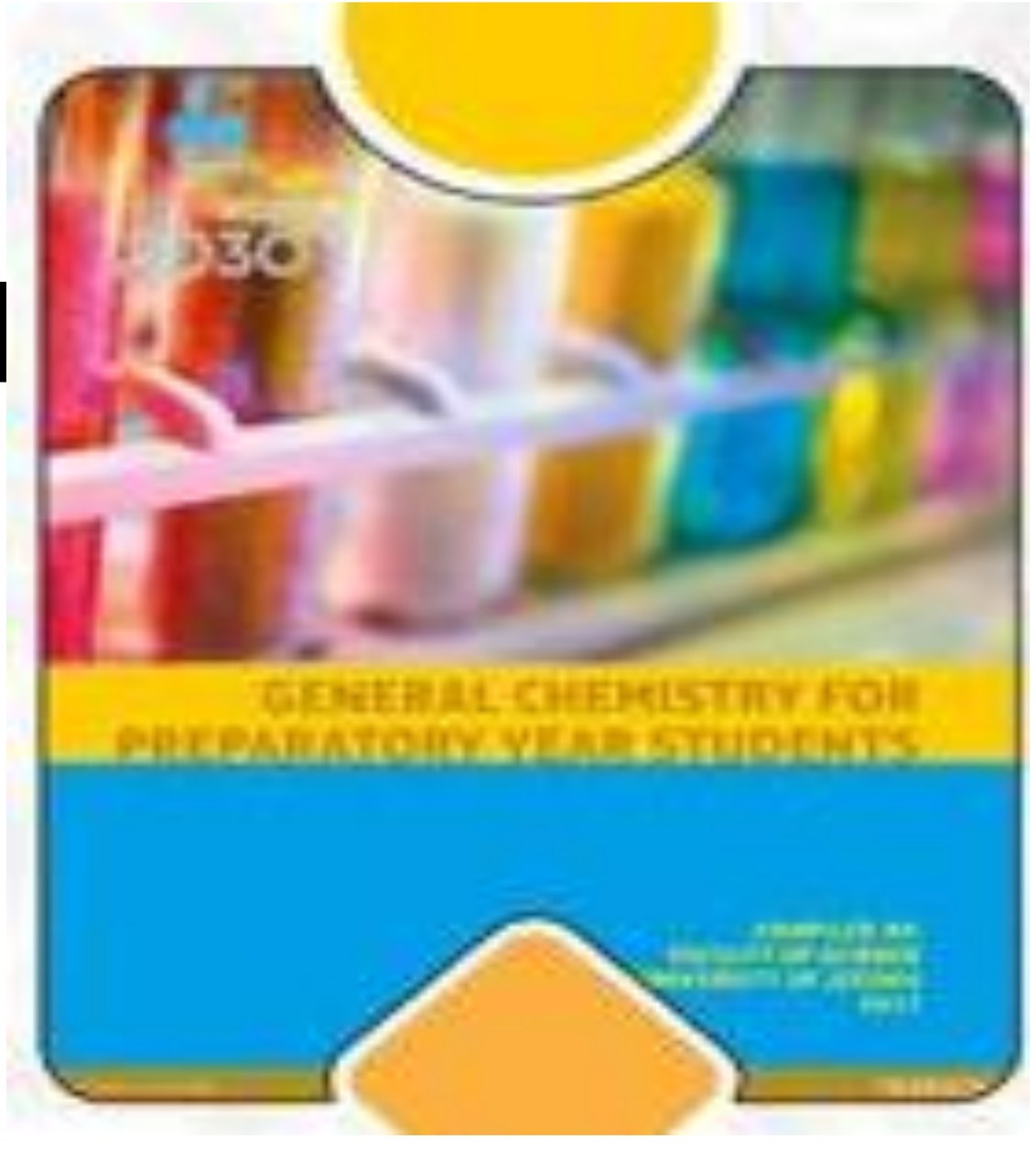
General chemistry-101

جامعة جدة

chapter:1



The Chemical World

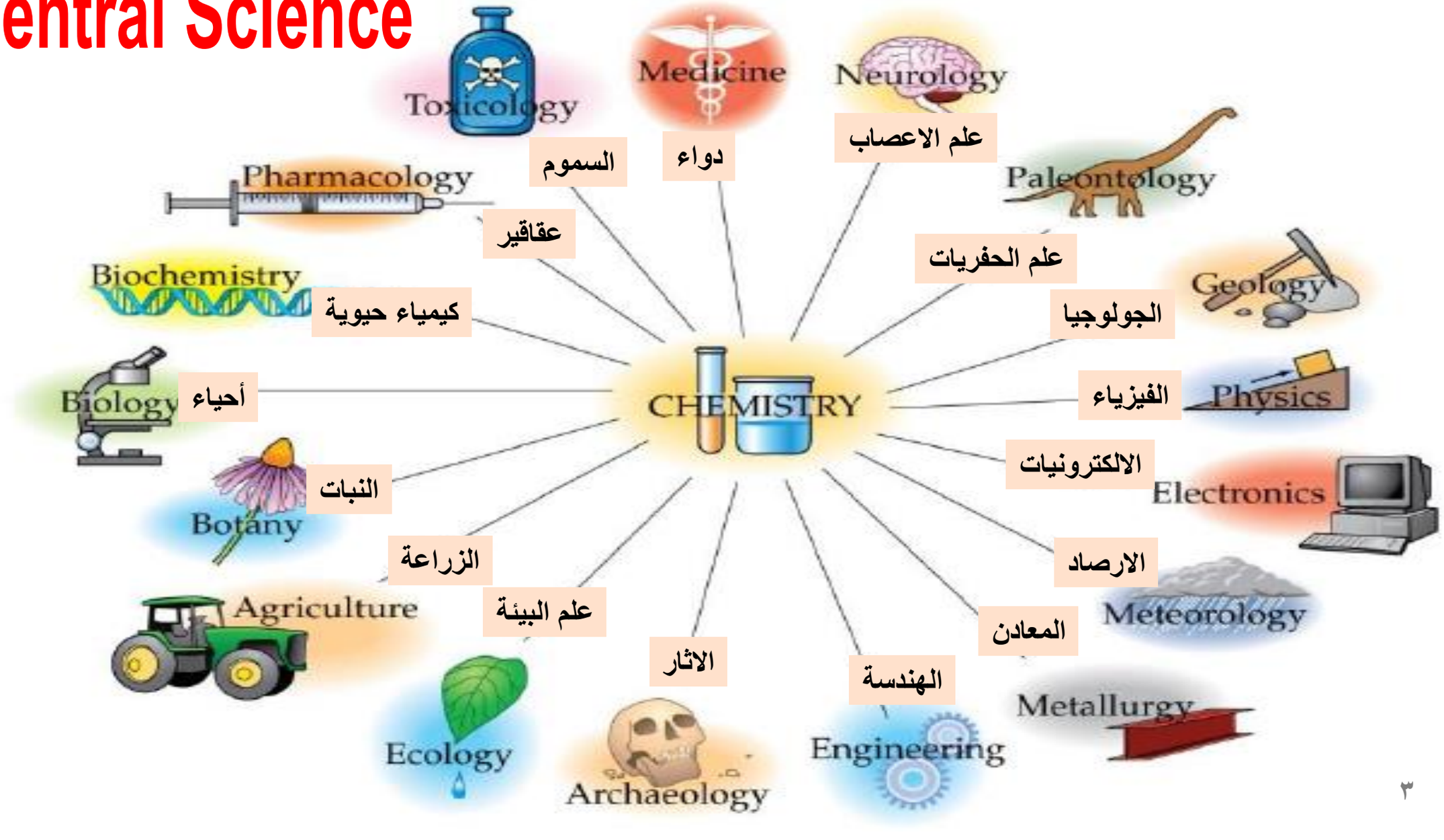
Chemistry:

- The science that seeks to understand the properties and behavior of matter by studying what atoms and molecules do.

- It is central to our fundamental understanding of many science related fields.

- Virtually, everything around us is composed of “Chemicals

The Central Science



1.1 Atoms and Molecules

Atoms are the building blocks of **matter**.

➢Each **element** is a substance that can not be separated into simpler substances by chemical means and made of a unique kind of **atoms**

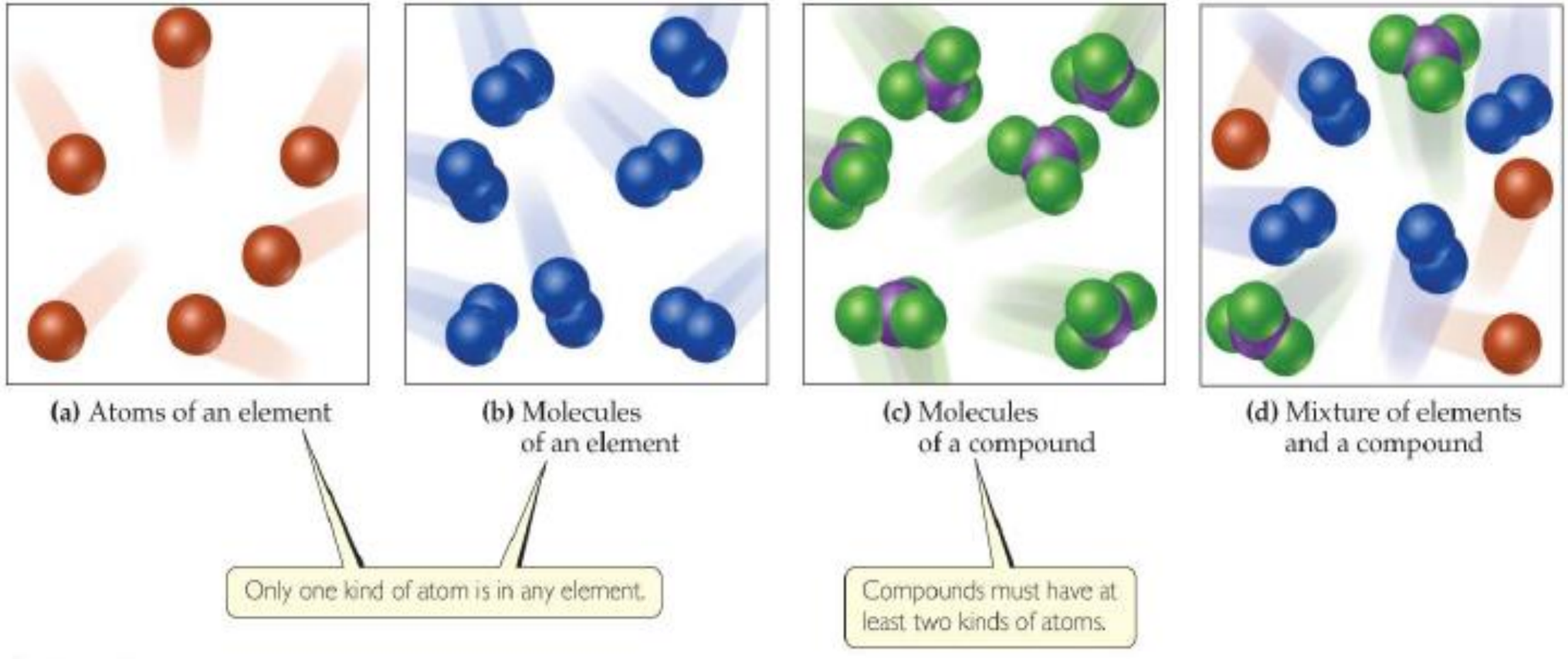
(so far, 118 elements are identified in the universe,
all are represented in the periodic table of elements).

