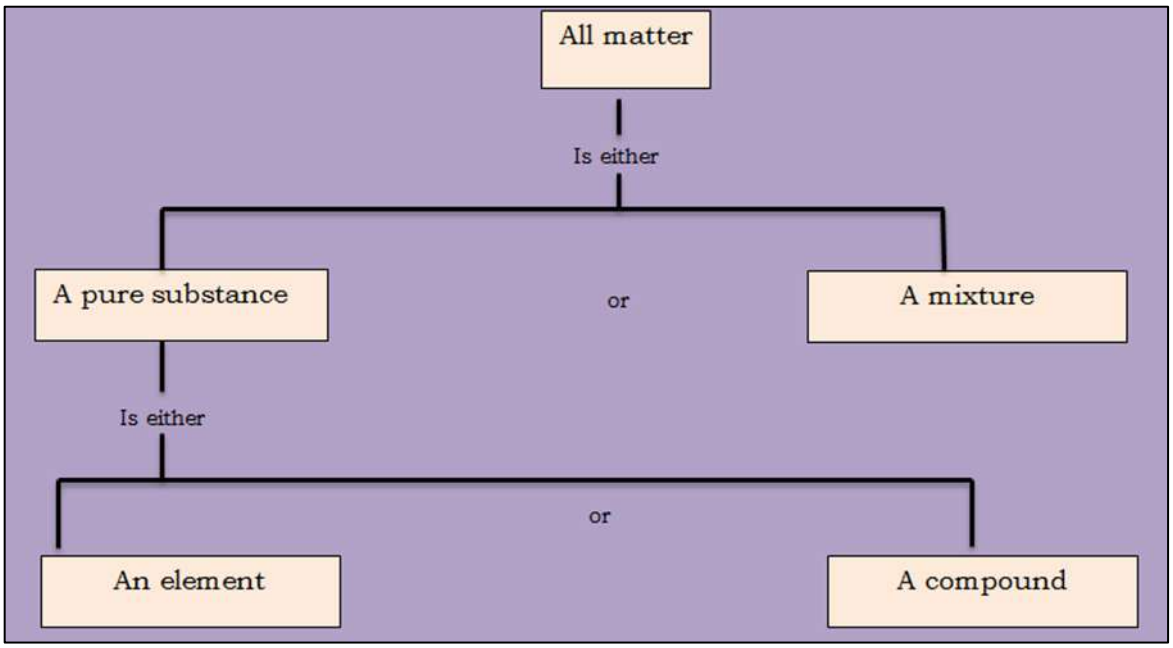
2.3 Elements, Compounds and Mixtures

Achievement Indicators:

Upon completion of this sub-strand, students will be able to:

- ✓ Define and identify pure and impure chemicals in terms of formulae and samples into elements, compounds and mixtures.
- ✓ Show and carry out experiments illustrating physical change.
- ✓ Explore and discuss examples of chemical change.
- ✓ Identify and illustrate factors affecting solubility.
- ✓ Explain and draw the solubility curve of a salt at different temperatures and concentrations.
- ✓ Differentiate and carryout methods of separation and purification of mixtures.



Elements

Elements are pure substances that are made up of only one type of atom. For example, carbon, hydrogen and oxygen. Carbon is made up of only carbon atoms, hydrogen is made up of only hydrogen atoms and likewise oxygen is made up of only oxygen atoms.

Compounds

Compounds are pure substances that are formed when atoms of two or more different elements are chemically joined together in a definite ratio. For example, sodium chloride - NaCl (common salt) and sucrose - $C_{12}H_{22}O_{11}$ (cane sugar) are examples of compounds. The properties of compounds are different from the properties of the substances it is made from.

Mixtures

In mixtures different kinds of particles are simply mixed together. For example, Yaqona is a mixture of kava and water and likewise tea is a mixture of tea leaves, sugar and water. The properties of mixtures are similar to the properties of its parts.

Pure chemicals

Chemical substances are often called 'pure' to set them apart from mixtures. In a pure chemical, all the particles are the same. A common example is pure water, it has the same properties and the same ratio of hydrogen to oxygen whether it is isolated from Rewa River or made in a laboratory. Limestone, gold and common salt are sometimes found in nearly pure forms.

