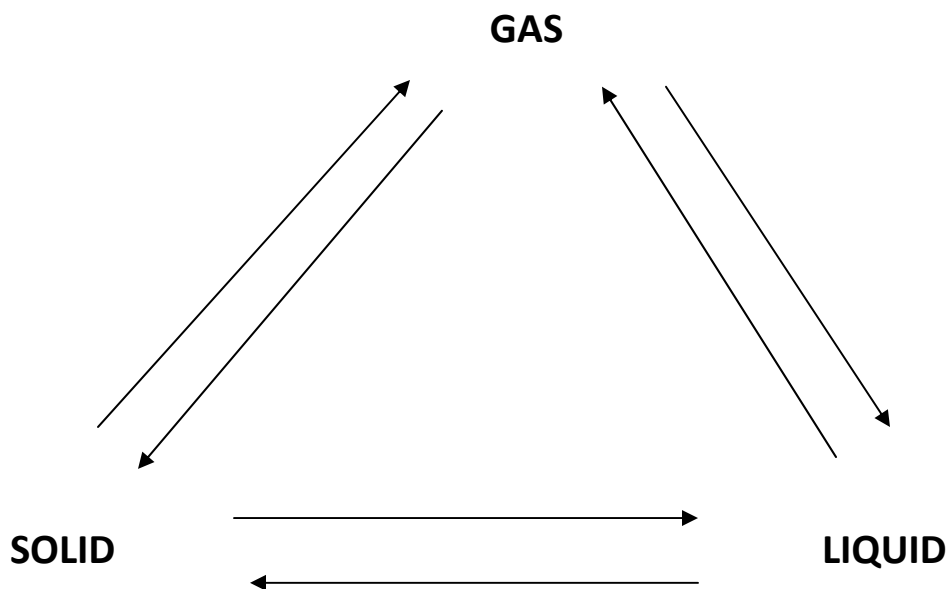


## MATTER

By definition, matter is anything that has mass and volume (e.g. a rock, water or the atmosphere). Matter is commonly found in 3 states: solid, liquid or gas.

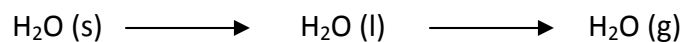
### The Changes of State of Matter



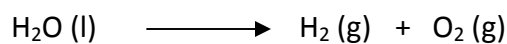
### PROPERTIES OF THE STATES OF MATTER

	SOLID	LIQUID	GAS
SHAPE	fixed	variable	variable
VOLUME	fixed	fixed	variable
COMPRESSIBILITY	<u>very</u> slight	slight	very compressible

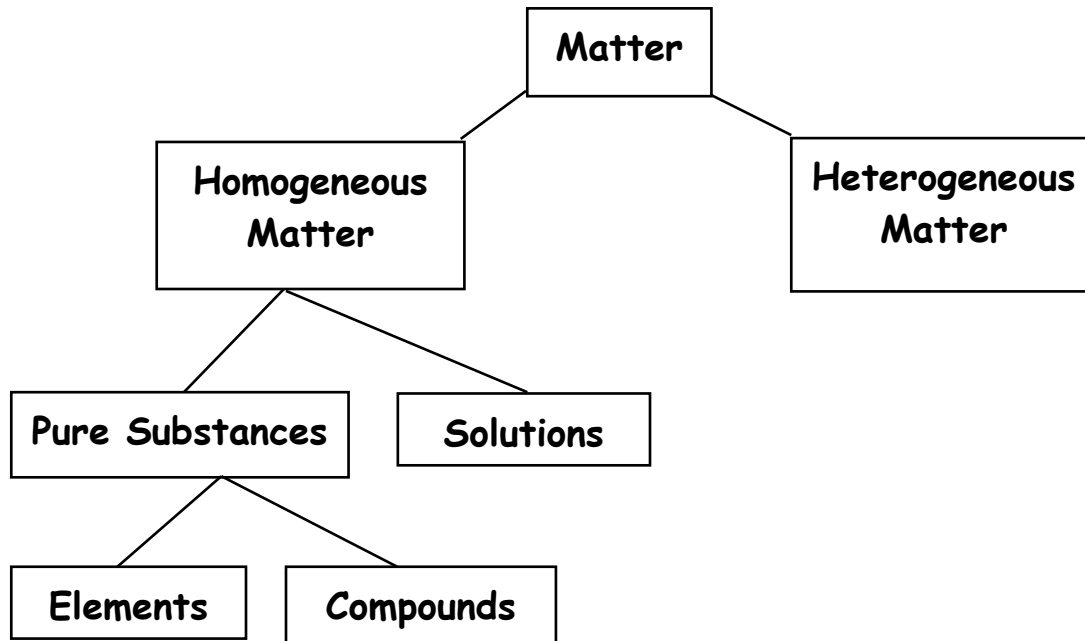
Changes of state are an example of **physical changes**. A physical change is one that alters the physical appearance of matter but does not affect the composition. For example, water as ice, liquid water or gaseous water vapour has the constant composition H<sub>2</sub>O (2 atoms of hydrogen + 1 atom of oxygen).