➢A **compound** is a substance composed of atoms of two or more elements chemically united in fixed proportions and can only be separated into their pure components (elements) by chemical means. Ex: water (H_2O).

is made of two or more atoms of different kinds of elements, bonded together to form **molecules**

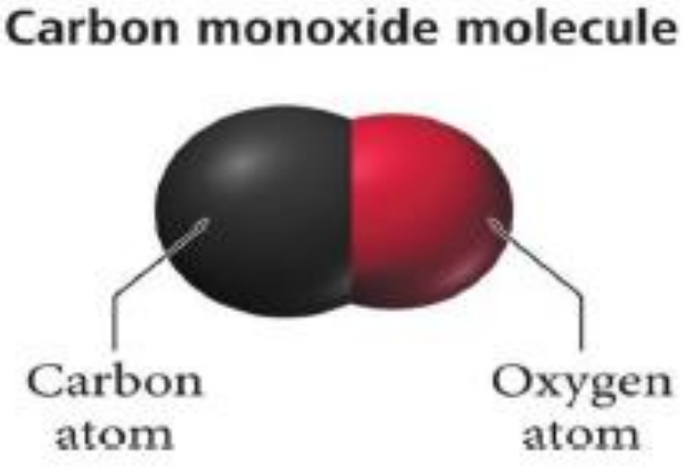
(molecules are the building blocks of compounds).

➢The properties of a substance are determined by the properties of its molecules and atoms.



Notice that: some elements are present in nature in the form of "**molecules**" instead of "**free atoms**", they are called: "**Molecular Elements**", such as: **H_2, N_2 , O_2 , F_2 , Cl_2 , Br_2 , I_2**

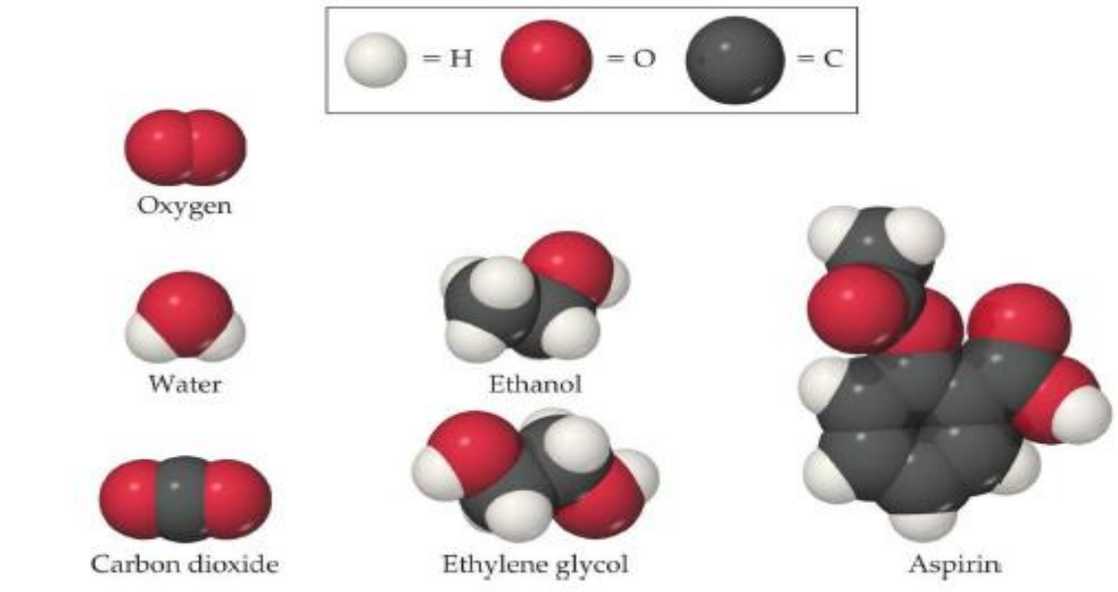
1.1 Atoms and Molecules - Example 1



✓The air contains **carbon monoxide** pollutant.

✓Each molecule contains a carbon **atom** and an oxygen **atom** held together by a **chemical bond**.

1.1 Atoms and Molecules - Example 2



Note: Balls of different colors are used to represent **atoms** of different **elements**. Attached balls represent connections between atoms that are seen in nature. These groups of atoms are called **molecules**

(Ex)-Which of the following is an element?

(a) H_2O (b) O_2 (c) C_2H_2 (d) CO

(Ex)-Which of the following is a compound?

(a) H_2O (b) O_2 (c) H_2 (d) F_2

(Ex)-What is the symbol for the element potassium?

a) K b) P c) Pt d) W

(Ex)-Which of the following is an element Iron ?

a) CO b) FE c) Fe d) H_2O

(Ex)-Which of the following is an atom?

a) CO b) O_2 c) Fe d) H_2

(Ex)-Which of the following is a molecule?

a) C b) O_2 c) Fe d) H

(Ex)-Which of the following is a molecule?

(a) H (b) O (c) C_2H_2 (d) C

1.2 The Classifications of Matter

•**Matter** is anything that **occupies space** and has **mass**.

Examples:
your textbook, your desk, your chair,
and even your body are all composed of matter.

•**Matter can be classified according to its:**
1.State (its physical form), or its:
2.Composition (the basic components that make it up).

Classifications of Matter

according to

1-State

Solid

Liquid

gas

2-Composition

Mixtures

Heterogeneous mixture

composition is not uniform throughout.

Ex: fruit salad

Homogeneous mixture

composition of the mixture is the same throughout.

Ex: sugar in water

Pure substances

compound

is a substance composed of atoms of two or more elements chemically united in fixed proportions and can only be separated into their pure components (elements) by chemical means. Ex: water (H_2O).

element

is a substance that can not be separated into simpler substances by chemical means

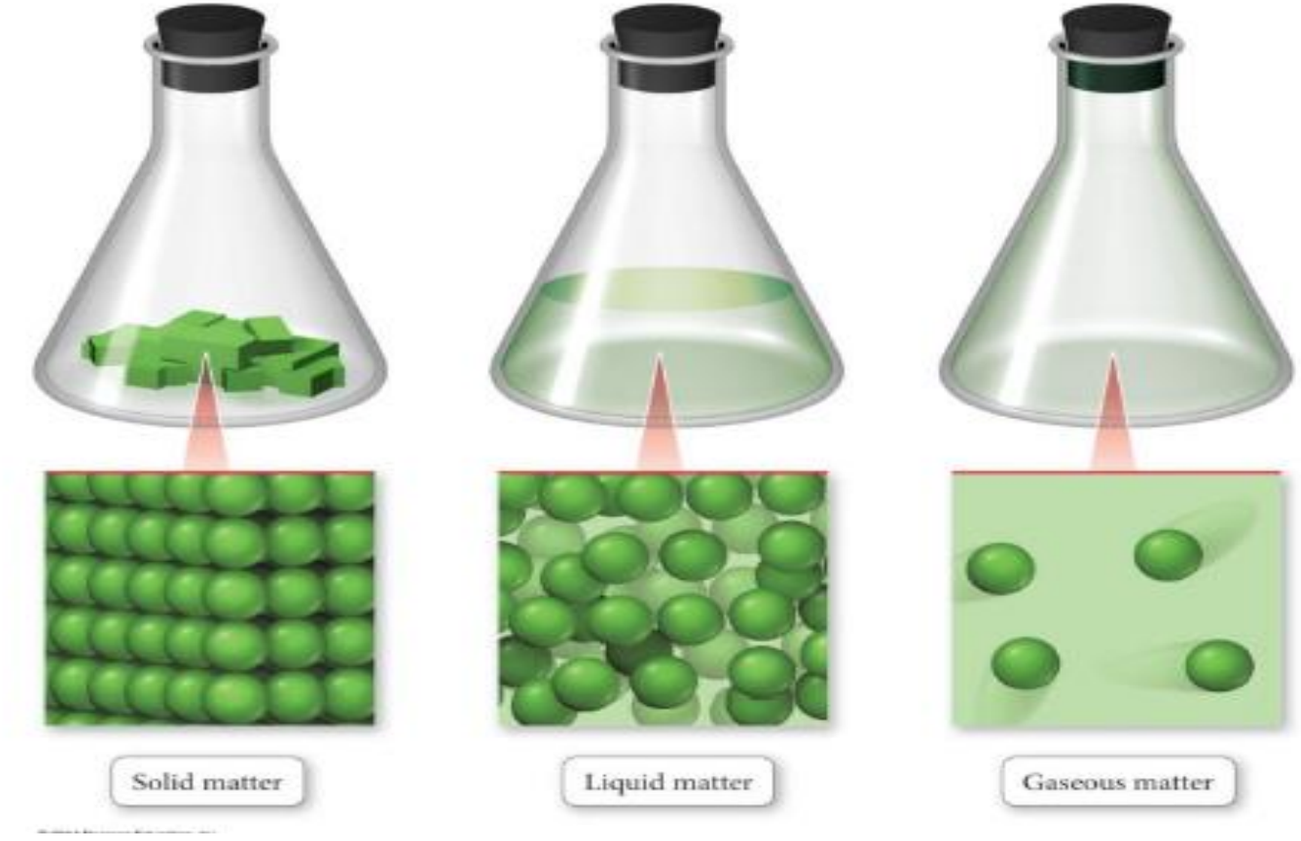
1-The States of Matter

- **Matter** can be classified as:
solid, **liquid**, or **gas**, based on which properties it exhibits.

- The state of matter changes from solid to liquid to gas with **increasing temperature**, and vice versa!

Structure of Atoms (or Molecules)

The atoms or molecules have different structures in solids, liquids, and gases — leading to different properties.



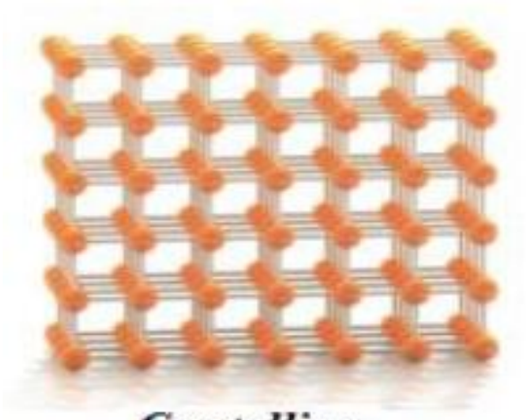
Solid Matter

- In **Solid Matter**,
 atoms or molecules pack close to each other in fixed locations.
- Although the atoms and molecules in a solid vibrate, they do not move around or past each other.
- Consequently, a solid has a
fixed volume and **rigid shape**.

