

Biomedical
Science

Molecular
Genetics



CHE 205 | Fall 2026-2027

General Chemistry
Introduction & Basics of Chemistry



Free Session

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Chemistry, Matter and Atoms

Chemistry is the study of **matter** and the changes it undergoes. Everything we do involves chemistry.

Matter

Anything that **occupies space** and **has mass**.

Substance

A form of matter that has a **definite composition** and **distinct properties**.

ATOMS AND MOLECULES IN MATTER

- Atoms are **very small**.
- Atoms and molecules are tiny particles that **compose all common matter**.
- The atoms are **bound together** to form several different types of **molecules**.
- **Chemical bonds** are the attachments that **hold atoms together**.

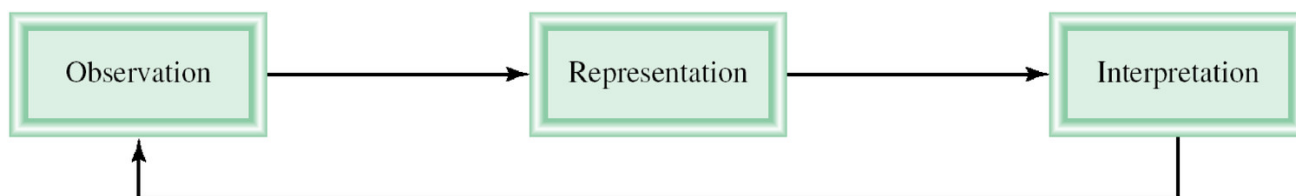
CHEMICALS COMPOSE ORDINARY THINGS

People often have a **very narrow view** of chemicals, thinking of them only as **dangerous poisons or pollutants**.



The Scientific Method

The scientific method is a **systematic approach to research**. A **hypothesis** is a tentative explanation for a set of observations — it is **tested** and **modified**.



KNOWLEDGE AS A RESULT OF THE SENSES

- 1 **Observations** involve measuring or observing some aspect of nature.
- 2 **Hypotheses** are tentative interpretations of the observations.
- 3 **Laws** summarize the results of a large number of observations.
- 4 **Theories** are models that explain and give the underlying causes for observations and laws.



Laws and Theories

Laws

- Summary of observations that combines all past observations into **one general statement**.
- A law explains **What?**
- A concise statement of a relationship between phenomena that is **always the same under the same conditions**. They have **mathematical equations**.

Law of Conservation of Mass — "In a chemical reaction matter is neither created nor destroyed."

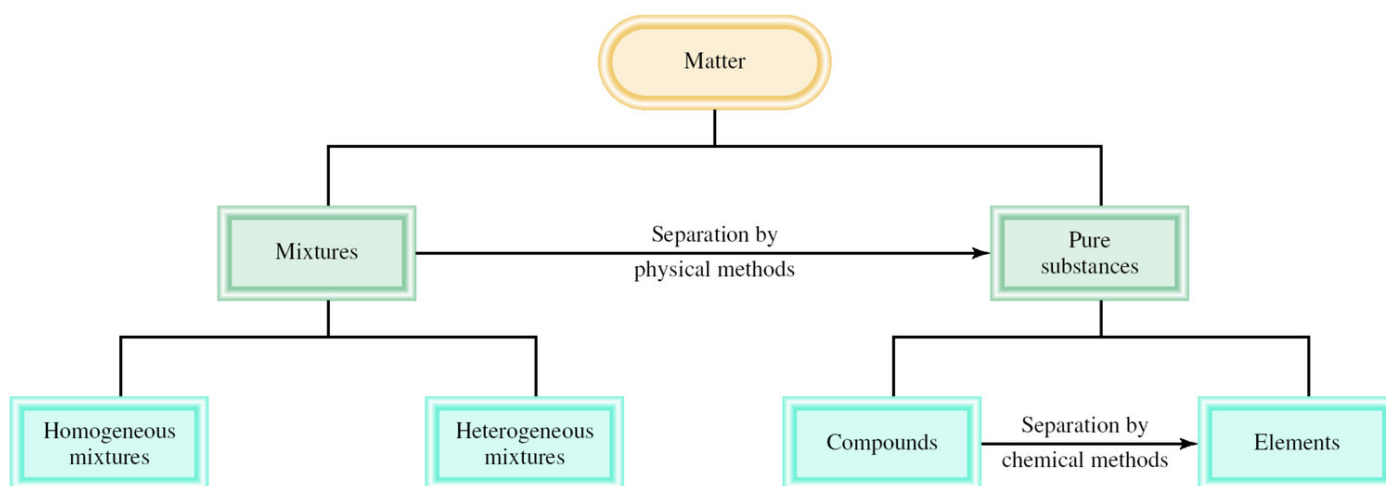
$$\text{Force} = \text{mass} \times \text{acceleration}$$

