Chapter 7: Heat Transfer in Nature

Exercises — Let Us Enhance Our Learning

Q1 Choose the correct option in each case.

(i) Your father bought a saucepan made of two different materials, A and B. The materials A and B have the following properties —

(a) Both A and B are good conductors of heat

(b) Both A and B are poor conductors of heat

(c) A is a good conductor and B is a poor conductor of heat

(d) A is a poor conductor and B is a good conductor of heat

(ii) Pins are stuck to a metal strip with wax and a burning candle is kept below the rod (pins labelled IV III II I from far to near the flame). Which of the following will happen?

(a) All the pins will fall almost at the same time

(b) Pins I and II will fall earlier than pins III and IV

(c) Pins I and II will fall later than pins III and IV

(d) Pins II and III will fall almost at the same time

(iii) A smoke detector is a device that detects smoke and sounds an alarm. Suppose you are fitting a smoke detector in your room. The most suitable place for this device will be:

(a) Near the floor

(b) In the middle of a wall

(c) On the ceiling

(d) Anywhere in the room

SOLUTION

(i) Correct option: (c) A is a good conductor and B is a poor conductor of heat.

The body of a saucepan (part A) is made of metal, which is a good conductor of heat. This allows heat to transfer quickly from the flame to the food.

The handle (part B) is made of a material such as wood, plastic, or rubber — a poor conductor of heat (insulator). This prevents heat from reaching the hand of the person holding the pan.

(ii) Correct option: (b) Pins I and II will fall earlier than pins III and IV.

Pin I is closest to the candle flame. Heat travels along the metal strip by conduction — from the hotter end (near the flame) towards the cooler end.

As heat reaches each pin's position, the wax holding it melts and the pin falls. Pin I (nearest) falls first, then pin II, then III, and finally pin IV.
The pins do NOT all fall at the same time because heat travels progressively along the strip, not instantaneously.

(iii) Correct option: (c) On the ceiling.
Smoke consists of hot gases and tiny solid particles. Being warmer and lighter than the surrounding air, smoke rises upward by convection.
A smoke detector placed on the ceiling will detect smoke as soon as it rises, giving the earliest possible warning.

Answer: (i) (c); (ii) (b); (iii) (c)

Q2 A shopkeeper serves you cold lassi in a tumbler. By chance, the tumbler had a small leak. You were given another tumbler by the shopkeeper to put the leaky tumbler in it. Will this arrangement help to keep the lassi cold for a longer time? Explain.

SOLUTION

Yes, this arrangement will help keep the lassi cold for a longer time.
When the leaky tumbler is placed inside the outer tumbler, a layer of air is trapped in the space between the two tumblers.
Air is a poor conductor of heat (an insulator). This trapped air layer slows down the transfer of heat from the warmer surroundings to the cold lassi inside.
As a result, less heat reaches the lassi and it stays cold for a longer time.
This is the same principle used when wearing two thin layers of clothing in winter — the air trapped between the layers acts as insulation and keeps us warm.

Answer: Yes, the double-tumbler arrangement keeps lassi cold longer because the trapped air between the tumblers acts as an insulator, slowing heat transfer from surroundings to the lassi.

Q3 State with reason(s) whether the following statements are True [T] or False [F].
(i) Heat transfer takes place in solids through convection.
(ii) Heat transfer through convection takes place by the actual movement of particles.
(iii) Areas with clay materials allow more seepage of water than those with sandy materials.
(iv) The movement of cooler air from land to sea is called land breeze.

SOLUTION

(i) False [F].
In solids, heat transfer takes place mainly through conduction, not convection. In conduction, particles pass heat to their neighbours without moving from their positions. Convection involves the actual movement of particles, which is not possible in solids.

(ii) True [T].
In convection, heat transfer takes place by the actual movement of particles of liquids and gases from one place to another. For example, when water is heated from below, the hotter water at the bottom expands, becomes lighter, and rises, while cooler water from the sides comes down to take its place.

(iii) False [F].
Areas with clay materials allow less seepage (infiltration) of water than those with sandy materials. The spaces between clay particles are much smaller and less connected than those between sand particles. Water seeps fastest through gravel, slower through sand, and slowest through clay.