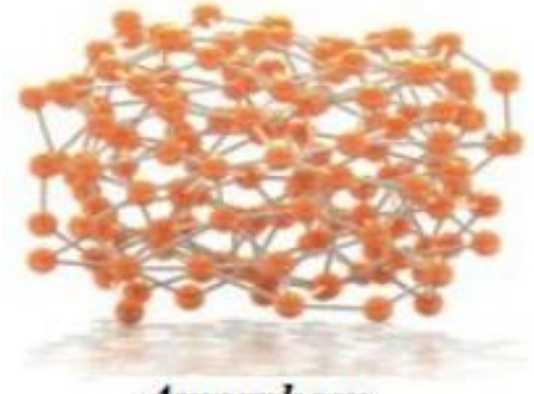
•Ice, aluminum, iron, wood, salt, and diamond are some examples of solids.

Solid Matter: Crystalline or Amorphous?

➢Solid matter may be **Crystalline**,
where atoms or molecules are in “patterns”
with long-range repeating order.
•Examples of **crystalline solids**
include table salt (NaCl) and diamond.


Crystalline

➢Others may be **Amorphous**,
where atoms or molecules
do not have any long-range order.
•Examples of **amorphous solids**
include graphite, rubber, glass and plastic.


Amorphous

Liquid Matter

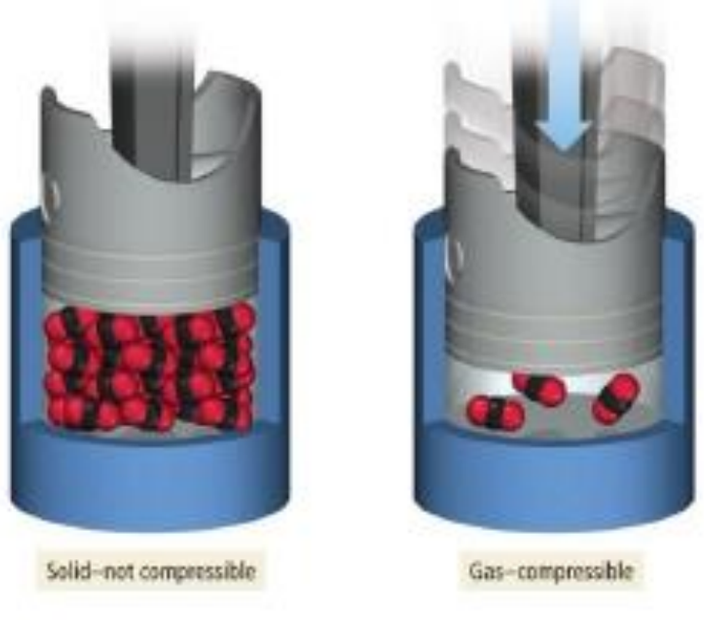
➢In **Liquid Matter**,
atoms or molecules pack about as closely as they do in solid matter, but they are free to move relative to each other.
➢The ability of liquids to flow, makes them assume the shape of their container.

➢Liquids have **fixed volume** but **not a fixed shape**.
•Water, alcohol, oil, and gasoline are liquid substances at room temperature**.**

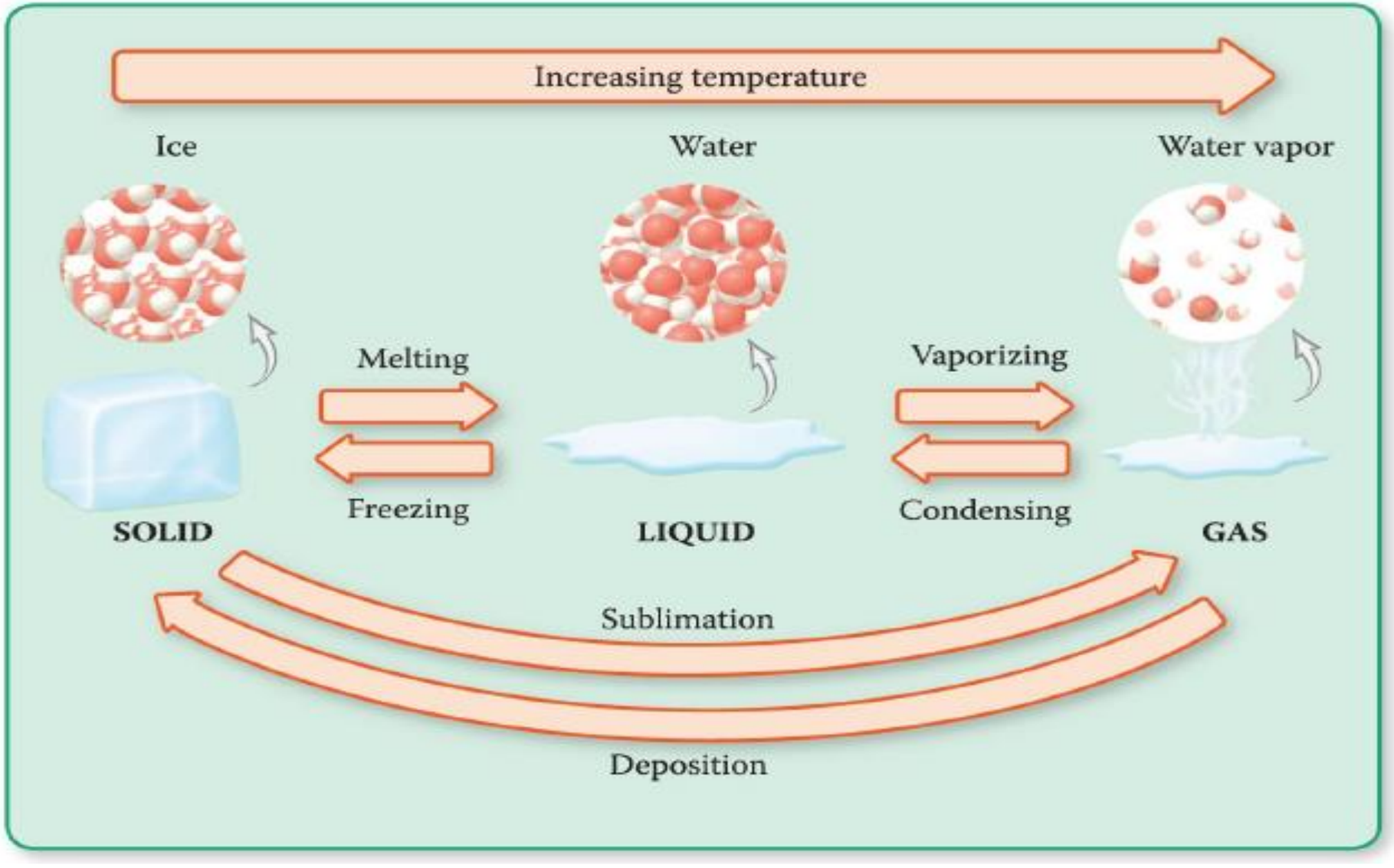
Gaseous Matter

- The **Gaseous Matter** has large spaces between atoms or molecules.
- Particles (atoms or molecules) of gases are free to move relative to one another.
- Gases have **no fixed volume** and **no fixed shape**, instead, they assume the volume and shape of their container.

These qualities make gases **compressible**.



Summary of State Changes of Matter



2- Classification of Matter According to its Composition

➢Matter can be divided into two classes:

1.Mixtures

2.Pure substances

➢**Mixtures:** are composed of more than one substance and can be physically separated into its component substances.

➢**Pure substances:** are composed of only one substance and can NOT be physically separated.

A- Mixtures

There are **two types of mixtures**:

1. Heterogeneous mixtures

2. Homogeneous mixtures

✓**Heterogeneous Mixtures:** do NOT have uniform properties throughout.

–(sand + water), (oil + water) or (gasoline + water) are examples on heterogeneous mixtures.

✓**Homogeneous Mixtures:** have uniform properties throughout.

–(salt water), (sugar + water) and alloys are homogeneous mixtures.

(Ex)- Sea Water is an example of a:

(a) Compound (b) heterogeneous mixture

(c) Element (d) homogeneous mixture

(Ex)-Grape juice is an example of a:

(a) Substance (b) heterogeneous mixture

(c) Element (d) homogeneous mixture

(Ex)-The gas nitrogen and oxygen in air are

a) Compound b) Mixture c) Liquids d) Solids

B- Pure Substances

There are **two types of pure substances:**

1.Compounds

2.Elements

✓ **Compounds:**

✓ can be chemically separated into individual elements. There are millions of compounds in the universe.

➢Water is a compound that can be separated into hydrogen and oxygen.

✓**Element:**

cannot be broken down further by chemical reactions.

➢ Elements are the 118 members of the periodic table of elements, such as: Sodium, Iron, Gold, Silver, Hydrogen, Oxygen, Carbon …... etc

Assessment

1- The process is which a solid substance is transformed directly into a gas is called _____ and it requires _____ of temperature.

2- _____ is the physical process which changes a gas into a liquid, and it needs _____ of temperature.

3- Which state of matter has a fixed volume but not a fixed shape.