Theories

- General explanation for the characteristics and behavior of nature — **Why it happens**.
- **Models of nature**, e.g. Dalton's Atomic Theory.
- Can be used to **predict future observations**, so they can be **tested by experiments**.
- A unifying principle that explains a **body of facts** and/or those laws that are based on them.



Classification of Matter



CATEGORY	DEFINITION
Pure substances	Composed of only one type of atom or molecule (iron, water, oxygen).
Elements	A substance that cannot be broken into simpler substances. It could be made of atoms or molecules (oxygen, hydrogen, nitrogen, iron).
Compounds	Composed of two or more elements in fixed definite proportions (water — H_2O ; salt — NaCl).
Mixtures	Composed of two or more types of atoms or molecules combined in variable proportions (air, brass, sea water).
Homogeneous	A mixture that has the same, uniform composition throughout. Also called a solution (sea water, air).
Heterogeneous	A mixture that has two or more regions with different compositions and properties (sand/water, oil/water).



Elements

An **element** is a substance that **cannot be separated into simpler substances** by chemical means.

118

elements have been
identified

82

occur **naturally** on
Earth
gold, aluminum, lead, oxygen,
carbon, sulfur

35

have been **created by**
scientists
technetium, americium,
seaborgium

TABLE 1.1 Some Common Elements and Their Symbols

Name	Symbol	Name	Symbol	Name	Symbol
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

Table 1.1 — Some common elements and their symbols.



Compounds and Mixtures

Compound

A substance composed of atoms of **two or more elements chemically united in fixed proportions**. Compounds can only be separated into their pure components (elements) by **chemical means**.



Lithium fluoride · quartz · dry ice (carbon dioxide)

Mixture

A combination of **two or more substances** in which the substances **retain their distinct identities**.

1 · Homogeneous mixture —

composition of the mixture is the **same throughout**.

soft drink, milk, solder

2 · Heterogeneous mixture —

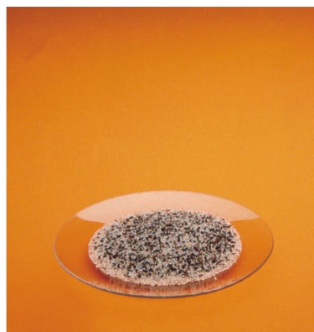
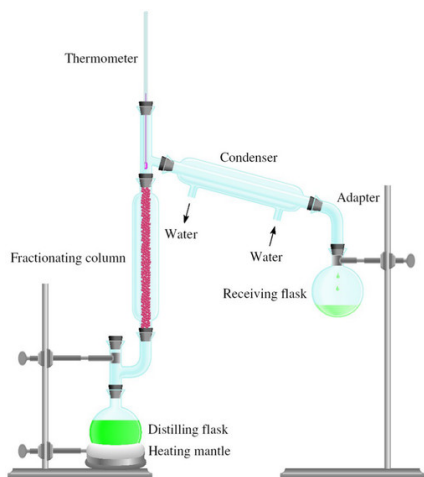
composition is **not uniform throughout**.

