is very important for the survival of marine animals and plants because it ensures that there is enough oxygen and food available at different depths.

Threat: Without convection, the deep ocean would lack oxygen, and surface waters would lack nutrients, making it difficult for marine ecosystems to thrive.

4. Heating and cooling of Rooms by Convection:

a. In winter:

In winter, gas heaters are often used to warm rooms. (Fig. 11.8)

Initial: When the heater is turned on, it warms the air near it.

Expansion and rising: This warm air become lighter (less dense) and rises toward the ceiling.



Fig. 11.8: Heating room by convection

Displacement: As the hot air moves up, cooler, heavier air moves down to take its place near the heater. This process is called convection current.

b. In summers:

In summers, air conditioning is used to cool the room.

Spreading of heat: It keeps the air moving and helps in spreading the heat evenly throughout the room.

Result: That is why rooms gradually become warmer without needing fans.

5. The Mechanism of a Household Hot-Water System:

Intake and heating process: In most homes, hot water is provided using a storage tank water heater.

Cold water inlet: The system works by bringing cold water into the house through pipes, where it splits into two lines. One for cold water use and one that goes into the water heater.

Heating Element: Inside the water heater, the cold water is heated using an electric heating element or a gas burner, depending on the type of system.

Density Change: As the water heats up, it becomes less dense and rises naturally to the top of the tank, while the cooler, denser water stays at the bottom.

Natural Rising: When someone turns on a hot water tap, the hot water from the top of the tank flows out easily, and new cold water enters from below to be heated.

Thermostat Control: A thermostat inside the tank controls the heating element or gas burner, ensuring that the water stays at a set temperature (Fig. 11.9).

This system ensures a steady supply of hot water.

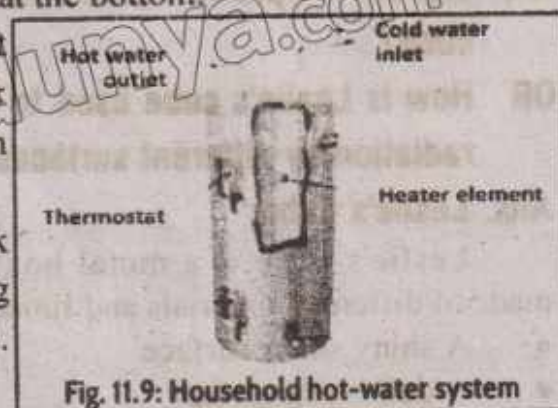


Fig. 11.9: Household hot-water system

11.3

Heat Transfer through Radiation

Q.7: Discuss the mechanism of heat transfer through radiation in detail? How it is different from conduction and convection?

Ans. Radiation: "Radiation is the process by which heat energy is transferred from one place to another in the form of electromagnetic waves."

(or) "In radiation, heat transfer occurs through electromagnetic waves without requiring a medium."

No medium: Unlike conduction and convection, radiation does not require a material medium (solid, liquid, or gas) to travel. It can move through a vacuum (empty space).

Speed: These waves travel at the speed of light.

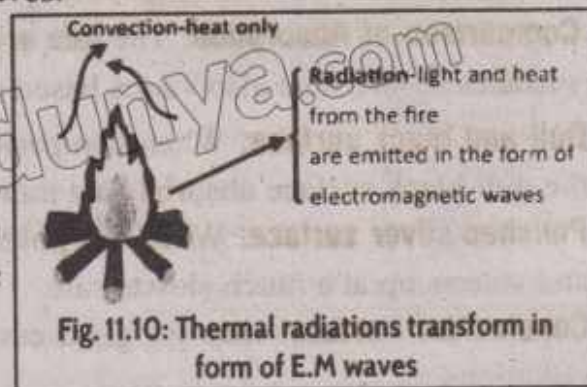


Fig. 11.10: Thermal radiations transform in form of E.M waves

The Sun: This is the primary mechanism by which the Sun heat reaches the Earth, as it must travel through the vacuum of space.

Example of Fire Place: Heat does not reach us via conduction through the air because air neither conducts heat efficiently nor transfers heat but radiation emitted is influenced by various factors, including:

- The color and texture of the surface.
- The temperature of the surface.
- The surface area.

Why objects cool or warm over time?

All objects in a room, including the walls, ceiling, and floor radiate and absorbing heat.

Cooling down: If temperature of an object is higher than that of its surroundings, it radiates more heat than it absorbs.

Warming up: If an object is colder than its surroundings, it absorbs more radiation that in emits, causing its temperature to rise.

Equilibrium: When the objects and its surroundings reach the same temperature, the rate of emission equals the rate of absorption.

