

[www.engrazz.com](http://www.engrazz.com)

# Chemistry: The Study of Change

## *Chapter 1*

**Chemistry** is the study of **matter** and the **changes** it undergoes

**الكيمياء** دراسة **المادة والتغيرات** التي تطرأ عليها

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

**المادة** هي كل ما يشغل **حيز** من الفراغ وله **كتلة**

**substance** is a form of matter that has a **definite composition** and **distinct properties**

**المادة النقية** شكل من أشكال المادة له **تركيبة محددة** و**خصائص فريدة**



liquid nitrogen  
سائل النيتروجين



gold ingots  
سبائك الذهب



silicon crystals  
كرستالات السيليكون

## examples of matter:

- Apple تفاحة
- Person شخص
- Table طاولة
- Air هواء
- Water ماء
- Computer حاسوب
- Paper ورق
- Iron حديد
- Etc.... الخ

## examples of substances:

- Tin قصدير
- Sulfur كبريت
- Dimond الماس
- Water ماء
- Table sugar سكر الطعام
- Table salt ملح الطعام
- Iron حديد
- Gold ذهب
- Etc.... الخ

أمثلة للتوضيح فقط - لا تُحفظ

**Mixture** is a combination of **two or more substances** in which the substances retain their distinct identities

**المخلوط** مجموعة من **مادتين نقيَّتين أو أكثر** بحيث تحتفظ كل مادة نقية بخصائصها وهويتها الفريدة

**Homogeneous Mixture** composition of the mixture is **uniform throughout**.

**المخلوط المتجانس** تركيبة المخلوط **متطابقة** خلال المادة

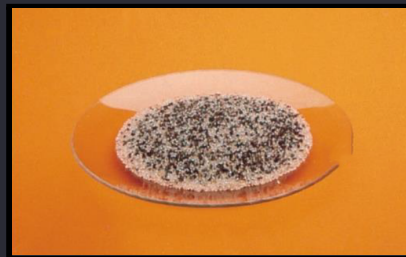
soft drink, milk, solder →



**Heterogeneous Mixture** composition is **not uniform throughout**.

**المخلوط الغير متجانس** تركيبة المخلوط **غير متطابقة** خلال المادة

cement, iron filings in sand →



VS

## Homogeneous Mixtures

Blood الدم

Sugar dissolved in water السكر المُذاب في الماء

Orange juice عصير البرتقال

Air الهواء

Tea or Coffee الشاي أو القهوة

Sea water ماء البحر

Etc.... الخ

لا يُمكن تمييز مكوناته بالعين المُجردة

## Heterogeneous Mixtures

Salt and pepper الملح و الفلفل

Ice cubes in cola مكعبات الثلج في الكولا

Chocolate chip cookies البسكويت

Sugar and sand السكر في الرمل

Concrete الخرسانة

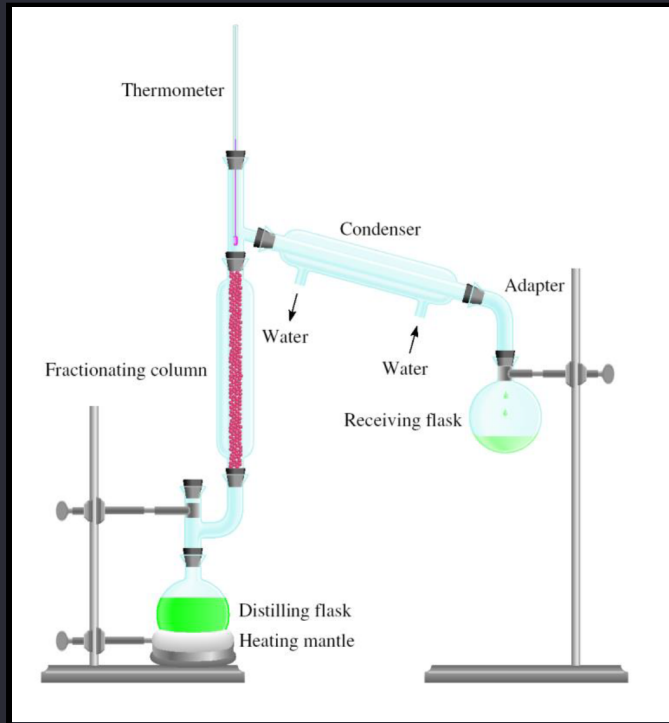
salad السلطة

Etc.... الخ

يُمكن تمييز مكوناته بالعين المُجردة

**Physical means** can be used to separate a **mixture** into its **pure substances**

الأساليب الفيزيائية يمكن استخدامها لفصل المخلوط لمواد نقية



التقطير (distillation)



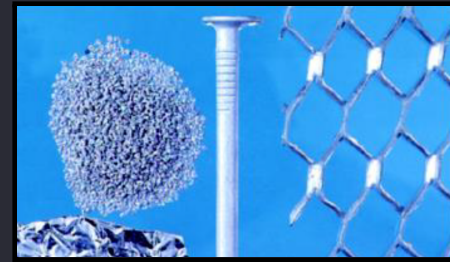
ميغناطيس (magnet)

