Energy and matter in chemical change slide deck

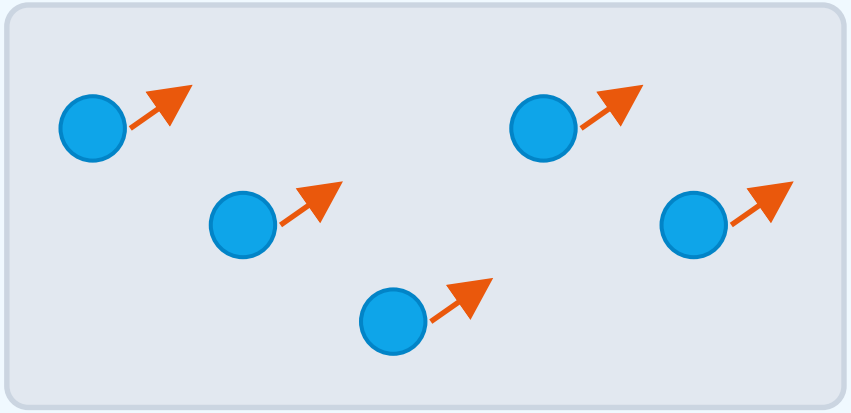
Science 10

Unit A: Energy and matter in chemical change

Particles of matter

Sugar in tea

- Solid sugar disappears into hot tea, the tea tastes sweet, and the glass has gained mass.
- The question is whether the sugar is still there, and what kind of change that was.
- The particle model is how this lesson answers that question.



Particles have space between them and move. Heating increases motion.

Dissolved sugar

- Dissolving sugar in tea is a powerful Grade 10 example of the particle model.
- The sweet taste and unchanged total mass show that sugar particles are still present.
- Those particles spread among water particles. They remain present.
- Dissolving is a physical change: no new chemical substance forms, which is different from burning sugar.

Key terms

particle model

The idea that all matter is made of tiny particles in motion with space between them.

pure substance

Matter with fixed composition (an element or a compound).

mixture

Two or more substances physically combined; composition can vary.

element

A pure substance made of one type of atom (one atomic number).

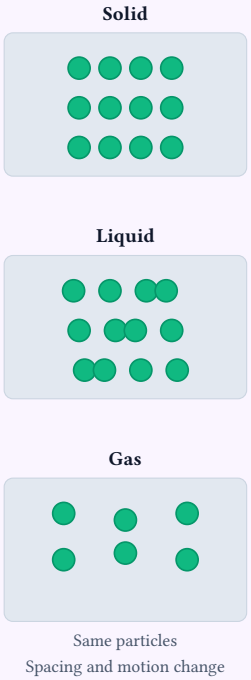
Key terms

compound

A pure substance with two or more elements chemically bonded in fixed ratios.

Particle model of matter

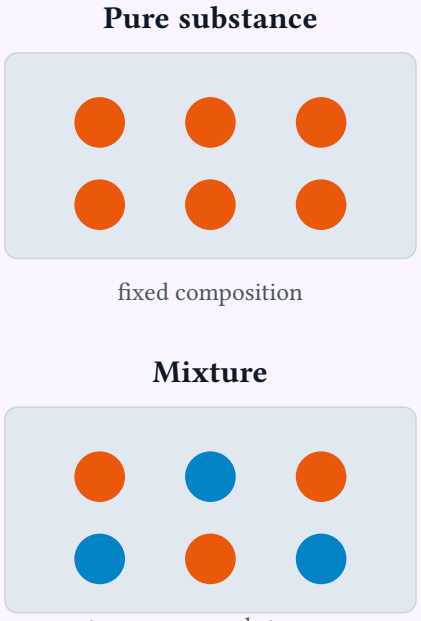
- All matter is made of tiny particles with space between them.
- Those particles move, and they move faster when the thermal energy increases.
- In a solid they stay close and vibrate. In a liquid they slide past one another. In a gas they are far apart and move quickly.



Same particles
Spacing and motion change

Pure substances and mixtures

- Copper and distilled water each have a fixed composition, so each is a pure substance.
- Salt water can be saltier or weaker, because a mixture's composition can vary.
- Salt water looks the same throughout. Gravel mixed with sand looks patchy.