Sodium chloride and magnesium is obtained from the sea. Sucrose is obtained from sugarcane and starch is found in foods such as dalo, roti and cassava. Similarly, nitrogen, oxygen and carbon dioxide are found in the air and bauxite, kerosene and other petroleum products are extracted from the ground.

Physical and Chemical Change

A physical change is a change of form or state. For example, melting of ice is a physical change. A chemical change is any change that results in the formation of new chemical substance(s). For example burning of wood is an example of chemical change.

Example of a Physical Change

Hydrous and anhydrous $CuSO_4$

Copper sulphate ($CuSO_4$) is a blue solid which is made up of crystals. When it is heated, the water is evaporated from the sample and is left with anhydrous copper sulphate (no water present) which is white in colour. Upon cooling after a few hours, the white copper sulphate absorbs water from the atmosphere to become hydrated copper sulphate again. Therefore, changing from hydrated to anhydrous $CuSO_4$ is a physical change since no new substance is formed.

Hydrated $CuSO_4$

Anhydrous $CuSO_4$

Examples of a Chemical Change

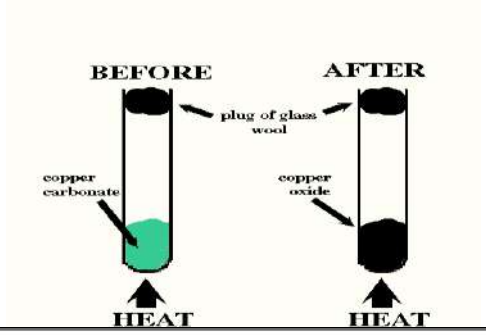
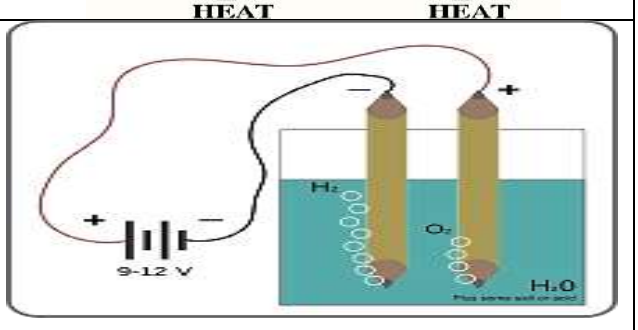
When magnesium burns, it combines with oxygen to form magnesium oxide which is a new substance.	
When green copper carbonate ($CuCO_3$) is heated, it decomposes to form two new substances namely copper oxide (CuO) and carbon dioxide (CO_2).	
When acidified water is electrolysed, hydrogen gas and oxygen gas are produced.	

Image source: http://www.leekhigh.staffs.sch.u

Summary

Physical Change	Chemical Change
No new substance is formed	New substance is formed
Usually reversible	Usually non-reversible
Does not usually release heat	Often releases heat

Exercise 2.3.1

1. Make a list of five elements, five compounds and five mixtures you have seen in your school laboratory or at home.

2. What is the difference between a compound and a mixture?

3. The difference between an element and a compound is that an element

   A. is a diatomic molecule.
   B. contains only one kind of atom.
   C. can be separated by physical means.
   D. is made from more than one kind of atom.

4. Which of the following is not a reversible change?

   A. burning fuel
   B. boiling water
   C. dissolving sugar in water
   D. mixing alcohol and water

5. Heating hydrated copper sulphate is a physical change.

   With reference to the above statement, answer the following questions.

   i. What color are the copper sulphate crystals before they are heated?
   ii. What color are the copper sulphate crystals after they are heated?
   iii. What happens to the crystals when they are heated that causes them to change color?
   iv. Why is this a reversible change?

6. Burning magnesium is a chemical change.

   With reference to the above statement, answer the following questions.

   i. Briefly describe the appearance of magnesium wire.
   ii. How would you describe the appearance of the substance that is formed when magnesium wire is burnt?
   iii. What observation is made when magnesium wire is burnt?
   iv. Is burning magnesium a reversible change or irreversible change. Justify your answer.

7. Define the following terms:

   i. Element
   ii. Hydrated
   iii. Anhydrous
   iv. Pure chemical

Separating Substances

Most materials in our world are mixtures. Very few materials are pure substances. The art of separating mixtures is important because it enables us to isolate pure substances. For instance, salt is separated from sea water.