Q.8: Explain the phenomenon of emission and absorption of radiation using Leslie's cube?

OR How is Leslie's cube used to demonstrate the emission and absorption of heat radiation by different surfaces?

Ans. Leslie's Cube:

Leslie's cube is a metal box with faces made of different materials and finishes, such as

- A shiny silver surface
- A dull black surface
- A white surface
- A colored surface.

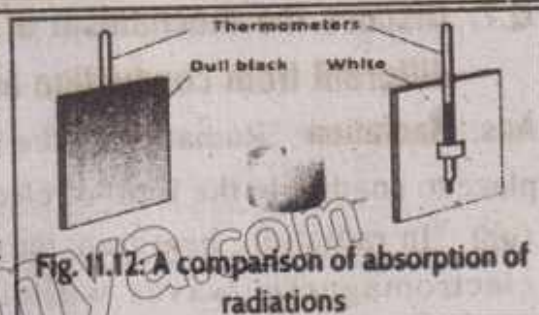
Observation: When the cube is filled with hot water, and one face is directed towards a radiation detector, it is found that the dull black surface is the most effective emitter of heat. (Fig. 11.11)

Comparison of Absorption: The rate at which different surfaces absorb heat also varies based on their nature.

Dull and black surface: When comparing a dull black surface with a polished silver one, the dull black surface absorbs heat more rapidly, causing its temperature to rise quickly.

Polished silver surface: While the polished silver surface absorbs heat much more slowly and warms up at a much slower rate.

Conclusion: Surfaces that are good emitters (like dull black) are also good absorbers of radiations.



Q.9: How do surface color and texture affect infrared radiation?

Ans. The color and texture of a surface have a strong effect on how it emits, absorbs, and reflects infrared radiation.

- **Dull and dark colored surfaces:**

These are very good absorbers and emitters of infrared radiation. This is why a dull black surface heats up quickly but also cools down faster by giving off more heat.

- **Shiny and light colored surface:**

These are poor absorbers and emitters. Instead, they reflect most of the infrared radiation away. This is why shiny surfaces, like polished metals, stay cooler under the Sun compared to dark surfaces.

Texture: The texture also matters.

- **Rough surfaces:** Rough surfaces absorb and emit radiation better.

- **Smooth surfaces:** Smooth surfaces tend to reflect more radiation.

Q.10: Discuss the impact of surface temperature and surface area on the rate of heat transfer through radiation. Additionally, explain the function and practical applications of an infrared thermometer?

Ans. **Impact of surface temperature and surface area on the rate of heat transfer:**

The rate at which an object emits radiation is significantly influenced by two main factors:

- Surface temperature
- Surface Area

1. **Surface temperature:**

Hotter objects emit more energy and heat compared to cooler ones. For instance, a hot iron rod will glow and release more heat than one that is merely warm.

2. **Surface area:**

An object with a larger surface area can emit or absorb heat at a much faster rate. This principle is used in room radiators, which are designed with many thin slots or fins to increase their surface area. This allows for more radiation to occur simultaneously, making heat transfer more efficient without the radiator taking up excessive space.

Both a higher surface area and a higher surface temperature work together to help an object emit thermal energy more rapidly via radiation.

Measuring temperature using an Infrared thermometer:

An infrared thermometer is a device used to measure the temperature of objects without need to make physical contact.

Working: The device detects the infrared radiation (heat) emitted by an object. To use it, a person points the thermometer at the target, presses the trigger, and reads the temperature, displayed on the screen.



Fig. 11.13: Infrared thermometer

Practical Applications: These thermometers are highly versatile and were used extensively during the COVID-19 pandemic to safely check body temperatures. They are

also useful for monitoring the heat of ovens machinery and dangerous materials, such as radioactive substances, where contact is not possible or safe.

Q.11: Discuss the applications of heat transfer in daily life?

OR Describe how heat transfer is used in common household and industrial activities?

Ans. 1. Heating objects such as kitchen pans:

In many daily tasks, we rely on materials that are good conductors to transfer heat quickly and evenly.

Kitchen Pans: One everyday application of heat transfer is when we cook food using kitchen pans. Cooking pans are typically made of metal because metals are excellent conductors.

Mechanism: When a pan is placed on a stove, heat from the flame or heating element transfers to the pan mainly by conduction.

Result: This causes the entire pan to become hot, allowing food placed inside to cook evenly.

2. Using Thermal insulation to maintain the Temperature of a liquid:

Conduction is often something we want to prevent to maintain the temperature of liquids. Thermal insulation helps to keep hot things hot and cold things cold.

Example: A Thermos flask (vacuum flask) has double walls with a vacuum between them.

