

Heat

Why are tall buildings fixed with shiny glass panels?

Why does a thick glass break when it is filled with hot water?

How do thermometers work?

Why is a bonfire lit on a cold night?

How does heat affect gas?

Let's understand:

- Relationship between temperature and heat
- Heat flow and thermal equilibrium
- Principle of expansion and contraction of matter
- Relationship between types of surface of object, and heat absorption and emission

SCIENCE BLOG

Infrared Cameras Hardly Detect Polar Bears

An infrared camera is an equipment used to detect heat emitted by the body and processes it to be shown as a thermal image. This equipment is often used to detect the location of animals or its habitat which is difficult to be seen with the naked eyes.

However, researchers find it difficult to detect polar bears using this equipment. Polar bears, which live in cold climates trap heat beneath its layers of fat and furs so well that it is almost undetectable by the infrared camera.

Keywords

- ▶ Heat
- ▶ Temperature
- ▶ Conduction
- ▶ Convection
- ▶ Radiation
- ▶ Heat conductor
- ▶ Heat insulator
- ▶ Expansion
- ▶ Contraction
- ▶ Land breeze
- ▶ Sea breeze
- ▶ Mercury

Try to recall the knowledge of heat and temperature that you have learned in primary school. Heat is obtained from various sources such as the Sun, electrical appliances and burning of fuel. **Heat** is a form of **energy**. Heat flows from a hotter region to a colder region.

What does temperature mean? **Temperature** is a measure of the degree of hotness or coldness of an object. Temperature increases in a hot environment and decreases in a cold environment (Photograph 9.1). Temperature is measured by using a **thermometer**.

When water is heated, its temperature increases.



When ice cubes are placed around bottles of juice, the temperature in the bottles decreases.

Photograph 9.1 Temperature changes according to its surroundings

Although heat and temperature are interrelated, both are not the same. Table 9.1 shows the differences between heat and temperature.

Table 9.1 The differences between heat and temperature

Heat	Temperature
A form of energy	The degree of hotness or coldness of an object
Measured in Joule (J)	Measured in degrees Celsius ($^{\circ}\text{C}$) or kelvin (K)
The amount of heat depends on the type of material, quantity of material and temperature	Temperature depends on the degree of movement of the particles in a matter.

Formative Practice 9.1

- State the S.I. unit of heat.
- Is the sense of touch a reliable method to determine if a person has fever? Give an explanation for your answer.
- Tick (\checkmark) the correct statement about heat and temperature.
 - When water is boiled in two beakers filled with 100 ml and 200 ml of water respectively, the temperature of the water is the same.
 - The smaller the mass of water, the longer the time taken for the water to boil.

9.2 Heat Flow and Thermal Equilibrium

Heat Flow

Heat flows from a **hot** object to a **cold** object. Ice cream left at room temperature absorbs heat and melts. What would happen to a hot kettle if it is left at room temperature?

Heat flow happens in three different ways, which are through **conduction**, **convection** and **radiation**. Let us carry out Activity 9.1 to understand these three ways of heat flow.



Photograph 9.2 Ice cream melts at room temperature

Activity 9.1

Aim: To show heat is transferred by conduction, convection and radiation.

Materials: Candle wax, water, matches, candle, incense stick, potassium permanganate crystal and thumbtacks

Apparatus: Copper rod, beaker, wire gauze, bell jar, bulb, T-shaped cardboard, thermometer, tripod stand, retort stand with clamp and Bunsen burner

A Conduction

1. Stick three thumbtacks on a copper rod using candle wax and set up the apparatus as shown in Figure 9.1.
2. Heat the end of the copper rod and observe the sequence in which the thumbtacks fall off.

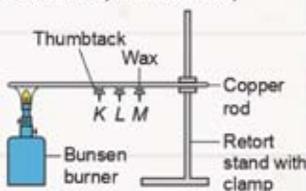


Figure 9.1

B Convection

(i) Convection in liquid



Make sure the potassium permanganate crystal sinks completely to the bottom of the beaker before it is heated up.

1. Fill a beaker with water and set up the apparatus as shown in Figure 9.2.
2. Heat the beaker slowly and observe the direction in which the potassium permanganate crystal moves inside the beaker.

