Science 7–8

Chapter 11 — Chemical sciences B: atoms and chemical change

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Contents

The atomic theory of matter: modelling elements, compounds and mixtures in two and three dimensions, and why we use symbols, chemical formulas and percentages

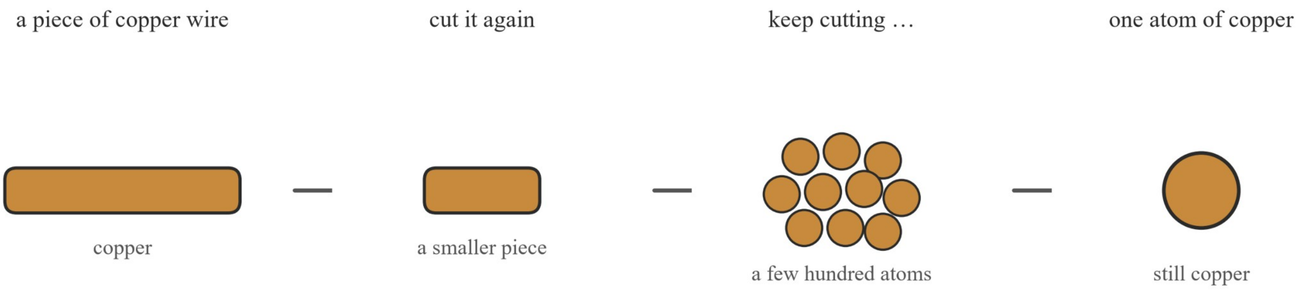
What we teach here — `VC2S8U07` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"the atomic theory of matter can be used to model and explain the difference between elements, compounds and mixtures; elements, compounds and mixtures can be represented as two-dimensional and three-dimensional models, elements can be represented by symbols, and molecules and compounds can be represented by chemical formulas"* **This subtopic owns the content description whole** — there is no partner split (D6). It teaches the atomic idea itself (matter is made of atoms), the three kinds of matter sorted by their atoms (elements, compounds, mixtures), the flat and solid models we build of them, and the three ways scientists write matter down: symbols for elements, chemical formulas for compounds and molecules, and percentages for mixtures. **In our words:** everything is made of atoms, and the *kinds* of atoms present — and whether they are joined or just mixed — decide what a sample of matter is. One kind of atom only: an element. Two or more kinds joined in a fixed recipe: a compound. Several substances together but not joined: a mixture. Symbols, formulas and percentages are the shorthand the whole world agrees on for writing those three ideas down. **Achievement-standard extract served here (D13):** *"They classify and represent matter as elements, compounds or mixtures, and distinguish between physical and chemical changes."* The first clause — classify and represent matter as elements, compounds or mixtures — is served in full here. The second clause — distinguish between physical and chemical changes — is served by the partner subtopics 11B and 11C, which cite this header by reference. **Elaborations drawn on:** `VC2S8U07.E01` (using virtual and physical models to distinguish between elements and compounds in terms of types of atoms), `VC2S8U07.E02` (examining how Dmitri Mendeleev arranged the elements in the first version of the periodic table and comparing his arrangement with the current version), `VC2S8U07.E03` (explaining why elements are represented by symbols, why compounds and molecules are represented by chemical formulas, and why mixtures are represented by percentages), `VC2S8U07.E04` (using representations to show the classification of matter as elements, compounds and different types of mixtures such as solutions, suspensions and colloids) and `VC2S8U07.E05` (examining the information conveyed by different types of representations of elements and compounds, and identifying where and why these different representations are used). E01 and E04 drive the model-building theory and the activity; E02 drives the Mendeleev section; E03 and E05 drive the symbols, formulas and percentages sections. **Scope notes.** The particle model used here is the one built in 10A–10C (`VC2S8U05`); it is applied, not re-taught. Atoms are **never split into smaller parts** in this subtopic: what an atom is made of inside — and what the element's own number counts — belongs to Levels 9–10 (`VC2S10U06`, `VC2S10U07`) and is not mentioned except in the forward note. No chemical equations — word or symbol — appear here (D9); symbols and formulas are used only as *representations*, never as parts of equations. Percentages are used as taught in Number 7–8 (`VC2M7N07`: percentage of a quantity; one quantity as a percentage of another). Very small sizes are written in words or smaller units, never in scientific notation (D11).

Definitional preface — what *atom*, *element*, *compound* and *mixture* mean here. The Victorian Curriculum uses these terms but does not define them. This subtopic therefore treats them as follows, and every question here is answerable on these definitions alone: an **atom** is the smallest particle of an element that is still that element. An **element** is a substance made of **one kind of atom only**. A **compound** is a substance in which **two or more kinds of atom are joined together** in a fixed recipe. A **mixture** is **two or more substances in the same place, not joined** — each keeps its own properties, and the recipe can vary from sample to sample. (This is the operational definition convention of the house; see CONTESTED_TERMS rule 1.)

Theory

The atomic idea: cut anything small enough and you reach one atom

Chapter 10 built the particle model of matter: every substance is made of tiny particles too small to see. The atomic theory of matter goes one step further and says that for every **element** there is a smallest possible piece. Imagine a piece of copper wire. Cut it in half: two smaller pieces of copper. Cut again, and again, and again — every piece is still copper, all the way down until you reach one single particle of copper: **one atom of copper**. Cut that atom apart and whatever you get is *no longer copper*. The atom is the smallest piece of an element that is still that element.



The smallest piece of copper that is still copper is one atom of copper. Cut further and it is no longer copper.
Atoms are tiny: about 40 million copper atoms in a row would measure about 1 cm (a copper atom is about 0.000 000 025 6 cm across).

Four panels in a row joined by arrows. Panel 1 shows a long rounded bar of copper labelled a piece of copper wire. Panel 2 shows a shorter copper bar labelled a smaller piece. Panel 3 shows a loose cluster of about ten copper-coloured circles labelled a few hundred atoms. Panel 4 shows a single copper-coloured circle labelled one atom of copper, still copper. A caption beneath reads: the smallest piece of copper that is still copper is one atom of copper; cut further and it is no longer copper. Atoms are tiny: about 40 million copper atoms in a row would measure about 1 cm, because a copper atom is about 0.000 000 025 6 cm across.

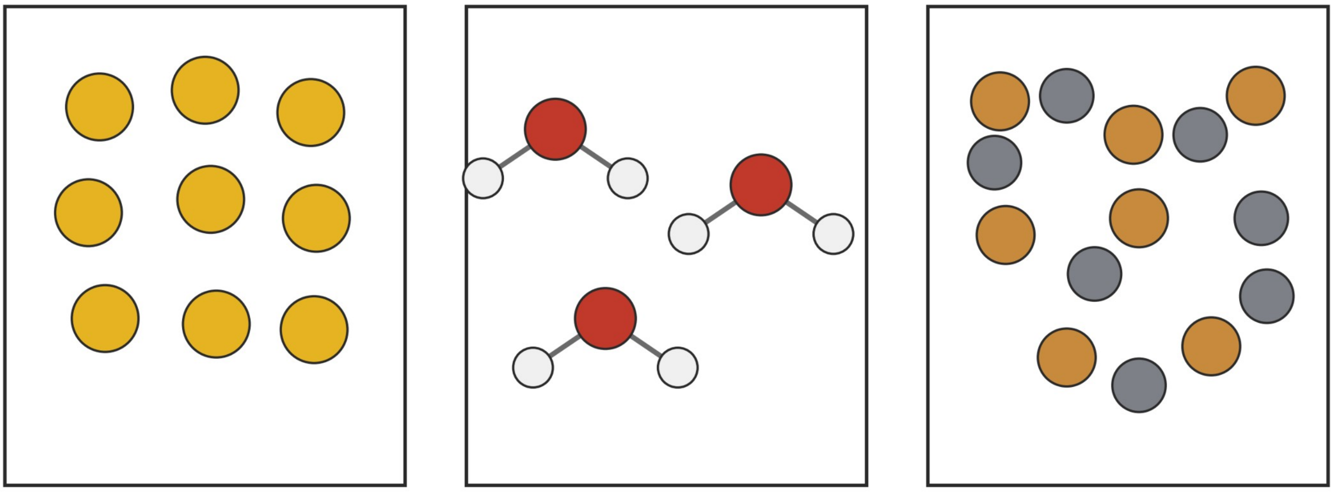
Atoms are far too small to see directly, which the caption puts a number on: a copper atom is about 0.000 000 025 6 cm across, so about 40 million copper atoms standing in a row would measure about 1 cm. Because atoms cannot be seen or handled one by one, almost everything in this subtopic is done with **models** — drawings, ball-and-stick builds and formulas that stand in for the real particles.

Three kinds of matter, sorted by their atoms

With the atom idea in hand, every sample of matter sorts into exactly three kinds. The definitions turn on two questions: *how many kinds of atom are present?* and *are the different kinds joined, or just in the same place?*

- An **element** is made of **one kind of atom only**. Gold, copper, oxygen and helium are elements. A lump of gold is nothing but gold atoms; the oxygen in the air is nothing but oxygen atoms (paired up, two at a time, but still one *kind*).
- A **compound** is made of **two or more kinds of atom joined together** in a fixed recipe. Water is a compound: every particle of water is two hydrogen atoms joined to one oxygen atom, and that recipe never varies.
- A **mixture** is **two or more substances together, not joined**. Brass is a mixture of the elements copper and zinc: copper atoms and zinc atoms sit side by side, but they keep their own properties and the recipe can vary — one brass coin may hold more zinc than another.

Three samples of matter, drawn as particles



ELEMENT
one kind of atom only
(here: gold atoms)

COMPOUND
two or more kinds of atom
joined together (here: water)

MIXTURE
different substances
together, not joined
(here: copper and zinc,
the metals in brass)

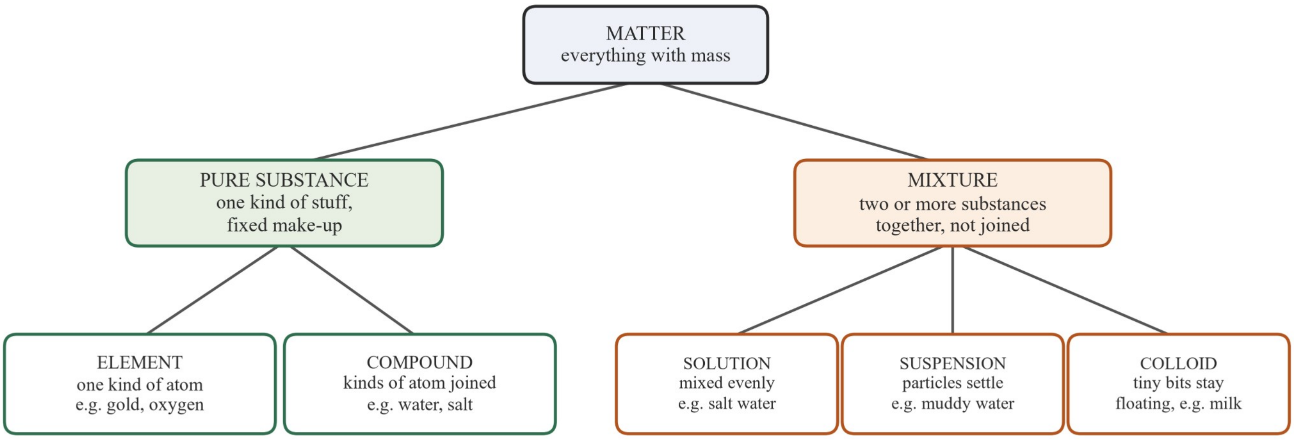
Three labelled boxes drawn as particle pictures. The left box, labelled ELEMENT — one kind of atom only (here: gold atoms), holds nine identical gold-coloured circles. The middle box, labelled COMPOUND — two or more kinds of atom joined together (here: water), holds three bent water molecules, each one red oxygen circle joined to two small white hydrogen circles. The right box, labelled MIXTURE — different substances together, not joined (here: copper and zinc, the metals in brass), holds copper-coloured circles and grey zinc circles scattered side by side, never touching in joined pairs.

Read the three boxes the way a scientist reads them: count the *kinds* of circles, and look for joins. One kind of circle = element. Two or more kinds joined into repeated little groups = compound. Two or more kinds sitting apart, each keeping its own identity = mixture. That reading is the whole skill of classifying matter at particle level.

> **Word watch — *element*.** In everyday talk, an *element* is a part or a feature of something (an element of surprise, the elements of a story). In science it means something much narrower: **a substance made of one kind of atom only**. Gold is an element; brass is not, because it holds two kinds of atom.
>
> **Word watch — *compound*.** In everyday talk, *compound* is usually a verb meaning *to make worse* (the problem was compounded by the rain). In science it is a noun: **a substance whose atoms are two or more kinds, joined in a fixed recipe**. Water is a compound; the salt in the sea is a compound.

The classification tree, and the three kinds of mixture (`VC2S8U07.E04`)

The three kinds sit inside one tidy tree. Matter divides first into **pure substances** — one kind of stuff with a fixed make-up, which means the elements and the compounds — and **mixtures**, whose recipe can vary. Mixtures then divide by how the substances are mixed: in a **solution** the dissolved particles are spread evenly and never settle; in a **suspension** the particles are large enough to settle if left; in a **colloid** tiny particles stay floating throughout and do not settle.

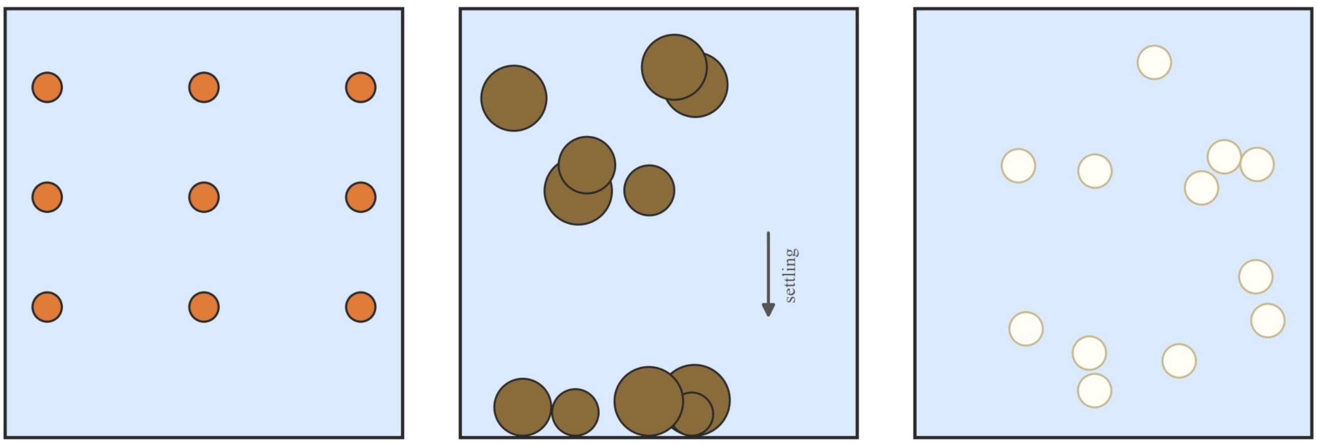


Elements and compounds are pure substances: every sample has the same make-up.
A mixture's make-up can change — that is why we describe a mixture by percentages.

A classification tree. The top box reads MATTER — everything with mass. It branches to two boxes: PURE SUBSTANCE — one kind of stuff, fixed make-up, and MIXTURE — two or more substances together, not joined. The pure-substance box branches to ELEMENT — one kind of atom, e.g. gold, oxygen, and COMPOUND — kinds of atom joined, e.g. water, salt. The mixture box branches to three boxes: SOLUTION — mixed evenly, e.g. salt water; SUSPENSION — particles settle, e.g. muddy water; COLLOID — tiny bits stay floating, e.g. milk. A footer line reads: elements and compounds are pure substances, every sample has the same make-up; a mixture's make-up can change, and that is why we describe a mixture by percentages.

You met solutions in 10C; here the tree adds names for the other two kinds. The particle pictures make the difference plain: it is a difference of particle *size* and of what the particles do over time.

Three kinds of mixture, drawn as particles



SOLUTION — salt water
the salt's particles are spread
evenly through and never settle

SUSPENSION — muddy water
big particles float for a while,
then settle at the bottom

COLLOID — milk
tiny particles stay floating
throughout and do not settle

Three labelled boxes drawn as particle pictures of mixtures. The left box, SOLUTION — salt water, shows small orange solute dots spaced evenly through pale blue water; the caption reads the salt's particles are spread evenly through and never settle. The middle box, SUSPENSION — muddy water, shows large brown mud particles, some floating high and some settled in a layer at the bottom, with a small arrow labelled settling; the caption reads big particles float for a while, then settle at the bottom. The right box, COLLOID — milk, shows medium cream-coloured droplets scattered throughout and never settling; the caption reads tiny particles stay floating throughout and do not settle.

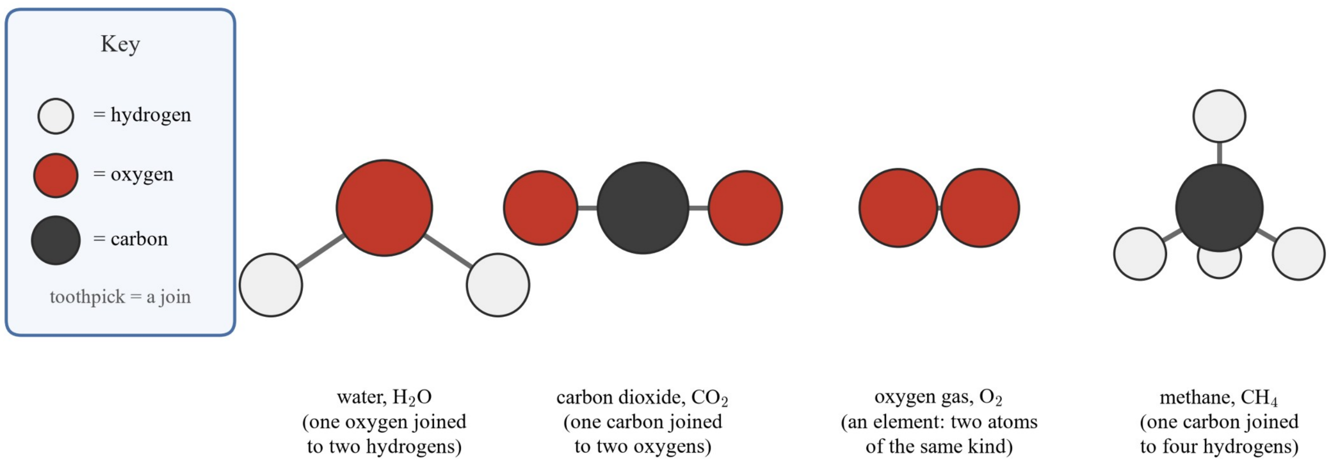
Notice what the solution box does *not* show: it never shows the water as a new substance. Dissolving salt in water is a physical change (11B) — the salt is still salt, spread among the water particles — so salt water is a mixture, and a sample of it can be saltier or less salty than another.

> **Word watch — *solution*.** In everyday talk, a *solution* is an answer to a problem. In science it is a kind of mixture: **one substance dissolved in another, spread evenly, never settling**. Salt water is a solution; so is the sugar in a soft drink.
>
> **Model note.** Every box of circles on this page is a model (4B): coloured dots standing in for particles that are billions of times too small to draw at true size. The dots' sizes and spacing are for reading, not for scale — what the model carries is the *idea*: how many kinds of particle are present, and whether they are joined.

Two-dimensional and three-dimensional models (`VC2S8U07.E01`)

Because atoms cannot be seen, chemists think with models. The cheapest model kit in the world is plasticine and toothpicks: a ball of plasticine stands for an atom, a toothpick stands for a join. Lay the build flat on the bench and it is a **two-dimensional (2D) model**; hold it up so the joins point in different directions in space and it is a **three-dimensional (3D) model**. The same kit distinguishes an element from a compound exactly as the definitions do — by the *types of atoms* present.

Models built from plasticine balls and toothpicks



Laid flat, each model is two-dimensional (2D). Held up, the joins point in different directions — a three-dimensional (3D) model.

A key and four models built from plasticine balls and toothpicks. The key shows a small white ball equals hydrogen, a red ball equals oxygen, a dark grey ball equals carbon, and a toothpick equals a join. Model 1 is water, H2O, one red ball joined to two white balls at an angle, captioned one oxygen joined to two hydrogens. Model 2 is carbon dioxide, CO2, a dark grey ball joined in a straight line to a red ball on each side, captioned one carbon joined to two oxygens. Model 3 is oxygen gas, O2, two red balls joined together, captioned an element: two atoms of the same kind. Model 4 is methane, CH4, a dark grey ball joined to four white balls, captioned one carbon joined to four hydrogens. A footer line reads: laid flat, each model is two-dimensional; held up, the joins point in different directions — a three-dimensional model.

Two kits built by computer do the same job with more polish, and each leaves something out:

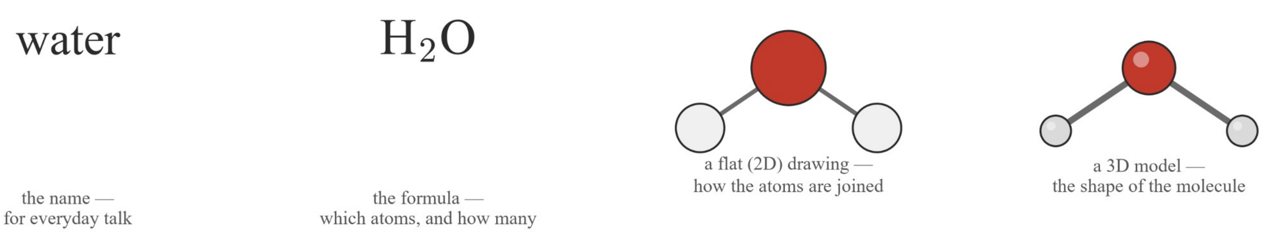
Methane, CH_4, drawn two ways. Both are models: each shows some things well and others not at all.

Methane, CH4, drawn two ways side by side. The left panel is a ball-and-stick model: a central dark carbon ball joined by grey sticks to four white hydrogen balls pointing in different directions; the caption reads the joins are easy to see, but atoms do not really hang apart on sticks. The right panel is a space-filling model of the same molecule: overlapping spheres packed into one lumpy shape; the caption reads it shows the space the atoms fill, but the joins are hidden. A footer line reads: both are models — each shows some things well and others not at all.

The ball-and-stick model shows the **joins** — which atom is joined to which — and hides the truth that atoms pack close together with no sticks between them. The space-filling model shows the **shape and the space the atoms fill**, and hides the joins. Neither is the molecule; each is a representation chosen for a job. That is the habit to keep: when you see a model, ask *what does it show well, and what does it hide?*

One substance, four representations (`VC2S8U07.E05`)

The same substance can be written down several ways, and each way carries different information. Water is the cleanest example: its name, its formula, a flat drawing and a solid model are four representations of the one substance.



Four ways to represent the same substance. Each one shows something the others do not — so scientists pick the one that fits the job.

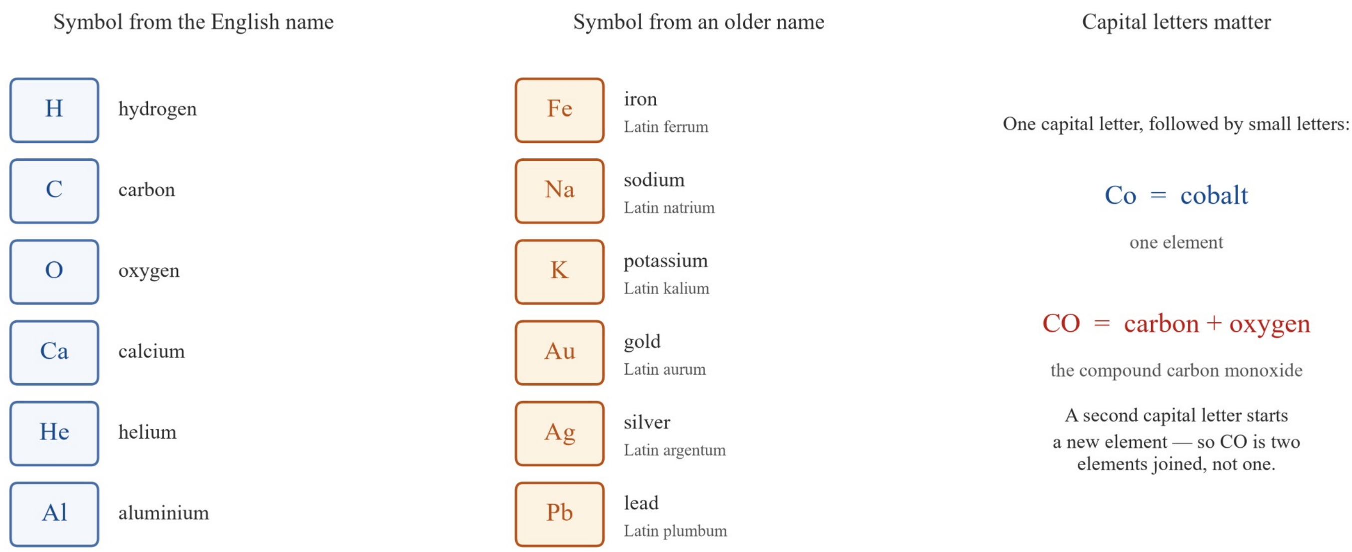
Four panels showing the same substance represented four ways. Panel 1 shows the word water in large type, captioned the name — for everyday talk. Panel 2 shows the formula H2O, captioned the formula — which atoms, and how many. Panel 3 shows a flat drawing of one red oxygen joined at an angle to two white hydrogens, captioned a flat

(2D) drawing — how the atoms are joined. Panel 4 shows a shaded 3D ball model of the same bent molecule, captioned a 3D model — the shape of the molecule. A footer line reads: four ways to represent the same substance; each one shows something the others do not, so scientists pick the one that fits the job.

The **name** is for everyday talk, but it tells you nothing about atoms — *water* could be any liquid. The **formula** H_2O tells you exactly which atoms are present and how many of each, in a few characters any scientist on Earth can read. The **2D drawing** shows how the atoms are joined. The **3D model** shows the shape the molecule really takes — bent, not straight. Each representation is used where its information is the information needed: a recipe card says *water*, a chemistry textbook writes H_2O, and a model kit shows the bend.