The vacuum stops heat transfer by conduction and convection because there is no air or material to move heat. The inside walls of the flask are coated with a reflective layer (silvered coating) that bounces back radiation to keep the liquid warm.

The outer casing and lid are made of insulating materials like plastic or stainless steel to prevent heat loss. This smart design helps liquids like tea, coffee, or soup to stay at the right temperature for many hours.

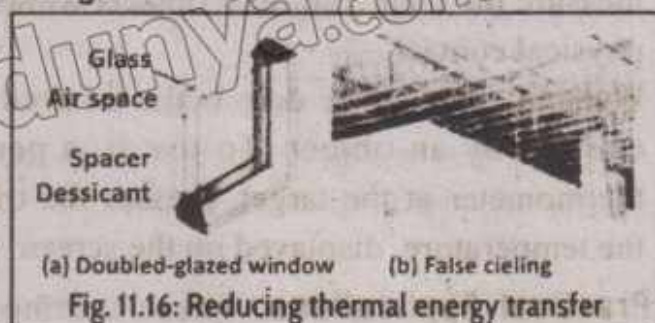
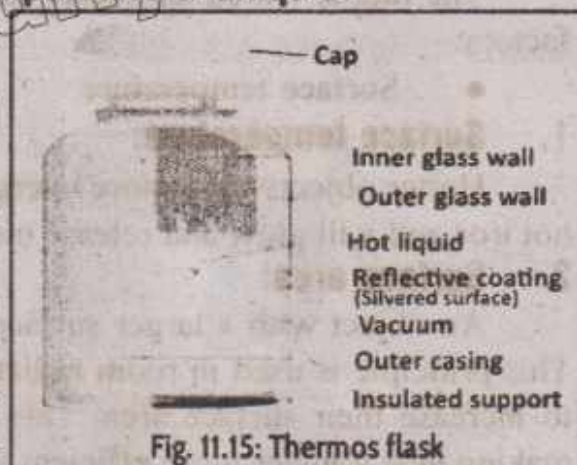
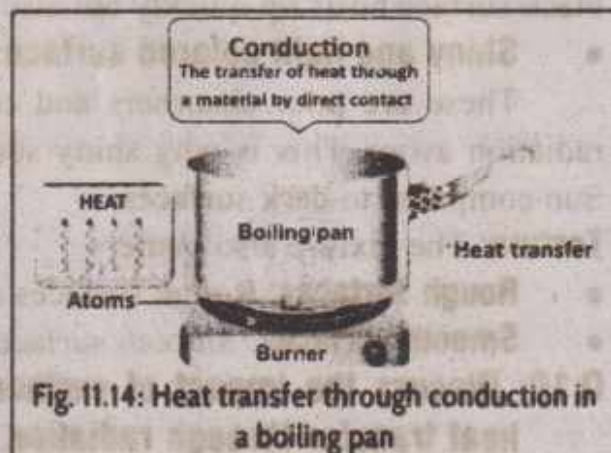
3. Reducing Thermal energy transfer in buildings:

Thermal insulation in buildings helps to keep them warm in winter and cool in summer.

Wall and Ceiling Insulation:

Adding thick curtains, foam in the walls, or false ceilings creates barriers that slow down the transfer of thermal energy.

Double-Gazed windows: These consist of two panes of glass with an air space between



them to reduce heat loss through conduction.

Benefits:

- We can reduce heat loss through conduction, convection and radiation.
- In cold weather, insulation stops warm indoor air from escaping.
- In hot weathers, it prevents heat from escaping.
- It reduces the need for heaters and air conditioners, saving energy and lowering costs.
- Even simple ideas like using proper shading outside the windows or ensuring good ventilation can make a big difference in controlling indoor temperature.

11.4

Greenhouse Effect

Q.12: Explain the greenhouse effect in detail. How does it occur in the Earth's atmosphere, and what role do greenhouse gases play in trapping heat?

Ans. Greenhouse Effect:

The greenhouse effect refers to the process by which the Earth's atmosphere traps some of the Sun's heat, maintaining a temperature that is suitable for life.

Without this effect, the planet would be too cold to support life as we know it.

Temperature regulation in a Greenhouse:

A physical greenhouse uses transparent materials such as glass or plastic, to create a heat trap. The mechanism involves:

Radiation Entry: The Sun emits short-wavelength light and ultraviolet radiation, along with long-wavelength thermal (infrared) radiations.

