Pharmaceutical analytical chemistry I

SPHINX UNIVERSITY

Lecture 1

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Substances and Matter

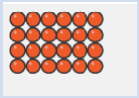
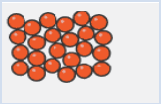
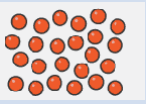
What is chemistry? study of matter and the changes it undergoes.

- **Matter** is *anything that occupies space and has mass.* (such as water, earth, trees and air).
- The classifications of matter include: mixtures, elements, compounds, as well as atoms and molecules

States of matter

Solid | Liquid | Gas

Different characteristics of matter.

Character	Solid	Liquid	Gas
Particle arrangement	Packed close in a regular arrangement	Packed close in an irregular arrangement	Arranged totally irregular
Shape	Fixed shape and volume	No fixed shape but fixed volume	No fixed shape and volume
Motion of particles	No freely motion but vibrate in its positions	Move around each other	Move randomly
Ability to compress	No compression	Little	Easy
Diagram			

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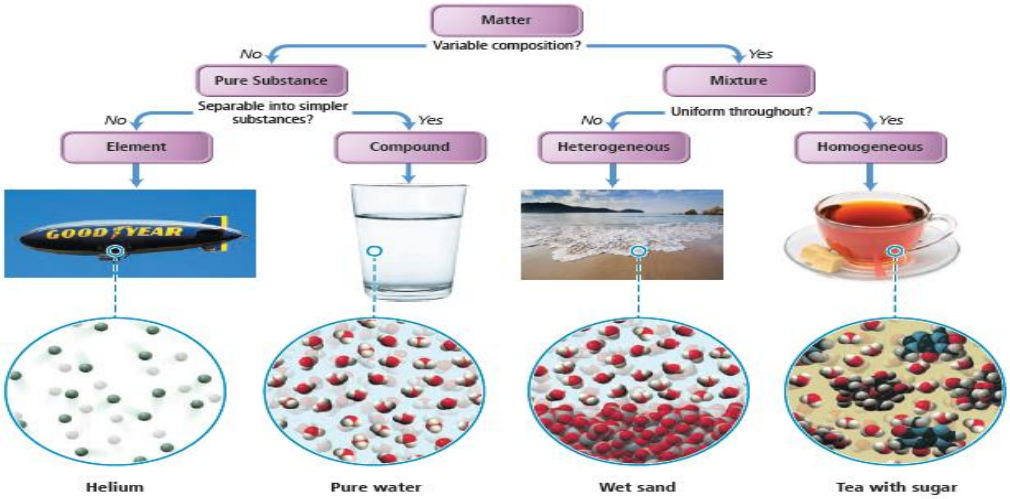
Classifying Matter by Composition: Pure substance, and Mixtures



Classifying Matter by Composition: Pure substance, and Mixtures

Pure substance	Mixture
All samples have the same physical and chemical properties	Different samples may show different properties
Constant Composition ⇒ all samples have the same composition	Variable composition
Homogeneous	Homogeneous or Heterogeneous
Separate into components based on **chemical properties**	Separate into components based on **physical properties** **N.B: All mixtures are made of pure substances**

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Classifying Matter by Composition: Pure substance, and Mixtures

- **I- Pure substance:** is made up of only one component, and its composition does not vary from one sample to another.
- The *components* of a pure substance can be individual atoms or groups of atoms joined together.
- For example, helium, water, and table salt (sodium chloride) are all pure substances.

an **element**, a substance that cannot be chemically broken down into simpler substances.
117 elements have been identified such as: aluminum, arsenic, Sulphur, zinc……tec.

a **compound**, substance composed of atoms of two or more elements chemically united in fixed proportions.

- Unlike mixtures, compounds can be separated only *by chemical means* into their pure components.
- Atoms of most elements interact with one another to form compounds.
- Hydrogen gas burns in oxygen gas to form water, which has properties completely different from those of oxygen or hydrogen.

