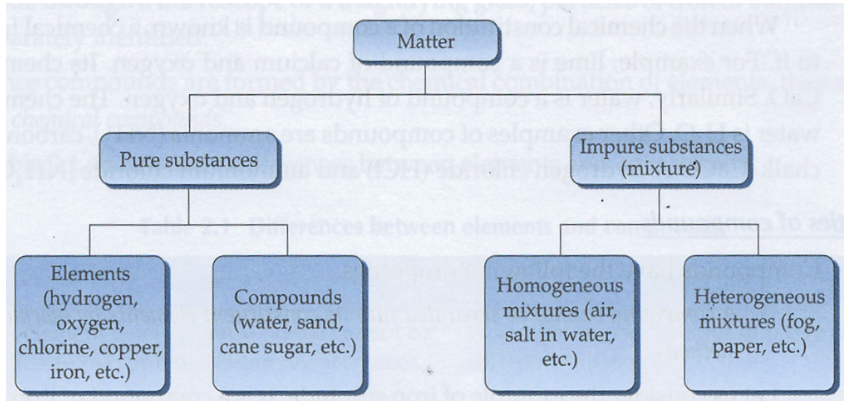
In chemistry when we say a substance is pure, it means that the substance is made up of only one type of constituent particles. A pure substance consists of a single type of particles. In other words, a substance is a pure single form of matter. Depending upon the chemical composition, matter is classified into elements, compounds (i.e. pure substances that are non separable by physical methods) and mixtures (separable by physical methods like sublimation).



<u>Pure substances:</u> substance that consists of only single type of constituent particles is called pure substance like gold, water etc. It can be of two types: elements and compounds.

1. **<u>Elements</u>: term** “element” was first used by Robert Boyle in 1661. An element is a pure substance which cannot be split into two or more simpler substances by any physical or chemical means. It is the simplest form of matter. Copper, iron, gold, hydrogen, oxygen, nitrogen and chlorine are examples of elements. At present, more than 118 elements are known. Out of these 92 are natural elements and others are man made. Hydrogen is an element because it cannot be split into two or more simpler substances by any physical or chemical method. Water is not an element because it can be split into two simpler substances (hydrogen and oxygen) by passing an electric current through it.

Classification of elements: Elements can be broadly divided into two categories—metals and nonmetals. There is also a third category of elements called metalloids. Such elements have properties lying between those of metals and nonmetals. Boron, silicon and arsenic are examples of metalloids.

<u>Metals</u> have lustre or shine. They are good conductors of heat and electricity. They are malleable and ductile in the solid state. Most metals are solid at room temperature, except mercury which is a liquid. Examples of metals are sodium, zinc, copper, gold, iron and aluminium.

<u>Nonmetals</u> usually lack lustre and are bad conductors of heat and electricity. They are generally gases, and those that are solid are soft and brittle. Bromine is the only example of a liquid nonmetal. Examples of nonmetals are hydrogen, oxygen, nitrogen, sulphur and phosphorus.

<u>Metalloids</u> have properties intermediate between those of metals and nonmetals. Silicon, boron, arsenic, antimony, bismuth, germanium, etc., are metalloids.

2. **<u>Compounds</u>:** A compound is a pure substance formed from two or more elements chemically combined together in a definite proportion. A compound can only be decomposed by a chemical action into two or more simpler substances. For example, lime is a compound of calcium and oxygen. Its chemical formula is CaO. Similarly, water is a compound of hydrogen and oxygen. The chemical formula of water is H_2O. Other examples of compounds are ammonia (NH_3), carbon dioxide (CO_2), chalk ($CaCO_3$), hydrogen chloride (HCl) and ammonium chloride (NH_3Cl).

Properties of compounds:

1. A compound cannot be separated into its constituent elements by mechanical or physical methods because the indivisual property of the element is lost during the formation of a compound. For example, water, iron sulphide, carbon dioxide.

ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
Ph No. +91-171-2631595, 9416541198, e-Mail: anusethi1968@yahoo.com Website: www. abhyasonline.in

2. The properties of a compound differ entirely from those of its constituent elements. For instance, water is a compound made up of hydrogen and oxygen. But, the properties of water are different from those of hydrogen and oxygen. Water is a liquid, while hydrogen and oxygen are gases. Similarly, sodium chloride is a compound. It is formed from the elements sodium (solid and highly reactive) and chlorine (gaseous and pungent smelling). Sodium chloride (common salt) can be directly taken with food, but both sodium and chlorine are poisonous.