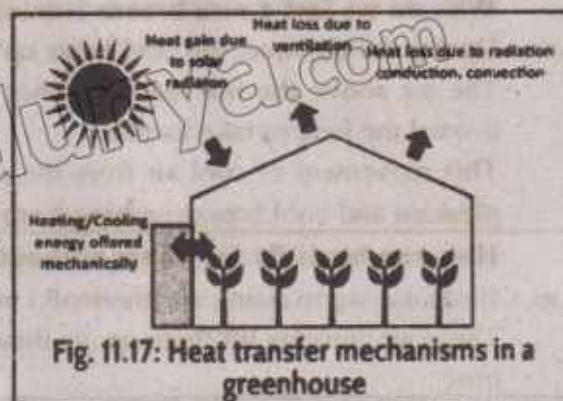
Selective Transparency: Glass and plastic allow short-wavelength radiations to pass through but block long-wavelength infrared radiation.

Internal Heating: Rays from the sun warm the object inside the greenhouse. These warmed objects then emit radiations with longer wavelengths.

Heat Trapping: The glass or plastic sheets prevent these longer-wavelength radiations from escaping, reflecting them back inside. This maintains a warm environment that benefits plant growth.

Greenhouse Effect on Earth: The Earth's atmosphere functions in a similar way to a Greenhouse, trapping heat from the Sun with gases, such as carbon dioxide and water vapours.

Global Warming: This helps to maintain the Earth's atmosphere. In recent years, the carbon dioxide in the atmosphere has increased significantly, strengthening the greenhouse effect. As a result, more heat is trapped, leading to a rise in the Earth's average temperature, a phenomenon known as global warming. This increase in temperature has serious implications for global climate patterns.



FOR YOUR INFORMATION



DO YOU KNOW?

Heat is transferred to an object, for example, how the stove "heats" the pot.



- Convection is when liquid or gases get heated.
- Conduction is when something is hot and it touches another object and it becomes hot.
- Radiation is when energy travels through E.M. waves to heat something up.
- Dull black surfaces absorb and emit more heat than shiny surfaces that is why solar panels are black.
- Greenhouse gases absorb solar energy and trap it in the atmosphere.
- Without greenhouse gases creating what is known as the "Greenhouse Effect" the Earth would not be warm enough for human to live.

Tidbits

Diamonds are the best heat conductors, far better than metals. A high quality diamond can conduct heat 4-5 times better than copper.

The handle of a cooking pan stays cool because it is made of poor conductors like wood or plastic.

Heat from the Sun reaches us through radiation, no air needed, just pure energy traveling across space.

The public has been led to believe that increased carbon dioxide from human activities in causing a greenhouse effect that is heating the planet. But carbon dioxide comprises only 0.035% of our atmosphere and is a very weak greenhouse gas.

Brain Teaser

1. Why do we feel a nice breeze coming from the sea during the daytime at the beach?

Ans. During the daytime, the land heats up faster than the sea because land absorbs heat more quickly. The air above the hot land becomes warm and rises up. Cooler air from the sea then moves toward the land to take its place. This movement of cool air from the sea to the land is called a sea breeze. This is why we feel a pleasant and cool breeze coming from the sea during the day at the beach.

2. How can birds fly for hours without moving their wings much in sunny weather?

Ans. Birds use warm rising air (thermals) in sunny weather to glide in the sky. These air currents lift them up, so they do not need to flap their wings much and can fly for a long time.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

11.1

Conduction

1. **Conduction is the primary method of heat transfer in:**
(a) Vacuums (b) Gases (c) Liquids (d) Solids
2. **Heat transfer in metals is fast because of:**
(a) Large atomic size (b) Expansion of particles
(c) Freely moving electrons (d) Movement of the material itself
3. **Which material would be the worst conductor of heat?**
(a) Copper (b) Aluminum (c) Wood (d) Iron
4. **A high-quality diamond conducts heat how much better than copper?**
(a) 2 times (b) 4-5 times (c) 10 times (d) 100 times
5. **Thermal equilibrium is reached when:**
(a) One object is hotter than the other
(b) Temperature difference between objects is zero
(c) Particles stop vibrating (d) Heat flows from cold to hot.
6. **In conduction, particles transfer energy by:**
(a) Changing their position (b) Colliding with neighboring particles
(c) Emitting E.M waves (d) Melting
7. **Kitchen pans are made of metal because metals:**
(a) Quickly absorb and pass heat (b) Are easy to clean
(c) Do not expand (d) Are insulators
8. **What stops heat transfer in a vacuum flask?**
(a) Silver coating (b) Plastic cap
(c) The vacuum between double walls (d) The glass material
9. **Double-gazed windows use a layer of air to**
(a) Increase radiation (b) Reduce heat loss via conduction
(c) Improve visibility (d) Allow convection
10. **The handle of cooking pan stays cool because it is made of:**
(a) Good conductors (b) Poor conductors (Insulators)
(c) Reflective metals (d) Polished silver

