1º ESO

UNIT 2: The physical states of matter

Susana Morales Bernal

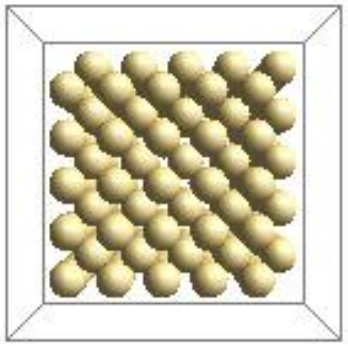
Objectives

1. To know that in all the states of aggregation the matter has mass and takes a place although depending on the state, can have or not, form and volume fixed.
2. To know that in principle, any substance can appear in the three states of aggregation.
3. To know that in the processes of expansion and compression of a gas, the volume of a system changes, but the amount of matter does not change.
4. To know that the substances in liquid or gaseous state spread with facility.
5. To know that liquids and solids do not compress practically.
6. To know the basic hypotheses of the TCM.
7. To know that the size of molecules is so small that there is no possibility of seeing them with average optician.
8. To know the differences that exist between the description of systems or processes and their kinetic-molecular interpretation.
9. To know how to interpret the differences between volume, amount of substance and mass of a gas with the TCM.
10. To know how to interpret with the TCM processes like the expansion and compression of a gas, the diffusion of a gas or a liquid or the low expansion and compression of a liquid or a solid.
11. To know how to define basic properties of solids, liquids and gases: hardness, superficial tension, viscosity, ductility, malleability, etc.
12. To know the names of the changes of aggregation states.
13. To know how to define the melting and boiling points.
14. To know how to interpret with the TCM the characteristics of the aggregation states and the changes of state.
15. To know how to draw molecular diagrams with substances in the three states.
16. To know how to recognize when a phrase talks about to an observable fact or a theoretical explanation.

PROPERTIES OF SOLIDS

The properties of solids are:

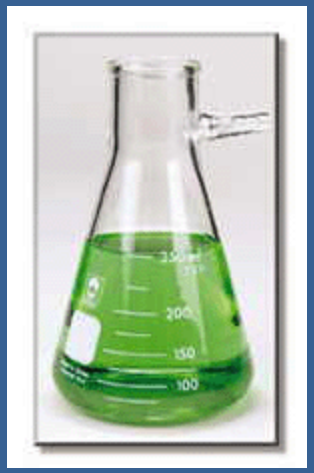
- They have mass
- They take up a place in space
- They have a definite volume that does not change
- They cannot change their shape easily

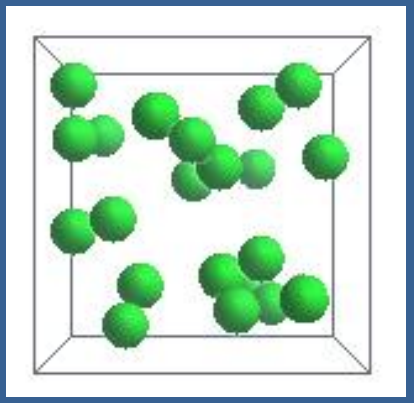


PROPERTIES OF LIQUIDS

The properties of liquids are:

- They have mass
- They take up a place in space
- They have a definite volume that does not change
- They flow
- They take the shape of their container

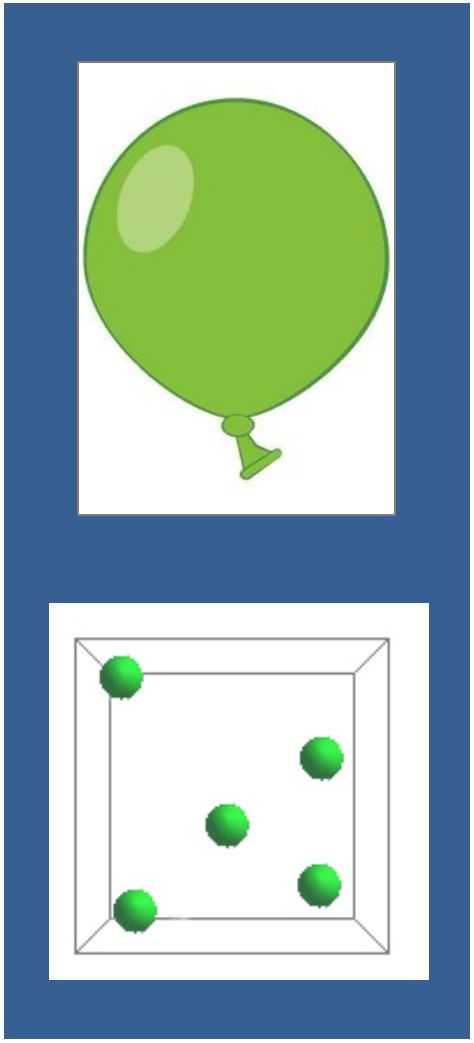




PROPERTIES OF GASES

The properties of gases are:

- They have mass
- They take up a place in space
- They take up all of the available space
- They take the shape of their container
- They mix readily with other gases
- They can compress into a small space and they can expand