cement, iron filings in sand



Separating Mixtures

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



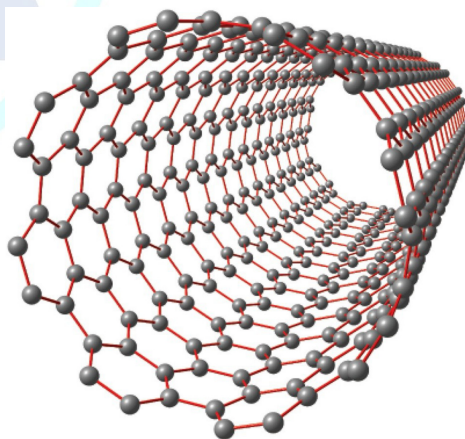
magnet

Distillation · magnet



The Nanoworld

Nanotechnology is the study of manipulating matter at the **atomic or molecular level**.





Physical Properties

Physical properties are those properties of a substance that can be **observed without changing the substance**. Examples are **colour**, **mass** and **weight**.

Table 1.2 Some Examples of Physical Properties

Property	Examples
Temperature	0 °C for ice water, 100 °C for boiling water.
Mass	A nickel weighs 5 g. A penny weighs 2.5 g.
Color	Sulfur is yellow. Bromine is reddish-brown.
Taste	Acids are sour. Bases are bitter.
Odor	Benzyl acetate smells like jasmine. Hydrogen sulfide smells like rotten eggs.
Boiling point	Water boils at 100 °C. Ethyl alcohol boils at 78.5 °C.
Hardness	Diamond is exceptionally hard. Sodium metal is soft.
Density	1.00 g/mL for water, 19.3 g/cm ³ for gold.

Table 1.3 – Some examples of physical properties.



Extensive and Intensive Properties

Extensive property

An extensive property of a material **depends upon how much matter** is being considered.

mass

length

volume

Intensive property

An intensive property of a material **does not depend upon how much matter** is being considered.

density

temperature

colour



Chemical Properties

Chemical properties are those properties of a substance that can **only be studied by forming new substances**.

Table 1.3 Some Examples of Chemical Properties

Substance	Typical Chemical Property
Iron	rusts (combines with oxygen to form iron oxide).
Carbon	burns (combines with oxygen to form carbon dioxide).
Silver	tarnishes (combines with sulfur to form silver sulfide).
Nitroglycerin	explodes (decomposes to produce a mixture of gases).
Carbon monoxide	is toxic (combines with hemoglobin, causing anoxia).
Neon	is inert (does not react with anything).

Table 1.3 — Some examples of chemical properties.



Types of Changes

Physical change

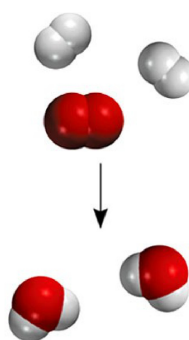
Does **not alter** the composition or identity of a substance.

ice melting · sugar dissolving in water

Chemical change

Alters the composition or identity of the substance(s) involved.

hydrogen burns in air to form water





International System of Units (SI)

TABLE 1.2 SI Base Units

Base Quantity	Name of Unit	Symbol
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

Table 1.2 — SI base units.



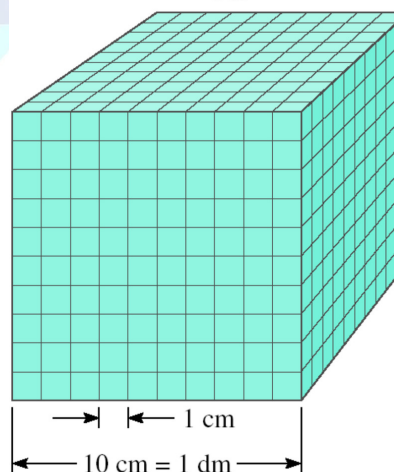
Volume

The SI derived unit for volume is the **cubic meter (m³)**.

