UNIT 4: MATTER: ELEMENTS, COMPOUNDS AND MIXTURES

Content:

Unit 4 Matter: Elements, Compounds and Mixtures

4.1. Difference between a pure substance and a mixture.
4.2. Classification of mixtures: homogeneous and heterogeneous.
4.3. Preparation of aqueous solutions.
  4.3.1. Mass percentage.
  4.3.2. Mass per unit volume.
  4.3.3. Moles per cubic decimetre of solution (concentration).

Learning Aims:

At the end of the unit, the student will know:

- To distinguish a pure substance from a mixture.
- To distinguish an element from a compound.
- To distinguish an homogeneous mixture from an heterogeneous mixture.
- To prepare aqueous solutions.
- To work out questions related to mass percentage.
- To work out questions related to concentration.

Initial Activities

1. Using the words: *suspension, atoms, solution, compound, molecule, particles, element, heterogeneous, homogeneous, mixture*, fill in the blanks with the correct word.

a) An ___________ is made up of just one kind of atom.
b) Two or more elements chemically combined form a ________________.
c) Granite is an example of a ________________.
d) A mixture that is not the same throughout is called a ____________ mixture.
e) Seawater is an example of a ______________ mixture because it is the same throughout.
f) In a ________________ one substance is dissolved in another.
g) In a mixture called a ________________ the particles are larger and can settle out.

2. What is the difference between distillate water and sea water?

3. Tell if the following statements are true or false:

a) Matter made up of just one kind of element is a compound.

b) Running water is a compound.

c) The components in a mixture can be separated by physical methods.

d) Oil and vinegar is an example of a heterogeneous mixture.

e) In an homogeneous mixture components are well differentiated with the naked eye.

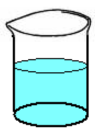
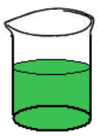
f) An increase in temperature often increases the solubility.

4. Identify each of the following as an element, a compound, a homogeneous mixture or a heterogeneous mixture.

$C_6H_{12}O_6$	O_2	Running water
Bronze	CO_2	Aluminium
Soft drink (Fanta …)	Sugar aqueous solution	H_2SO_4

5. How many grams of sodium chloride are in 200 grams of a 5% solution of sodium chloride?

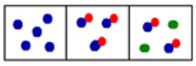
Key words:

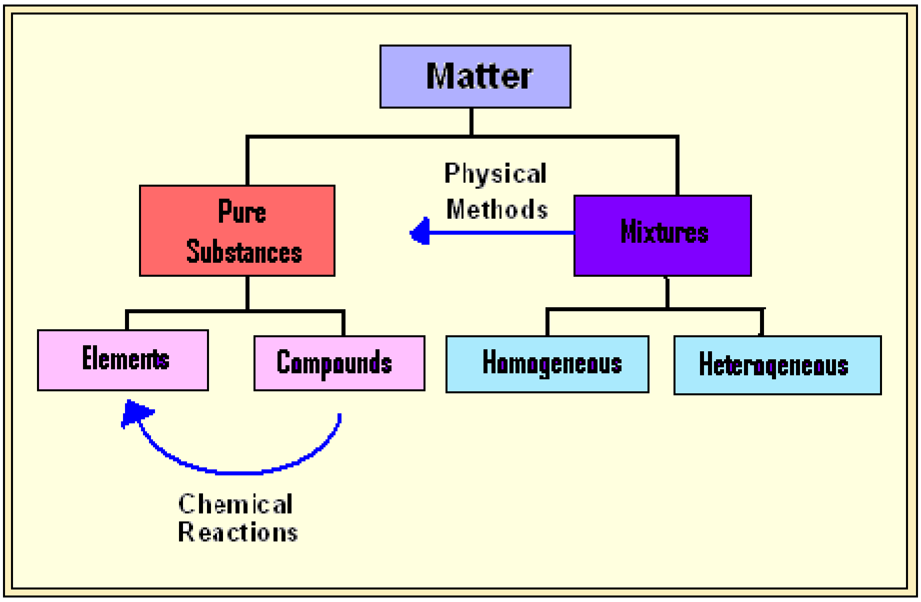
Element  **Cu**	Substance composed of atoms having an identical number of protons in each nucleus.
Compound  **$CaCO_3$**	Combination of two or more elements in definite proportions that cannot be separated by physical means.
Solution 	Homogeneous mixture of two or more substances that can be separated by physical means.
Homogeneous Mixture 	Mixtures with uniform composition.