The kinetic-molecular theory

The kinetic-molecular theory is a physical theory that explains the behavior of matter on the basis of the following assumptions:

- Any material thing of the universe has a very large number of very tiny particles called molecules that are in continuous movement
- Molecules are not all equal, but they can have form and different sizes, depending on the type of material
- Among molecules there are empty spaces
- Solid molecules are close and tidy. They can only vibrate
- Liquid molecules are close and untidy. They move relative to each other
- Gas molecules are very distant with respect to their size. They are in continuous movement
- Gas molecules crash into each other and into every object that surrounds them
- The speed of molecules depends on their temperature. It grows when the temperature increases and it diminishes when the temperature decreases

STRUCTURE OF SOLIDS

There are intense attractive forces in solids that hold the molecules together, this is the reason why solids keep their shape and their volume and they can only vibrate

STRUCTURE OF LIQUIDS

There are attractive forces in liquids (but less intense than in solids) that hold the liquid molecules together. These attractive forces prevent that the molecules from separating but not from moving relative to each other, this is the reason why liquids keep their volume but do not hold their shape.

STRUCTURE OF GASES

There are not attractive forces in gases. This is the reason why molecules of gases are very distant, can move freely in any direction and they don't keep their shape, and don't keep their volume either.

Behavior of substances in gaseous state

Description of the observations	Interpretation according to the molecular kinetic theory
The volume of a gas reduces when we push it from outside. We call this process, compression	In the compression the molecules approach and diminish the medium ranges among them
The volume of a gas increases when it extends through the available space. We call this process, expansion	In the expansion the molecules move away and increase the medium ranges among them
Any gas moves through another gas and it can mix with it. We call this process, diffusion	In the diffusion the molecules move to each other through the empty spaces among molecules of the other gas, mixing themselves

Don´t be confused about this

- Molecules are very small, any small piece of matter, has thousand of millions of molecules

- Molecules do not expand or compresse, the molecules move away or approach

- The speed of molecules does not change if the temperature does not change

Don´t confuse volume of a gas with the amount of substance

Description of the observations	Interpretation according to the molecular kinetic theory
When we move the piston of a syringe inwards or outwards, with a stopper at the end, the volume that takes the air that it contains increases or diminishes respectively.	The volume of an object is the space that their molecules take, including the empty space among them. This space can change for a certain number of molecules, being able to be closer or more separated.
If we have an iron bottle full of oxygen and we inject it with more oxygen, the space that the oxygen takes, does not change but the amount of oxygen changes and so does its mass (weight)	The amount of substance depends on the number of molecules that form an object. The mass of an object is the sum of the masses each one of its molecules. The mass of a gas only changes when the number of molecules changes.

Flexible and rigid containers

Gases have not own volume; its volume is always that of the container that contains them, because they always take all the available space. For that reason, the changes in the volume of a gas depend on the changes in the volume of the container.

Flexible containers

syringe

globe

When the gas is inside a flexible walls container, as a balloon or a syringe, the volume that the gas takes, can change.

Rigid container

Bottles of oxygen

When the gas is inside a rigid walls container , like a glass or iron bottle, the volume that it takes, cannot change.

Susana Morales Bernal

Behaviour of the substances in liquid and solid states

Description of the observations	Interpretation according to the molecular kinetic theory
Liquids and solids compress in very small proportion	Molecules of solids and liquids are close (although empty spaces exist). If we want to approach them, repulsive forces appear, that prevent their approaching
Solids and liquids practically do not expand and, when they do, it is in very small proportion	In solid and liquid states , the forces among molecules are sufficiently intense to prevent them from separating
Solids do not flow and keep the same shape. Liquids can flow and they do not keep the shape	Molecules of solids only can vibrate. Molecules of liquids can move relative to each other
Some solids present a crystalline structure	Molecules of crystalline solids are tidied following the directions of regular geometric figures. If the molecules of a solid are not in order, we call the solid "*amorphous solid*"

Some properties of solids

Property	Description
Hardness	It is the ability of a substance to scratch or be scratched. The hardest mineral is the diamond. Hard is the opposite of soft
Fragility	It is the ability to break easily. The diamond is very hard but it is fragile. Fragile is the opposite of strong
Ductility	It is the ability to form wires or filaments.
Malleability	It is the ability to form thin sheets.
Flexibility	It is the ability to deform easily. Flexible is the opposite of rigid
Elasticity	It is the physical property of a material when it is deformed because of stress (external forces), but turns into its original shape when the stress removes. Elastic is the opposite of plastic.

Hardness is one of the physical properties of minerals

Hardness is one measure of the strength of the structure of minerals relative to the strength of its chemical bonds

A hard mineral can scratch a softer mineral, but a soft mineral cannot scratch a harder mineral (no matter how hard you try)

A French mineralogist Friedrich Mohs proposed almost one hundred and seventy years ago, a relative scale to account for the differences in hardness simply by seeing which minerals scratch another

The **Mohs Hardness Scale** starts with talc at 1 and ends with diamond at 10. The higher the number, the harder the mineral.