Symbols: one or two letters the whole world agrees on (`VC2S8U07.E03`)

Every element has a **symbol** of one or two letters: the first letter capitalised, the second, if there is one, small. Most symbols come from the English name; some come from older names, often Latin, because chemistry was written in Latin for centuries. Why bother with symbols at all? Three reasons. A symbol is **short** (C, not *the element carbon*); it is **exact** (a name can be vague, a symbol names one element only); and it is **the same in every language** — a chemist in Australia, Japan and Brazil all reads Cu as copper, whatever their word for the metal is. The symbol is a representation chosen so that the whole world reads it the same way.



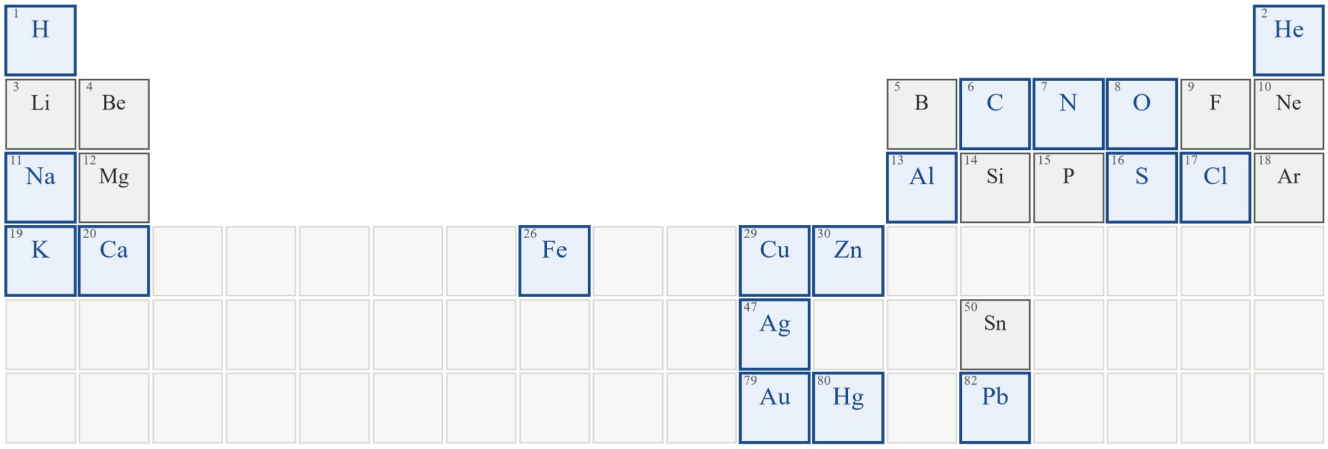
Every element has a symbol of one or two letters. The first letter is always capitalised; the second, if there is one, is always small.

Three columns. The first column, headed Symbol from the English name, lists H hydrogen, C carbon, O oxygen, Ca calcium, He helium, Al aluminium. The second column, headed Symbol from an older name, lists Fe iron from Latin ferrum, Na sodium from Latin natrium, K potassium from Latin kalium, Au gold from Latin aurum, Ag silver from Latin argentum, Pb lead from Latin plumbum. The third column, headed Capital letters matter, shows Co in blue equals cobalt, one element, and CO in red equals carbon plus oxygen, the compound carbon monoxide, with the note a second capital letter starts a new element, so CO is two elements joined, not one. A footer line reads: every element has a symbol of one or two letters; the first letter is always capitalised and the second, if there is one, is always small.

The third column is the classic trap. **Co** (one capital, one small letter) is the element cobalt. **CO** (two capitals) is two elements joined — carbon and oxygen — the compound carbon monoxide. The capital letters are doing real work: they say where one element ends and the next begins.

All the known symbols sit in one chart, the **periodic table**, in which every element has its own square and its own number, increasing by one from one element to the next.

The periodic table — every element has its own square



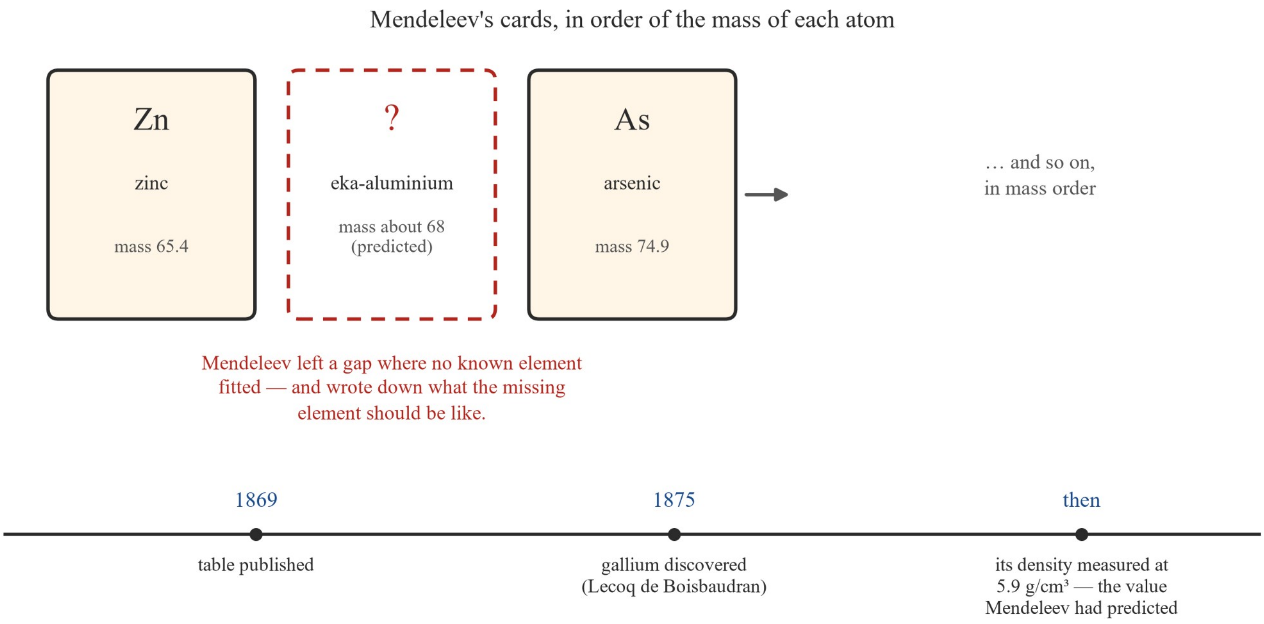
Blue squares: elements named in this subtopic (number = the element's own number, increasing by one from one element to the next). Grey squares: the other elements — 118 in all, by August 2026.

A simplified periodic table of six rows and eighteen columns of small squares. Eighteen squares are highlighted in blue and carry the element symbols named in this subtopic with their numbers: H 1, He 2, C 6, N 7, O 8, Na 11, S 16, Cl 17, K 19, Ca 20, Fe 26, Cu 29, Zn 30, Ag 47, Sn 50, Au 79, Hg 80, Pb 82; the remaining squares are grey. A caption reads: blue squares are the elements named in this subtopic, the number is the element's own number increasing by one from one element to the next; grey squares are the other elements — 118 in all, by August 2026.

By August 2026 the table holds **118 elements**. What the element's own number actually counts is a story about the inside of the atom, and that story belongs to Levels 9–10 — here the number is used only as the element's fixed place in the order.

Mendeleev and the first table: the gaps that made predictions (`VC2S8U07.E02`)

The periodic table was not found fully formed; it was built. In 1869 the Russian chemist **Dmitri Mendeleev** wrote each known element on a card with the mass of its atom, and laid the cards out in order of that mass. Where the order broke down — where no known element fitted the pattern — he did something bold: he **left a gap**, and predicted that a missing element with the right properties would one day be found.



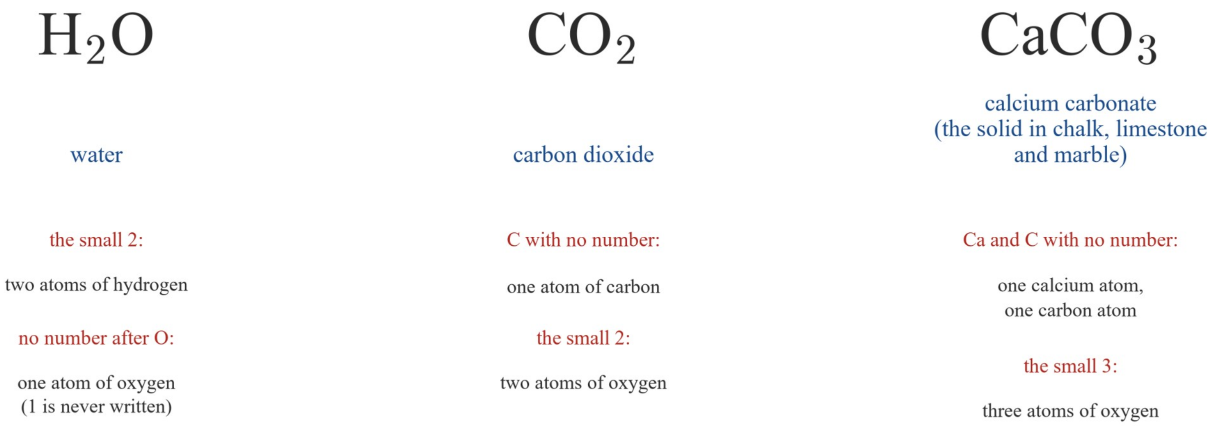
A row of three cards and a timeline. The first card reads Zn, zinc, mass 65.4. The middle card is a dashed red outline reading ?, eka-aluminium, mass about 68 (predicted). The third card reads As, arsenic, mass 74.9, followed by an arrow and the words and so on, in mass order. A red note beneath reads: Mendeleev left a gap where no known element fitted, and wrote down what the missing element should be like. Below, a timeline runs from 1869, table published, to 1875, gallium discovered (Lecoq de Boisbaudran), to then, its density measured at 5.9 g/cm³ — the value Mendeleev had predicted.

The prediction in the figure is his famous **eka-aluminium**: a missing element, mass about 68, that should behave like aluminium. In 1875 the French chemist **Lecoq de Boisbaudran** discovered a new element, **gallium**, in exactly that gap — and when its density was measured at 5.9 g/cm³, it matched the value Mendeleev had written down before the element was known. A table that could predict the future was a table worth keeping.

Comparing the two versions of the table, then and now: Mendeleev ordered his cards by the **mass** of each atom, with about 60 of the 118 elements known; the current table orders the elements by **the element's own number** (the one shown small in each blue square above), which fixes the places where mass order and the pattern disagreed, and holds all 118. Both tables do the same job — they arrange the elements so that the pattern shows — and the gaps in the first version were its strongest evidence, not a weakness.

Chemical formulas: a fixed recipe can be written down (`VC2S8U07.E03`)

A compound's recipe never varies — every particle of water is two hydrogens joined to one oxygen — so the recipe can be written as a **chemical formula**: the symbols of the elements present, with a small subscript number after a symbol to count the atoms of that element. No number after a symbol means one atom of it; the number 1 is never written.



A chemical formula names the elements present and counts the atoms of each. The counts are written as small subscript numbers.

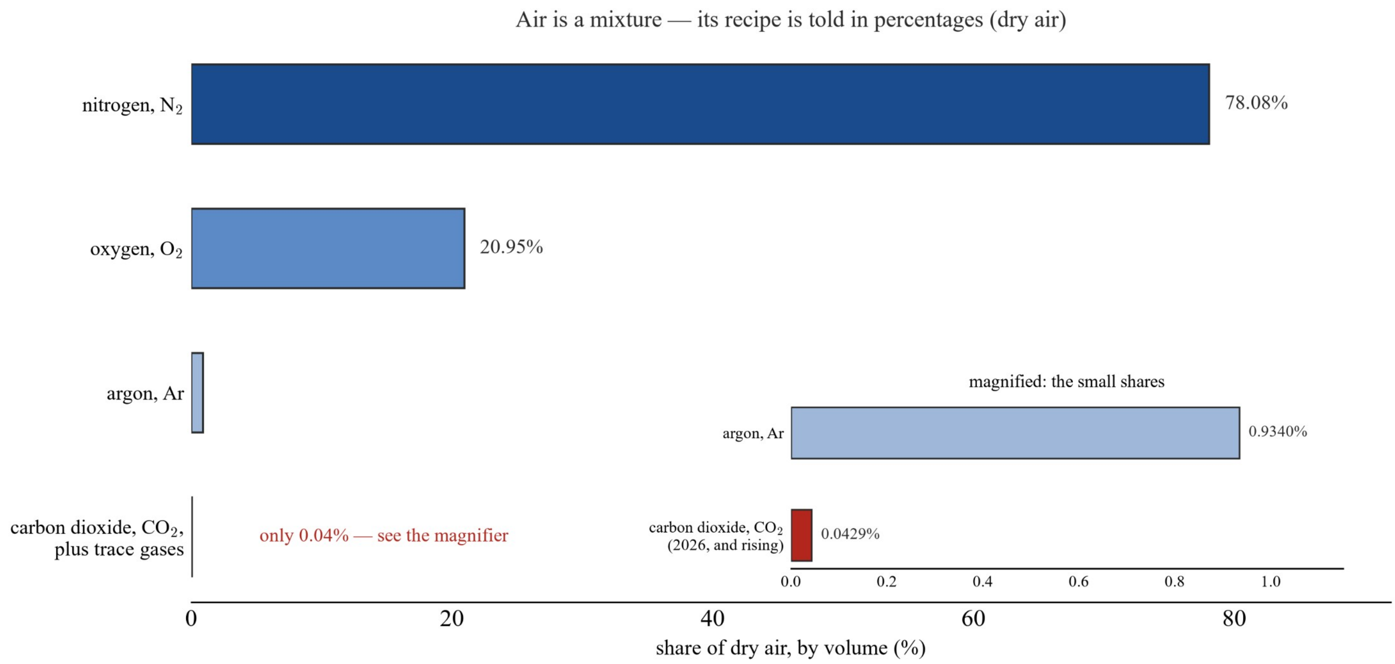
Three panels showing how to read a chemical formula. Panel 1 shows H2O, water: the small 2 means two atoms of hydrogen; no number after O means one atom of oxygen, because 1 is never written. Panel 2 shows CO2, carbon dioxide: C with no number means one atom of carbon; the small 2 means two atoms of oxygen. Panel 3 shows CaCO3, calcium carbonate, the solid in chalk, limestone and marble: Ca and C with no number mean one calcium atom and one carbon atom; the small 3 means three atoms of oxygen. A footer line reads: a chemical formula names the elements present and counts the atoms of each; the counts are written as small subscript numbers.

Formulas are not only for compounds. Some elements exist as joined pairs or groups of their own atoms, and the formula shows that too: the oxygen in air is O_2 (two oxygen atoms joined), the nitrogen in air is N_2. Why use formulas at all? For the same three reasons as symbols: a formula is **short** (H_2O, not *two hydrogens joined to one oxygen*), **exact** (it fixes the recipe — any sample of pure water is H_2O), and **readable in every language**. Two chemists who share no spoken language can hand each other $CaCO_3$ and know exactly what is meant.

> **Word watch — *formula*.** In everyday talk, a *formula* is a recipe or a winning plan (a racing car, a baby formula). In science a **chemical formula** is narrower: symbols and subscript numbers that name the elements in a substance and count the atoms of each.

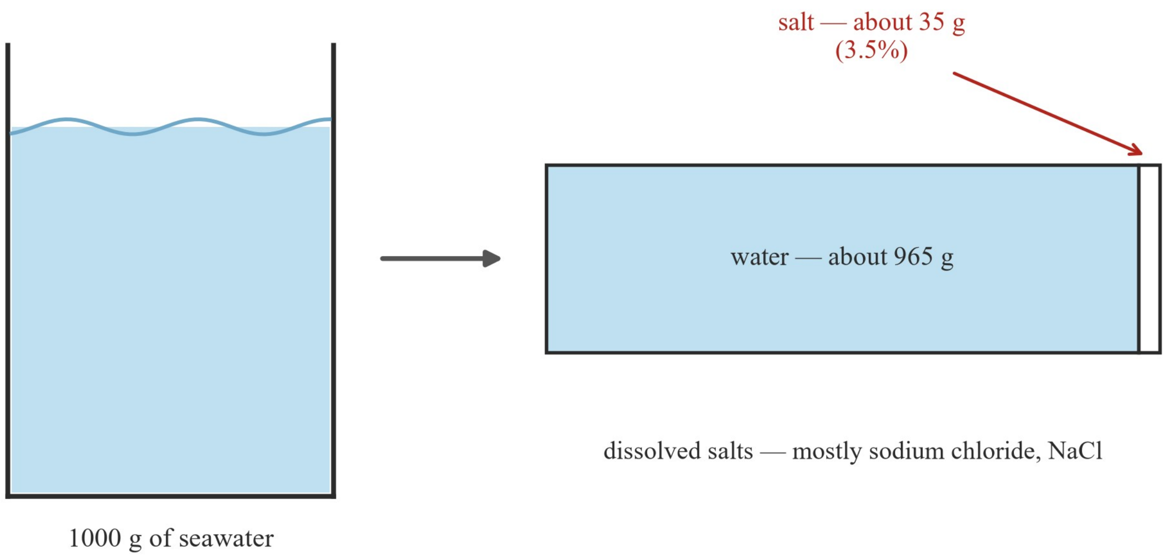
Percentages: the way to write a mixture down (`VC2M7N07`, `VC2S8U07.E03`)

A mixture has no fixed recipe, so it *cannot* be given a formula — the recipe of brass varies from coin to coin, and the recipe of the air varies from place to place and year to year. Instead, mixtures are described by **percentages**: the share of each substance, out of every 100 parts. Percentages are the right tool because they express one quantity as a part of another (Number 7–8, `VC2M7N07`), and a mixture is exactly that — one quantity of each substance inside the whole.



A horizontal bar chart titled Air is a mixture — its recipe is told in percentages (dry air). The bars read: nitrogen, N2, 78.08%; oxygen, O2, 20.95%; argon (a third gas in the air), Ar, a thin bar; carbon dioxide, CO2, plus trace gases, a bar too small to see, labelled only about 0.04% — see the magnifier. A magnified inset on the right repeats the small shares: argon (the third gas), Ar, 0.9340%, and carbon dioxide, CO2 (2026, and rising), 0.0429%.

Dry air is about 78% nitrogen and about 21% oxygen, with **argon** — a third gas in the air — making up most of the rest. The carbon dioxide share is tiny — about 0.04% — and it is the one share in the figure that is visibly *not* fixed: measured around the world, it was about 0.0429% of the air in 2026 and rises a little every year. A changing number like that could never be a formula; it can only be a percentage, re-measured.



Seawater's saltiness changes from place to place, so it is given as a percentage, not a formula.

A beaker labelled 1000 g of seawater beside a long split bar. The bar shows water, about 965 g, and a small white end segment labelled salt — about 35 g (3.5%), with a note that the dissolved salts are mostly sodium chloride, NaCl. A footer line reads: seawater's saltiness changes from place to place, so it is given as a percentage, not a formula.

Seawater tells the same story. In every 1000 g of typical seawater there are about 35 g of dissolved salt — mostly sodium chloride, itself a compound with the fixed formula NaCl — so the salt share is about 3.5%. (The arithmetic is the percentage idea from Number 7–8: 35 g out of 1000 g is 3.5 g out of every 100 g, that is 3.5%.) But the Dead Sea is far saltier than the Pacific, so *seawater* as a whole gets a percentage, never a formula. The compound in it gets a formula; the mixture gets a percentage. That pairing — **formula for the fixed, percentage for the variable** — is the last idea of this subtopic.

Forward note — where these ideas go next

Everything above stops at the *outside* of the atom on purpose. In Levels 9–10 the atom is opened up: the element's own number turns out to count particles inside the atom (`VC2S10U06`, `VC2S10U07`), joined atoms that carry a charge explain why salt dissolves the way it does, and chemical formulas become parts of chemical equations (`VC2S10U08`). None of that is needed here — and none of it changes a single definition in this subtopic. The atomic theory of matter at Levels 7–8 is the sorting and the shorthand: one kind of atom, joined kinds, or mixed kinds — written as a symbol, a formula, or a percentage.

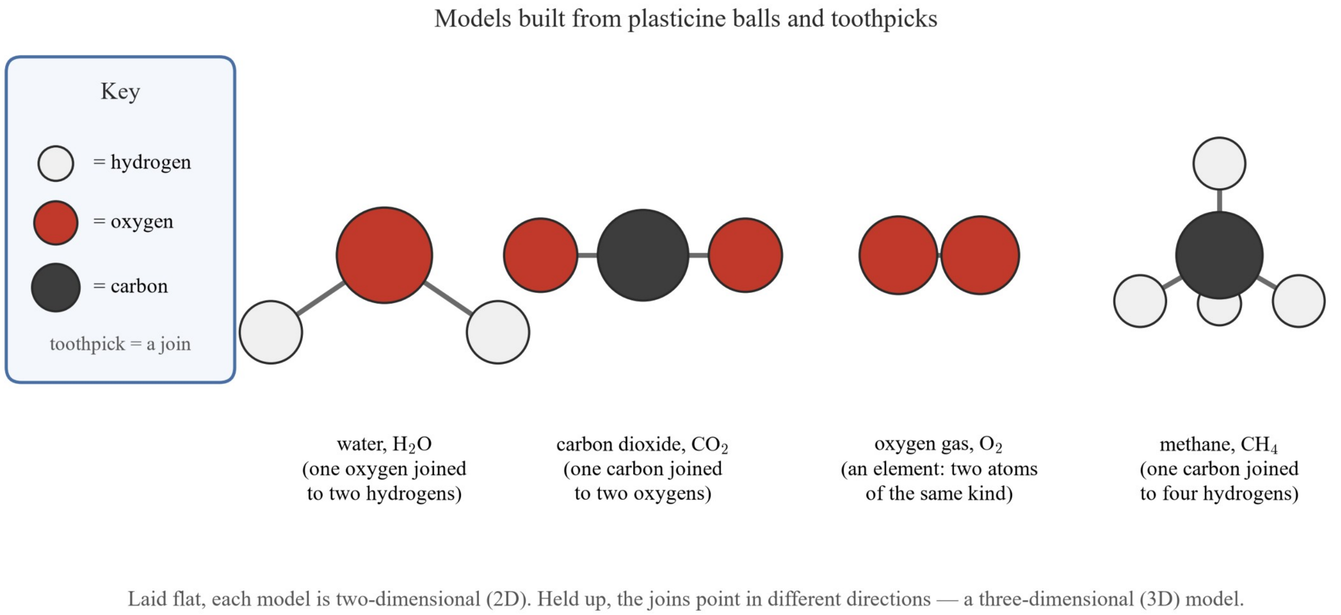
Activity: build it flat, hold it up

This activity practises the E01 skill — distinguishing elements from compounds by types of atoms — by building 2D and 3D models with plasticine and toothpicks, then judging what each model shows and hides.

- **Risk (subtopic 3B):** low-hazard build. Toothpicks are pointed — carry models carefully, never gesture with one, and count them out and back in; plasticine is for modelling, not for eating; wipe the bench afterwards. Plan and run with the risk-management guidance from Science ASSIST (see Sources).
- **Recording (subtopic 3C):** copy the table before you start, and record what your model actually shows — not what the diagram shows.

Build each model twice: once laid flat on the bench (2D), once held up with the joins pointing in different directions (3D).

Model	Balls used	Element or compound?	One thing your model shows well	One thing it cannot show
water, H_2O	1 oxygen + 2 hydrogen			
carbon dioxide, CO_2	1 carbon + 2 oxygen			
oxygen gas, O_2	2 oxygen			
methane, CH_4	1 carbon + 4 hydrogen			



A key and four models built from plasticine balls and toothpicks, as in the activity: water H2O bent, carbon dioxide CO2 in a straight line, oxygen gas O2 as a joined pair, and methane CH4 as a carbon with four hydrogens. A footer line reads: laid flat, each model is two-dimensional; held up, it is three-dimensional.

Argue about oxygen gas last. It is made of joined atoms — but of *one kind only*, so it is an element, and its formula O_2 is a molecule's formula, not a compound's. That single case is the sharpest test of the definitions: *joined* does not mean *compound*; **two or more kinds of atom** does.

Words to know in 11A

Term	Meaning
atom	the smallest particle of an element that is still that element
element	a substance made of one kind of atom only (gold, oxygen, helium)
compound	a substance in which two or more kinds of atom are joined in a fixed recipe (water, salt)
mixture	two or more substances in the same place, not joined; the recipe can vary (air, brass, seawater)
molecule	a joined group of atoms; the formulas of molecules such as O_2 and H_2O show how many atoms of each kind are joined
pure substance	one kind of stuff with a fixed make-up — the elements and the compounds
solution	a mixture in which the dissolved particles are spread evenly and never settle (salt water)
suspension	a mixture whose large particles settle if left (muddy water)
colloid	a mixture whose tiny particles stay floating throughout and do not settle (milk)
symbol	the one- or two-letter name of an element, first letter capitalised (Cu, O, Na)
chemical formula	symbols and subscript numbers naming the elements in a substance and counting the atoms of each (H_2O, $CaCO_3$)

Term	Meaning
subscript	the small number written low after a symbol in a formula, counting atoms of that element
periodic table	the chart of all the elements, each with its own square and number, arranged so the pattern shows
percentage	a share out of every 100 parts; the way a mixture's varying recipe is written down

Worked examples

Example 1 — scaffolded

Classify each sample as an element, a compound or a mixture, using the particle descriptions given.

(i) A gold ring: nothing but gold atoms.
(ii) The gas in a party balloon: nothing but helium atoms.
(iii) Carbon dioxide: every particle is one carbon atom joined to two oxygen atoms.
(iv) Air: nitrogen molecules, oxygen molecules, argon atoms and others, all in the same place, none joined to each other.
(v) Brass: copper atoms and zinc atoms sitting side by side, each keeping its own properties.

(Scaffold: count the kinds of atoms, then ask whether different kinds are joined or just together. One kind of atom = element; joined kinds in a fixed recipe = compound; substances together, not joined = mixture.)