3. When a compound is formed, energy is usually released or absorbed (in the form of heat or light) during the chemical reaction. For example water, the constituent elements of water —hydrogen and oxygen —are both gases and do not react with each other unless an electric spark is provided, i.e., energy is supplied. Similarly, the constituents of iron sulphide—iron and sulphur—if kept together, do not react on their own. But, if the mixture is heated, a vigorous reaction occurs and black iron sulphide is formed.

4. In a compound, the constituent elements are present in a definite proportion by weight. In water, hydrogen and oxygen are present in a fixed ratio of 1: 8 by weight.

5. A compound has a fixed melting point, a fixed boiling point, etc. For example, ice always melts at 0°C.

6. A compound is a homogeneous substance, i.e., a compound is such a substance which is the same throughout in its properties and composition. For example, iron sulphide is a compound of iron and sulphur. If we see iron sulphide through a microscope or a magnifying glass, particles of iron or sulphur cannot be separately identified.

Element	Compound
1. An element is a substance which cannot be split into two or more different substances.	A compound can be split into two or more different substances.
2. An element is formed from atoms of the same kind.	A compound is formed from atoms of different kinds.

Mixtures: A mixture is a material containing two or more elements or compounds that are in close contact and mixed together in any proportion. The components of a mixture can be separated by simple mechanical means. Some examples are:

1. Air is a mixture of nitrogen, oxygen, carbon dioxide, water vapour (moisture) and a small amount of other substances.
2. Gunpowder is a mixture of nitre (potassium nitrate), sulphur and coal.
3. Steel is a mixture of iron, carbon, and small amounts of nickel, chromium, manganese and vanadium.

Properties of mixtures

1. A mixture may be homogeneous or heterogeneous: A homogeneous mixture has a uniform composition throughout its mass. There are no visible and sharp boundaries between the various constituents of a homogeneous mixture. For example, sugar solution is a mixture of sugar in water. A mixture of two miscible liquids, i.e., liquids which mix into one another completely, is also homogeneous. For example, when we mix water with alcohol, we get a homogeneous mixture. Air is a homogeneous mixture of oxygen, nitrogen, carbon dioxide, etc. A heterogeneous mixture does not have a uniform composition throughout its mass. There are visible and sharp boundaries between the various constituents of such a mixture. For example, a mixture of sand and common salt is heterogeneous. The mixture of two immiscible liquids is also heterogeneous. For instance, when oil and water are mixed together, they get separated into two layers, one above the other. This is because oil and water are immiscible.

2. The constituents of a mixture can be separated by physical methods such as filtration, evaporation, sublimation and magnetic separation: Take a mixture of iron filings and sulphur. When a magnet is put in the mixture, the iron particles get attracted to the

ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
Ph No. +91-171-2631595, 9416541198, e-Mail: anusethi1968@yahoo.com Website: www. abhyasonline.in

magnet, stick to it and can thus be separated from the mixture. Sulphur is not attracted to the magnet.
3. In the preparation of a mixture, energy is usually neither given out nor absorbed: during mixing of sugar and sand together, there is no energy change, i.e., energy is neither released nor absorbed.
4. The composition of a mixture is not fixed: it varies from one part to another. The constituents of the mixture may be present in any proportion by weight.
5. A mixture has no definite melting point, boiling point, etc.
6. In the formation of a mixture, no chemical reaction occurs.

Types of mixtures: Mixtures can be categorized into various types, depending on the physical states of the constituents. Some of these types are discussed here.

1. **Solid—solid mixture:** A mixture of sodium chloride (solid) and ammonium chloride (solid) and a mixture of sugar (solid) and sand (solid) are examples of solid—solid mixtures.
2. **Solid—liquid mixture:** A mixture of common salt (solid) and water (liquid) is an example of a solid—liquid mixture. A mixture of iodine in ethanol (tincture of iodine) is also a solid—liquid mixture.
3. **Solid—gas mixture:** Air entrapped in the pores of soil particles is an example of this type of mixture.
4. **Liquid—gas mixture:** All gases are partially miscible with liquids. When a gas, such as hydrogen, oxygen or nitrogen is brought into contact with water, a small amount of the gas dissolves to form a mixture.
5. **Gas—gas mixture:** All gases mix together, provided they do not react chemically. For example, hydrogen and oxygen gases mix together in all proportions. Air is a mixture of several gases.
6. **Liquid—liquid mixture** Examples of liquid—liquid mixtures are water—alcohol mixture and water-oil mixture.