Separating Insoluble Solids from Liquids

1. **Sedimentation** – Is a process in which insoluble particles can be removed from water or any other liquid. For example, when muddy water is stirred and left for a while, the dirt (impurities) in the water gradually settles down at the bottom of the container.

2. **Decantation** - Is pouring a solution from a container, leaving the sediments (precipitate) in the bottom of the container. For example, once the dirt has settled down, the water can be poured into another container.

3. **Filtration** – Is using a filter to remove solid particles from a liquid by causing the liquid to pass through the filter. For example, mixing yaqona is an example of filtration. The cloth traps the solid (kosa) and lets the liquid (yaqona) pass through.

4. **Centrifugation** – Uses centrifugal force to separate components of a substance. For example, separating dirt particles from clothes in a washing machine.

Separating Solutes from Solvents

1. **Evaporation** – Separates a solute from a solvent by changing the solvent to a gas. For example, when salt water is heated, the water is evaporated (changes to gas) and the solute (salt) is left behind.

2. **Chromatography** – Is a process of separating out different parts of chemical mixtures onto an absorbent material that can then be individually analysed because different parts are caught on the material at different rates. For example, separation of plant pigments is the most common use of paper chromatography in biology.

3. **Distillation** – Is a way of separating the solvent from a solution by evaporation and condensation. For example, we can get pure water from sea water through the process of distillation.

Separating Immiscible Liquids

Liquids are said to be immiscible if they do not mix together. A very good example is oil and water. Immiscible liquids can either be separated by decantation or by the use a separating funnel as shown in Figure below.

Source: SMC Lab Album

Separating Miscible Liquids

Miscible liquids are liquids that can mix together. An example includes water and alcohol. Miscible liquids can be separated by fractional distillation. Fractional distillation separates liquids by their boiling points.

Solutions

A **solute** is the solid part of a solution. For example, salt in salt solution.

A **solvent** is the liquid part of a solution. For example water in salt solution.

A **solution** is a homogeneous mixture of a solute and solvent. For example lemon juice is a mixture of lemon juice, sugar and water.

A **saturated solution** is a solution in which the maximum amount of solvent has been dissolved. Any more solute added will sit at the bottom of the container.

An **unsaturated** solution is a solution which can dissolve more solute. For example, a glass of water to which only one teaspoon of sugar is added is an unsaturated solution.

A **supersaturated solution** is a solution that is holding more dissolved solid that it can normally hold at that temperature. For example, supersaturated solutions of sugar and water are commonly used to make rock candy.

Separating Solids from other Solids

If there are two solids and one is soluble and the other is not, they can be separated by dissolving the soluble solid. For example, in a mixture of salt and sand, sand can be obtained by dissolving the salt in water and then filtering the solution.

Sublimation can also be used to separate a solid that sublimes from the one that does not. For example, a mixture of ammonium chloride and sodium chloride can be separated by sublimation because ammonium chloride can sublime.

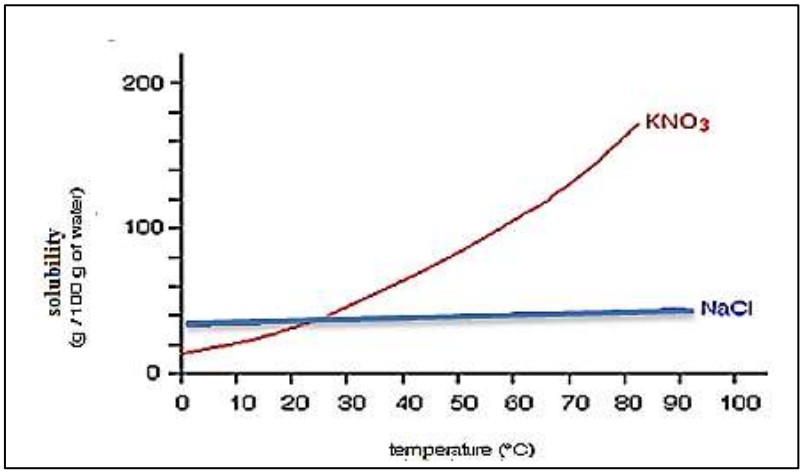
Solubility

Solubility is the quantity of solute that dissolves in a given quantity of solvent to form a saturated solution. It is the maximum amount of solute that will dissolve. The solubility of a substance depends on the temperature.