Heterogeneous Mixture 	Mixtures with non-uniform composition.
Suspension 	Heterogeneous mixture where particles of one substance are suspended in the other substance.
Miscible 	Can be mixed in all proportions.
Immiscible 	Liquids that cannot mix together.
Foam 	Particles of a gas dispersed throughout a liquid or solid.
Emulsion 	Mixture of two liquids in which particles of one are suspended evenly throughout the other.
Aerosol 	Particles of a solid or liquid dispersed throughout a gas.
Percentage in mass %	Mass of solute contained in 100 grams of solution.
Concentration $mol \cdot dm^{-3}$	Number of moles of a given substance per liter of solution.

http://www.thefreedictionary.com/ (dictionary with pronunciation)

4.1. Difference between a pure substance and a mixture.





Pure substances cannot be separated in smaller particles by physical methods (filtration, distillation, etc). **Elements** and **compounds** are both pure substances. The difference between them is that **elements** consist of only one type of atom whereas **compounds** consist of more than one type of atom combined together in defined proportions.

The difference between **elements** and **compounds** is that elements do not break down in a normal chemical reaction, but we can separate the elements in a compound from a chemical reaction.

Example: Oxygen (O_2) is an element; sucrose ($C_{12}H_{22}O_{11}$) is a compound.

A **mixture** contains more than one pure substance combined together, but these compounds can be separated by physical methods.

Another difference between a **compound** and a **mixture** is that the components of a mixture retain their properties (density, boiling point, etc), but the characteristics of a compound are completely different from the isolated elements.

Example: Quartz (SiO_2) is a compound and granite is a mixture of quartz, feldspar and mica.

Questions

1. Identify each of the following as an element, a compound or a mixture: sodium carbonate; vinegar; platinum; wine; nitric acid; aluminium oxide; drinking water; phosphorus; iodine; calcium fluoride.

2. Tell if the following statements are true or false:

a) Sulphur is a chemical compound.

b) Combination of two or more elements chemically forms a compound.

c) At least two millions of compounds are known.

d) Many compounds have been obtained from plants.

e) Most of the foods we eat are pure substances.

f) An atom is the smallest particle of a compound.

g) In mixtures the properties of their components remains the same.

h) Drinking water is a pure substance.

i) In a mixture two or more substances are chemically combined.

j) In a compound, each of the different substances maintains its own properties.

k) An element can be easily changed into a simpler substance.

3. Choose the correct answer:

3.1. Kind of matter which cannot be broken down into a simpler substance.
a) Compound
b) Mixture
c) Element

3.2. Matter composed of two different substances in no definite ratio.
a) Compound
b) Mixture
c) Element

3.3. Can be separated into individual substances by a physical change.
a) Compound
b) Mixture
c) Element

3.4. Matter that only can be separated into other substances by a chemical change.
a) Compound
b) Mixture
c) Element

3.5. Matter composed of only one kind of atom.
a) Compound
b) Mixture
c) Element

3.6. A chemical symbol represents a
a) Compound
b) Mixture
c) Element

3.7. Which of the following is not a pure substance?

a) Aluminum

b) Carbon dioxide

c) Glucose

d) Bleach

3.8. The word pure substance refers to?

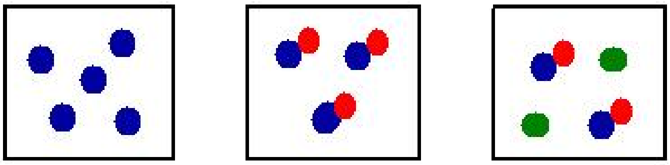
a) Mixtures

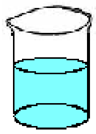
b) Solids

c) Solutions

d) Elements and compounds

4. In the following diagrams, atoms are represented by circles; circles with the same size and colour correspond to the same kind of atom. Identify each of the diagrams as a compound element or mixture. Explain the atomic composition of each diagram.