11.2

Convection in liquids and Gases

11. **Convection occurs in:**
(a) Solids and liquids (b) Liquids and gases
(c) Solids only (d) Vacuums only

12. When a fluid heated it:
(a) Becomes denser and sinks (b) Becomes less dense and rises
(c) Contracts and stays at the bottom (d) Stops moving
13. Potassium permagnate crystals in water are used to show:
(a) Conduction (b) Convection currents
(c) Radiation (d) Evaporation
14. Sea breeze blows during the:
(a) Day (b) Night (c) Winter only (d) Evening only
15. A Land breeze occurs because:
(a) Sea cools faster than land (b) Land cools faster than the sea
(c) The sun warms the water at night (d) Air moves from sea to land
16. Birds like eagles and vultures stay aloft for hours by using:
(a) Conduction (b) Radiation
(c) Thermals (d) Flapping wings constantly
17. In a house hold hot-water system, the hot water outlet is at the:
(a) Top of the tank (b) Bottom of the tank
(c) Middle of the tank (d) Outside the tank
18. Convection is essential for marine life because it:
(a) Heats the water of boiling (b) Mixes oxygen and brings up nutrients
(c) Stop water from moving (d) Keeps the salt at the bottom
19. To cool a room efficiently, an air conditioner should be placed:
(a) Near the floor (b) Near the ceiling (c) Behind a curtain (d) under a table
20. Why do convection currents stop when a burner is removed?
(a) The water disappears
(b) Temperature becomes uniform (equilibrium)
(c) The water becomes lighter (d) Gravity stops working

11.3

Heat Transfer through Radiation

21. Radiation is unique because it:
(a) Only happens in solids (b) Does not require a medium
(c) Is very slow (d) Only happens at night
22. Thermal radiation travels in the form of:
(a) Sound waves (b) Water waves
(c) Electromagnetic waves (d) vibrating atoms
23. Which surface is the best absorber of infrared radiation?
(a) Dull black (b) Shiny silver (c) Polished white (d) Smooth glass
24. Which surface is the best reflector of radiation?
(a) Rough black (b) Dull grey (c) Shiny silver (d) Dark green
25. Leslie's cube is used to study:
(a) Convection speed (b) Conduction in metals
(c) Emission and absorption of radiation (d) The green house effect

26. Hotter objects emit _____ radiation compared to cooler ones.
 (a) More (b) Less
 (c) The same amount of (d) No
27. Radiators have thin slots or fins to increase:
 (a) Temperature (b) Density (c) Surface area (d) Weight
28. An infrared thermometer detects heat without touching an object by measuring:
 (a) Conduction (b) Convection (c) Radiation (d) Specific heat
29. Solar planets are usually black because they need to:
 (a) Reflect sunlight (b) Absorb maximum heat
 (c) Stay cool (d) Look better
30. Rough surfaces _____ radiation better than smooth surfaces.
 (a) Absorb and emit (b) Reflect (c) Block (d) Insulate

11.4

Greenhouse Effect

31. The greenhouse effect is necessary because it:
 (a) Causes global warming (b) Maintains a temperature suitable for life
 (c) Stops all sunlight from reaching Earth (d) Makes the air thinner
32. Transparent glass in a green house allows _____ radiation to pass through:
 (a) Short wave-length (b) Long wave-length
 (c) Sound (d) Microwave
33. The Earth's atmosphere traps heat primarily using:
 (a) Oxygen and Nitrogen (b) Carbon dioxide and water vapour
 (c) Helium and Neon (d) Hydrogen
34. Without the greenhouse effect, Earth's temperature would be about:
 (a) 60 °F (b) 32 °F (c) 0 °F (d) -100 °F
35. The increase in CO₂ in recent years has led to:
 (a) Global cooling (b) Global warming
 (c) More conduction (d) A thicker ozone layer
36. Greenhouse glass blocks _____ radiation from escaping:
 (a) Short-wavelength (b) Long-wavelength
 (c) Ultra violet (d) Visible light
37. A thermos flask is silvered to reduce heat loss by:
 (a) Conduction (b) Convection (c) Radiation (d) Insulation
38. Air is a poor conductor, therefore, it acts as a good:
 (a) Radiator (b) Absorber (c) Insulator (d) Reflector
39. The movement of a glider is an example of:
 (a) Conduction (b) Convection (c) Radiation (d) Friction
40. Which process explains why a hand held beside a fire feels warm?
 (a) Conduction (b) Convection (c) Radiation (d) Sublimation
41. Shiny surfaces stay _____ under the Sun compared to dark surfaces:
 (a) Hotter (b) Cooler (c) The Same (d) Liquid

