

Classification of Matter

What is the difference between elements, compounds and mixtures?

●○○ Beginner

Foundations

Last reviewed 4 October 2026

What is it?

Matter is anything that has mass and takes up space. Chemists sort matter in two ways: by its **state** (solid, liquid or gas) and by its **composition** (what it is made of).

By composition, every sample of matter is either a **pure substance** or a **mixture**:

- A **pure substance** has a fixed composition and the same properties throughout. It is either an **element** or a **compound**.
- A **mixture** contains two or more substances that are not chemically joined. Its composition can vary.

Type	Made of	Can be separated by	Examples
Element	one kind of atom	cannot be broken down chemically	iron, Fe; oxygen, O ₂ ; helium, He
Compound	two or more elements chemically combined in a fixed ratio	chemical reactions only	water, H ₂ O; sodium chloride, NaCl
Mixture	two or more substances, not chemically combined	physical methods	salt water, air, sand and iron filings

KEY IDEA

Elements and compounds are **pure substances**. A compound has a **fixed** composition (water is always 11.19% hydrogen by mass); a mixture does not (salt water can be weak or strong).

Why does it matter?

- **It decides how to separate things.** You can filter sand out of water, but you cannot filter hydrogen out of water: that needs a chemical reaction.
- **It explains properties.** A compound's properties are completely different from those of its elements. Sodium is a reactive metal and chlorine a toxic gas, but sodium chloride is table salt.
- **It is the language of chemistry.** Words like *element*, *compound*, *solution* and *chemical change* appear in every later topic.

How does it work?

1. Elements and compounds

An **element** contains only one kind of atom. Some elements exist as single atoms (He, Ne), others as molecules (O₂, N₂, P₄). They are listed in the periodic table.

A **compound** contains two or more elements **chemically bonded** in a **fixed ratio**, shown by its formula. Carbon dioxide is always one C atom to two O atoms: CO₂.

2. Mixtures

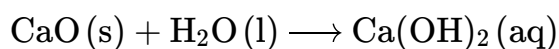
- **Homogeneous mixtures** (also called **solutions**) are uniform throughout: you cannot see separate parts. Examples: salt water, air, brass (an alloy of copper and zinc).
- **Heterogeneous mixtures** are not uniform: you can see or detect different parts. Examples: sand in water, oil and water, granite.

3. Physical and chemical properties and changes

	Physical	Chemical
Property	observed without changing the substance: colour, density, melting point, boiling point	describes how it reacts: flammability, reaction with acid, tendency to rust
Change	no new substance forms: melting, boiling, dissolving, cutting	new substance(s) form: burning, rusting, cooking an egg

Signs that a **chemical change** may have happened: a gas is given off, a colour change, a precipitate (solid) forms, or heat or light is released. These are clues, not proof: boiling water also releases gas bubbles, but it is a physical change.

Is dissolving always a physical change? Usually it is: when sugar or salt dissolves, evaporating the water gets the original solid back. But some substances **react** with water as they “dissolve”. Calcium oxide (quicklime) is an example:



The mixture becomes hot, and evaporating the water gives **calcium hydroxide**, not calcium oxide: a new substance has formed, so this is a chemical change. Similarly, hydrogen chloride gas reacts with water as it dissolves, forming ions:

$\text{HCl (g)} + \text{H}_2\text{O (l)} \longrightarrow \text{H}_3\text{O}^+ \text{ (aq)} + \text{Cl}^- \text{ (aq)}$. The test is always the same: **can the original substance be recovered unchanged?**

4. Separating mixtures

Method	Separates	Example
Filtration	an insoluble solid from a liquid	sand from water
Evaporation / crystallisation	a dissolved solid from its solvent	salt from salt water
Distillation	a liquid from a solution, or liquids with different boiling points	pure water from sea water
Chromatography	dissolved substances that move at different speeds through a medium	the dyes in ink
Magnetism	magnetic from non-magnetic solids	iron filings from sand

∞ THINK OF IT LIKE THIS

A compound is like a cake: once flour, eggs and sugar are baked together, you can't pick the egg back out, and the cake has new properties. A mixture is like a fruit salad: the pieces are just mixed, keep their own properties, and can be picked apart again.