4.2. Classification of mixtures: homogeneous and heterogeneous.

Mixtures can be classified in **homogeneous** or **heterogeneous**.

In **homogeneous mixtures** composition is uniform throughout the material and the component cannot be visually differentiated. Homogeneous mixtures are also known as **solutions**. In solutions, a **solute** is dissolved in another substance, known as a **solvent**. A solution that can hold no more of the solute at a particular temperature is said to be a **saturated**.

Mixture of two liquids in which particles of one are suspended evenly throughout the other are called **emulsions**.

Example: In a solution of salt and water, water is the solvent and salt is the solute. Mayonnaise is an emulsion

In **heterogeneous mixtures** composition is not uniform throughout the material and the component can be visually differentiated.

Example: A mixture of water and flour.

Suspensions, **composites**, **foams** and **colloids** are heterogeneous mixtures.

Suspensions contain solid or liquid particles dispersed in a liquid or gas; these particles are sufficiently large for sedimentation. When particles are less than 1 μm in diameter they do not settle and the mixture is called **colloid**. A suspension liquid droplets or fine solid particles in a gas are called an **aerosol**.

Examples: Sand in water is a suspension and milk is a colloid. Examples of aerosols are the atmospheric air and sprays.

In **composites** two or more different structurally substances, especially metals, ceramics, glasses and polymers, combine to produce structural or functional properties not present in any individual component.

Examples: Adobe brick (straw mixed with mud or clay); plywood (thin slabs of wood held together by an adhesive). These composites make the structure stronger.

Questions

1. Mach one of the following words with their corresponding definition: *element; volume; mass; solution; homogeneous mixture; aerosol; molecule; pure substance; matter; suspension; mixture; atom; foam; heterogeneous mixture; compound; colloid; composite.*

- **a)** Anything that has mass and volume.
- **b)** Composed of only one kind of particle.
- **c)** Two or more pure substances combined retaining their own properties and combined in any ratio
- **d)** Muddy water is an example of that kind of mixture.
- **e)** The smallest part of an element.
- **f)** Cannot be broken down by ordinary chemical means
- **g)** Two or more elements chemically combined in a definite ratio.
- **h)** Bread is an example of that kind of mixture.
- **i)** A cloud is an example of that kind of mixture.
- **j)** Mixture that has the substances evenly distributed throughout.

2. Tell if the following statements are true or false:

- **a)** Iced tea is a solution.
- **b)** Granite is a homogeneous mixture.
- **c)** After-sun is an emulsion.
- **d)** Running water is a suspension.
- **e)** In a solution only one substance can be the solute.
- **f)** A mixture that is not the same throughout is called a heterogeneous mixture.
- **g)** Oil and vinegar are miscible.
- **h)** Gelatine is an example of foam.
- **i)** In smoke, particles are suspended in the air.
- **j)** In colloids particles are very small, but are large enough to reflect light.

k) In suspensions, particles can settle out.

l) Substance dissolved in a liquid is called solute.

m) Solutions can be solids, liquids or gases.

n) Solubility increases with temperature.

o) In a saturated solution usually is not possible to solve more quantity of solute.

3. Many medicines are suspensions. Why is necessary to shake them before taken them?

4. Complete the following table, referred to mixtures, written in each box one example of heterogeneous mixtures and another one of homogeneous mixtures:

	Solid	**Liquid**	**Gas**
Solid			
Liquid			
Gas			

5. 

Tell the composition of the following composites:

a) Adobe brick.

b) Plywood

c) Glass fibres.

d) Tires.

6. 

a) Look for the definition of **alloy**.