**Element** is a substance that **cannot be separated** into simpler substances by chemical means

**العنصر** مادة نقية لا يمكن فصلها لمواد أبسط بالأساليب الكيميائية

118 elements have been identified, 94 elements occur naturally on Earth  
118 عنصر تم اكتشافه، 94 عنصر منهم موجودين بشكل طبيعي في الكرة الأرضية

examples: gold, aluminum, lead, oxygen, carbon, sulfur  
أمثلة: الذهب، الألمونيوم، الرصاص، الأكسجين، الكربون، الكبريت



aluminum



sulfur

24 elements have been created by scientists  
24 عنصر تم تصنيعها من قبل العلماء

examples: technetium, americium, seaborgium

أمثلة: تیکنيوم، أمريسيوم، سيبورجيم

**TABLE 1.1****Some Common Elements and Their Symbols**

<b>Name</b>	<b>Symbol</b>	<b>Name</b>	<b>Symbol</b>	<b>Name</b>	<b>Symbol</b>
Aluminum	Al	Fluorine	F	Oxygen	O
Arsenic	As	Gold	Au	Phosphorus	P
Barium	Ba	Hydrogen	H	Platinum	Pt
Bismuth	Bi	Iodine	I	Potassium	K
Bromine	Br	Iron	Fe	Silicon	Si
Calcium	Ca	Lead	Pb	Silver	Ag
Carbon	C	Magnesium	Mg	Sodium	Na
Chlorine	Cl	Manganese	Mn	Sulfur	S
Chromium	Cr	Mercury	Hg	Tin	Sn
Cobalt	Co	Nickel	Ni	Tungsten	W
Copper	Cu	Nitrogen	N	Zinc	Zn



**Compound** is a substance composed of atoms of **two or more elements** chemically united in fixed proportions

**المركب** هو مادة نقية مكونة من ذرات تنتمي **لعنصرين أو أكثر** متحدة كيميائياً بنسب ثابتة

Compounds can only be separated into their pure components (elements) by chemical means  
المركبات يمكن فصلها إلى مكوناتها النقية (عناصر) بأساليب كيميائية



lithium fluoride

فلوريد الليثيوم



quartz

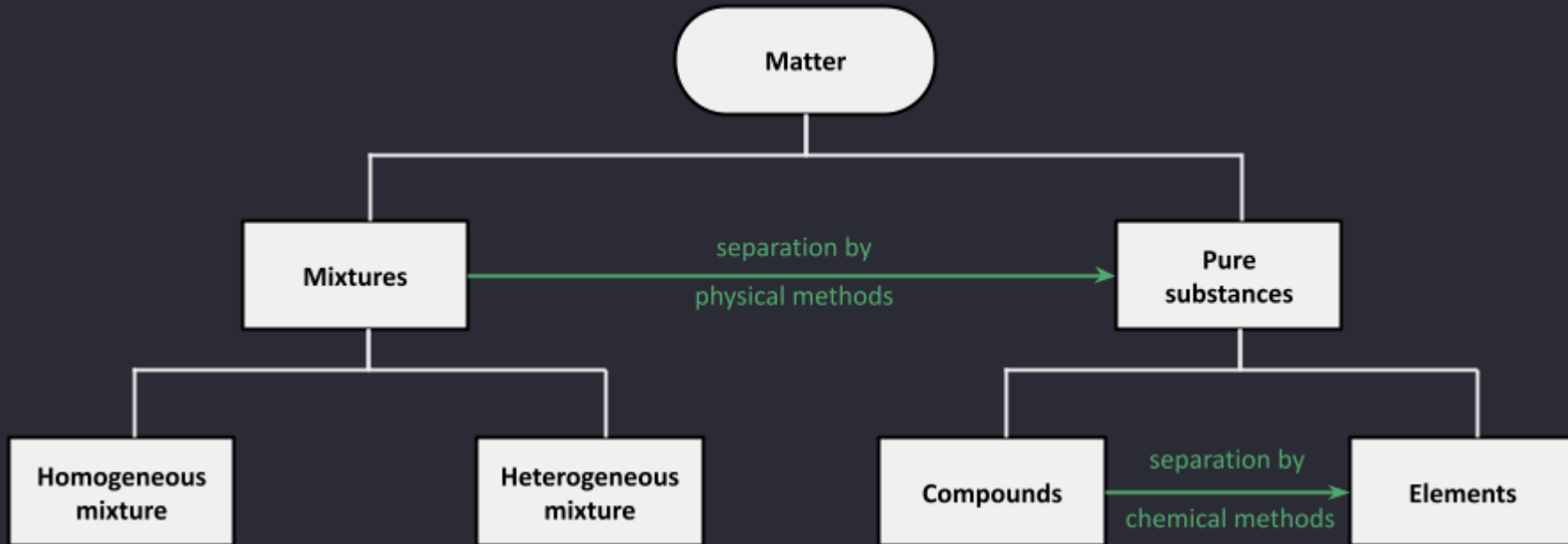
المرو



dry ice (carbon dioxide)

التلج الجاف (ثاني أكسيد الكربون)

# Classification of Matter



**Problem** NaCl (table salt) is identified as \_\_\_\_\_

A] Element

B] Heterogeneous mixture

C] Compound

D] homogeneous mixture

**Problem** What do scientists call a pure substance that cannot be broken down into other pure substances?

A] An element

B] An emulsion

C] compound

D] a particle

**Problem** A sample contains two substances and has uniform properties.

The sample is \_\_\_\_\_

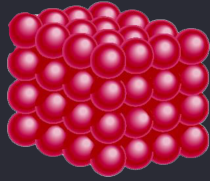
A] An element

B] A compound

C] a homogeneous mixture

D] a heterogeneous mixture

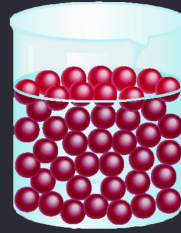
# A Comparison: The Three States of Matter



