
PHYSICS
Heat Capacity and
Modes of Heat Transfer
Unit 10 Overview
1 Quick Revision Sheet Notes
2 Topical Wise Notes with Detailed Theory
3 Key Info Boxes with Detailed Explanation
4 Short Response Questions (Hot Questions)
5 MCQs with Explanation
6 Exercise Short Questions with MCQs
7 Exercise Numericals
Physics
Unit 10 Overview
SBBM
Notes Series

Quick Review Sheet

Notes

SBBM ONE PAGE REVISION NOTES

SPECIFIC HEAT CAPACITY

Specific heat capacity (c) is the amount of **heat** required to change the temperature of 1 kg of its substance by 1 degree celsius.

$$c = \frac{Q}{m\Delta T} \quad (10.1)$$

Where 'c' is is the specific heat of the material, 'Q' is the amount of heat absorbed or lost, Joules; m'is the mass of the substance (kg) and 'ΔT (I.e., $T_{final} - T_{initial}$) is' the $T_{initial} - T_{initial}$) is the change in temperáure (K or °C).

SI Unit: joule per kilogram per kelvin (J/kg K)

Other Units: J/g °C or cal/g °C

USES OF LARGE SPECIFIC HEAT OF WATER

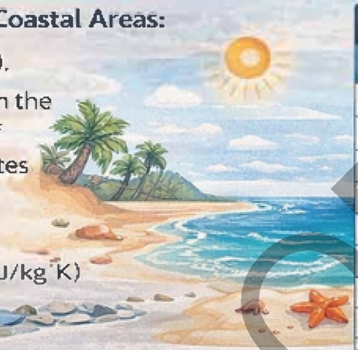
A. Temperature Variation in Land and Coastal Areas:

Water has a large specific heat (4200 J/kg'K').

- Oceans and lakes absorb a lot of heat from the sun during the summer and release a lot of heat to the atmosphere in winters, moderates coastal temperatures, keeping them lower in the summer and higher in the swinter.

Water has a large specific heat (4200 J/kg K)

SBBM Notes @ sbbmnotes



SPECIFIC HEATS OF SELECTED SUBSTANCES	
Materials	**Specific heat J/kg K**
Aluminum	900
Copper	387
Glass	840
Gold	129
Iron / Steel	452
Lead	128
Silver	235
Ethanol	2450
Oxygen	651

10.3 APPLICATIONS OF HEAT TRANSFER

APPLICATIONS OF HEAT TRANSFER

(CONDUCTION, CONVECTION, RADIATION)

COOKING IN KITCHEN PANS

Cooking involves all three types of heat transfer.

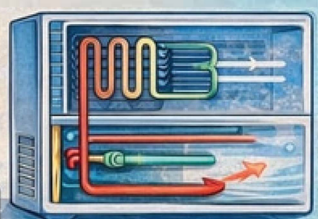
- **Radiation:** Infrared from the flame transfers heat to the pan.
- **Conduction:** The metal pan transfers heat to its contents from its base
- **Convection:** Water in the pot heats up and the hot water rises while cooler water sinks, creating convection currents.

✓ This is how food is cooked evenly.

HOUSEHOLD REFRIGERATORS

1. The **compressor** compresses the refrigerant gas, increasing its pressure and temperature.
2. Condenser coils release heat to the surrounding air mainly by convection.
3. The refrigerant passes through an expansion valve.
4. Evaporator absorbs heat from the fridge's air.

✓ Freezer is located at the top because cold air sinks while warm air rises, keeping the lower part of the fridge cooler.



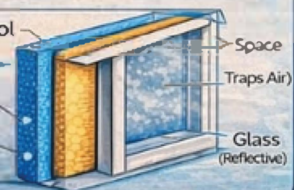
THERMOS BOTTLES

The thermos bottles vacuum walls minimize heat transfer by conduction, and convection, while the shiny reflective lining reduces heat loss by radiation, keeping drinks hot or cold by minimizing heat transfer

- Conduction
- Space (Vacuum)
- Reflective (Radiation)

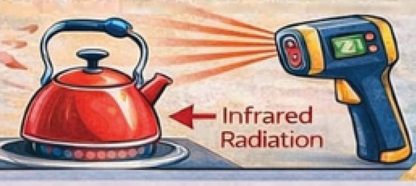
INSULATING BUILDINGS

Insulating materials (glass wool) reduce heat transfer mairlyby conduction, and also by convection, keeping buildings warmer in winter and cooler in summer.

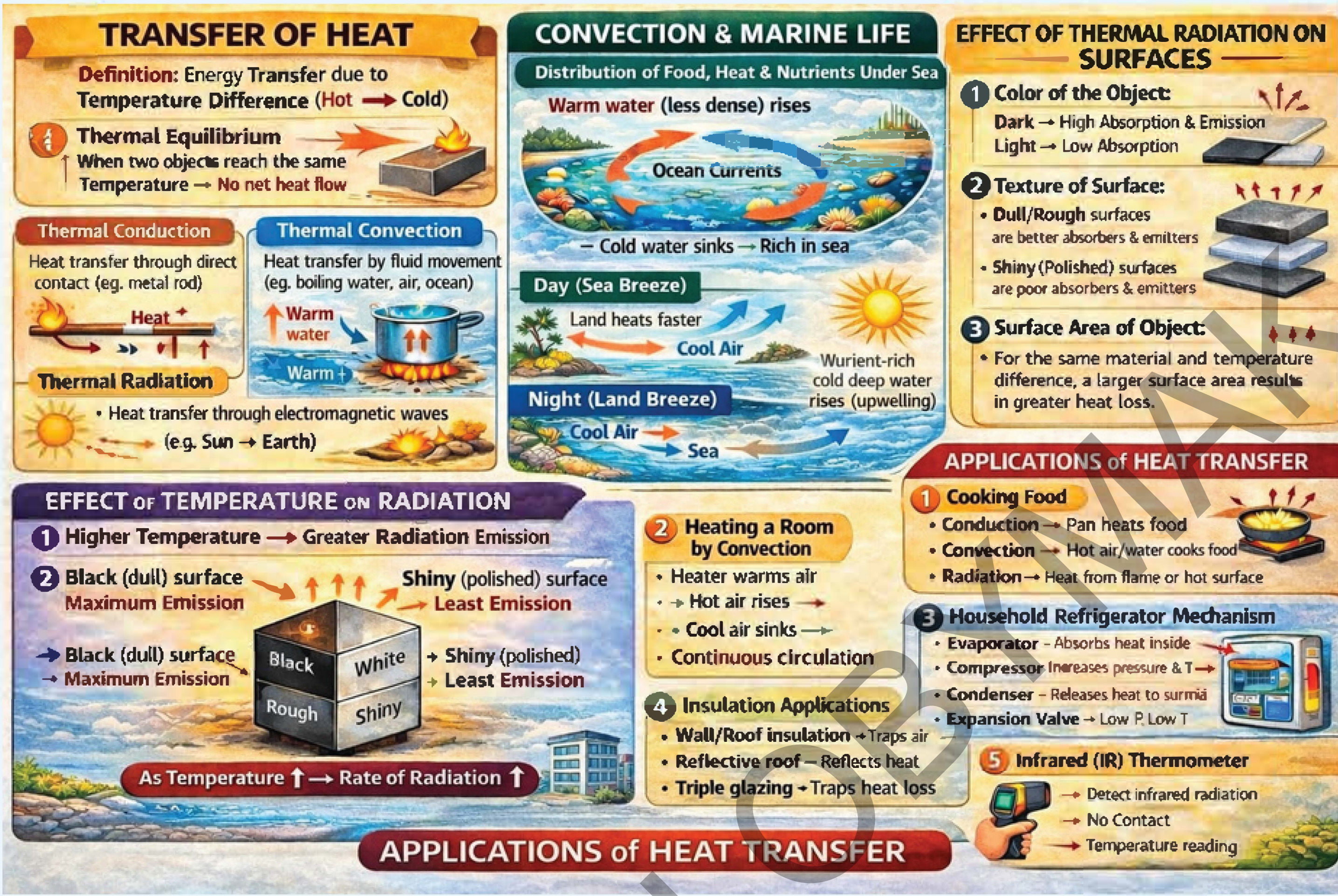


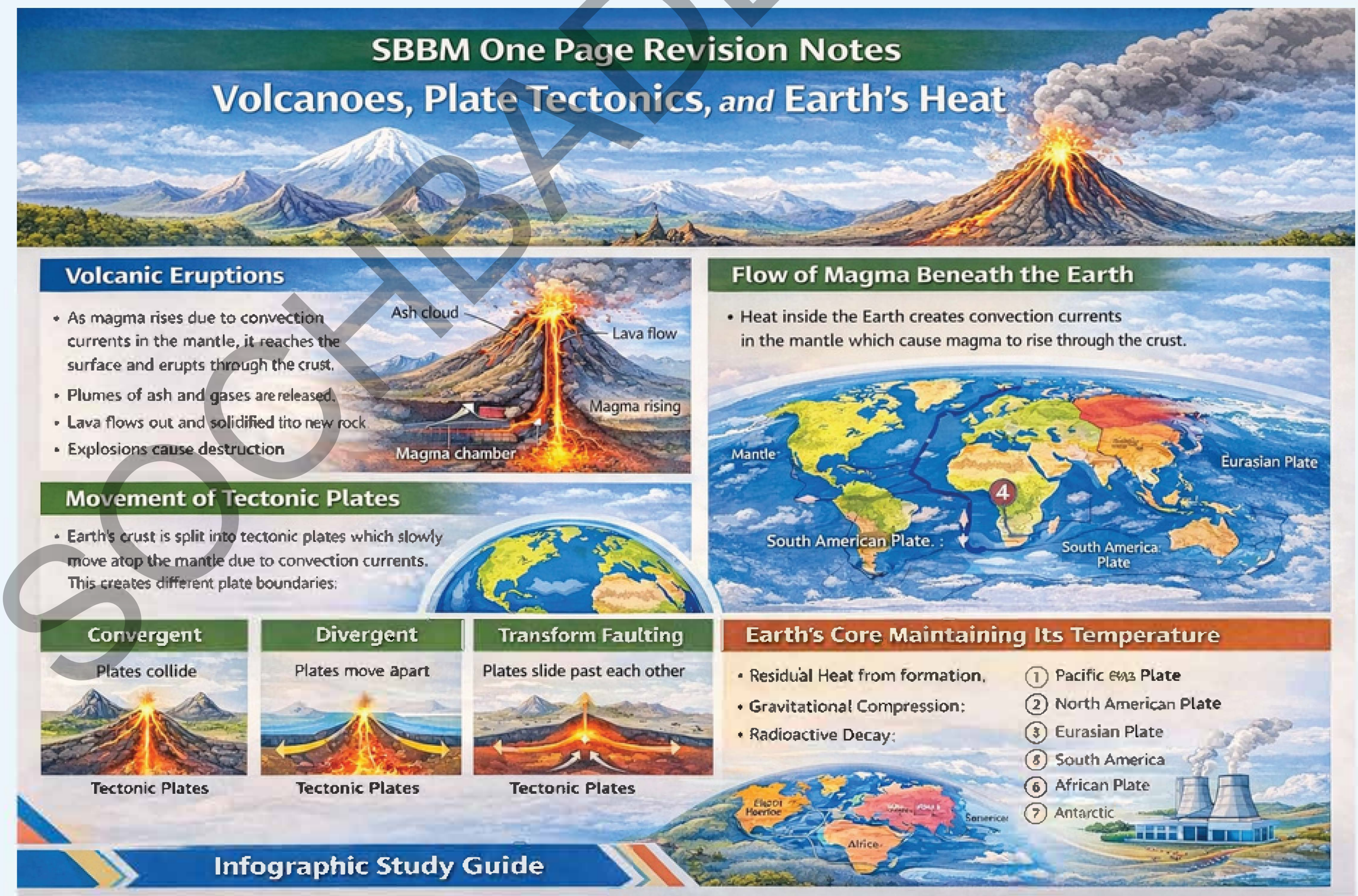
MEASURING TEMPERATURE WITH INFRARED THERMOMETERS

Infrared thermometers detect (receive) infrared radiation emilted by objects to measure their temperature from a distance without making contact, capturing accurate temperature measurements.