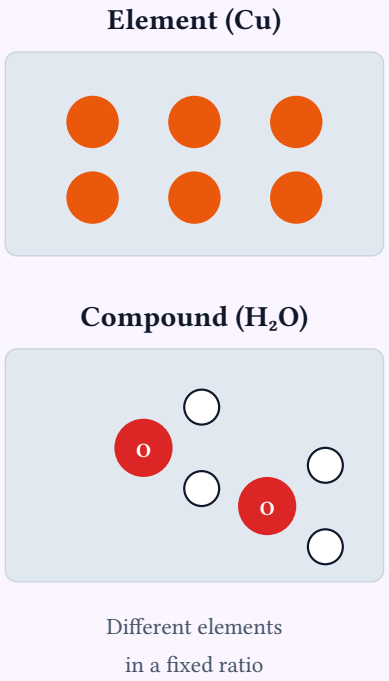


Materials and human needs

- Before contact, First Nations communities used living and non-living materials to meet basic needs.
- Plant extracts for dyes/medicines; minerals for tools; animal products for clothing and shelter.
- Knowledge was tested and passed on: an early form of empirical science.

Elements and compounds

- An element, such as copper or oxygen, is one kind of atom.
- A compound bonds two or more elements in a fixed ratio.
- A physical change keeps the same substances. A chemical change produces new ones.



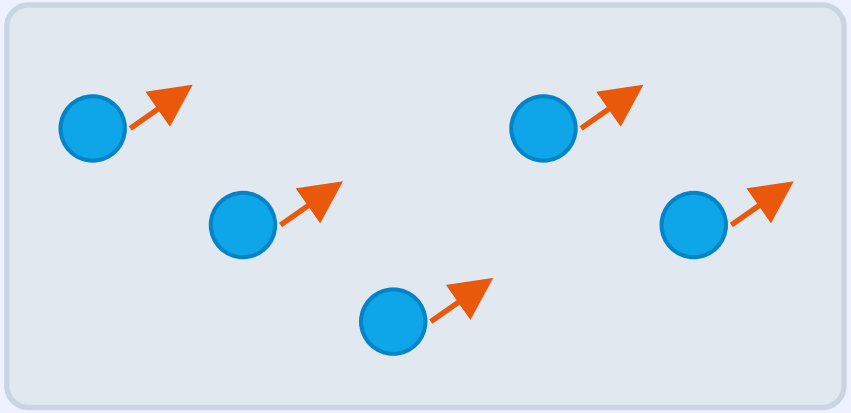
Different elements in a fixed ratio

Classifying samples

- Sort these samples: air, distilled water, salt water, gold, carbon dioxide, and gravel mixed with sand.
- Label each one as an element, a compound, a homogeneous mixture, or a heterogeneous mixture.
- Justify each label with the particle model.

Uses of models

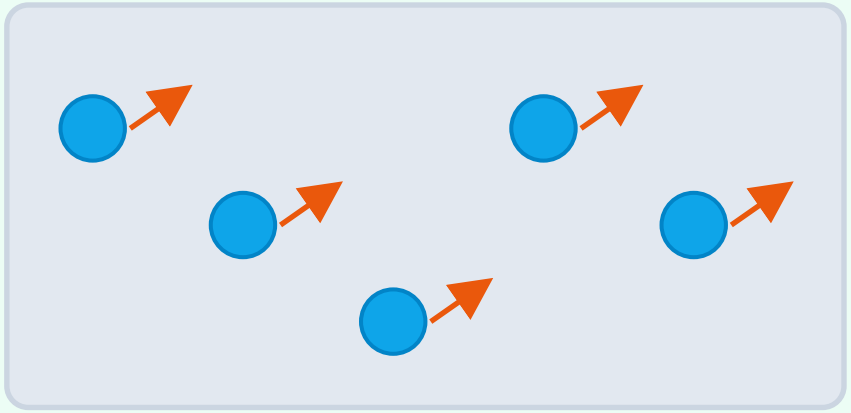
- Science uses models to explain and predict: models are re-vised when evidence demands.
- Technologies (microscopes, mass spectrometers) extend what we can observe.



Particles have space between them and move. Heating increases motion.