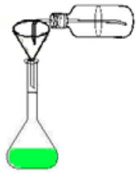
b) Prepare a Power Point about alloys with the following slides:

b.1. Title

b.2. Index

b.3. Different slides that include **definition** of alloy, **composition**, **properties** and **uses** of the following alloys: *steel, duralumin, bronze, stainless steel, pewter, manganin, nichrome, cupronickel, solder, brass and dental amalgam.*

b.4. Bibliography



4.3. Preparation of aqueous solutions

4.3.1. Mass percentage

The **mass percentage** of a compound in a solution is the mass of the compound found in 100 g of solution:

$$\text{mass \%} = \frac{\text{mass}_{\text{substance}}}{\text{mass}_{\text{solution}}} \cdot 100$$

Example: The mass percentage of a solution containing 10 grams of glucose solved in 190 grams of water will be:

$$\text{mass \%} = \frac{10\text{ g}}{200\text{ g}} \cdot 100 = 5\%$$

Commercial concentrated aqueous reagents such as acids and bases are often labeled in concentrations of mass percentage (abbreviated as **mass %**, **%w/w**, or **wt%**).

In mixtures of gases and sometimes in liquid-liquid solutions, **volume-volume percentage** (**% v /v**) is used. This percentage describes the volume of the solute in mL per 100 mL of solution. Volume is only additive in the case of mixtures of ideal gases.

Example: The volume percentage of a solution containing 12 mL of alcohol in 150 mL of solution will be:

$$\text{\% v/v} = \frac{12\text{ mL}}{150\text{ mL}} \cdot 100 = 8\%$$

4.3.2. Mass per unit volume

Mass-volume percentage (**m/v** or **w/v**) describes the mass of solute divided by the volume of solution. This measure of concentration is often used for solutions made from a solid dissolved in a liquid.

$$\text{m/v} = \frac{\text{mass}_{\text{solute}}}{\text{volume}_{\text{solution}}}$$

Example: a 40 g · dm^{-3} sugar solution contains 40 g of sugar per 1 dm^3 of solution.

4.3.3. Moles per cubic decimetre of solution (concentration)

A mole per cubic decimetre is also known as **molarity** or **concentration**. It indicates the number of moles of solute contained in a litre of solution. This is the most widely used unit for concentration when preparing solutions in chemistry or biology.

$$[\text{solute}] = \frac{\text{moles of solute}}{\text{dm}^3 \text{ of solution}}$$

Example: What is the concentration of a litre of solution containing 0,2 moles of $CaCl_2$ in 800 cm^3 of solution?

$$[CaCl_2] = \frac{0{,}2 \text{ moles}}{0{,}9 \text{ dm}^3} = 0{,}25 \text{ mol} \cdot \text{dm}^{-3}$$

Questions

1. A solution contains 20 g of KCl dissolved in 500 g of water. Calculate the mass percentage of potassium chloride in solution.

2. A 950 cm^3 of solution contains 45 g of $NaHCO_3$ dissolved. Calculate the concentration of $NaHCO_3$ in kg of solute per dm^3 of solution.

3. 10 g of NaCl are dissolved in 1,5 dm^3 of water solution. Calculate the concentration of NaCl.

4. 12 g of KCl are dissolved in 1,0 litre of water solution. Calculate the concentration of KCl.

5. After doing calculations, choose the right answer.

5.1. 10,0 g of sugar are dissolved in 90 g of water. The mass percent of sugar is:

- **a)** 1 %
- **b)** 0,9 %
- **c)** 10 %
- **d)** None of these are correct

5.2 A 200 g solution of alcohol contains 150 g of water. The mass percent of alcohol is:

- **a)** 5 %.
- **b)** 10 %
- **c)** 50%
- **d)** None of these are correct

5.3. How many grams of NaBr are needed to make 150 g of a 5.0% solution

a) 7,5 g

b) 0,125 g

c) 0,75 g

d) None of these are correct

5.4. How many grams of KOH are needed to make 500 cm^3 of a 5 g . dm^{-3}?

a) 5 g

b) 0,25 g

c) 2,5 g

d) None of these are correct

5.5. Which volume of 2 g · dm^{-3} Na_2SO_4 solution contain 1 g of Na_2SO_4?

a) 50 cm^3

b) 5 dm^3

c) 500 cm^3

d) None of these are correct

5.6. How many moles of $CaCl_2$ are there in 50 mL of 0,25 mol · dm^{-3} solution?.

a) 0,0025 moles.

b) 0,0125 moles.

c) 0,125 moles.