42. Carbon dioxide comprises _____ of our atmosphere.
(a) 10 % (b) 1 % (c) 0.035 % (d) 21 %

Answers

- | | | | | | | |
|---------|---------|---------|---------|---------|---------|---------|
| 1. (d) | 2. (c) | 3. (c) | 4. (b) | 5. (b) | 6. (b) | 7. (a) |
| 8. (c) | 9. (b) | 10. (b) | 11. (b) | 12. (b) | 13. (b) | 14. (a) |
| 15. (b) | 16. (c) | 17. (a) | 18. (b) | 19. (b) | 20. (b) | 21. (b) |
| 22. (c) | 23. (a) | 24. (c) | 25. (c) | 26. (a) | 27. (c) | 28. (c) |
| 29. (b) | 30. (a) | 31. (b) | 32. (a) | 33. (b) | 34. (c) | 35. (b) |
| 36. (b) | 37. (c) | 38. (c) | 39. (b) | 40. (c) | 41. (b) | 42. (c) |

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

11.1

Conduction

1. What is conduction?

Ans. It is the transfer of heat through direct contact between particles in a material without the actual movement of the material itself.

2. Why are metals better conductors than non-metals?

Ans. Metals have densely packed particles and freely moving electrons that facilitate the quick transfer of energy.

3. In which state of matter is conduction most efficient?

Ans. In solids, conduction is most efficient.

4. How does a heat travel through a metal rod?

Ans. Heated particles vibrate more vigorously and collide with neighboring atoms, transferring kinetic energy along the rod.

5. What is thermal equilibrium?

Ans. The state where thermal energy has transferred until two objects reach the same temperature and heat flow stops.

6. Why does a metal spoon feel hotter than a wooden spoon in hot water?

Ans. Metal is a good conductor that transfer heat quickly, while wood is a poor conductor (insulator). That's why metal spoon feel hotter than a wooden spoon in hot water.

7. What is the "best" known heat conductor?

Ans. High-quality diamond (Conducts 4-5 times better than copper).

8. How do kitchen pans use conduction?

Ans. The metal bottom absorbs heat from the burner and passes it directly to the food through the surface.

11.2

Convection in liquids and Gases

9. Define Convection?

Ans. The transfer of heat through the actual movement of molecules from a hot area to a

cooler area in liquids and gases.

10. Why does heated fluid rise?

Ans. When heated, fluid expands, become less dense (lighter), and are pushed upward by cooler, denser fluid.

11. What is a convection current?

Ans. The continuous cycle of warm fluid rising and cool fluid sinking to take its place.

12. Describe a "sea breeze".

Ans. During the day time air over the land rises, and cooler air from the sea moves in to replace it.

13. Describe a "Land breeze".

Ans. At night, land cools faster than the sea, the warm air over the sea rises, and cool air from the land moves toward the sea.

14. How do gliders stay in the air without an engine?

Ans. They use "thermals"; which are upward moving currents of warm air created by convection.

15. Why is convection important for marine life?

Ans. It moves oxygen from the surface to deeper layers and brings nutrients from the ocean floor to the surface.

16. Where should a heater be placed in a room for maximum efficiency?

Ans. Near the floor, so the rising warm air creates a convection current to warm the entire room.

17. How does a house holed hot water system use convection?

Ans. Hot water becomes less dense and rises to the top of the storage tank, where the outlet is located.

11.3

Heat Transfer through Radiation

18. What is Radiation?

Ans. Heat transfer through electromagnetic waves that does not require a medium (can travel through a vacuum).

19. How does the Sun's heat reach the Earth?

Ans. Through radiation, the Sun's heat reach the Earth.

20. Which surface color is the best absorber of radiation?

Ans. Dull black surface color is the best absorber of radiation.

21. Which surface color is the best reflector of radiation?

Ans. Shiny or silver surfaces is the best reflector of radiation.

22. What is Leslie's cube used for?

Ans. To demonstrate how different surface textures and colors emit and absorb radiation at different rates.

23. How does surface area affect radiation?

Ans. A larger surface area allows an objects to emit or absorb heat more quickly.

24. Why do radiators have "fins"?

Ans. To increase the surface area, making heat transfer more efficient.

25. How does an infrared thermometer work?

Ans. It detects the infrared radiation (heat) emitted by an object and converts it into a temperature reading.

26. What is the purpose of a vacuum in a thermos flask?

Ans. It stops heat transfer by conduction and convection because there are no particles to move the heat.

27. Why is the inner wall of a thermos flask silvered?

Ans. To reflect radiation back into the liquid, preventing heat loss.

28. What is double-glazing?

Ans. Windows with two panes of glass and an air space between them to reduce heat loss via conduction.