Oxygen is an Element: No other element has yet been found to be present in oxygen. When pure oxygen is made to react with pure hydrogen, only water is formed. Hence, oxygen is considered to be an element.

Mixture	Compound
1. It is made up of two or more pure substances mixed in any proportion.	It is a pure substance made up of two or more elements combined together in a fixed proportion.
2. The constituents of a mixture can be separated by simple physical processes.	The constituents of a compound cannot be separated by such physical methods.
3. In a mixture, the properties of the constituents do not disappear. Hence, the properties of a mixture are the average of the properties of its constituents.	The properties of a compound are entirely different from those of its constituents.
4. It may be homogeneous or heterogeneous.	It is always homogeneous.
5. In its formation, no new substance is formed.	It is a new substance, entirely different from its constituents.
6. No energy change takes place during its formation.	The formation of a compound is always accompanied by energy change.
7. It has no definite melting point, boiling point, etc.	A compound has a definite melting point, boiling point, etc.

Q Air is a Mixture, not a Compound:
Q: Water is a Compound and not a Mixture

Some Useful Mixtures:

1. Milk is not a pure substance. It is made of water, fat, proteins, etc.
2. Ink is a mixture made of water and one or more dyes.
3. Soft drinks (lemonade, soda water, etc.) that you see in your daily life are also not pure substances but are homogeneous mixtures.
4. Tincture of iodine which is used as an antiseptic is a mixture of iodine and ethanol.
5. Air is a mixture of oxygen, nitrogen, carbon dioxide, water vapour, etc.
6. An alloy is a homogeneous mixture, of a metal and other metal(s) or nonmetals. Brass is an alloy of copper and zinc. Gold has to be alloyed with silver and copper to make it hard enough for making jewelleries and ornaments.

Solutions, Suspensions and Colloids: A mixture of two or more substances can be a solution, a suspension or a colloid.

Solution: A solution is a homogeneous mixture of two or more substances. 'Homogeneous' means 'uniform throughout'. Thus, a solution will have its composition uniform throughout. Usually, a solution is formed when a substance is dissolved in a liquid. For example, when sodium chloride is dissolved in water, we get a solution.

Solvents: The liquid in which a substance is dissolved is called a solvent. A solvent is thus a dissolving agent. In a solution, the solvent is called the medium of dispersion.

Solute: The substance which is dissolved in a solvent to produce a solution is called a solute. The solute particles in a solution are called dispersed particles.

Examples: Sodium chloride, ammonium chloride, copper sulphate and sugar, which dissolve in water to form solutions, are called solutes, whereas water is called the solvent. Usually, the substance present in lesser amount in a solution is called the solute, and that present in greater amount is called the solvent.

'Tincture of iodine' is a solution of iodine and alcohol. Here, iodine is the solute and alcohol is the solvent.

Aqueous solution: A solution produced by dissolving a substance in water is known as the aqueous solution of the substance. For example, the solutions of sodium chloride, ammonium chloride and copper sulphate in water are all aqueous solutions of these substances.

Non aqueous solution: There are some substances which can form solutions by dissolving in liquids other than water such as alcohol, acetone, carbon tetrachloride and carbon disulphide. Such solutions are called Nonaqueous solutions.

True solution: If the mixture of the substances in a solution is truly homogeneous, the particles cannot be distinguished from one another, even under a microscope. In such a solution, the solute particles disappear into the space between the particles of the solvent. Such a solution is called a true solution. Solutions of salt, sugar and vinegar in water are examples of true solutions.

Properties of a Solution

1. A solution is clear and transparent. For example, a solution of sodium chloride in water is clear and transparent.
2. The solute in a solution does not settle down even after the solution is kept undisturbed for some time.
3. In a solution, the solute particles cannot be distinguished from the solvent particles even under a microscope. In a- true solution, the particles of the solute disappear into the space between the particles of the solvent.
4. A solution is homogeneous, i.e., the composition of a solution is the same throughout.
5. The components of a solution cannot be separated by filtration.
6. The diameter of the solute particles in a solution is of the order of 10^{-8} cm.

Types of Solutions: It is possible to dissolve different amounts of a solute in a given quantity of a solvent to obtain solutions of different concentrations. Solutions can be divided into two classes depending upon the amounts of solute dissolved.

ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
Ph No. +91-171-2631595, 9416541198, e-Mail: anusethi1968@yahoo.com Website: www. abhyasonline.in

1. Unsaturated solution: An unsaturated solution is one in which more solute can be dissolved at a given temperature. For example, a solution of sugar in water in which more sugar can be dissolved at a given temperature is an unsaturated solution.

2. Saturated solution: There is a limit to the amount of solute that can be dissolved in a fixed amount of a solvent at a particular temperature. A solution in which the maximum possible amount of a solute is dissolved at a given temperature is known as a saturated solution

Test for Saturation and Unsaturation: To test whether a solution is saturated or unsaturated, we add more solute to the solution and stir it thoroughly. If the solute dissolves, the solution is unsaturated. If it remains undissolved, the solution is saturated.

Solubility: The amount of a solute in grams dissolved in 100 grams of a solvent to make a saturated solution is called the solubility of the solute in the given solvent at the given temperature and pressure of the solution. Suppose 'w' g of a solute dissolves in 'W' g of a solvent to make a saturated solution at a fixed temperature and pressure. The solubility of the solute will be given by:

$$\frac{w}{W}\times 100 = \frac{\text{mass of the solute}}{\text{mass of the solvent}}\times 100.$$

Effect of Temperature and Pressure on Solubility of a Solid: The solubility of a solid in a liquid generally increases with the rise in temperature but hardly changes with the change in pressure. However, the extent of increase in solubility depends upon the nature of the solid. For substances such as calcium sulphate and calcium acetate, the solubility decreases with the rise in temperature. In general, the solubility of those substances which dissolve with the absorption of heat (endothermic process), increases with rise in temperature. On the contrary, the solubility of those substances which dissolve with the evolution of heat (exothermic process), decreases with rise in temperature.

Effect of Temperature on the Solubility of a Gas: The solubility of a gas in a liquid decrease with the rise in temperature, but increases with the increase in pressure.

Suspensions : A suspension is a heterogeneous mixture in which small particles of a solid remain suspended throughout the mass of the liquid or gas. For example, mud, sand and chalk particles remain suspended in water. Solid particles may remain suspended even in a gas. These mixtures are called suspensions. **Examples:** Muddy water, sand—water mixture, chalk—water mixture, paints, etc., are suspensions.

Properties of suspensions

1. A suspension is a heterogeneous mixture.
2. The particles in a suspension are large enough to be visible either to the unaided eye or under an ordinary microscope.
3. The particles in a suspension are too large to remain in suspension for a long period. Further, the intermolecular forces between the particles are not so strong as to keep them suspended. So, if a suspension is allowed to stand, the suspended particles may settle down at the bottom.
4. The particles in a suspension can be separated from the liquid by filtration.
5. In a suspension, the size (diameter) of the particles is of the order of 10^{-5} cm or larger.
6. They show tyndall effect.

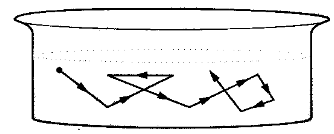
Colloids or colloidal solutions: A colloid has properties that are intermediate between those of a true solution and a suspension. Colloids have particles that are larger than the particles of a true solution but are smaller than those of a suspension. Examples of colloids or colloidal solutions are milk, ink, blood, toothpaste, starch solution, air (containing dust), clouds, mist (dispersion of water droplets in air), smoke and jellies. A colloid is usually translucent or opaque.

Properties of a colloidal solution

1. Heterogeneous nature: A colloidal solution is heterogeneous. The particles are visible under a powerful microscope.

ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
Ph No. +91-171-2631595, 9416541198, e-Mail: anusethi1968@yahoo.com Website: www. abhyasonline.in

2. Filtration: The particles in a colloid can pass through a filter paper.
3. Stability: The particles in a colloid are quite stable. They do not settle down at the bottom when the colloid is left undisturbed.
4. Size of particles: The most characteristic property of a colloidal particle is its size. Colloidal particles have sizes ranging from 10^{-7} cm to 10^{-5} cm.
5. Brownian movement Colloidal particles are in a state of constant and rapid zigzag motion, called Brownian movement. Brownian movement arises due to the collisions of the colloidal particles with the particles of the solvent.
6. **Tyndall effect**: Many colloids scatter light. This means that a beam of light passing through such a colloid can be seen. If a beam of light is passed through a colloid kept in a dark room, the path of light through it can be seen due to the scattering of light by the colloidal particles. This scattering of light by colloidal particles is known as Tyndall effect. A true solution does not scatter light, i.e., it does not show the Tyndall effect.