Working	Comment
(i) One kind of atom only (gold).	Element.
(ii) One kind of atom only (helium).	Element.
(iii) Two kinds of atom (carbon, oxygen) joined in a fixed recipe, 1:2.	Compound.
(iv) Several substances in the same place, not joined; the recipe varies from place to place.	Mixture.
(v) Two kinds of atom (copper, zinc) side by side, not joined; the recipe varies from coin to coin.	Mixture.

Example 2 — scaffolded

For each formula, name the elements present and count the atoms of each. Then say whether the formula is a compound's formula or an element's formula.

(i) H_2O (ii) CO_2 (iii) $CaCO_3$ (iv) O_2

(Scaffold: read left to right; a subscript counts the atoms of the symbol before it; no subscript means one atom; two capitals in a row are two different elements.)

Working	Comment
(i) Hydrogen ×2, oxygen ×1.	Two kinds of atom joined → compound.
(ii) Carbon ×1, oxygen ×2.	Two kinds of atom joined → compound.
(iii) Calcium ×1, carbon ×1, oxygen ×3.	Three kinds of atom joined → compound.
(iv) Oxygen ×2.	One kind of atom only → an element (as joined pairs).

Example 3 — unscaffolded

Typical seawater holds about 35 g of dissolved salt in every 1000 g of seawater.

(a) Write the salt's share as a percentage.
(b) Hence find the mass of salt in 2000 g of the same seawater.

35 g out of 1000 g is 3.5 g out of every 100 g — dividing both quantities by 10 — so the salt's share is 3.5%. For 2000 g of the same seawater, double the sample doubles the salt: 2 × 35 g = 70 g. (Check: 3.5% of 2000 g = 3.5 × 20 = 70 g.)

∴ (a) 3.5%; (b) 70 g of salt — and note the *percentage* stays 3.5% whatever the sample size: it describes the mixture, not the bucket.

Example 4 — unscaffolded

Water is represented by the formula H_2O, but air is represented by percentages (about 78% nitrogen, about 21% oxygen). Explain, using the definitions of compound and mixture, why each substance gets the representation it gets.

Water is a compound: every particle of it is two hydrogen atoms joined to one oxygen atom, and that recipe is fixed — any pure sample of water has exactly that make-up — so the fixed recipe can be written as a formula, H_2O. Air is a mixture: nitrogen, oxygen, argon and other substances share the same space, none joined to the others, and the recipe varies — the carbon dioxide share rises year by year, and humid air holds more water vapour than dry air. A varying recipe cannot be a formula, so air is written as percentages, the shares out of every 100 parts.

∴ a formula needs a fixed recipe (compound); a percentage describes a varying one (mixture).

Practice questions

Scaffolded

Q1. Define, in your own words: *(Scaffold: the key ideas are how many kinds of atom are present, and whether different kinds are joined or just together.)* (a) element; (b) compound; (c) mixture.

Q2. Classify each sample as an element, a compound or a mixture. *(Scaffold: one kind of atom = element; joined kinds, fixed recipe = compound; substances together, not joined = mixture.)* (a) An iron nail: nothing but iron atoms. (b) Methane, CH_4: one carbon joined to four hydrogens in every particle. (c) Sugar stirred into water until it seems to vanish. (d) The oxygen in air: O_2 molecules only. (e) Muddy water left to stand in a jar. (f) Distilled water: H_2O and nothing else.

Q3. For each formula, name the elements present and count the atoms of each. *(Scaffold: a subscript counts the atoms of the symbol before it; no subscript means one atom.)* (a) H_2O (b) CO_2 (c) NH_3 (d) $CaCO_3$

Q4. A student writes the symbol for cobalt as **CO**. Is that correct? If not, write it correctly and say what **CO** means instead. *(Scaffold: first letter capital, second letter small; a second capital starts a new element.)*

Q5. Using the rule that some symbols come from older names, give the symbols for: *(Scaffold: the Latin names are ferrum, natrium, kalium, aurum, argentum, plumbum.)* (a) iron; (b) sodium; (c) gold; (d) lead.

Q6. The figure of methane shows a ball-and-stick model and a space-filling model of the same molecule. *(Scaffold: every model shows some things well and hides others.)* (a) Give one thing the ball-and-stick model shows well. (b) Give one thing the space-filling model shows well. (c) Give one thing the ball-and-stick model hides or gets wrong.

Unscaffolded

Q7. A sealed box holds three O_2 molecules and two N_2 molecules, all in the same space and none joined to each other. Is the contents of the box an element, a compound or a mixture? Justify your answer from the definitions.

Q8. Give two reasons why scientists represent elements by symbols rather than by full names in their writing.

Q9. About the first periodic table of Mendeleev: (a) What did Mendeleev do where no known element fitted his mass order? (b) How did the discovery of gallium in 1875 support his table? (c) Give one way the order of the current periodic table is different from the order of the first table.

Q10. Sodium chloride, the salt in the sea, has the formula NaCl — yet seawater itself is never given a formula. Explain why, using the definitions of compound and mixture.

Q11. Dry air is 78.08% nitrogen by volume. In 1000 L of dry air, about how many litres are nitrogen? Give your answer to the nearest litre.

Q12. For water, the formula H_2O, a flat 2D drawing, and a 3D model are three representations. (a) What does the formula tell you that the 2D drawing does not? (b) What does the 3D model tell you that the formula does not?

Q13. Three unlabelled jars hold salt water, muddy water and milk. Using only what you can observe over an hour, and the ideas of solution, suspension and colloid, explain how you would tell which jar is which.

Q14. About 40 million copper atoms in a row would measure about 1 cm. (a) What does this fact tell you about the size of one atom? (b) Explain why this fact forces scientists to work with models of atoms rather than with atoms themselves.

Answers

Q1. (a) A substance made of one kind of atom only. (b) A substance in which two or more kinds of atom are joined in a fixed recipe. (c) Two or more substances in the same place, not joined. **Q2.** (a) Element; (b) compound; (c) mixture; (d) element; (e) mixture; (f) compound. **Q3.** (a) Hydrogen ×2, oxygen ×1; (b) carbon ×1, oxygen ×2; (c) nitrogen ×1, hydrogen ×3; (d) calcium ×1, carbon ×1, oxygen ×3. **Q4.** No — Co. CO means carbon and oxygen joined: the compound carbon monoxide. **Q5.** (a) Fe; (b) Na; (c) Au; (d) Pb. **Q6.** (a) The joins — which atom is joined to which. (b) The space the atoms fill, the molecule's true shape and bulk. (c) It hides that atoms pack close together — there are no sticks between atoms. **Q7.** Mixture — see solutions. **Q8.** Any two of: short; exact; the same in every language — see solutions. **Q9.** (a) Left a gap and predicted the missing element's properties; (b) gallium matched the prediction (density 5.9 g/cm³); (c) ordered by the element's own number, not by mass — see solutions. **Q10.** NaCl is a compound (fixed recipe); seawater is a mixture (varying recipe) — see solutions. **Q11.** About 781 L. **Q12.** (a) The exact counts of each atom; (b) the shape of the molecule (bent) — see solutions. **Q13.** The suspension settles, the colloid stays cloudy, the solution stays clear — see solutions. **Q14.** (a) Atoms are extremely small; (b) atoms cannot be seen or handled one by one — see solutions.

Fully-worked solutions

Q1. *(3 marks)* (a) An element is a substance made of one kind of atom only. *(1 mark)* (b) A compound is a substance in which two or more kinds of atom are joined together in a fixed recipe. *(1 mark)* (c) A mixture is two or more substances in the same place, not joined — each keeps its own properties and the recipe can vary. *(1 mark)*

Q2. *(6 marks)* (a) Element — one kind of atom only (iron). *(1 mark)* (b) Compound — two kinds of atom (carbon, hydrogen) joined in a fixed recipe. *(1 mark)* (c) Mixture — sugar and water together, not joined; the sugar is still sugar (dissolving is a physical change). *(1 mark)* (d) Element — one kind of atom only (oxygen), even though the atoms come in joined pairs. *(1 mark)* (e) Mixture — mud and water together, not joined; the mud settles, so it is a suspension. *(1 mark)* (f) Compound — every particle is two hydrogens joined to one oxygen; a fixed recipe. *(1 mark)*

Q3. *(4 marks)* (a) Hydrogen ×2, oxygen ×1. *(1 mark)* (b) Carbon ×1, oxygen ×2. *(1 mark)* (c) Nitrogen ×1, hydrogen ×3. *(1 mark)* (d) Calcium ×1, carbon ×1, oxygen ×3. *(1 mark)*

Q4. *(2 marks)* No: the symbol for cobalt is **Co**, one capital and one small letter. *(1 mark)* **CO**, with two capitals, is two elements joined — carbon and oxygen — the compound carbon monoxide. *(1 mark)*

Q5. *(4 marks)* (a) Fe, from Latin ferrum. *(1 mark)* (b) Na, from Latin natrium. *(1 mark)* (c) Au, from Latin aurum. *(1 mark)* (d) Pb, from Latin plumbum. *(1 mark)*

Q6. *(3 marks)* (a) The ball-and-stick model shows the joins — which atom is joined to which — clearly. *(1 mark)* (b) The space-filling model shows the space the atoms fill and the molecule's overall shape. *(1 mark)* (c) The ball-and-stick model gets the spacing wrong: real atoms pack close together and there are no sticks between them. *(1 mark)*

Q7. *(2 marks)* A mixture. *(1 mark)* Two substances — the element oxygen (O_2) and the element nitrogen (N_2) — are in the same space, not joined to each other, so the definitions make it a mixture (it is, in fact, a tiny model of air). *(1 mark)*

Q8. *(2 marks)* Any two of: a symbol is short, so formulas and notes stay compact; a symbol is exact, naming one element only; a symbol is the same in every language, so scientists worldwide read it the same way. *(1 mark each, max 2)*

Q9. *(3 marks)* (a) He left a gap and wrote down the properties the missing element should have (a prediction). *(1 mark)* (b) Gallium, discovered in 1875, fitted the eka-aluminium gap, and its measured density of 5.9 g/cm³ matched his prediction — evidence that the arrangement captured something real. *(1 mark)* (c) The current table orders the elements by the element's own number, not by the mass of the atom (and it holds all 118 elements, not the ~60 known in 1869). *(1 mark)*

Q10. *(2 marks)* NaCl is a compound: the two elements sodium and chlorine joined in a fixed recipe, so the recipe can be written as a formula. *(1 mark)* Seawater is a mixture: salt and water together, not joined, and the saltiness varies from place to place — a varying recipe can only be written as a percentage (about 3.5%), never as a formula. *(1 mark)*

Q11. *(2 marks)* 78.08% of 1000 L = 78.08 × 1000 ÷ 100 = 780.8 L. *(1 mark)* To the nearest litre, about 781 L of the 1000 L are nitrogen. *(1 mark)*

Q12. *(2 marks)* (a) The formula gives the exact counts — two hydrogen atoms and one oxygen atom in every particle — which a drawing alone does not state. *(1 mark)* (b) The 3D model shows the molecule's real shape — bent, not straight — which the formula does not show. *(1 mark)*

Q13. *(3 marks)* Leave the jars for an hour. The jar whose particles settle to the bottom, leaving clearer water above, is the suspension — muddy water. *(1 mark)* The jar that stays evenly cloudy throughout, never settling, is the colloid — milk. *(1 mark)* The jar that stays clear, with nothing ever settling, is the solution — salt water. *(1 mark)*

Q14. *(2 marks)* (a) One atom is extremely small — about 0.000 000 025 6 cm across for copper — far below anything we can see. *(1 mark)* (b) Because atoms cannot be seen, counted or handled one by one, scientists must represent them with models — drawings, ball-and-stick builds, symbols and formulas — and judge each model by what it shows and what it hides. *(1 mark)*

Sources

- Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8 — content description `VC2S8U07` (owned whole) and elaborations `VC2S8U07.E01`–`VC2S8U07.E05`, used as elaboration contexts (D6/D12); achievement-standard extract as cited in the header (D13).
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- Wikipedia, Seawater, 2026 — about 35 g of dissolved salts per kilogram of seawater (about 3.5%), predominantly sodium and chloride, i.e. mostly sodium chloride.
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- Wikipedia, Gallium and Mendeleev's predicted elements, 2026 — eka-aluminium predicted by Mendeleev (1871) with mass about 68; gallium discovered by Lecoq de Boisbaudran in 1875; density measured at 5.9 g/cm^3, the value Mendeleev had predicted.
- Wikipedia, Periodic table, 2026 — 118 elements recognised in the current table, of which about 60 were known when Mendeleev made his first table in 1869.
- ASTA (Science ASSIST), Science Safety Essentials: Risk Assessment in Science (published 2022-10-25, modified 2025-12-15)
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Web sources above were retrieved 2026-08-21.

Physical change against chemical change — and how to tell which one you just watched

What we teach here — `VC2S8U08` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"physical changes can be distinguished from chemical changes; a chemical change can be identified by a colour change, a temperature change, the production of a gas (including laboratory preparation and testing of oxygen, carbon dioxide and hydrogen gases) or the formation of a precipitate"* **This subtopic owns the first clause only**: distinguishing physical changes from chemical changes — what each kind of change is, what the particles are doing in each, how to decide which kind of change you have just watched, and how the physical and chemical properties of a substance shape its production and use. The second clause — the four named indicators of chemical change and the laboratory preparation and testing of oxygen, carbon dioxide and hydrogen — belongs to the partner subtopic **11C** († split delivery, D6). **In our words:** some changes only alter how a substance looks or where it is — the substance stays the same substance. Other changes make brand-new substances with brand-new properties. The whole skill of this subtopic is watching a change and asking one question: *was a new substance made?* **Achievement-standard extract served here (D13):** *"They classify and represent matter as elements, compounds or mixtures, and distinguish between physical and chemical changes."* 11B is the owner of `VC2S8U08`, so the extract appears here in full; the partner subtopic 11C cites it by reference to this header. **Elaborations drawn on:** `VC2S8U08.E02` (analysing and interpreting data on the properties of substances before and after the substances interact, to determine if a chemical or physical change has occurred) and `VC2S8U08.E03` (examining how the physical and chemical properties of a substance will affect its production or use). E02 is the method of the middle theory sections and of Worked Example 2; E03 is the method of the final theory section and of Worked Example 4. **Scope notes.** The particle view used here is the one built in 10A and 10B (`VC2S8U05`) and the element–compound–mixture idea is the one built in 11A (`VC2S8U07`); neither is re-taught. No chemical equations, word or symbol, appear in this subtopic (they belong to Levels 9–10, D9), and atoms are never split into smaller parts here. The four observable indicators named in the second clause of the CD are previewed here as *signs to watch for* and taught in full, with the three gas tests, in 11C.

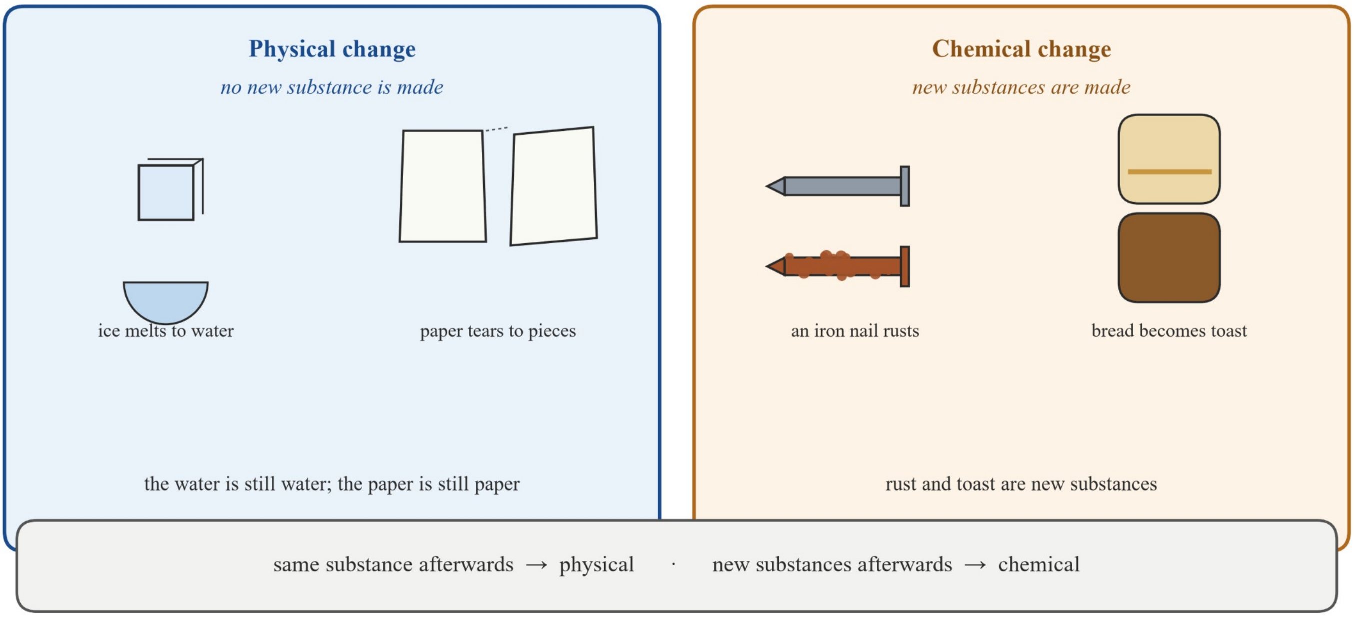
Definitional preface — what *physical change* and *chemical change* mean here. The Victorian Curriculum uses the terms *physical change* and *chemical change* but does not define them. This subtopic therefore treats them as follows, and every question here is answerable on these definitions alone: a **physical change** is a change in which **no new substance is made** — the substance or substances present afterwards are the same ones that were present beforehand, perhaps in a different shape, size or state. A **chemical change** is a change in which **one or more new substances are made**, with properties different from the substances present beforehand. (This is the operational definition convention of the house; see CONTESTED_TERMS rule 1.)

Theory

Change is everywhere — but there are two kinds

Look around any kitchen and you will see matter changing: ice melts in a glass, water boils in a kettle, bread browns in the toaster, a nail in the garden slowly turns orange-brown. All of these are changes, but they are not the same *kind* of change. Science sorts them into two groups, and the difference between the two groups is one of the most useful ideas in chemistry.

- A **physical change** makes **no new substance**. The matter present after the change is the same matter that was present before it — it may look different, be in a different place, or be in a different state (solid, liquid or gas), but it is the same substance.
- A **chemical change** makes **one or more new substances**. The matter present after the change is not the same as before: new substances have been made, and each new substance has its own set of properties.



Two panels side by side. The left panel is headed physical change — no new substance is made, and shows two examples: an ice cube melting into a puddle of water, and a sheet of paper being torn into two pieces; a caption reads the water is still water and the paper is still paper. The right panel is headed chemical change — new substances are made, and shows two examples: a grey iron nail turning orange-brown as it rusts, and a slice of bread turning dark brown in a toaster; a caption reads rust and toast are new substances that were not there at the start. A strip across the bottom reads: same substance afterwards → physical; new substances afterwards → chemical.

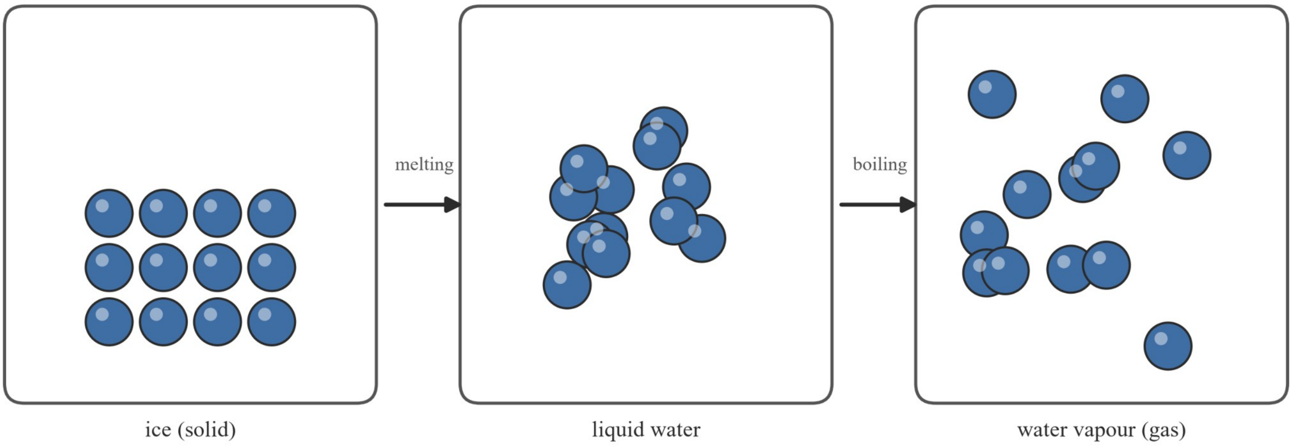
Here is a first pair to hold in mind. When an ice cube melts, the solid becomes a liquid — but it is still water, and if you cool the liquid again it freezes back into ice. That is a physical change. When a slice of bread is toasted, the heat makes new brown substances with a new smell and a new taste — and no kitchen can turn toast back into bread. That is a chemical change.

> **Word watch — *physical*.** In everyday talk, *physical* often means *of the body* (a physical injury) or *involving force* (a physical game). In this subtopic, *physical* means something much narrower: a change to do with **appearance and state, not with what the substance is**. A physical change can be dramatic — a car crushed into a cube is a dramatic change — yet still physical, because the metal and glass are the same substances they were before.

What the particles are doing

Chapter 10 built the particle model of matter: every substance is made of tiny particles, and the arrangement, motion and attraction of those particles explain what a substance does (10A, 10B). The particle model also gives the cleanest way to see the difference between the two kinds of change.

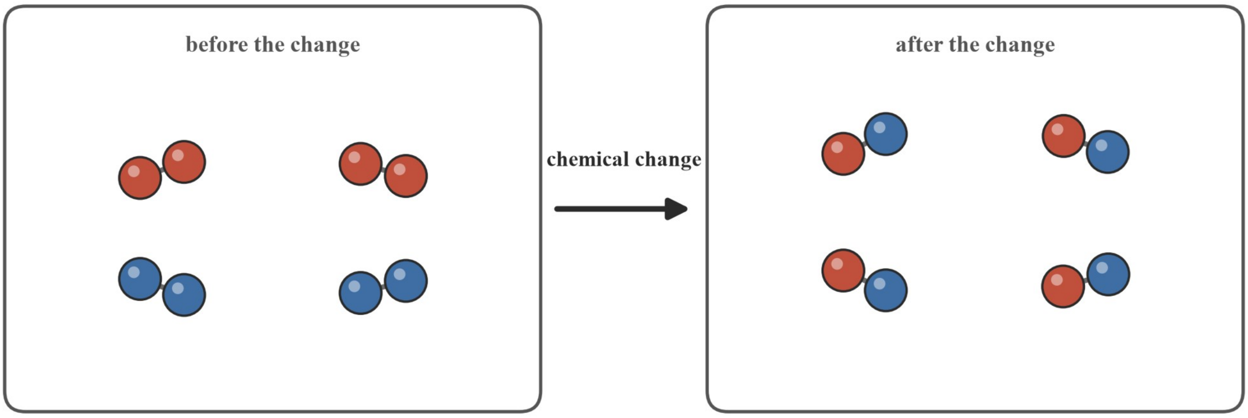
In a **physical change, the particles themselves do not change** — only their arrangement, their spacing or their motion changes. When ice melts, the water particles that were locked in place in the solid break free to slide around one another as a liquid. The particles after the change are the same particles as before it.



a physical change in the particle model — the particles are the same before and after; only their arrangement, spacing and motion change

Three boxes in a row joined by arrows, each holding the same twelve small blue particles drawn in the house particle style. Box 1, labelled ice (solid), shows the particles in neat rows, touching. Box 2, labelled liquid water, shows the same number of particles slightly further apart and jumbled. Box 3, labelled water vapour (gas), shows the same number of particles far apart and scattered. A caption beneath reads: a physical change in the particle model — the particles are the same before and after; only their arrangement, spacing and motion change.

In a **chemical change, the particles themselves are rearranged to make the particles of new substances**. The particles that made up the starting substances come apart and join together in new combinations, and each new combination is a new substance with its own properties. This is what happens when iron rusts, when wood burns, or when a cake bakes: the particles present at the end are not the particles present at the start, arranged in a new way — they are *new groupings of particles* making new substances.



the particles have rearranged into new groupings — each new grouping is a new substance;
no particles are lost and none are added. Coloured balls are a model, not a chemical equation.

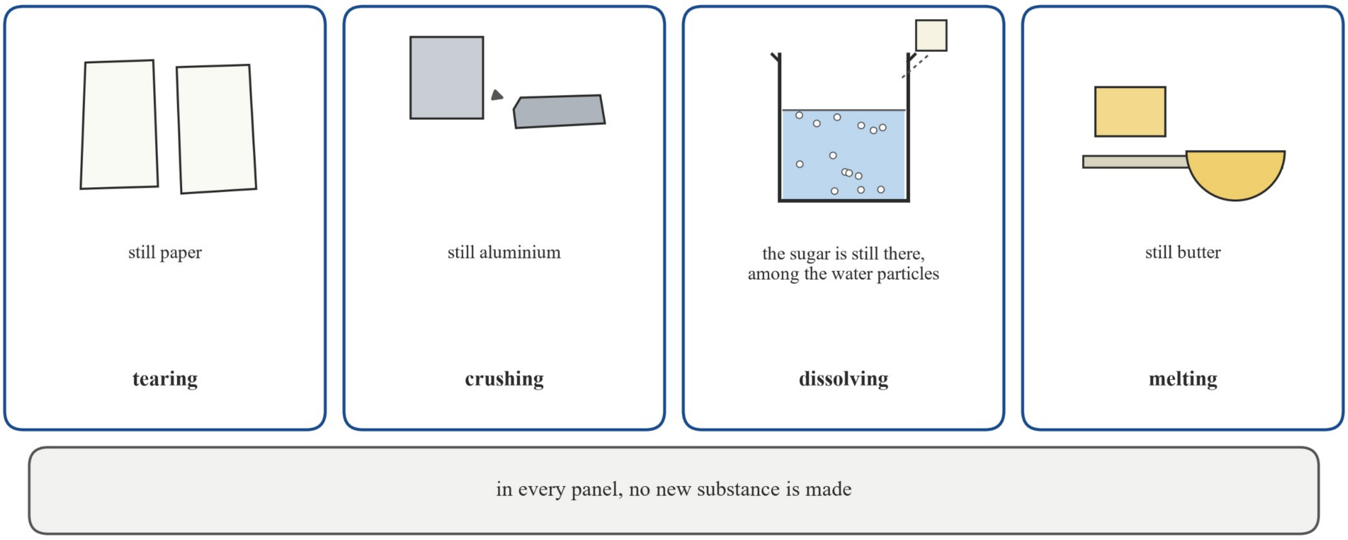
Two boxes joined by a large arrow. The left box is labelled before the change and holds particles in pairs: two red particles bonded together, twice, and two blue particles bonded together, twice. The right box is labelled after the change and holds four pairs in which each pair is one red particle bonded to one blue particle. A caption beneath reads: a chemical change in the particle model — the particles have rearranged into new groupings, and each new grouping is a new substance. No particles are lost and none are added; they are partnered in a new way. The drawing is a model with coloured balls standing in for particles; it is not a chemical equation.