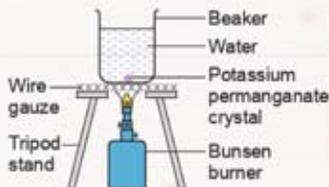


Figure 9.2

(ii) Convection in gas

1. Light a candle and place it inside a beaker on one side and place the T-shaped cardboard in the middle of the beaker (Figure 9.3).
2. Bring a glowing incense stick close to the mouth of the beaker on the opposite side of the candle.
3. Observe the movement of smoke in the beaker.

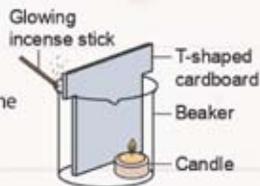


Figure 9.3

C Radiation

1. Set up the apparatus as shown in Figure 9.4.
2. Fix the vacuum pump to the bell jar and remove the air from the jar.
3. Place your palms on the sides of the bell jar to feel the heat.
4. Switch on the bulb. After 10 minutes, place your palms on the sides of the bell jar to feel the heat.

Questions

1. Give an inference for your observation in Activity A.
2. Draw the direction of the convection current in liquid.
3. What is the use of the incense stick in Activity B?
4. State other ways to detect surface heat of the bell jar in Activity C.

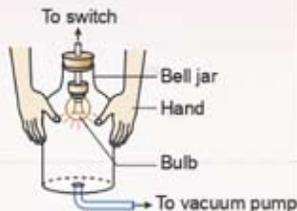
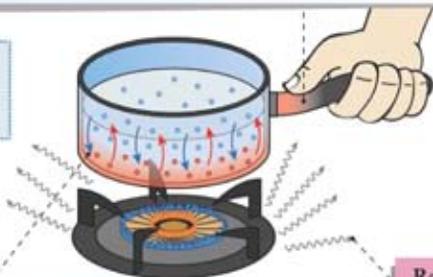
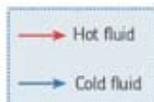
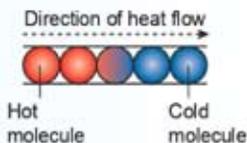


Figure 9.4

Conduction

- The process of heat transfer from hotter regions to colder regions through a **solid medium**.
- The particles that receive heat energy will **vibrate** and **collide** with one another more frequently and transfer the heat to the whole medium.



Brain Teaser

Why does a carpet feel warmer than marble tiles when we step on them?

Convection

- Heat is transferred by the **movement of fluid** (liquid and gas) from hotter regions to colder regions.
- The part of the fluid that receives heat will expand, become less dense and rise.
- The colder and more dense fluid moves downwards.
- The circulating stream that rises and falls continuously is known as **convection current**.

Radiation

- The process of transferring heat **without any medium**.
- Heat can propagate through an **empty space or vacuum**.
- The types of surface, temperature and total surface area of an object will influence the rate of heat flow.

Heat Flow in Natural Phenomena

Can you identify the method of heat flow from the Sun to the Earth? Heat energy from the Sun is transferred to the Earth through radiation. It is the only method that can propagate through an empty space (Figure 9.5). Energy that is radiated from the Sun penetrates the atmosphere before being absorbed by land and water. The warming of the Earth by the Sun causes changes in climate and the occurrence of natural phenomena such as sea breeze, land breeze, thunderstorms and so on.

Warming of the Earth by the Sun

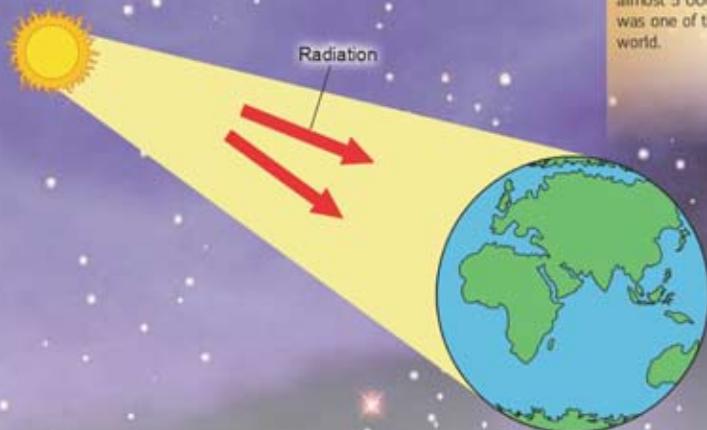


Figure 9.5 Radiation from the Sun to the Earth

Today in History

In 1936, North America was hit by a massive heat wave. The heat wave claimed almost 5 000 lives and it was one of the worst in the world.