Solid  
صلب

definite shape  
definite volume  
شكل ثابت و حجم ثابت

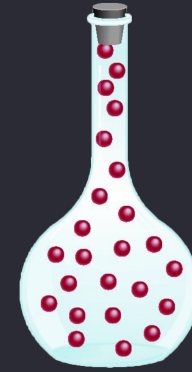
مُستقلة عن الحاوية



Liquid  
سائل

indefinite shape  
definite volume  
شكل غير ثابت  
حجم ثابت

تأخذ شكل الحاوية

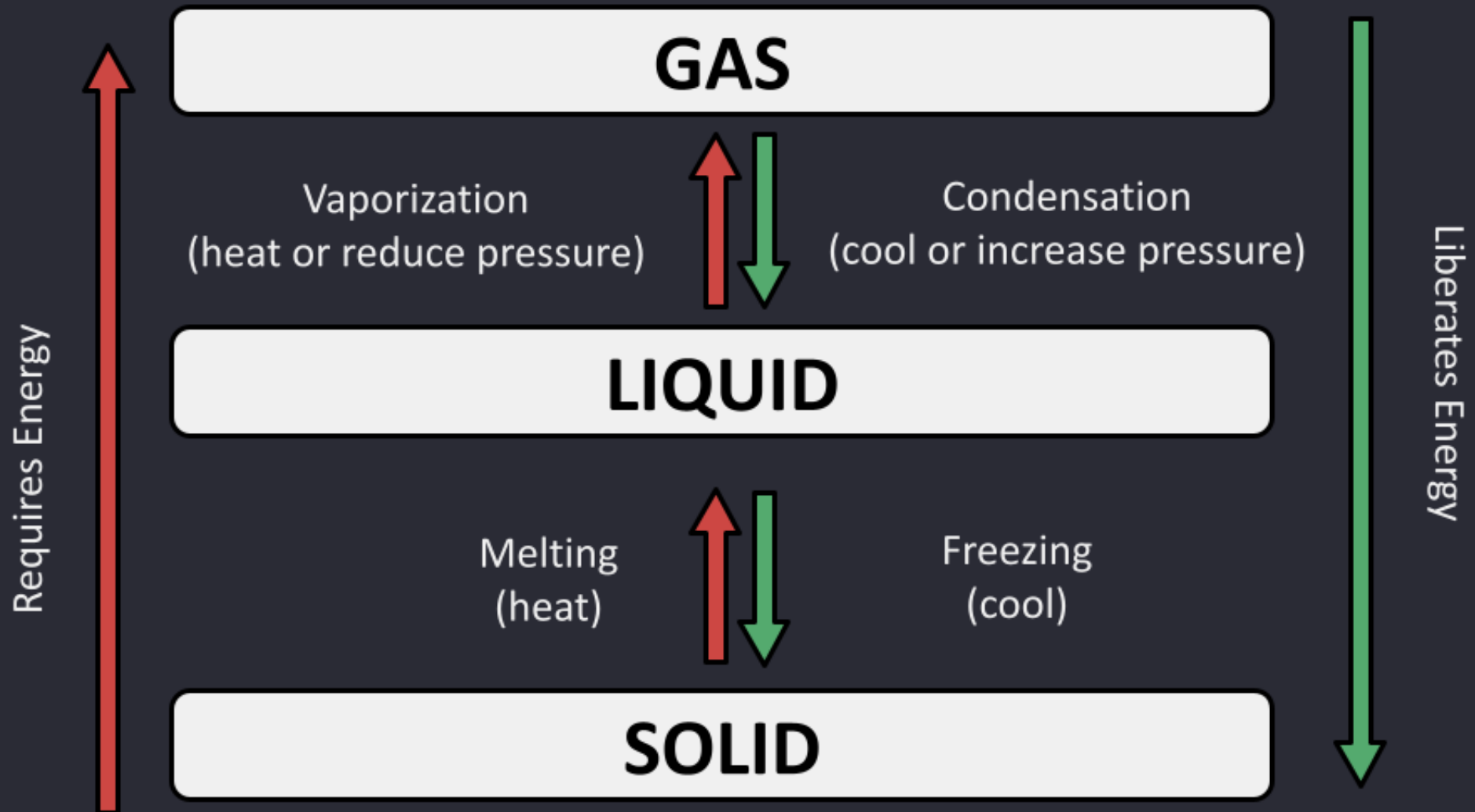


Gas  
غاز

indefinite shape  
indefinite volume  
شكل وحجم غير ثابتين

تأخذ شكل وحجم الحاوية

# The Three States of Matter



**Problem** The process of changing gas to liquid is called \_\_\_\_\_

A] Evaporation

B] condensation

C] Sublimation

D] Deposition



# Types of Changes

**Physical Change** does **not alter the composition** or identity of a substance

التغير الفيزيائي لا يغير تركيبة أو هوية المادة النقيّة

examples: ice melting, sugar dissolving in water

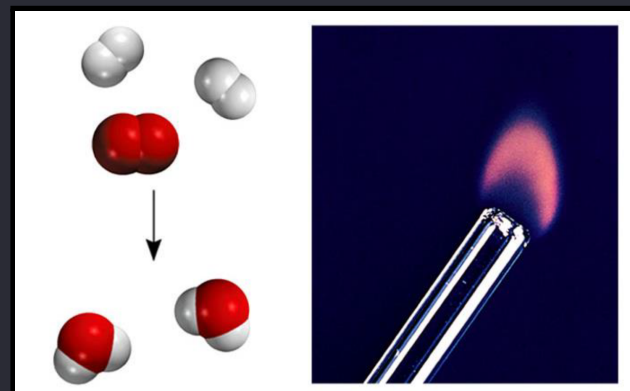
أمثلة: إنصهار الثلج، ذوبان السكر في الماء