Evidence and opinion

- What observation would convince you that matter is made of particles?
- A convincing answer uses an observation other people could repeat.



Particles have space between them and move. Heating increases motion.

Particle-model retrieval check

- Classify copper, distilled water, air, and muddy water as elements, compounds, or mixtures.
- Explain dissolving sugar without saying the sugar disappears.
- State one observation that supports the particle model, even though atoms are too small to see.

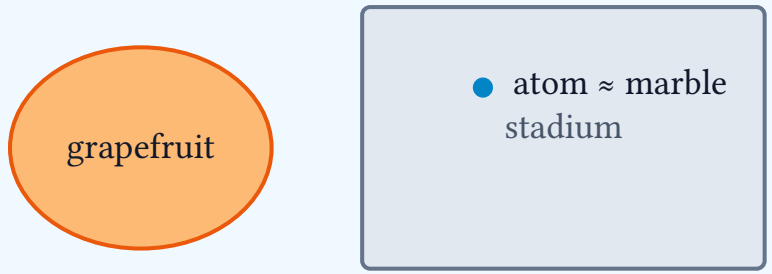
Science 10

Unit A: Energy and matter in chemical change

Atomic models and evidence

The size of an atom

- If you expanded a grapefruit to stadium size, atoms would be marble-sized.
- Atoms are far too small for classroom microscopes: how do we know their structure?



If a grapefruit were an atom, a stadium models its relative size

Two experiments on atomic structure

- Cathode rays bend toward a positive plate, evidence that atoms contain negatively charged electrons.
- Most alpha particles passed through the gold foil.
- A few deflected sharply, which is evidence of a tiny, dense, positive nucleus.
- For carbon-12, atomic number 6 means 6 protons; mass number 12 means 6 protons plus 6 neutrons.

Key terms

proton

Positively charged particle in an atomic nucleus.

neutron

Uncharged particle in an atomic nucleus.

electron

Negatively charged particle found outside an atomic nucleus.

nucleus

Dense central region of an atom containing protons and neutrons.

Key terms

atomic number

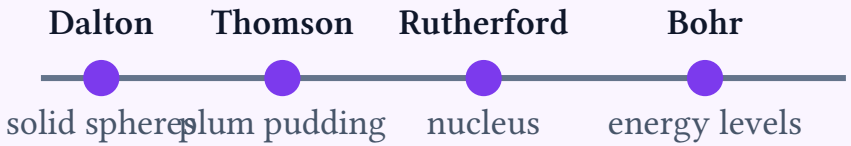
Number of protons in an atom's nucleus.

mass number

Total number of protons and neutrons in a particular atom.