Activity 9.2

21st Century

Aim: To discuss heat flow in natural phenomena.

Instruction

1. Work in groups.
2. Gather information on heat flow that can be observed in natural phenomena such as land breeze, sea breeze and warming of the Earth by the Sun.
3. Present your discussion.

Sea breeze

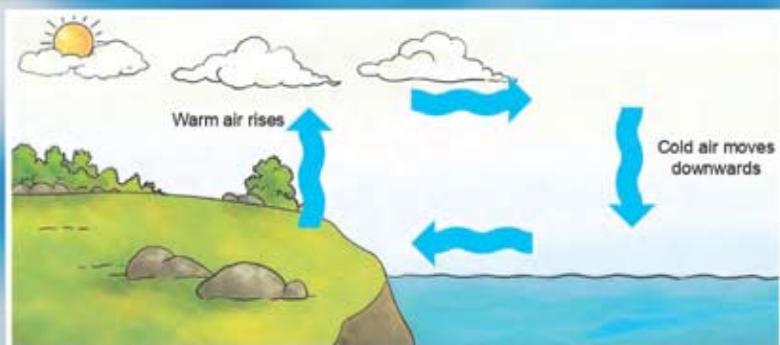


Figure 9.6 Sea breeze

The formation of **land breeze** and **sea breeze** are examples of a natural **convection process**. During the day, the Sun heats up the land faster than the sea. Warm air on land expands, becomes less dense and rises because it is lighter. The cold air from the surface of the sea that is more dense is drawn in to replace the warm air on land. This results in sea breeze (Figure 9.6).

Land breeze

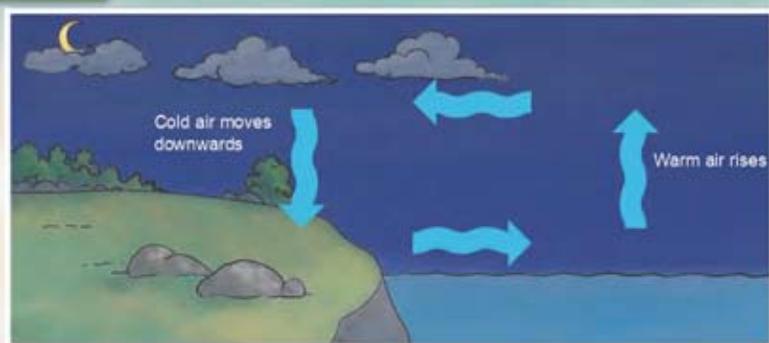


Figure 9.7 Land breeze

At night, the land cools faster than the sea. The air above the sea which is warmer becomes less dense and rises. The cold and more dense air from land begins to move to the sea resulting in land breeze (Figure 9.7).

Heat Conductors and Heat Insulators

Materials that allow heat flow are known as **heat conductors**.

Mercury in thermometers is a **good heat conductor**. It can detect change in temperature very quickly.



The bottom of a pan is made of **metal** that **allows heat to flow** quickly to the food.



The base of an iron is made of metal to enable it to **conduct heat** so that clothes can be ironed quickly.



Photograph 9.3 The uses of heat conductors in daily life

Materials that prevent heat flow are known as **heat insulators**.

Oven gloves that are **heat insulators** can prevent your hands from getting scalded while taking food trays out from the oven.



The **wall of an ice box** is made of fibreglass or polystyrene, which are **heat insulators** that can maintain the coolness of substances inside the box.



Cooking utensils made of **wood** are capable of **preventing heat** from flowing to the hand while cooking.



Photograph 9.4 The uses of heat insulators in daily life



Activity 9.3

21
minutes

Aim: To discuss the uses of various heat conductors and heat insulators in daily life.

