PURES SUBSTANCES AND MIXTURES

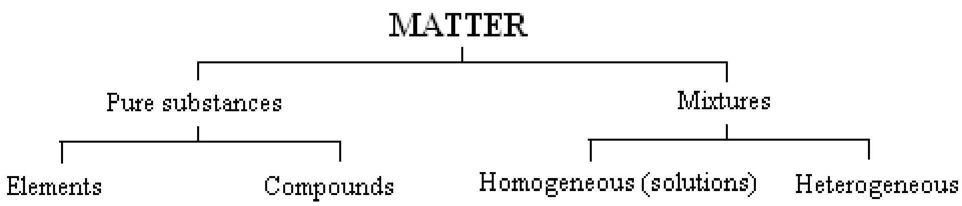
Key Words

- solution
- solute
- solvent
- mixture
- homogenous
- heterogeneous
- pure
- substance
- compound
- element
- molecule
- atom
- solubility
- concentration

Pure substances and mixtures

Remember that matter is everything that takes up space and has mass. Everything is made of matter. All that surrounds us is matter.

Matter can present itself in different forms: **mixtures** and **pure substances**.



There are lots of **pure substances**: water, iron, common salt, oxygen, sugar, butane, etc. Others less familiar such as sulfuric acid, calcium carbonate, benzene, etc.

- A **pure substance** always features the same composition and properties throughout *(colour, odour, lustre, point of fusion, etc.)* and cannot be dissociated into simpler ones by simple physical methods.

All molecules in a pure substance are identical. Pure substances can be **simple substances or compounds**. A simple substance is formed by atoms of just one element, and a compound by different types of atoms.

Remember:

- ✓ **Simple substances** are made of only one type of atom; e.g.: Au is made of only gold atoms, O_2 is made of only oxygen atoms, Fe is made of only iron atoms, etc.
- ✓ **Compound substances** are made up of different types of atoms joined together (molecules), where all the molecules are the same; ex: pure water, ammonia (NH_3) etc.

Remember: a **chemical element** is a substance that can not be broken down into two or more simpler substances by chemical means. Chemical elements represent each type of atom. There are 118 known elements therefore, there are 118 different atoms.

However, in the world around us, pure substances are usually found together as mixtures. So what is a mixture?

Mixtures contain more than one substance and have different composition and properties in different parts of the sample. In a mixture the substances are just mixed together and not chemically combined. Air is an example of a mixture. Air is formed by nitrogen, oxygen, carbon dioxide and other gases. Another example is salt water.

- If the mixture has a uniform appearance is called a **homogenous mixture** (air, sea water, gasoline). Homogenous mixtures are also called **solutions**.
- If you can see differences among its parts, the mixture is **heterogeneous** (granite, the soil we step on and a lentil casserole among others).

Separating Mixtures

You can have a mixture of two or more liquids together; two or more solids together; or mixtures of solids and liquids together. How can we separate the components of a mixture? There are different techniques you can use to separate the components of a mixture. The **separation technique** used will depend on the properties of the components of the mixture.

- If you want to **separate a mixture of two solids** you can use a **sieve**. A sieve allows you to separate solid particles of different size.
- If you want to **separate two liquids**, you will use different techniques whether the liquids are miscible (they dissolve) or immiscible (don't dissolve)
    - ➢ **Decantation:** It is used to separate liquids that don't mix. An example is water and oil.
    - ➢ **Distillation:** It is used to separate liquids that mix. An example is water and alcohol. Distillation is based on the difference of boiling points in order to separate the components of the mixture.
- If you want to separate a **mixture of a solid and a liquid,** you have to take into account the solubility of the solid in that particular liquid.

E.g. If you take a mixture of sand and water, the sand does not dissolve in the water, therefore you can separate the two by a technique known as **filtration.**

- ➢ **Filtration** is used to separate the components of a mixture of a solid and a liquid where the solid does not dissolve in the liquid.
- ➢ However, if the solute dissolves in the solvent, having a solution, you need to use a technique known as **evaporation.**

SOLUTIONS

1. Solution Concentration

If you take a glass of water add sugar and stir it, you will see how the sugar disappears, becoming a clear solution. You have made a solution, where the sugar, the **solute**, has dissolved in the water, the **solvent.** Obviously, the sugar is there even if we don't see it. And if you were to taste the water, you will notice a particular 'sweet' flavour. Therefore, the mass of the solution will be the mass of the solute plus the mass of the solvent.