The Mohs Hardness Scale is below

Talc
Gypsum
Calcite
Fluorite
Apatite
Orthoclase
Quartz
Topaz
Corundum (ruby and sapphire)
Diamond

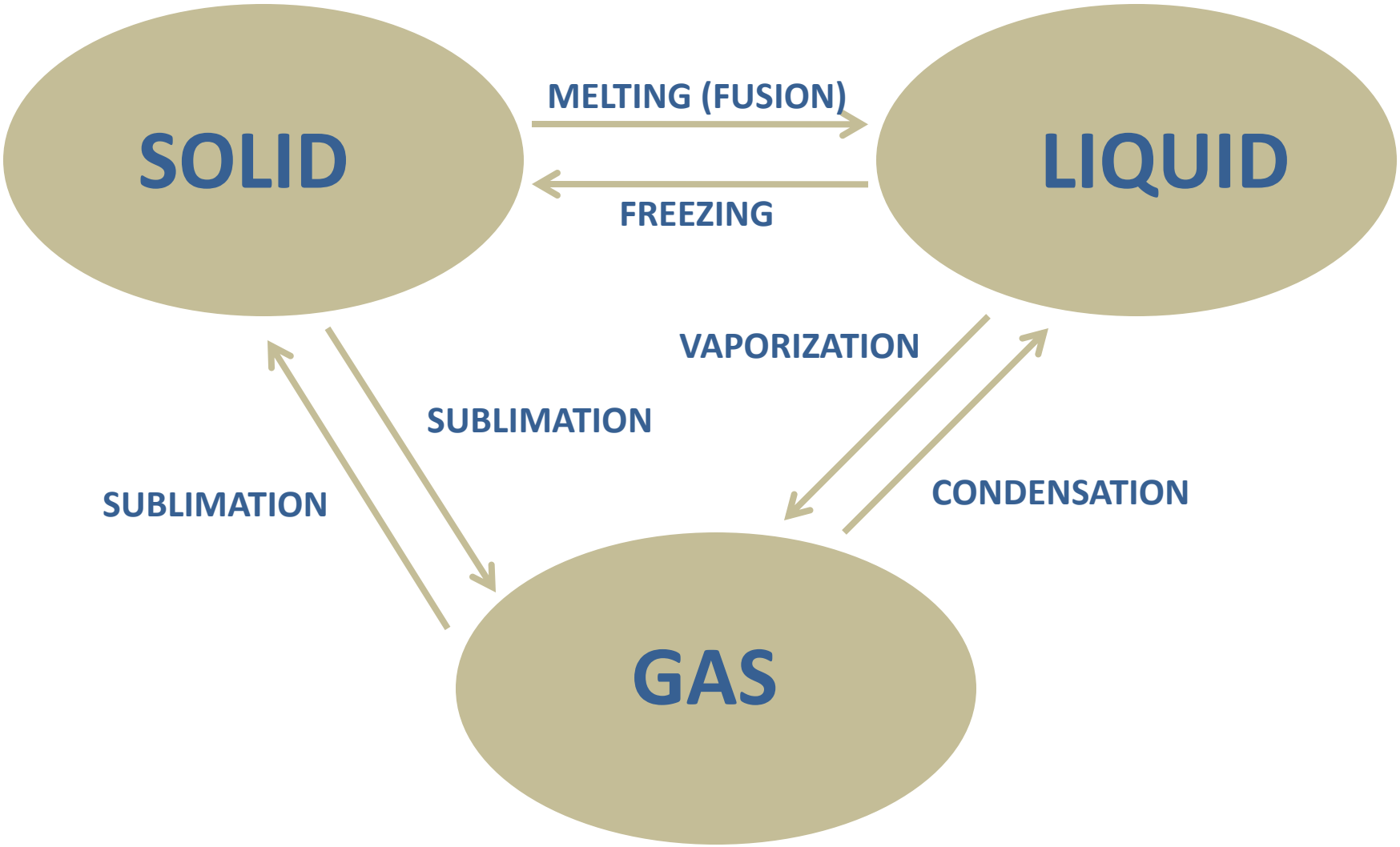
Some properties of liquids

Some properties of liquids are: **superficial tension and viscosity**

The **superficial tension** of a liquid is the resistance to the penetration of bodies in it. One of the substances that has greater superficial tension is water. For that reason, it is possible that some insects walk on water. The superficial tension is the cause of the spherical form of the drops of liquids. Another consequence of the superficial tension is the ascent of liquids within tubes of small diameter.

Viscosity is the resistance of a liquid to flow. Oil is less dense than water because it floats on water but it is more viscous because the oil slides worse on a surface.