Model note. The particle drawings in this subtopic are models (4B): coloured balls standing in for particles, drawn big enough to see. Real particles are far smaller than any drawing, and the drawing is not a chemical equation — it shows the *idea* of rearrangement, and nothing is counted or balanced in this book (equations belong to Levels 9–10, D9).

Physical changes: same substance, different look

Changes of state are the cleanest physical changes, and you already met them in 10A: melting, freezing, boiling, condensing and subliming are all changes in which the substance keeps its identity. Steam, liquid water and ice are three faces of the one substance, water. But physical changes are not only changes of state. Each of these is a physical change too, because in each one no new substance is made:

- **Changing shape** — crushing a drink can, bending a wire, tearing paper, cutting a carrot. The pieces are smaller or bent, but they are the same substance.
- **Dissolving** — stirring sugar into water. The sugar seems to vanish, but the sugar is still there, spread out among the water particles as a solution (10C). Let the water evaporate and the sugar is left behind, unchanged.
- **Mixing** — stirring sand into water, or mixing two foods in a bowl. Each substance keeps its own properties and could be separated again (10D).



Four rounded panels of everyday physical changes. Panel 1: a sheet of paper torn into two pieces, captioned tearing — still paper. Panel 2: an aluminium drink can crushed flat, captioned crushing — still aluminium. Panel 3: sugar crystals stirred into a beaker of water with the crystals disappearing, captioned dissolving — the sugar is still there, spread among the water particles. Panel 4: a pat of butter softening and slumping on a warm plate, captioned melting — still butter. A footer line reads: in every panel, no new substance is made.

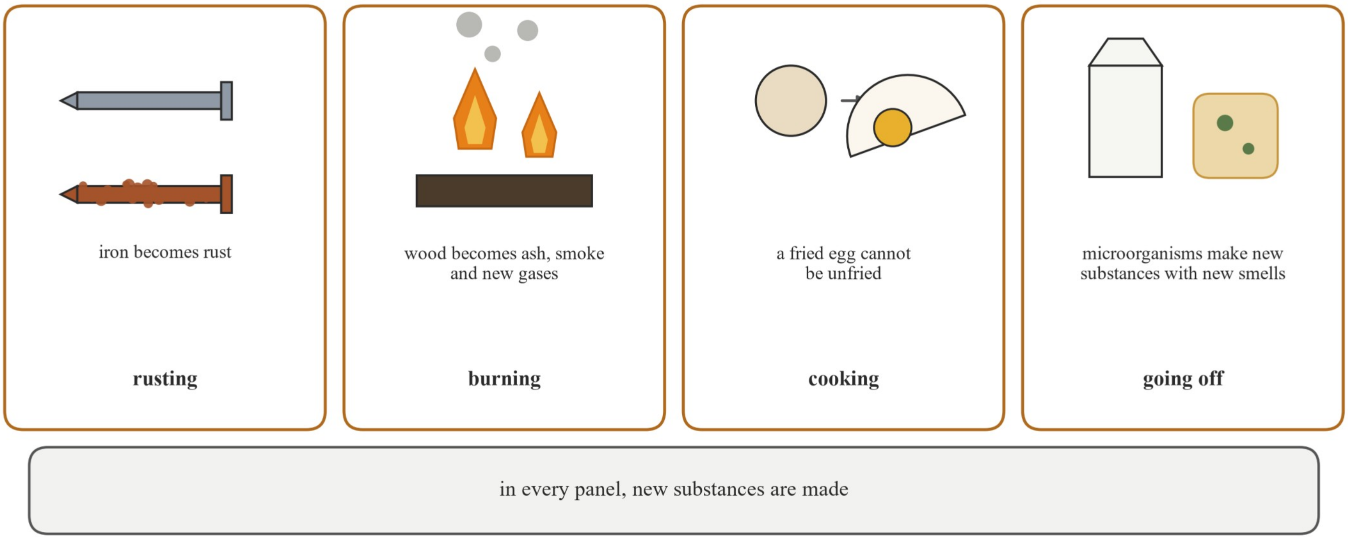
Word watch — *dissolve* is not *melt*. Both words describe something that seems to disappear, but they are different changes. **Melting** is a change of state: one substance, heated, becomes a liquid (ice → water). **Dissolving** needs *two* substances: one spreads out among the particles of the other to form a solution (sugar in water). Melted butter is still one substance; dissolved sugar is sugar *and* water together. Both are physical changes — but for different reasons.

Chemical changes: new substances everywhere

Chemical changes are just as common as physical ones; they are simply harder to undo. Each of these makes new substances:

- **Rusting** — iron left in damp air slowly changes into rust, a crumbly orange-brown substance with properties quite unlike iron's.
- **Burning** — wood, paper, gas or candle wax burning makes new substances you can see (smoke, soot, ash) and new substances you cannot see (gases that rise into the air).

- **Cooking** — frying an egg, baking a cake, toasting bread. The heat drives chemical changes that make new substances: a fried egg cannot be unfried.
- **Going off** — milk turning sour and fruit going mouldy are chemical changes made by living microorganisms (9A): new substances with new smells and tastes are being produced.



Four rounded panels of everyday chemical changes. Panel 1: a grey iron nail beside the same nail covered in flaky orange-brown rust, captioned rusting — iron becomes rust, a new substance. Panel 2: a small campfire of burning wood with flames, smoke and a black charred log, captioned burning — wood becomes ash, smoke and new gases. Panel 3: a raw egg beside a fried egg with a set white, captioned cooking — the heat makes new substances; a fried egg cannot be unfried. Panel 4: a milk carton beside a slice of bread with two green mould spots on it, captioned going off — microorganisms make new substances with new smells. A footer line reads: in every panel, new substances are made.

Chemical changes matter far beyond the kitchen. The food industry, the building industry and medicine all depend on making wanted chemical changes happen — and stopping unwanted ones (more on this in the final theory section).

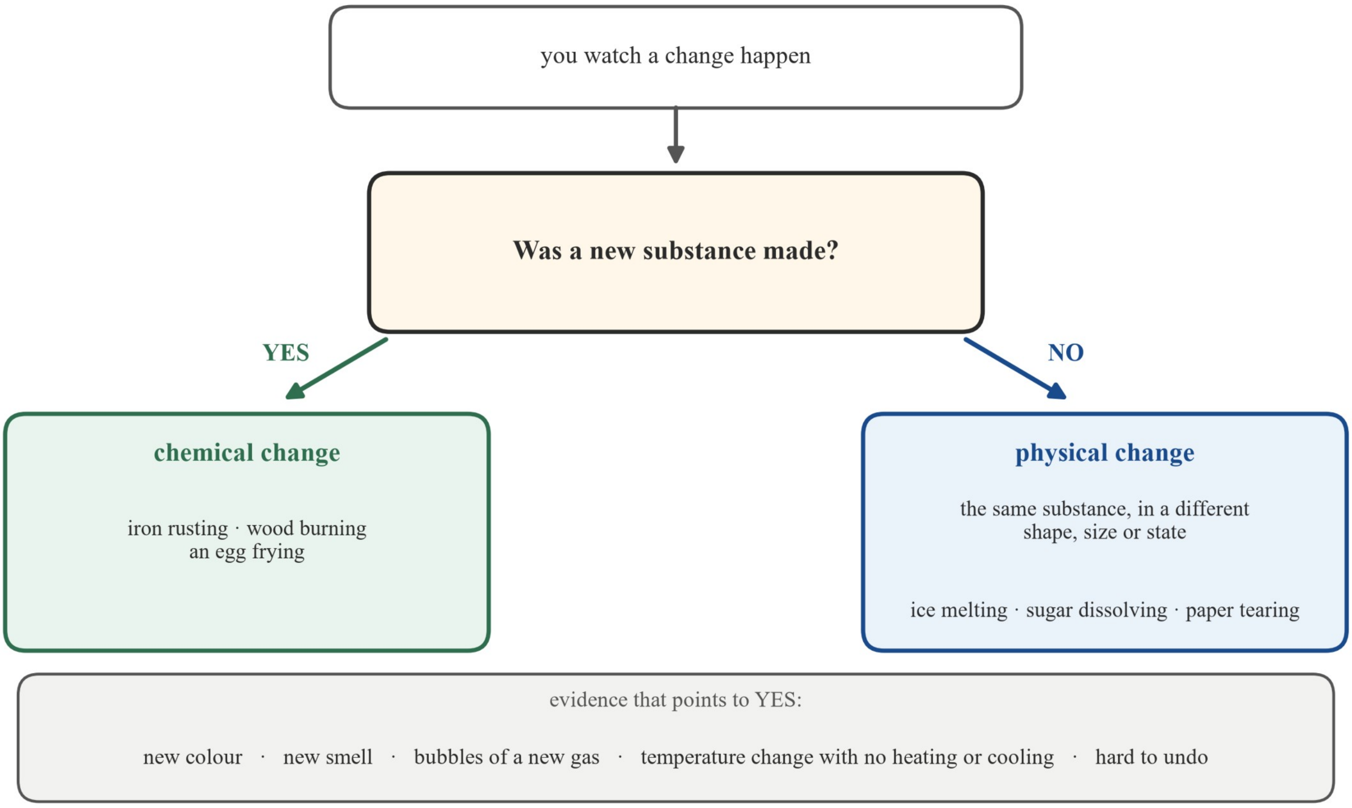
How to tell which one you just watched

Now the skill this subtopic is named for. You watch something happen — a solid melts, a colour appears, bubbles rise — and you are asked: *physical or chemical?* The deciding question is always the same:

Was a new substance made?

Everything else is evidence for or against that one question. Look at the change and ask:

1. **Do the properties afterwards differ from the properties before?** A new colour, a new smell, a new behaviour (a liquid that now conducts, a metal that now crumbles) all point to a new substance. If every property you can check is the same as before — same colour, same melting point, same density — then no new substance was made.
2. **What did you see happen?** Signs worth watching for include a colour appearing that nobody added, a temperature rising or falling with no heating or cooling, bubbles of a new gas, or a solid appearing where there was none. The next subtopic, **11C**, takes these observable signs — the *indicators* of chemical change — in turn and teaches how to test them the right way. Here they serve as clues to the one question above.
3. **Is the change easy to undo?** Many physical changes reverse easily (freeze the water back, evaporate the water and keep the sugar). Chemical changes usually do not reverse easily, if at all. Use this as a clue only — the next section explains why.

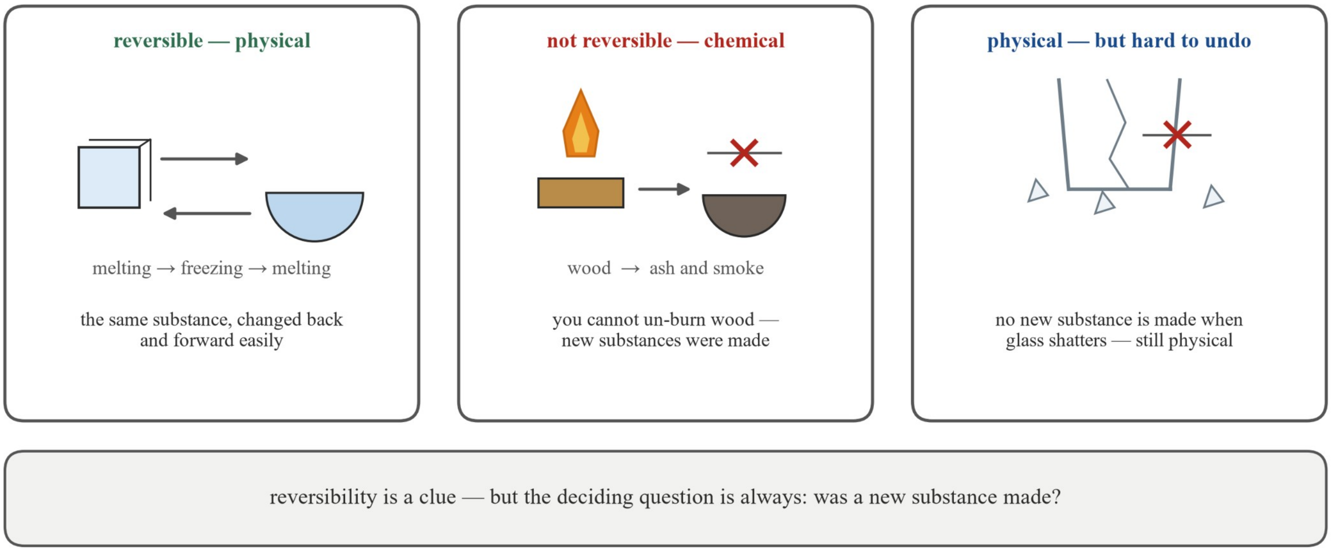


A decision chart. A top box reads: you watch a change happen. One arrow leads down to a large question box: was a new substance made? From the question box, a YES arrow leads left to a green box reading chemical change — examples: iron rusting, wood burning, an egg frying. A NO arrow leads right to a blue box reading physical change — the same substance, in a different shape, size or state — examples: ice melting, sugar dissolving, paper tearing. Beneath the chart a strip of evidence chips reads: new colour · new smell · bubbles of a new gas · temperature change with no heating or cooling · hard to undo — each one is evidence pointing toward YES.

Reversibility: a clue, not the rule

Because so many physical changes reverse easily, students often learn the short rule *physical changes can be undone, chemical changes cannot*. The rule is a useful clue — and it is not reliable enough to decide with. Two cases break it:

- Some **physical** changes are very hard to undo. Smashing a glass or crushing a can makes no new substance — the change is physical — but you cannot easily put the pieces back.
- Some **chemical** changes *can* be undone, given the right conditions. A rechargeable battery runs its chemical change one way when it is being used and the other way when it is being charged.



Three panels. Panel 1, labelled reversible — physical: an ice cube melting to water with a forward arrow, and the water freezing back to ice with a return arrow, captioned melting and freezing undo each other easily. Panel 2, labelled not reversible — chemical: wood burning to ash and smoke with a forward arrow and a crossed-out return arrow, captioned you cannot un-burn wood; new substances were made. Panel 3, labelled physical but hard to undo: a drinking glass shattered on the floor with a crossed-out return arrow, captioned no new substance is made when glass shatters — the change is physical even though it cannot easily be undone. A footer line reads: reversibility is a clue, but the deciding question is always was a new substance made?

So keep the clue, but do not let it decide for you. A shattered glass and a crushed can are physical changes that are hard to undo; burning paper is a chemical change that is impossible to undo; a charging battery is a chemical change that *is* undone. Through all four cases, the question that never gets it wrong is the one about new substances.

> **Word watch — *reversible*.** In everyday talk, *reversible* often just means *able to be changed back* (a reversible decision). In this subtopic it means able to be changed back **into the original substances**. Melting is reversible because water freezes back into ice — the same substance. Toast is not, because no process hands back the bread.

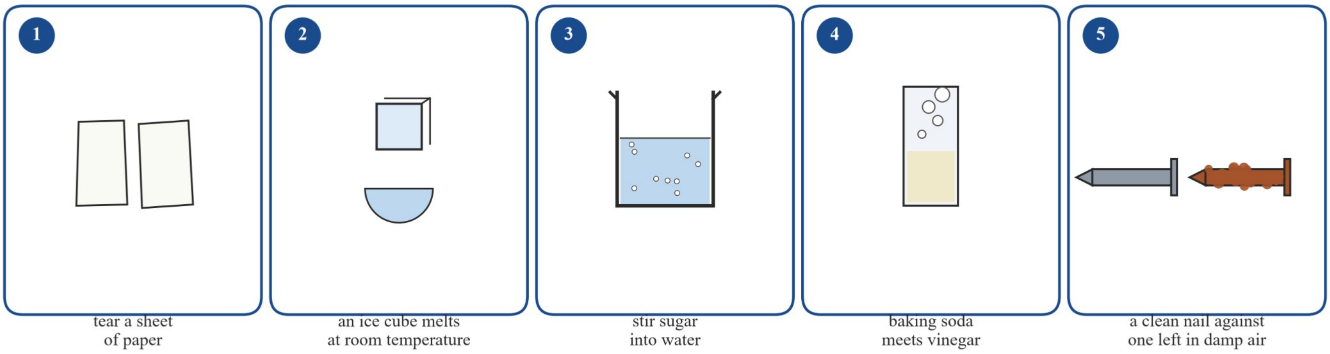
Activity: five stations, one question

This activity practises the deciding question at five small stations. It is a classification observation, not a fair test — there is no variable being measured (3A), and the skill being practised is recording what you see accurately (3C).

- **Risk (subtopic 3B):** all five stations are low-hazard. Small quantities only; spills wiped up at once; no tasting anything in the laboratory; the rusted nail is handled by its clean end or with gloves; used mixtures go to the container your teacher names. Plan and run with the risk-management guidance from Science ASSIST (see Sources).
- **Recording (subtopic 3C):** copy the table below before you start, and record what you actually see at each station — not what you expected to see.

Station	What is done	What you observe	New substance made?	Physical or chemical?
1	Tear a sheet of paper in half			
2	Leave an ice cube in a beaker at room temperature			
3	Stir a spoon of sugar into water until it			

Station	What is done	What you observe	New substance made?	Physical or chemical?
	seems to vanish			
4	Mix a small spoon of baking soda with vinegar in a test tube			
5	Compare a clean iron nail with one left in damp air for weeks			



at each station: record what you observe, then ask the deciding question — was a new substance made?

Five station cards in a row. Station 1: a sheet of paper torn into two pieces. Station 2: an ice cube melting into a small puddle. Station 3: a beaker of water with sugar crystals spread through it and a sugar cube being tipped in. Station 4: a test tube of vinegar with bubbles rising after baking soda was added. Station 5: a shiny nail and a rusty nail side by side. A caption beneath the row reads: at each station, record what you observe, then ask the deciding question — was a new substance made?

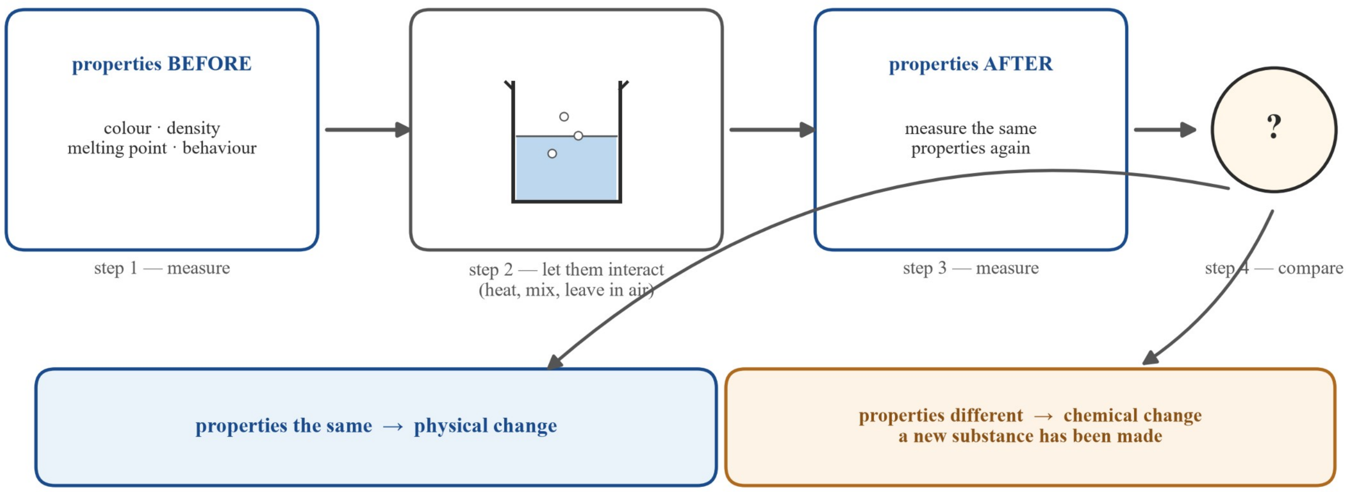
Station 4 is the interesting one to argue about. Bubbles of a new gas rise when baking soda meets vinegar — evidence that something new is being made — and the mixture's temperature changes too. You have met the sort of evidence that points to a chemical change; in 11C you will learn to name and test each sign the right way. Stations 1–3 and 5 sort cleanly: tearing, melting, dissolving and comparing the nails each leave the substances themselves unchanged (station 5 shows the *result* of a chemical change that already happened over weeks, not a change happening in front of you).

Deciding with data: properties before and after (`VC2S8U08.E02`)

The surest way to tell the two changes apart is not to watch the change at all — it is to compare the **properties** of the substances before and after. A **property** is anything about a substance you can measure or observe: its colour, its density, its melting point, whether it conducts electricity, whether it is attracted to a magnet, how it behaves with acids or in water.

The method has four steps:

1. Record the properties of the substances **before** they interact.
2. Let the substances interact (heat them, mix them, leave them in air or water).
3. Record the properties of whatever is present **after**.
4. Compare. **If the properties are the same, the change is physical. If the properties differ, a new substance has been made and the change is chemical.**

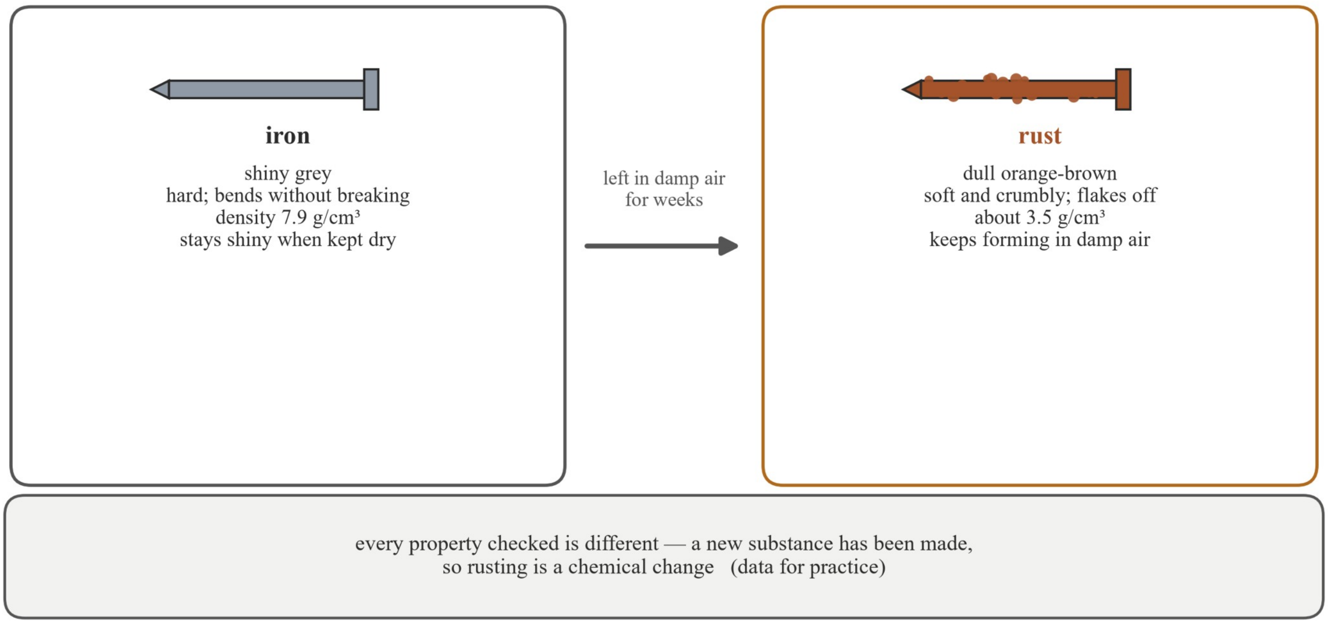


A four-step method chain, left to right. Step 1: a clipboard labelled properties BEFORE — measure colour, density, melting point, behaviour. Step 2: two substances meeting in a beaker, labelled let the substances interact. Step 3: a clipboard labelled properties AFTER — measure the same properties again. Step 4: a balance comparing the two clipboards, with two outcomes below it: properties the same → physical change, and properties different → chemical change, a new substance has been made.

Worked through on a real case: an iron nail left in damp air. Before, the nail is a shiny grey metal that is hard, bendable and dense. After some weeks, part of it has become rust. The table compares the two substances.

Property	Iron (before)	Rust (after)
Colour	shiny grey	dull orange-brown
Hardness and feel	hard; bends without breaking	soft and crumbly; flakes off
Density	7.9 g/cm³	about 3.5 g/cm³
Behaviour in damp air	stays shiny if kept dry	keeps forming, flake by flake

(Data for practice.)