(iv) True [T].
At night, land cools faster than the sea. The air above the warmer sea rises, and cooler air from the land moves towards the sea to take its place. This movement of cooler air from the land towards the sea is called land breeze.

Answer: (i) F — solids transfer heat by conduction; (ii) T — convection moves particles; (iii) F — clay allows less seepage than sand; (iv) T — land breeze is cool air moving from land to sea at night.

Q4 Some ice cubes placed in a dish melt into water after sometime. Where do the ice cubes get heat for this transformation?

SOLUTION

The ice cubes get heat from the surroundings.

The surroundings (the dish, the room air, and nearby objects) are at a higher temperature than the ice (which is at 0°C or below).

Heat is transferred from the warmer surroundings to the colder ice through all three processes:

— Conduction: from the dish in contact with the ice.

— Convection: from the warm air circulating over the ice.

— Radiation: from the walls, ceiling, and objects around the dish, which radiate heat to the ice.

As the ice absorbs this heat, it melts and transforms into water.

Answer: Ice cubes get heat from the warmer surroundings (dish, air, nearby objects) through conduction, convection, and radiation, which causes them to melt.

Q5 A burning incense stick is fixed, pointing downwards. In which direction would the smoke from the incense stick move? Show the movement of smoke with a diagram.

SOLUTION

The smoke from the incense stick will move UPWARD, away from the burning tip.

Reason: Smoke is a mixture of hot gases and tiny solid particles. Being warmer than the surrounding air, it is lighter and rises upward due to convection — regardless of which direction the incense stick is pointing.

Even though the incense stick points downward, the smoke does not follow the direction of the stick. Instead, it rises upward (against gravity direction of the stick).

Diagram description:

The incense stick is held pointing downwards with the burning tip at the bottom. Smoke rises in a column upward from the burning tip, curving and spreading as it moves up. Arrows show the smoke moving upward, away from the tip.

[Diagram: incense stick pointing down, burning end at bottom, smoke arrows pointing upward from the burning tip]

Answer: Smoke moves upward (away from the burning tip) because hot smoke is lighter than surrounding air and rises by convection, regardless of the stick's orientation.

Q6 Two test tubes with water are heated by a candle flame as shown in Fig. 7.16. Which thermometers (Fig. 7.16a or Fig. 7.16b) will record a higher temperature? Explain.

SOLUTION

In Fig. 7.16a the test tube is held tilted and the candle heats the water near the BOTTOM (lower end) of the tube, with the thermometer bulb dipped in the water above the flame. In Fig. 7.16b the test tube is upright, the candle heats the water near the TOP, and the thermometer bulb is placed near the BOTTOM.

The thermometer in Fig. 7.16a will record a higher temperature.

Explanation for Fig. 7.16a (heated from below):
When water is heated from the bottom, the water at the base warms up, expands, becomes lighter, and rises.
Cooler water from above moves down to take its place and gets heated in turn.
This sets up a convection current that carries heat through the whole column of water, so the water around the thermometer bulb heats up quickly.

Explanation for Fig. 7.16b (heated from the top):
When water is heated at the top, the hot water there is already lighter and stays at the top — no convection current is set up to carry the heat downward.
Heat can reach the lower water only by conduction, which is very slow in water.
So the thermometer bulb near the bottom stays much cooler and records a lower temperature.

Therefore, heating from below (Fig. 7.16a) sets up convection and heats the water more effectively, giving the higher thermometer reading.

Answer: Fig. 7.16a records the higher temperature. There the candle heats the water from the bottom, so convection currents carry heat up through the whole water column to the thermometer. In Fig. 7.16b the water is heated at the top; the hot water stays at the top (no downward convection) and heat reaches the lower thermometer only by slow conduction, so it stays cooler.

Q7 Why are hollow bricks used to construct the outer walls of houses in hot regions?