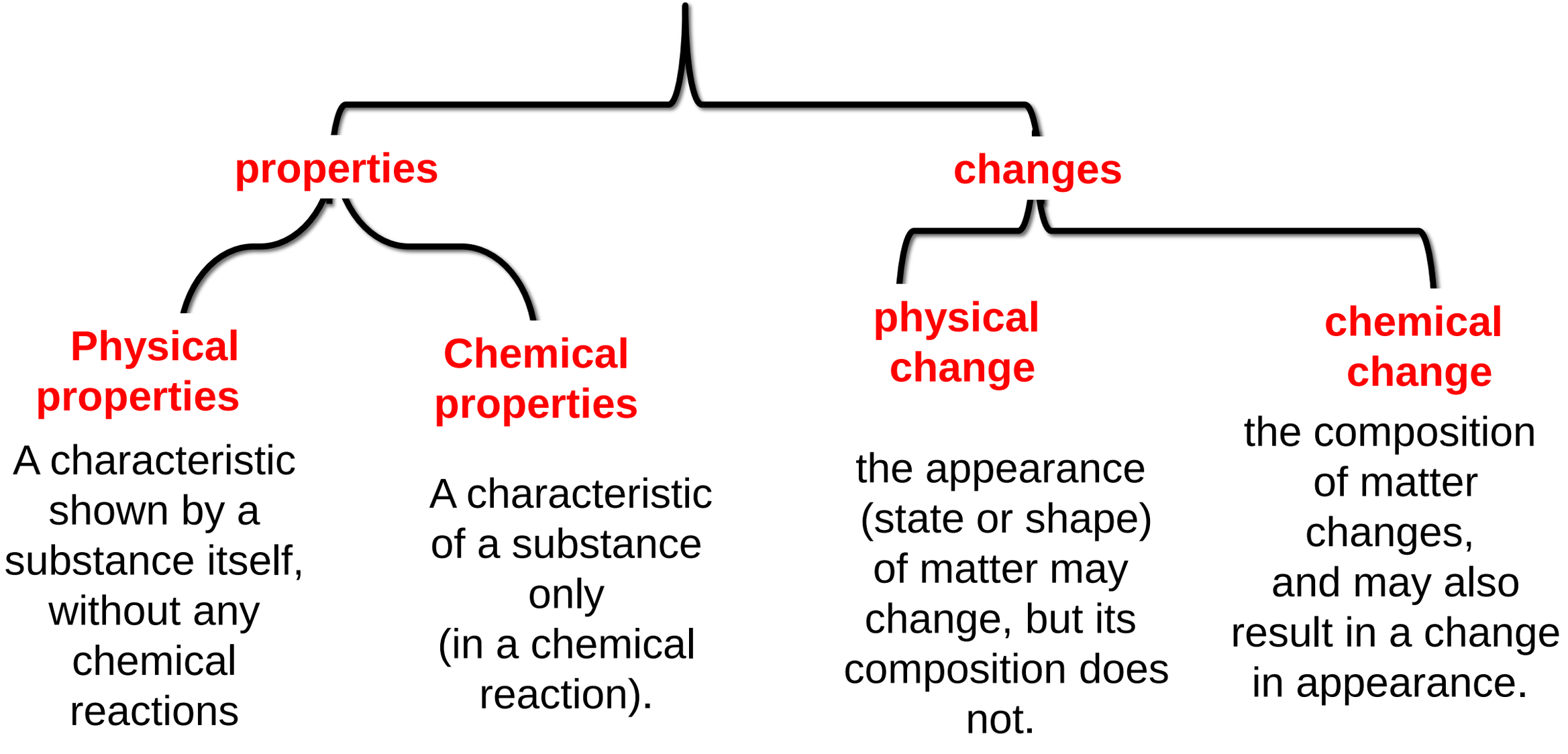
4- A_____ matter is able to assume both the shape and volume of its container.

5- The ability of both _____ and _____ states of matter to flow makes them able to change their shape to the shape of their reservoir.

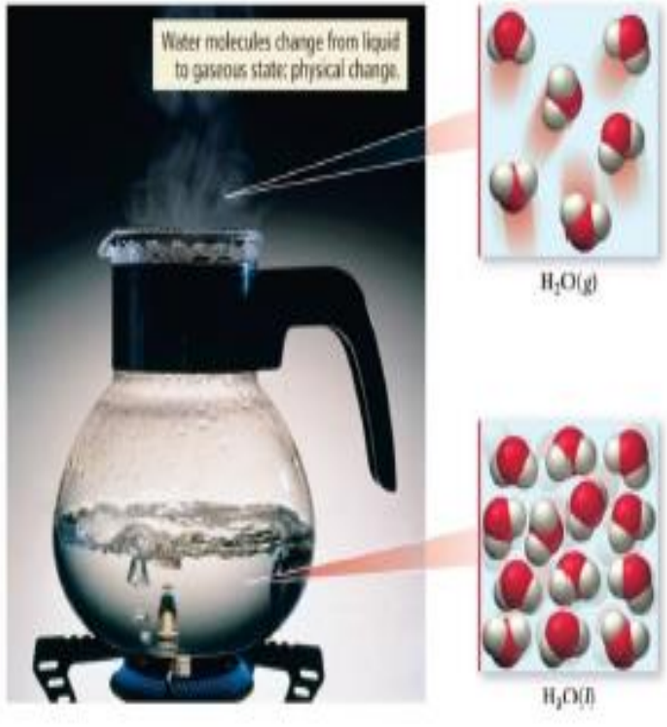
6- Classify each substance as a pure substance or a mixture, and indicate the type of each of them (element, compound or homogeneous, heterogeneous):

a. sweat b. carbon dioxide c. aluminum d. sand e. rust f. wet sand
g. air h. oxygen gas i. bronze alloy j. honey

Properties and Changes of Matter



1.3 Physical and Chemical Changes & Properties



Physical Changes:

•Changes that alter only the appearance (state or shape) , but NOT the chemical composition.

Example 1: when water (H_2O) boils, it changes its state from liquid to gas.

➢The gas remains composed of water molecules H_2O, so this is a physical change.

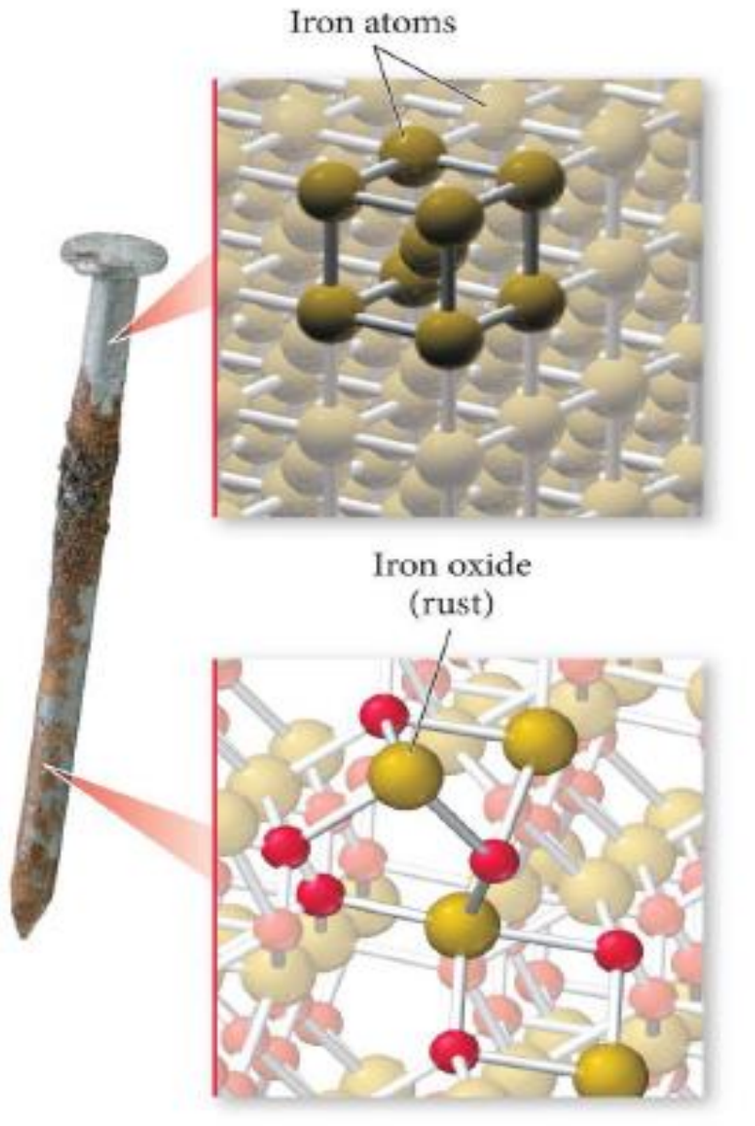
Example 2: when a piece of paper is shredded, or a glass window is broken, only their shapes have changed, but their chemical compositions remained unchanged, so, those are physical changes.

1.3 Physical and Chemical Changes & Properties

Chemical Changes:

•Changes that alter the composition of matter.

➢During a chemical change, atoms rearrange, transforming the original substances into different substances.



Examples

Example 1:

rusting of iron is a chemical change:

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3$$

Example 2:

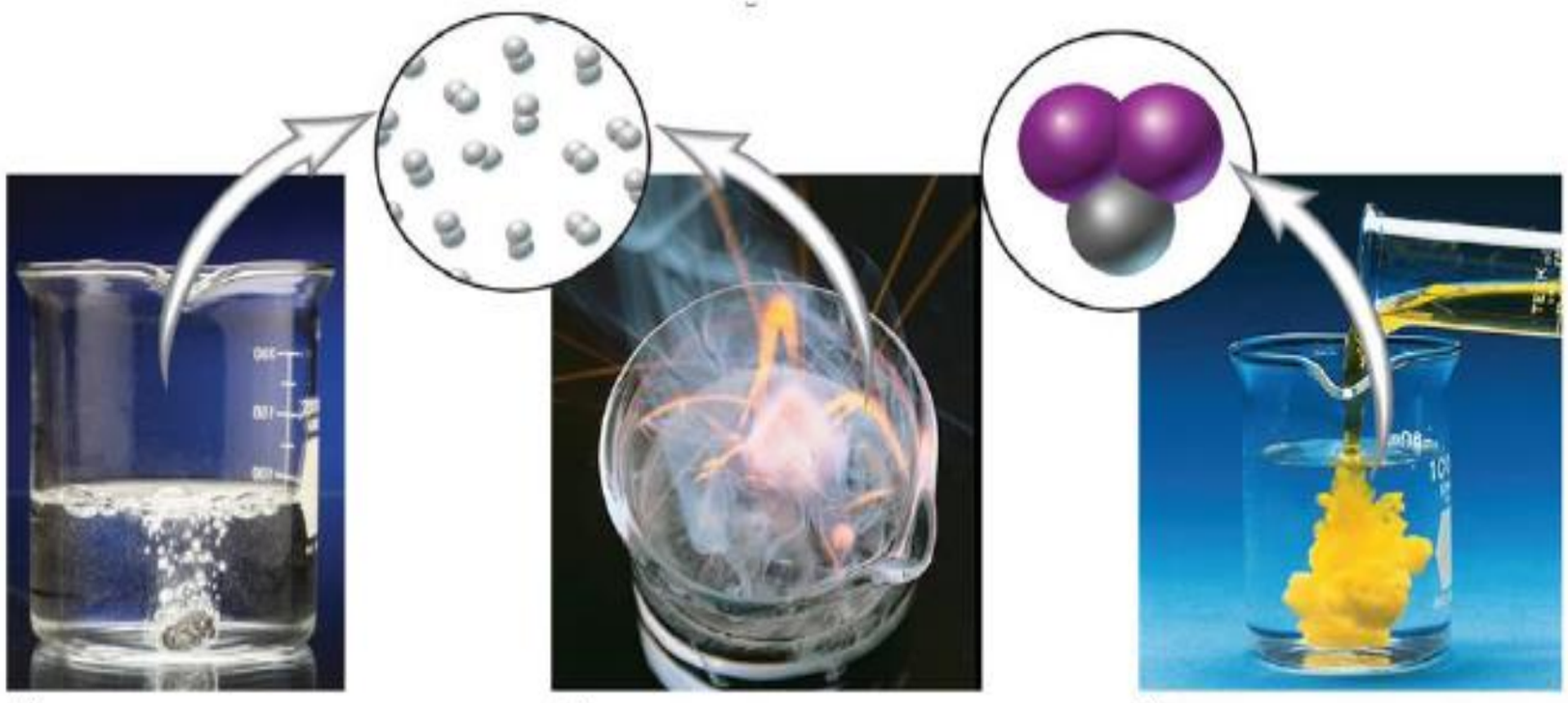
burning of gasoline produces

$CO_2 + H_2O$,

so it's a chemical change

Evidences for Chemical Changes

a)release of a gas (bubbles).
b)emission of light or heat.
c)a permanent change in color.