SBBM Notes   Like • Repin • Share SCIENTIFICALLY ACCURATE APPLICATIONS OF HEAT TRANSFER INFOGRAPHIC


TRANSFER OF HEAT
Definition: Energy Transfer due to Temperature Difference (Hot → Cold)
Thermal Equilibrium
When two objects reach the same Temperature → No net heat flow
Thermal Conduction
Heat transfer through direct contact (eg. metal rod)
Heat
Thermal Convection
Heat transfer by fluid movement (eg. boiling water, air, ocean)
Warm water
Warm
Thermal Radiation
• Heat transfer through electromagnetic waves (e.g. Sun → Earth)
CONVECTION & MARINE LIFE
Distribution of Food, Heat & Nutrients Under Sea
Warm water (less dense) rises
Ocean Currents
– Cold water sinks → Rich in sea
Day (Sea Breeze)
Land heats faster
Cool Air
Wurient-rich cold deep water rises (upwelling)
Night (Land Breeze)
Cool Air
Sea
EFFECT OF THERMAL RADIATION ON SURFACES
1 Color of the Object:
Dark → High Absorption & Emission
Light → Low Absorption
2 Texture of Surface:
• Dull/Rough surfaces are better absorbers & emitters
• Shiny (Polished) surfaces are poor absorbers & emitters
3 Surface Area of Object:
• For the same material and temperature difference, a larger surface area results in greater heat loss.
APPLICATIONS of HEAT TRANSFER
1 Cooking Food
• Conduction → Pan heats food
• Convection → Hot air/water cooks food
• Radiation → Heat from flame or hot surface
EFFECT OF TEMPERATURE ON RADIATION
1 Higher Temperature → Greater Radiation Emission
2 Black (dull) surface Maximum Emission
Shiny (polished) surface → Least Emission
→ Black (dull) surface → Maximum Emission
Black
White
Rough
Shiny
→ Shiny (polished) → Least Emission
As Temperature ↑ → Rate of Radiation ↑
2 Heating a Room by Convection
• Heater warms air
• → Hot air rises →
• Cool air sinks →
• Continuous circulation
3 Household Refrigerator Mechanism
• Evaporator – Absorbs heat inside
• Compressor Increases pressure & T →
• Condenser – Releases heat to surmia
• Expansion Valve → Low P, Low T
4 Insulation Applications
• Wall/Roof insulation → Traps air
• Reflective roof – Reflects heat
• Triple glazing → Traps heat loss
5 Infrared (IR) Thermometer
→ Detect infrared radiation
→ No Contact
→ Temperature reading
APPLICATIONS of HEAT TRANSFER


SBBM One Page Revision Notes
Volcanoes, Plate Tectonics, and Earth's Heat
Volcanic Eruptions
• As magma rises due to convection currents in the mantle, it reaches the surface and erupts through the crust.
• Plumes of ash and gases are released.
• Lava flows out and solidified tito new rock
• Explosions cause destruction
Ash cloud
Lava flow
Magma rising
Magma chamber
Flow of Magma Beneath the Earth
• Heat inside the Earth creates convection currents in the mantle which cause magma to rise through the crust.
Mantle
Eurasian Plate
4
South American Plate.
South America Plate
Movement of Tectonic Plates
• Earth's crust is split into tectonic plates which slowly move atop the mantle due to convection currents. This creates different plate boundaries.
Convergent
Plates collide
Tectonic Plates
Divergent
Plates move apart
Tectonic Plates
Transform Faulting
Plates slide past each other
Tectonic Plates
Earth's Core Maintaining Its Temperature
• Residual Heat from formation.
• Gravitational Compression:
• Radioactive Decay:
1 Pacific Plate
2 North American Plate
3 Eurasian Plate
South America
6 African Plate
7 Antarctic
Africe
Infographic Study Guide

Topical Wise Notes

SRQs + MCQs

UNIT:10 HEAT CAPACITY AND MODES OF HEAT TRANSFER

10.1 SPECIFIC HEAT CAPACITY

Definition:

Specific heat capacity is the amount of heat energy required to raise the temperature of 1 kilogram of a substance by 1 degree Celsius (or 1 Kelvin). It tells us how much energy a material needs to change its temperature

Core Formula

$Q = mc\Delta T$ | $c = Q / (m \times \Delta T)$

Variables & SI Unit

1. Q = Heat absorbed or released (Joules, J)
2. m = Mass of the substance (kilograms, kg)
3. c = Specific heat capacity
4. ΔT = Change in temperature ($T_2 - T_1$) in °C or K
5. SI Unit: $J\ kg^{-1}\ K^{-1}$ (also written as J/kg°C)
6. Note: A change of 1 K = 1°C —

Why does a person enjoy comparatively cooler weather near sea at day compared to land areas?

Coastal areas are cooler during the day because water has a high specific heat capacity, so it heats up more slowly than land. As land becomes hotter, warm air rises and creates low pressure. Cooler air from the sea (high pressure) moves toward land as a sea breeze, lowering the temperature near coastal areas.

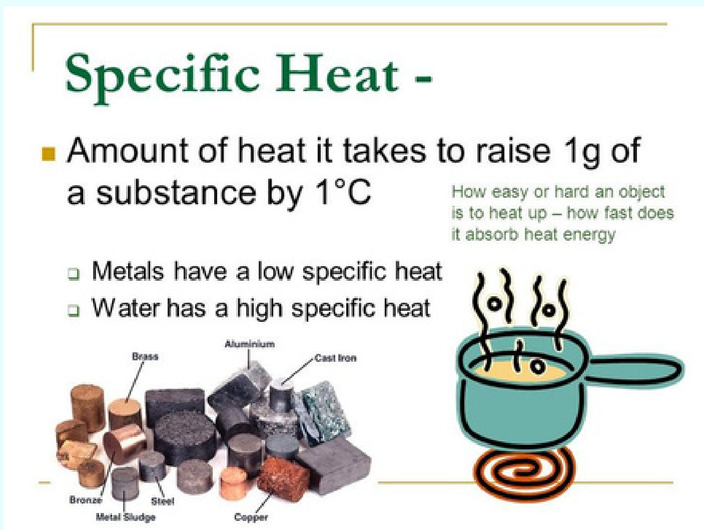
Formulas:

- Q directly proportional to ΔT
- $Q = \Delta T$
- $Q = C\Delta T$
- $Q = mc\Delta T$

Where:

- $C = Q/m\Delta T$
- C= specific heat capacity of substance
- Q= heat absorbed or released
- m= Mass(kg)
- ΔT= Change in temperature (°C or K)

T = Tf - Ti is the change in temperature of a substance.



Example:

Aluminium has a specific heat capacity of 900 J kg^{-1} K^{-1}

Also written as:

900 J kg^{-1} $°C^{-1}$

0.9 cJ g^{-1} $°C^{-1}$

Materials with high and low specific heat capacity:

- **Low Specific Heat Capacity:**

1. Materials like copper, aluminium, iron, and diamond require only a small amount of heat to raise their temperature.
2. These materials heat up and cool down quickly because they have low specific heat values.

Stable over time, even if the weather changes. It absorbs a lot of heat during the day and releases it slowly at night, preventing the temperature from fluctuating too much.

(Remains hot for shorter period) (Remains hot for a longer period)

- **Low Specific Heat Capacity:**

1. Require small amount of heat to raise temperature.
2. Heat up and cool down quickly.
3. Cannot store much heat.
4. Release heat quickly.
5. Are good conductors of heat.

Examples:

Copper, iron, diamond.

- **High Specific Heat Capacity:**

1. Require large amount of heat to raise temperature.
2. Heat up and cool down slowly.
3. Can store a large amount of heat.
4. Release heat slowly.
5. Are poor conductors of heat.

Examples:

Water, oil, glycerin.

J/kg°C J/g°C

1. They are good conductors of heat transferring heat efficiently.
2. Due to their ability to change temperature rapidly, these materials can retain heat for too long.
3. Applications: Used in heat sinks, where quick heat dissipation is essential.

- **High Specific heat Capacity:**

1. Materials with a high specific heat capacity require a lot of energy to change their temperature.
2. Water requires a lot of heat energy to raise the temperature of a cup of water by just a few degrees.
3. Because of this property, these materials do not change their temperature quickly. They retain heat for a long time.

- **Applications**: Used for temperature control. For example, water in swimming pools or thermal tanks keeps the temperature.

Uses of large specific heat of water

A) Temperature variations in land and coastal areas:

1. Water has a specific heat of 4200 J kg^{-1} K^{-1}. This means that it can absorb a large amount of heat without a significant rise in temperature.
2. Dry soil has a low specific heat of about 800 J kg^{-1} K^{-1}, which is around five times smaller than water, as a result, land heats up and cool down quickly.

Land Vs Coastal Areas:

1. -Land in summer can heat up quickly to temperatures between 45°C to 50°C.
2. Land in winter cools down quickly with temperatures dropping from 5°C to 0°C.
3. Coastal areas like Karachi experience smaller temperature variations, around 19°C to 32°C because:
4. In summer, oceans and lakes absorb heat slowly, without significant temperature rise.

- In winter, they release heat gradually, maintaining a stable temperature.

Property	Low Specific Heat	High Specific Heat
Heat to raise temp	Small amount needed	Large amount needed
Heating / Cooling	Quickly	Slowly
Heat Storage	Cannot store much	Stores large amounts
Heat Release	Quickly	Slowly
Examples	Copper, Iron, Diamond	Water, Oil, Glycerin

C. Human Body Temperature Regulation:

1. The human body is made up of 60% of water.
2. Water's high specific heat capacity helps the human body to maintain a stable internal temperature (37°C).
3. When the body gets hot, water in the body absorbs the excess heat, without a sharp temperature rise, preventing overheating.
4. When the body gets cold, the stored heat in the body's water slowly releases to maintain a constant temperature, helping prevent the body from getting too cold.

D. Cooling Systems in Heat Exchangers:

Water is commonly used as a coolant in power plants, industrial processes and radiators due to its high specific heat.

1. Due to its ability to absorb a large amount of heat and minimal rise in temperature, it can remove excess heat from machinery and systems. It helps to prevent overheating and increases efficiency.
2. Working of a heat exchanger: In a heat exchanger, water transfers heat from a hot system (e.g, a machine) to another medium (air, liquid) without letting the machine or system's temperature rise too quickly.
3. It ensures machine's working at an optimal temperature, thereby ensuring efficiency.

1. Cooking Processes:

Water is used in cooking due to its large specific heat capacity, it heats up slowly and distributes heat evenly across the food.

1. This prevents burning and ensures that:

The food cooks at a steady temperature. Hot drinks, like tea and coffee, stay warmer for a long time due to high specific heat capacity of water, which allows it to retain heat for extended periods. It does not cools down quickly, meaning that the heat stays in the beverage longer, keeping it warm for consumption.

SRQS

Q1: What is the SI unit of specific heat capacity?

The SI unit is joule per kilogram per kelvin ($J\ kg^{-1}\ K^{-1}$).

Q2: Why do metals have low specific heat capacity?

Metals need less heat to change temperature because:
Their particles transfer energy quickly
Temperature rises rapidly with small heat
So, metals heat and cool quickly.

Q3: What is specific heat capacity?

Answer:

Specific heat capacity is the amount of heat required to raise the temperature of 1 kg of a substance by 1 K (or 1°C). It is an intrinsic material property.

Q4: Write the formula and explain each term.

Answer:

Formula: $Q = mc\Delta T \rightarrow c = Q / (m\Delta T)$

- Q = heat supplied (Joules)
- m = mass (kg)
- c = specific heat capacity (J/kg°C)
- ΔT = change in temperature (°C or K)

Q5: Why does water have a high specific heat capacity?

Answer:

Water has strong intermolecular hydrogen bonds that require more energy to break. It absorbs more heat before temperature rises significantly, so it heats up and cools down slowly.

Q6: Why are coastal areas cooler during daytime?

Answer:

Water has high specific heat capacity, so it heats up slowly compared to land. The sea breeze brings cool air from the ocean to the land. Therefore, coastal areas remain cooler than inland areas.

Q7: Why does water help in maintaining body temperature?

Answer:

Human body is 60% water. Water absorbs excess heat without causing a large temperature rise, keeping body temperature stable at about 37°C. When cold, stored heat releases slowly.

Q. Why coastal areas stay moderate?

Oceans and lakes absorb a lot of heat from the sun during the summer season and store it. In winter, oceans and lakes release heat into the atmosphere.

Maintaining Stability in Ocean and Lake Temperatures:

Oceans and lakes can absorb a lot of heat from the sun during the summer without significant temperature increases. In winter, they release the stored heat gradually, which helps maintain stable water temperatures.

1. It prevents rapid temperature increases and ensures a suitable environment for aquatic life.

Q. Why does water retain heat?

Due to water's large specific heat, it absorbs a lot of heat without increasing the temperature much. This property allows water to store heat efficiently and release it slowly over time, which is why hot drinks stay warmer longer and cooking occurs evenly without burning.

Q9: Why do deserts experience extreme temperatures?

Answer:

Sand has low specific heat capacity. It heats up very quickly during the day and cools rapidly at night, resulting in large temperature differences.

Q8: Why do deserts experience extreme temperatures?

Answer:

Sand has low specific heat capacity. It heats up very quickly during the day and cools rapidly at night, resulting in large temperature differences.

Side Box — Why is it cooler near the sea during the day?

Coastal areas are cooler in daytime because water's high specific heat capacity means it warms much more gradually than land. As land heats quickly, air above it rises (low pressure). Cooler, denser sea air moves inland to fill this gap — creating a sea breeze that moderates coastal temperatures.