**Chemical Change** **alters the composition** or identity of the substance(s) involved

التغير الكيميائي يغير تركيبة أو هوية المواد الداخلة في التفاعل

examples: hydrogen burns in air to form water

أمثلة: احتراق الهيدروجين في الهواء لتكوين الماء



VS

## Chemical Changes

Radioactivity الإشعاعية

Explosion الانفجار

Tarnishing التآكل

Burning or Combustion الاحتراق

Oxidation التأكسد

Rust الصدأ

Erosion التعرية

Rot العفن

Decay الاضمحلال

Digesting الهضم

## Physical Changes

Boiling الغليان

vaporization التبخر

Dissolving الذوبان

Frosting التجمد

Melting الإنصهار

Freezing التجمد

Crushing الكسر

Cracking التكسير

Cutting القطع

**PROBLEM** Decide whether each of the following processes is primarily a **physical** or a **chemical** change, and explain briefly.

a] **Frost** forms as the temperature drops on a humid winter night.

b] Dynamite **explodes** to form a mixture of gases.

c] **Dissolving** sugar and water.

d] A silver fork **tarnishes** in air.

**Criteria** Does the substance change **composition** or just change **form**?

# SOLUTION

a] physical change

b] chemical change

c] physical change

d] chemical change

**Problem** Which of the following is a chemical change?

- A] Oxidation in air
- B] Freezing of water
- C] Crushing a can
- D] Dissolving sugar

**Problem** Which of the following is a chemical change?

A] Oxidation of iron in air

B] Mixing water and oil

C] Melting ice

D] Dissolving sugar in water

**Problem** A change that occurs when one or more substances change into entirely new

substances with different properties?

A] Intensive change

B] Chemical change

C] Physical change

D] Extensive Change

**Problem** Dissolving sugar in water can be described as \_\_\_\_\_

A] Chemical change, heterogeneous mixture

B] Chemical change, homogenous mixture

C] Physical change, heterogeneous mixture

D] Physical change, homogenous mixture

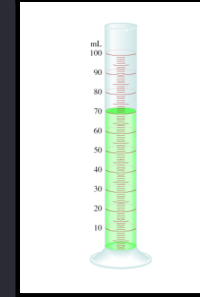


**Extensive Property** of a material **depends** upon how much matter is being considered

الخاصية الكميّة للمادة **تعتمد** على كمية المادة المُعتبرة

Examples: mass, length, volume, etc . . .

أمثلة: الكتلة، الطول، الحجم، الخ . . .

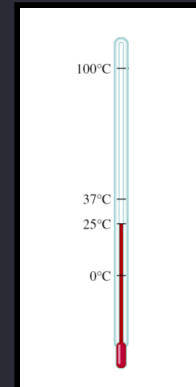


**Intensive Property** of a material does **not depend** upon how much matter is being considered

الخاصية النوعيّة للمادة **لا تعتمد** على كمية المادة المُعتبرة

Examples: density, temperature, color, etc . . .

أمثلة: الكثافة، درجة الحرارة، اللون، الخ . . .



VS

## Extensive Properties

Mass الكتلة

Length الطول

Volume الحجم

Area المساحة

Size الحجم

تتأثر بالكمية

## Intensive Properties

Melting Point درجة الانصهار

Boiling Point درجة الغليان

Density الكثافة

Temperature درجة الحرارة

Color اللون

Smell الرائحة

لا تتأثر بالكمية

**Problem** Which of the following is an extensive property of matter?

A] Melting point

B] Temperatur

C] Volume

D] Density

**Problem** Which of the following is intensive property?

A] Density

B] Mass

C] Length

D] Volume

**Problem** Which of the following is an extensive property of matter?

A] Color

B] Mass

C] Boiling point

D] Density

# International System of Units (SI)

**TABLE 1.2** SI Base Units

<b>Base Quantity</b>	<b>Name of Unit</b>	<b>Symbol</b>
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electrical current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

## Additional SI Units:

<i>Derived</i> Quantity		<i>Derived</i> SI Unit	
Area	A	meter squared	$m^2$
Volume	V	meter cubed	$m^3$
Speed/Velocity	v	meter/second	m/s
Acceleration	a	meter/second <sup>2</sup>	$m/s^2$
Force	F	newton	$N = kg\ m\ s^{-2}$
Energy	E	joule	$J = kg\ m^2\ s^{-2}$
Density	p (or d)	kilogram/meter cubed	$kg/m^3$
Work	w	joule	$J = kg\ m^2\ s^{-2}$
Pressure	P	pascal	$Pa = kg\ m^{-1}\ s^{-2}$