In contrast, a **chemical change** is a change in a substance which converts it into different form(s) of matter, each with a different composition and unique properties.



## The Classification of Matter



**Matter:** - anything that has mass and takes up space.

**Mixture:** - a combination of 2 or more pure substances.

**Heterogeneous Matter:**

- consists of 2 or more pure substances
- also called mechanical mixtures (ordinary, colloid, suspension)
- the mixture has 2 or more phases or parts

**Homogeneous Matter:**

- has only one phase with the same properties throughout
- may be a pure substance or a solution (a uniform mixture)

**Solutions:**

- homogeneous mixtures consisting of 2 or more substances
- can consist of liquids, solids or gases

**Elements:** - elements are pure substances that cannot be broken down into simpler substances by chemical reactions.

**Compounds:** - compounds are pure substances consisting of 2 or more elements bonded together. Compounds can be decomposed into simpler substances by chemical reactions.

Elements and Compounds have distinct and unique properties that can be used to identify them (e.g. boiling point, melting point, density, colour, odour, hardness etc.).

## Physical and Chemical Changes

### 1. Physical Changes

A physical change is a change which alters one or more properties of the substance with no change in the composition or identity. It does not result in the formation of a new substance.

Examples of Physical Changes:

- dissolving of salt in water
- mixing of alcohol and water
- freezing of water
- evaporation of gasoline
- sublimation of a moth ball

Matter can exist in different states such as solid, liquid and gas. However these changes do not alter the composition and are therefore physical changes.

### 2. Chemical Changes

A chemical change is a change in a substance which converts it into a different form or forms of matter, each with a different composition and unique properties. This it results in the formation of new and different substances. Chemical changes are more commonly called chemical reactions.

**Reactants** (starting substances)                       $\longrightarrow$                       **Products** (new substances)

Examples of Chemical Changes:

- |                   |                        |                       |
|-------------------|------------------------|-----------------------|
| - burning of wood | - tarnishing of silver | - baking bread        |
| - rusting of iron | - cooking an egg       | - fireworks exploding |

Any evidence for a chemical change must come from observing the formation of new substances. Some clues for recognizing a chemical change are:

1. **ENERGY CHANGE** – A chemical change may be accompanied by the release of heat or light. It may also be accompanied by the absorption of heat or light.
2. **FORMATION OF A GAS** - Some chemical reactions produce a gas as a product. This may be observed as bubbles forming in a liquid solution. This is distinct from evaporation, which is a physical change.
3. **FORMATION OF A PRECIPITATE** – When some liquid solutions are mixed together, one of the products may be practically insoluble. This solid product collects at the bottom of the solution and is called a precipitate.
4. **COLOUR CHANGE** – A chemical change may involve the formation of a new substance which has a different colour than the original substance.

## Properties of Substances

The characteristics by which one can identify a substance are called its properties. Properties can be divided into two categories. The **physical properties** of a substance are those properties which can be determined without changing its composition such as colour, odour, melting point, etc. The **chemical properties** of a substance are those properties which can be observed only when the substance undergoes a change in composition (such as combustibility, rusting, reactivity with acid, etc.). In most cases, one must examine a number of properties in order to identify a substance. The following list contains some of the common properties which are used to identify substances:

- Appearance** - colour  
- transparent (clear)/translucent/opaque  
- lustre(shiny)/dull  
- shape (crystalline/amorphous)
- Texture** - fine/smooth/rough/course
- Odour** - spicy/putrid/suffocating/sharp/choking  
- odours can compared to other things such as rotten eggs (sulfur). etc.
- Taste** - sour/sweet/bitter/salty
- State** - solid (definite volume and definite shape)  
- liquid (definite volume but no definite shape)  
- gas (no definite volume or shape)
- Density** - the mass per unit volume of a substance ( $D = m/V$ )
- Hardness** - ranges from very soft to extremely hard
- Fusibility** - this refers to whether or not a substance melts
- Melting Point** - this refers to the specific temperature at which a substance melts or freezes
- Boiling Point** - this refers to the specific temperature at which a substance boils or condenses
- Solubility** - this refers to whether or not a substance dissolves in a liquid (water/alcohol) to form a clear solution (soluble/partially soluble/insoluble).  
- do not confuse this with a substance that reacts with a liquid. That is a chemical property of the substance.
- Conductivity** - this refers to whether a substance conducts heat and/or electricity
- Combustibility** - if a substance is combustible, it will burn. That means that it will produce its own heat / light after the original source of heat is removed.
- Chemical Reactivity** - a substance could be unreactive or it could undergo a characteristic reaction with some chemical

## Physical and Chemical Properties and Changes Exercise

1. State whether the properties given below are physical or chemical properties.
  - a. Milk sours when acid is added to it.
  - b. Wood turns to ash when burned.
  - c. Hydrogen is a colourless gas.
  - d. Oxygen supports combustion.
  - e. The formation of a powder into a pellet by pressing.
  - f. A diamond is the hardest natural substance known.
  - g. The melting point of ice is  $0^{\circ}\text{C}$ .
  - h. Sodium is a soft metal.
  - i. Iodine dissolves in alcohol.
  - j. Phosphorus ignites when exposed to air.
  - k. Gold does not tarnish.
  - l. Lead is useful in making weights for scuba divers.
  - m. Copper is easily drawn into thin wires.
  - n. Laughing gas supports combustion.
  - o. Gallium metal melts in your hand.
  - p. Mercury has a density of  $13600\text{ kg/m}^3$ .
  