MCQS

Q1. Specific heat capacity is the heat required to raise temperature of:	
A) 1 g by 1°C	**✓ B) 1 kg by 1°C**
C) 1 kg by 10°C	D) 100 g by 1°C
Ans: *By definition, specific heat capacity refers to 1 kg of substance raised by 1°C (or 1 K).*	

Q2. SI unit of specific heat capacity is:	
A) J/kg	B) J/K
✓ **C) J kg^{-1} K^{-1}**	D) kg J^{-1}
Ans: *Standard SI unit is joule per kilogram per kelvin.*	

Q3. Which substance has the highest specific heat capacity?	
A) Copper	B) Iron
✓ **C) Water**	D) Lead
Ans: *Water has about 4200 J/kgK — much higher than metals.*	

Q4. Land heats faster than sea because it has:	
A) High specific heat	✓ **B) Low specific heat**
C) High density	D) High pressure
Ans: *Low specific heat means less heat is needed to raise temperature.*	

Q5. If mass is doubled, heat required becomes:	
A) Half	✓ **B) Double**
C) Same	D) Zero
Ans: *Q is proportional to m, so doubling mass doubles the heat required.*	

Q6. Water is used in car radiators because:	
A) It is cheap	B) It has low density
✓ **C) It has high specific heat**	D) It evaporates fast
Ans: *It absorbs large amounts of heat without a large temperature rise.*	

Q7. Coastal areas stay cooler than inland during daytime because:	
A) Sand has high heat capacity	✓ **B) Water heats slowly due to high specific heat**
C) Sun is weaker near coast	D) Air pressure is low near sea
Ans: *Water's high specific heat keeps coastal temperatures moderate.*	

Q8. Human body temperature stays stable due to:	
A) Bones	✓ **B) Water content (60%)**
C) Skin colour	D) Only muscles
Ans: *Water (60% of body) absorbs excess heat without sharp temperature rise.*	

Q9. Specific heat capacity does NOT depend on:	
A) Nature of substance	✓ **B) Mass**
C) Material type	D) Atomic structure
Ans: *Specific heat is an intrinsic material property — mass does not change the value of c.*	

Q10. The specific heat capacity of water is approximately:	
✓ A) 4200 J/kgK	B) 900 J/kgK
C) 100 J/kgK	D) 50 J/kgK
Ans: *Standard value is about 4180–4200 J/kgK.*	

10.2 MEASURMENT OF SPECIFIC HEAT CAPACITY

A) Method of Mixtures (Calorimeter Method)

Principle:

This method uses a calorimeter to determine the specific heat capacity of a solid by applying the law of "conservation of energy". When a solid sample is placed into cooler water within the calorimeter, heat is transferred from the solid to the water and the calorimeter. Assuming no heat to the surroundings.

Apparatus

1. Bunsen burner or hot plate
2. Copper calorimeter with lid
3. Stirrer and insulating cover
4. Metallic solid cylinder (brass or copper)
5. Two thermometer
6. Weighting machine
7. Water, beaker, laboratory stand

HEAT BALANCE EQUATION

$$MS \cdot CS \cdot (T_2 - T_3) = MW \cdot CW \cdot (T_3 - T_1) + MC \cdot CC \cdot (T_3 - T_1)$$

Variables:

→ **Independent:** Initial temperature of the metal block.

→ **Dependent:** Energy supplied to the metal block by heating

→ Procedure

1. Measure the mass of empty calorimeter with a known specific heat capacity 'c'.
2. Fill the calorimeter with enough water, so now calculate the mass of water mw.

mw = m - mc
→ *mass of empty calorimeter*
→ *mass of water calculated*

1. Place the calorimeter in the insulating cover.
2. Measure its initial temperature with the thermometer, which will be equal to the surroundings. Ti
3. Measure mass of solid as "ms"
4. Boil the water and heat the solid, Ti until it reaches thermal equilibrium.
5. Remove solid from the boiling water and shake off excess water.
6. Place the hot solid into the calorimeter.
7. Cover the calorimeter and stir the water gently but continuously to ensure uniform distribution.
8. Measure the final temperature of the mixture once it becomes constant on attaining equilibrium T_3.

Symbol	Meaning
ms, Cs	Mass and specific heat of solid sample
mw, Cw	Mass and specific heat of water (4200 J/kgK)
mc, Cc	Mass and specific heat of calorimeter
T_1	Initial temperature of water & calorimeter
T_2	Initial temperature of hot solid
T_3	Final equilibrium temperature after mixing

Heat loss by solid = Heat gained by water in calorimeter + Heat gained by calorimeter

$$Qs = Qw + Qc$$

$$msCs(T_2 - T_3) = mwCw(T_3 - T_1) + mcCc(T_3 - T_1)$$

$Qs \rightarrow msCs(T_2 - T_3)$
$Qw \rightarrow mwCw(T_3 - T_1)$
$Qc \rightarrow mcCc(T_3 - T_1)$

Solve for Cs:

$$Cs = (mwCw(T_3 - T_1) + mcCc(T_3 - T_1)) / ms(T_2 - T_3)$$

$$Cs = (mwCw + mcCc)(T_3 - T_1) / ms(T_2 - T_3)$$

Conservation: "Heat lost by solid in decreasing its temperature from T_2 to T_3 is equal to the heat gained by water in increasing its temperature from T_1 to T_3."

Procedure for Liquid:
Same procedure and experiment is used.
Liquid of unknown specific heat capacity "Cl" is used.

Formula:

$$c_l = (m_{sc} s(T_2 - T_3) - m_c c(T_3 - T_1)) / m_1(T_3 - T_1)$$

B) Electrical heating Method:

Solids:

Purpose: To find the specific heat capacity of a solid using electrical heating method.

Method Summary: Heat is transferred to a solid block using immersion heater and change in heat is measured.

Apparatus:

1. Solid block
2. Voltmeter
3. Thermometer
4. Immersion heater
5. Ammeter
6. Cotton wool

$$C = Q / m\Delta T$$

Procedure:

1. Measure the mass of the solid block.
2. Place the immersion heater into the hole in the block and connect it to the voltmeter and ammeter.
3. Insert thermometer in the smaller hole.
4. Insulate the block with cotton wool.
5. Record the initial temperature.
6. Connect the heater to the supply and turn it on for ten minutes. Record voltage and current.
7. Turn off the heater and record the highest temperature reached.
8. Calculate by the formula:

C) Heat Capacity of Liquids:

Apparatus:

1.- Immersion heater
2.- Voltmeter
3.- Ammeter
4.- Thermometer
5.- Water
6.- Calorimeter
7.- Measuring Scale

Procedure:

1. Measure mass of empty calorimeter = mc
2. Add liquid into calorimeter and measure its total mass.
3. Mass of liquid = m(Total mass) - mc
4. Measure the initial temperature of liquid using thermometer, Ti.
5. Place immersion heater and thermometer inside the liquid and connect voltmeter and ammeter to it measure current and voltage.
6. When temperature reach 10°C, turn the thermometer off, stir it well.
7. Find difference between initial and highest temperature.

Formula:

$$C_L = (Q_{Heater} - mcC(T_F - T_i)) / mL(T_F - T_i)$$

10.3 TRANSFER OF HEAT --- OVERVIEW

Definition:
Heat transfer occurs when thermal energy travels from one object to another and until they reaches the same the temperature known as thermal equilibrium. This process continues until they both reach the same temperature.

Mode	Medium Needed?	Occurs In	Example
Conduction	Yes	Solids	Heating a metal rod
Convection	Yes	Fluids (liquids & gases)	Boiling water in a pan
Radiation	No	Vacuum / Any medium	Sunlight heating Earth

SRQS

Q1: Define heat transfer.
Answer:
Heat transfer is the process by which thermal energy moves from a region of higher temperature to a region of lower temperature. This continues until both objects reach the same temperature (thermal equilibrium).

Q2: Name and explain the three methods of heat transfer.
Answer:
1. Conduction: Transfer of heat through a solid without movement of the substance itself.
2. Convection: Transfer of heat in fluids through actual movement of particles forming currents.
3. Radiation: Transfer of heat in the form of electromagnetic waves that can travel through vacuum.

Q3: What is the difference between conduction, convection, and radiation?
Answer:
Conduction: Requires physical contact, occurs in solids via particle vibration and free electrons.
Convection: Requires a fluid medium, occurs via bulk movement of hot/cold fluid particles.
Radiation: Requires NO medium — can travel through vacuum as electromagnetic waves.

Q4: What is conduction? Explain with an example.

Ans: Conduction is the process of heat transfer through a solid without the overall movement of the substance. In conduction, heat energy is passed from particle to particle by vibrations and collisions.
Example: When one end of a metal rod is heated, the heat travels to the other end through conduction. The particles at the hot end vibrate faster and transfer energy to neighboring particles, gradually heating the entire rod.

Q5: **What is convection? Explain with an example.**

Ans: Convection is the transfer of heat in liquids and gases due to the actual movement of particles. When a fluid is heated, the particles become less dense and rise, while cooler, denser fluid sinks. This movement creates convection currents that transfer heat.
Example: Boiling water in a pot demonstrates convection. Hot water at the bottom rises while cooler water descends, forming a continuous current until the water reaches a uniform temperature.

Q6: **What is radiation? Explain with an example.**

Ans: Radiation is the transfer of heat in the form of electromagnetic waves, mainly infrared, without requiring a medium. Radiation can occur through solids, liquids, gases, or even empty space.
Example: The heat from the Sun reaches the Earth through the vacuum of space by radiation. Another example is feeling the warmth of a fire even without touching it.

Q7: Explain real-life examples of heat transfer ?

Ans:Conduction: Cooking on a metal pan. The heat from the stove passes through the metal to cook food.
Convection: Heating a room with a radiator. Warm air rises while cooler air sinks, creating a circulation that warms the room.
Radiation: Sun heating the Earth or feeling warmth from an electric heater without touching it.

MCQS

Q1. Which of the following is not a method of heat transfer?	
A) Conduction	B) Convection
C) Radiation	✓ **D) Reflection**
Ans: Heat can be transferred by conduction, convection, and radiation. Reflection is the bouncing back of light or heat, not transfer.	

Q2. Heat transfer through a solid occurs mainly by:	
A) Convection	B) Radiation
✓ **C) Conduction**	D) Evaporation
Ans: In solids, particles are closely packed and transfer heat through vibrations and collisions.	

Q3. Which material is the best conductor of heat?	
A) Wood	✓ **B) Copper**
C) Plastic	D) Air
Ans: Metals like copper have free electrons that transfer energy efficiently.	

Q4. Which process does not require a medium to transfer heat?	
A) Conduction	B) Convection
✓ **C) Radiation**	D) All require a medium
Ans: Radiation transfers heat through electromagnetic waves and does not need matter.	

Q5. Which of these is an example of convection?	
A) Heating a metal rod	✓ **B) Boiling water in a pan**
C) Sunlight warming the Earth	D) Touching a hot object
Ans: Convection occurs when fluid motion transfers heat; boiling water shows this.	

Q6. In conduction, energy is transferred by:	
A) Moving particles from one place to another	✓ **B) Vibrations of particles**
C) Heat waves	D) None of these
Ans: In solids, particles vibrate and pass energy to neighboring particles.	

Q7. Which of the following is a poor conductor of heat?	
A) Aluminum	B) Silver
✓ **C) Wood**	D) Copper
Ans: Wood has no free electrons and does not transfer heat efficiently.	

Q8. Which of the following reduces heat loss by conduction?	
A) Using metals	✓ **B) Using insulators like wood**
C) Increasing contact area	D) Using liquids
Ans: Insulators resist the flow of heat.	

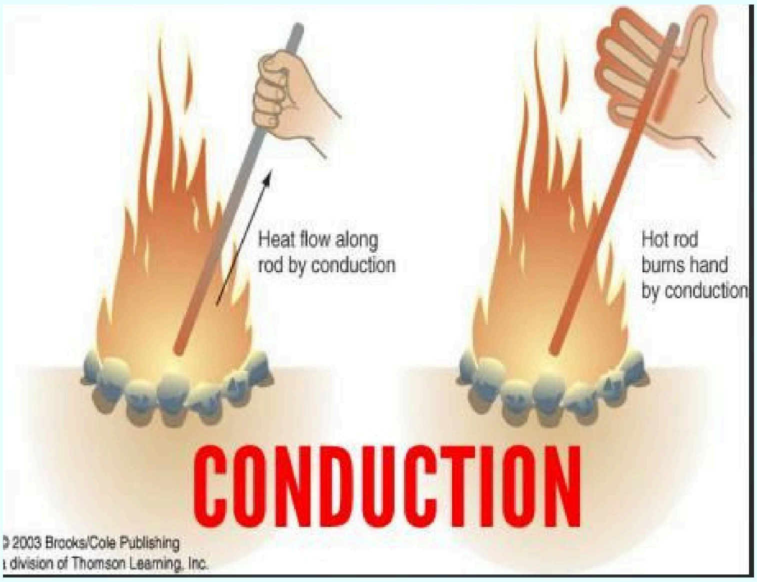
10.3.1 THERMAL CONDUCTION

Definition:
Thermal conduction is the transfer of heat through a solid without any movement of the solid itself. It happens when particles in a material pass their kinetic energy to neighbouring particles.

Working / Mechanism
1. When one end of a solid is heated, particles gain energy and vibrate more vigorously
2. These energetic particles collide with neighbours, passing energy — causing them to vibrate faster
3. In metals, conduction is faster because they contain FREE ELECTRONS
4. Free electrons move rapidly through the metal and carry energy from hot to cold end
5. This is why metals are good conductors of heat

Property	Good Conductors	Poor Conductors (Insulators)
Heat transfer	Allow heat to pass quickly	Transfer heat very slowly
Free electrons	Present (in metals)	Absent
Examples	Copper, Iron, Silver	Air, Wood, Rubber, Plastic
Applications	Cooking utensils, heat sinks	Pot handles, thermal clothing

Experiment — Conduction in Metal Rod
1. A metal rod is coated with wax and several pins fixed along it using wax
2. When one end is heated, heat travels through rod → melts wax → pins fall off one by one
3. Demonstrates: Conduction occurs from hot end toward cool end progressively



SRQS

Q1. What is conduction? Give an example.