وحدات إضافية للتوضيح - لا تُحفظ

**Problem** NonSI unit from the following is:

A] inch

B] second

C] kilogram

D] meter



**Problem** The SI unit for mass is:

A] pound (lb)

B] kilogram (kg)

C] gram (g)

D] ounce (oz)

**Problem** Which of the following is an SI derived unit:

A] cubic meter ( $\text{m}^3$ ) for volume

B] gram per liter (g/L) for density

C] gram (g) for mass

D] mile per hour (mi/hr) for speed

E] Kelvin (K) for temperature

**Problem** Which of the following is not an SI derived unit?

A]  $\text{g}/\text{cm}^3$

B]  $\text{kg m}/\text{s}^2$

C]  $\text{m}/\text{s}$

D]  $\text{m}^3$

**TABLE 1.3** Prefixes Used with SI Units

Prefix	Symbol	Meaning	Example
tera-	T	1,000,000,000,000, or $10^{12}$	1 terameter (Tm) = $1 \times 10^{12}$ m
giga-	G	1,000,000,000, or $10^9$	1 gigameter (Gm) = $1 \times 10^9$ m
mega-	M	1,000,000, or $10^6$	1 megameter (Mm) = $1 \times 10^6$ m
kilo-	k	1,000, or $10^3$	1 kilometer (km) = $1 \times 10^3$ 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-	$\mu$	1/1,000,000, or $10^{-6}$	1 micrometer ( $\mu\text{m}$ ) = $1 \times 10^{-6}$ m
nano-	n	1/1,000,000,000, or $10^{-9}$	1 nanometer (nm) = $1 \times 10^{-9}$ m
pico-	p	1/1,000,000,000,000, or $10^{-12}$	1 picometer (pm) = $1 \times 10^{-12}$ m

## Unit Conversions تحويل الوحدات

$p_m$	$n_m$	$\mu_m$	$m_m$	$c_m$	$d_m$	$m$	$k_m$	$M_m$	$G_m$	$T_m$
-------	-------	---------	-------	-------	-------	-----	-------	-------	-------	-------

1. Write amount and unit given.

2. Multiply by a fraction with:

A. Given unit on bottom, wanted unit on top.

B. Fill in the numerical relationship between units:

Larger unit: gets 1; Smaller unit: subtract exponents,

Result is exponent for the smaller unit.

١. قم بكتابة الكمية والوحدة المعطاة.

٢. قم بالضرب بكسر حيث:

أ. الوحدة المعطاة في المقام، الوحدة المرغوبة في البسط.

ب. قم بتعبئة البسط والمقام بالعلاقة الحسابية بين الوحدتين وذلك:

الوحدة الأكبر: تحصل على العدد ١، الوحدة الأصغر: أطرح الأسس،

النتيجة هي الأس للوحدة الأصغر (والأساس ١٠).

**Problem** Convert 153 grams (g) to nanograms (ng)

T	1,000,000,000,000, or $10^{12}$
G	1,000,000,000, or $10^9$
M	1,000,000, or $10^6$
k	1,000, or $10^3$
d	1/10, or $10^{-1}$
c	1/100, or $10^{-2}$
m	1/1,000, or $10^{-3}$
$\mu$	1/1,000,000, or $10^{-6}$
n	1/1,000,000,000, or $10^{-9}$
p	1/1,000,000,000,000, or $10^{-12}$

**Problem** Express 0.67 picoseconds (ps) in seconds (s)

T	1,000,000,000,000, or $10^{12}$
G	1,000,000,000, or $10^9$
M	1,000,000, or $10^6$
k	1,000, or $10^3$
d	1/10, or $10^{-1}$
c	1/100, or $10^{-2}$
m	1/1,000, or $10^{-3}$
$\mu$	1/1,000,000, or $10^{-6}$
n	1/1,000,000,000, or $10^{-9}$
p	1/1,000,000,000,000, or $10^{-12}$

**Problem** The diameter of an atom is  $1.5 \times 10^{-7}$  mm. What is this

diameter when expressed in nanometers (nm)?

A]  $1.5 \times 10^{-18}$

B]  $1.5 \times 10^{-1}$

C]  $1.5 \times 10^{-15}$

D]  $1.5 \times 10^{-1}$

T	1,000,000,000,000, or $10^{12}$
G	1,000,000,000, or $10^9$
M	1,000,000, or $10^6$
k	1,000, or $10^3$
d	1/10, or $10^{-1}$
c	1/100, or $10^{-2}$
m	1/1,000, or $10^{-3}$
$\mu$	1/1,000,000, or $10^{-6}$
n	1/1,000,000,000, or $10^{-9}$
p	1/1,000,000,000,000, or $10^{-12}$



**Problem** Convert 40 mg into kg?

A]  $4 \times 10^{-4}$

B]  $4 \times 10^{-5}$

C]  $4 \times 10^{-6}$

D]  $4 \times 10^{-7}$

T	1,000,000,000,000, or $10^{12}$
G	1,000,000,000, or $10^9$
M	1,000,000, or $10^6$
k	1,000, or $10^3$
d	1/10, or $10^{-1}$
c	1/100, or $10^{-2}$
m	1/1,000, or $10^{-3}$
$\mu$	1/1,000,000, or $10^{-6}$
n	1/1,000,000,000, or $10^{-9}$
p	1/1,000,000,000,000, or $10^{-12}$