Changes of aggregation states

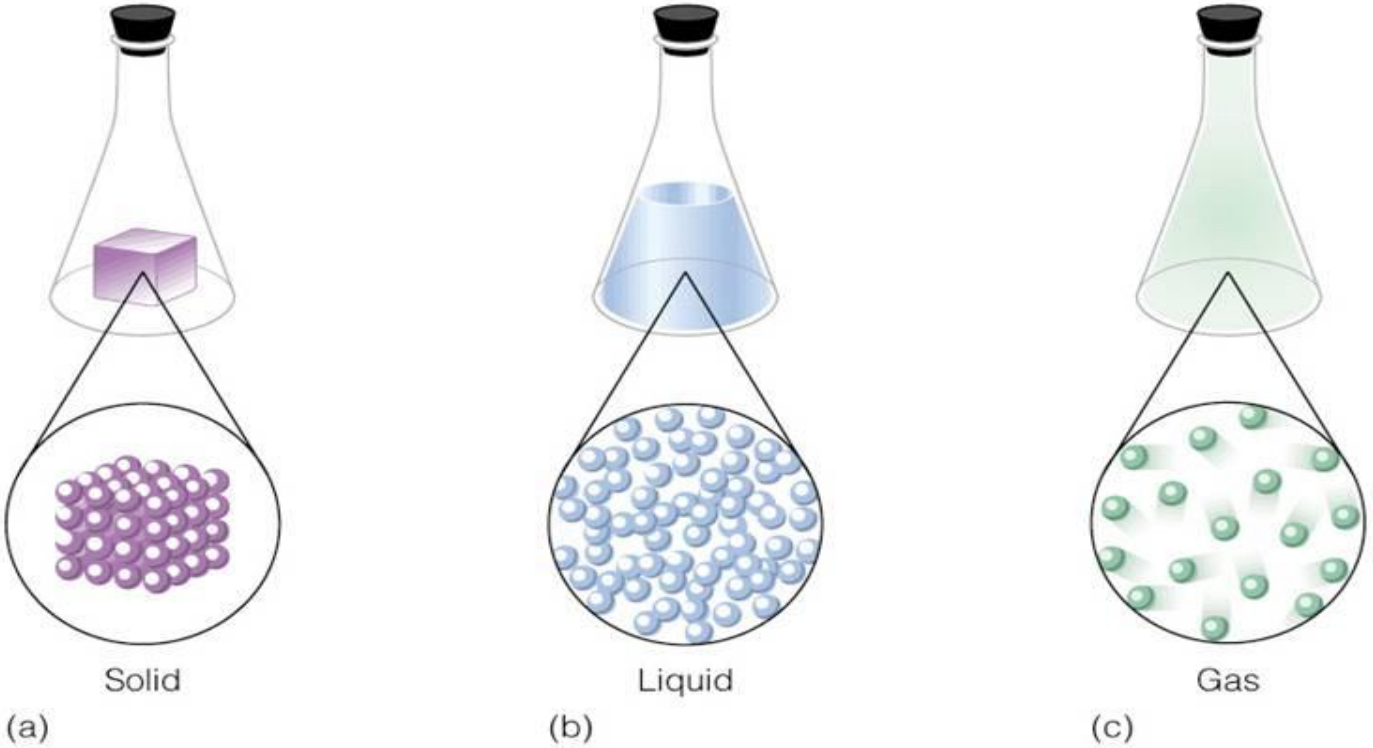


CHANGE OF STATE	WHAT IS IT?
Melting	It is the change from a solid to a liquid.
Freezing	It is the change from a liquid to a solid.
Vaporization	It is the change from a liquid to a gas, to the temperature of boiling and in all the mass of the liquid.
Evaporation	It is the change from a liquid to a gas, to any temperature and in the surface of the liquid.
Condensation	It is the change from a gas to a liquid.
Sublimation	It is the change from a solid to a gas.
Sublimation	It is the change from a gas to a solid.

States of matter

Any substance can exist as a solid material, liquid, or gas, depending on the conditions of temperature or pressure.

Matter can change its own state when we heat it or when we cool it.



Solids + energy ⟶ liquids (Melting)

Liquids + energy ⟶ gases (Vaporization and Evaporation)

Liquids - energy ⟶ solids (Freezing)

Gases - energy ⟶ liquids (Condensation)

As a solid, matter has a fixed volume and shape and is usually unable to flow, except in the case of glaciers.

The melting point is the constant temperature when a solid turns to a liquid. The melting point of water is 0 °C. The opposite is the freezing point.

When we heat the solid state of matter, it turns into a liquid. As a liquid, a substance has a fixed volume, but its shape changes to fill the shape of its container.