- **II- Mixtures:**
- Mixtures are either homogeneous or heterogeneous.
- In a ***homogeneous mixture*** : *the composition of the mixture is the same throughout (such as a sugar solution).*

- Any solution is a homogeneous mixture.
- **If you stir a spoonful of sugar into a glass of water, sugar is the solute that gets dissolved, water is the solvent.**
- **Sugar water is now a solution, or homogeneous mixture, of sugar and water**

- In a ***heterogeneous mixture*** : *the composition is not uniform (a mixture of sand and iron).*

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Any mixture, whether homogeneous or heterogeneous, can be created and then separated by physical means into pure components without changing the identities of the components:

- Sugar can be recovered from a water solution by: heating solution , evaporating it to dryness and condensing the vapor will give us back the water component.
- To separate the iron-sand mixture: we can use a magnet to remove the iron from the sand, because sand is not attracted to the magnet

(a) (b)

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Separating mixtures

- Mixtures are separable because the different components have different physical or chemical properties.

➢Example of *some* methods for separating mixtures:

- 1-Filtration
- 2-Distilation
- 3-Centrifugation
- 4-Sedimentation

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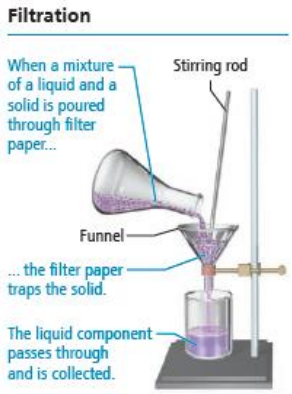
Methods for Separating Mixtures

1-Filtration: is a method that allows a good separation of liquid phase (the filtrate) which passes through filter paper from a solid phase which is the residue that remains on filter paper



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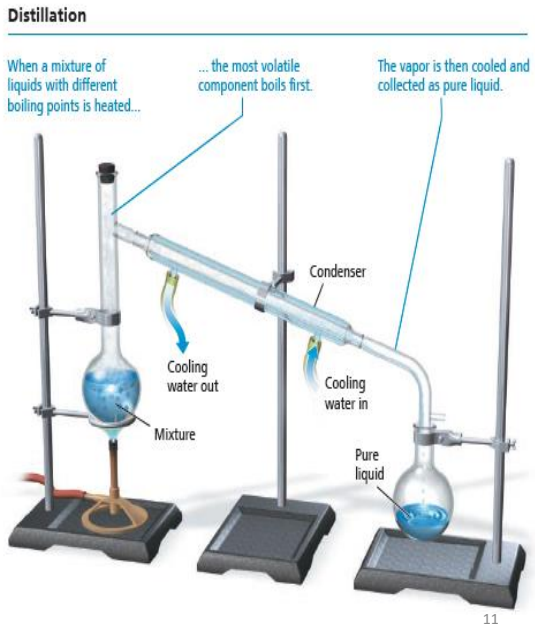
Methods for Separating Mixtures

2- Distillation: used for separating a homogenous mixture of liquids

- Distillation can be used for separation of a mixture of two liquids that have different boiling points.
- Example : water & acetone
  water & alcohol

- Can you drink sea water?

Yes, if you distill it first



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Methods for Separating Mixtures

- 3- Sedimentation:
  - Sedimentation is good for separating large particles from liquid mixtures where you don't need to get 100% of them.
  - E.g. in a mixture of sand and water, sand settles down at the bottom

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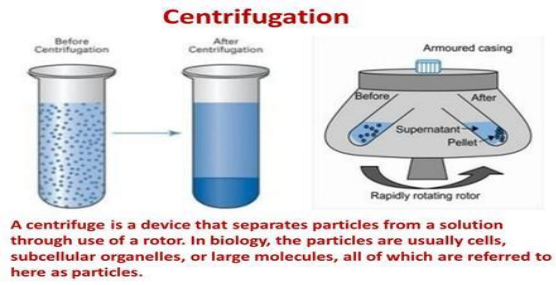
Methods for Separating Mixtures

4-Centrifugation

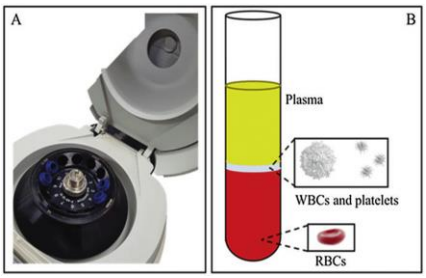
This technique is used when mixture contains solid particles so small that settling is impossible , as in the dairy industry laboratories , Blood (red blood cells can be separated from plasma)