Mass of solution(g) = mass of solute(g) + mass of solvent(g)

There are different types of solvents; water being the most common. When we talk of aqueous solutions that means, by definition, that the solvent used is water (*aqua* in Latin means water).

Solutions can be **diluted** or **concentrated** depending on the amounts of solute and solvent that make up a particular solution. However, saying that a solution is diluted or concentrated does not tell us much about the actual amounts (quantitative aspect) of solute and solvent.
The **concentration** of a solution is the relationship between the amount of solute and the amount of solvent. It is a measure of the quantity of solute in a given quantity of solvent or solution.

There are several ways of expressing concentration. We are going to study two different ways to express the concentration of a solution: **mass percent and concentration by weight.**

Mass Percent (also called percent by weight)

$$\text{mass \%} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$$

Example: We use 180 mL of pure water and 20g of alcohol to make a solution. What is the mass percent of alcohol of the solution?

Data	Equation/Formula	180
mL of pure water = 180 g		
20 g EtOH	mass % = (g solute/ g solution) x 100	
mass %. = ?		

Calculations

mass % = 20/ (180 + 20) * 100 = 20/200 * 100 % **= 10.0%**

Concentration by Weight (also referred to as mass concentration)

$$\text{Concentration by weight} = \frac{\text{mass of solute (in g)}}{\text{volume of solution (in L)}}$$

Example: Determine the concentration in g/L of a NaCl solution, if we dissolved 20 g of NaCl in 500 L of solution

Data	Equation/Formula
20g NaCl	
500 l solution	mass concentration = g solute/L solution
mass conc. = ?	

Calculations

mass concentration = 20g/500 L **= 0.04 g/L**

2. Solubility

If we keep adding sugar to our mixture, eventually we will saturate the solution to the point that the sugar will no longer dissolve in the water. At that point, we will start to see the solute settling at the bottom of the glass. We now have a **saturated solution.** At that particular temperature no more sugar can be dissolved in that amount of water. It has reached its maximum capacity of solubility. Each and every substance has a specific solubility at a given temperature.

Therefore, **solubility** is the maximum amount of solute that will dissolve in a solvent at a given temperature.

Exercises:

1. How many grams of table salt do we need to make a 250 mL solution with a mass concentration of 10 g/L?

2. The concentration of a solution is 45 g/L. How many grams of solute do we have in a 350 mL solution?

3. We dissolve 30 g of solute in water to make a 180 mL solution; what is the mass concentration of the solution?

4. A solution of water and sugar has a mass concentration of 20 g/L. If 18 g of sugar were added to the water, what is the volume of our solution?

5. I have two 500 mL samples of saltwater, with a mass concentration of 25 g/L and 34 g/L respectively. How much salt does each sample contain?

6. How many grams of solute do I need to prepare a 2.5 dL solution with a mass concentration of 0.01kg/L

7. How many grams of solute do I need to make a 400 cm^3 of a solution with a mass concentration of 12g/L?

8. We dissolve 10 g of solute in water to make a solution with a mass concentration of 2.5g/L. What is the volume, in cm^3 , of my solution

9. We dissolve 0.009 kg of salt in water to make a 75 mL solution; what is the mass concentration of the solution?

10. How many grams of table salt are there in a 10 mL solution with a mass concentration of 2 g/L?

11. We use 50 mL of pure water to make a NaCl solution. Calculate the amount of NaCl used if the solution is 30% NaCl by mass.

12. Calculate the mass percent of the following solutions: a) 40 g of table salt in 250 g of water; b) 50 g of sugar in 1 kg of solution; c) 12 g silver nitrate in half a litre of pure water.

13. We have an aqueous solution where 12 g of sugar have been dissolved in 200 mL of solution. The density of the solution is 1.022 g/cm^3. Calculate: a) The concentration in mass percent; b) the concentration by weight in g/L.

14. We dissolve 20 g of sulfuric acid in 100 mL of pure water reaching the solution a final volume of 0.111 L. Calculate: a) the concentration of the solution in mass %; b) the mass concentration.

15. We use 50 mL of pure water to make a NaCl solution. Calculate the amount of NaCl used if the solution is 30% NaCl by mass.