Instruction

1. Work in groups.
2. Gather information and photographs related to various uses of heat conductors and heat insulators in daily life.
3. Present your discussion using a mind map.

Experiment 9.1

Aim: To study the uses of different materials as heat insulators.

Problem statement: Which is a good heat insulator, cotton, felt or aluminium foil?

Hypothesis: Cotton and felt are good heat insulators.

Variables:

- Constant variable: Volume of water in the flat-bottom flasks
- Manipulated variable: Types of insulators
- Responding variable: Final temperature

Materials: Cotton, felt, aluminium foil and boiling water

Apparatus: Flat-bottom flask, rubber stopper, thermometer and stopwatch

Procedure:

- Prepare four flat-bottom flasks as shown in Figure 9.8.
- Record the initial temperature of each flask.
- Record the final temperature of each flask after 10 minutes.

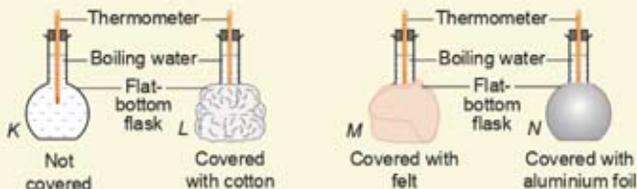


Figure 9.8

Observation:

Flat-bottom flask	K	L	M	N
Initial temperature (°C)				
Final temperature (°C)				
Difference in temperature (°C)				

Conclusion:

Is the hypothesis accepted? Give your reasons.

Questions

- State an inference for the observation made for flask N.
- What is the use of flask K?

Thermal Equilibrium

Two objects which are in **thermal contact** can exchange heat energy between them. The heat energy is transferred from the object with a higher temperature to the object with a lower temperature. When there is no net transfer of heat energy between the objects, the objects are said to be in **thermal equilibrium**. Two objects that are in thermal equilibrium have the same temperature.

Formative Practice

9.2

1. Why is the heating coil in an electric kettle placed at the bottom of the kettle?
2. The chicken that we roast in an oven is usually wrapped in an aluminium foil. Why?
3. Why is a polystyrene container used to store ice cubes?
4. Amirah uses a thick blanket for sleeping during cold weather. What is the function of the blanket? Explain your answer.

9.3

Principle of Expansion and Contraction of Matter

Expansion and Contraction of Matter

You have learned the three states of matter in Form One. Do you know the effect of changes in temperature towards matter? Let us carry out Activity 9.4 to study the effect of heat on the states of matter.



Activity 9.4

Aim: To show that heat can cause solid, liquid and gas to expand and contract.

A Solid

Apparatus: Bunsen burner, gauge and metal bar

Instruction

1. Try to fit the metal bar into the gauge (Figure 9.9).
2. Heat the end of the metal bar using a Bunsen burner for five minutes.
3. Try to fit the hot metal bar into the gauge. Record your observation.
4. Let the metal bar to cool and try to fit it into the gauge again. Record your observation.

Safety

Precaution
Be careful when handling a hot metal bar.

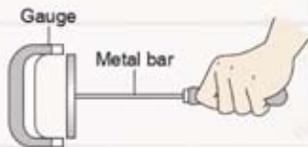


Figure 9.9

B Liquid

Materials: Coloured water, ice cubes and hot water

Apparatus: Conical flask, basin, rubber stopper and glass tube

Instruction

1. Set up the apparatus as shown in Figure 9.10 and mark the coloured water level in the glass tube at the beginning of the experiment.
2. Place the conical flask into a basin of hot water and observe the coloured water level.
3. Repeat steps 1 and 2 by replacing the hot water with ice cubes and record your observations.

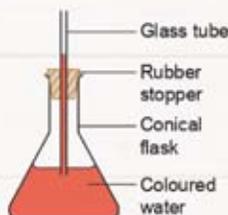


Figure 9.10

C Gas

Materials: Hot water, ice cubes and balloon

Apparatus: Conical flask and basin

Instruction

1. Set up the apparatus as shown in Figure 9.11.
2. Observe and record the condition of the balloon after three minutes.
3. Repeat steps 1 and 2. Replace the hot water with ice cubes.

Questions

1. Give an inference for your observation in Activity A.
2. Why is coloured water used in Activity B?
3. What causes the physical changes to the balloon in Activity C?