29. How do false ceilings help in buildings?

Ans. They trap a layer of air, which acts as an insulator to reduce thermal energy transfer.

11.4

Greenhouse Effect

30. What is the Greenhouse Effect?

Ans. The process by which the Earth's atmosphere traps some of the Sun's heat to maintain a temperature suitable for life.

31. Name two major greenhouse gasses?

Ans. • Carbon dioxide (CO_2)
• Water vapours

32. What is Global warming?

Ans. The rises in Earth's average temperature due to increased levels of greenhouse gasses trapping more heat.

33. What would happen to Earth without the greenhouse effect?

Ans. The planet would be too cold to support life as we know it.

34. Why are solar panels usually black?

Ans. Dull black surfaces absorb the most solar radiation, maximizing energy collection.

Exercise Questions (Solved)

A. Multiple Choice Questions

★ Tick (✓) the correct answer.

11.1 Which method of heat transfer requires direct contact between particles?

- (a) Convection (b) Radiation (c) Conduction (d) Evaporation

11.2 What causes convection currents in liquids and gases?

- (a) The continuous movement of particles in all directions
(b) The rising of warm regions and sinking of cooler regions
(c) The conduction of heat through the medium
(d) The reflection of heat waves

11.3 The natural phenomenon caused by convection currents is:

- (a) earthquakes
- (b) land and sea breezes
- (c) magnetic fields
- (d) solar eclipses

11.4 How does heat transfer occur through radiation?

- (a) Through direct contact between objects
- (b) Through the movement of heated fluid
- (c) Through electromagnetic waves without needing a medium
- (d) Through the absorption of water molecules

11.5 The surface which absorbs and emits the most radiation is:

- (a) smooth and shiny surfaces
- (b) dark and rough surfaces
- (c) transparent and thin surfaces
- (d) polished and white surfaces

11.6 What is the role of the greenhouse effect in Earth's temperature regulation?

- (a) It allows all heat to escape into space
- (b) It blocks heat from entering the atmosphere
- (c) It traps heat to maintain a stable temperature
- (d) It causes immediate cooling of Earth's surface

11.7 The Sun's heat reaches the Earth:

- (a) through conduction between air particles
- (b) through convection in space
- (c) through radiation via electromagnetic waves
- (d) through reflection by the moon

Answers

11.1 (c) 11.2 (b) 11.3 (b) 11.4 (c) 11.5 (b) 11.6 (c) 11.7 (c)

B. Short Answer Questions

11.1 What are the three primary types of heat transfer?

Ans. The three primary types of heat transfer are:

- Conduction
- Convection
- Radiation

11.2 Why does heat travel faster in metals compared to non-metals?

Ans. Heat travels faster in metals compared to non-metals because metals have free electrons that move easily and transfer energy quickly.

11.3 How does convection transfer heat in liquids and gases?

Ans. Convection transfers heat in liquids and gases by the movement of warm fluid (liquid and gases) that rise and are replaced by cooler fluids.

11.4 What natural phenomenon causes land and sea breezes?

Ans. Land and sea breezes are caused by the difference in heating rates between land and water.

11.5 How do birds and gliders take advantage of convection currents?

Ans. Birds and gliders take advantage of rising warm air currents (thermals) which lift

them upward without much wing flapping.

11.6 What is radiation, and how does it transfer heat?

Ans. Radiation is the transfer of heat through electromagnetic waves and does not require a medium (it can travel through space).

11.7 Why does a dull black surface emit and absorb more radiation than a shiny silver surface?

Ans. A dull black surface absorbs and emits more radiation because dark and rough surfaces are good absorbers and emitters, while shiny silver surfaces reflect heat.

11.8 How does the greenhouse effect help regulate Earth's temperature?

Ans. The greenhouse effect helps regulate Earth's temperature by trapping some of the Sun's heat in the atmosphere, keeping the planet warm enough for life.

C. Constructed Response Questions

11.1 During the Leslie's Cube experiment, why does the dull black surface radiate more heat than the shiny silver one, even though they are at the same temperature?

Ans. In Leslie's Cube experiment, the dull black surface radiates more heat because black and rough surfaces are better emitters of radiation. The shiny silver surface reflects most heat and emits less, even at the same temperature.

11.2 How does the size (surface area) of a radiator affect the amount of heat it emits through radiation? Explain using a real-world example.

Ans. A larger surface area emits more heat because more area is available to radiate energy.

Example:

A big room heater warms a room faster than a small one because it has a larger radiating surface.

11.3 Why is convection not possible in solids, and how do convection currents in liquids and gases compensate for their poor thermal conductivity?