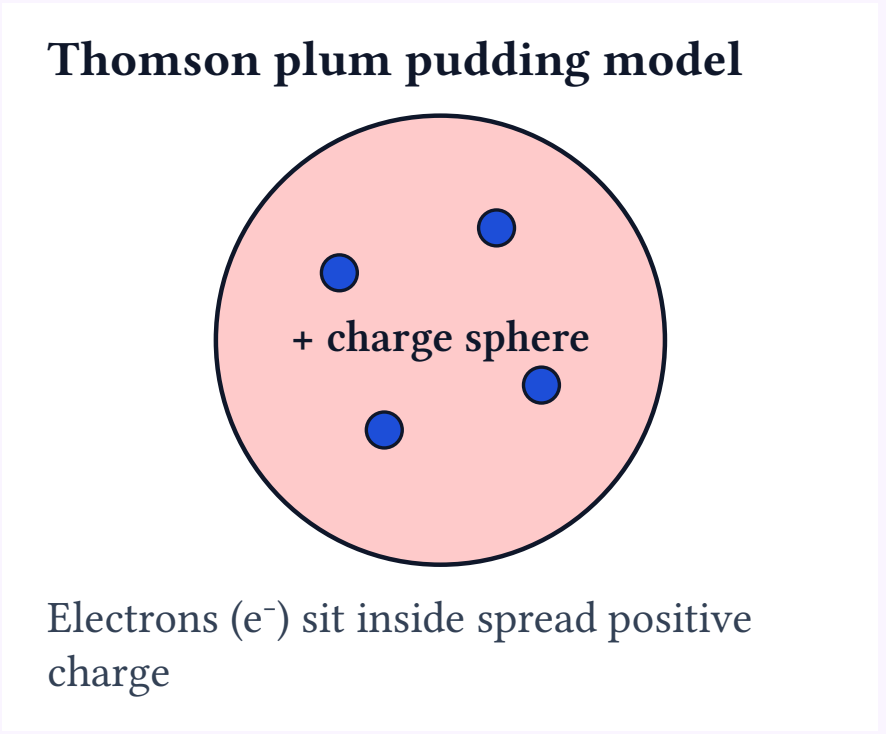
Dalton’s solid sphere model

- Dalton pictured each element’s atoms as solid spheres that stayed whole.
- That picture explains why a compound always combines elements in the same proportion.
- It leaves electric charge unexplained.



Thomson’s plum pudding model

- Thomson’s cathode-ray experiments showed that atoms contain electrons, which are negatively charged.
- He placed those electrons inside a sphere of positive charge, the picture nicknamed plum pudding.
- That picture failed to explain why some alpha particles bounce back from thin gold foil.

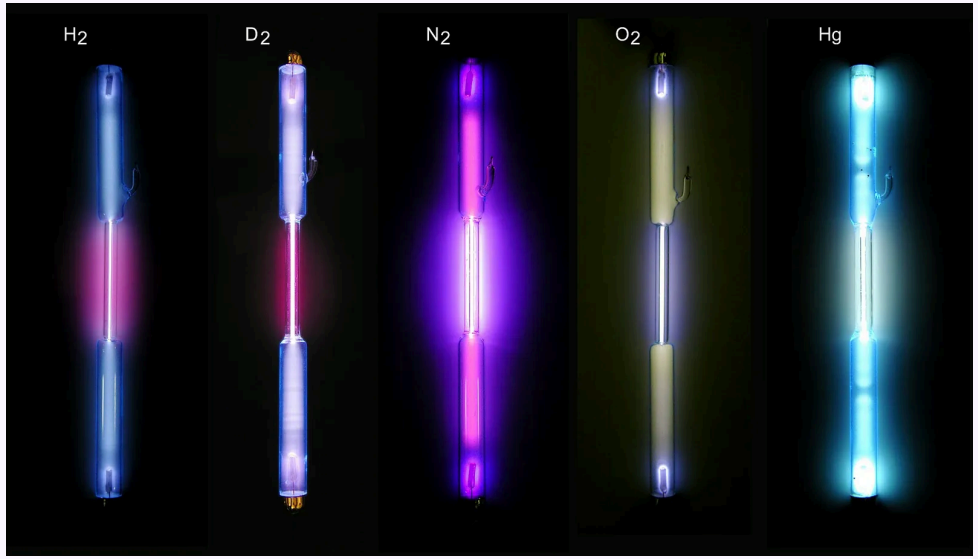


Rutherford’s nuclear model

- Most alpha particles passed straight through the foil, so the atom is mostly empty space.
- The few that bounced require a tiny region that is both dense and positively charged.
- Electrons sit outside that nucleus. The foil results replaced the spread-out positive charge.

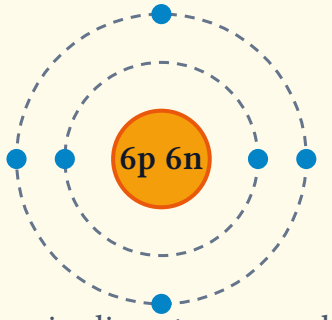
Bohr's energy level model

- Bohr allowed electrons only certain energies, a limited set of orbits.
- Those allowed energies explain the bright-line spectrum of hydrogen.
- A later model describes an electron as a cloud of probability. In this course you name that cloud. Calculating it comes in later courses.