(a) (b) (c)

Physical and Chemical Changes: Examples

Sugar dissolving:

$C_{12}H_{22}O_{11}(s) \longrightarrow C_{12}H_{22}O_{11}(aq)$

Chemical composition unaltered

Physical change

$C_{12}H_{22}O_{11}(s)$
Solid sugar

$C_{12}H_{22}O_{11}(aq)$
Dissolved sugar

Propane gas burning:

$C_3H_8(g) + 5\,O_2(g) \longrightarrow 3\,CO_2(g) + 4\,H_2O(g)$

Chemical composition altered

Chemical change

$CO_2(g)$, $H_2O(g)$

Carbon dioxide and water

$C_3H_8(g)$

Propane

Physical and Chemical Properties of Matter

1.Physical Properties

A characteristic shown by a substance itself, it may be observed and measured without changing the composition of a sample

(without any chemical reactions)

- Color
- Odor
- Density
- Melting Point
- Boiling Point
- Malleability
- Viscosity
- Hardness
- Metallic Luster
- Ductility

Physical and Chemical Properties of Matter

2.Chemical Properties –

A characteristic of a substance only appears when the substance interacts with, or transforms into other substances (in a chemical reaction).

- Reactivity with other chemicals
- Acidity or Basicity
- Solubility
- Flammability
- Chemical stability
- Toxicity
- Radioactivity

Assessment

Answer the following questions:

1- Identify the following as a chemical or physical property:

1. blue color
2. melting point
3. density
4. reacts with water
5. flammability
6. hardness
7. Solubility
8. boiling point
9. reacts with acid
10. luster
11. odor
12. sour taste

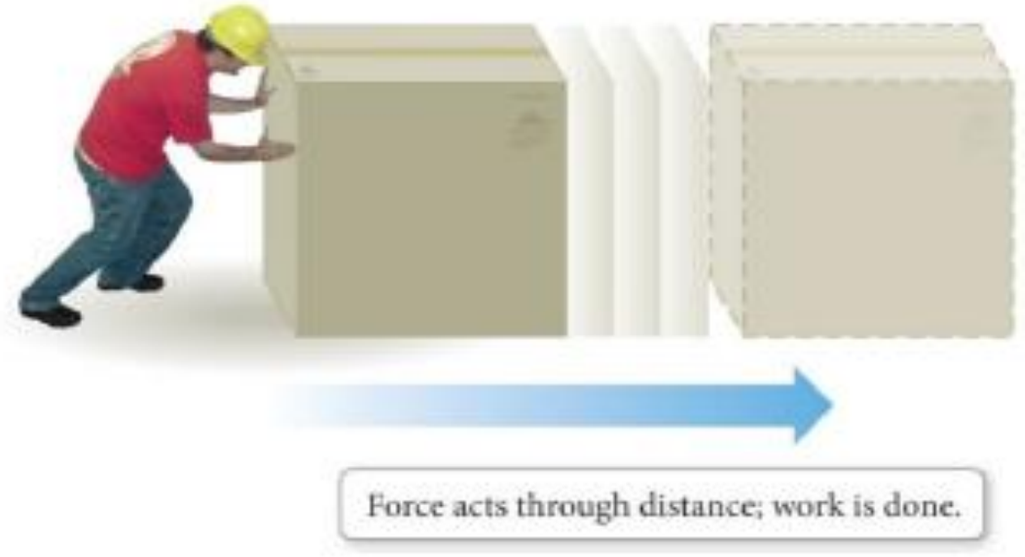
2- Identify the following as physical or chemical changes:

1. NaCl (Table Salt) dissolves in water.
2. Sugar dissolves in water.
3. Ag (Silver) tarnishes.
4. Milk sours.
5. An apple is cut.
6. Wood rots.
7. Heat changes H_2O to steam.
8. Pancakes cook.
9. Baking soda reacts to vinegar.
10. Grass grows.
11. Fe (Iron) rusts.
12. A tire is inflated.
13. Alcohol evaporates.
14. Food is digested.
15. Ice melts.
16. Paper absorbs water

1.4 Energy: A Fundamental Part of Physical and Chemical Changes

- **Energy** is the ability to do work.
- **Work** is defined as the action of a force through a distance.

- When you push a box across the floor or pedal your bicycle across the street, you have done **work**.



The law of conservation of energy:
energy can neither be created nor destroyed, but only changes from one form into another.

Potential and Kinetic Energy

➢**Potential energy**,

PE: is any form of stored energy; it results from position or composition (examples: chemical and nuclear energy)

➢**Kinetic energy**,

KE: is the energy matter has as a result of its motion (examples: thermal and electrical energy).

✓Energy can be converted between the two types.

✓All substances have both potential and kinetic energies, regardless to their physical states.

✓**Solids** have the lowest kinetic energy, and **gases** have the greatest kinetic energy.

✓As we increase the temperature of a substance, its kinetic energy increases

1.5 The Units of Measurement

We use measurements in everyday life, for example:

- walking 2.25 km to the university campus,
- carrying a backpack with a mass of 12 kg, and
- observing when the outside temperature has reached 40°C.

1.5 The Units of Measurement

➢**Units:** standard quantities used to specify measurements, they are critical in chemistry.

•The most common systems of units are:

1.The English system: used in the United States

2.The Metric system: used in most of the rest of the world.

3.The International System of Units (SI):
used by scientists, and it is based on the metric system.

Units in the Metric and SI Systems

➢In the metric and SI systems, one unit is used for each type of measurement:

Measurement	Metric	SI
Length	meter (m)	meter (m)
Volume	liter (L)	cubic meter (m^3)
Mass	gram (g)	kilogram (kg)
Temperature	Celsius (□C)	Kelvin (K)
Time	second (s)	second (s)

(Ex)- The unit of mass in the SI system is:

a) kg b) m c) m/s d) s e) m/s^2

(Ex)- The unit of Length in the SI system is:

a) kg b) m c) m/s d) s e) m/s^2

(Ex)- The unit of Time in the SI system is:

a) kg b) m c) m/s d) s e) m/s^2

Basic Units of SI system

Length	**Meter**	**m**
Mass	**Kilogram**	**Kg**
Time	**Second**	**S**
Temperature	**Kelvin**	**K^{o}**
Amount of substance	**Mole**	**mol**
Electric current	**Ampere**	**A**
Luminous intensity	**Candela**	**Cd**

(Ex)-The SI unit of time is the

(a) Hour (b) second (c) minute (d) ampere

(Ex)-The SI unit of Length is the

(a) Hour (b) second (c) Meter (d) ampere

(Ex)-The SI unit of Electric current is the

(a) Hour (b) second (c) minute (d) ampere

(Ex)-The SI unit of Temperature is the

(a) Hour (b) Kelvin (c) minute (d) ampere

Derived SI Units

Force	Newton	N	Kg m / s^2
Pressure	Pascal	Pa	(N/m^2) $Kg.m^{-1}$ s^{-2}
Energy	Joule	J	$Kg.m^2/s^2$ (N.m)
Electrical charge	Coulomb	C	A.S
Electrical Potential	Volt	V	J/C
Frequency	Hertz	S^{-1}(HZ)	S^{-1}(1/s)
Power	Watt	W	J/s ($Kg.m^2/s^3$)
Velocity			m/s
Acceleration			m/s^2
Area			m^2
Volume			m^3
Density			Kg/m^3

(Ex)-The SI unit of Frequency is the

(a) Hour (b) s^{-1} (c) minute (d) ampere

(Ex)-The SI unit of Pressure is the

(a) Pascal (b) s^{-1} (c) minute (d) ampere

(Ex)-The SI unit of Electrical Potential is the

(a) Hour (b) Volt (c) minute (d) ampere

(Ex)-The SI unit of Acceleration is the

(a) Hour (b) s^{-1} (c) m/s^2 (d) ampere

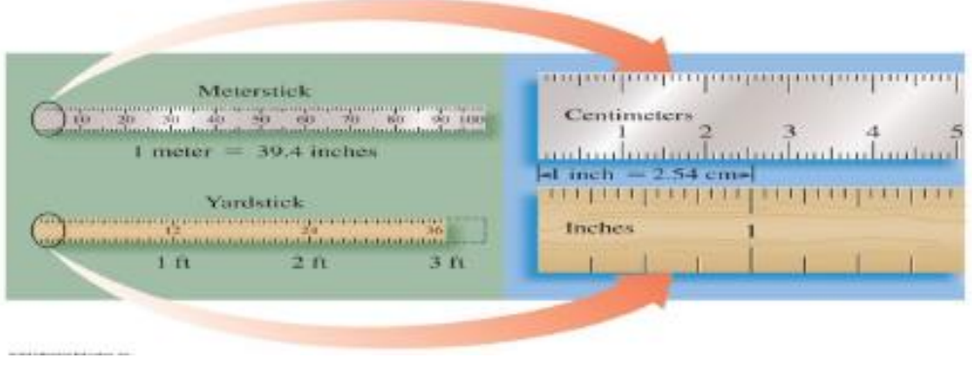
(Ex)-The SI unit of Energy is the

(a) Joule (b) m/s^2 (c) minute (d) ampere

The Meter: A Measure of Length

Length

- is measured using a meter stick.
- uses the unit **meter (m)** in both the metric and SI systems.
- uses centimeters (cm) for smaller units of length.



➢ **Useful relationships between the units of length**

- 2.54 cm = 1 in.
- 1 m = 100 cm
- 1 m = 39.4 in.
- 1 m = 1.09 yd

The Kilogram: A Measure of Mass

- The **mass** of an object is a measure of the quantity of matter within it.
- The SI unit of mass is **kilogram (kg):**

1 kg = 2.21 lb (pound)

- Another common unit of mass is the **gram (g):**

1 gram is 1/1000 kg.

- **Weight**

of an object is a measure of the gravitational pull on its matter.

Units of Time Measurement

Time measurement:

- uses the unit

second (s) in both the metric and SI systems.