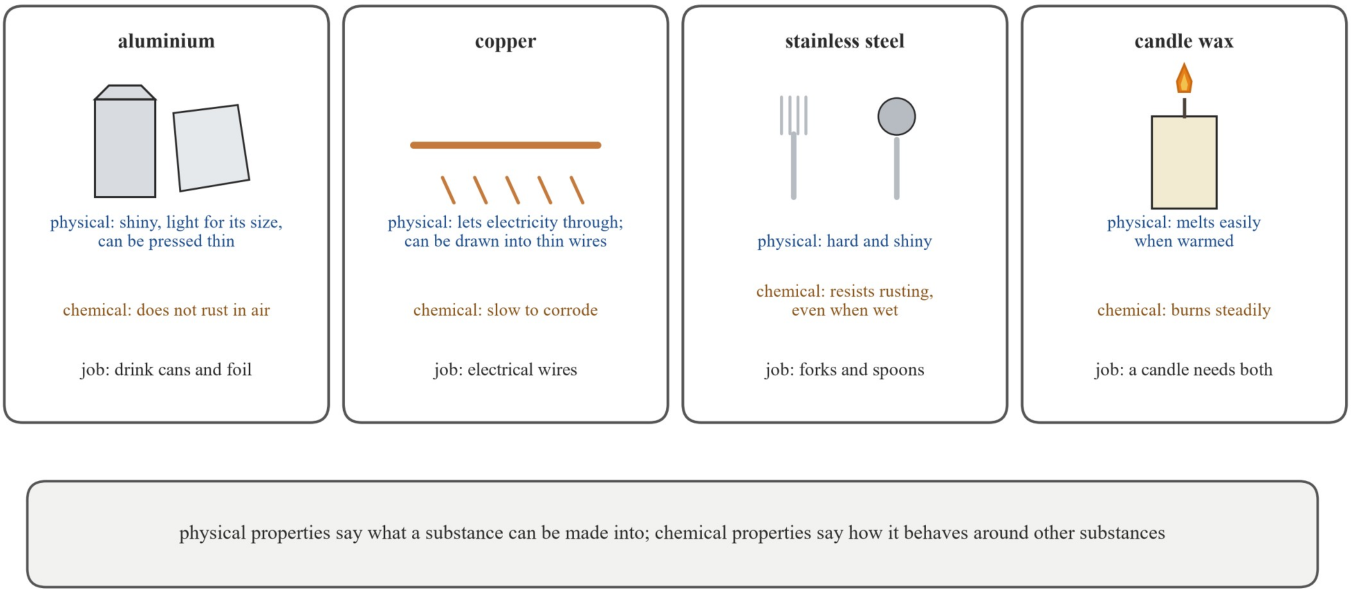


A comparison figure for the iron-to-rust change. On the left, a labelled sketch of a shiny grey nail with the word iron and its four properties listed: shiny grey; hard and bendable; density 7.9 grams per cubic centimetre; stays shiny *when dry. In the middle, a large arrow labelled left in damp air for weeks. On the right, a labelled sketch of the same nail now flaky and orange-brown with the word rust and its four properties: dull orange-brown; soft and crumbly; about 3.5 grams per cubic centimetre; keeps forming in damp air. A footer strip reads: every property checked is different — a new substance has been made, so rusting is a chemical change. Data for practice.*

Every property checked is different. The substance after the change behaves nothing like the substance before it — so rusting is a chemical change. The same method, applied to melting ice, finds the opposite: water and ice share the same properties (the same melting point, the same density at the same temperature, the same behaviour with other substances), so melting is physical.

Properties decide the job (`VC2S8U08.E03`)

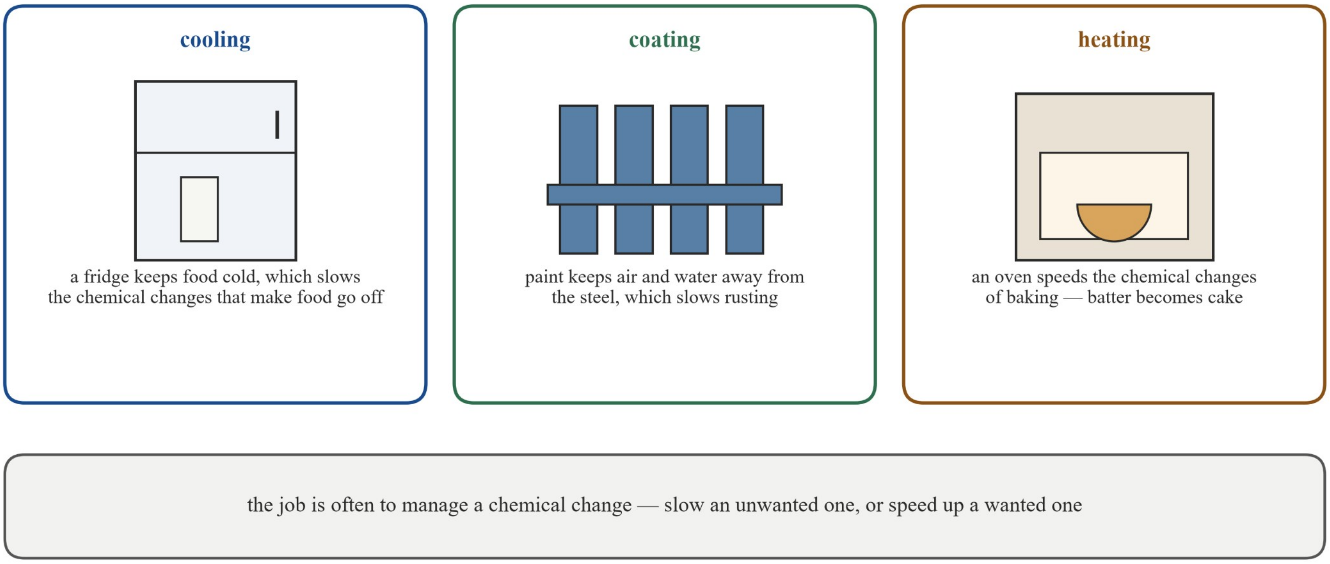
People who make things — engineers, cooks, manufacturers — choose a substance for a job by asking what it does: what its **physical properties** and **chemical properties** are. A substance's properties decide whether it is any good for a job, and they decide how it must be produced, protected and used.



Four rounded panels, each linking a substance, its properties and its job. Panel 1: an aluminium drink can and a sheet of aluminium foil; labels read aluminium is shiny, light for its size and can be pressed thin without breaking — physical properties — and it does not rust in air — a chemical property — so it suits cans and foil. Panel 2: a copper electrical wire; labels read copper lets electricity through easily and can be stretched into thin wires — physical properties — and it is slow to corrode — a chemical property — so it suits wires. Panel 3: stainless-steel cutlery; labels read stainless steel is hard and shiny — physical properties — and resists rusting even when wet — a chemical property — so it suits forks and spoons. Panel 4: a candle with a flame; labels read candle wax melts easily when warmed — a physical property — and burns steadily — a chemical property — and a candle needs both.

Read each panel the same way: the **physical properties** say what the substance can be *made into* (pressed thin, stretched, melted), and the **chemical properties** say how it *behaves around other substances* (does it rust? does it burn? does it resist acids?). The candle is the neatest example: a candle only works because of both kinds of property at once — the wax must melt (a physical change) so it can soak up the wick, and it must burn (a chemical change) to give light.

The same idea runs through how we **control** chemical changes in daily life. Very often, the job is to slow a chemical change down, or to speed a wanted one up:



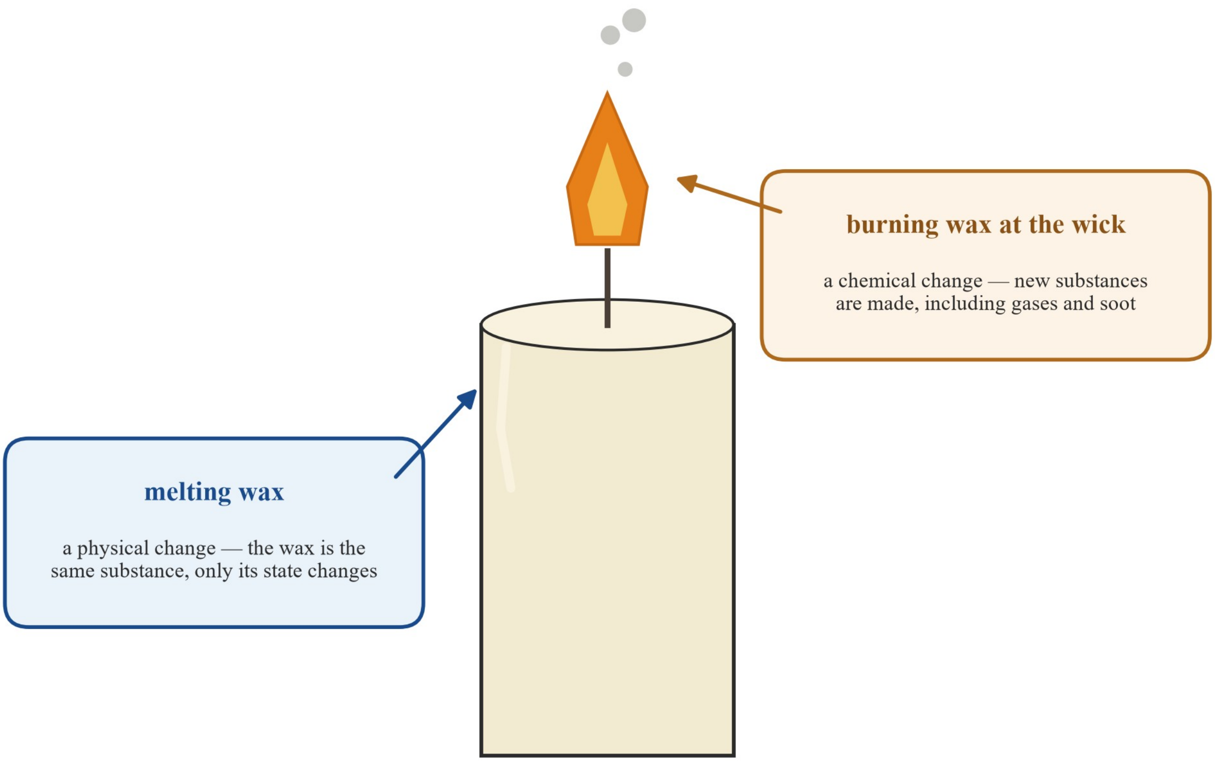
Three panels showing chemical changes being controlled. Panel 1: a carton of milk inside a refrigerator, captioned cooling — a fridge keeps food cold, which slows the chemical changes that make food go off. Panel 2: a steel fence being painted, captioned coating — paint keeps air and water away from the steel, which slows rusting. Panel 3: a cake rising in an oven, captioned heating — an oven speeds the chemical changes of baking, which turn batter into cake. A footer line reads: the job is often to manage a chemical change — to slow an unwanted one or speed a wanted one.

- **Cooling** slows the chemical changes that make food go off — that is what a refrigerator is for.
- **Coating** keeps air and water away from iron and steel, which slows rusting — that is what paint on a fence is for.
- **Heating** speeds wanted chemical changes — that is what an oven does to cake batter, and what a toaster does to bread.

Notice what this section adds to the deciding question: once you can tell physical and chemical changes apart, you can start to *use* the difference — choosing substances for jobs, and controlling the changes you want or do not want.

One change, or two at once? The candle

A burning candle looks like one change, but it is a useful way to close this subtopic because it shows **both kinds of change happening together**. Watch a candle carefully and you can separate them.



one candle, two changes — the deciding question separates them

A labelled candle with a flame. Near the flame, solid wax is melting into a clear pool of liquid wax; a blue label reads melting wax — a physical change: the wax is the same substance, only its state has changed. At the wick, the flame burns with a faint trail of smoke; an orange label reads burning wax at the wick — a chemical change: new substances are made, including gases you cannot see and the soot in the smoke. A footer line reads: one candle, two changes — the deciding question separates them.

Near the flame, solid wax **melts** into liquid wax — a physical change: the liquid is the same substance as the solid, and it would set again if cooled. At the wick, wax **burns** — a chemical change: new substances are made, including gases you cannot see and the dark soot you sometimes see in the smoke. So when someone asks *which kind of change did you just watch?* about a candle, the honest answer is *both* — and the deciding question is what separates them.

Words to know in 11B

Term	Meaning
physical change	a change in which no new substance is made — the same substances are present afterwards, perhaps in a different shape, size or state
chemical change	a change in which one or more new substances are made, with different properties
property	anything about a substance that can be measured or observed — colour, density, melting point, hardness, whether it conducts, how it behaves with other substances
physical property	a property you can observe or measure without changing the substance into something new — colour, density, melting point, how it bends or flows
chemical property	a property about how a substance behaves when it *could* become something new — whether it rusts, burns, or resists acids

Term	Meaning
reversibility	whether a change can be turned back into the original substances; a clue, not the deciding test
dissolving	one substance spreading out among the particles of another to form a solution; a physical change
rusting	the slow chemical change in which iron in damp air becomes rust, a crumbly orange-brown substance
indicator (of chemical change)	an observable sign — such as a new colour or a gas appearing — that suggests new substances are being made; the four named indicators are taught in 11C

Worked examples

Example 1 — scaffolded

Classify each change as physical or chemical, and give the reason.

- (i) An ice cube melts in a glass.
- (ii) An egg is fried in a pan.
- (iii) Sugar is stirred into tea and seems to vanish.
- (iv) A log burns on a fire.
- (v) A piece of wire is bent into a hook.

(Scaffold: ask the deciding question — was a new substance made? Changes of state, dissolving and changes of shape make no new substance.)

Working	Comment
(i) The solid water becomes liquid water — the same substance in a different state.	No new substance → physical change.
(ii) The heat sets the egg into new substances with new properties; a fried egg cannot be unfried.	New substances → chemical change.
(iii) The sugar spreads among the water particles as a solution; evaporate the water and the sugar is still there.	No new substance → physical change (dissolving).
(iv) The log becomes ash, smoke and new gases with new properties.	New substances → chemical change.
(v) The wire changes shape only; it is the same metal.	No new substance → physical change.

Example 2 — scaffolded

A student measures properties before and after two changes (data for practice).

	Case A: solid wax → melted wax	Case B: a shiny metal strip → a white powder, after strong heating in air
Colour	white before; white after	shiny grey before; white after
Melting point	same before and after	different after
How it behaves with acid	same before and after	different after

Decide, for each case, whether the change is physical or chemical, and give the reason.

Working	Comment
Case A: every property measured is the same before and after.	Same substance, different state → physical change (melting).
Case B: colour, melting point and behaviour with acid are all different after the change.	Properties differ → a new substance was made → chemical change.

Example 3 — unscaffolded

A candle burns for an hour. Identify one physical change and one chemical change happening in that hour, and give the evidence for each.

The solid wax near the flame melts into liquid wax: the liquid is the same substance as the solid (only its state has changed, and it would set again on cooling), so melting is a physical change. At the wick, wax burns: new substances are made — gases you cannot see, and soot, which you can see as dark smoke — so burning is a chemical change. The candle shows both kinds of change at once; the deciding question separates them.

∴ melting wax = physical change (same substance, new state); burning wax = chemical change (new substances made).

Example 4 — unscaffolded

Explain, using one physical property and one chemical property in each case, why aluminium is a good choice for drink cans and why copper is a good choice for electrical wires.

For drink cans: aluminium can be pressed thin and shaped without breaking, and it is light for its size — physical properties that let it be made into a can and carried easily. It also does not rust in air — a chemical property that lets the can sit on shelves, and in fridges, without being slowly destroyed. For wires: copper lets electricity through easily and can be stretched into thin wires — physical properties a wire must have. It is also slow to corrode — a chemical property that lets the wire last for years inside walls without turning into a crumbly new substance.

∴ in both cases a physical property says what the substance can be made into, and a chemical property says how well it survives its surroundings.

Practice questions

Scaffolded

Q1. Define, in your own words: *(Scaffold: the key idea in each definition is whether a new substance is made.)* (a) physical change; (b) chemical change.

Q2. Classify each change as physical or chemical. *(Scaffold: changes of state, dissolving and changes of shape make no new substance.)* (a) Water boils in a kettle. (b) A slice of bread is toasted. (c) Salt is stirred into soup and seems to vanish. (d) A steel nail rusts in the rain. (e) A carrot is chopped into pieces. (f) Milk goes sour.

Q3. For each change, tick the correct kind and give one thing you could observe that supports your answer. (a) Ice melting in a drink. (b) Wood burning in a fireplace.

Q4. Reversibility as a clue. For each change, say whether it is easy to undo, and say whether that fact alone is enough to classify it. (a) Water freezing into ice. (b) Paper burning. (c) A drinking glass shattering on the floor.

Q5. A student records properties before and after a change (data for practice): the colour is the same before and after, the density is the same before and after, and the melting point is the same before and after. *(Scaffold: use step 4 of the before-and-after method.)* (a) Was a new substance made? (b) Is the change physical or chemical?

Q6. Match each property to the job it suits. *(Scaffold: a physical property suits a job about shape or flow; a chemical property suits a job about surviving other substances.)* Properties: (1) lets electricity through easily; (2) does not rust when wet; (3) melts easily when warmed; (4) can be pressed very thin without breaking. Jobs: (a) the coating of a fork; (b) electrical wiring; (c) candle wax; (d) aluminium foil.

Unscaffolded

Q7. A student writes: "Dissolving salt in water is a chemical change, because the salt disappears." Is the student correct? Justify your answer using the deciding question.

Q8. Melting butter and frying an egg both happen in a hot pan, but one is a physical change and the other is chemical. Classify each and explain the difference in terms of substances and properties.

Q9. The iron-and-rust table in the Theory section shows four properties of iron and four of rust. (a) Is rusting a physical or a chemical change? (b) Identify two properties in the table that support your answer. (c) Rusting is very hard to undo. Does that fact alone prove your answer to (a)? Explain.

Q10. A candle burns beside a student. (a) Identify the physical change. (b) Identify the chemical change. (c) Give the evidence for each.

Q11. Explain, using ideas about chemical change: (a) why steel fences are painted; (b) why milk is kept in a refrigerator.

Q12. A glass bottle is smashed with a hammer. A sheet of paper is burned. Both changes are hard to undo, but only one of them is a chemical change. Explain which is which, and why "hard to undo" did not decide the answer.

Q13. A student heats a silvery metal powder strongly in air. Afterwards, the powder is white. Further tests (data for practice) show the white powder melts at a much higher temperature than the metal, and does not conduct electricity, while the metal did. (a) Is the change physical or chemical? Give the reason. (b) Name the observable sign of chemical change the student saw first. (c) Suggest one more observation, from the signs previewed in this subtopic, that would add evidence for your answer.

Q14. Sort these eight changes into physical and chemical, and give a one-line reason for each: boiling water in a kettle; boiling an egg; condensation forming on a cold drink can; toasting bread; mixing sand and water; burning steel wool; crushing an aluminium can; baking a cake.

Answers

Q1. (a) A change in which no new substance is made. (b) A change in which one or more new substances are made. **Q2.** (a) Physical; (b) chemical; (c) physical; (d) chemical; (e) physical; (f) chemical. **Q3.** (a) Physical — the water is still water; it could freeze back. (b) Chemical — ash, smoke and new gases are made. **Q4.** (a) Easy to undo; but that is a clue, not the reason — it is physical because no new substance is made. (b) Not easy to undo; chemical because new substances were made. (c) Not easy to undo, yet still physical — no new substance is made when glass shatters. **Q5.** (a) No. (b) Physical. **Q6.** (1)–(b); (2)–(a); (3)–(c); (4)–(d). **Q7.** No — see solutions. **Q8.** Melting butter physical; frying an egg chemical — see solutions. **Q9.** (a) Chemical; (b) any two properties from the table; (c) no — see solutions. **Q10.** (a) Melting wax; (b) burning wax; (c) see solutions. **Q11.** (a) Paint keeps air and water away, slowing rusting; (b) cooling slows the chemical changes that make milk go off. **Q12.** Smashing physical, burning chemical — see solutions. **Q13.** (a) Chemical; (b) the colour change; (c) any previewed sign — see solutions. **Q14.** Physical: boiling water, condensation, mixing sand and water, crushing the can. Chemical: boiling an egg, toasting bread, burning steel wool, baking a cake.

Fully-worked solutions

Q1. *(2 marks)* (a) A physical change is a change in which no new substance is made — the same substances are present afterwards, perhaps in a different shape, size or state. *(1 mark)* (b) A chemical change is a change in which one or more new substances are made, with different properties. *(1 mark)*

Q2. *(6 marks)* (a) Physical — boiling is a change of state; the steam is still water. *(1 mark)* (b) Chemical — toasting makes new brown substances with a new smell and taste. *(1 mark)* (c) Physical — the salt is still present, spread among the water particles; it could be recovered by evaporation. *(1 mark)* (d) Chemical — the iron becomes rust, a new substance with different properties. *(1 mark)* (e) Physical — the pieces are still carrot, only smaller. *(1 mark)* (f) Chemical — souring makes new substances with a new smell and taste. *(1 mark)*

Q3. *(4 marks)* (a) Physical change. *(1 mark)* Evidence: the water is still water — no new colour, smell or gas appears, and it could be frozen back into ice. *(1 mark)* (b) Chemical change. *(1 mark)* Evidence: new substances are made — ash, smoke and new gases — and the change cannot be undone. *(1 mark)*

Q4. *(3 marks)* (a) Easy to undo (melt the ice back), but the deciding reason is that no new substance is made — it is a physical change. *(1 mark)* (b) Not easy to undo — and chemical, because new substances (ash, smoke, gases) were made. *(1 mark)* (c) Not easy to undo, yet still physical: no new substance is made when glass shatters. Reversibility is a clue only; the deciding question is whether a new substance was made. *(1 mark)*

Q5. *(2 marks)* (a) No — every property measured is the same before and after. *(1 mark)* (b) Physical change: the same substance is present afterwards. *(1 mark)*

Q6. *(4 marks)* (1) lets electricity through → (b) electrical wiring. *(1 mark)* (2) does not rust when wet → (a) the coating of a fork. *(1 mark)* (3) melts easily when warmed → (c) candle wax. *(1 mark)* (4) can be pressed very thin → (d) aluminium foil. *(1 mark)*

Q7. *(2 marks)* No. *(1 mark)* The salt has not become a new substance: it is still present, spread among the water particles, and letting the water evaporate leaves the salt behind unchanged. "Disappearing" is the look of dissolving, which is a physical change. *(1 mark)*

Q8. *(3 marks)* Melting butter is a physical change: the butter becomes liquid butter — the same substance in a new state, with the same properties, and it sets again on cooling. *(1 mark)* Frying an egg is a chemical change: the heat makes new substances — the runny white and yolk set into new materials with new properties. *(1 mark)* The difference: melting changes only the state of one substance; frying makes new substances. *(1 mark)*

Q9. *(3 marks)* (a) Chemical change. *(1 mark)* (b) Any two of: colour (shiny grey → dull orange-brown); hardness and feel (hard and bendable → soft and crumbly); density (7.9 g/cm³ → about 3.5 g/cm³); behaviour in damp air (stays shiny when dry → keeps forming). *(1 mark)* (c) No. Being hard to undo is a clue to a chemical change, not proof: some physical changes (a shattered glass) are also hard to undo. The proof is that rust's properties differ from iron's — a new substance was made. *(1 mark)*

Q10. *(3 marks)* (a) The melting of the solid wax near the flame. *(1 mark)* (b) The burning of wax at the wick. *(1 mark)* (c) Melting: the liquid wax is the same substance as the solid — no new substance, and it would set again on cooling. Burning: new substances are made — gases you cannot see, and soot, visible as dark smoke. *(1 mark)*

Q11. *(4 marks)* (a) Rusting is a chemical change that needs air and water. Paint coats the steel and keeps air and water away from it, which slows the unwanted chemical change (rusting). *(2 marks)* (b) Going off is caused by chemical changes. Cooling the milk slows those chemical changes, so the milk stays drinkable for longer. *(2 marks)*

Q12. *(2 marks)* Smashing the bottle is a physical change: the pieces are still glass — no new substance is made, even though the change cannot easily be undone. *(1 mark)* Burning the paper is a chemical change: the paper becomes ash, smoke and new gases — new substances with new properties. "Hard to undo" is only a clue; the deciding question is whether a new substance was made. *(1 mark)*

Q13. *(3 marks)* (a) Chemical change: the properties after the change (white colour, much higher melting point, no conduction) differ from the metal's — a new substance has been made. *(1 mark)* (b) The colour change — silvery to white. *(1 mark)* (c) Any one previewed clue or sign, for example: checking whether the change can be undone — the white powder cannot be turned back into the silvery metal by any simple means. *(1 mark)*

Q14. *(8 marks)* Boiling water in a kettle — physical: a change of state; the steam is still water. *(1 mark)* Boiling an egg — chemical: the heat makes new substances; the set egg cannot be un-boiled. *(1 mark)* Condensation on a cold drink can — physical: water vapour changing state to liquid water; still water. *(1 mark)* Toasting bread — chemical: new brown substances with a new smell and taste are made. *(1 mark)* Mixing sand and water — physical: each substance keeps its own properties and could be separated again. *(1 mark)* Burning steel wool — chemical: the glowing steel becomes a brittle new substance. *(1 mark)* Crushing an aluminium can — physical: the aluminium is the same substance, only flattened. *(1 mark)* Baking a cake — chemical: the heat makes new substances; batter cannot be recovered from cake. *(1 mark)*

Sources

- Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8 — content description `VC2S8U08` (first clause owned here; second clause owned by 11C) and elaborations `VC2S8U08.E02`, `VC2S8U08.E03`, used as elaboration contexts (D6/D12).
- ASTA (Science ASSIST), Science Safety Essentials: Risk Assessment in Science (published 2022-10-25, modified 2025-12-15)
- ASTA (Science ASSIST), Science Safety Essentials: Risk Management in Science (published 2022-10-26, modified 2025-12-15)
- All property values in tables and figures (densities, melting behaviour, conduction) are labelled "data for practice" and are authored for this subtopic; no external data source is cited for them.

Web sources above were retrieved 2026-08-21.

The indicators of chemical change: colour change, temperature change, precipitate formation, and preparing and testing oxygen, carbon dioxide and hydrogen

What we teach here — `VC2S8U08` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"physical changes can be distinguished from chemical changes; a chemical change can be identified by a colour change, a temperature change, the production of a gas (including laboratory preparation and testing of oxygen, carbon dioxide and hydrogen gases) or the formation of a precipitate"*

This subtopic owns the second clause only: 11B teaches the first clause — what physical and chemical changes are, and how to tell them apart. This subtopic, 11C, teaches the second clause — the observable *indicators* that a chemical change has happened (a colour change, a temperature change, a gas being made, a precipitate forming), including the laboratory preparation and testing of oxygen, carbon dioxide and hydrogen.

In our words: a chemical change makes new substances, but we cannot watch the new substances being made. What we *can* watch for are the signs — a new colour, a temperature rise or fall with no heating or cooling, bubbles of a new gas, or a solid appearing in a clear mixture. This subtopic also teaches the three classic school gas tests: how to make oxygen, carbon dioxide and hydrogen in the laboratory, and how to prove which gas is which.

Achievement-standard extract served here (D13): cited by reference to the header of the owner subtopic 11B, where the extract appears in full.