SOLUTION

Hollow bricks are used to construct outer walls because they trap air inside their hollow cavities.
Air is a poor conductor of heat (an insulator).
In hot regions, the outside temperature is high. The layer of trapped air inside the hollow bricks slows down the transfer of heat from the hot outside to the cooler inside of the house.
As a result, the house remains cooler in summer.
Similarly, in cold weather, the same trapped air prevents heat from escaping the house, keeping it warm in winter.
This principle is the same as why woollen clothes (which trap air in their pores) keep us warm, and why two thin blankets are warmer than one thick blanket.

Answer: Hollow bricks trap air in their cavities. Since air is a poor conductor of heat, it reduces heat transfer from the hot outside to the inside of the house, keeping it cool in summer and warm in winter.

Q8 Explain how large water bodies prevent extreme temperature in areas around them.

SOLUTION

Large water bodies such as seas and oceans moderate the temperature of nearby land areas, preventing extreme heat in summer and extreme cold in winter.

The reason is that water heats up and cools down more slowly than land.

During summer (day/hot season):
Land heats up quickly under the Sun, but the nearby sea water heats up slowly and stays cooler.
Warm air over the land rises, and cooler air from the sea moves in as sea breeze, reducing the extreme heat on land.

During winter (night/cold season):
Land cools down quickly, but the sea water cools down slowly and stays warmer.
Warm air above the sea rises, and the land breeze carries some warmth, preventing temperatures from dropping to extremes.

This continuous exchange of air between the land and the large water body keeps the coastal areas from experiencing the extreme temperatures that inland areas (far from water bodies) experience.

Answer: Water heats and cools more slowly than land. This moderates coastal temperatures: sea breeze cools land during the day/summer, and the slow-cooling sea warms land at night/winter, preventing extreme temperatures.

Q9 Explain how water seeps through the surface of the Earth and gets stored as groundwater.

SOLUTION

When rain falls on the surface of the Earth, some of it flows into ponds, lakes, rivers, and oceans, while the rest seeps into the ground. This process of surface water seeping through soil and rocks is called infiltration.

Water infiltrates through the spaces (pores) between soil and rock particles:
— Gravel has wide, open, and well-connected spaces — water seeps through it very fast.
— Sand has smaller spaces — water seeps through it at a moderate rate.
— Clay has very tiny, poorly connected spaces — water seeps through it very slowly.

As water moves deeper, it passes through layers of soil and rock. It gets stored in the pore spaces of sediments and in the openings of rocks beneath the Earth's surface.

The underground layers of sediments and rocks that store water in their pore spaces are called aquifers. Aquifers can be a few metres to hundreds of metres below the ground.

This stored groundwater can be extracted by digging wells or drilling bore wells into the aquifer. Rainwater harvesting and recharge pits help replenish groundwater.

Answer: Rainwater seeps through soil and rock pores (infiltration) — fastest through gravel, slowest through clay — and gets stored in underground rock/sediment pore spaces called aquifers, which supply wells and bore wells.

Q10 The water cycle helps in the redistribution and replenishment of water on the Earth. Justify the statement.

SOLUTION

The water cycle is the continuous movement of water — upward as water vapour and downward through precipitation, passing through soil, rocks, and plants, and finally returning to water bodies.

How the water cycle redistributes water:
The Sun's heat causes water in oceans, rivers, and lakes to evaporate and rise as water vapour. Water also enters the atmosphere through transpiration from plants.
As water vapour rises, it cools and condenses to form clouds, which can travel to different regions.
Clouds bring precipitation (rain, snow, hail) over land and sea, distributing water to places far from the original water bodies.
This way, water is continuously moved from one place to another, redistributing it across the Earth.

How the water cycle replenishes water:
Precipitation that falls on land flows into rivers, lakes, and oceans, refilling them.
Some precipitation seeps into the ground, recharging aquifers (groundwater).
Snow and glaciers formed in winters melt in summers and flow as rivers, replenishing surface water.
Thus, the water cycle ensures a continuous and renewable supply of fresh water, conserving the total amount of water on the Earth.

Answer: The water cycle redistributes water by moving it from oceans to land via evaporation, cloud formation, and precipitation. It replenishes rivers, lakes, and groundwater through that precipitation and seepage — ensuring a continuous fresh water supply.