d) None of these are correct

5.7. 0,05 moles of NaCl occupy a volume of 100 mL. What is the concentration of the solution?

a) 0.05 mol · dm^{-3}.

b) 0.5 mol · dm^{-3}.

c) 0.005 mol · dm^{-3}.

d) None of these are correct

5.8. 4 g of NaOH were used to create a 0,1 mol · dm^{-3} solution. What is the volume of the solution?

a) 1 dm^3.

b) 0,1 dm^3.

c) 10 cm^3.

d) None of these are correct

5.9. What is the concentration of a solution containing 0,3 moles of NaCl in 300 cm^3 solution?

a) 10 mol · dm^{-3}.

b) 0,1 mol · dm^{-3}.

c) 1 mol · dm^{-3}.

d) None of these are correct

5.10. How many moles are there in 400 ml of 0,20 mol · dm^{-3} solution of sodium chloride?

a) 8 moles.

b) 80 moles.

c) 0,8 moles.

d) None of these are correct

6. Solve the following questions:

6. 1. How many grams of KNO_3 and water are needed to prepare 50 g of a 4,0 % solution?

6.2. What mass of NaI must be mixed with 25 mL = 25 g (water's density: 1 g · cm^{-3}) of water to obtain a 5% solution.

6.3. A 500 g solution of sugar contains 100 g of water. What is the mass percent of solute in this solution?

6.4. What is the mass percent of a solution created by adding 20 g of alcohol to 180 g of water?

6.5. What is the concentration, expressed in g · dm^{-3} for 8 g of NaBr dissolved in 800 cm^3 of solution

6.6. How many grams of KNO_3 are needed to make 250 cm^3 of a 4 g · cm^{-3} solution?

6.7. Calculate the molarity of 15 g $CuSO_4$ contained in 500 cm^3 of solution.

6.8. How many mL of alcohol solute are in a 2 L sample of a 12% (% v/v) solution of alcohol dissolved in water?

6.9. What is the concentration of a solution in g · dm^{-3} when 10 grams of potassium chloride, KCl, are dissolved in 1.500 cm^3 of solution?

6.10. How many grams of calcium chloride are in 100 cm^3 of a 0,1 mol · dm^{-3} solution of calcium chloride?

Hint: In some questions about molarity concentration, remember first to calculate the number of moles.

Held: Web site http://www.unitconversion.org/ will help you to prove if you have done correctly mass, volume, etc. arithmetic conversions.

STUDENT SELF-EVALUATION CHECKLIST
(WHAT STUDENTS HAVE LEARNT)

1.- When you know the meaning of the following words, tick the box:

- Chemical element ☐
- Chemical compound ☐
- Chemical Solution ☐
- Heterogeneous mixture ☐
- Homogeneous mixture ☐
- Suspension ☐
- Miscible ☐
- Immiscible ☐
- Foam ☐
- Emulsion ☐
- Aerosol ☐
- Percentage in mass ☐
- Mass per unit volume ☐
- Concentration, Molarity ☐

2.- Tick the one you think is your answer:

	I know very well	**I need some revision**	**I need some more help**
I know the difference between an element, a compound and a mixture.			
I know the difference between a heterogeneous mixture and a homogeneous mixture.			
I know the difference between immiscible and miscible liquids.			
I can differentiate the terms: suspension, foam, emulsion and aerosol.			
I know how to solve questions and do calculations related to percentage in mass solution concentration.			
I know how to solve questions and do calculations related to mass per unit volume solution concentration.			
I know how to solve questions and do calculations related to molarity.			

3.- What ideas or parts of this unit do you think are:

- More interesting.
- More difficult.
- Boring
- Not enough explained.
- Best learned.
- Not enough worked.

4.- Tell the tasks you have done the best.

5.- Tell the tasks you have done incorrectly.

Experiments:

Experiment 1: Elements, Compounds and Mixtures

OBJECTIVE

Investigate some of the characteristics of both elements and compounds.