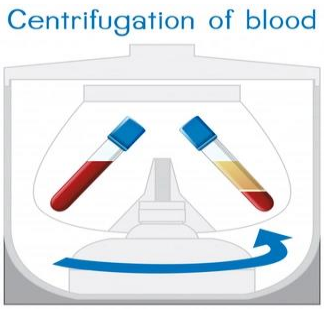
Mixture is poured into containers that **are put in rotation around a fixed axis :**
as a result of centrifugal force القوة الطاردة المركزية,**heavier particles are expelled into bottom of container.**

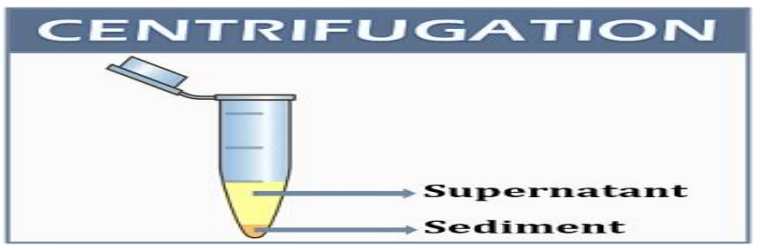


4-Centrifugation

Centrifuge







Physical, chemical changes and properties

Physical and Chemical Changes

A physical change

- a change that alter only state or appearance, but not composition of the matter.
- A physical change results in a different form of the same substance
- Example: Boiling of water

A chemical change

- A change that alter the composition of matter .
- a chemical change results in a completely different substance.
- Example: Rusting of iron

Physical and Chemical Properties of Matter

A ***physical property*** *can be measured and observed without changing the composition or identity of a substance.*

- *Example:* melting point: the melting point of ice is measured by heating a block of ice and recording the temperature at which the ice is converted to water.
- Water differs from ice only in appearance, not in composition, so this is a physical change; we can freeze water to recover the original ice. So, melting point of a substance is a physical property.

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Chemical property: *is that property that require a change in substance's chemical structure to be determined.*

- Example: burning of hydrogen gas in oxygen to form water. After the change, hydrogen gas, will disappear and a different chemical substance is formed (water). Hydrogen cannot be recovered from water by means of a physical change, such as boiling or freezing.

Physical properties of matter can be classified into extensive and intensive properties.

- Extensive property: depends on how much matter to be measured. (example: mass ,volume and length).
- Intensive property: does not depend on how much matter is measured.

(example: density and temperature).

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- ***Physical properties of matter:***

Extensive property: *depends on how much matter is being measured.*
Values of the same extensive property can be added together

1- Mass, which is *the quantity of matter in a sample of the substance,*
More matter means more mass.

Also, the mass of two copper coins equals the combined mass of both.

2- ***length*** of two tennis courts is the sum of the lengths of each tennis court.

3- Volume, defined as *cubed length*.

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Intensive property: *does not depend on how much matter is being considered.*
intensive properties values are not additive.

- ***1- Density,*** defined as *the mass of an object divided by its volume,*

is an intensive property.

$$d = m/v$$

- (d = density, m = mass, v = volume)

- The standard units of density of different matter:

g/ml (liquid), g/cm^3 (solid), g/L (gas)

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- Why is density considered as intensive property?

Intensive properties are independent of the amount of the substance :
Take 10 ml of water and measure its density it will come out to be 1 g/cm^3. Now take 10 L of water and measure its density, it will still come out to be 1g /cm^3. Therefore it is an intensive property!

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- **2- Temperature:** Suppose that we have two beakers of water at the same temperature. If we combine them to make a single quantity of water in a larger beaker, the temperature of the larger quantity of water will be the same as it was in two separate beakers, that is because temperature is intensive physical property which is non additive.
- There are three common units of temperature:
- - **Celsius C°**: commonly used in scientific community
- - **Kelvin**: (K) SI base unit; based on absolute temperature scale (K = 273 + °C)

- **Fahrenheit**:(F) common temperature scale in United States
  - (not used in science)

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Problem 1:

1. Convert the temperature given in the Celsius scale to the Kelvin scale:
(i) 25° C
(ii) 45° C

Answer:

