5. Substances in the Surroundings – Their States and Properties

Can you recall? Name the solid, liquid and gaseous states of water.

Change of state of substances

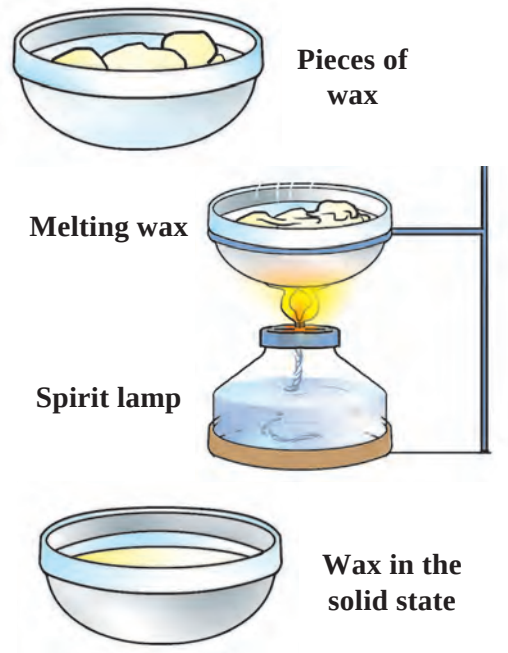
Let's try this.

Take pieces of wax in a bowl and heat them on a candle or spirit lamp.

1. How do the pieces of wax change?
2. What was the initial state of wax?
3. What did it get converted into?

Now keep the same bowl in cold water. What happens?

When a substance changes from one state to another, the process is called **change of state of the substance**.



5.1 : Change of state of wax

Can you tell?

Read this list of substances : Spirit, camphor, petrol, ghee, coconut oil, naphthalene balls, ammonium chloride (*navsagar*).

1. Which ones freeze in winter?
2. Which liquid have you seen change into a vapour?
3. Which solids directly change into the gaseous state?

What do we learn from this?

The state of a substance changes if it is heated or cooled. Every substance in our surroundings, is found in either the solid, liquid, or gaseous state.

5.2 : Various substances

In the past...

In the 19th century, the scientist J. Willard Gibbs showed that the characteristic properties of a substance depend on its physical state and the arrangement of particles in it.

Points	Solids	Liquids	Gases
Example	A piece of iron	Water, spirit, oil	Air
Shape	Has a shape of its own. Retains shape, no matter how it is kept.	Does not have a shape of its own. Takes the shape of the container.	Does not have a shape of its own. Occupies all the available space.
Volume	Has a definite volume. Solids like sugar, sand when poured on a flat surface, form a heap.	It has a specific volume. Occupies definite portion of a container. Spreads on a flat surface on pouring. Flows downwards along a slope.	Does not have a definite volume. On changing the pressure on a gas in a closed container, its volume also changes.

Heat and change of physical state

You have learnt that change in the physical state of a substance is an effect of the amount of heat in it. On gaining heat the substance changes from solid to liquid and liquid to gas. On the other hand, when the substance cools, or loses heat, it changes from gaseous to liquid and liquid to solid state.

Changes of state

on heating on heating
Solid ⇌ Liquid ⇌ Gas
on cooling on cooling

Can you tell?

Does water change into vapour the moment we place the vessel on a stove? Does water kept in fridge change at once into ice?

A specific amount of heat must be gained or lost before the state of a substance can change. The change in physical state is determined by how hot the substance becomes on gaining heat, or how cold, on losing it.

How do we tell how hot or cold a substance is?

5.3 : Thermometer

The temperature and a thermometer

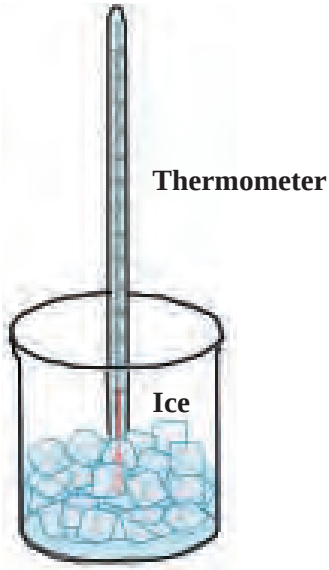
When a substance gets heat, it becomes warm and then hot. We put our hand or finger in the water to judge how hot it is, but that is not an accurate measure. Besides, if the substance is very hot, we could get scalded.