EQUIPMENT

Safety goggles
Magnet
Watch glass
Bunsen burner
Test tube
Test tube tongs
Beaker

MATERIALS

Iron filings,
Powdered sulphur
Water

PROCEDURE

1. Place a small amount of powdered sulphur on a watch glass. Write your observations in the table.
2. In another watch glass place a small amount of iron filings. Write your observations in the table.
3. Draw the magnet toward the iron filings and the powdered sulphur. Write your observations in the table.

	Colour	State	Element, compound or Mixture?	Magnetic or non-magnetic?
Iron				
Sulphur				

4. Stir the mixture well. Draw the magnet toward the iron filings, and then put the mixture into a beaker with 100 cm^3 of water. Write your observations in the table.

	Homogeneous or heterogeneous mixture	Magnetic or no-magnetic	Float or sink?
Mixture		Iron: Sulphur:	Iron: Sulphur:

5*.

a) **Teacher** will combine the mixture of sulphur and iron filings from several students in a test tube mixing them well.

b) Pick up the test tube with test tube tongs and heat the tube with the flame of a Bunsen burner for five minutes.

c) After five minutes, immerse the test tube cold water to break the test tube. If the test tube does not break, wrap it with paper towels and carefully broke it with an object.

d) Carefully remove the substance from the pieces of glass.

e) Observe the compound obtained, repeat the tests previously made with the reactants and annotate the observations in the table.

CAUTION:

Do not point the open end of the test tube away from people!

Wear eye protection (safety goggles)

	Colour	State	Element, compound or Mixture?	Magnetic or non-magnetic?	Float or sink
Substance (Iron (II) sulphide)					

***** This part of the activity will be conducted by the **teacher**.

QUESTIONS

1. Compare the properties of iron and sulphur with those of compound obtained. How they differ from those of the separate elements?

2. Is it possible to separate sulphur and iron mixture into its individual parts? Is it possible to separate the compound obtained after heating into the initial sulphur and iron?

3. Complete this word equation for the previous reaction:

Iron + …………….. → ………………. sulphide

Experiment 2: Preparation of aqueous solution

OBJECTIVE

Prepare 100 cm^3 of a 2 g · dm^{-3} aqueous solution of sugar.

EQUIPMENT

Beaker
Balance
Spatula
Funnel
Watch glass
Balance
100 mL volumetric flask
Pipette
100 ml graduated cylinder
Densimeter

MATERIALS

Sugar
Distilled water

PROCEDURE

1. Before doing the solution is necessary to calculate how many sugar do we need to prepare 100 cm^3 of a 2 g · dm^{-3} aqueous solution. Annotate the mass of sugar needed:

Mass of sugar = ……………… g

2. Weight the sugar on an electronic balance (or a gram balance).

3. Dissolve the salt in a beaker with a little amount of water.

4. Transfer the solution to the volumetric flask (use a funnel so that you do not spill the solution).

5. Rinse the beaker two or three times and, again, transfer this solution to the volumetric flask in order to have all the sugar in the solution.

6. Add distillate water to the volumetric flask, close up the 100 cm^3 signal.

7. Add the last drops of water with a pipette, to avoid going beyond the signal

8. Put a stopper to the flask and sake the solution.

9. Transfer the solution to a 100 ml graduated cylinder and calculate the density with a densimeter.

10. Transfer the solution to a 1 litre bottle

QUESTIONS

1. Why do you use a clean spatula to get a solid?

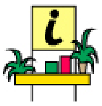
2. Sugar has to be weighted on a watch glass. Why?

3. All the sugar has to be added to the flask. Why?

4. How do you have to look at the flask signal? Up to where liquid has to come to know that we have exactly the volume that we want to prepare?

5. This mixture of sugar in water is a homogeneous or a heterogeneous mixture? Why?

6. With a densimeter, calculate the density of the prepared solution and compare it with that of the distilled water. Explain why they do not have the same value.




Activity

In web page **http://sciencehack.com/videos/category/2** watch this video about solutions.

a) If you have some problem in word pronunciation, consult the wed site **http://www.thefreedictionary.com/** (dictionary with pronunciation).

b) If you want to listen with a good pronunciation a text, paragraph, etc, of these chemistry units, web sites: **http://vozme.com/index.php?lang=ca** and **http://www.voki.com/create.php** have a program to generate sound.