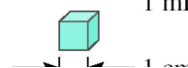
$$1 \text{ L} = 1000 \text{ mL} = 1000 \text{ cm}^3 = 1 \text{ dm}^3$$

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

Volume: 1000 cm³;
1000 mL;
1 dm³;
1 L



Volume: 1 cm³;
1 mL





Density

The SI derived unit for density is **kg/m³**.

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

$$d = m / V$$

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

WORKED EXAMPLE

A piece of platinum metal with a density of **21.5 g/cm³** has a volume of **4.49 cm³**. What is its mass?

$$m = d \times V = 21.5 \text{ g/cm}^3 \times 4.49 \text{ cm}^3 = \mathbf{96.5 \text{ g}}$$

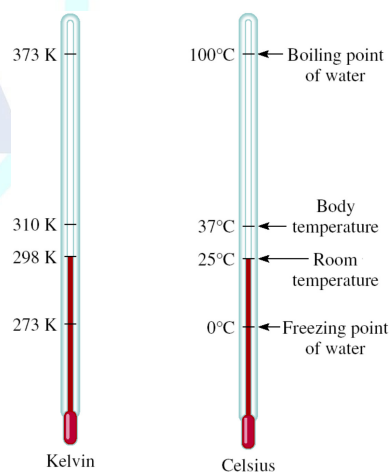


A Comparison of Temperature Scales

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

$$273 \text{ K} = 0 \text{ } ^\circ\text{C}$$

$$373 \text{ K} = 100 \text{ } ^\circ\text{C}$$





Scientific Notation

A very large number

The number of atoms in 12 g of carbon:

602,200,000,000,000,000,000

$$6.022 \times 10^{23}$$

A very small number

The mass of a single carbon atom in grams:

0.000000000000000000000000199

$$1.99 \times 10^{-23}$$

Multiplication

- Multiply N_1 and N_2
- **Add** exponents n_1 and n_2

$$\begin{aligned} &(4.0 \times 10^{-5}) \times (7.0 \times 10^3) \\ &= (4.0 \times 7.0) \times 10^{-5+3} \\ &= 28 \times 10^{-2} = 2.8 \times 10^{-1} \end{aligned}$$

Division

- Divide N_1 and N_2
- **Subtract** exponents n_1 and n_2

$$\begin{aligned} &8.5 \times 10^4 \div 5.0 \times 10^9 \\ &= (8.5 \div 5.0) \times 10^{4-9} \\ &= 1.7 \times 10^{-5} \end{aligned}$$



Significant Figures · The Rules

- 1 Any digit that is **not zero** is significant.
1.234 kg → **4** significant figures
- 2 Zeros **between nonzero digits** are significant.
606 m → **3** significant figures
- 3 Zeros **to the left of the first nonzero digit** are **not** significant.
0.08 L → **1** significant figure
- 4 If a number is **greater than 1**, then all zeros to the right of the decimal point are significant.
2.0 mg → **2** significant figures
- 5 If a number is **less than 1**, then only the zeros that are at the end and in the middle of the number are significant.
0.00420 g → **3** significant figures

HOW MANY SIGNIFICANT FIGURES?

24 ML	3001 G	0.0320 M ³	6.4×10^4	560 KG
2	4	3	2	2



Significant Figures · In Calculations

Addition or subtraction

The answer **cannot have more digits to the right of the decimal point** than any of the original numbers.