Answer:

Conduction is the process of heat transfer through a material without any bulk movement of the material itself. Energy is transferred from hotter to cooler regions via vibration and collision of particles.

Example: Heating a metal spoon in hot tea — heat is conducted from the hot end to the cooler end you hold.

Q2. Why are metals better conductors than non-metals?

Answer:

Metals have free electrons that move freely within the metal lattice and transfer energy quickly from hot to cooler regions. In non-metals, there are no free electrons — conduction occurs only through vibrating atoms, which is much slower.

Q3. How can conduction be reduced?

Answer:

Conduction can be reduced by:

- Using materials with low thermal conductivity (insulators)
- Minimising direct contact between hot and cold regions
- Using air gaps, wool, rubber, and plastic coverings as insulators

Example: Wooden handles on cooking utensils prevent heat transfer to hands.

Side Box — Is rubber a better insulator than air?

Yes! Rubber has lower thermal conductivity than air, meaning it reduces heat transfer more effectively. Rubber has tightly bound electrons which resist heat energy flow. Rubber can resist heat flow about 4 to 8 times better than air, which is why it is used in cooking pot handles and electrical safety tools.

Q4. How does heat transfer occur in solids?

Ans: In solids, heat transfer occurs mainly by conduction. The particles in a solid vibrate about their mean positions. When the particles in the hotter region gain energy, they vibrate faster and collide with neighboring particles, transferring energy to them. This chain of collisions continues, causing the heat to travel from the hot end to the cold end. In metals, free electrons also carry energy efficiently, making conduction faster.

Q5. Define thermal conductivity.

Ans: Thermal conductivity is a measure of a material's ability to conduct heat. It is denoted by the symbol k and is defined as the amount of heat transferred per second through a unit area of the material with a unit temperature difference across a unit thickness. Materials with high thermal conductivity, like copper and silver, transfer heat quickly, while materials with low thermal conductivity, like wood and plastic, are poor conductors.

Q6. How does particle arrangement affect conduction?

Ans: The arrangement of particles plays a crucial role in conduction. In solids, particles are tightly packed in a fixed structure, which allows efficient transfer of vibrational energy from one particle to the next. In liquids, particles are close but can move past each other, so conduction is slower. In gases, particles are widely separated, making conduction very inefficient

Q7. How can conduction be reduced?

Ans: Conduction can be reduced by using materials with low thermal conductivity (insulators) and by minimizing direct contact between hot and cold regions. For example, wearing wooden handles on cooking utensils prevents heat transfer to hands. Air gaps, wool, and plastic coverings also act as insulators to reduce conduction.

MCQS

Q1. Thermal conduction is the transfer of heat through.	
A) Vacuum only	✓ **B) Solid only**
C) Fluid only	D) Both solid and fluid
Ans: *Heat is mainly conducted through solids because particles are closely packed.*	

Q2. Metals conduct heat better because they	
A) Are heavier	✓ **B) Have free electrons**
C) Are shiny	D) Are dense
Ans: *Free electrons in metals move easily, transferring thermal energy quickly.*	

Q3. Which has the highest thermal conductivity?	
✓ **A) Silver**	B) Aluminium
C) Iron	D) Glass
Ans: *Silver is the best metal conductor of heat.*	

Q4. Poor conductors of heat are also called:	
✓ **A) Insulators**	B) Conductors
C) Semi-conductors	D) Superconductors
Ans: *Materials like wood, air, and glass resist heat flow and are called insulators.*	

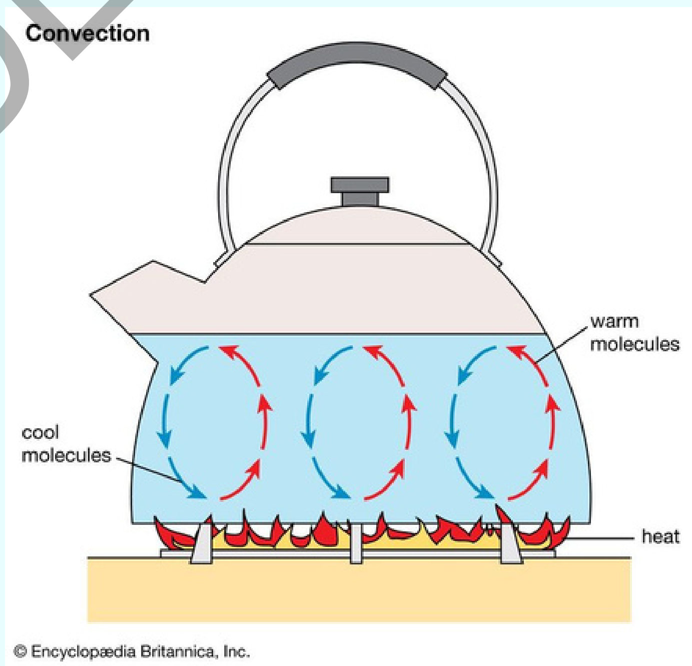
Q5. Heat transfer through stationary particles is called:	
✓ **A) Conduction**	B) Convection
C) Radiation	D) Diffusion
Ans: *Conduction occurs without bulk movement of material.*	

10.3.2 CONVECTION

Definition:
Convection is the transfer of heat in fluids (liquids and gases) due to the bulk movement of molecules or particles. It occurs because heated particles become less dense and rise, while cooler particles sink to take their place.

KMT — How Convection Works

1. Particles of liquids and gases are always in random motion.
2. When a fluid is heated, its particles gain kinetic energy and move faster.
3. Faster motion causes particles to move farther apart.
4. The heated part of the fluid becomes less dense.
5. The less dense (hot) fluid rises upward.
6. The cooler and denser fluid sinks downward.
7. This continuous movement of rising hot fluid and sinking cool fluid forms convection currents.
8. These currents transfer heat through the fluid.



Type	Description	Example
Natural Convection	Occurs due to temperature/density differences without external force	Boiling water, warm air in room
Forced Convection	External agent (fan/pump) moves fluid to transfer heat faster	Air conditioner, refrigerator compressor

Example:

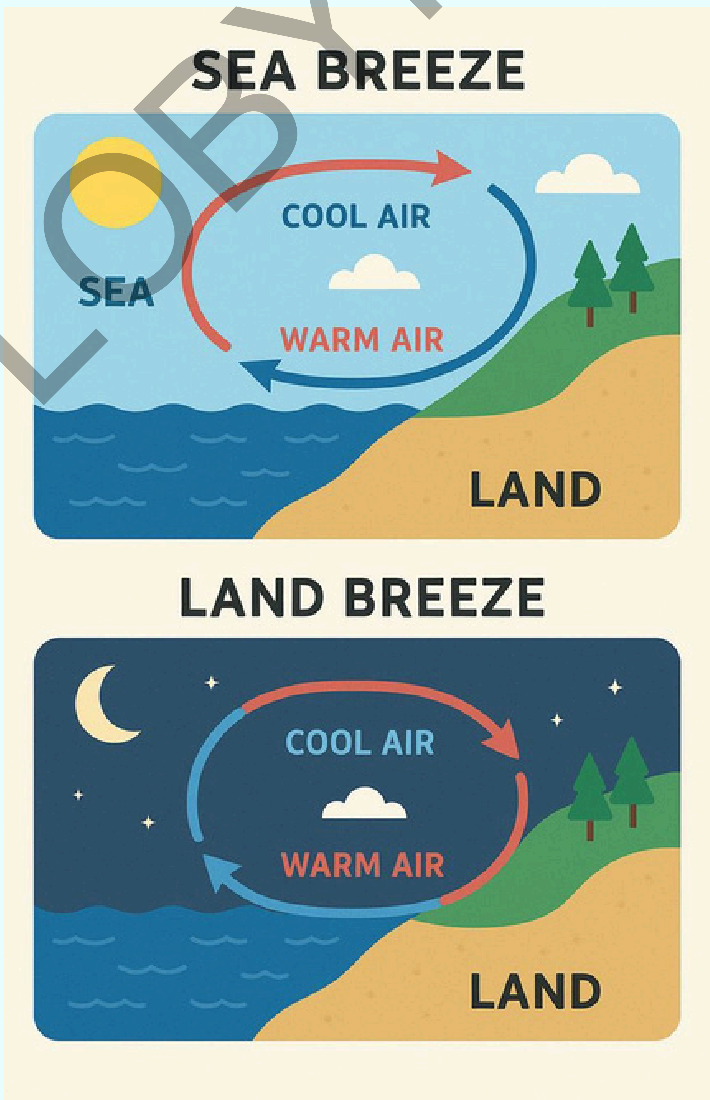
i) Water in a pot: The water at the bottom gets the heat first so it becomes less dense and rises while the cooler water at the top moves to take its place. This convection current distributes heat.

Convection and Marine Life

Convection current play a very important role in marine ecosystem.

a) Sea Breeze (Daytime)

1. Land heats up faster than sea (land has low specific heat capacity)
2. Air above the land becomes hot, expands and becomes less dense.
3. Hot air rises above the land.
4. Cooler air from the sea moves toward land to fill the gap
5. This movement of air is called Sea Breeze



b) Land Breeze (Nighttime)

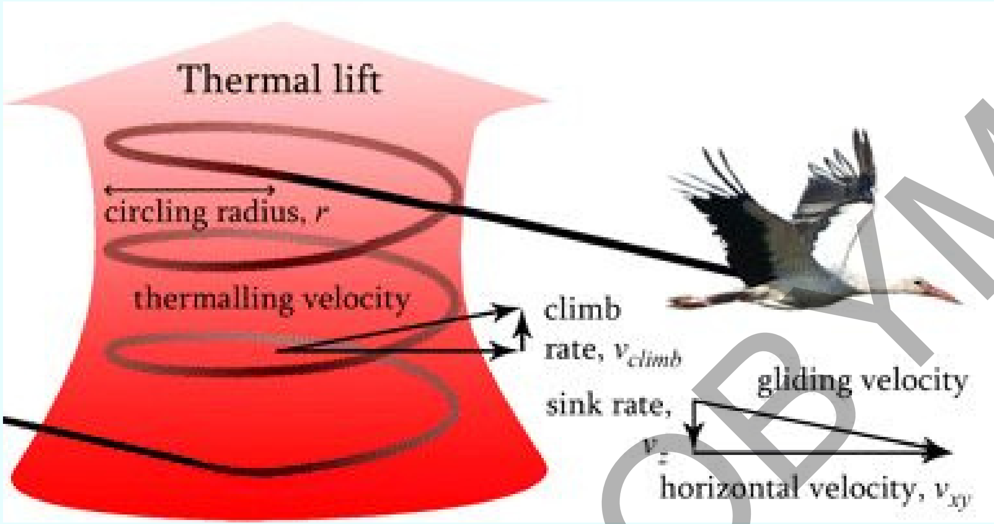
1. Land cools down faster than the sea due to its low specific heat capacity.
2. Sea retains heat longer because of its high specific heat capacity.
3. Air above the sea is warmer than the air above land.
4. Warm air rises above the sea.
5. Cold air from the land moves toward the sea to fill the gap.
6. This movement is called a land breeze.

Effects of Sea and land Breeze:

1. Help maintain moderate temperatures in coastal areas.
2. Result in more coder and stable climate near coastal areas.

Thermals and Bird Flight:

1. During the day, sunlight heats the land creating hot, air columns called thermals.
2. These are surrounded by coder air, forming rising warm air currents.
3. Birds like eagles, hawks and vultures are excellent thermal riders.
4. The birds glide themselves in the thermals to gain height.
5. This allows them to stay air born for long periods.



Upwelling:

1. In some oceans, cold, deep water rises to the surface.
2. This water is rich in nutrients like mineral and organic matter (phosphorus, magnesium).
3. Plankton uses this nutrients to grow and multiply, which is a food force for zooplankton and whales.

Distribution of oxygen:

1. Most oxygen is dissolved in the upper water and exposed to the atmosphere, which sinks to deeper layers.
2. This provides oxygen to marine to animals like fish, which live at the bottom.

Heat Distributions:

1. - Convection distributes heat from warm surface waters towards colder regions.
2. - This can help to keep a stable temperature.
3. Help in preventing extreme hot or cold.
4. releasing heat, making the air lighter.
5. - This rising warm air creates a low-pressure area.
6. Air moves in, creating a spinning motion.
7. - If strong enough, it forms a cyclone with high winds and heavy rain.

SRQS

Q1. Define convection.

Answer:

Convection is the transfer of heat in liquids and gases due to the actual movement of particles. When fluid is heated, particles gain energy, move faster, spread apart — making the fluid less dense. This warmer fluid rises, and cooler denser fluid sinks, forming convection currents.

Q2. What is a sea breeze? How does it form?

Answer:

A sea breeze blows from the ocean toward the land during daytime.

Land has low specific heat → heats up quickly under sun

Air above land becomes hot, expands and rises (low pressure)

Cooler denser air from sea moves inland → Sea Breeze

Brings cooler, moist air to coastal areas, moderating temperatures.

Q3. What is a land breeze and how does it differ from sea breeze?

Answer:

A land breeze blows from land toward the sea at night.

At night, land cools faster than sea

Sea retains heat → air above sea is warmer → rises

Cool air from land flows toward sea → Land Breeze

Difference: Sea breeze is daytime (sea to land); Land breeze is nighttime (land to sea).