7. **Electrophoresis**: Many colloidal particles are electrically charged. So, when an electric field is set up in a colloidal solution, the charged colloidal particles move towards the oppositely charged electrodes and are precipitated. The movement of charged colloidal particles under the influence of an electric field is known as electrophoresis.

True solution, colloidal solution and suspensions: A Comparison

1. Compositon is homogeneous	Composition is heterogeneous	Composition is heterogeneous
2. Passes through filter paper	Passes through filter paper	The liquid passes through filter paper; the suspended particles do not
3. Diameter of the particle is of the order of 10^{-8} cm	Particle diameter lies between 10^{-7} cm and 10^{-5} cm	Particle diameter is of the order of 10^{-5} cm
4. Does not scatter light, i.e., does not show Tyndall effect	Shows Tyndall effect as colloidal particles scatter light	Shows no Tyndall effect
5. Shows no Brownian movement	Shows Brownian movement	Shows no Brownian movement
6. Does not show electrophoresis	Many colloids show electrophoresis	Does not show electrophoresis
7. Particles cannot be seen	Particles can be seen through a powerful microscope	Particles can be seen with unaided eyes or through a simple microscope
8. Transparent	Translucent or opaque	Translucent
9. Solute particles do not settle down on standing	Colloidal particles do not settle down on standing	Solute particles settle down on standing

Different types of colloids

Type of Colloid	Dispersed Phase	Dispersion Medium	Examples
Aerosol	Liquid	Gas	Fog,cloud,mist
Aerosol	Solid	Gas	Smoke,automobile exhaust
Foam	Gas	Liquid	Shaving cream
Sol	Solid	Liquid	Milk of magnesia, mud
Foam	Gas	Solid	Foam, rubber, sponge
Gel	Liquid	Solid	Jelly, cheese, butter
Solid sol	Solid	Solid	Milky glass, coloured gemstones.

ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
Ph No. +91-171-2631595, 9416541198, e-Mail: anusethi1968@yahoo.com Website: www. abhyasonline.in

nConcentrations or Strengths of Solutions: The concentration or strength of a solution depends on how much solute is dissolved in it. The amount of solute dissolved in a unit quantity (volume or mass) of a solution is known as the concentration or strength of the solution. There are various methods to express the concentration of a solution. One of them is mentioned here.

Percentage: The concentration of a solution may be expressed in terms of percentage, by mass or by volume.

(a) Percentage by mass: It is defined as the number of parts by mass of the solute dissolved per hundred parts by mass of the solution. For example, a 10% by mass of a solution of urea in water will have 10 g of urea dissolved in 90 g of water.

The concentration of the solution is then expressed as

$\frac{10g}{10g+90g}=\frac{10}{10}$=10%urea by mass

Similarly, the concentration of a solution containing 5 g of NaC1 in 95 g of water can be expressed as

$\frac{5g}{5g+95g}=\frac{5}{100}$=5% Nacl by mass.

Thus, percentage by mass=$\frac{\text{mass of solute}}{\text{mass of solution}}$*100

(b) **Percentage by volume** It is defined as the number of parts by volume of the solute dissolved in hundred parts by volume of the solution.

For example, 20% by volume of a solution of ethanol will have 20 cm^3 of ethanol dissolved in 80 cm^3 of water, i.e., 100 cm^3 of the solution will have 20 cm^3 of ethanol and 80 cm^3 of water.

Thus, percentage by volume=$\frac{\text{volume of solute}}{\text{volume of solution}}$*100

EXAMPLE 1: 0.5 g of a substance is dissolved in 25 g of a solvent. Calculate the percentage amount of the substance in the solution.

EXAMPLE 2: 20 cm3 of an alcohol is dissolved in 80 cm3 of water. Calculate the percentage of alcohol in the solution.

EXAMPLE 3: what is the volume per cent of a solution prepared by dissolving 15 cm3 of methanol in 100 cm3 of ethanol?

EXAM PLE 4: Calculate the concentration of a solution in volume per cent made when 56 g of water is mixed with 0.17 L of ethanol.

ABHYAS Academy, Behind Pragat Shiv Mandir, Near Govt. College, Nishat Cinema Road, Ambala Cantt.
Ph No. +91-171-2631595, 9416541198, e-Mail: anusethi1968@yahoo.com Website: www. abhyasonline.in