Figure 9.11

The particles in a solid vibrate at a fixed position. When the solid is heated, the particles vibrate faster and move further apart from one another. This causes the volume of the solid to increase because the **solid expands**. Conversely, when the solid is cooled, the particles vibrate slower and move closer to one another. This causes the volume of the solid to decrease because the **solid contracts**.

The particles in liquid and gas move freely. When the liquid and the gas are heated, the particles move faster and randomly. The distance between the particles also increases. This causes the volume of the liquid and the gas to increase because the **liquid** and the **gas expand**. Conversely, when the liquid and gas are cooled, the particles move slower and closer to one another. This causes the volume of the liquid and the gas to decrease because the **liquid** and the **gas contract**.

The Uses of Expansion and Contraction of Matter in Daily Life



Photograph 9.5

Mercury in a thermometer is a heat conductor that can expand and contract (Photograph 9.5).

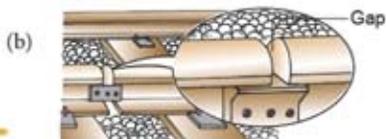


Figure 9.12

Railway tracks have small gaps between their rails to enable them to expand in hot weather. Without these gaps, the tracks will buckle and overlap (Figure 9.12).

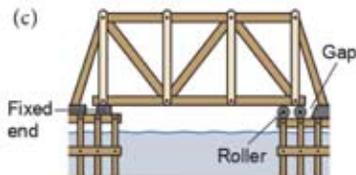


Figure 9.13

Steel bridges are built with rollers and a gap on one end. This allows the bridges to expand in hot weather (Figure 9.13).

- (d) A bimetallic strip is usually used in devices that depend on temperature regulation. The strip is made from two different types of metal strips that can expand and contract at different rates. The fire alarm system shown in Figure 9.14 is designed with a circuit which is incomplete at room temperature.

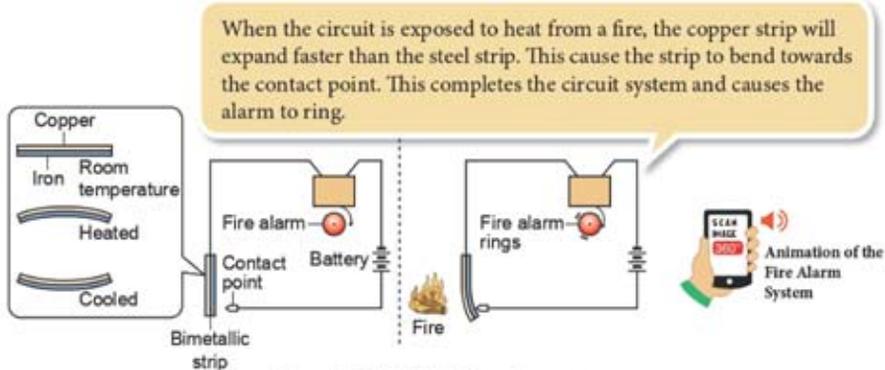


Figure 9.14 Model of a fire alarm system

The Uses of the Principle of Expansion and Contraction of Matter to Solve Simple Problems

Situation 1



Situation 2



1. What happens to the volume of water when it is heated?
2. Explain briefly why electric transmission cables on poles are hung loosely.
3. Will the expansion and contraction of matter be harmful to the structure of buildings? Give your opinion.

9.4 Relationship between Types of Surface of Object, and Heat Absorption and Emission

Absorption and Radiation of Heat

Have you ever wondered why fuel tanks are painted in bright colours such as white or silver? This is because bright colours do not absorb a lot of heat, therefore the evaporation of fuel is reduced. The ability of an object to absorb or radiate heat depends on the **type and colour of its surface**.



Photograph 9.6 Fuel tank truck

Experiment 9.2

Aim: To study how a dark object absorbs and radiates heat better than a white object.

Problem statement: Do dark objects absorb and radiate heat better than white objects?

Hypothesis: Dark objects absorb and radiate heat better than white objects.