Subatomic inventory

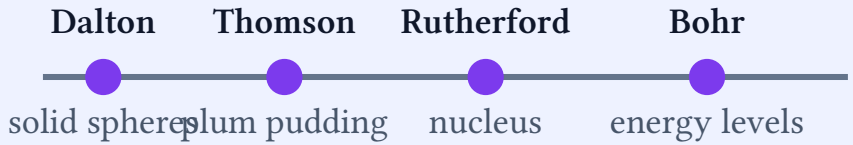
- A neutral carbon-12 atom has 6 protons, 6 neutrons in the common isotope, and 6 electrons.
- Atomic number is the proton count. Mass number is protons plus neutrons.



rade 10 model: electrons in discrete energy levels (2 + 4 for carbo

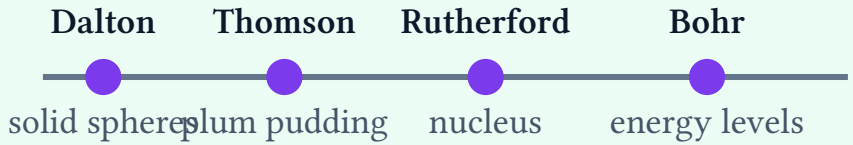
Careers using atomic structure

- Chemical engineering, cosmetology, and food processing use atomic evidence in different jobs.
- In Alberta that evidence shows up in oil-sands analysis, water treatment, medical tests, and farming.



Timeline sort

- Put the models in historical order, from the solid sphere to allowed energy levels.
- For each model, name one observation that the older model failed to explain.



Atomic evidence retrieval check

- Match cathode-ray deflection to the particle Thomson added to the atomic model.
- Match rare large alpha-particle deflections to Rutherford's nuclear revision.
- For carbon-12, determine proton, neutron, and electron counts in a neutral atom.

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Alchemist-hp www.pse-mendelejew.de, Gase-in-Entladungsroehren, CC BY-SA 3.0

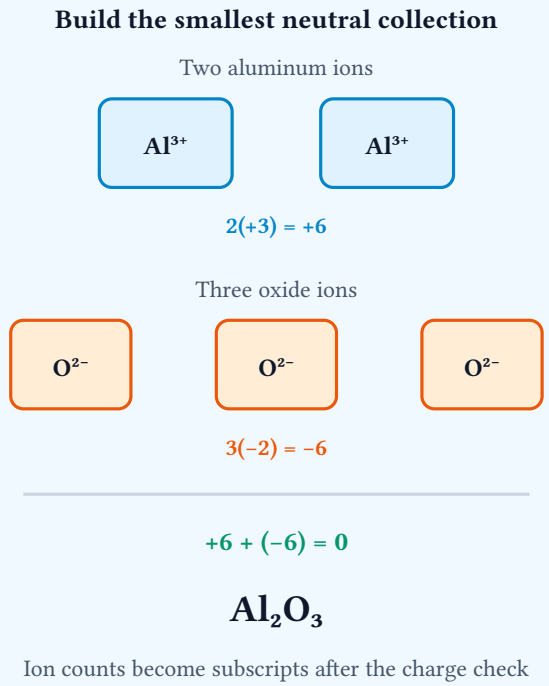
Science 10

Unit A: Energy and matter in chemical change

Periodic table patterns and combining ratios

The fixed formula of sodium chloride

- Sodium chloride is NaCl. $NaCl_2$ and Na_2Cl_5 are wrong.
- That repeating formula has to come from how the atoms are built.



Three decisions in this chapter

- Use main-group periodic position to predict common outer-electron behaviour and ion charge.
- Build the smallest whole-number ion ratio that makes total charge zero.
- Distinguish an ionic formula-unit ratio from the atom counts in a molecular formula.

Key terms

group

A vertical column of the periodic table whose elements often have similar chemical properties.

period

A horizontal row of the periodic table.

valence

The combining capacity associated with an atom’s outer electrons in the Grade 10 model.

ion

An atom or group of atoms with a net electric charge after gaining or losing electrons.