89.332

+ 1.1

90.432

one significant figure after decimal point

round off to **90.4**

3.70

– 2.9133

0.7867

two significant figures after decimal point

round off to **0.79**

Multiplication or division

The number of significant figures in the result is set by the original number that has the **smallest number of significant figures.**

$4.51 \times 3.6666 = 16.536366$

4.51 has 3 sig figs

round to **16.5**

$6.8 \div 112.04 = 0.0606926$

6.8 has 2 sig figs

round to **0.061**



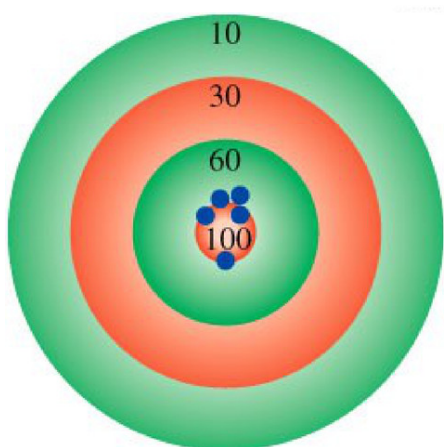
Accuracy and Precision

Accuracy

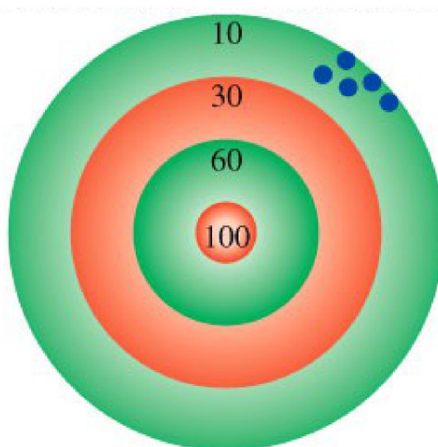
How close a measurement is to the **true value.**

Precision

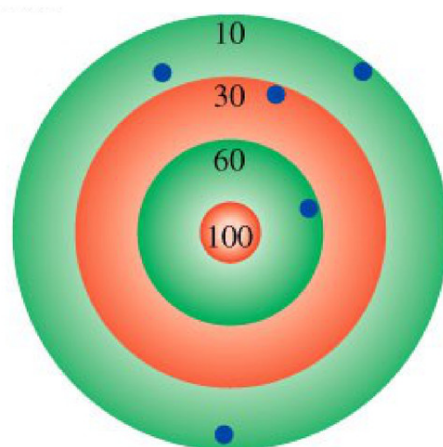
How close a set of measurements are to **each other.**



accurate



precise



not accurate

Left: accurate & precise · **Centre:** precise but not accurate · **Right:** not accurate & not precise.

CHEMISTRY REQUIRES COMMITMENT

You must do your work **regularly and carefully.** If you do, you will succeed — and you will be rewarded by seeing a whole new world: **the world of molecules and atoms.**



To Summarise...

MATTER 2

Pure substances vs mixtures

- **Elements** cannot be broken down further
- **Compounds** — elements in fixed proportions
- **Mixtures** — variable proportions, homogeneous or heterogeneous

ELEMENTS 118

Identified elements

- **82** occur naturally on Earth
- **35** have been created by scientists
- Separated only by **chemical means**

METHOD 4

The scientific method

- **Observations** → **hypotheses**
- **Laws** summarise — they explain **what**
- **Theories** explain **why** and can be tested

PROPERTIES 2 + 2

Ways to classify

- **Physical** — observed without change
- **Chemical** — only by forming new substances
- **Extensive** depends on amount; **intensive** does not

KEY FORMULA $d = m/v$

Density and temperature

- $1 \text{ g/cm}^3 = 1 \text{ g/mL} = 1000 \text{ kg/m}^3$
- $1 \text{ L} = 1000 \text{ mL} = 1000 \text{ cm}^3 = 1 \text{ dm}^3$
- $\text{K} = ^\circ\text{C} + 273$

FIGURES 5

Significant figure rules

- Add / subtract — fewest **decimal places** wins
- Multiply / divide — fewest **sig figs** wins
- **Accuracy** is truth; **precision** is agreement

CHAPTER CONTENTS

Scientific method

Properties of matter

Classification of matter

SI units

Density

Uncertainties & significant figures