A thermometer is used to measure temperature. Degrees Celsius (°C) is the unit of measuring temperature. There are several types of thermometers available. Nowadays digital thermometers are frequently used.

Let's try this.

Take a thermometer from the laboratory. The bulb at its lower end is filled with mercury. The mercury rises to a certain level in the capillary tube above the bulb. You will see a scale next to the mercury column. Reading the figure near the level of the mercury tells us the temperature of air around the bulb of the thermometer.

Hold the thermometer in water so that the bulb is completely immersed in the water and read the temperature of the water. Repeat the activity taking some hot water in one vessel, and cold water or ice in another. Note the temperatures.



5.4 : Recording the temperature

Some examples	Temperature
Boiling water	100 ^{0}C
Freezing water	0 ^{0}C
Air (winter night)	<15 ^{0}C
Air (summer afternoon)	>35 ^{0}C
Inside a fridge	< 5 ^{0}C
Inside the freezer	< -18 ^{0}C
Body temperature	Approx. 37 ^{0}C

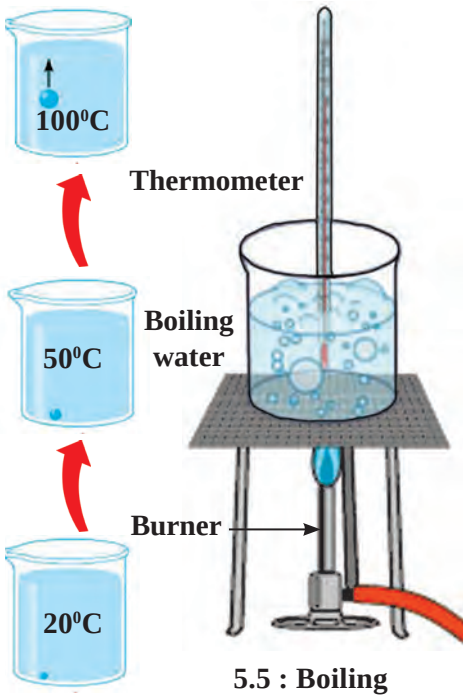
Do be careful !

Boiling

Water is continuously evaporating. We know that water spilled on the floor dries up slowly on its own. This evaporation occurs from the surface of the water.

What happens when water boils? As the water gets heated, its temperature increases and it evaporates at a faster and faster rate.

When water kept on a stove attains a particular temperature or level of heat, then evaporation takes place in all parts of the body of water. Then we see water bubbles rising at faster and faster rates to the surface and steam mixing in the air. This is called **boiling of water** or **ebullition**. At sea-level, pure water boils at 100^{0}C. This is the boiling point of water. When water vapour cools, it is converted into water again. This process is called **condensation**. Condensation of steam also takes place at 100^{0}C. It means that the boiling point and condensation point of water are one and the same.



5.5 : Boiling

Let's try this.

Take some water in a beaker and place a thermometer in it. Heat the beaker on a spirit lamp. Note the boiling point of water. Repeat the activity, adding salt or sugar to the water and note the boiling point again. What do you infer from it?

Freezing

The water kept in a fridge or on ice becomes cooler and cooler, that is, its temperature falls. At a certain temperature, water does not get any cooler, but starts freezing and forms ice. The temperature at which this happens, is called the freezing point of water.

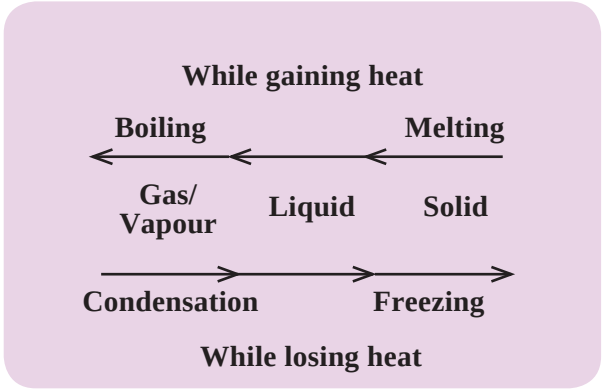
The temperature of a substance can fall below 0^0C, e.g., the temperature of air in the freezer of a refrigerator is around -18^0C. It is read as 'minus 18 degrees Celsius'.

When ice gets heat, it starts melting or changing into the liquid state again. Ice melts at 0^0C. It means that the freezing point and melting point of water are one and the same.

Each substance has a specific boiling point which is also its condensation point.