**Volume** SI derived unit for volume is cubic meter ( $\text{m}^3$ )

**الحجم** الوحدة الدولية المشتقة للحجم هي المتر المكعب ( $\text{م}^3$ )

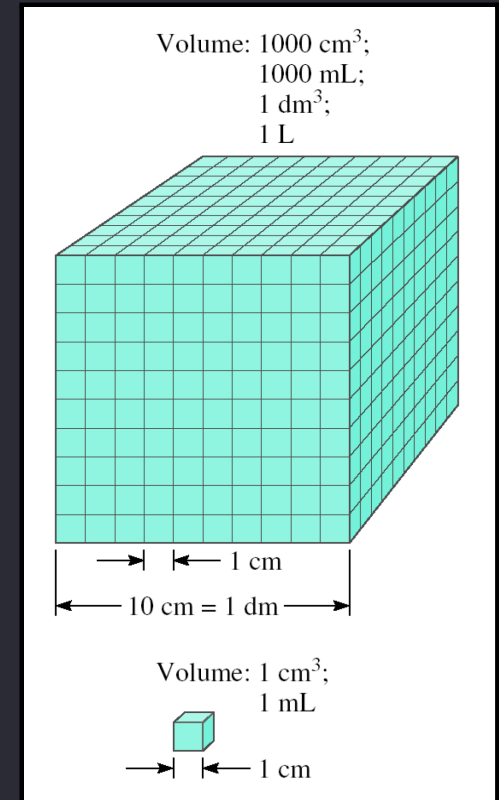
$$1 \text{ cm}^3 = (1 \times 10^{-2} \text{ m})^3 = 1 \times 10^{-6} \text{ m}^3$$

$$1 \text{ dm}^3 = (1 \times 10^{-1} \text{ m})^3 = 1 \times 10^{-3} \text{ m}^3$$

$$1 \text{ L} = 1000 \text{ mL} = 1000 \text{ cm}^3 = 1 \text{ dm}^3$$

$$1 \text{ mL} = 1 \text{ cm}^3$$

$$1 \text{ L} = 1 \text{ dm}^3$$



**Problem** Convert  $11.5 \text{ m}^2$  to  $\text{cm}^2$

T	1,000,000,000,000, or $10^{12}$
G	1,000,000,000, or $10^9$
M	1,000,000, or $10^6$
k	1,000, or $10^3$
d	1/10, or $10^{-1}$
c	1/100, or $10^{-2}$
m	1/1,000, or $10^{-3}$
$\mu$	1/1,000,000, or $10^{-6}$
n	1/1,000,000,000, or $10^{-9}$
p	1/1,000,000,000,000, or $10^{-12}$

**Problem** The volume of a room is  $1.08 \times 10^8 \text{ dm}^3$ .

What is the volume in  $\text{m}^3$ ?

T	1,000,000,000,000, or $10^{12}$
G	1,000,000,000, or $10^9$
M	1,000,000, or $10^6$
k	1,000, or $10^3$
d	1/10, or $10^{-1}$
c	1/100, or $10^{-2}$
m	1/1,000, or $10^{-3}$
$\mu$	1/1,000,000, or $10^{-6}$
n	1/1,000,000,000, or $10^{-9}$
p	1/1,000,000,000,000, or $10^{-12}$

**Problem** How many  $\text{mm}^3$  equal one  $\text{nm}^3$  ?

A]  $10^{-6}$

B]  $10^{-12}$

C]  $10^{-3}$

D]  $10^{-18}$

T	1,000,000,000,000, or $10^{12}$
G	1,000,000,000, or $10^9$
M	1,000,000, or $10^6$
k	1,000, or $10^3$
d	1/10, or $10^{-1}$
c	1/100, or $10^{-2}$
m	1/1,000, or $10^{-3}$
$\mu$	1/1,000,000, or $10^{-6}$
n	1/1,000,000,000, or $10^{-9}$
p	1/1,000,000,000,000, or $10^{-12}$

**Problem** An average adult has 5.2 L of blood.

What is the volume of blood in  $\text{m}^3$ ?

T	1,000,000,000,000, or $10^{12}$
G	1,000,000,000, or $10^9$
M	1,000,000, or $10^6$
k	1,000, or $10^3$
d	1/10, or $10^{-1}$
c	1/100, or $10^{-2}$
m	1/1,000, or $10^{-3}$
$\mu$	1/1,000,000, or $10^{-6}$
n	1/1,000,000,000, or $10^{-9}$
p	1/1,000,000,000,000, or $10^{-12}$

# Handling Time Conversion: Digram



**Problem** At a certain temperature, if the speed of sound is 343 m/s, its speed in km/h is:

A]  $1.23 \times 10^3$

B]  $1.23 \times 10^6$

C]  $1.26 \times 10^4$

D]  $2.10 \times 10^4$

T	1,000,000,000,000, or $10^{12}$
G	1,000,000,000, or $10^9$
M	1,000,000, or $10^6$
k	1,000, or $10^3$
d	1/10, or $10^{-1}$
c	1/100, or $10^{-2}$
m	1/1,000, or $10^{-3}$
$\mu$	1/1,000,000, or $10^{-6}$
n	1/1,000,000,000, or $10^{-9}$
p	1/1,000,000,000,000, or $10^{-12}$



**Problem** Liquid nitrogen is obtained from liquefied air and is used to prepare frozen goods in low-temperature research. The density of the liquid at its boiling point ( $-196\text{ }^{\circ}\text{C}$  or  $77\text{ K}$ ) is  $0.808\text{ g/cm}^3$ . Convert the density to units of  $\text{kg/m}^3$ .