Q4.Give two examples of convection in daily life.

Ans:

1).Boiling water in a pot: hot water rises while cold water sinks, forming convection currents.

2).Warm air in a room: heaters warm the air, which rises, while cooler air sinks, circulating warmth throughout the room.

Q5. How do thermals help birds in flight?

Answer:

Thermals are columns of rising warm air formed when sun unevenly heats Earth's surface. Birds like eagles glide into thermals and circle within rising air to gain altitude without flapping wings — conserving energy during migration or hunting.

> **<u>Side Box — Why is the freezer at the TOP of a refrigerator?</u>**
> *The freezer is at the top to use convection efficiently. Cold air from the freezer is denser and travels downward, cooling the food compartment below. Warm air from the bottom rises and gets cooled again in the freezer — creating a continuous convection cycle that keeps all compartments cool efficiently.*

Q6. In which states of matter does convection occur?

Ans: Convection occurs in liquids and gases only. It cannot occur in solids because the particles in solids are fixed in position and cannot move freely. In fluids, particles can move and carry thermal energy from hotter to cooler regions.

Q7. What are convection currents?

Ans: Convection currents are circular movements of a fluid caused by differences in temperature and density. The hot fluid rises because it is less dense, while the cold fluid sinks because it is denser. This continuous cycle transfers heat throughout the fluid, helping in uniform heating.

Q8. Explain why hot air rises and cold air sinks ?

Ans: When air is heated, its particles move faster and spread apart, reducing its density. Less dense, warm air rises above the denser, cooler air. As the warm air rises, cooler air moves in to replace it, creating a continuous flow of air known as a convection current.

Q9. How does convection help in heating a room?

Ans: In a heated room, warm air from radiators or heaters rises because it is less dense. Cooler air moves down to take its place. This cycle continues, creating convection currents that distribute heat evenly throughout the room, keeping it warm.

MCQS

Q1. Convection is the transfer of heat by:	
A) Direct contact of particles	✓ **B) Movement of fluid**
C) Radiation in vacuum	D) Chemical reaction
Ans: *Convection occurs due to the bulk movement of liquids or gases.*	

Q2. Convection is possible in:	
A) Solids only	B) Liquids only
C) Gases only	✓ **D) Liquids and gases**
Ans: *Fluids can flow, which is essential for convection.*	

Q3. Sea breeze occurs due to:	
A) Conduction	✓ **B) Convection**
C) Radiation	D) Conduction and radiation
Ans: *Air moves from cooler sea to warmer land due to temperature differences.*	

Q4. In convection, fluid motion is caused by:	
A) Pressure difference only	B) Temperature difference only
C) Gravity only	✓ **density differences**
Ans: *Hot fluid rises due to lower density; cooler fluid sinks.*	

Q5. Fluids can flow, which is essential for convection.	
A) Forced convection	✓ **B) Natural convection**
C) Thermal conduction	D) Radiation
Ans: Hot fluid becomes less dense and rises, creating natural circulation.	

Q6. Forced convection occurs when	
A) Fluid moves on its own	✓ **B) External agent moves the fluid**
C) Fluid is solidified	D) Heat transfer is zero
Ans: Fans, pumps, or blowers cause forced convection	

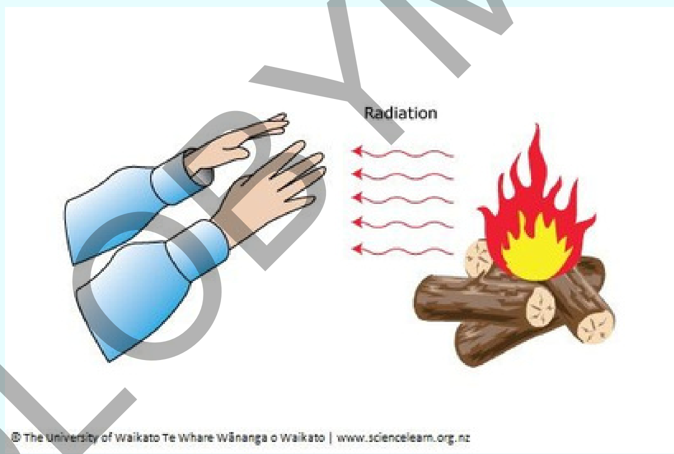
Q7. Which of the following is an example of natural convection?	
✓ **A) Boiling water on stove**	B) Air cooled by a fan
C) Heating water using a pump	D) Using refrigerator compressor
Ans:Hot water rises and cold water sinks naturally without external help.	

Q8. Heat transfer in atmosphere is mainly by	
A) Conduction	✓ **B) Convection**
C) Radiation	D) None of these
Ans: Warm air rises and cold air sinks, transferring heat in the atmosphere.	

10.3.2 THERMAL RADIATION

Definition:
1. Radiation, it is the process of heat transfer without any physical contact or medium.
2. It involves energy transfer in the form of electromagnetic radiation and infrared radiations.

Example:
1. The sun heats the Earth through radiation, even though there is a vacuum between them.
2. We feel warmth from a fire place even at a distance.



Radiation vs Conduction / Convection:
1. Conduction and convection require a medium (solid, liquid, or gas) to transfer heat.
2. Radiation does not need any medium; it can occur in any space.

Factors impacting radiation:
1. A body's ability to absorb or emit radiation depends on various factors.

1) Surface color:
1. Dark surfaces are good absorbers and good emitters but bad reflectors.
2. Emit more radiation when hot.
3. Efficient in both gaining and loosing heat.

Example: Wearing black clothes on a sunny day feels hotter.
1. Laptop chargers are black to release heat quickly.
2. Light or shiny surfaces are poor absorbers and emitters but good reflectors.

2) Texture of Surface

Rough or Dull Surfaces:

1. Absorb more radiation.
2. Rough, dull, and dark surfaces are good absorbers or emitters.
3. They are the worst reflectors.

Smooth or Shiny Surfaces:

1. Bad absorbers and bad emitters.
2. They are good reflectors.

Example: Before painting, walls are made smooth and painted white to reduce heat absorption.

3) Surface Area of the Object

1. Larger surface area means more heat emitted or absorbed.
2. Small surface area means less heat emitted.

Example: Radiators have more surface area to conduct heat.

Temperature and Radiation

1. The rate of infrared radiation emitted is directly proportional to the object's temperature.
2. **Higher Temperature** = Higher rate of radiation
3. **Lower Temperature** = Lower rate of radiation

Examples:

1. **Sun**: High temperature + large surface area emits a large amount of radiation.
2. **Cooking Stove**: Lower temperature + small surface area emits less radiation.

Working of Thermal Equilibrium

1. When an object is heated, its temperature rises and it radiates more.
2. If an object radiates more heat than it absorbs, its temperature decreases.
3. If it absorbs and radiates heat equally, its temperature stays constant. This state is called Thermal Equilibrium.

Example: A hot cup of tea placed on a table

1. Initially, its temperature is higher than surroundings.
2. It radiates heat and starts cooling.
3. Eventually, it reaches the same temperature as surroundings = Thermal Equilibrium.

Leslie Cube Experiment

1. Used to demonstrate how surface texture affects thermal radiation.
2. The cube has four sides with different surfaces:

- Black Matte
- White
- Dark Color
- Shiny Surface

Steps:

1. Boiling water is poured into the hollow cube.
2. Wait until the cube reaches a steady temperature.
3. Use an infrared thermometer to measure radiation from each side.
4. The thermometer detects which surface emits more or less IR radiation.

Conclusions: Summary Table

Color	Absorber	Emitter	Reflector
Black	Best	Best	Worst
Dull / Dark	Good	Good	Bad
White	Bad	Bad	Good
Shiny Silver	Worst	Worst	Best

SRQS

Q1. Define thermal radiation.

Answer:

Thermal radiation is the emission of electromagnetic energy from the surface of an object due to its temperature. All bodies above absolute zero emit radiation, primarily in the infrared spectrum, which can travel through vacuum at the speed of light.

Q2. Why does radiation not require a medium?

Answer:

Heat transfer by radiation occurs through electromagnetic waves (photons) consisting of oscillating electric and magnetic fields. These waves do NOT need particles to carry energy, allowing them to propagate through empty space — this is why the Sun's energy reaches Earth.

Q3. Compare radiation with conduction and convection.

Answer:

Conduction and Convection need a medium (solid, liquid, or gas).
Radiation does NOT need any medium — can occur in vacuum.
Radiation travels at the speed of light — fastest heat transfer method.
Conduction: particle-to-particle vibration.
Convection: bulk fluid movement.
Radiation: electromagnetic wave emission.

Q4. Name two everyday sources of thermal radiation ?

Ans:

1). The Sun, which emits a broad spectrum of electromagnetic radiation (visible, UV, infrared) that provides Earth with light and heat.
2). A fire (burning wood), whose flames generate intense infrared radiation that heats nearby objects through emission and absorption of electromagnetic energy. Both sources demonstrate how hot bodies release thermal radiation that can be felt or measured.

Q5. What does the solar spectrum illustrate about the Sun's energy?

Ans:

The solar spectrum displays the intensity of the Sun's electromagnetic radiation versus wavelength, showing three main regions: ultraviolet, visible, and infrared. The peak intensity lies in the visible range, with substantial infrared energy that contributes to heating. The spectrum explains how the Earth receives both luminous energy (for vision and photosynthesis) and thermal energy (for warming), and it highlights that radiation travels at light speed, making it the fastest heat-transfer mechanism.

Q6 How does an object's temperature affect the amount of thermal radiation it emits?

Ans:

An object's temperature directly influences its thermal radiation emission according to the Stefan-Boltzmann law: $P = \sigma \varepsilon A T^4$, where power P is proportional to the fourth power of absolute temperature T. Thus, a small temperature increase causes a large rise in emitted radiation. Hot objects emit more energy and shift emission toward shorter wavelengths (e.g., visible light for very hot bodies), while cooler objects emit longer-wavelength infrared radiation. This relationship is crucial in thermodynamics and engineering design.

MCQS

Q1. Thermal radiation is the transfer of heat through:	
A) Solids only	B) Fluids only
✓ **C) Electromagnetic waves**	D) Conduction
Ans: *Radiation transfers heat via infrared electromagnetic waves and does not need a medium.*	

Q2. Radiation can occur in:	
✓ **A) Vacuum**	B) Solids only
C) Fluids only	D) Solids and fluids only
Ans: *Unlike conduction or convection, radiation can transfer heat through empty space.*	

Q3. Which surface will radiate heat fastest?	
✓ **A) Black and rough**	B) White and shiny
C) Silvered polished	D) Polished aluminium
Ans: *Dark, rough surfaces are the best emitters of radiation.*	

Q4. Heat from the Sun reaches Earth by:	
A) Conduction	B) Convection
✓ **C) Radiation**	D) All of these
Ans: *Space is a vacuum, so radiation is the only possible method.*	

Q5. A perfect black body:	
A) Reflects all radiation	✓ **radiation**
C) Transmits all radiation	D) Emits no radiation
Ans: *A perfect black body absorbs ALL incident radiation.*	

Q6. Polished silver reflects most incident radiation. This means it is a	
A) Good absorber	✓ **B) Poor absorber**
C) Good emitter	D) Poor reflector
Ans: surface that reflects most incident radiation absorbs very little of it (unlike a Black body radiation which absorbs all radiation).	

Q7 .Poor emitters of radiation are	
A) Dark and rough surfaces	✓ **surfaces**
C) Black surfaces	D) Matte surfaces
Ans: Reflect most radiation, emit little.	

Q8 .Which of the following is a good absorber and emitter of radiation?	
A) White body	✓ **B) Black body**
C) Silver plate	D) Polished aluminum
Ans: A black body absorbs all incident radiation and emits maximum radiation.	

10.4 APPLICATIONS OF HEAT TRANSFER

1) Heating a Pan — All Three Modes

Conduction

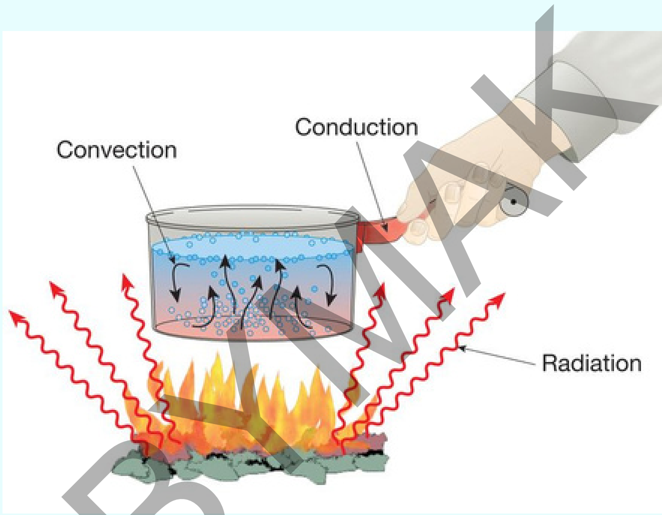
1. Heat moves from the burner to the pan's base by direct contact.
2. The metal pan absorbs that energy and passes it on to the food touching the pan.
3. Some heat also travels up the handle—hence handles are made up of plastic or wood, which are poor conductors.

Convection

1. In a pot of water, the layer at the bottom heats up, becomes less dense and rises.
2. Cooler denser water from the above moves to the bottom, creating a circulation that evens out the temperature until boiling.