Key terms

ionic bond

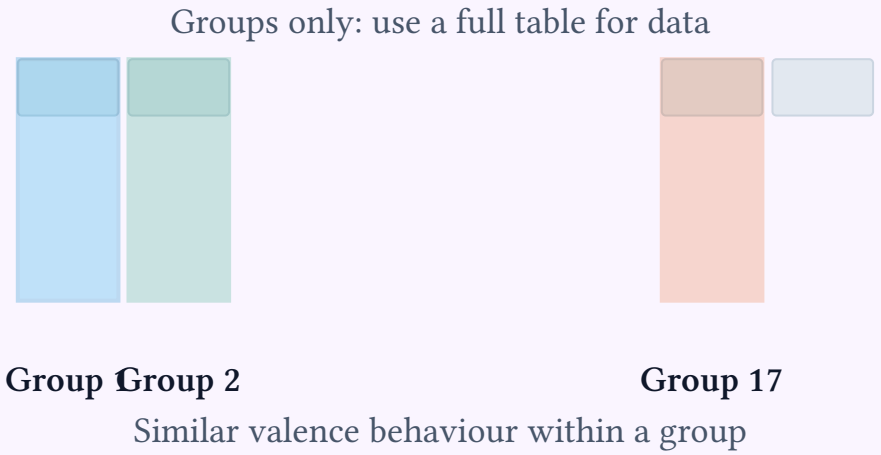
Attraction between oppositely charged ions after electron transfer.

covalent bond

Electrons shared between atoms in a molecule.

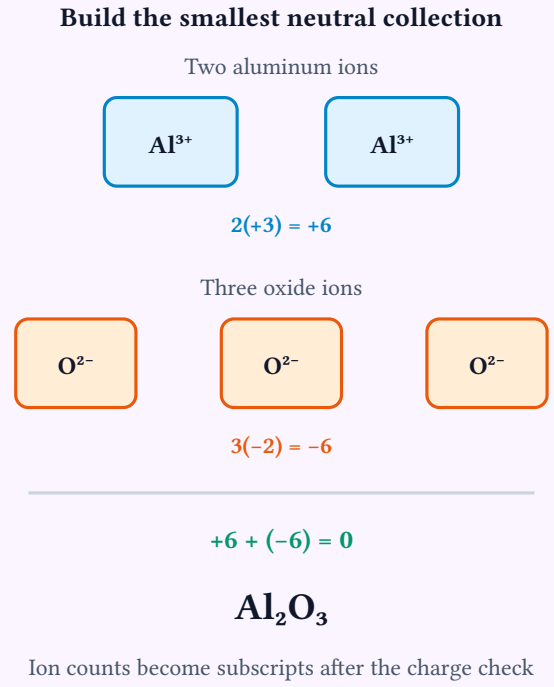
Periodic position and outer electrons

- A period shows the occupied energy levels in the Grade 10 model; a main-group column shows a recurring outer-electron pattern.
- Group 1 and 2 metals commonly form 1+ and 2+ ions by losing outer electrons; Group 17 and 16 non-metals commonly form 1− and 2− ions by gaining electrons.
- Two non-metals often share electrons, forming a covalent bond.



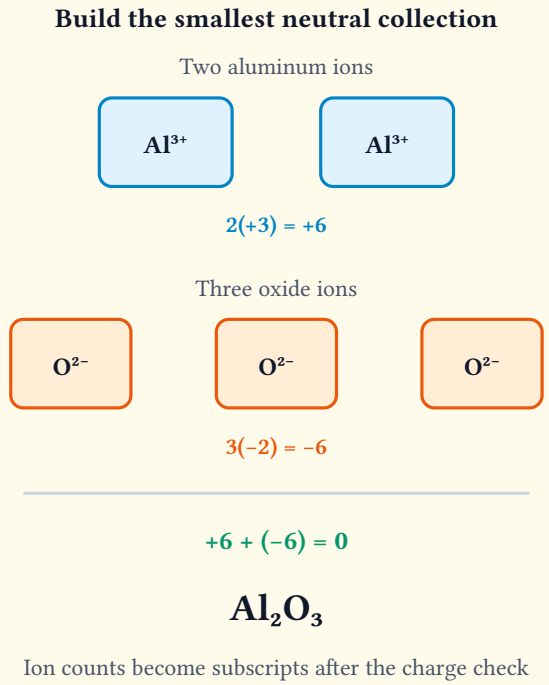
Smallest neutral ion ratio

- Write each ion with its charge, then combine ions until total positive charge equals total negative charge.
- Use the smallest whole-number ratio: two Al^{3+} ions give +6 and three O^{2-} ions give −6, so the formula is Al_2O_3.
- Check neutrality and reduce the ratio before removing charge symbols; keep each ion's internal subscripts exactly as they are.