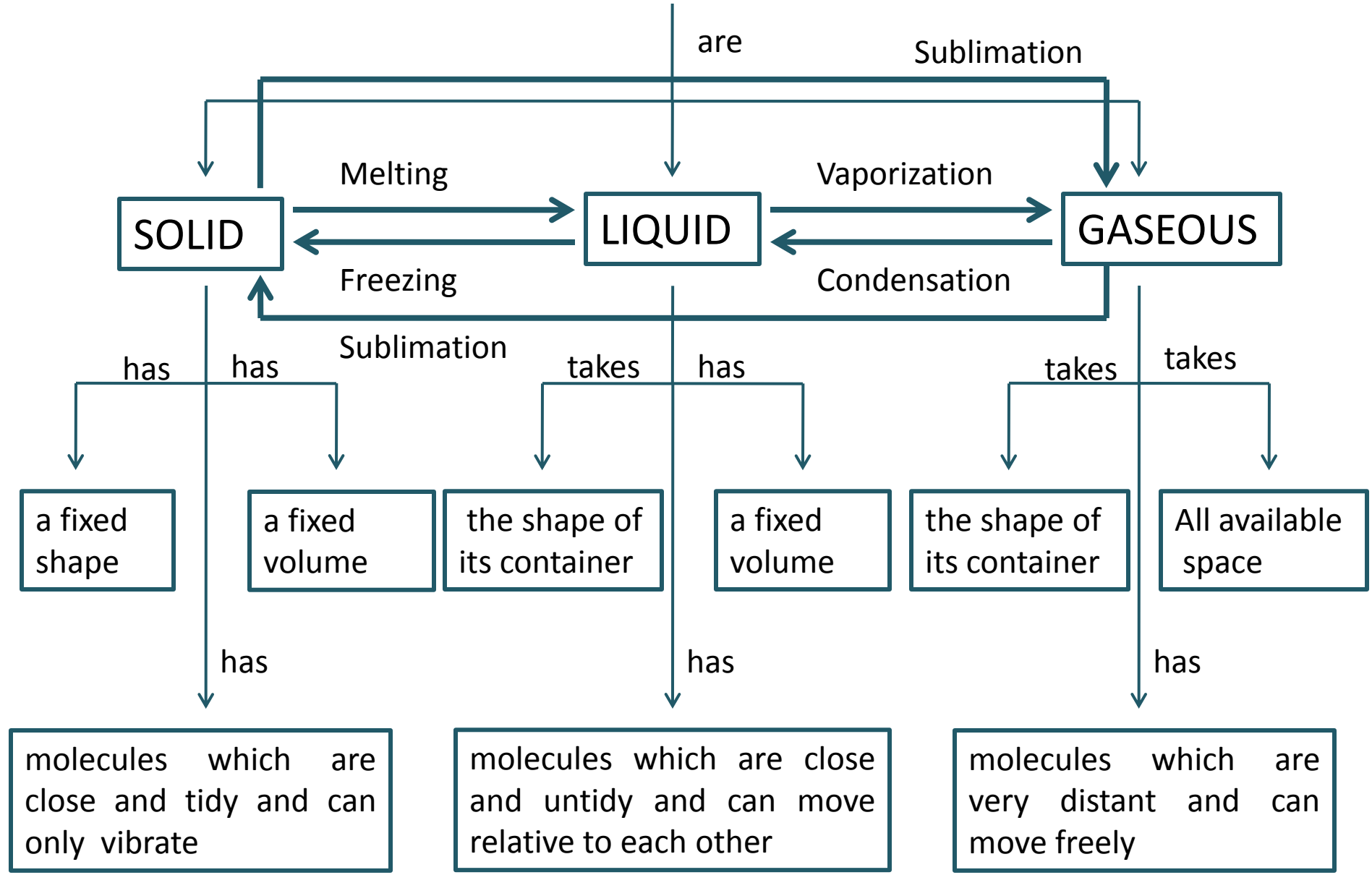
The boiling point is the constant temperature when a liquid turns to a gas. The boiling point of water is 100 °C. The opposite is the condensation point.

When we heat the liquid state of matter, it turns into a gas. As a gas, a substance does not have a fixed volume or shape. Gas expands to fill the shape and volume of its container.

Don´t be confused about this

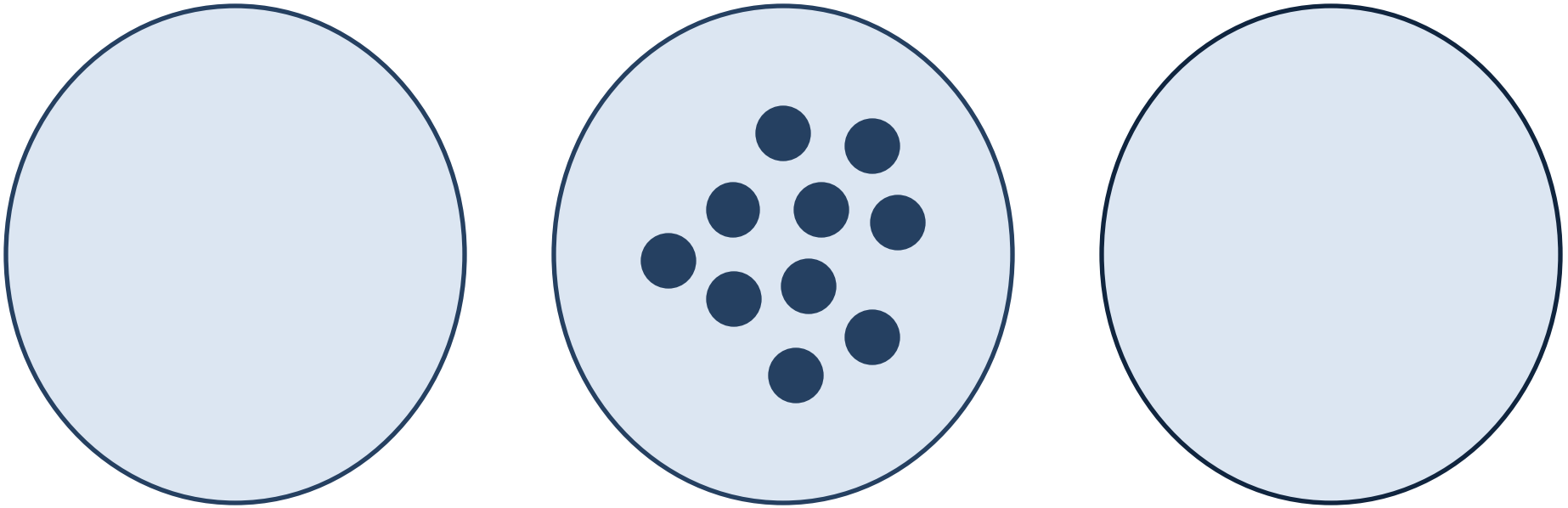
- Molecules do not melt, do not solidify, do not change of volume
- Molecules do not boil, do not condense
- Molecules move faster or slower
- Molecules approach each other or move away