Ans. Convection is not possible in solids because solid particles are tightly packed and cannot move freely. In liquids and gases, particles can move, so warm parts rise and cool parts sink, transferring heat effectively.

11.4 How do birds like eagles and gliders manage to stay aloft without flapping their wings for hours? Explain the scientific principle involved.

Ans. Birds like eagles and gliders stay aloft by using thermals (rising warm air). Warm air rises due to lower density, carrying them upward without constant flapping their wings.

11.5 Why does a hot metal object placed in a cooler room eventually cool down? Explain using the concepts of radiation and thermal equilibrium.

Ans. A hot metal object cools in a cooler room because it radiates heat to the surroundings. Overtime, it reaches thermal equilibrium, where its temperature becomes equal to the room temperature.

D. Comprehensive Questions

11.1 Describe how convection occurs in fluids. How do convection currents contribute to natural phenomena such as sea breezes and wind patterns?

Ans. • Convection is the process of heat transfer in fluids (liquids and gases) by the movement of the fluid itself. It occurs when a fluid is heated unevenly. The warmer, less dense part of the fluid rises, while the cooler, denser part sinks. This creates a circular motion known as a convection current.

- Sea breezes are a result of convection. During the day, land heats up faster than the sea. The warm air above the land rises, creating a low-pressure area. Cooler air from over the sea then flows in to replace the rising warm air, creating a sea breeze.
- Wind patterns are also influenced by convection. Uneven heating of the Earth's surface, particularly between the equator and the poles, creates large-scale convection currents in the atmosphere. Warm air rises at the equator and moves towards the poles, while cooler air sinks at the poles and moves towards the equator. These convection currents, along with the Earth's rotation, create global wind patterns.

11.2 How does radiation differ from conduction and convection in terms of heat transfer? Give examples of radiation in everyday life and explain how different surfaces affect radiation absorption and emission.

Ans. • Radiation is the transfer of heat through electromagnetic waves. Unlike conduction and convection, radiation does not require a medium to transfer heat; it can occur in a vacuum.

- Examples of radiation in everyday life include the warmth felt from the sun, the heat from a light bulb, and the heat radiated by a fire.
- Different surfaces affect radiation absorption and emission differently. Dark, rough surfaces are good absorbers and emitters of radiation, while light, smooth surfaces are poor absorbers and emitters but good reflectors. For example, a black car heats up more quickly in the sun than a white car because black surfaces absorb more solar radiation.

11.3 Discuss the role of the greenhouse effect in regulating Earth's temperature. What are the potential consequences of an enhanced greenhouse effect due to human activities?

Ans. • The greenhouse effect is the process by which certain gases in the Earth's atmosphere trap thermal radiation, warming the planet. These gases, known as greenhouse gases (e.g., carbon dioxide, methane, water vapor), allow sunlight to pass through but absorb the infrared radiation emitted by the Earth's surface.

- The greenhouse effect is essential for regulating Earth's temperature, making it

habitable. Without it, the Earth would be much colder.

- An enhanced greenhouse effect, caused by increased concentrations of greenhouse gases due to human activities (e.g., burning fossil fuels, deforestation), can lead to global warming and climate change. Potential consequences include rising sea levels, more frequent and intense heatwaves, changes in precipitation patterns, and disruptions to ecosystems.

11.4 Compare the absorption and emission of heat by different surfaces. How does the colour and texture of a surface affect its ability to absorb and emit heat?

Ans. • Different surfaces absorb and emit heat differently based on their properties.

Dark-colored surfaces absorb more heat than light-colored surfaces. Rough surfaces emit heat more effectively than smooth surfaces.

- The color of a surface affects its ability to absorb and emit heat because dark colors absorb more electromagnetic radiation across the spectrum, including visible light and infrared radiation (heat). Light colors reflect more radiation.
- The texture of a surface affects its ability to emit heat because rough surfaces have a larger surface area for radiation to escape from, and they also tend to have higher emissivity (the ability to emit thermal radiation). Smooth surfaces have lower emissivity.

11.5 Analyze how uneven heating of Earth's surface leads to the formation of convection currents and influence with patterns.

Ans. • Uneven heating of Earth's surface occurs because different parts of the Earth receive varying amounts of solar radiation. The equator receives more direct sunlight than the poles, leading to warmer temperatures.

- This uneven heating creates temperature gradients, which drive the formation of convection currents. Warm air at the equator rises, creating a low-pressure zone, while cold air at the poles sinks, creating a high-pressure zone.
- These convection currents influence wind patterns. Air flows from high-pressure areas to low-pressure areas, creating winds. The Coriolis effect, caused by Earth's rotation, deflects these winds, resulting in global wind patterns such as trade winds and westerlies.