From periodic position to formula

- Aluminum is in Group 13 and commonly forms Al^{3+}; oxygen is in Group 16 and commonly forms O^{2-} in this course model.
- The smallest neutral collection is two Al^{3+} ions and three O^{2-} ions.
- Write Al_2O_3, then verify $2(+3) + 3(-2) = 0$.



Formula practice

- Write formulas for magnesium oxide, sodium sulfide, and aluminum fluoride.
- For each compound, show ion charges, the smallest neutral ratio, and a total-charge check.
- Attempt all three before opening the solution; correct the first reasoning step that differs.

Communicating formulas

- A formula states which atoms are present and in what ratio.
- $CaCl_2$ and CaCl are separate formulas. The subscript changes the substance in this model.
- Laboratories and emergency crews rely on that ratio.
- A wrong ratio can waste a reaction or create a hazard.



Periodic pattern and formula retrieval check

- Predict the common ion charges for magnesium and chlorine from their periodic-table groups.
- Use charge balance to write magnesium chloride.
- Explain why MgCl and $MgCl_3$ both fail as neutral ionic compounds.

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James St. John, Halite crystals (four), CC BY 2.0

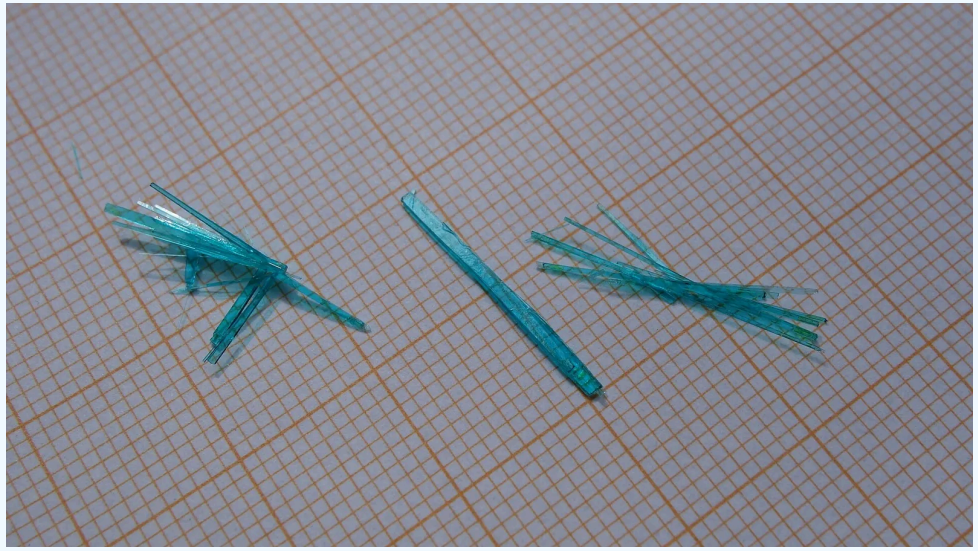
Science 10

Unit A: Energy and matter in chemical change

Naming ionic and molecular compounds

An incomplete label

- A shelf label that says only “copper chloride” could refer to CuCl or $CuCl_2$.
- The formulas contain different copper-ion charges and identify different compounds.
- A systematic name must preserve the evidence needed to identify the intended substance.



Choosing a naming system

- Metal or ammonium with an anion: use the ionic path and determine whether a Roman numeral is required.
- Two non-metals: use the binary molecular path and let prefixes state atom counts.
- A formula beginning with hydrogen and marked aqueous: use the required acid naming path.

Key terms

International Union of Pure and Applied Chemistry (IUPAC)

International organization that develops standardized chemical naming recommendations.

prefix

A word part that indicates the number of atoms in a molecular-compound name.