The aggregation states of matter



EXERCISE 1

Draw particles of a solid and a gas. The particles of the liquid are those of the drawing



EXERCISE 2

Classify the following characteristics into solids, liquids or gases

Definite shape	Changeable volume	Hardness	Molecules close and tidy
Changeable shape	Definite volume	Viscosity	Molecules close and untidy
Changeable shape	Definite volume	Expansion	Molecules distant

SOLID	LIQUID	GAS

EXERCISE 3

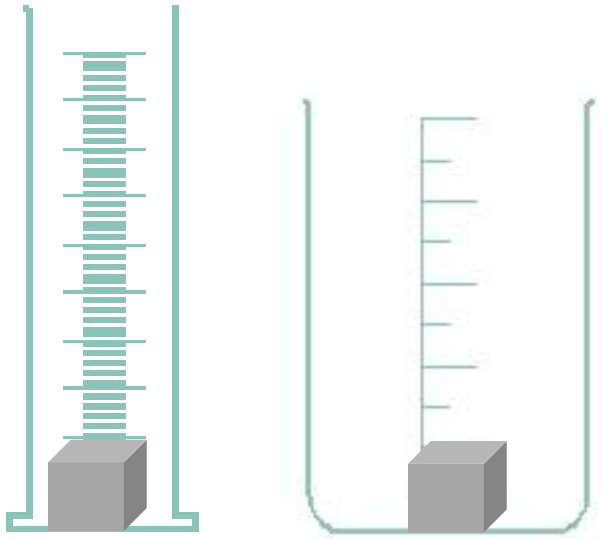
We take a metal cube and we pass it from a container to another, what changes?

A. The volume of the cube

B. The shape of the cube

C. The mass of the cube

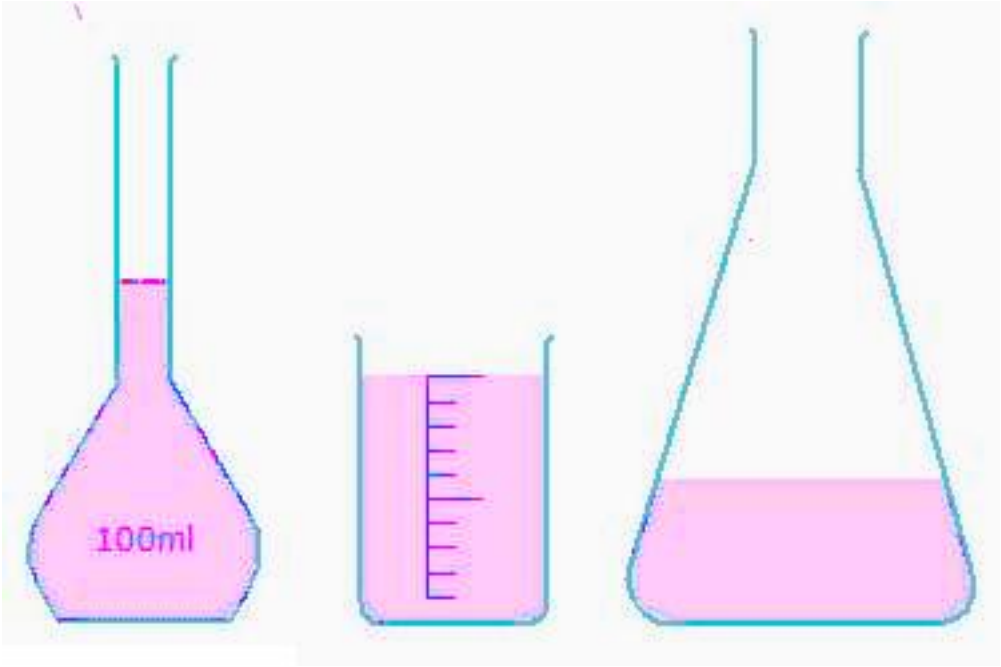
D. Nothing, the cube has the same volume, mass and shape



EXERCISE 4

We take a certain amount of liquid and we transfer it from one container to another, what changes?