T	1,000,000,000,000, or $10^{12}$
G	1,000,000,000, or $10^9$
M	1,000,000, or $10^6$
k	1,000, or $10^3$
d	1/10, or $10^{-1}$
c	1/100, or $10^{-2}$
m	1/1,000, or $10^{-3}$
$\mu$	1/1,000,000, or $10^{-6}$
n	1/1,000,000,000, or $10^{-9}$
p	1/1,000,000,000,000, or $10^{-12}$

**Problem** The density of the lightest metal, lithium (Li), is  $5.34 \times 10^2 \text{ kg/m}^3$ . Convert the density to  $\text{g/cm}^3$ .

T	1,000,000,000,000, or $10^{12}$
G	1,000,000,000, or $10^9$
M	1,000,000, or $10^6$
k	1,000, or $10^3$
d	1/10, or $10^{-1}$
c	1/100, or $10^{-2}$
m	1/1,000, or $10^{-3}$
$\mu$	1/1,000,000, or $10^{-6}$
n	1/1,000,000,000, or $10^{-9}$
p	1/1,000,000,000,000, or $10^{-12}$

**Density** of a substance is its mass per unit volume (the volumetric mass)

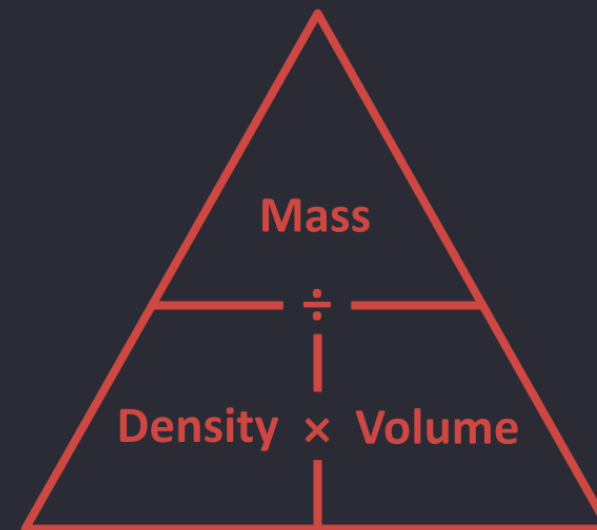
**الكثافة** لمادة هي كتلتها لكل وحدة حجم (الكتلة الحجمية)

SI derived unit for density is  $\text{kg/m}^3$

$$1 \text{ g/cm}^3 = 1 \text{ g/mL} = 1000 \text{ kg/m}^3$$

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

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



كثافة بعض المواد في درجة حرارة الغرفة (٢٥ درجة مئوية)  
للتوضيح فقط - لا تُحفظ

**TABLE 1.4**

**Densities of Some  
Substances at 25°C**

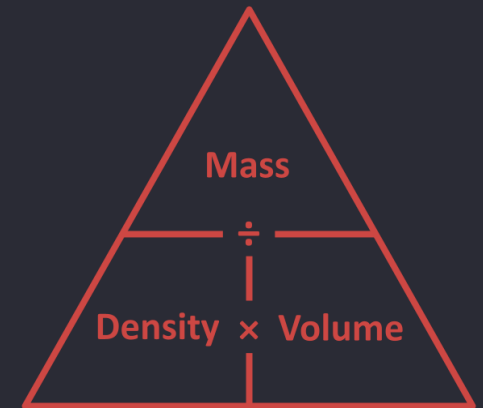
<b>Substance</b>	<b>Density (g/cm<sup>3</sup>)</b>
Air*	0.001
Ethanol	0.79
Water	1.00
Mercury	13.6
Table salt	2.2
Iron	7.9
Gold	19.3
Osmium <sup>†</sup>	22.6

\*Measured at 1 atmosphere.

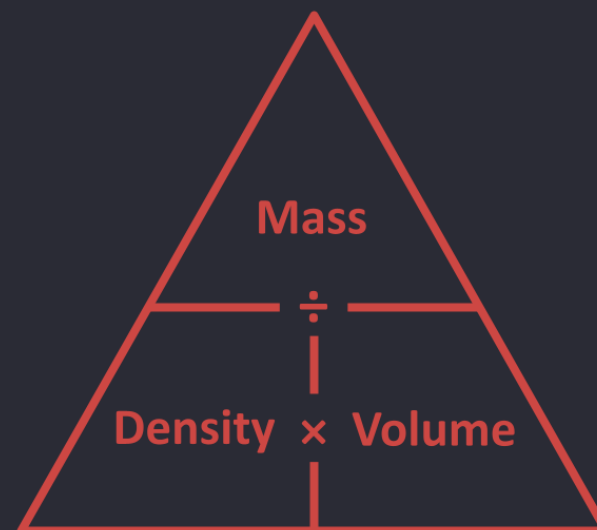
<sup>†</sup>Osmium (Os) is the densest element known.