2. State four properties each for iron and for rust (iron oxide).
  
3. For each of the following, state three properties that could be used to distinguish between the two substances:
  - a. gold and fool's gold
  - b. silver and lead
  - c. powdered sugar and starch
  - d. water and gasoline
  - e. diamond and quartz
  - f. air and oxygen
  - g. gasoline and kerosene
  
4. For each of the following, state whether it involves a physical or chemical change.
  - a. magnetizing iron
  - b. melting wax
  - c. decaying food
  - d. tarnishing of silver
  - e. burning coal
  - f. baking a cake
  - g. fermentation of grape juice
  - h. melting of solder (used in plumbing to adhere pipes together)
  - i. evaporation of water from a lake
  - j. formation of clouds
  - k. liquefaction of air
  - l. crushing stones
  - m. burning natural gas in a home furnace or water heater

- n. twisting copper wire into a coil
  - o. mixing sand and water
  - p. dissolving ammonium chloride in water inside a 'cold pack'
  - q. neutralizing excess acid by taking Roloids or Tums
  - r. mixing baking soda and cream of tartar (a.k.a. baking powder)
  - s. using baking powder to make cakes rise during baking.
  - t. softening hard water by precipitation with washing soda.
  - u. burning of Leaves
  - v. explosion of dynamite
5. Identify each of the following properties of sodium chloride as either physical or chemical. Indicate whether the physical properties are qualitative or quantitative.
- a. It is soluble in water.
  - b. It melts at  $801^{\circ}\text{C}$ .
  - c. It reacts with sulphuric acid to form hydrogen chloride gas.
  - d. It forms cubic crystals.
  - e. It possesses a distinctive salty taste.
  - f. It has density of  $2.2\text{ g/cm}^3$ .
6. State one important difference between each pair of items.
- a. a mechanical mixture and a solution
  - b. a mechanical mixture and a compound
  - c. an element and a compound
7. Identify the following pure substances as either elements or compounds.
- a. chlorine
  - b. carbon monoxide
  - c. water
  - d. helium
  - e. baking soda (sodium bicarbonate)
  - f. sodium fluoride
  - g. acetic acid
  - h. sugar
8. Identify the following samples of matter as homogeneous or heterogeneous.
- a. nail polish remover
  - b. vinegar
  - c. soil
  - d. clean air
  - e. fog
  - f. an orange
  - g. oil and vinegar salad dressing

9. What is an impurity? What effects might the presence of an impurity have on a substance?
10. Suggest how one might determine whether Gatorade™ is a pure substance or a solution.
11. Classify each of the following as a pure substance (ps), a solution (s) or a mechanical mixture (mm).
- |                     |                     |
|---------------------|---------------------|
| 1. clear honey      | 13. slush           |
| 2. aspirin          | 14. air             |
| 3. diamond (carbon) | 15. sulfur          |
| 4. vinegar          | 16. oil and vinegar |
| 5. brass            | 17. sand and water  |
| 6. titanium         | 18. bronze          |
| 7. paint            | 19. raisin bran     |
| 8. oxygen           | 20. calcium oxide   |
| 9. milk             | 21. pizza           |
| 10. granite         | 22. chalk           |
| 11. corn syrup      | 23. clear tea       |
| 12. gold            | 24. tap water       |
12. Which of the pure substances in Question 11 are a) elements or b) compounds?
13. Why is milk considered to be a heterogeneous mixture?
14. A pure brown-coloured substance on heating produces a shiny metallic residue and gives off a colourless gas. Was the original substance an element or a compound?
15. On the basis of the evidence supplied, decide whether each of the materials described below is a pure substance, a solution or a mechanical mixture. There may be examples where a single choice cannot be made. In those cases, you should narrow down the choices as much as possible.
- a. A colourless liquid is allowed to evaporate in an open dish. When all the liquid is gone, a white crystalline residue remains.
- b. A colourless liquid is set in a cold bath to cool. At 18° C, white crystals begin to form in the liquid. More and more crystals form, with the temperature remaining at 18° C, until the whole mass is solidified.
- c. A liquid is set to evaporate in an open dish. Eventually it all evaporates, leaving no residue.
- d. A brown coloured liquid is set in a centrifuge tube and subjected to high-speed spinning in a centrifuge. After this, there is seen to be a light brown material at the bottom of the tube, and a dark brown clear liquid at the top.