Effect of Temperature on Solubility

As the temperature increases, so does the solubility of salts. Most substances are more soluble in hot water than in cold water. A solubility curve is graph of solubility versus temperature.

Example **The solubility curve of KNO_3 and NaCl**



Source: http://www.chemguide.co.uk

The solubility curve above shows that the solubilities of potassium nitrate and sodium chloride increases with temperature.

Exercise 2.3.2

1. Complete the statements below using the words given:

   Compound, distillation, crystallisation, water

The two types of pure chemicals are elements and _____.Some solutions like seawater are separated by_____. The formation of a substance from a solution is called _____. A universal solvent is _____.

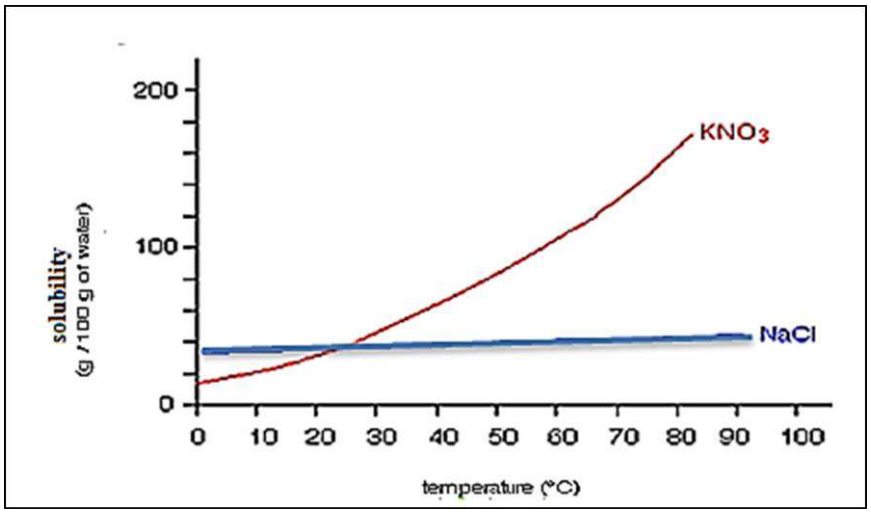
2. Briefly describe how you would separate:

   i. Alcohol from a mixture of alcohol and water.
   ii. Sand from a mixture of sand and salt.
   iii. Salt from a mixture of salt and water.
   iv. Different pigments in the leaves.
   v. Pure water from sea water
   vi. Oil from a mixture of oil and water.
   vii. Clean water from a mixture of mud and water.
   viii. Sugar from a mixture of sugar and naphthalene.
   ix. Tea from a mixture of tea leaves and tea.

3. When salt is dissolved in a beaker of water, a salt solution is made.

   i. What is a solution?
   ii. What is a solute? What is the solute in the salt solution?
   iii. What is a solvent? What is the solvent in the salt solution?