Each substance has a specific melting point which is the same as its freezing point.

The temperature at which a substance boils while heating is the same as the temperature at which it condenses when it is cooled. Similarly, the temperature at which a substance freezes while cooling is the same as the temperature at which it melts when it is heated.



Use your brain power!

The chart given below shows the boiling point and freezing point of some substances. State whether these substances are solid, liquid or gaseous at room temperature.

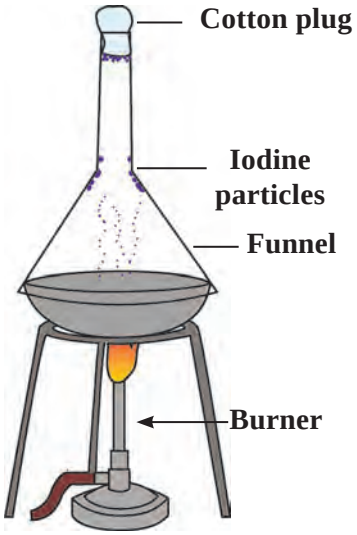
Substance	Freezing point	Boiling point
Candle	60^0C	350^0C
Plastic	>250^0C	954^0C
Iron	1535^0C	2862^0C

Various uses of changes in physical state

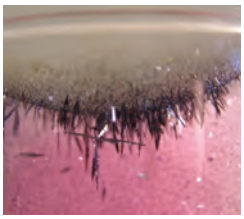
1. Candles are made by melting paraffin wax.
2. Solid carbon dioxide (dry ice) is used to make ice cream and to keep it frozen.
3. Liquid nitrogen is used in animal husbandry.
4. Sand (silica) is melted to make glass.
5. Metals like gold and silver are melted to make ornaments.
6. Iron is melted to make tools.



Let's try this. Take some sand in a crucible. Put a few iodine crystals on it. Place the crucible on a tripod to heat it. Block the stem of the funnel with a cotton plug and place it inverted over the crucible. Light the burner and heat the mixture in the crucible. Observe the changes.



5.6 : Sublimation



Actual particles of iodine seen during the experiment in the laboratory

Why does this happen?

Sublimation

Iodine crystals do not melt on heating but change directly to the gaseous state. When the fumes of iodine hit the walls of the funnel they cool to form solid crystals of iodine and stick to the funnel walls. Thus, on heating, iodine does not melt and change to a liquid but directly changes to the gaseous state.

The change of a solid substance directly into a gas or vapour without first changing into a liquid is called **sublimation.**

Use your brain power !

On opening a box of camphor, its smell spreads all around.
Why does this happen?

Can you tell?

5.7 : Identifying various substances and objects

How will you identify the following?

- A glass : Is it made of plastic, steel or glass?
- A rod : Iron or aluminium?
- A door : Wooden or glass?
- A white powder : Salt or chalk powder?

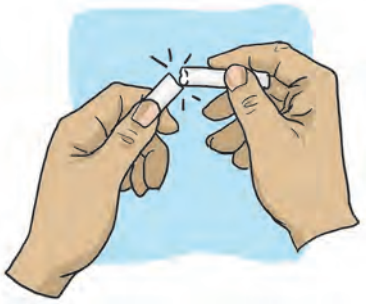
To answer the above questions, you considered their properties, e.g., their transparency, hardness, weight, colour, the sound produced from it, solubility in water, etc. Substances can be identified by studying their properties. They can be put to use according to their properties.

Let's study the properties of substances in greater detail.

Properties of substances.

Let's try this.

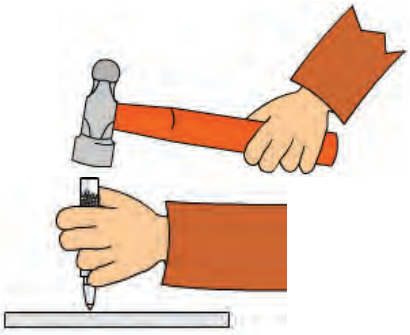
- What will happen if pressure is applied on substances like chalk, brick, alum, glass or a *rajgira wadi* ? These substances break into small pieces or particles. Such substances are said to be brittle. This property of substances is called **brittleness**.