Elaborations drawn on: `VC2S8U08.E01` (performing simple chemical reactions to identify the indicators of chemical change), `VC2S8U08.E04` (indicators of chemical change used for identifying particular substances, as in soil, water and medical testing kits), `VC2S8U08.E05` (applying knowledge of common chemical changes to identify a set of mystery powders).

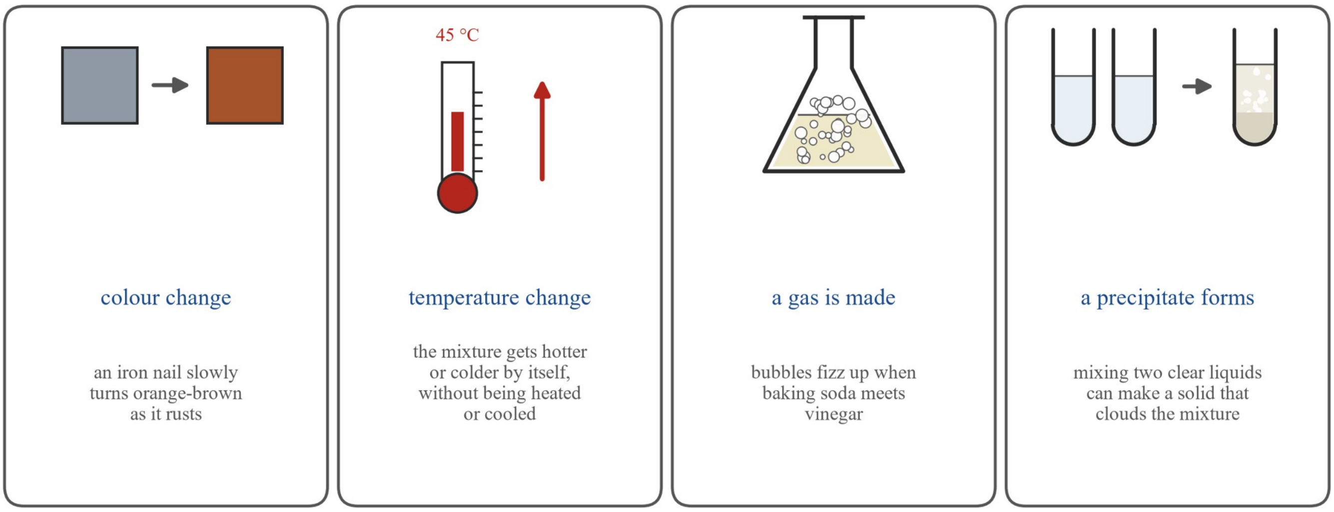
Authored from the CD text (D12): the content description names the laboratory preparation and testing of oxygen, carbon dioxide and hydrogen, but no elaboration illustrates it. The three preparations and tests below are therefore authored from the CD text itself, as school-standard safe practice written to Science ASSIST (ASTA) guidance. They are examinable content for this band.

Theory

Chemical changes make new substances — the indicators are how we spot them

In 11B we met the difference between physical and chemical changes. A chemical change makes new substances with new properties; a physical change does not. The trouble is that we cannot see substances being made. Instead, we look for the observable signs that the curriculum calls the indicators of chemical change: a **colour change**, a **temperature change**, **the production of a gas**, or **the formation of a precipitate**. If we see one or more of these, a chemical change has probably happened.

Four indicators that suggest a chemical change has happened



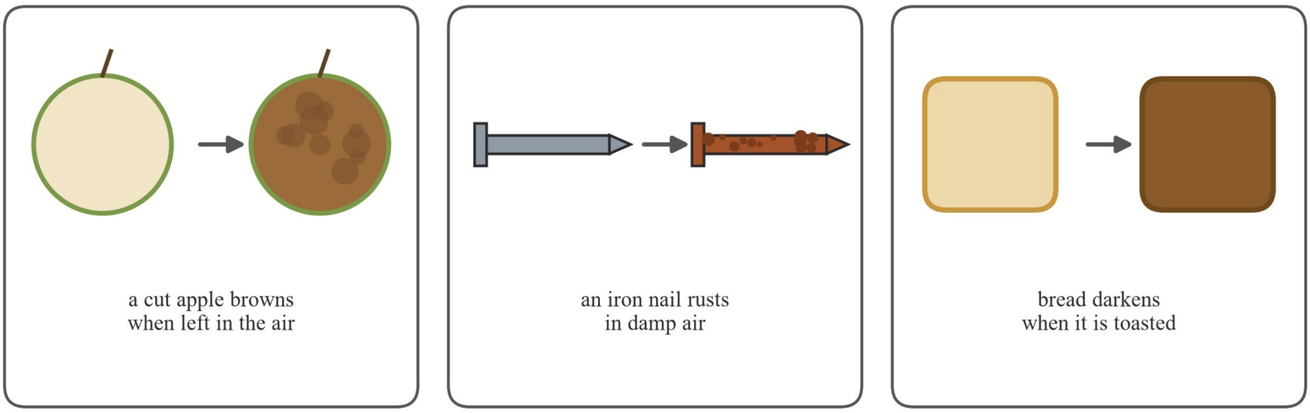
Four rounded panels, one for each indicator. Panel 1 shows a grey square changing to an orange-brown square, labelled colour change, with the example an iron nail slowly turns orange-brown as it rusts. Panel 2 shows a thermometer with a rising red column and an up arrow, labelled temperature change. Panel 3 shows a small fizzing flask, labelled a gas is made, with the example bubbles fizz up when baking soda meets vinegar. Panel 4 shows two clear test tubes being mixed into one cloudy tube with a settled solid, labelled a precipitate forms.

One word of warning before we look at each indicator: an indicator only counts if the change really made something new. Adding paint to water gives a new colour but no new substance; that is mixing, not a chemical change. Each indicator below is about a colour, a temperature change, a gas or a solid *appearing that was not there before*.

Indicator 1 — colour change

A new colour appearing, when no colour was added, is evidence that new substances have formed. A cut apple left on the bench turns brown; a shiny grey nail left in damp air slowly turns orange-brown as it rusts; pale bread darkens when it is toasted. In each case the new colour belongs to a new substance that was not there at the start.

Colour change: three everyday chemical changes



In each pair, the new colour is evidence that new substances have formed.

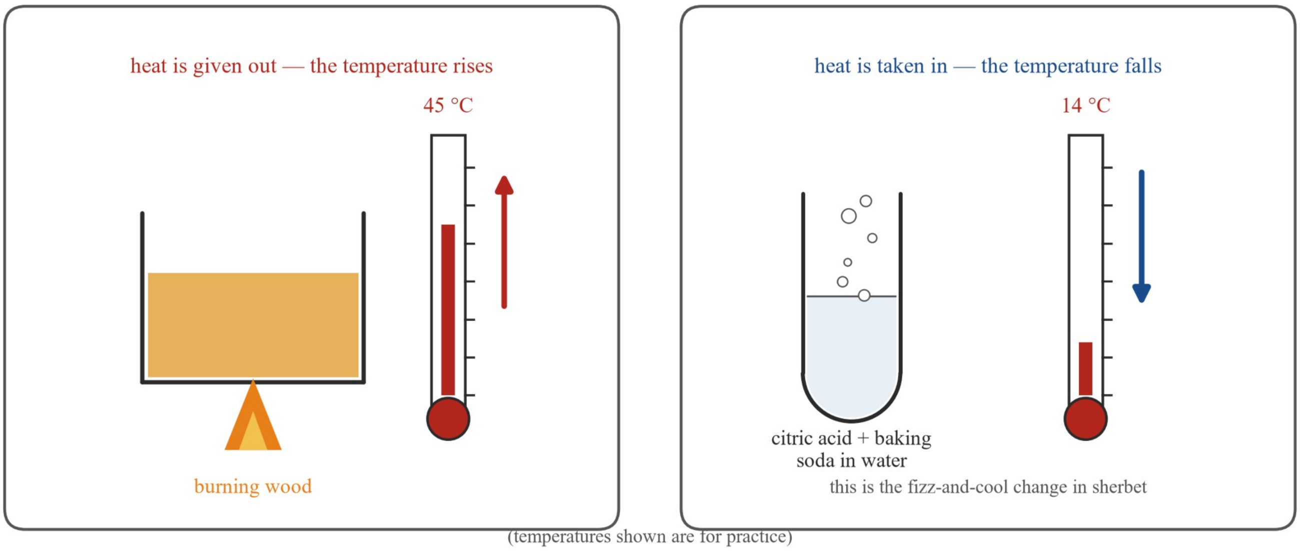
Three before-and-after pairs in rounded panels. First pair: a pale cut apple changing to a brown cut apple, captioned a cut apple browns when left in the air. Second pair: a grey iron nail changing to an orange-brown rusty nail, captioned an iron nail rusts in damp air. Third pair: a pale slice of bread changing to a dark brown slice of toast, captioned bread darkens when it is toasted. A footer line reads: in each pair, the new colour is evidence that new substances have formed.

Word watch — adding a colour is not a colour change. Stirring food dye into water colours the water, but the dye is still dye and the water is still water — nothing new was made, so this is mixing (a physical change, 11B). The indicator is a new colour *appearing*, like the brown on a cut apple, not a colour being *added*.

Indicator 2 — temperature change

Some chemical changes give out heat: burning wood makes everything near it hotter, and a thermometer near the change rises. Other chemical changes take heat in: when citric acid (the acid in lemon juice) and baking soda are mixed in water, the mixture feels cold and a thermometer in it falls — this is the same fizz-and-cool change you taste in sherbet. The key idea is that the temperature changes *by itself*: if the mixture gets hotter or colder with no heating or cooling from outside, a chemical change is a likely cause.

Temperature change: the mixture gets hotter or colder by itself



(temperatures shown are for practice)

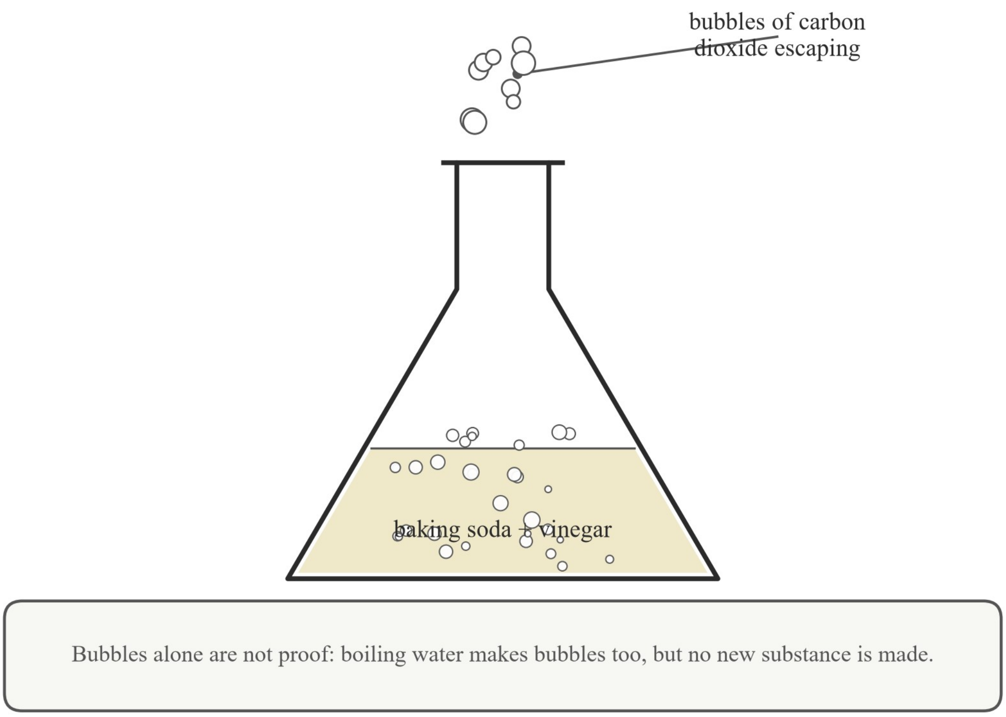
Two panels. Left panel: a beaker of wood over a small flame with a thermometer reading 45 °C and a rising red arrow, captioned heat is given out — the temperature rises. Right panel: a fizzing test tube of citric acid and baking soda in water beside a thermometer reading 14 °C with a falling blue arrow, captioned heat is taken in — the temperature falls. A footer note reads: temperatures shown are for practice.

Heating something on a hotplate does **not** count: the temperature rise then comes from the hotplate, not from a chemical change. The indicator is a rise or fall that the mixture causes on its own.

Indicator 3 — a gas is made

When baking soda and vinegar are mixed, bubbles fizz up. The bubbles are a gas — carbon dioxide — that was not there before the two were mixed, so a new substance is being made.

A gas is made: bubbles fizz up

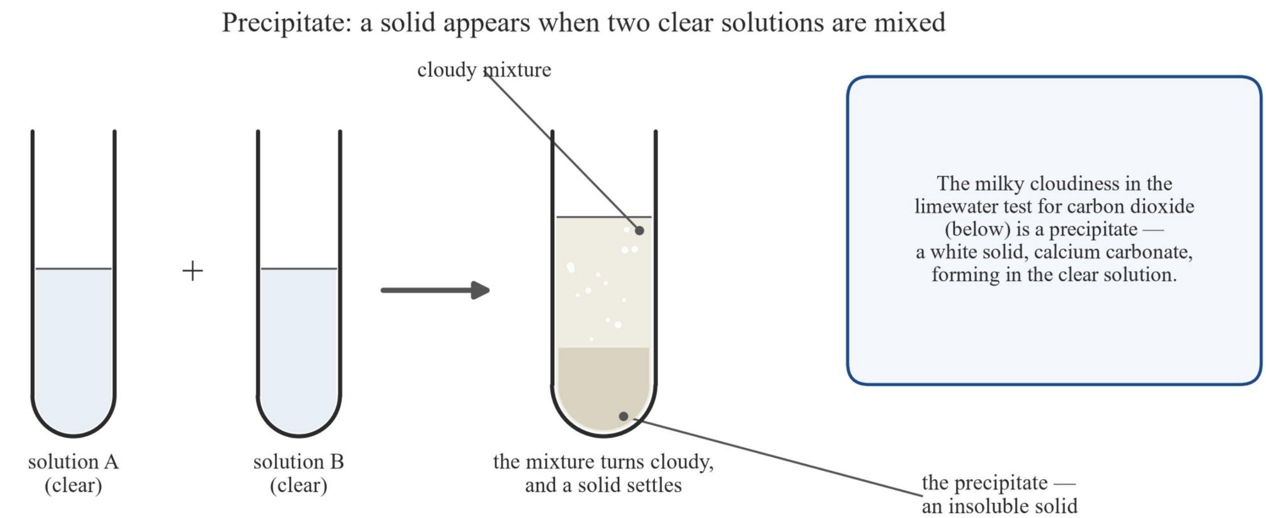


A conical flask holding a fizzing pale liquid labelled baking soda plus vinegar, with bubbles rising inside the liquid, breaking the surface, and escaping above the neck, labelled bubbles of carbon dioxide escaping. A boxed note below reads: bubbles alone are not proof — boiling water makes bubbles too, but no new substance is made.

> **Word watch — fizzing versus boiling.** A pot of boiling water also makes bubbles, but those bubbles are water changing state from liquid to gas (a physical change, 11B) — no new substance is made. The indicator is bubbles of a *new* gas appearing when substances are mixed, like the carbon dioxide from baking soda and vinegar, at room temperature with no heating.

Indicator 4 — a precipitate forms

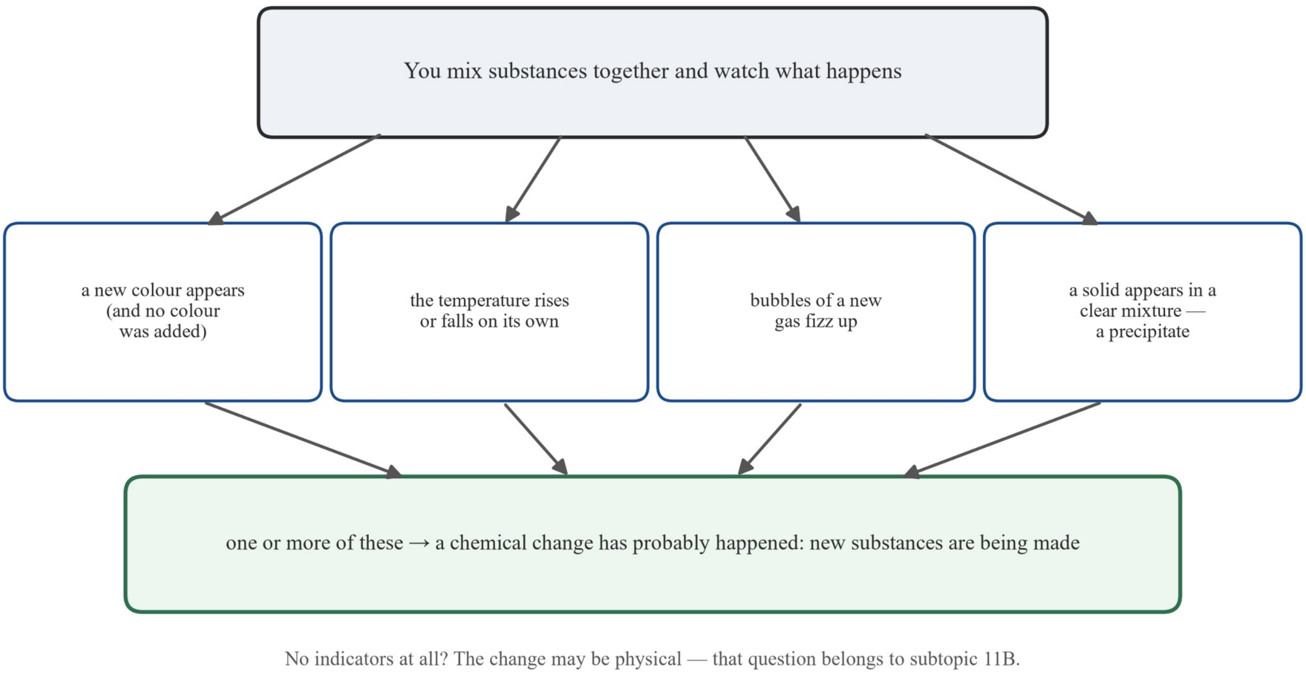
A **precipitate** is an insoluble solid that appears when two clear solutions are mixed. Imagine two perfectly clear liquids; you pour them together and the mixture turns cloudy, and after a while a solid settles to the bottom. The solid was not stirred in — it was *made* by the change. That new solid is the precipitate, and the word **insoluble** means it does not dissolve: it stays as a solid in the liquid instead.



Two clear test tubes labelled solution A (clear) and solution B (clear) joined by a plus sign, an arrow, then one cloudy test tube with white specks in the liquid and a layer of settled solid at the bottom, captioned the mixture turns cloudy, and a solid settles. Leader lines label the cloudy mixture and the precipitate — an insoluble solid. A blue note box reads: the milky cloudiness in the limewater test for carbon dioxide (below) is a precipitate — a white solid, calcium carbonate, forming in the clear solution.

Putting the indicators together

The four indicators work as a checklist. Mix substances, watch carefully, and ask: did a new colour appear? Did the temperature rise or fall on its own? Did bubbles of a new gas fizz up? Did a solid appear in a clear mixture? One or more yes answers mean a chemical change has probably happened. No indicators at all suggests the change may be physical — and that question belongs to 11B.



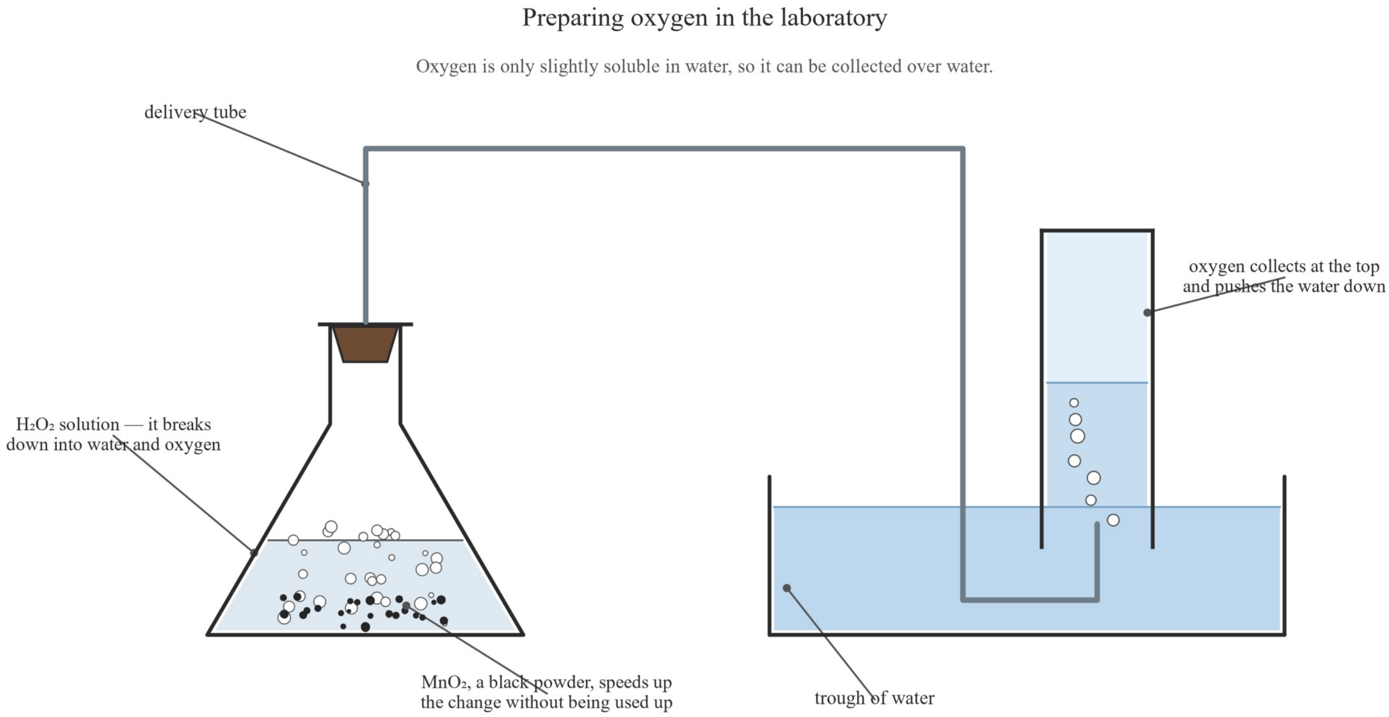
A flowchart. A top box reads: you mix substances together and watch what happens. Four arrows fan down to four boxes: a new colour appears (and no colour was added); the temperature rises or falls on its own; bubbles of a new gas fizz up; a solid appears in a clear mixture — a precipitate. Four arrows converge on a green box: one or more of *these → a chemical change has probably happened: new substances are being made. A footer line reads: no indicators at all? The change may be physical — that question belongs to subtopic 11B.*

Preparing and testing gases in the laboratory

The content description for this subtopic names three gases that you should be able to prepare and test in the laboratory: **oxygen**, **carbon dioxide** and **hydrogen**. All three are colourless, so you cannot tell them apart by looking — each has its own test. First, the safety rules that every one of these practicals follows.

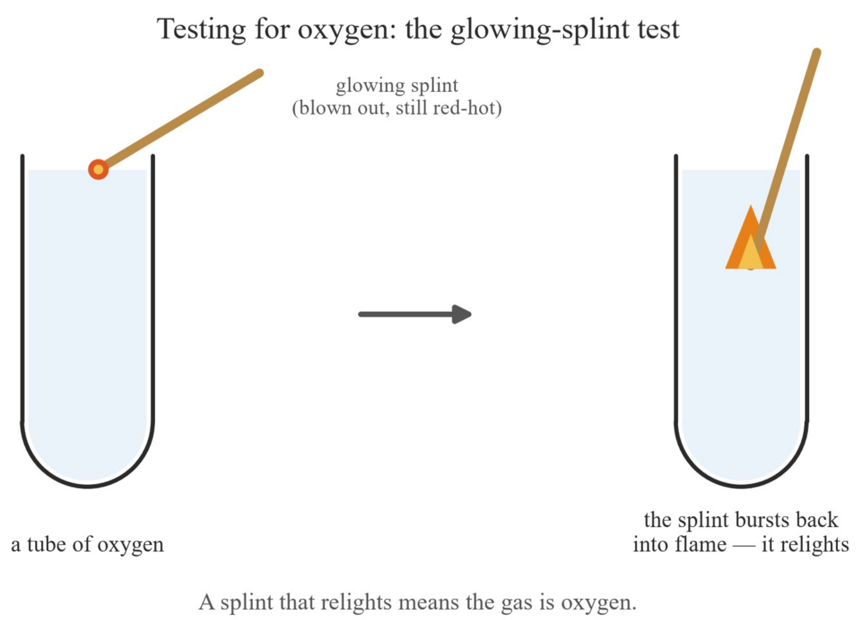
> **Safety and risk assessment** — Every practical in this subtopic is carried out under a risk assessment written to Science ASSIST (ASTA) guidance (both pages retrieved 2026-08-20). The standing controls are: safety glasses worn at all times; long hair tied back; small quantities only; vinegar handled as the mild, weak acid it is, with spills wiped up; the black powder MnO_2 handled by the teacher so nobody breathes dust; and all flame tests done by the teacher's method, well away from the gas being made. Hydrogen burns easily, so only tiny tubes of it are ever collected, and the pop test is done one small tube at a time, away from the generator.

Oxygen — preparing it. A solution of H_2O_2 slowly breaks down into water and oxygen on its own; adding the black powder MnO_2 makes the change run fast without the MnO_2 being used up. A substance that speeds up a change without being used up is called a **catalyst**. The oxygen bubbles are led through a delivery tube into an inverted measuring cylinder full of water standing in a trough; because oxygen is only slightly soluble in water, the gas collects at the top of the cylinder and pushes the water down.