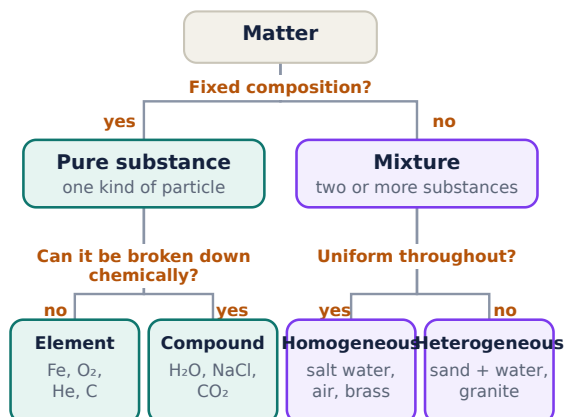
Q MORE PRECISELY

The **law of definite proportions** states that a given compound always contains its elements in the same proportions by mass, whatever its source. That is why percent composition can be calculated from the formula alone. Some solids (for example certain metal oxides) deviate slightly from ideal ratios; these “non-stoichiometric” compounds are an advanced exception.

Visualise it

Classifying matter

Ask the question at each branch to sort any sample.



Mixtures can be separated by physical methods (filtering, distilling); compounds need chemical reactions.

Two questions sort any sample: fixed composition? and can it be broken down or is it uniform?

Worked example

✂ WORKED EXAMPLE: Classifying samples

Question: Classify each as an element, a compound, a homogeneous mixture or a heterogeneous mixture: (a) copper wire (b) sugar dissolved in water (c) carbon dioxide (d) a salad.

Step 1 Copper contains only Cu atoms: **element**.

Step 2 Sugar water is uniform and its composition can vary: **homogeneous mixture** (a solution).

Step 3 CO₂ is two elements bonded in a fixed 1 : 2 ratio: **compound**.

Step 4 A salad has visibly different parts: **heterogeneous mixture**.

 WORKED EXAMPLE: Physical or chemical change?

Question: Which of these are chemical changes: ice melting, a match burning, iron rusting, sugar dissolving?

Step 1 Ice melting: still H_2O , so **physical**.

Step 2 A match burning: new substances (carbon dioxide, water, ash) and heat and light, so **chemical**.

Step 3 Iron rusting: iron reacts with oxygen and water to form iron oxide, so **chemical**.

Step 4 Sugar dissolving: the sugar molecules are unchanged and can be recovered by evaporating the water, so **physical**.

Common mistake

 COMMON MISTAKE: Calling every pure-looking liquid a pure substance

Clear liquids are often mixtures. Tap water, vinegar and air look uniform but are homogeneous mixtures. “Pure” in chemistry means one substance only.

 COMMON MISTAKE: Thinking molecules are always compounds

O_2 and N_2 are molecules, but they are **elements**, because each contains only one kind of atom. A compound needs at least two different elements.

 COMMON MISTAKE: Treating a change of state as chemical

Melting, freezing, boiling and condensing are **physical** changes: the substance stays the same.

 NOTATION NOTE

- “Solution” means a homogeneous mixture, not only a liquid one: air (a gas) and brass (a solid) are solutions too.
- State symbols in equations: (s) solid, (l) liquid, (g) gas, (aq) dissolved in water.

Remember this

REMEMBER THIS

- **Pure substances:** elements (one kind of atom) and compounds (elements bonded in a fixed ratio).
- **Mixtures:** homogeneous (uniform, solutions) or heterogeneous (not uniform); composition can vary.
- **Physical change:** no new substance. **Chemical change:** new substance(s) form.
- **Mixtures separate by physical methods; compounds only by chemical reactions.**

References

1. Brown, T. L.; LeMay, H. E., Jr.; Bursten, B. E.; Murphy, C. J.; Woodward, P. M.; Stoltzfus, M. W. Chemistry: The Central Science, 15th ed.; Pearson, 2022.

Practise this topic with flashcards and a quiz at chemistryclarity.com/chemistry/classification-of-matter/