A. Density
B. Shape
C. Volume
D. Mass



EXERCISE 5

Why can we pour a liquid from one container to another?

A. Because they have not definite mass

B. Because their particles are not as strongly united as in a solid

C. Because they tend to take all the volume

D. Because their particles are as strongly united as in a solid

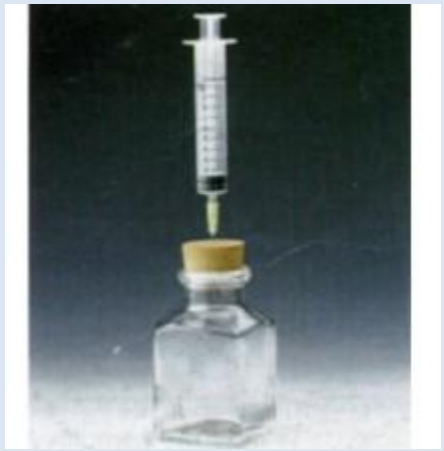
EXERCISE 6

If we inject a certain amount of air into a container, what happens to the mass of that air?

A. It changes

B. It does not change

C. It depends



D. It changes because the air is in a greater container

EXERCISE 7

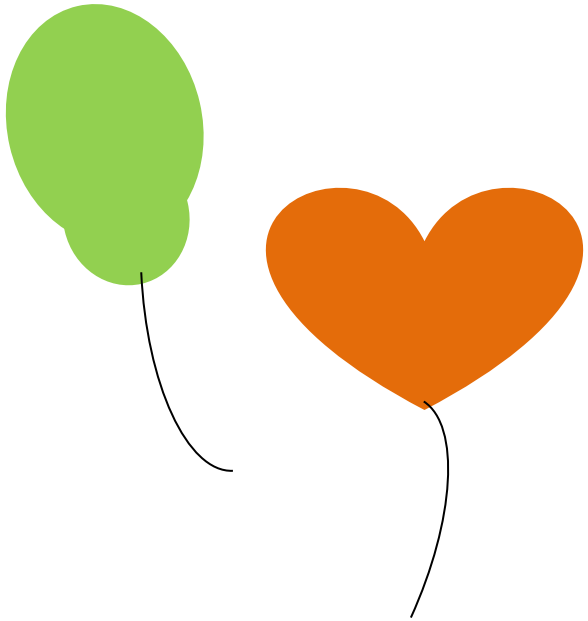
If we pass gas from one balloon to another, what happens to its mass?

A. It depends

B. It changes because it has a different volume

C. It changes its shape or volume but not its mass

D. It changes because it has a different shape



EXERCISE 8

An iron bottle has a capacity of twenty litres. We have it full of oxygen.

If we add two litres of oxygen

A. What volume takes now the oxygen in the bottle?
B. Will the bottle weigh more or less?

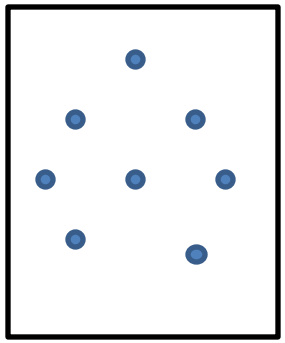
If we take one litre of oxygen out

A. What volume takes now the oxygen in the bottle?
B. Will the bottle weigh more or less?

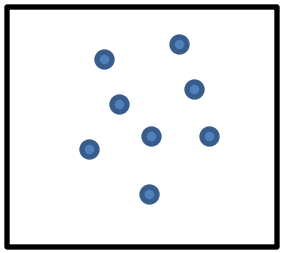
EXERCISE 9

What happens if we compress a gas too much?

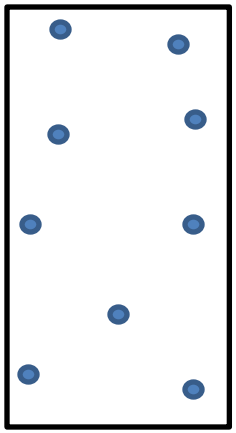
A. It has a greater volume
B. It has less mass
C. It disappears
D. It turns to liquid state



Normal gas



Compressed gas



Expanded gas

EXERCISE 10

This open container does not contain any liquid, what has in its interior?

A. Nothing

B. 250 g of air

C. 250 L of air

D. 250 mL of air

EXERCISE 11

Order the following words to form a text with sense

, when they do

and liquids

to prevent

Solids

practically do not expand and

, it is in very small proportion

In solid and liquid states ,

the forces

them from separating

among molecules

are sufficiently intense

EXERCISE 12

Are the following phrases true or false?