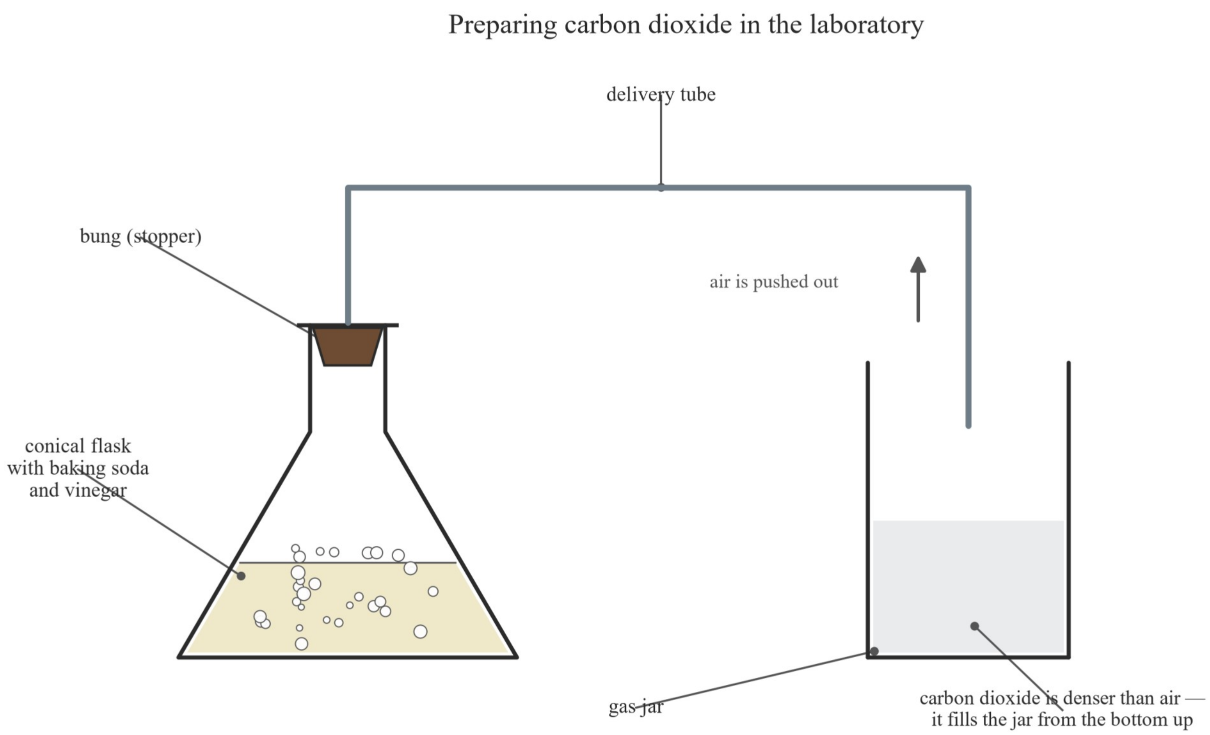
Apparatus diagram. A conical flask on the left holds a fizzing pale liquid with black specks; labels read H_2O_2 solution — it breaks down into water and oxygen, and MnO_2, a black powder, speeds up the change without being used up. A bung seals the neck and a delivery tube runs up, across, down into a trough of water, under the open mouth of an inverted measuring cylinder, and up inside it. Inside the cylinder, a pale blue region of collected gas sits above the water line, with bubbles rising from the tube end; a label reads oxygen collects at the top and pushes the water down. A subtitle reads: oxygen is only slightly soluble in water, so it can be collected over water.

Oxygen — testing it. Push a **splint** — a thin wooden stick, like a match without the head — into a flame, blow the flame out, and lower the still-glowing splint into the tube of gas. If the gas is oxygen, the splint bursts back into flame: it **relights**. Oxygen itself does not burn; it makes burning faster, which is why a glowing splint relights in it.



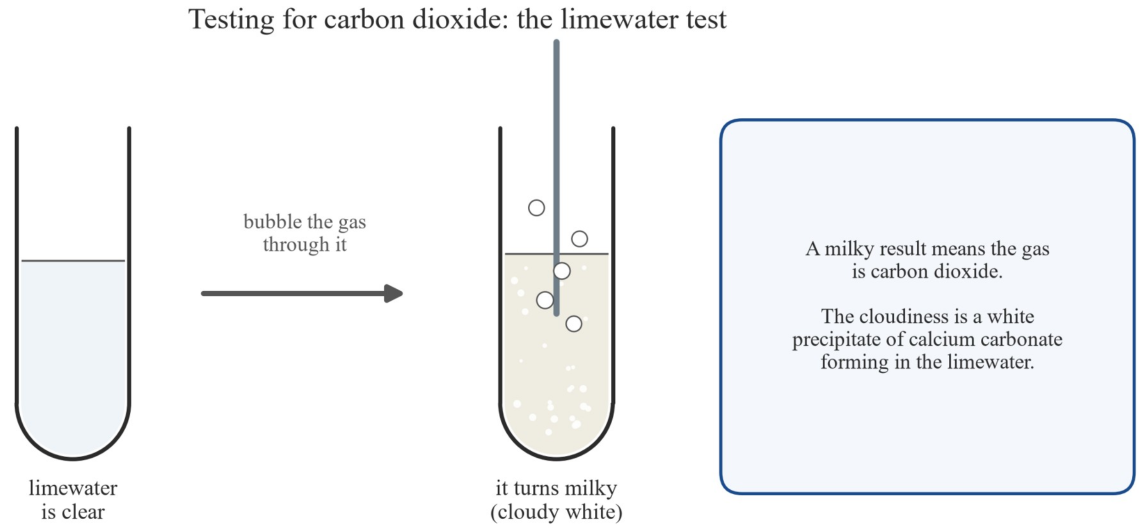
Two-frame diagram. Frame 1: a glowing splint (blown out, still red-hot) held at the mouth of a test tube of oxygen. Frame 2, after an arrow: the same splint lowered into the tube has burst into a flame, captioned the splint bursts back into flame — it relights. A footer line reads: a splint that relights means the gas is oxygen.

Carbon dioxide — preparing it. Mix baking soda and vinegar in a conical flask and carbon dioxide fizzes up. The gas is led through a delivery tube into an **upright** gas jar. Carbon dioxide is denser than air, so it sinks to the bottom of the jar and fills it from the bottom up, pushing the lighter air out through the top. (Marble chips with a dilute acid work the same way and are the classic school method.)



Apparatus diagram. A conical flask on the left holds fizzing pale liquid, labelled conical flask with baking soda and vinegar; a bung seals the neck and a delivery tube runs up, across, and down into an upright gas jar on the right. A grey shaded region of carbon dioxide pools at the bottom of the jar, labelled carbon dioxide is denser than air — it fills the jar from the bottom up, and an upward arrow at the open top is labelled air is pushed out.

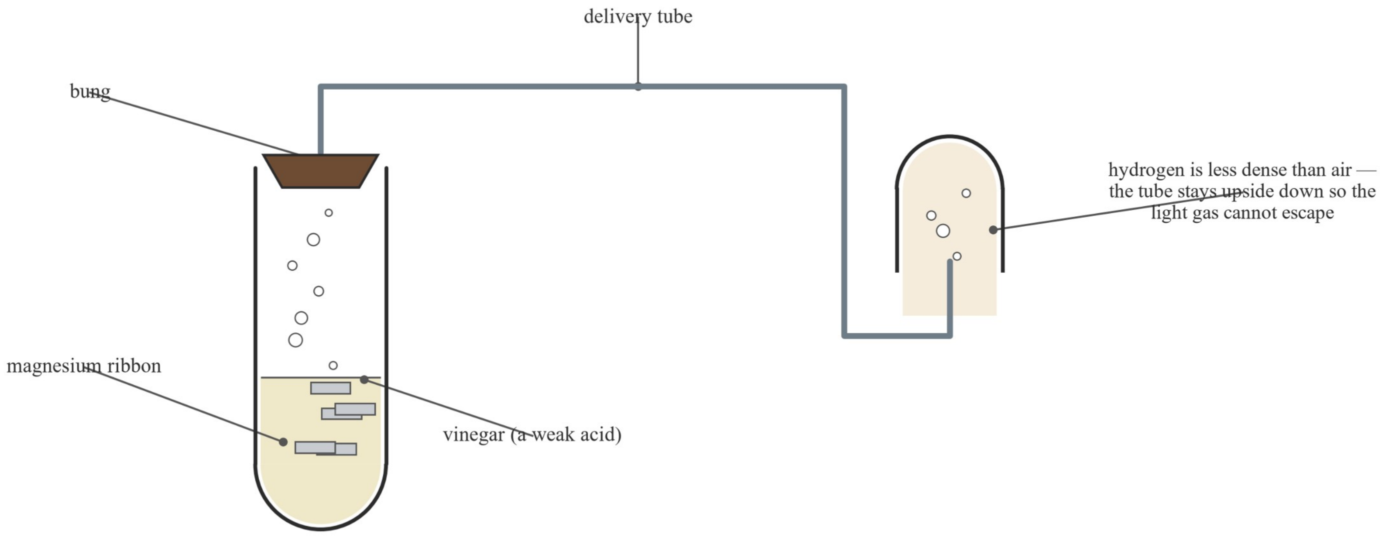
Carbon dioxide — testing it. Bubble the gas through **limewater**, a clear liquid that turns milky when carbon dioxide is passed through it. The milky cloudiness is itself a precipitate: a white solid, calcium carbonate, forming in the clear solution — which is why the limewater test links this gas test back to Indicator 4.



Two-frame diagram. Frame 1: a test tube of clear liquid labelled limewater is clear. An arrow labelled bubble the gas through it leads to frame 2: the same tube now cloudy white with a delivery tube bubbling gas through it, labelled it turns milky (cloudy white). A blue note box reads: a milky result means the gas is carbon dioxide; the cloudiness is a white precipitate of calcium carbonate forming in the limewater.

Hydrogen — preparing it. Drop a short piece of magnesium ribbon into vinegar in a test tube and bubbles of hydrogen fizz up. (Zinc with a dilute acid works the same way.) Because hydrogen is much less dense than air, it is collected in a **downward** tube — an inverted test tube, mouth down — so the light gas rises into the tube and cannot fall out.

Preparing hydrogen in the laboratory

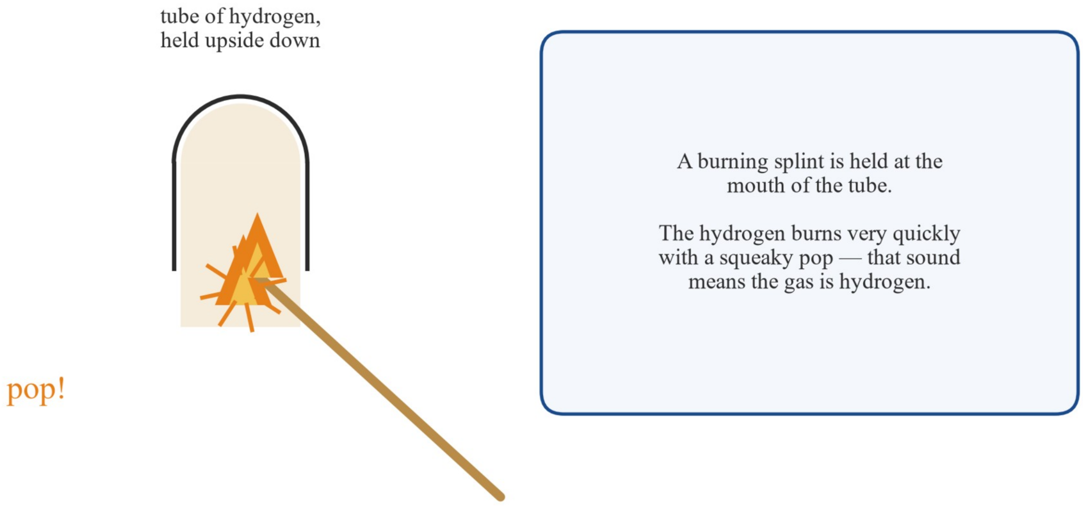


Bubbles of hydrogen rise into the inverted tube and push the air out.

Apparatus diagram. A large test tube on the left holds pale liquid with silver strips of magnesium ribbon and rising bubbles; labels read magnesium ribbon and vinegar (a weak acid). A bung seals the mouth and a delivery tube runs up, across, down outside an inverted small test tube, under its open mouth, and up inside it; the inverted tube is shaded as full of hydrogen, labelled hydrogen is less dense than air — the tube stays upside down so the light gas cannot escape. A footer line reads: bubbles of hydrogen rise into the inverted tube and push the air out.

Hydrogen — testing it. Hold the tube mouth-down and bring a burning splint to its mouth. The hydrogen burns very quickly with a squeaky **pop** — that sound is the test. Only ever test one tiny tube at a time, well away from the gas being made.

Testing for hydrogen: the pop test



Only tiny tubes of hydrogen are tested, well away from the gas being made.

Diagram of an inverted test tube of hydrogen held mouth-down while a burning splint is brought up to the mouth; a starburst and flame at the mouth are labelled pop! A blue note box reads: a burning splint is held at the mouth of the tube; the hydrogen burns very quickly with a squeaky pop — that sound means the gas is hydrogen. A footer line reads: only tiny tubes of hydrogen are tested, well away from the gas being made.

The three gases in one chart. Learn the chart: how each gas is made, how it is collected and why, and the test and result that identify it.

Preparing and testing three gases — summary

Gas	How it is made	How it is collected	The test	The result
Oxygen	a solution of H_2O_2 breaks down; MnO_2 speeds up the change	over water, in an inverted cylinder	a glowing splint is put into the tube	the splint relights
Carbon dioxide	baking soda + vinegar (or marble chips + a dilute acid)	in an upright jar — the gas is denser than air	bubble the gas through limewater	the limewater turns milky
Hydrogen	magnesium + vinegar (or zinc + a dilute acid)	in a downward tube — the gas is less dense than air	a burning splint at the mouth of the tube	a squeaky pop

All three gases are colourless — it is the tests that tell them apart.

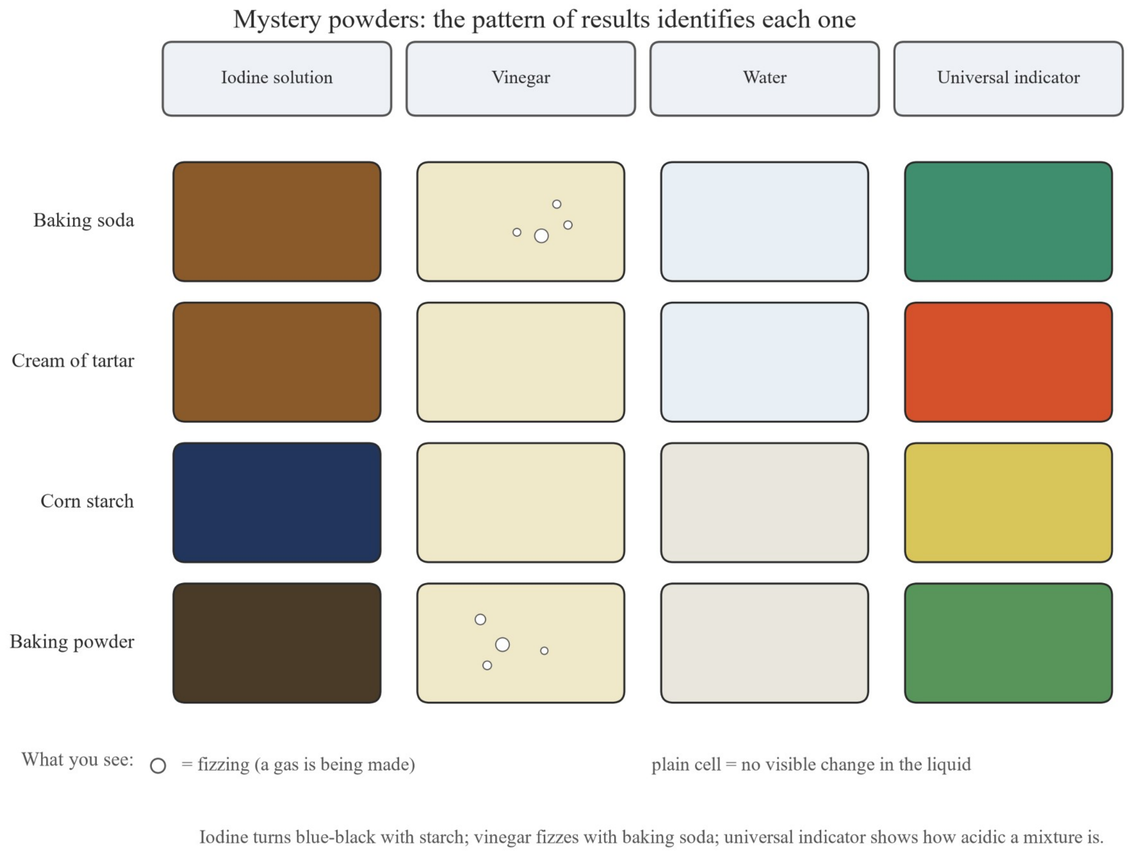
Summary table with five columns — gas; how it is made; how it is collected; the test; the result — and three rows. Oxygen: a solution of H_2O_2 breaks down, MnO_2 speeds up the change; over water, in an inverted cylinder; a glowing splint is put into the tube; the splint relights. Carbon dioxide: baking soda plus vinegar (or marble chips plus a dilute acid); in an upright jar — the gas is denser than air; bubble the gas through limewater; the limewater turns milky. Hydrogen: magnesium plus vinegar (or zinc plus a dilute acid); in a downward tube — the gas is less dense than air; a burning splint at the mouth of the tube; a squeaky pop. A footer line reads: all three gases are colourless — it is the tests that tell them apart.

The indicators at work in the wider world

The indicators of chemical change are not just school tricks — they are built into everyday testing kits (this is the idea behind elaboration E04). A pool test kit drops a tablet into pool water and reads the colour that appears to check the water is safe to swim in. Medical testing kits work the same way: a test strip dipped in a sample changes colour if a particular substance is present, such as the sugar that a doctor may check for in urine. Gardeners use soil test kits whose colours show what is in the soil. In every case, a colour change produced by a chemical change is doing the detecting.

Mystery powders: identifying substances with the indicators

Elaboration E05 applies the indicators to a puzzle: four white powders — baking soda, cream of tartar, corn starch and baking powder — look identical, but each gives a different pattern of results with four everyday liquids: iodine solution, vinegar, water and universal indicator (a solution that shows how acidic a mixture is by its colour). Iodine turns blue-black where starch is present; vinegar fizzes where baking soda is present; universal indicator turns red-orange in an acidic mixture and blue-green in a mixture that is not acidic. Reading the whole pattern of results identifies each powder.



A four-by-four grid. Columns are headed iodine solution, vinegar, water, universal indicator; rows are labelled baking soda, cream of tartar, corn starch, baking powder. Baking soda row: stays brown; fizzing; clear solution; blue-green. Cream of tartar row: stays brown; no change; clear solution; red-orange. Corn starch row: blue-black; no change; cloudy white; yellow. Baking powder row: dark brown-black; fizzing; cloudy; green. A legend reads: small circle = fizzing (a gas is being made); plain cell = no visible change in the liquid. A footer line reads: iodine turns blue-black with starch; vinegar fizzes with baking soda; universal indicator shows how acidic a mixture is.

Notice how the logic works: no single test is enough (both baking soda and baking powder fizz with vinegar), but the *pattern* across all four liquids is different for every powder. That is exactly how the indicators of chemical change identify substances in real kits.

Words to know in 11C

Term	Meaning
indicator (of chemical change)	an observable sign — a colour change, a temperature change, a gas being made, or a precipitate — that suggests new substances are forming
precipitate	an insoluble solid that appears when two clear solutions are mixed
insoluble	does not dissolve; stays as a solid in the liquid
catalyst	a substance that speeds up a chemical change without being used up (such as MnO_2 in the preparation of oxygen)
limewater	a clear liquid that turns milky (cloudy white) when carbon dioxide is bubbled through it
splint	a thin wooden stick, like a match without the head, used in gas tests
glowing-splint test	the test for oxygen: a glowing splint relights in the gas
limewater test	the test for carbon dioxide: the gas turns limewater

Term	Meaning
	milky
pop test	the test for hydrogen: a burning splint at the mouth of the tube gives a squeaky pop

Worked examples

Example 1 — scaffolded

Decide whether each observation is an indicator of chemical change.

(i) Bread goes brown in the toaster.
(ii) Ice left on the bench turns to liquid water.
(iii) Sherbet fizzes and feels cold on your tongue.
(iv) A spoon of salt is stirred into water and the water stays clear.

Working	Comment
(i) A new colour appears that was not added.	Colour change → indicator. The browning is new substances forming.
(ii) The water changes state, solid to liquid, but no new colour, gas, heat or solid appears.	No indicator → a physical change (11B).
(iii) Bubbles of gas appear, and the temperature falls with no cooling from outside.	Two indicators at once (gas + temperature change) → chemical change.
(iv) The salt disappears into solution, but the water stays clear and nothing new appears.	Dissolving is a physical change (11B) → no indicator.

Example 2 — scaffolded

Three tubes hold oxygen, carbon dioxide and hydrogen in some order. The results are:

- Tube A: a glowing splint put into the tube relights.
- Tube B: a burning splint at the mouth gives a squeaky pop.
- Tube C: the gas turns limewater milky.

Name the gas in each tube.

Working	Comment
Tube A: relights a glowing splint.	That is the test for oxygen → tube A holds oxygen.
Tube B: squeaky pop with a burning splint.	That is the test for hydrogen → tube B holds hydrogen.
Tube C: turns limewater milky.	That is the test for carbon dioxide → tube C holds carbon dioxide.

Example 3 — unscaffolded

A mystery powder is one of the four from the grid above. With iodine solution it stays brown; with vinegar it fizzes; with universal indicator it turns blue-green. Identify the powder and give the evidence.

The powder fizzes with vinegar, so it must contain baking soda — that narrows it to baking soda or baking powder. With iodine it stays brown, so no starch is present; baking powder contains starch and would have turned blue-black, so the powder is not baking powder. The blue-green result with universal indicator matches baking soda’s row of the grid.

∴ the powder is **baking soda**: it fizzes with vinegar, stays brown with iodine (no starch), and turns universal indicator blue-green.

Example 4 — unscaffolded

Explain, using the properties of the gases, why oxygen is collected over water in an inverted cylinder, carbon dioxide is collected in an upright jar, and hydrogen is collected in a downward (inverted) tube.

Oxygen is only slightly soluble in water, so bubbles of it can travel through water and gather at the top of an inverted, water-filled cylinder, pushing the water down — collection over water works. Carbon dioxide and hydrogen are both collected by pushing air out of a container, so density decides the way up: carbon dioxide is denser than air, so it sinks into an upright jar and fills it from the bottom, and the lighter air leaves through the top; hydrogen is much less dense than air, so it rises into an inverted tube held mouth-down, and the heavier air falls out beneath it.

∴ solubility allows oxygen to be collected over water; density puts the carbon dioxide jar mouth-up and the hydrogen tube mouth-down.

Practice questions

Scaffolded

Q1. For each observation, state whether it is an indicator of chemical change. *(Scaffold: the indicators are a colour change, a temperature change on its own, a new gas, or a precipitate.)* (a) A clean iron nail left in damp air turns orange-brown. (b) A spoon of sugar is stirred into water and the water stays clear. (c) Two powders mixed with water make the tube feel colder. (d) A pot of water on a hotplate makes bubbles.

Q2. Name the indicator at work in each case. (a) Two clear solutions are mixed and the mixture goes cloudy. (b) A campfire makes the air around it hotter. (c) Baking soda and vinegar fizz when mixed. (d) A cut banana turns brown.

Q3. Match each gas to its test: (1) oxygen, (2) carbon dioxide, (3) hydrogen. (a) Bubble the gas through limewater. (b) Put a glowing splint into the tube. (c) Hold a burning splint at the mouth of the tube.

Q4. Match each gas to how it is collected, and give the property behind the choice. (a) Over water, in an inverted cylinder. (b) In an upright jar. (c) In a downward (inverted) tube.

Q5. A gas is bubbled through limewater and the limewater turns milky. (a) Name the gas. (b) Name the indicator at work. (c) What word names the white solid that makes the limewater cloudy?

Q6. In the preparation of oxygen, the black powder MnO_2 is added to the H_2O_2 solution. (a) What does the MnO_2 do? (b) Is the MnO_2 used up? (c) What is the word for a substance that behaves like this?

Unscaffolded

Q7. A student writes: “bubbles always mean a chemical change.” Is the student correct? Justify your answer with one example.

Q8. Describe, step by step, how the oxygen made in a flask of H_2O_2 solution and MnO_2 is collected in a measuring cylinder over water.

Q9. Three unlabelled tubes hold oxygen, carbon dioxide and hydrogen. Describe a plan of tests that will identify each tube, and the result you expect from each test.

Q10. Powder X is one of the four mystery powders. With iodine solution it stays brown; with vinegar it does not fizz; with universal indicator it turns red-orange. Identify powder X.

Q11. A student mixes two substances at room temperature. The thermometer reads 20 °C at the start and 45 °C a minute later, and nothing was heated. (a) Name the indicator. (b) Is heat given out or taken in? (c) What may the student conclude about the change?

Q12. Explain why a tube of hydrogen is stored mouth-down while a jar of carbon dioxide is stored mouth-up.

Q13. Two clear solutions are poured together; the mixture turns cloudy and a solid settles. (a) Name the indicator. (b) What word names the solid? (c) Is this a chemical or a physical change? Give a reason.

Q14. A pool test kit turns a drop of pool water from yellow to green. (a) Which indicator of chemical change is the kit using? (b) What is the kit for?

Answers

Q1. (a) Yes — colour change. (b) No — dissolving is physical. (c) Yes — temperature change. (d) No — boiling is physical. **Q2.** (a) A precipitate forms. (b) Temperature change. (c) A gas is made. (d) Colour change. **Q3.** (1)–(b); (2)–(a); (3)–(c). **Q4.** (a) Oxygen — only slightly soluble in water. (b) Carbon dioxide — denser than air. (c) Hydrogen — less dense than air. **Q5.** (a) Carbon dioxide. (b) A precipitate forms (the limewater turns milky). (c) Precipitate. **Q6.** (a) It speeds up the change. (b) No. (c) Catalyst. **Q7.** No — boiling water makes bubbles but is a physical change; the bubbles must be a *new* gas. **Q8.** Fit a bung and delivery tube to the flask; fill a measuring cylinder with water and invert it in a trough of water; lead the tube end under the cylinder mouth; collect the gas as it pushes the water down. **Q9.** Glowing splint into each/one at a time: relights → oxygen. Burning splint at the mouth: pop → hydrogen. Bubble the remainder through limewater: milky → carbon dioxide. **Q10.** Cream of tartar. **Q11.** (a) Temperature change. (b) Given out. (c) A chemical change has probably happened. **Q12.** Hydrogen is less dense than air and would escape from an open, upright tube; carbon dioxide is denser than air and would fall out of an inverted one. **Q13.** (a) A precipitate forms. (b) Precipitate (an insoluble solid). (c) Chemical — a new substance (the solid) has been made. **Q14.** (a) Colour change. (b) To identify what is in the water (checking the pool water is safe).