A Good heat absorber

Variables:

- (a) Constant variable: Distance from the heat source
- (b) Manipulated variable: Colour of surface
- (c) Responding variable: Increase in temperature

Materials: Black paint and white paint

Apparatus: Bunsen burner, thermometer, empty milk can, iron plate, wire gauze, tripod stand and wooden block



Video of Good Absorber and Radiator of Heat
<http://bukatekskssm.my/Science/Video3.mp4>

Procedure:

1. Prepare two empty milk cans, one painted in white and the other in black. Then label the cans as *J* and *K*.
2. Set up the apparatus as shown in Figure 9.15 by placing both cans as close as possible to the Bunsen burner.
3. Record the initial temperature of the air inside each can and light up the Bunsen burner.
4. Observe and record the final temperature of each can after 10 minutes.

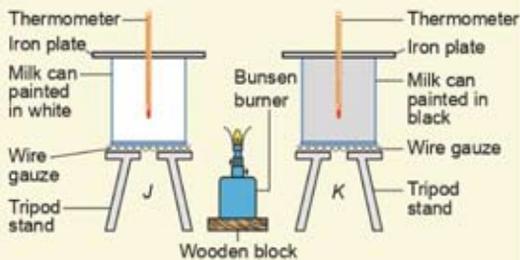


Figure 9.15

Observation:

Can	Temperature ($^{\circ}\text{C}$)		Increase in temperature ($^{\circ}\text{C}$)
	Initial	Final	
<i>J</i>			
<i>K</i>			

Conclusion:

Is the hypothesis accepted? Give your reasons.

Questions

1. Which can absorbs heat better?
2. What inference can you make from this activity?

B Good heat radiator**Variables:**

- (a) Constant variable: Volume of hot water
- (b) Manipulated variable: Colour of surface
- (c) Responding variable: Decrease in temperature

Materials: Black paint, white paint and hot water

Apparatus: Thermometer, empty milk can, iron plate and wooden block

Procedure:

1. Prepare two empty milk cans, one painted in white and the other in black. Then label the cans as *J* and *K*.
2. Fill both cans with hot water as shown in Figure 9.16.
3. Record the initial temperature of the water inside each can.
4. Observe and record the final temperature of each can after 10 minutes.

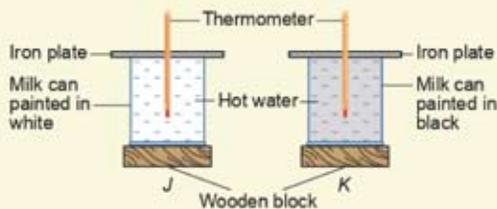


Figure 9.16

Observation:

Can	Temperature ($^{\circ}\text{C}$)		Decrease in temperature ($^{\circ}\text{C}$)
	Initial	Final	
J			
K			

Conclusion:

Is the hypothesis accepted? Give your reasons.

Questions

1. Which can radiates heat better?
2. What inference can you make from this activity?
3. What method of heat flow causes the cans to lose heat?
4. Design an experiment to study whether a dull or shiny object absorbs and radiates heat better.

When an object absorbs heat, its temperature increases. However, when an object radiates heat, its temperature decreases. **Dark and dull** surfaces are **better heat absorbers and radiators** compared to **white and shiny** surfaces.

Heat Concept in Daily Life

The **Green Building Concept** is an idea developed to reduce the effects of rapid development on the environment and our health. The features of green buildings are listed below:

- has high energy efficiency through the usage of solar energy or renewable energy.
- has good water flow system, air circulation and lighting.
- uses recycled materials.