A. Any substance can exist in the three states of matter

B. If 100 g of a gaseous substance take all the volume of a container, 50 g of that same gas take half of the container

C. The particles of matter are in continuous movement

D. When we compress a gas, its particles diminish in size

E. When we expand a gas, its particles increase in size

EXERCISE 13

Relate the terms of the two columns

A. Elasticity	**1. It is the ability to deform easily.**
B. Fragility	**2. It is the ability of a substance to scratch or be scratched.**
C. Ductility	**3. It is the ability to break easily.**
D. Malleability	**4. It is the ability to form wires or filaments.**
E. Flexibility	**5. It is the ability to form thin sheets.**
F. Hardness	**6. It is the physical property of a material when it is deformed because of stress (external forces), but turns to its original shape when the stress removes.**

EXERCISE 14

Connect the terms of the two columns

A. Change from solid to gas	**1. Melting**
B. Change from gas to liquid	**2. Sublimation**
C. Change from liquid to solid	**3. Condensation**
D. Change from solid to liquid	**4. Vaporization**
E. Change from liquid to gas	**5. Freezing**

EXERCISE 15

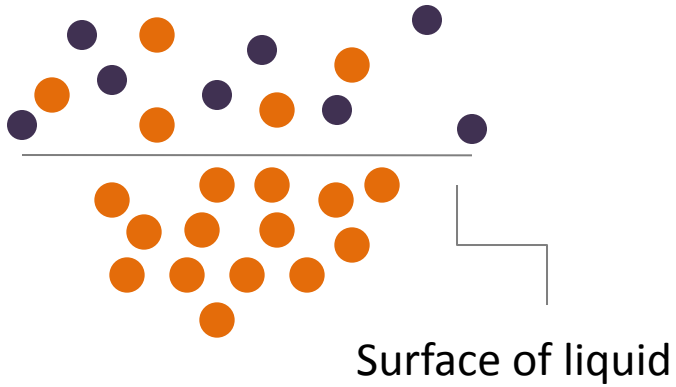
What happens to the water of a pool that disappears?

A. It disappears

B. It turns to gas and its particles mix with the particles of air

C. It is a sublimation

D. It is a vaporization



EXERCISE 16

We know that water boils at 100 °C and that ice melts at 0 °C

What temperature does water condense at?

What temperature does water freeze at?

EXERCISE 17

What happens to the particles of subtances with the changes of state?

A. That the particles become solid, liquid and gaseous

B. That they become greater or smaller

C. That they separate or they approach

D. Nothing

Which changes of state require cooling to take place?

..... and .....

EXERCISE 18

100 g of a liquid substance has a volume of 125 mL. When this substance turns to a solid, it has a volume of 105 mL.

A. Does the mass of this substance change with this process? Why?

B. What is the density of this substance in liquid state? And in solid state?

EXERCISE 19

Identify the process that happens

IT HAPPENS	PROCESS
When the mirror of the bath fogs	
When liquid water turns to ice	
When we see our breath on a cold morning	
When we open a bottle of ammonia and we can smell it from a distance	
When we heat iron until it turns to liquid	
When the water of a pool dries up	
The wax of a candle melts	
When the lava of a volcano cools and hardens	
When we heat water until 100 °C	
When we pass a certain amount of gas to a larger container	
When we pass a certain amount of gas to a smaller container	

EXERCISE 20

Revise your vocabulary

Choose a word and fill the blanks below

softest, ductility, untidy, mixing, hardest, expansion, melting, away, vibrate, close , temperature, boiling, increase, continuous, distant, compression, diffusion, vaporization, malleability

A. Solid molecules are …….. and tidy. They can only ……..
B. Liquid molecules are close and …….. They move relative to each other.
C. Gas molecules are very …….. with respect to the size of molecules. They are in …….. movement.
D. In the …….. molecules approach and diminish the medium ranges among them.
E. In the …….. molecules move …….. and …….. the medium ranges among them.
F. In the …….. molecules move to each other through the empty spaces among molecules of the other gas, …….. themselves
G. Diamond is the …….. mineral. Talc is the …….. mineral.
H. …….. is the ability to form thin sheets.
I. …….. is the ability to form wires.
J. …….. is the change from a liquid to a gas, to the temperature of …….. and in all the mass of the liquid.
K. The …….. point is the constant… when a solid turns to a liquid.

GLOSSARY

- ❑ Attractive
- ❑ Close
- ❑ Container
- ❑ Condensation
- ❑ Difussion
- ❑ Ductility
- ❑ Elastic
- ❑ Elasticity
- ❑ Evaporation
- ❑ Flexibility
- ❑ Flexible
- ❑ Force
- ❑ Fragile
- ❑ Fragility
- ❑ Freely
- ❑ Freezing
- ❑ Gas
- ❑ Hard
- ❑ Hardness
- ❑ Kinetic
- ❑ Liquid
- ❑ Malleability
- ❑ Melting
- ❑ Molecule
- ❑ Particle
- ❑ Plastic
- ❑ Rigid
- ❑ Shape
- ❑ Soft
- ❑ Solid
- ❑ Speed
- ❑ State of matter
- ❑ Strong
- ❑ Sublimation
- ❑ Tidy
- ❑ To approach
- ❑ To compress
- ❑ To crash
- ❑ To decrease
- ❑ To diminish
- ❑ To expand
- ❑ To flow
- ❑ To grow
- ❑ To hold
- ❑ To increase
- ❑ To keep
- ❑ To mix
- ❑ To move
- ❑ To push
- ❑ To reduce
- ❑ To vibrate
- ❑ Untidy
- ❑ Vaporization
- ❑ Viscosity

Susana Morales Bernal