Radiation

1. In grilling or broiling, heat radiates as infrared waves straight from the hot coals or heating element to the pan, without the need for physical contact.

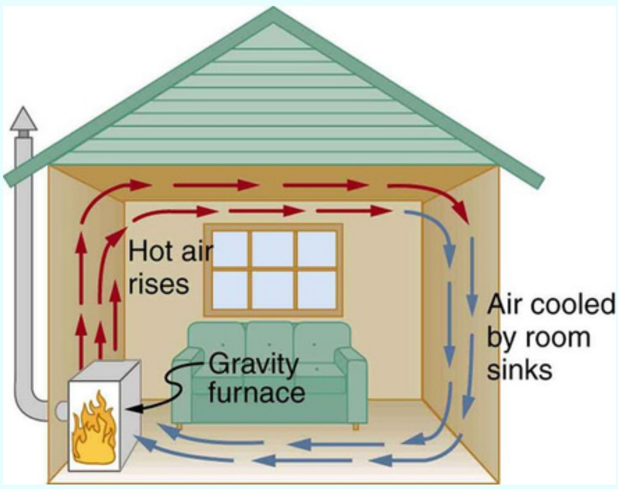


2) Household Hot Water System

1. Cold water enters the bottom of storage tank
2. Electric element heats the water inside
3. Hot water rises to top layer by convection
4. As hot water is used, fresh cold water refills the bottom — continuous supply

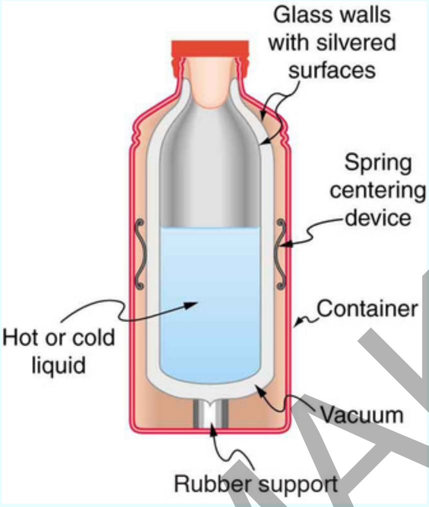
3) Heating a Room by Convection

1. When the heater is turned on, it heats the surrounding air.
2. Hot air becomes less dense and rises.
3. As the hot air rises, cooler air moves in from the rest of the room to replace it.
4. The cooler air heats up, becomes less dense and rises, and the cycle repeats.
5. This creates a convection current, raising the overall temperature of the room.



4) Thermos Flask

1. Double-wall construction with a VACUUM between walls
2. Conduction: Minimised — no medium to transfer heat through vacuum
3. Convection: Cannot occur — no air to carry heat
4. Radiation: Minimised — inner wall is SILVERED so it reflects heat back

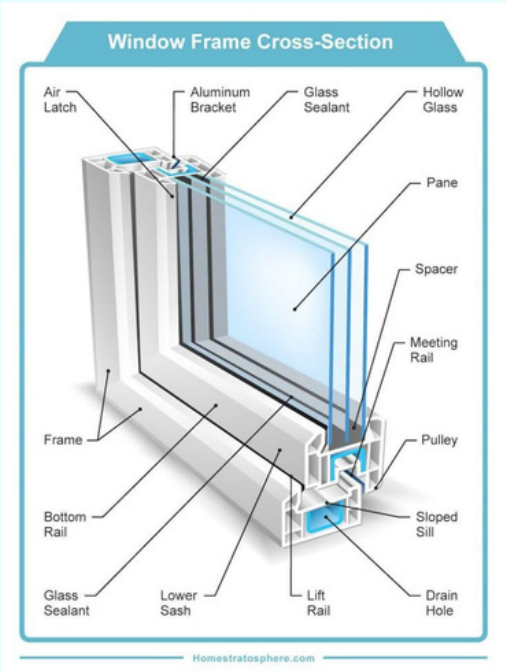


5) Measuring Temperature with Infrared Thermometers:

1. All object emit infrared radiations.
2. Used to measure temperature without a physical contact.
3. Used in furnaces and industries.
4. Food storage facilities.
5. Hazardous areas where contact is risky.

Methods to reduce heat transfer:

Double-glazed windows, which contain a vacuum or air gap between two panes of glass, help reduce heat transfer.
Proper roof and wall insulation helps keep the interior temperature stable.
Using thick curtains and ventilation.
Proper shading, false ceilings acts as insulation
Proper Orientation



SRQS

Q1. How does heat transfer occur in cooking using a kitchen pan?

Answer:

Three modes work together:

Conduction: Heat transfers from hot pan directly to food through contact.

Convection: Heat circulates within liquids due to movement of fluid particles.

Radiation: In grilling, heat radiates as infrared waves from hot coals to food.

Q2. How does a thermos flask prevent heat transfer?

Answer:

A thermos flask has a double-wall construction with vacuum between walls:

Conduction: minimised — vacuum has no medium to transfer heat

Convection: cannot occur — no air to carry heat

Radiation: minimised — inner wall is silvered, reflects heat back

This keeps hot liquids hot and cold liquids cold for extended periods.

Q3. How does convection help in heating a room?

Answer:

Working of Convection in Room Heating

Warm Air Expansion

Air near the heater gets warm, expands, and becomes less dense.

Rising of Warm Air

The warm air rises upward while cooler air moves downward.

Formation of Convection Currents

This continuous movement creates convection currents that distribute heat evenly.

Q4. What is the mechanism of a household hot water system?

Answer:

Working Principle of Water Heating System

Heating at the Bottom

The heating element warms water at the base of the tank.

Convection Currents

Hot water rises to the top while cooler water sinks to the bottom.

Continuous Circulation

This cycle continues until all water becomes uniformly heated.

Q5. How is the temperature of a liquid measured?

Answer:

Using a Thermometer:

A thermometer is placed in the liquid to measure its temperature.

Expansion of Liquid:

When heated, the liquid inside the thermometer expands and rises in the narrow tube, indicating the temperature.

Correct Placement:

The thermometer bulb should be fully immersed in the liquid and must not touch the sides or bottom of the container to ensure an accurate reading.

Q6. How can thermal energy transfer be reduced in buildings?

Answer:

Use of Insulation Materials:

Materials such as fiberglass trap air and reduce heat transfer.

Double-Glazed Windows:

The air gap between two glass panes acts as an insulator and reduces heat loss or gain.

Reflective Surfaces:

Light-colored roofs and walls reflect heat radiation and reduce heat absorption.

Q7. How do infrared thermometers measure temperature?

Answer:

Working of Infrared Thermometers

Detection of Infrared Radiation

All objects emit infrared radiation based on their temperature.

Non-Contact Measurement

These thermometers measure temperature without touching the object.

Role of Emissivity

Accuracy depends on the emissivity of the surface being measured.

MCQS

Q1. In a metal pan, heat reaches food mainly through:	
A) Radiation	B) Convection
✓ **C) Conduction**	D) Evaporation
Ans: *Direct contact between pan and food transfers heat by conduction.*	

Q2. A heater is placed near the floor to:	
A) Maximise radiation	B) Increase conduction
✓ **currents in room**	D) Reduce heat loss
Ans: *Warm air rises and creates circulation throughout the room.*	

Q3. Double-glazed windows reduce heat loss by:	
A) Increasing conduction	✓ **panes**
C) Increasing radiation	D) Removing convection
Ans: *Trapped air acts as an insulator, reducing heat transfer.*	

Q4. Why is the heating element at bottom of a water heater?	
A) To increase radiation	B) To reduce cost
✓ [illegible] **currents**	D) To avoid conduction
Ans: *Heating from below ensures hot water rises and cold water sinks — proper convection flow.*	

Q5. Infrared thermometers measure temperature by detecting:	
A) Conduction	B) Convection
✓ **C) Infrared radiation**	D) Visible light
Ans: *All objects emit infrared radiation based on their temperature.*	

Q6. Why does stirring food increase cooking efficiency?	
A) It increases radiation	✓ [illegible] **currents**
C) It reduces conduction	D) It stops heat loss
Ans: Stirring improves convection by distributing heat evenly.	

UNIT:10 HEAT CAPACITY AND MODES OF HEAT TRANSFER

10.5 GREENHOUSE EFFECT & GLOBAL WARMING

Natural Process of earth's energy distribution mechanism.

Greenhouse Effect:
Earth absorbs high energy radiations and emits low energy radiations into space.

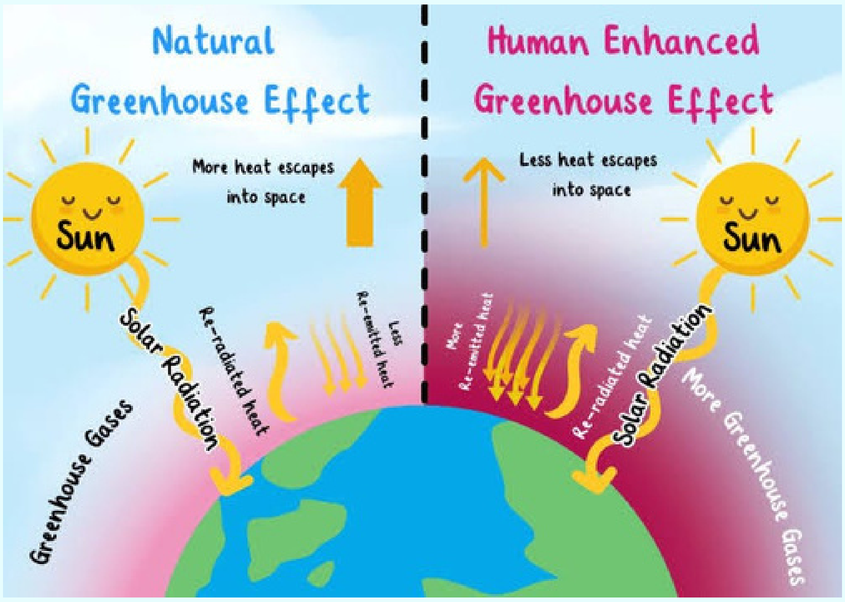
Heat Trapping:
1. Water vapours, methane, Carbondioxide, etc absorb the outgoing infrared radiation.
2. Re-emits much of it back to the Earth 》Warms lower temperature.

Life-Supporting Blanket:
1. Without it, nighttime temperatures would drop to -180°C.

Increase in Greenhouse Gases
1. Vehicle exhaust and industrial smoke release Carbondioxide.
2. Methane from livestock and paddies.
3. Nitrous Oxidizes from fertilizers.
4. Deforestation increases CO^2 levels.

Global Warming:
These gases acts like a blanket, preventing the heat reflecting.

Definition:
Gradual increase in earths average temperature.



Effects of Global Warming

1. Increased rainfall and flooding in some areas.
2. Faster melting of glaciers, raising sea levels.
3. Stronger hurricanes due to more moisture content.
4. Heavier snowfalls due to increased moisture from the atmosphere.
   due to more moisture content in atmosphere

Drying of land:

1. Increased evaporation and reduced water retention in soil and plants.
2. Harder for plants to grow.
3. Increased Wildfires:
4. Dry vegetation and high temperature make conditions ideal for wildfires.
5. Fire spread quickly and reduce air quality due to smoke.

Solutions

1. Stop deforestation and promote afforrstation
2. Forests act as natural carbon sinks absorbing CO^2
3. Use energy sources that emit little or no greenhouse gases.
4. Develop climate-resilient infrastructure to withstand extreme weather.

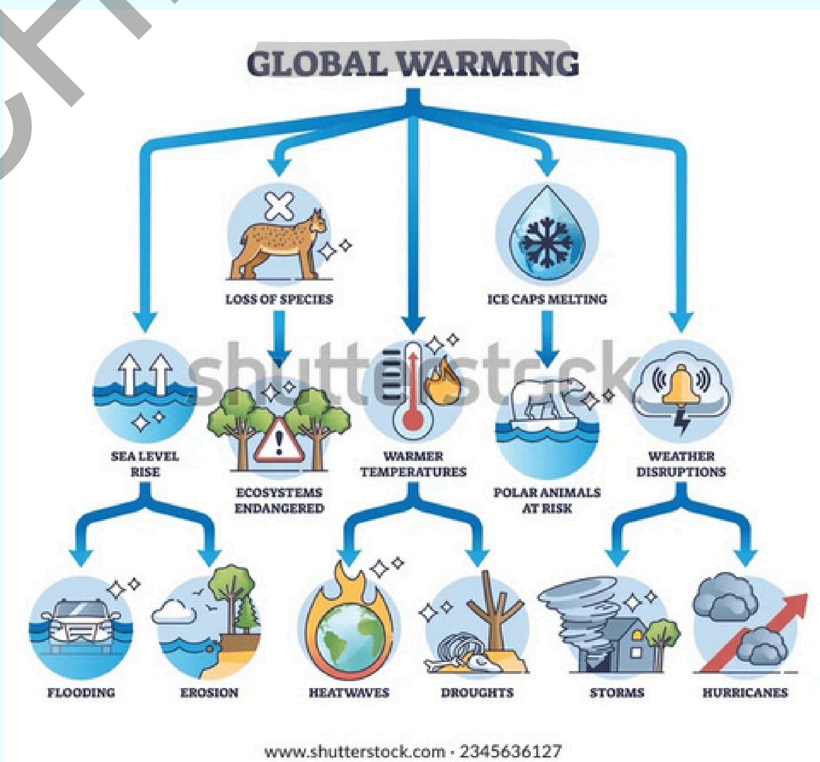
Difference between greenhouse effect and global warming?