Activity 9.5



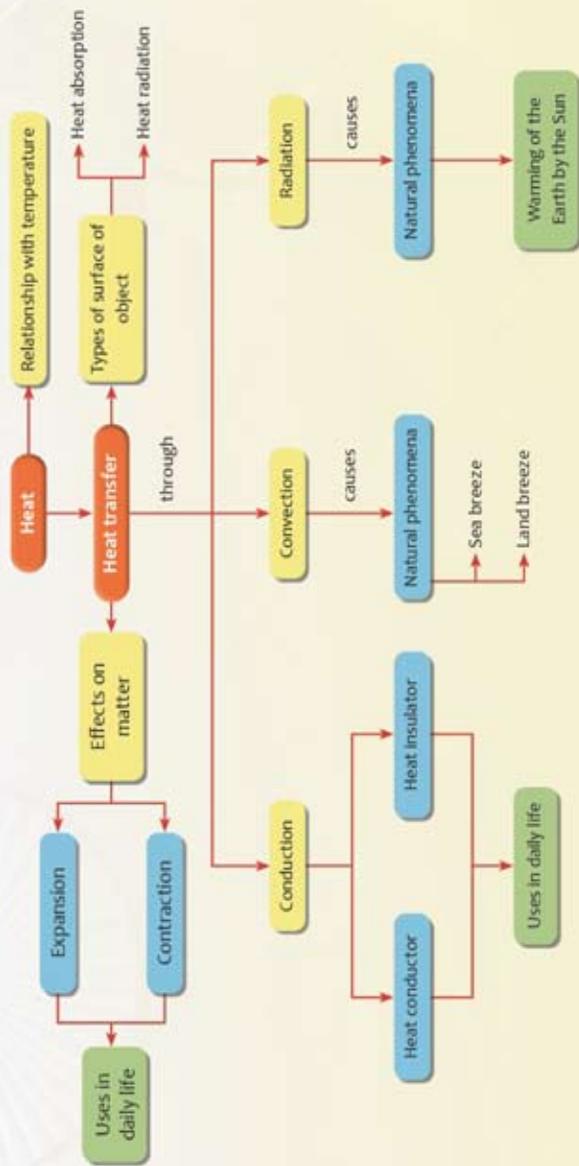
Project based learning

Design a Green Home where energy used for cooling the house or vice versa can be reduced. You can design or innovate in a local or global context. 

Formative Practice 9.4

1. What is the benefit of wearing bright coloured clothing in hot weather?
2. What is the feature of the wall of a thermos flask that allows it to maintain the temperature of hot water for a long time?
3. State two good heat absorbers and radiators that can be used in our daily life.

Summary



Interactive Quiz 9



Quiz



SELF-REFLECTION

After learning this chapter, you are able to:

9.1 Relationship between Temperature and Heat

- Make a comparison between heat and temperature.

9.2 Heat Flow and Thermal Equilibrium

- Explain how heat flows from a hot region to a cold region.
- Explain and communicate about heat flow in natural phenomena.
- Communicate about heat conductors and heat insulators and their uses in daily life.

9.3 Principle of Expansion and Contraction of Matter

- Explain how heat can cause the expansion and contraction in solid, liquid and gas.
- Communicate about the various uses of expansion and contraction of matter in daily life.

9.4 Relationship between Types of Surface of Object, and Heat Absorption and Emission

- Demonstrate how dark, dull objects absorb heat better than white, shiny objects.
- Demonstrate how dark, dull objects radiate heat better than white, shiny objects.
- Conceptualise and design using the heat concept in daily life.

Summative Practice 9

- Figure 1 shows a car at a parking lot exposed to sunlight. The windscreen of the car cracks the moment the air conditioner is turned on.
 - Explain the phenomenon shown in Figure 1.
 - Suggest and explain a precautionary step that should be taken to prevent this incident. 🧠



Figure 1

2.

Keep away from heat or fire!

The warning above is seen on a can of insecticide. Discuss what might happen if the empty can of insecticide is thrown into a rubbish dump. 🧠

3. How can you prove that heat transfer by radiation does not need a medium? Give a brief explanation. 🧠
4. (a) What causes convection current?
(b) Which heat transfer method is the fastest? Explain your answer. 🧠

HOTS Mastery 9

5. Cold weather on a rainy day causes Dayah to have difficulty in sleeping. She uses one thick blanket but still feels cold. Suggest a design of a blanket that can solve this problem (use the heat-trapping concept). 🧠
6. Figure 2 shows the apparatus of an experiment to study transmission of heat.

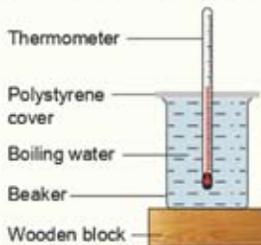


Figure 2

After the apparatus is left for 10 minutes, the reading of the thermometer was at 60°C . Suggest and explain modifications that need to be made to the arrangement of the apparatus so that the temperature of water reaches room temperature quickly. 🧠