5.8 : Brittleness

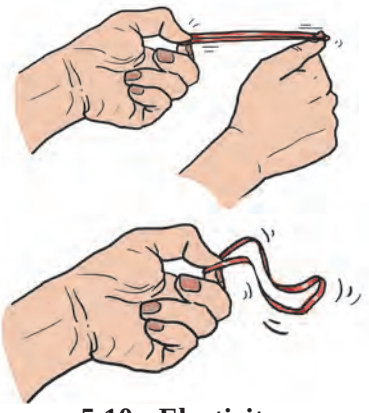
- Take an iron nail. Try to pierce a cardboard sheet, wet mud and a piece of wood using the nail. What happens? The nail easily pierces wet mud, but not the piece of wood. It can pierce the cardboard sheet with some effort. Why does this happen? The **hardness** of a substance is determined by how much resistance it offers to the substances being pushed through it.

  Which is the hardest known substance?



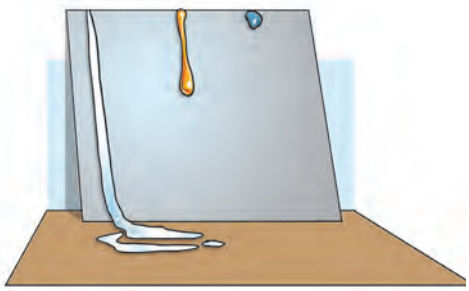
5.9 : Hardness

- Stretch a rubber band and let it go or apply pressure on a piece of sponge and release it. What do you see? The rubber band and the sponge go back to their original shape. Some substances change their shape when a force is applied on them but return to their original shape and size when the force is removed. This property is called **elasticity**.



5.10 : Elasticity

- Take a flat metal sheet of the size of a notebook. Holding it at an angle, put a drop of water, honey and gum at different places on the board. Observe how they flow down the slope. Liquids flow downward on a sloping surface. This property is called **fluidity**. The fluidity of any liquid is determined by how easily it flows.



5.11 : Fluidity

- If two blocks of the same size, one wooden and the other of iron, are weighed in a balance, how would they compare? The mass of different substances having the same volume can be different. This difference is because of the difference in their **densities**. Between substances of the same volume, the ones with greater density are heavier than the those of lesser density.

- Take a glass of water. Add some salt, fine sand and sugar to it and try to dissolve them. Repeat this, replacing water with kerosene. What do you observe? Some solid substances dissolve in a particular liquid. If a solid does not dissolve in a liquid, it is said to be insoluble in that liquid e.g. salt is soluble in water, but insoluble in kerosene. You know of many beverages, made by using water and soluble substances. The property of a substance of getting dissolved, is called its **solubility**.
- When we can look through a substance and see things on the other side, then that substance is said to be **transparent**. This property of the substance is called **transparency**. Glass, some types of plastic, clean water and air are transparent substances.

Can you tell?

Identify the objects shown in figure 5.14. From which substances are they made? What are these substances called as a group?

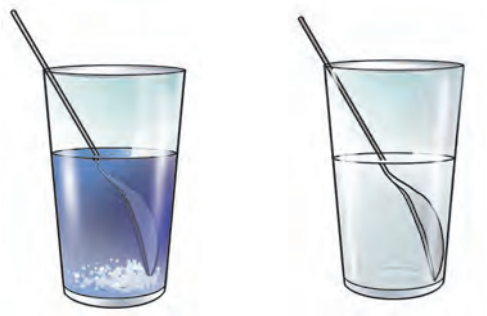
Metals : Substances like copper, gold, iron, aluminium are called metals. Metals are found in the form of minerals deep inside the earth. Minerals from the earth's crust are processed to obtain the metal. In daily life, metals have various important uses. Let us study some common properties of metals.

Properties of metals

Let's try this.

Take a piece of copper or aluminium wire or a small nail. Hammer it repeatedly. What do you observe?

On hammering repeatedly, the wire becomes flat, i.e., it forms a thin sheet. Metals can be converted into sheets by hammering. This property of metals is called **malleability**.



5.12 : Solubility

5.13 : Transparency

5.14 : Metals

5.15 : Malleability

Observe and discuss.

Hot iron is hammered and made into thin sheets. Visit a blacksmith's shop to observe how this hammering causes it to stretch. Iron bars made to revolve continuously while being hammered become longer. The iron can be drawn into a wire.

Metals can be stretched and drawn into wires. This property of metals is called **ductility**. Metals like silver, gold, copper, platinum can be drawn into fine wires.

5.16 : Ductility

Can you tell?

1. Why are the electric boards fitted on the wall made of plastic or wood?
2. The handle of a cooker is made of plastic. Why?