Greenhouse effect:

1. It is a natural process.
2. Traps enough heat from the Sun.
3. Keeps the earth warm enough to support life.

Global warming:

1. Long-term rise in Earth's temperature.
2. Caused by human activities.
3. Increases greenhouse effect.



SRQS

Q1. What is the greenhouse effect?
Answer:
The greenhouse effect is the process in which certain gases in the atmosphere trap heat and keep Earth warm. Sunlight enters Earth's surface, and the heat radiated back is absorbed and re-emitted by greenhouse gases (CO_2, methane, water vapor), preventing it from escaping to space. It is a NATURAL process essential for life.

Q2. What is global warming?
Answer:
Global warming is the gradual increase in Earth's average temperature due to increased concentration of greenhouse gases caused by human activities such as burning fossil fuels, deforestation, and industrial processes.

Q3. How can global warming be reduced?
Answer:
1. Planting more trees (forests absorb CO_2)
2. Reducing fossil fuel use
3. Using renewable energy (solar, wind)
4. Reducing vehicle emissions
5. Developing energy-efficient technology
6. Building climate-resilient infrastructure

Side Box — Why will global fires increase by 19% by 2050?
Climate models predict a 19% increase in global fires by 2050 (vs 2015) due to:
1. Hotter, Drier Conditions: Warmer climate causes more evaporation, drier soil and vegetation, more flammable fuel.
2. Longer Fire Seasons: Warmer temperatures extend the window for hot, dry conditions.
3. Changed Rainfall Patterns: Some areas receive less rain due to climate change, increasing drought and fire risk.

Q4. How do human activities increase greenhouse gases?

Answer:

Human activities increase greenhouse gases in several ways:

1)Burning fossil fuels (coal, oil, gas) releases CO_2.
2)Vehicles produce smoke and harmful gases.
3)Industrial activities release methane and nitrous oxide.
4)Deforestation reduces the number of trees that absorb CO_2.

These actions increase the concentration of greenhouse gases in the atmosphere.

Q5. How does global warming cause flooding?

Answer:

Global warming causes flooding in the following ways:

1)Rising temperatures melt glaciers.
2)Melting glaciers increase sea levels.
3)Higher sea levels flood coastal areas.
4)Heavy rainfall also increases due to increased evaporation.
5)This leads to damage to land and property.

Q6. Why are droughts increasing due to global warming?

Answer:

Droughts increase because:

1)Higher temperatures cause more evaporation.
2)Soil loses moisture quickly.
3)Plants receive less water.
4)Rainfall patterns change in some regions.

This makes land dry and reduces agricultural production.

Q7. How does global warming affect hurricanes?

Answer:

1)Global warming heats up oceans.
2)Warm oceans give more energy to hurricanes.
3)Hurricanes become stronger.
4)They produce faster winds.
5)They bring heavier rainfall.

This increases destruction in affected areas.

MCQS

Q1. The greenhouse effect involves Earth:	
A) Only absorbing radiation	✓ **B) Absorbing high-energy, emitting low-energy radiation**
C) Reflecting all radiation	D) Only emitting radiation
Ans: *Earth absorbs high-energy solar radiation and emits low-energy infrared radiation, trapped by greenhouse gases.*	

Q2. Without atmosphere, Earth's nighttime temperature would drop to:	
A) +40°C	B) 0°C
✓ **C) -180°C**	D) Remain constant
Ans: *Without an atmosphere, nighttime temperature would be about -180°C (like the Moon).*	

Q3. Which of the following is NOT a greenhouse gas?	
A) Carbon Dioxide	B) Methane
C) Nitrogen Oxide	✓ **D) Helium**
Ans: *Water vapor, CO_2, methane, and nitrogen oxide trap heat. Helium does not.*	

Q4. Deforestation contributes to global warming by:	
A) Increasing reflection	✓ **B) Reducing CO_2 absorption**
C) Producing methane	D) Cooling Earth
Ans: *Trees absorb CO_2; cutting them reduces absorption, increasing CO_2 levels.*	

Q5. Wildfires are increasing due to global warming because:	
A) More rainfall	✓ **out vegetation**
C) More trees planted	D) Decreased evaporation
Ans: *Higher temperatures lead to hotter, drier conditions making vegetation more flammable.*	

Q6. Which gas contributes the most to the greenhouse effect in global warming	
A) Oxygen	B) Nitrogen
✓ **C) Carbon dioxide**	D) Hydrogen
Ans: *Carbon dioxide is the major greenhouse gas due to human activities.*	

Q7. Which human activity is the largest source of carbon dioxide?	
A) Agriculture	✓ **B) Burning fossil fuels**
C) Fishing	D) Mining salt
Ans: Combustion of coal, oil, and gas releases large amounts of CO_2.	

Q8. Methane is more effective than carbon dioxide in trapping heat because it:	
A) Is heavier	✓ **absorption capacity**
C) Is more abundant	D) Is colorless
Ans: Methane traps more heat per molecule than CO_2.	

UNIT:10 HEAT CAPACITY AND MODES OF HEAT TRANSFER

QUICK REVISION — KEY POINTS SUMMARY

Specific Heat Capacity

- Definition: Heat needed to raise 1 kg of substance by 1°C or 1 K
- Formula: $Q = mc\Delta T$ | $c = Q/(m\Delta T)$
- SI Unit: $J\ kg^{-1}\ K^{-1}$
- Water (4200 J/kgK) = highest — heats and cools slowly
- Metals have LOW specific heat — heat and cool quickly

Modes of Heat Transfer

- Conduction: Through solids via vibrating particles and free electrons
- Convection: Through fluids via bulk movement (hot rises, cold sinks)
- Radiation: Through electromagnetic waves — NO medium needed

Radiation Surface Properties

- Black/dark/rough → Best absorber, Best emitter, Worst reflector
- White/shiny/smooth → Worst absorber, Worst emitter, Best reflector

Greenhouse Effect & Global Warming

- Natural process — keeps Earth warm by trapping low-energy infrared radiation
- Without it → Earth drops to -180°C at night
- Global warming = human-caused increase in greenhouse gases → rising temperatures
- Solutions: Renewable energy, afforestation, reduce fossil fuel use

Excercise SRQs + MCQS + Numericals

SRQS

(QNO:01): Why should we wear dark-colored clothes in winter and white colored clothes in summer?

Answer

We should wear dark-colored clothes in winter because they absorb more heat. from the surroundings, helping to keep our body warm In summer, we should wear Light-colored clothes because they reflect. most of the sunlight, keeping us cool

(QNO:02): In house geysers or water boilers are fitted on the ground floor, and still we get Sing Warm water on the top floor without a pump How is it possible?

Answer

We get Warm water on the top floor without using a pump because when water is heated in a geyser, it becomes less dense and rises naturally. This upward movement of water happens due to convection, which allows the hot water to reach higher floors without the need for pumps.

(QNO:03): Where will you get more heat from. a wood fire, I meter above the woods or one meter from the front of the woods?

Answer

We will get more heat from 1 meter above the wood. This is because, in addition to radiation, hot air rises due to convection, carrying heat upwards-So, above the fire we receive heat by both radiation and convection, while in front of the fire, we get heat mostly by radiations only.

(QNO:04): Why do crowded city areas feel hotter compared to the outskirts on a hot Summer? State reasons.

Answer

Crowded city Outskirts because buildings, roads and vehicles store a large areas feel hotter than the. amount of heat and release it slowly. This increases heat through radiation. Also, cities have less greenery. So there is less cooling from evaporation. In contrast, outskirts have more open Land and plants, which help to keep the area coder.

(QNO:05): Why is the metallic handle of a door colder than the wood of the same door when touched?

Answer

The metallic handle feels colder than the wooden part because metal is a good conductor of heat. It quickly absorbs heat from our hands, making it feel cooler. Wood being a poor Conductor, absorbs heat slowly, So, it feels warmer when touched.

(QNO:06): How do trees help to reduce the effeds of climate change, and what could happen if trees are depleted?

Answer

Trees help to reduce climate change by absorbing carbon dioxide and releasing Oxygen through photosynthesis. If forests are depleted, less CO_2 is absorbed, leading to more global warming and increase in natural disasters like storms and cyclones.

(QNO:07): How does gravity contributes to Earth's Core temperature?

Answer

Gravity contributes to earth's core temperature by pulling heavy metals like iron toward the center. As these materials move inward, the pressure increases, which generates heat. This heat, Combined with the compression from gravity. Keeps the core extremely hot.

(QNO:08): Why do certain gases in the atmosphere trap more heat than the others?

Answer

Green house gases trap more heat because they absorb Infrared radiations released by the Earth and reradiate it back to the surface. Examples include: methane, Carbon dioxide and water vapours. Gases can lead to climate change and global warming.

(QNO:09): What are the potential impacts of extraction of geothermal energy?

Answer

1. Land degradation and ecosystem disruption Depletion of underground reservoirs if not managed properly.
2. Release of harmful gases like sulfur dioxide and hydrogen sulfide.

(QNO:10): How does the specific heat capacity of different materials affect their use in Cookware?

Answer

The specific heat capacity of a material affects how it heats up and cools down. Cookware made from materials with low specific heat, like aluminum, heats quickly. and is useful for fast cooking Materials with high specific heat, like cast iron, take longer to heat, but retain heat well, making it ideal for even cooking.

(QNO:11): Water at 20°C is sent deep underground into heated layers where it turns into a mix of steam and hot water at 100°C. As the steam and hot water cool down back to 20°C, why does one kg of steam release more energy than one kgbof hot water?

Answer:

Steam releases more energy than hot water when cooled because it changes its state into liquid, releasing Latent heat during condensation. Hot water only loses heat by cooling down without a change of state. This is why 1 kg of steam gives off more energy than 1 kg of hot water.

MCQS

Q1.Why is water used in radiators of automobile as coolant?	
A) It is easily available	B) It is low cost or free
✓ **C) It has large specific heat**	D) It has oxygen
Ans: Water absorbs a large amount of heat without heating up quickly. So it cools the engine effectively.	

Q2.Which of the following situations is the best example of conduction?	
✓ **hot when placed in boiling water**	B) Warm air rising near a heater
C) Sunlight warming the surface of the Earth	D) A microwave oven heating food
Ans: Heat transfers through direct contact in solids. The spoon gets hot by conduction.	

Q3.Which combination of heat transfer methods would be dominant when you place your hand near, but not touching, a fire?	
A) Conduction and radiation	B) Convection and conduction
✓ **C) Radiation and convection**	D) Conduction and insulation
Ans: You feel heat through radiation (heat waves) and convection (hot air). No conduction because there is no contact.	

Q4.What is symbol and what is unit for the heat capacity of an object?	
✓ **A) J °C^{-1}**	B) J kg^{-1} K^{-1}
C) J kg K^{-1}	D) J kg^{-1} K
Ans: Heat capacity is measured in Joule per degree Celsius. It shows how much heat is needed to raise temperature by 1°C.	

Q5.If the same amount of heat energy is supplied to equal masses of water and copper, why does the temperature of copper increase faster?	
✓ **A) Copper has a lower specific heat capacity**	B) Water is a poor conductor of heat
C) Convection in water dissipates heat energy quickly	D) Radiation from water is stronger
Ans: Copper needs less heat to raise its temperature, so it heats up faster than water.	

Q6.The transfer of heat that takes place because of density difference in fluids is	
A) Conduction	B) Radiation
✓ **C) Convection**	D) Insulation
Ans: Hot fluid becomes lighter and rises, cold fluid sinks. This movement is called convection.	

Q7.Which of the following statements best explains why the Earth experiences more heat from the Sun than the Moon, despite being almost the same distance away?	
A) Earth is better conductor than the Moon	✓ **B) The Earth has greenhouse gases**
C) The Moon reflects most of the Sun's radiation	D) Moon traps heat effectively
Ans: Earth's atmosphere contains greenhouse gases that trap heat. The Moon has no atmosphere.	

Q8.Dull black colour on a surface is the best absorber of radiation, which of the following is the best radiator?	
✓ **A) Dull black surface**	B) Shining silver surface
C) Red coloured surface	D) White surface
Ans: A dull black surface is both the best absorber and the best radiator of heat.	

Q9.How does the enhanced greenhouse effect contribute to global warming?	
A) It increases the Earth's ability to reflect solar radiation	✓ **B) It traps more heat in the Earth's atmosphere, raising global temperatures**
C) It blocks ultraviolet rays from entering the atmosphere	D) It increases the Earth's rotation speed, causing heat buildup
Ans: More greenhouse gases trap more heat, which increases Earth's temperature.	

Q10.What is the primary driving force behind the movement of tectonic plates?	
A) Gravitational pull of the Moon	B) Solar radiation
✓ **currents**	D) Magnetic field of the Earth
Ans: Hot material inside Earth moves in circular currents. This movement pushes tectonic plates.	

Q11.Which layer of the Earth is composed of partially molten rock that can flow slowly?	
A) Lithosphere	✓ **B) Asthenosphere**
C) Mesosphere	D) Outer core
Ans: The asthenosphere is soft and semi-molten, so it flows slowly and allows plate movement.	