Fully-worked solutions

Q1. *(4 marks)* (a) A new colour appears on the nail → indicator (colour change). *(1 mark)* (b) The sugar dissolves; the water stays clear and nothing new appears → not an indicator (dissolving is a physical change). *(1 mark)* (c) The tube gets colder with no cooling from outside → indicator (temperature change). *(1 mark)* (d) The bubbles come from boiling (water changing state), not from a new gas → not an indicator. *(1 mark)*

Q2. *(4 marks)* (a) A solid appears in a clear mixture → a precipitate forms. *(1 mark)* (b) The air gets hotter near the fire → temperature change (heat given out). *(1 mark)* (c) Bubbles of carbon dioxide appear → a gas is made. *(1 mark)* (d) A new brown colour appears → colour change. *(1 mark)*

Q3. *(3 marks)* Oxygen → (b) glowing splint, which relights. *(1 mark)* Carbon dioxide → (a) limewater, which turns milky. *(1 mark)* Hydrogen → (c) burning splint at the mouth, which gives a squeaky pop. *(1 mark)*

Q4. *(3 marks)* (a) Oxygen: it is only slightly soluble in water, so it can be collected over water. *(1 mark)* (b) Carbon dioxide: it is denser than air, so it sinks into an upright jar. *(1 mark)* (c) Hydrogen: it is less dense than air, so it rises into a downward tube. *(1 mark)*

Q5. *(3 marks)* (a) The gas is carbon dioxide — it turns limewater milky. *(1 mark)* (b) The indicator is the formation of a precipitate (the milky solid in the clear limewater). *(1 mark)* (c) The white solid is a precipitate (calcium carbonate). *(1 mark)*

Q6. *(3 marks)* (a) It speeds up the breaking-down of the H_2O_2 solution. *(1 mark)* (b) No — it is not used up. *(1 mark)* (c) A catalyst. *(1 mark)*

Q7. *(2 marks)* No. *(1 mark)* Boiling water makes bubbles, yet no new substance is made — it is a physical change; the indicator is bubbles of a *new* gas, such as the carbon dioxide from baking soda and vinegar. *(1 mark)*

Q8. *(4 marks)* Step 1: fit the flask with a bung and delivery tube so the gas cannot escape into the room. *(1 mark)* Step 2: fill a measuring cylinder completely with water, cover the mouth, and turn it upside down in a trough of water. *(1 mark)* Step 3: lead the end of the delivery tube under the mouth of the inverted cylinder. *(1 mark)* Step 4: let the bubbles rise into the cylinder; the oxygen collects at the top and pushes the water down until the cylinder is full of gas. *(1 mark)*

Q9. *(3 marks)* Test 1: put a glowing splint into a tube — if it relights, that tube holds oxygen. *(1 mark)* Test 2: hold a burning splint at the mouth of another tube — a squeaky pop means hydrogen. *(1 mark)* Test 3: bubble the gas from the last tube through limewater — milky means carbon dioxide. *(1 mark)*

Q10. *(3 marks)* Staying brown with iodine rules out corn starch and baking powder (both contain starch, which turns blue-black). *(1 mark)* Not fizzing with vinegar rules out baking soda and baking powder. *(1 mark)* The red-orange (acidic) result with universal indicator matches cream of tartar. ∴ powder X is cream of tartar. *(1 mark)*

Q11. *(3 marks)* (a) Temperature change — the mixture got hotter on its own. *(1 mark)* (b) Heat is given out (the reading rose from 20 °C to 45 °C). *(1 mark)* (c) A chemical change has probably happened — new substances are being made. *(1 mark)*

Q12. *(2 marks)* Hydrogen is less dense than air, so from an upright, open tube it would rise and escape; held mouth-down, the light gas stays in. *(1 mark)* Carbon dioxide is denser than air, so from an inverted tube it would fall out; held mouth-up, the heavy gas stays in the jar. *(1 mark)*

Q13. *(3 marks)* (a) The indicator is the formation of a precipitate. *(1 mark)* (b) The solid is a precipitate — an insoluble solid. *(1 mark)* (c) Chemical change: the solid is a new substance that was not present before the solutions were mixed. *(1 mark)*

Q14. *(2 marks)* (a) Colour change — a new colour appears when the tablet reacts with the pool water. *(1 mark)* (b) The kit identifies what is in the water (such as how acidic it is), to check the pool is safe to swim in. *(1 mark)*

Sources

- Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8 — content description `VC2S8U08` (second clause owned here; first clause owned by 11B) and elaborations `VC2S8U08.E01`, `VC2S8U08.E04`, `VC2S8U08.E05`, used as elaboration contexts (D6/D12).
- ASTA (Science ASSIST), Science Safety Essentials: Risk Assessment in Science (published 2022-10-25, modified 2025-12-15)
- ASTA (Science ASSIST), Science Safety Essentials: Risk Management in Science (published 2022-10-26, modified 2025-12-15)
- The laboratory preparations and tests for oxygen, carbon dioxide and hydrogen are authored from the CD text under D12 as school-standard safe practice written to the ASTA guidance above.

Web sources below were retrieved 2026-08-20.

Test A

Topic test T5 — Chemical sciences Science 7–8 · Victorian Curriculum 2.0 · Levels 7 and 8

> This is a school-designed paper. It is not a VCAA instrument and it is not a VCAA examination. Levels 7 and 8 carry no VCAA examination and no external assessment. Achievement at Levels 7 and 8 is reported against the Victorian Curriculum 2.0 achievement standard on teacher judgement, and the marks in this paper are one source of evidence towards that judgement.

About this test

- **Total: 40 marks** — Test A has 10 multiple-choice marks and Test B has 30 marks of short and structured response, including one separation-design item and one density calculation. Answer every question.
- **Suggested time: 45 minutes.** This test is untimed: a student may take as long as they need to complete it.
- **A scientific calculator is permitted** for this paper. There is no formula sheet and no reading time.
- **Reading support is available.** The assessment plan does not assign this test any special reading support, so students may use whatever reading support their classroom normally provides — for example, a teacher reading questions aloud. Reading is not being tested.
- The paper covers Topic 5 — Chemical sciences: Chapter 10 — Chemical sciences A: particles, properties and mixtures (subtopics 10A, 10B, 10C and 10D) and Chapter 11 — Chemical sciences B: atoms and chemical change (subtopics 11A, 11B and 11C). It assesses VC2S8U05, VC2S8U06, VC2S8U07 and VC2S8U08.
- **6 of the 40 marks are inquiry-strand marks** (codes VC2S8I03 and VC2S8I06). They attach to the Chapter 10 density investigation practical, and they are above the required minimum of 5 inquiry-strand marks per topic test.

What this paper assesses

> "the particle and kinetic theories of matter can be used to describe the arrangement and motion of particles in a substance, including the attraction between particles, and to explain the properties and behaviour of substances, including melting point, boiling point, density, compressibility, gas pressure, viscosity, diffusion, sublimation, and expansion and contraction" — VC2S8U05
>
> "matter can be classified as pure substances such as elements and compounds or impure substances such as mixtures (including solutions), and can be modelled using the particle model; mixtures may have a uniform (homogeneous) or non-uniform (heterogeneous) composition and can be separated based on the properties of their components using techniques including filtration, decantation, evaporation, crystallisation, magnetic separation, distillation and chromatography" — VC2S8U06
>
> "the atomic theory of matter can be used to model and explain the difference between elements, compounds and mixtures; elements, compounds and mixtures can be represented as two-dimensional and three-dimensional models, elements can be represented by symbols, and molecules and compounds can be represented by chemical formulas" — VC2S8U07
>
> "physical changes can be distinguished from chemical changes; a chemical change can be identified by a colour change, a temperature change, the production of a gas (including laboratory preparation and testing of oxygen, carbon dioxide and hydrogen gases) or the formation of a precipitate" — VC2S8U08

Answer all ten questions. For each question, choose A, B, C or D. Each question is worth 1 mark.

Q1. You warm a copper coin without melting it. What happens to the particles in the coin?

- A. They leave their positions and spread far apart.
- B. They vibrate more while remaining near their positions.
- C. They stop vibrating because the coin is heated.
- D. They begin sliding past one another like a liquid.

Q2. You observe dry ice changing directly into carbon dioxide gas without becoming a liquid. Which particle transition matches this change?

- A. Close particles vibrating in place become close particles moving past one another.
- B. Far-apart moving particles become close particles fixed in place.
- C. Close particles vibrating in place become far-apart particles that are free to move.
- D. Particles become larger but remain in fixed positions.

Q3. A density column has settled into three layers: honey (density 1.4 g/cm³) at the bottom, dyed water (1.0 g/cm³) in the middle, and cooking oil (0.9 g/cm³) on top. A fourth liquid, with a density of 1.2 g/cm³, is poured slowly into the column. Where does the fourth liquid settle?

- A. On top of the oil
- B. At the bottom, below the honey
- C. Between the water and the oil
- D. Between the honey and the water

Q4. You are given a particle diagram with six matching particles. Every particle has one triangle atom joined to one square atom. Triangles and squares represent different atom types, and no other particle is present. What classification fits the sample?

- A. A pure compound
- B. A mixture
- C. A pure element
- D. Unable to classify because the atom names are not given

Q5. You sort four labelled samples: pure copper, pure water, sugar water, and milk. Which pair should you place in the group called impure substances, or mixtures?

- A. Pure copper and pure water
- B. Sugar water and milk
- C. Pure copper and milk
- D. Pure water and sugar water

Q6. Filtration separates an insoluble solid from a liquid by passing the mixture through filter paper in a funnel. Which difference between the components does filtration exploit?

- A. Their density — the solid is denser than the liquid and sinks.
- B. Their magnetism — the solid is attracted to the filter paper.
- C. Their particle size — the solid pieces are too big to pass through the paper, and the liquid passes through.
- D. Their boiling point — the liquid boils away as it passes through the paper.

Q7. In chemistry, substances can be classified as elements, compounds or mixtures. Which statement best describes what an element is made of?

- A. Two or more different types of atoms chemically joined together
- B. Different types of atoms mixed together but not joined
- C. A single atom on its own
- D. Only one type of atom

Q8. Choose the statement that best describes how the scientist who made the first periodic table organised the elements.

- A. He mostly ordered elements by increasing mass and placed elements with similar chemical properties together.
- B. He ordered elements by the number of bits inside each atom and placed elements with similar chemical properties together.
- C. He placed all metals before all non-metals, without using a repeating pattern of properties.

- D. He ordered elements by the mass of each atom only, without grouping elements that behaved in similar ways.

Q9. A test tube holds a colourless gas that might be oxygen. Which test and result identify the gas as oxygen?

- A. Bubble the gas through limewater; the limewater turns milky.
- B. Put a glowing splint into the tube; the splint bursts back into flame.
- C. Hold a burning splint at the mouth of the tube; the gas burns with a squeaky pop.
- D. Look closely at the gas; oxygen has a pale blue colour.

Q10. You heat 6 grams of white sugar. After heating, it becomes brown, has a new smell, and does not return to white crystals when cooled. What type of change occurred?

- A. Physical, because the brown material is only melted sugar.
- B. Physical, because the mass stayed at 6 grams.
- C. Chemical, because brown material with new properties formed.
- D. Physical, because cooling makes all changes reverse.

Test B

Topic test T5 — Chemical sciences Science 7–8 · Victorian Curriculum 2.0 · Levels 7 and 8

Answer every question. Write your answer in the space your teacher provides. The marks for each part are shown in brackets.

Q11. (3 marks · VC2S8U05)

A bottle of eucalyptus oil is opened at the front of the classroom. After a short time, students sitting at the back of the room can smell the oil.

(a) Name the process by which the oil smell spreads through the room. (1 mark)

(b) Use the particle model to explain how the smell spreads from the front of the room to the back. (1 mark)

(c) On a hotter day, the smell reaches the back of the room more quickly. Explain why. (1 mark)

Q12. (3 marks · VC2S8U07)

A student draws three model boxes. Each circle and each square represents one atom, and atoms of different shapes are different elements.

- **Box 1** contains only particles that each have two identical circles joined together.
- **Box 2** contains only particles that each have one circle joined to one square.
- **Box 3** contains loose single circles and loose single squares, not joined to each other.

(a) Classify the sample in Box 1 as an element, a compound or a mixture. Give the reason for your answer. (1 mark)

(b) Classify the sample in Box 2 as an element, a compound or a mixture. Give the reason for your answer. (1 mark)

(c) Classify the sample in Box 3 as an element, a compound or a mixture. Give the reason for your answer. (1 mark)

Q13. (3 marks · VC2S8U08)

A student observes two processes.

- **Process 1:** An ice cube melts into liquid water. When the water is cooled, it freezes back into ice.
- **Process 2:** Vinegar is mixed with baking soda. Bubbles form and the mixture becomes colder.

(a) Classify Process 1 as a physical change or a chemical change. Give the evidence for your answer. (1 mark)

(b) Classify Process 2 as a physical change or a chemical change. Give the evidence for your answer. (1 mark)

(c) State the key difference between a physical change and a chemical change. (1 mark)

Q14. (4 marks · VC2S8U06)

You are given a dry mixture of iron filings, sand and salt.

(a) Design a procedure that separates the mixture into its three components. Write the steps in order and name the separation technique used at each step. (2 marks)

(b) Choose two of the steps you wrote in (a). For each one, state the property of the components that the technique uses. (2 marks)

The density investigation

A group investigates the density of a small block of aluminium. They measure its mass as 54.0 g. They half-fill a measuring cylinder with water and read the water level. They then lower the block gently into the water and read the new water level. The water level rises by 20 mL.

(The measurements in this investigation are simulated data for practice.)

Q15. (4 marks · VC2S8U05)

(a) State the formula that links density, mass and volume. (1 mark)

(b) Calculate the density of the aluminium block. Show your working and give the unit. (2 marks)

(c) The density of water is 1.0 g/cm^3. Predict whether the aluminium block sinks or floats in water, and explain your answer. (1 mark)

Q16. (3 marks · VC2S8I03)

The group wants to measure the mass and the volume of the block as accurately as they can.

(a) Name the piece of equipment the group uses to measure the mass of the block. (1 mark)

(b) The measuring cylinder is marked in 1 mL steps. State the smallest change in volume this measuring cylinder can show. (1 mark)

(c) State why the group should read the water level at eye level rather than from above. (1 mark)

Q17. (3 marks · VC2S8I06)

Another group carries out the same investigation, but they drop the block into the measuring cylinder quickly and some water splashes out over the rim.

(a) State how the splash affects the measured rise in the water level. (1 mark)

(b) Predict whether the density this group calculates is too high, too low, or correct, and explain your answer. (1 mark)

(c) Suggest one improvement to the method that would prevent this problem. (1 mark)

Q18. (3 marks · VC2S8U08)

A student has three test tubes, each holding a colourless gas: oxygen (O_2), carbon dioxide (CO_2) and hydrogen (H_2). The tubes are not labelled. She uses only a small amount of each gas, keeps her face away from the mouth of each tube, and wears safety glasses.

(a) Describe the test and a positive result for carbon dioxide. (1 mark)

(b) Describe the test and a positive result for hydrogen. (1 mark)

(c) Describe the test and a positive result for oxygen. (1 mark)

Q19. (4 marks · VC2S8U06)

A student stirs salt into a beaker of water until no more salt will dissolve. She then adds a little sand and stirs again.

(a) Name the term for a solution that contains the maximum amount of dissolved solute. (1 mark)

(b) State whether the salt water (before the sand is added) is a homogeneous or a heterogeneous mixture, and explain your answer. (1 mark)

(c) State whether the mixture after the sand is added is a homogeneous or a heterogeneous mixture, and explain your answer. (1 mark)

(d) Name the technique the student could use to remove the sand from the salt water, and state the property of the sand that this technique uses. (1 mark)

Marking guide

Topic test T5 — Chemical sciences · Marking guide

This guide gives model answers and mark allocations for Topic test T5. Marking is point-based: award whole marks only, and do not award half marks. Where a student gives a correct answer in different words from the model, award the mark if the idea is the same.

Where the multiple-choice items come from. The ten multiple-choice items are drawn from the Victorian Curriculum 2.0 Science Levels 7–8 MCQ bank for codes VC2S8U05, VC2S8U06, VC2S8U07 and VC2S8U08. The draw uses 3 items from VC2S8U05, 3 from VC2S8U06, 2 from VC2S8U07 and 2 from VC2S8U08, mixing easy and medium difficulties. No item was moved to a neighbouring code to fill a gap: where the bank could not supply an item at the right difficulty, a new item was written against the same code only. The stems and options are printed as stored in the bank; only the positions of the options have been changed so that the correct answers spread across A, B, C and D. Two typographical normalisations have been applied: “g/cm3” is printed as g/cm^3, and the bank’s lowercase answer letter “a” is printed as “A”. No vocabulary repair was needed, and no item draws on VC2S8U06.E05 (First Nations separation techniques), which is excluded under CONTENT_POLICY Rule 1.

Test A — answers (10 marks)

Each multiple-choice question is worth 1 mark.

Q	Answer	As printed	Source
Q1	B	They vibrate more while remaining near their positions.	VC2S8U05.E01.S01.D1.V04
Q2	C	Close particles vibrating in place become far-apart particles that are free to move.	VC2S8U05.E01.S01.D2.V03
Q3	D	Between the honey and the water	VC2S8U05.E06.S01.D2.V01
Q4	A	A pure compound	VC2S8U06.E01.S01.D1.V03
Q5	B	Sugar water and milk	VC2S8U06.E02.S01.D2.V07
Q6	C	Their particle size — the solid pieces are too big to pass through the paper, and the liquid passes through.	VC2S8U06.E03.S01.D1.V01
Q7	D	Only one type of atom	VC2S8U07.E01.S01.D1.V01
Q8	A	He mostly ordered elements by increasing mass and placed elements with similar chemical properties together.	VC2S8U07.E02.S01.D2.V01
Q9	B	Put a glowing splint into the tube; the splint bursts back into flame.	VC2S8U08.CORE.S01.D1.V01
Q10	C	Chemical, because brown material with new properties formed.	VC2S8U08.E02.S01.D2.V06

Test B — marking (30 marks)

Q11. (3 marks · VC2S8U05)

(a) Diffusion. (1 mark)

(b) The oil particles move randomly and spread out from where there are many of them (the front of the room, where concentration is higher) to where there are fewer of them (the back of the room). (1 mark) *Accept: "particles spread from a region of higher concentration to a region of lower concentration". Do not accept "the smell travels on the wind" with no particle explanation.*

(c) On a hotter day the particles have more energy, so they move faster and spread more quickly. (1 mark) *Accept: "higher temperature means faster-moving particles".*

Q12. (3 marks · VC2S8U07)

(a) Element. Every particle is the same, and each is made of only one type of atom. (1 mark)

(b) Compound. Every particle is the same, and each is made of two different types of atom joined together. (1 mark)

(c) Mixture. It contains two different types of atom that are not joined to each other, so more than one substance is present. (1 mark)

Marker note: award each mark for the correct classification together with a reason that matches it. A correct classification with no reason does not earn the mark.

Q13. (3 marks · VC2S8U08)

(a) Physical change. The water can be turned back into ice, so no new substance is formed; it is still water. (1 mark)

(b) Chemical change. A gas forms (the bubbles) and the temperature changes, which are indicators that a new substance forms. (1 mark)

(c) A physical change does not make a new substance; a chemical change makes one or more new substances. (1 mark)

Q14. (4 marks · VC2S8U06)

(a) Award up to 2 marks for a correct ordered procedure with the techniques named. Model answer:

1. Move a magnet through the mixture to pull out the iron filings (magnetic separation).
2. Add water to what remains and stir, so the salt dissolves. Filter the mixture (filtration); the sand stays on the filter paper and the salt water passes through.
3. Evaporate the water from the salt water (evaporation) to recover the salt.

Award 1 mark for a procedure that correctly separates all three components in a valid order, and 1 mark for naming a correct technique at each step. *Accept any valid order that removes the iron first with a magnet, dissolves the salt in water, filters out the sand, and evaporates the water to recover the salt.*

(b) Award 1 mark for each of two correct property–technique pairings, up to 2 marks. Acceptable pairings:

- Magnetic separation uses the fact that the iron filings are magnetic and the sand and salt are not.
- Filtration uses the fact that the sand does not dissolve and its particles are too large to pass through the filter paper.
- Evaporation uses the fact that the water evaporates but the salt does not.

The density investigation

The measurements (mass 54.0 g, volume rise 20 mL) are simulated data for practice. They are chosen so the calculated density (2.7 g/cm^3) matches the accepted density of aluminium, but the student calculates the value rather than recalling it.

Q15. (4 marks · VC2S8U05)

(a) density = mass ÷ volume. (1 mark) *Accept "density = mass / volume".*

(b) density = 54.0 g ÷ 20 cm^3 = 2.7 g/cm^3. (2 marks: 1 mark for the correct substitution and working, 1 mark for the correct answer with the unit g/cm^3.) *Note: 20 mL = 20 cm^3. Award the answer mark only if the unit is given.*

(c) The block sinks, because its density (2.7 g/cm^3) is greater than the density of water (1.0 g/cm^3). (1 mark)

Q16. (3 marks · VC2S8I03)

(a) A balance (or electronic balance, or scale). (1 mark)

(b) 1 mL. (1 mark)

(c) Reading from above gives a reading that is too high or too low because of parallax; reading at eye level avoids this and gives an accurate reading. (1 mark) *Accept: "reading at eye level avoids parallax error".*

Q17. (3 marks · VC2S8I06)

(a) Some water is lost over the rim, so the measured rise in the water level is smaller than the true volume of the block. (1 mark)

(b) The calculated density is too high. The mass is correct, but the volume is too small, and dividing the mass by a smaller volume gives a larger density. (1 mark)

(c) Lower the block gently and slowly into the water so that no water splashes out. (1 mark) *Accept any reasonable improvement that prevents splashing, for example using a wider cylinder or a displacement can.*

Q18. (3 marks · VC2S8U08)

(a) Bubble the gas through limewater; the limewater turns milky (cloudy). (1 mark)

(b) Hold a burning splint at the mouth of the tube; the gas burns with a squeaky pop. (1 mark)

(c) Put a glowing splint into the tube; the splint bursts back into flame (relights). (1 mark)

Marker note: award each mark for the correct test together with its correct positive result. A test with no result, or a result with no test, does not earn the mark.

Q19. (4 marks · VC2S8U06)

(a) Saturated. (1 mark)

(b) Homogeneous. The salt is dissolved and spread evenly through the water, so the composition is the same throughout. (1 mark)

(c) Heterogeneous. The sand does not dissolve and is not spread evenly, so the composition is not the same throughout. (1 mark)

(d) Filtration. It uses the fact that the sand is insoluble and its particles are too large to pass through the filter paper. (1 mark)

Mark summary and curriculum map

Section	Marks	Inquiry-strand marks
Test A — multiple choice	10	0
Test B — short and structured response	30	6
Total	**40**	**6** (required minimum: 5)

Items	Code	Achievement-standard extract
Q1, Q2, Q3, Q11, Q15	VC2S8U05	"They use the particle and kinetic theories of matter to explain the structure, properties and behaviour of substances."
Q4, Q5, Q6,	VC2S8U06	"They distinguish between pure substances and mixtures, and design procedures

Items	Code	Achievement-standard extract
Q14, Q19		to separate mixtures."
Q7, Q8, Q12	VC2S8U07	"They classify and represent matter as elements, compounds or mixtures, and distinguish between physical and chemical changes."
Q9, Q10, Q13, Q18	VC2S8U08	"They classify and represent matter as elements, compounds or mixtures, and distinguish between physical and chemical changes."
Q16	VC2S8I03	"They select and use equipment to generate and record data with precision."
Q17	VC2S8I06	"They identify assumptions and sources of error in methods and analyse conclusions and claims with reference to conflicting evidence and unanswered questions."

Sources

- Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8: content descriptions VC2S8U05, VC2S8U06, VC2S8U07, VC2S8U08, VC2S8I03, VC2S8I06, their elaborations, and the achievement standard. Victorian Curriculum and Assessment Authority. https://www.vcaa.vic.edu.au/curriculum/f-10-curriculum/science/ — retrieved 2026-08-22.
- All numerical data in Test B (the density investigation in Q15–Q17) are simulated data for practice. No real measured data are reproduced.
- The ten multiple-choice items are drawn from the Victorian Curriculum 2.0 Science Levels 7–8 MCQ bank. Item ids are listed in the Test A answer table above.

Teacher-facing note

This is a school-designed assessment instrument (D14). It is not a VCAA instrument and it is not a VCAA examination. Levels 7 and 8 carry no external assessment; the marks here are one source of evidence towards reporting against the Victorian Curriculum 2.0 achievement standard on teacher judgement.

Administration: the suggested time is 45 minutes, but the test is untimed and students may take as long as they need. A scientific calculator is permitted (needed for Q15). There is no formula sheet and no reading time. Reading support follows what the classroom normally provides; reading is not being tested.

Marking is point-based, with whole marks only. Model answers and accept-lists are given above for Test B.

Inquiry coverage: 6 of the 40 marks are inquiry-strand marks (VC2S8I03 in Q16 and VC2S8I06 in Q17), above the required minimum of 5. They attach to the Chapter 10 density investigation practical, in line with the plan's rule that T4–T7 inquiry marks attach to that chapter block's own practical work.

CONTENT_POLICY Rule 1: no First Nations content is assessed in this paper. The elaboration VC2S8U06.E05 (Indigenous separation techniques) is not drawn, and the separation-design item (Q14) uses a standard laboratory mixture.

D9 scope ceiling: this paper assesses Levels 7–8 content only. It does not assess any Levels 9–10 or VCE content, and it does not assess subatomic structure, chemical equations, the mole or bonding.