**Problem** A piece of platinum metal with a density of  $21.5 \text{ g/cm}^3$  has a volume of  $4.49 \text{ cm}^3$

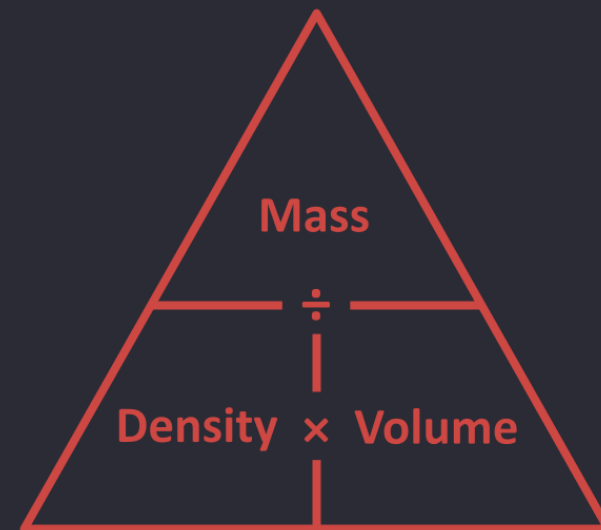
What is its mass (in g) ?



**Problem** Gold is a precious metal that is chemically unreactive. It is used mainly in jewelry, dentistry, and electronic devices. A piece of gold ingot with a mass of 301 g has a volume of 15.6 cm<sup>3</sup>. Calculate the density of gold (in g/cm<sup>3</sup>).



**Problem** The density of mercury, the only metal that is liquid at room temperature, is 13.6 g/mL. Calculate the mass (in g) of 5.50 mL of the liquid.



# A Comparison of Temperature Scales

$$K = ^\circ C + 273.15$$

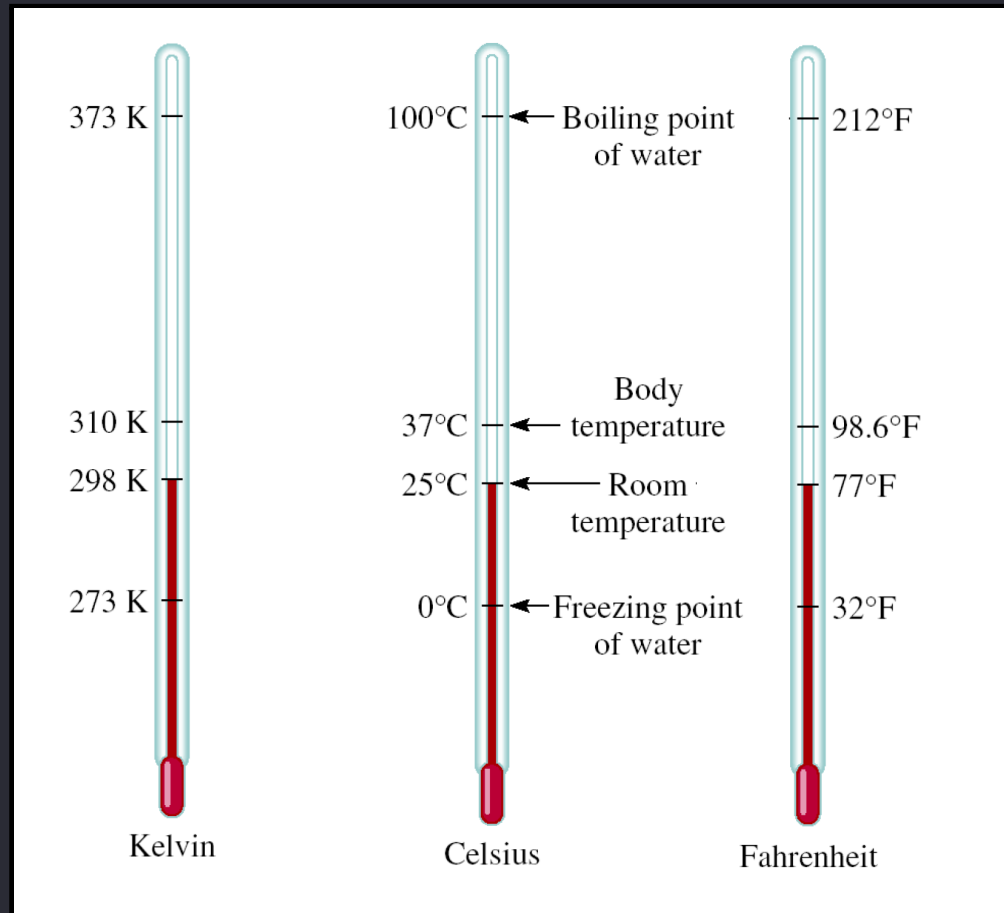
$$273 K = 0 ^\circ C$$

$$373 K = 100 ^\circ C$$

$$^\circ F = \frac{9}{5} \times ^\circ C + 32$$

$$32 ^\circ F = 0 ^\circ C$$

$$212 ^\circ F = 100 ^\circ C$$





**Problem** Convert 172.9 °F to degrees Celsius

**Problem** Solder is an alloy made of tin and lead that is used in electronic circuits. A certain solder has a melting point of  $224\text{ }^{\circ}\text{C}$ . What is its melting point in degrees Fahrenheit ( $^{\circ}\text{F}$ )?

**Problem** Helium has the lowest boiling point of all the elements at  $-452$  °F. Convert this temperature to degrees Celsius.

**Problem** Mercury, the only metal that exists as liquid at room temperature, melts at  $-38.9\text{ }^{\circ}\text{C}$ . Convert its melting point to kelvins.