Q12.Which of the following extreme weather events is most directly associated with rising sea levels?	
A) Tornadoes	B) Wildfires
✓	D) Earthquakes
Ans: Rising sea levels make hurricanes more dangerous because they cause stronger flooding and storm surges.	

NUMERICALS

Q1

Convert the specific heat of water 4180 J/kg·K into units of J/g·°C. Solve this Numerical.

GIVEN:

- Specific heat of water = 4180 J/kg·K

REQUIRED:

- Specific heat of water in J/g·°C=?

SOLUTION:

Step 1: **Convert kg to g**

- 1 kg = 1000 g. So,

$$\frac{4180\ \text{J/kg·K}}{1000} = 4.180\ \text{J/g·K}$$
$$= 4.18\ \text{J/g·K}$$

Step 2: **Convert Kelvin to Celsius**

- A change of 1 K = 1 °C
- So the numerical value remains the same.

✓ Final Answer

4.18 J/g·°C

So, the specific heat of water is 4.18 J/g·°C.

Q2

Calculate amount of heat given to 25 Kg of water to increase its temperature by 50°C. Solve this Numerical.

GIVEN:

- Mass of water; m = 25 kg
- Change in temperature, $\Delta T = 50\,°C$
- Specific heat capacity of water, $c = 4180\ J/kg\,°C$

REQUIRED:

- Heat supplied, Q = ?

SOLUTION:

Step 1: Heat energy supplied: = $\Delta Q = mc\Delta T$

- $Q = mc\Delta T$

Step 2: Substituting above

- $Q = (25)(4180)(50)$

Step 3: Solving:

- $Q = (25)(4180)(50)$
- $Q = 5{,}225{,}000\ J$
- $Q = 5225\ kJ$

Final Answer

$$Q = 5.225 \times 10^{6}\ J = 5225\ kJ$$

So, 5,225,000 joules (or 5225 kJ) of heat is required.

Q3

A half kg block of an unknown metal is heated from 30°C to 80°C, requiring 19 kJ of heat energy, (a) Calculate the specific heat capacity of the metal. (b) if the same metal block is heated from 80°C to 125°C, how much additional heat energy would be needed? Solve this Numerical.

GIVEN:

- Mass of metal, m = 0.5 kg
- Initial temperature, $T_1 = 30\,°C$
- Final temperature, $T_2 = 80\,°C$
- Heat supplied, Q = 19 kJ = 19000 J

REQUIRED:

- (a) Specific heat capacity of metal, c = ?
- (b) Additional heat required from 80°C to 125°C, Q = ?

(a) Calculate specific heat capacity:

Step 1: Find change in temperature:

- $\Delta T = T_2 - T_1$

  $\Delta T = 80 - 30 = 50\,°C$

Step 2: Use formula:

- $Q = mc\Delta T \Rightarrow c = \dfrac{Q}{m\Delta T}$

Step 3: Substitute values:

- $c = \dfrac{19000}{(0.5)(50)} \Rightarrow c\ 760\ J/kg\cdot°C$
- $c = 760\ J/kg\cdot°C$

✅ **Answer (a):** $c = 760\ J/kg\cdot°C$

(b) Additional heat from 80°C to 125°C

Step 1: Find new temperature change:

- $\Delta T = 125 - 80 = 45\,°C$

Step 2: Used again:

- $Q = mc\ \Delta T$
- $Q = (0.5)(760)(45)$
- $Q = (0.5)(34200)$
- $Q = 17100\ J$

Step 3: Solving:

- $Q = 17100\ J$
- $Q = 17.1\ kJ$

✅ **Answer (b):** Q = 17100 J = 17.1 kJ

Final Answers:

- (a) Specific heat capacity = $760\ J/kg\cdot°C$
- (b) Additional heat required = 17.1 kJ

Q4

Calculate the change in temperature of 5 litres of water if it absorbs 8.4 MJ of heat energy? (Use specific heat of water = 4200 J/kg·K)

GIVEN:

- Volume of water = 5 litres
- Heat absorbed, Q = 8.4 MJ
- Specific heat capacity of water, c = 4200 J/kg·K

REQUIRED:

- (a) Change in temperature, ΔT = ?

SOLUTION:

Step 1: Convert units

- 1 litre of water ≈ 1 kg

So,

- Mass, m = 5 kg

Convert heat into joules:

- 8.4 MJ = 8.4×10^6 J
- Q = 8,400,000 J

Step 2: Use formula

- $Q = mc\Delta T$

$$\Delta T = = -\frac{Q}{mc}$$

Step 3: Substitute values

- $\Delta T = \frac{8,400,000}{21,000} = \frac{5 \times 4200}{}$
- ΔT = 400 K

Since temperature change in Kelvin equals temperature change in Celsius, ΔT = 400°C

✅ **Final Answer:** Change in temperature = 400°C

Q5

In a container, 100g of water at 80°C is mixed with 200g of water at 20°C. What will be the final temperature of the mixture, assuming no heat loss to the surrounding (and container)?
(Use specific heat capacity of water = 4200 J/kg·K or 4.2 J/g·K)

GIVEN:

- Mass of hot water = 100 g
- Mass of cold water = 200 g
- Temperature of hot water = 80°C
- Temperature of cold water = 20°C
- Specific heat capacity of water, c = 4200 J/kg·K = 4.2 J/g·K

REQUIRED:

- (a) Final temperature of the mixture, T

SOLUTION:

Step 1: Apply heat balance

- Heat lost by hot water = Heat gained by cold water

$100 \times 4.2 \times (80 - T) = 200 \times 4.2 \times (T - 20)$

Specific heat capacity (= cancels out). $100(80 - T) = 200(T - 20)$

Step 2: Expand and arrange

- $100(80 - T) = 200(T - 20)$

$= 8000 - 100T = 200T - 4000$

$= 8000 + 4000 = 300T$

$\rightarrow 12000 = 300T$

Step 3: Solve for T:

- $12000 = 300T$

$T = \frac{12000}{300} = 40°°C$

✅ **Final Answer:** Final temperature of the mixture = 40°C

Q6

A 200g piece of an unknown solid cylinder is heated to 110°C and then placed into a calorimeter containing 200g of water at 20°C. The calorimeter has a mass of 60g and specific heat capacity of 0.9 J/g°C. The final temperature of the system (solid, water, and calorimeter) is 35°C. Assume no heat is lost to the surroundings. Calculate the specific heat capacity of the solid.

GIVEN:

- Mass of solid metal = 200g
- Initial temperature of solid = 110°C
- Mass of water = 200 g
- Initial temperature of water = 20°C
- Mass of calorimeter = 60 g
- Specific heat capacity of calorimeter, c_c
  $c = 0.9$ J/g°C
- Final temperature of the system = 35°C

REQUIRED:

- (a) Specific heat capacity of the solid, c_s =

SOLUTION:

Step 1: Apply Heat Balance

- Heat lost by solid = Heat gained by water + calorimeter

Step 2: Write Heat Expressions

- Heat lost by solid:
  $Q_s = m_s c_s (110 - 35)$
  $Q_s = 200\ c_s (75)$
  $Q_s = 15000\ c_s$

- Heat gained by water:
  $Q_w = m_w c_w (35 - 20)$
  $Q_w = 200 \times 4.2 \times 15$
  $Q_w = 12600$ J

- Heat gained by calorimeter:
  $Q_c = m_c c_c (35 - 20)$
  $Q_c = 60 \times 0.9 \times 15$
  $Q_c = 810$ J

Step 3: Total Heat Gained

- $Q_{total\ gained} = Q_{water} + Q_{calorimeter}$
- $Q_{total\ gained} = 12600 + 810$
- $Q_{total\ gained} = 13410$ J

Step 4: Equate Heat Lost and Gained

- $15000\ c_s = 13410$
  $c_s = \frac{13410}{15000} = 0.894$ J/g°C

Final Answer: Specific heat capacity of the solid, $c_s \approx$ **0.89** J/g°C

Q7

A hot steel rod is cooled by plunging it into cold water. The steel rod has a mass of 3 kg and is initially at a temperature of 450°C. It cools to 50°C when placed in the water. The specific heat capacity of steel is 460 J/kg-°C. Calculate the thermal energy lost by the steel rod as it cools to 50°C.

GIVEN:

- Mass of steel rod = 3 kg
- Initial temperature, T_1 = 450°C
- Final temperature, T_2 = 50°C
- Specific heat capacity of steel, c = 460 J/kg°C

REQUIRED:

- (a) Thermal energy lost by the steel rod,

SOLUTION:

Step 1: Write Formula

- Since the rod is cooling:

  $\Delta T = T_1 - T_2$

  $\Delta T = 450 - 50$

  $\Delta T = 400°C$

Step 2: Substitute Values

- $Q = 3 \times 460 \times 400$

Step 3: Calculate

- $460 \times 400 = 184000$
- $Q = 3 \times 184000$
- $Q = 552\,000$ J

Final Answer:

Thermal energy lost by the steel rod, $Q = 5.52 \times 10^5$ J

or $Q = 552$ kJ

Example 10.1

A 200 g sample of a solid metal is heated from 25°C to 75°C. If 3,500 joules of heat energy is required to raise the temperature of the metal, what is the specific heat of the metal?

GIVEN:

- Mass: $m = 200\ g = 0.2\ kg$
- Change in temperature: $\Delta T = 75°C - 25°C = 50°C$
  (Change in temperature in Celsius and Kelvin scales is same)
- Heat energy: $Q = 3{,}500\ J$

REQUIRED:

Specific heat capacity is given by:

$$c = \frac{Q}{m\Delta T}\text{, putting values}$$

$$c = \frac{3{,}500\ J}{(0{,}2\ kg)(50\ K)}$$

$$c = \frac{350}{J\ kg\ K}$$

$$c = \frac{350\ J}{kg\ K}$$

Therefore, the specific heat of the metal is 350 J/kg K.

ANSWER

$c = 350\ J/kg\ K$

Example 10.2

A half kilogram sample of aluminum (specific heat capacity c = 900 $J/kg^{1} K^{1}$) is heated from room temperature of 25 °C to 100 °C. How much heat is absorbed by the aluminum to raise its temperature?

GIVEN:

- Mass 'm = 0.5 kg
- Specific heat 'c' = ' = 900 J kg^{1} $K^{'1}$
- Initial temperature $T_{initial}$' = 25 °C
- Final temperature T_{Final}' = 100 °C
- Change in temperature 'ΔT' = 25 °C = 75 °C = 75 K

REQUIRED:

Heat absorbed 'Q' = ?

SOLUTION:

Specific heat capacity is given by:

$$Q = c \times m \times \Delta T \quad \text{or} \quad Q = m c \Delta T$$

putting values

$$Q = (0.5\ kg) \times (900\ J/kg\ K) \times (75\ K)$$

$$Q = 33{,}750\ J = 33.75\ kJ$$

Therefore, the amount of heat required by sample of aluminum is 33.75 kJ.

ANSWER

Q = 33,750 J = 33.75 kJ

Example 10.3

A 150 g piece of an unknown solid cylinder is heated to 100 °C and then placed into a calorimeter containing 200 g of water at 25 °C. The calorimeter has a mass of 50 g and a specific heat capacity of 0.9 J/g °C. The final temperature of the system (solid, water, and calorimeter) is 30 °C. Assume no heat is lost to the surroundings. Calculate the specific heat capacity of the solid.

GIVEN:

- Mass of solid cylinder 'm_1' = 150 g
- Mass of water in calorimeter 'm_w = 200 g
- Mass of calorimeter 'm_c' = 50 g
- Initial temperature 'T_1' = 25 °C
- Temperature of solid cylinder 'T_2 = = 100 °C
- Final temperature 'T = 30 °C

REQUIRED:

Specific heat capacity 'c_1' = ? (in J/g°C)

SOLUTION:

From principle of calorimetry, we have:

$$c_1 = \frac{(m_w c_w + m_c c_c)(T - T_1)}{m_1 (T_2 - T)}$$

$$= \frac{(200\,g \times 4.18\,J/g°C + 50\,g \times 0{,}9\,J/g°C) \times (30°C - 25°C)}{(150\,g) \times (100°C - 30\,°C}$$

$$= \frac{1090 \times 5\,°C}{150\,g \times 70°C} = \frac{5450}{10500} = 0.42\,J/g°C$$

The specific heat capacity of the solid is 0.42 J/g°C.

ANSWER

$c_1 = 0.42\,J/g°C$

Credits

Credits

Written by: Inaya Toufique

Compiled by: Ibrahim Siddique and Zoobia Raza Hashmi

SRQs and MCQs credit: Muhammad Hussain Arshi, Amna Kareem, Haram Jawad, Muhammad Ammar Ajmal, Bilal Mazhar

Topical-wise side boxes and Example numericals: Muhammad Rehan

Exercise numericals: Inaya Toufique and Muhamnad Rehan.

Exercise Short Questions: Inaya Toufique

Quick Revision sheet Credit: Maida kazmi, Eman Tahir, Rohan Raza, Muhammad Saqlain

Exercise MCQs: Alisha Syed

Additional support: Muhammad Bilal Mazhar and Inaya Toufique

Reviewed by: Muhamnad Bilal Mazhar, Zoobia Raza Hashmi, Inaya Toufique, Muhammad Ammar Ajmal, and Mam Irza Maryam

Supervised by: Sir MAK and Mam Irza Maryam

Uploaded by: Sir Abdur Rehman