Days, Hours, Minutes, Seconds x

➢**Useful relationships between the units of time:**

- 1 day = 24 h
- 1 h = 60 min
- 1 min = 60 s

(Ex)-How many seconds are there in a solar year (365.24 days), expressed in the correct Number of significant figures?

(a) 3.1557×10^{7} s **(b) 5.2595×10^{5} s**

(c) 3.1×10^{7} s **(d) 3.1557×10^{8} s**

(Ex)- A man has a height of 120cm. His height in meters is

a) 1.2cm **b) $1.2x10^{-2}$m** **c) $1.2x10^{5}$m** **<u>d) 1.2m</u>** **e) 120m**

(Ex)- A gram is equal to:

(a) 10^{-2}kg **<u>(b) 10^{-3}kg</u>** **(c) 10kg** **(d) 1kg** **(e) 10^{-1}kg**

(Ex)- 10min = …….. S

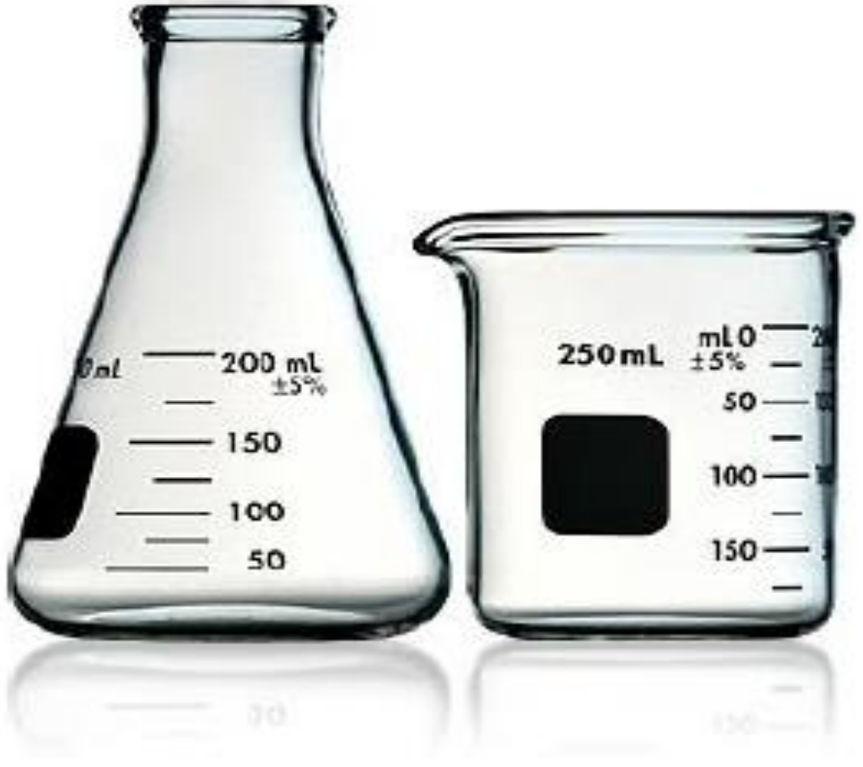
(a) 10 **<u>(b) 600</u>** **(c) 0.1** **(d) 0.01** **(e) 0.001**

Units for Volume Measurement

➢The common units for volume measurements are:
Quart (qt), Liter (L), Milliliter (mL), and Cubic Meter (m_3)

➢**Useful relationships between the units of volume**

- 1 L = 1000 mL
- 1 L = 1.06 qt
- 946 mL = 1 qt
- 1000 L = 1 m^3

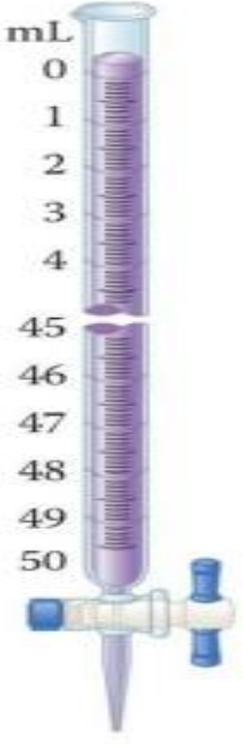


Lab Tools for Volume Measurement

- Volume is the amount of space occupied by a substance

Graduated cylinder

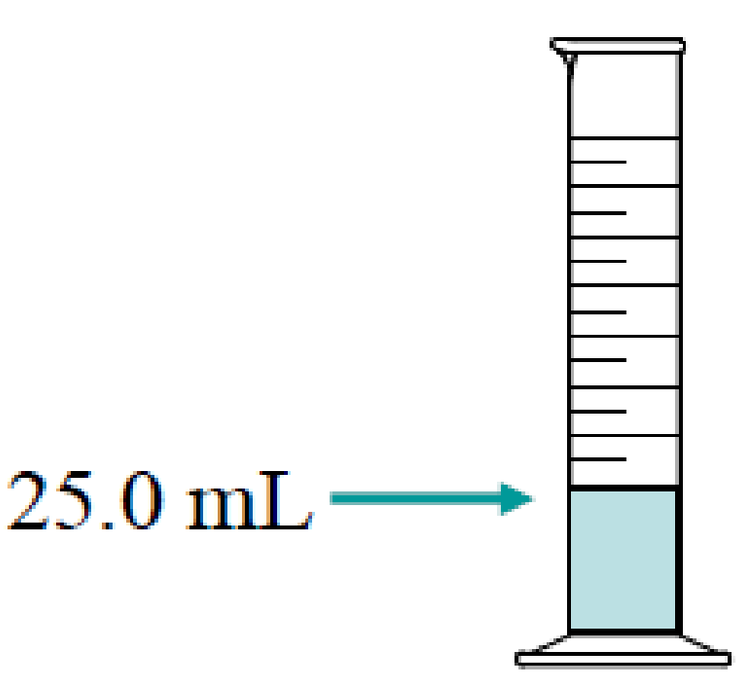
Syringe

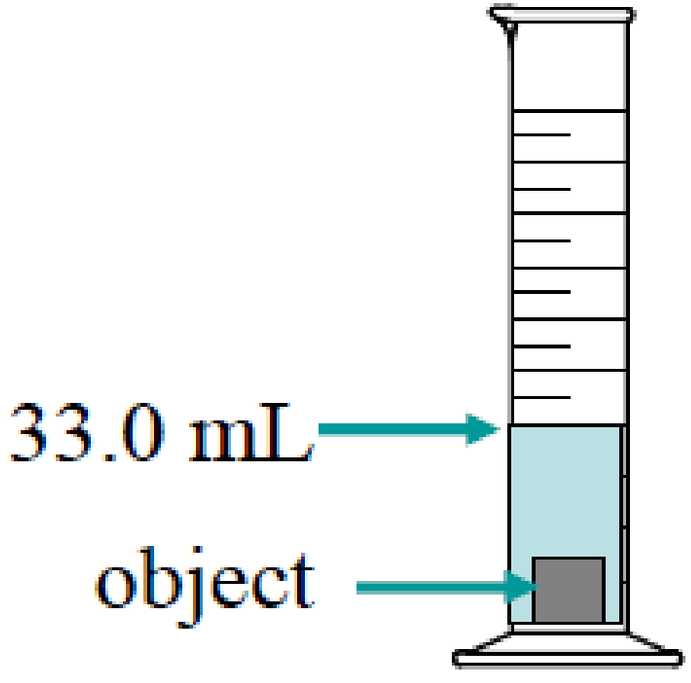


Buret

Pipet

Volumetric flask


25.0 mL


33.0 mL
object

(Ex)- A cubic box with an edge of exactly 1cm has a volume of (volume = edge^3)

(a) $10^{-6}m^3$ (b) 8 x 10^{-6} m3 (c) 2.7 x 10^{-5} m3 (d) 6.4 x 10^{-5} m3

(Ex)- Volume of cube V= 1.84 inch^3 if 1 inch = 2.54cm. Find its volume in SI-units.

(a) 30.2 x 10^6m^3 **(b) $30x10^{-6}m^3$** (c) $3x10^{-6}m^3$

(Ex)- A cube of edge 95mm, its volume in SI units is:

(a) $95m^3$ (b) $0.95m^3$ **(c) 8.6 x $10^{-4}m^3$** (d) $7m^3$

Prefix Multipliers

•The International System of Units (SI) uses the **prefix multipliers** with the standard units.

•These multipliers **change the value of the unit** (makes units larger or smaller than the initial unit by one or more factors of 10).

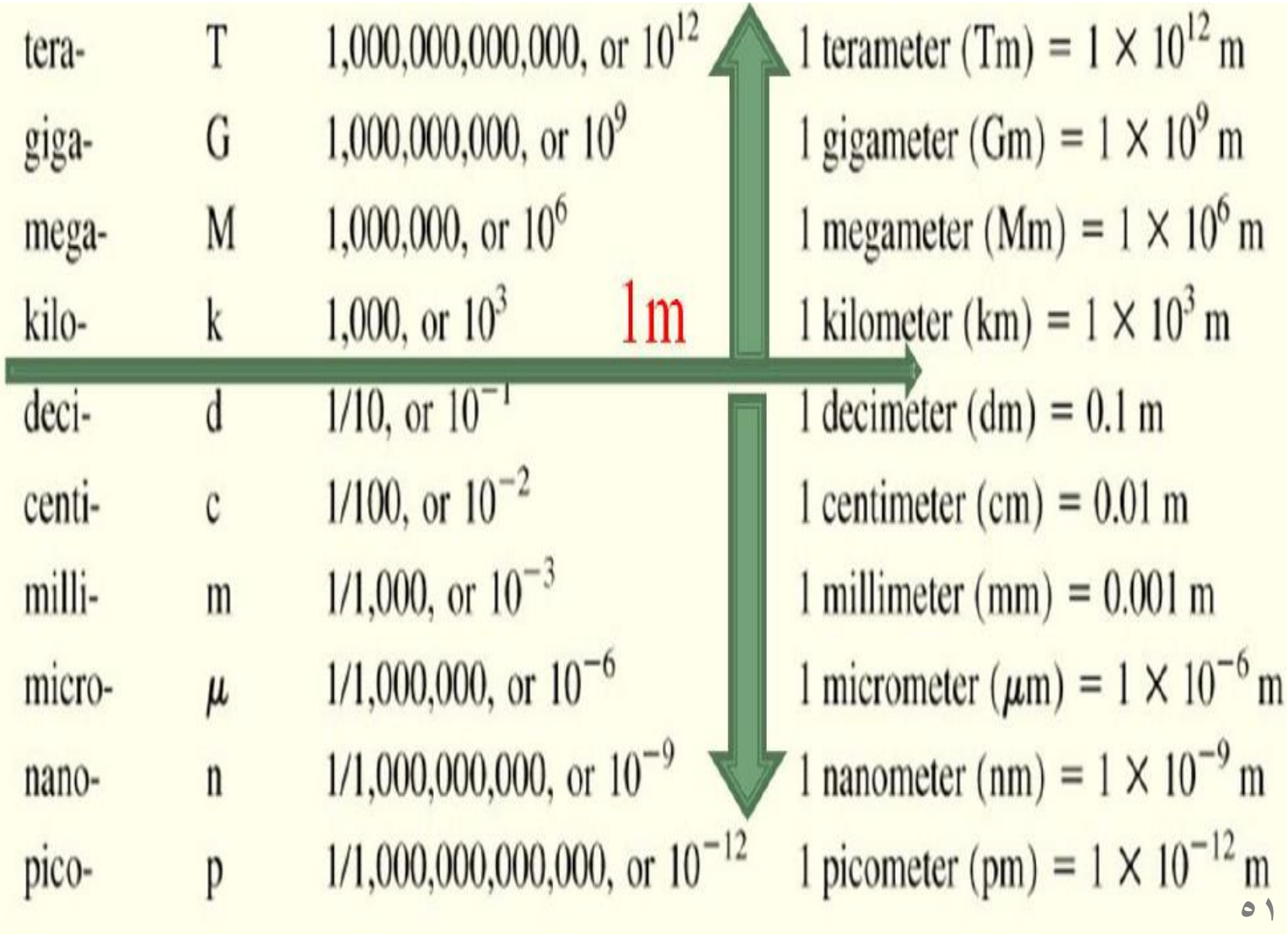
•For example, the kilometer has the prefix **kilo**, meaning 1000 meter or $\mathbf{10^3}$ **meters**.