4. Consider the graph given below and answer the questions that follow.

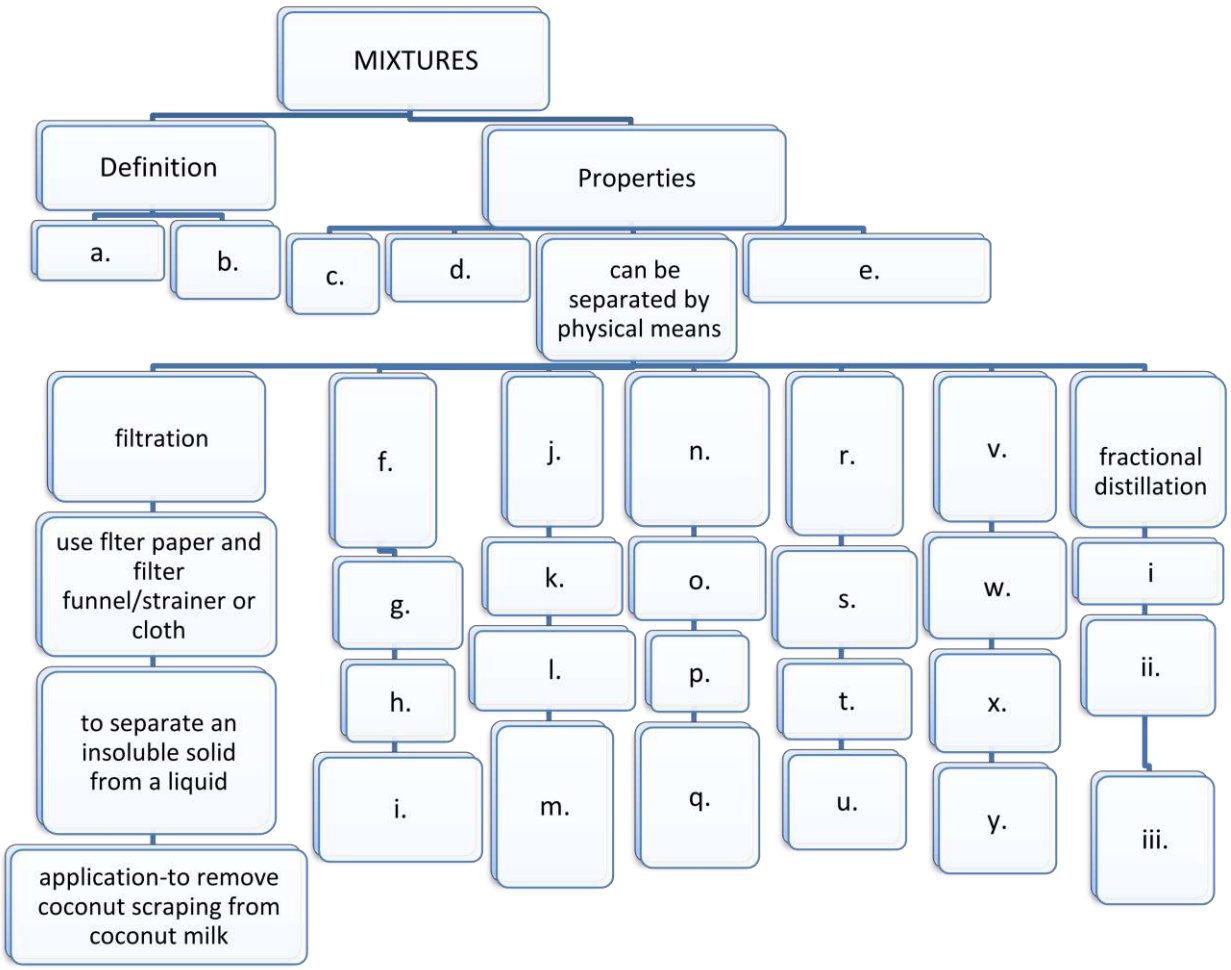


Source: http://www.chemguide.co.uk

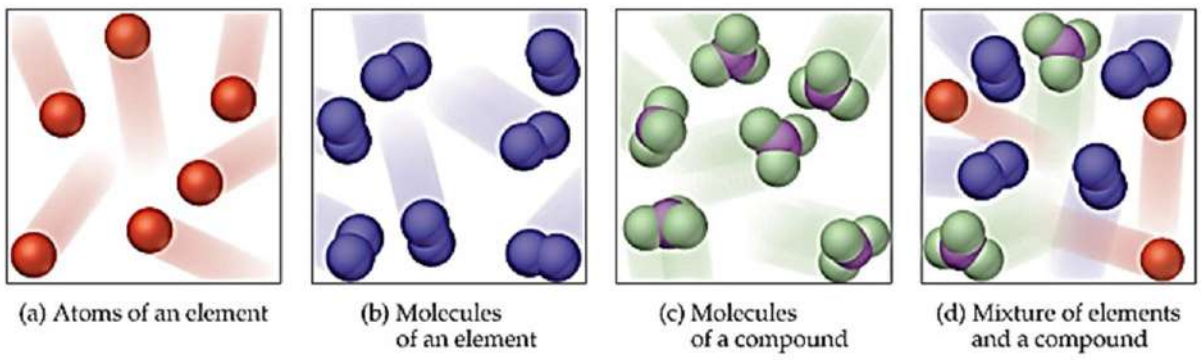
   i. What name is generally given to such graphs?

   ii. Describe the relationship between the solubility of potassium nitrate (KNO_3) and temperature.

5. Complete the concept map given below.



Summary



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