Electricity flows through metals. All metals are conductors of electricity to a greater or lesser extent. This property is called **electrical conductivity.**

Even when a piece of a metal is heated at one place, the whole of it becomes hot. It shows that metals allow heat to flow through them. This property is called **thermal conductivity**.

Metals have a typical shine or **lustre**. Every metal has a **characteristic colour** by which it can be identified.

5.17 : Thermal conductivity

Try this.

1. Pluck the string of a musical instrument like a *tanpura* or *veena*, ring a bell or hit a steel box with a metal spoon.
2. Strike a wooden table or a marble floor with a wooden stick.

Note the difference in the sounds produced in the two cases.

Metals produce a ringing sound. This property is called the **sonority** of metals.

5.18 : Uses of metals

Always remember...

During the rainy season or at any other time, do not touch the exposed electric wires or metal parts.

Keep all electric lamps or other appliances switched off when not in use. For example, even when the TV is switched off by remote control, do not forget to put off the main switch. It helps to save electricity besides protecting us from any possible danger.

Ask your seniors at home to check the electric wiring and fittings in the house periodically.

What we have learnt–

- Solids, liquids and gases are the three states of substances.
- The temperature of a substance, (how hot or cold it is), can be measured with the help of a thermometer.
- Heat is the cause of the change of state of substances.
- Substances have various properties like hardness, elasticity, brittleness, fluidity, density, solubility and transparency.
- Metals form a separate group of substances.
- Metals have some common properties like malleability, ductility, thermal conductivity, electrical conductivity, sonority, lustre, and characteristic colour.

Science watch ...

Science is developing continuously. How much do we know of it ? Research work goes on at the State, national and global level. If we wish to keep ourselves informed about it, we must be aware of the various happenings around us. Make newspapers your friends, read newspapers daily. Read and collect articles on science. Discuss and share them with others.

Exercise

1. In the paragraph below, write 'solid', 'liquid' or 'gas' in each of the brackets depending on the substance referred to just before.

On a bright sunny day, Riya and Gargi are playing with a ball ( ) in the park. Gargi feels thirsty. So, Riya brings tender coconut water ( ) for her. At the same time, a strong breeze ( ) starts blowing and it also begins to rain ( ). They run back into the house ( ), change their clothes ( ) and then their mother gives them a cup ( ) of hot milk ( ) to drink.

2. Discuss.

(a) Riya pours some water from her bottle into another bottle. Does it change the shape of the water?

(b) Halima picks up a small stone from the ground and puts it in the water in a dish. Does the shape of the stone change?

3. Write the properties of these substances.

Water, glass, chalk, iron ball, sugar, salt, flour, coal, soil, pen, ink, soap.

4. What is sublimation? Write the names of everyday substances that sublimate.

5. What is it made from? Why?

(a) A sickle to cut sugarcane.
(b) The sheets used for roofing.
(c) A screwdriver
(d) A pair of tongs.
(e) Electric cables.
(f) Ornaments.
(g) Pots and pans.

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6 What will happen if….? And why?

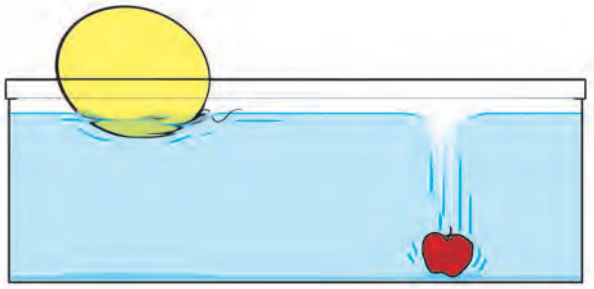
(a) Nails are made of plastic.
(b) A bell is made of wood.
(c) Rubber is not fitted on a pair of tongs.
(d) A knife is made of wood.
(e) An axe is made of rubber.

7. Who am I?

(a) I'm found in a thermometer, I measure your temperature.
(b) I make things hot or cold.
(c) I have no shape whatsoever!
(d) I dissolve in water, but not in kerosene.

8. Why does this happen?

(a) Coconut oil thickens in winter.
(b) Kerosene left open in a dish disappears.
(c) The fragrance of incense sticks lighted in one corner of a room spreads to the other corner.
(d) What you see in the picture.



Activity :

- Find out how the big statues of wax are made.
- Visit a jeweller's shop and find out how ornaments are made.