•Another example, the millimeter has the prefix **milli**, meaning 1/1000 meter or $\mathbf{10^{-3}}$ **meter**.

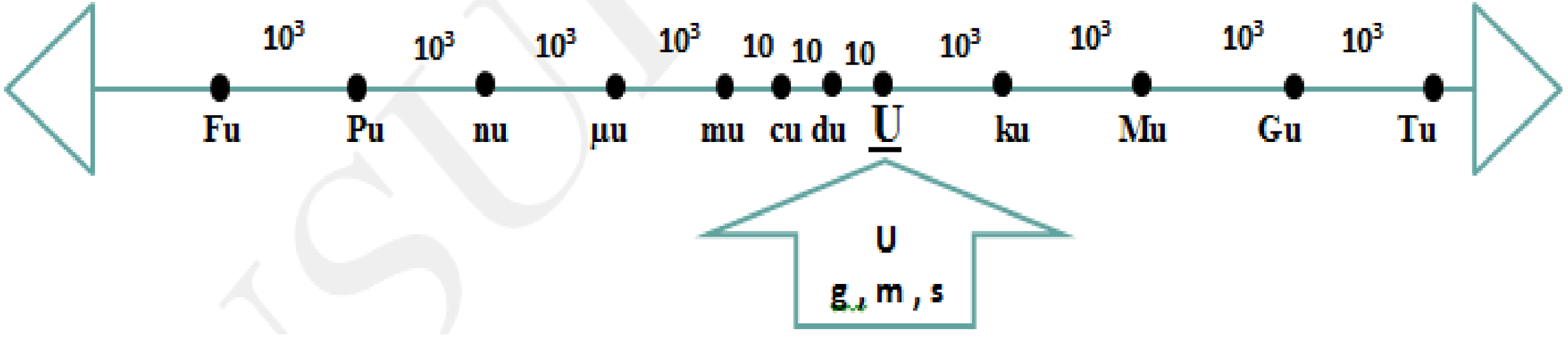
Prefix Multipliers: Increasing The Size of The Unit

Prefixes that increase the size of the unit:

Prefixes that Decrease the size of the unit:



tera-	T	1,000,000,000,000, or 10^{12}	1 terameter (Tm) = 1×10^{12} m
giga-	G	1,000,000,000, or 10^{9}	1 gigameter (Gm) = 1×10^{9} m
mega-	M	1,000,000, or 10^{6}	1 megameter (Mm) = 1×10^{6} m
kilo-	k	1,000, or 10^{3}	1 kilometer (km) = 1×10^{3} m
deci-	d	1/10, or 10^{-1}	1 decimeter (dm) = 0.1 m
centi-	c	1/100, or 10^{-2}	1 centimeter (cm) = 0.01 m
milli-	m	1/1,000, or 10^{-3}	1 millimeter (mm) = 0.001 m
micro-	μ	1/1,000,000, or 10^{-6}	1 micrometer (μm) = 1×10^{-6} m
nano-	n	1/1,000,000,000, or 10^{-9}	1 nanometer (nm) = 1×10^{-9} m
pico-	p	1/1,000,000,000,000, or 10^{-12}	1 picometer (pm) = 1×10^{-12} m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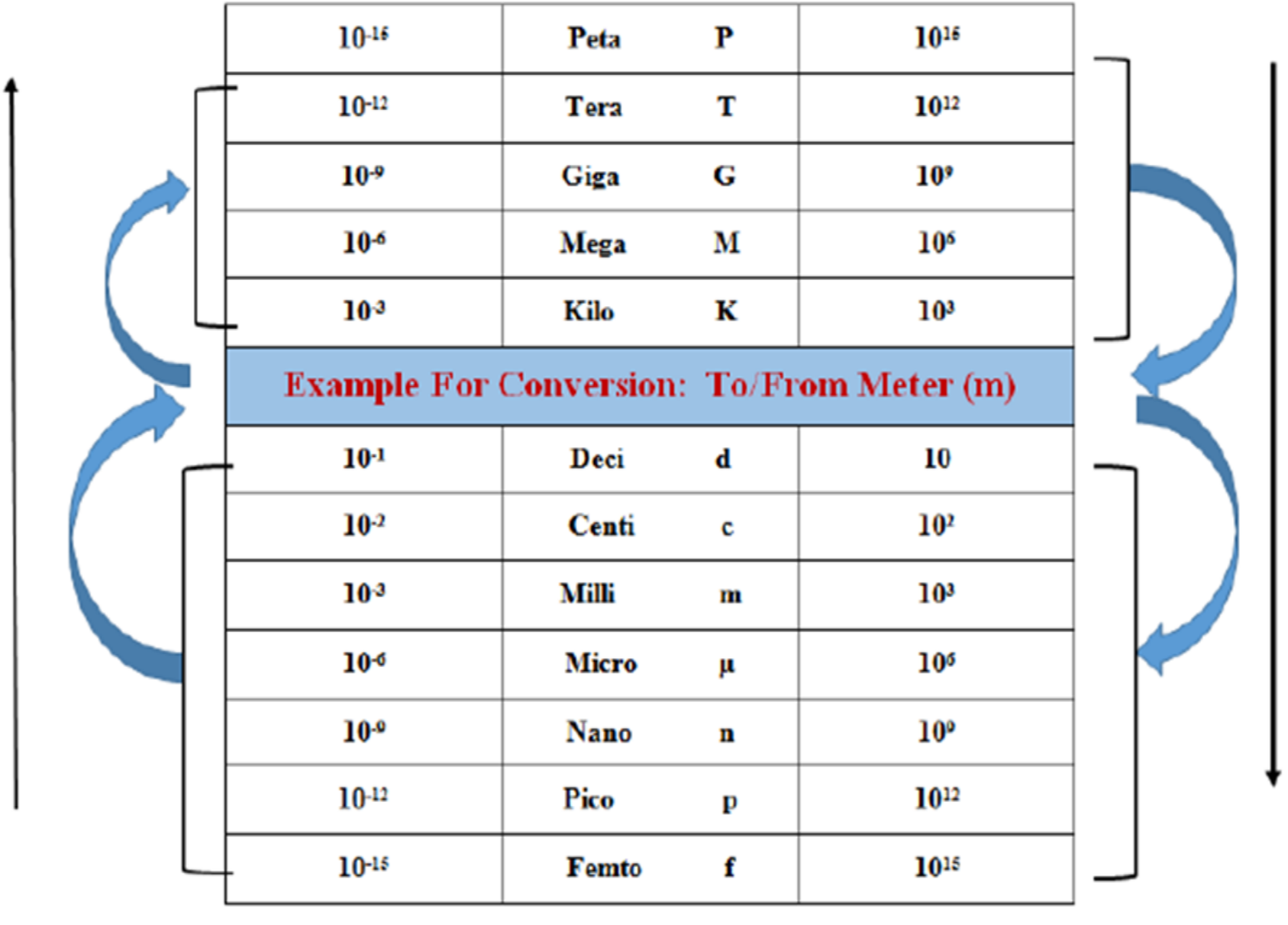


10^{-15}	Peta	P	10^{15}
10^{-12}	Tera	T	10^{12}
10^{-9}	Giga	G	10^{9}
10^{-6}	Mega	M	10^{6}
10^{-3}	Kilo	K	10^{3}
Example For Conversion: To/From Meter (m)			
10^{-1}	Deci	d	10
10^{-2}	Centi	c	10^{2}
10^{-3}	Milli	m	10^{3}
10^{-6}	Micro	µ	10^{6}
10^{-9}	Nano	n	10^{9}
10^{-12}	Pico	p	10^{12}
10^{-15}	Femto	f	10^{15}

(Ex)-The SI prefixes kilo and centi represent, respectively:

(a) 10^{3} and 10^{-2} (b) 10^{6} and 10^{-1}

(b) (c) 10^{-3} and 10^{-2} (d) 10^{-6} and 10^{2}.