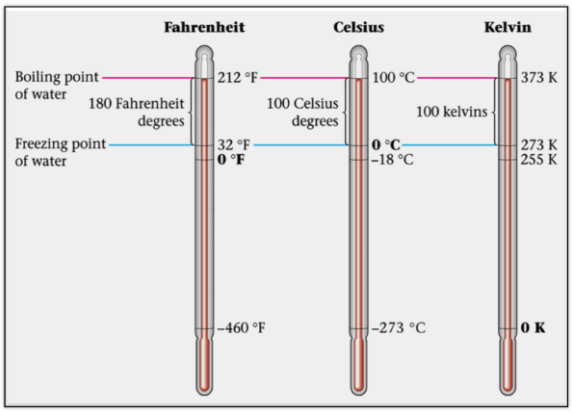
(i) Temperature in kelvin = temperature in Celsius + 273 = 25 + 273 = 298 ° K
(ii) Temperature in kelvin = temperature in Celsius + 273 = 45 + 273 = 318 ° K

Problem 2:

The boiling point of liquid nitrogen is 77 °K, convert this temperature to degrees Celsius

Answer:

Temperature in Celsius = temperature in kelvin - 273 = 77 - 273 = -196 ° C



- **3- Mass**

It is the amount of matter. It can be expressed in different units , example

- kilogram (kg) , the gram (g) and milligram (mg)
- 1 kg = 1000 g
- 1 g = 1000 mg
- **4- Volume**

It is the space that a substance occupies.

- liter (L), milliliter (mL), cubic centimeters (cc^3) and cubic meters (m^3)
- 1 L = 1000 mL
- 1 mL = 1 cc^3
- • 1000 L = 1m^3
- **5- States of matter**

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Other intensive physical properties include: taste, odor, color, Boiling point (temperature at which substance boils) and melting point (temperature at which substance melts).

Chemical properties of matter:

- Chemical property is that property leads to change in substance's chemical structure.

➢ **Examples of chemical properties**:

A. ***Heat of combustion (ΔHc):*** **Energy released upon complete combustion (burning) of compound with oxygen.**

B. ***Stability*****: refers to reactions that alter chemical structures of compounds such as oxidation (reaction with oxygen), hydrolysis (reaction with water) and photosensitivity (decomposition by light).**

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- **C. *Flammability*: ability of compound to burn when exposed to flame. Commonly high temperature in presence of oxygen.**
- **D. *Oxidation-Reduction:* oxidation refers to loss of electrons while reduction is gain of electrons.**

$$M \underset{\text{Reduction}}{\overset{\text{Oxidation}}{\rightleftharpoons}} M^{+n} + e^{-}$$

➢**Chemical change or chemical reaction: process that cause a substance to change into a new substance with a new chemical formula.**

A+B (reactants) ⟶ C (product)

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Q. Classify Each of the following as Physical or Chemical Properties

• The boiling point of ethyl alcohol is 78°C.

- Physical property – describes inherent characteristic of alcohol – boiling point

• Diamond is very hard.

- Physical property – describes inherent characteristic of diamond – hardness

• Sugar ferments to form ethyl alcohol.

- Chemical property – describes behavior of sugar – forming a new substance (ethyl alcohol)

• Iron combines with oxygen to form rust.

- Chemical change – describes how iron and oxygen react to make a new substance, rust

Q. Determine whether each change is physical or chemical. What kind of property (chemical or physical) is demonstrated in each case?

- the evaporation of alcohol

- When alcohol evaporates, it changes from liquid to gas, but it remains alcohol—this is a physical change. The volatility (the ability to evaporate easily) of alcohol is therefore a physical property.

- the burning of lamp oil

- Lamp oil burns because it reacts with oxygen in air to form carbon dioxide and water—this is a chemical change. The flammability of lamp oil is therefore a chemical property.

Q. Determine whether each change is physical or chemical. What kind of property (chemical or physical) is demonstrated in each case?

- the bleaching of hair with hydrogen peroxide

- Applying hydrogen peroxide to hair changes pigment molecules in hair that give it color—this is a chemical change. The susceptibility of hair to bleaching is therefore a chemical property.

- the formation of frost on a cold night

Frost forms on a cold night because water vapor in air changes its state to form solid ice—this is a physical change. The temperature at which water freezes is therefore a physical property.