(Ex)-The SI prefixes Giga and micro represent, respectively:

A. 10^{-9} and 10^{-3} B. 10^{6} and 10^{-3}

C.10^{3} and 10^{-3}. D. 10^{9} and 10^{-6}

(Ex)-The number of nano-seconds (ns) which Equivalent to 2 minutes is:

a) 1.2×10^{11} b) 1.2×10^{-11}

c) 1.2×10^{14} d) 1.2×10^{8}

(Ex)-The largest value among the following is

a) 0.02 mm b) 2 μm

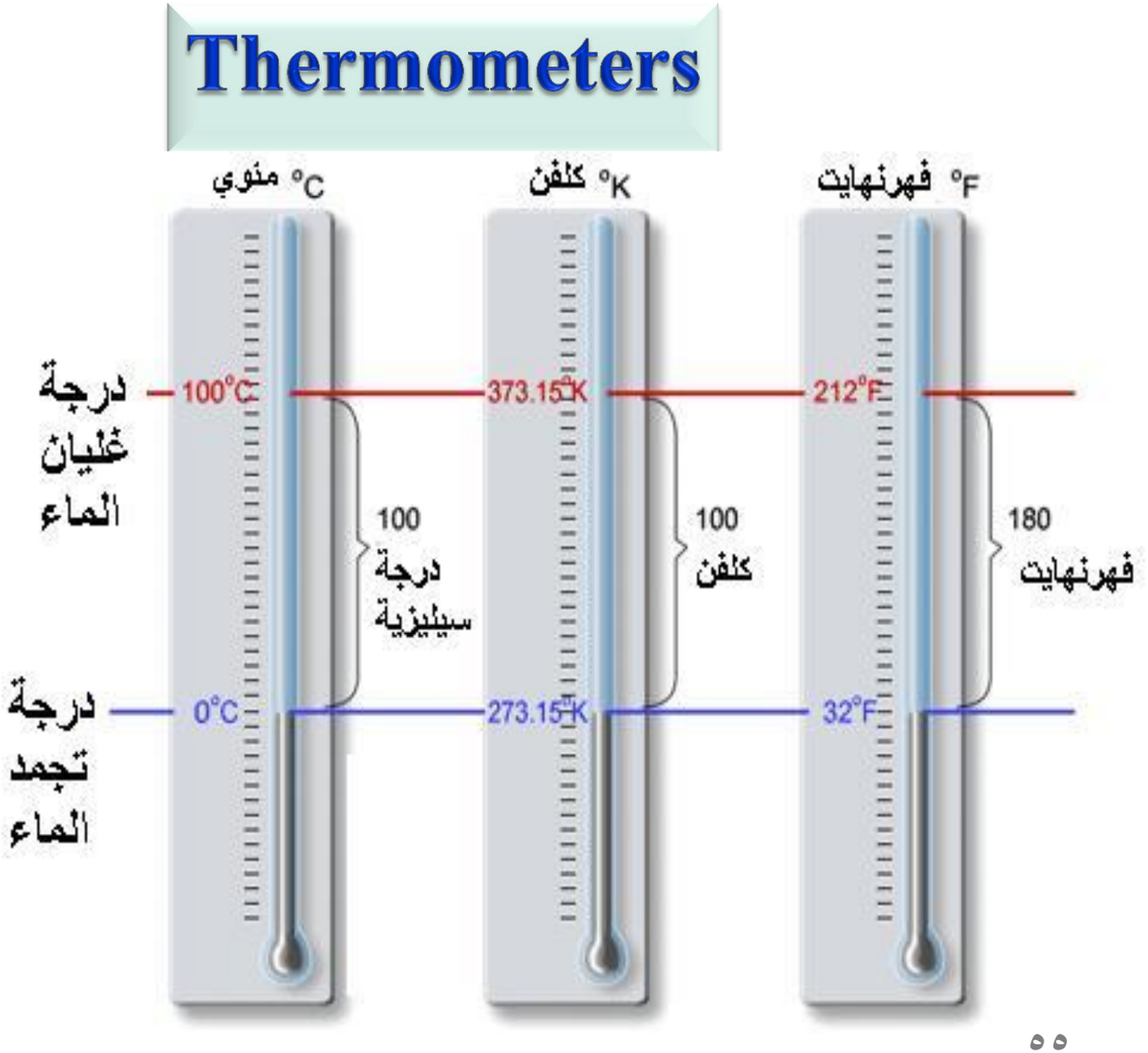
b) c) 200 nm d) 2000 Pm

$\frac{F-32}{1.8}$

Units of Temperature Measurement

$$K = C^{o} + 273 \qquad C^{o} = \frac{F-32}{1.8}$$

$$K = C^{o} + 273 \qquad F^{o} = 1.8\,C + 32$$



1) - The melting point of water is…….C^0 or …….F^0 or ……. K^0

2) - The boiling point of water is…….C^0 or …….F^0 or ……. K^0

3)-the temperature does the numerical reading on a Fahrenheit thermometer equal that on a cilices thermometer is…….

4)- The melting point of sulfur is 113°C. What temperature is this in K° ?

Solution

→ $K = C^{\circ} + 273 = 113 + 273 = 386^{\circ}K$

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5)-Convert 77°K to degrees.

→ Solution

$C = K - 273 \quad = 77 - 273 \quad = -196^{\circ}C$

6)- Lead melts at 601.0°C. What temperature is this in °F

Solution

$$C^\circ = \frac{F - 32}{1.8} \qquad F^\circ = 1.8\,C + 32$$

$$= 601 \times 1.8 + 32 \quad = 1113.8 = \quad 1114\ F^\circ$$

7)-Many home freezes maintain a temperature of 0° F.

Express this temperature to °C.

Solution

$$C = \frac{F - 32}{1.8} \quad = \frac{0 - 32}{1.8} \quad = -17.7 \quad = -18^\circ C$$

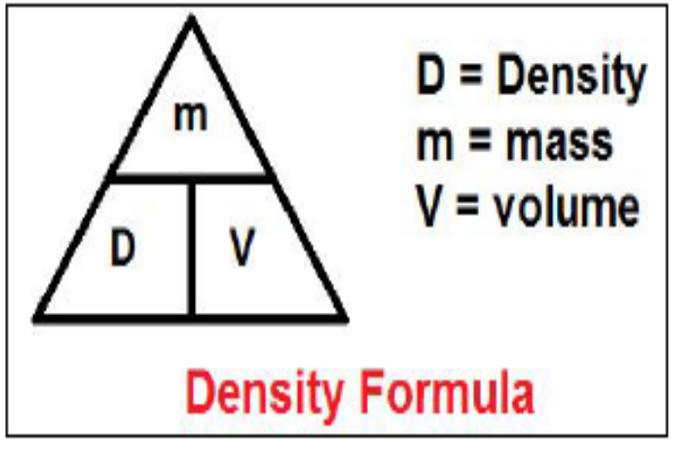
Density Of Materials

- **Material's Density** is defined as its mass per unit volume.
- It measured in g/L for gases.
- It measured in g/cm3 or g/mL for solids and liquids.

➢ **Density Expression**:

$$D = \frac{\text{mass}}{\text{volume}} = \frac{g}{mL} \text{ or } \frac{g}{cm^3} = g/cm^3$$

Note: 1 mL = 1 cm^3



Calculating Density - Example

If a **0.258 g** sample of HDL has a volume of **0.215 cm3**, what is the density, in **g/cm3**, of the HDL sample?

Step 1: State the given and needed quantities.

Analyze the Problem

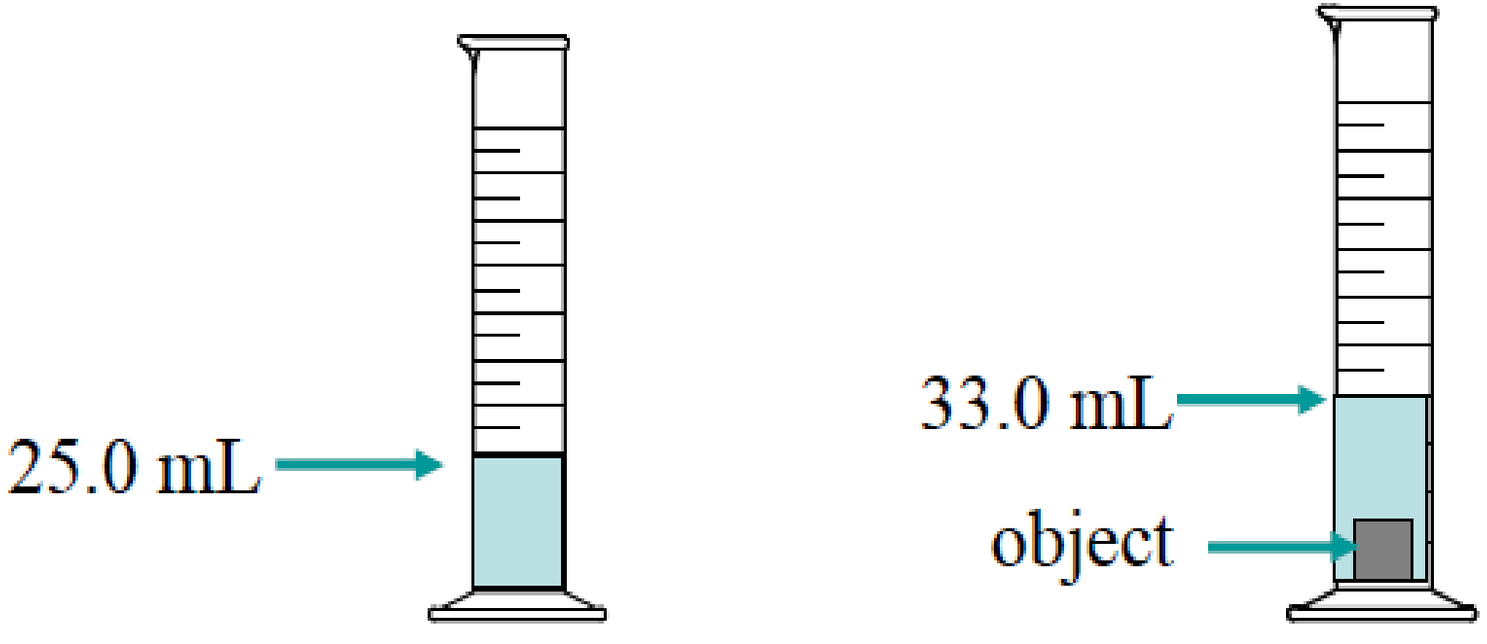
Given	Needed
0.258 g HDL	
0.215 cm3 HDL	density in g/cm3 of HDL

Step 2: Use the relation

$$\text{Density} = \frac{\text{mass of substance}}{\text{volume of substance}} = \frac{0.258\ \text{g}}{0.215\ \text{cm}^3} = \frac{1.20\ \text{g}}{\text{cm}^3} = 1.20\ \text{g/cm}^3$$

Calculating Density Using Volume Displacement

What is the density (g/cm3) of a 48.0 g sample of a metal if the level of water in a graduated cylinder rises from 25.0 mL to 33.0 mL after the metal is added?



Density = 48.0 g / 8.0 mL = 6.0 g/mL

(Ex-33)- A piece of metal with a mass of 125 g is placed into a graduated cylinder that contains 25.00 mL of water, raising the water level to 56.00 mL. What is the density of the metal?

A) 5.00 g/cm^3 B)4.03 g/cm^3 C)2.23 g/cm^3 D)1.51 g/cm^3 E)0.25 g/cm^3

Solution

$m=125g$

$V_1=25ml$

$V_2=56ml$

$V=v_2-v_1=31ml$

$D=??$

ملحوظة هامة cm^3 **هو نفسة** **ml**

$$d=\frac{m}{V}$$

$$=\frac{125}{31}$$

$$=4.03g/cm^3$$

Assessment

Answer the following questions:

1- Complete the missing values:

a. 517 m = _____ km = _____ cm

b. 115 s = _____ ms = _____ ks

c. 122 g = _____ pg = _____ ng

d. 3.35 L = _____ mL = _____ µL

2- Convert −80 °F to °C and K.

3- Perform each of the following unit conversions:

a. 228 m to yd

b. 2.55 kg to lb

c. 2.41 L to qt

d. 157 mm to in

4- A new penny has a mass of 2.49 g and a volume of 0.349 cm3, calculate its density.