binary molecular

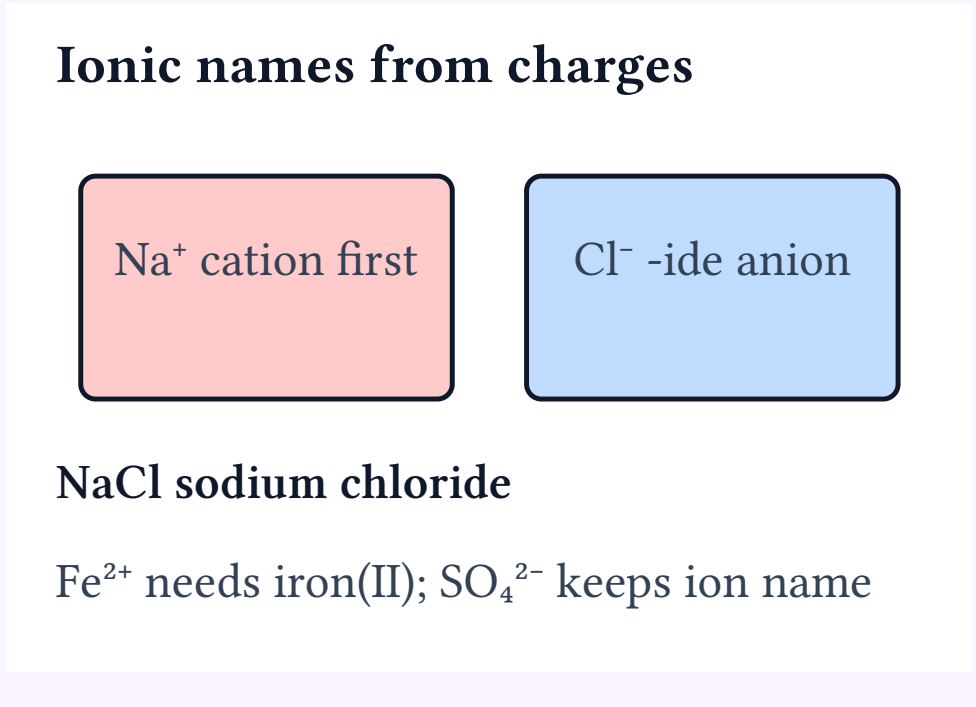
Describing a molecular compound made from two different elements.

polyatomic ion

A charged group of covalently bonded atoms that acts as one ion.

Ionic names from charges

- Name the cation first; a fixed-charge metal needs no Roman numeral, while a variable-charge metal does.
- A monatomic anion ends in -ide; a polyatomic ion keeps its established ion name.
- For $FeCl_3$, three Cl^- ions total −3, so iron is Fe^{3+} and the name is iron(III) chloride.



Molecular naming

- Prefixes show atom counts: carbon dioxide, dinitrogen tetroxide.
- Second element ends in -ide with prefix even if mono- (monoxide).

mono-	= 1	CO (carbon monoxide)
di-	= 2	CO_2 (carbon dioxide)
tri-	= 3	SO_3
tetra-	= 4	CCl_4

Aqueous solutions and acid names

- HCl(g) is hydrogen chloride; HCl(aq) is hydrochloric acid in the required acid-naming set.
- For a binary acid, identify the anion stem, then use hydro- + stem + -ic acid.
- Reverse-check the completed acid name against the aqueous formula and the supplied ion table.

Naming and writing

- Name K_2S, $CuCl_2$, SF_6, and $HNO_3(aq)$; classify each before applying a rule.
- Write formulas for sodium carbonate, iron(III) oxide, sulfur trioxide, and hydrochloric acid.
- Reverse-check every answer by rebuilding the starting name or formula.

Safety

Labels matter

- A prefix, a Roman numeral, or an ion name can point to a different substance.
- Match the full name to the formula before you look up hazards.
- The same name can still need different handling if the concentration or state changes.
- Use the product label and the safety data sheet. Check each name against the formula.

Chemical naming retrieval check

- Name Na_2SO_4 and explain why no molecular prefixes are used.
- Name P_4O_{10} using molecular prefixes.
- Write formulas for calcium chloride and dinitrogen monoxide.

mono-	= 1	CO (carbon monoxide)
di-	= 2	CO_2 (carbon dioxide)
tri-	= 3	SO_3
tetra-	= 4	CCl_4

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Science 10

Unit A: Energy and matter in chemical change

Acid and base safety

Household chemicals

- A window cleaner and a drain opener can both look like clear liquids, but their particles, pH, and hazards can be very different.
- A chemical with a familiar household use can still cause harm; concentration, exposure route, and amount all matter.
- Before use, read the product label and safety data sheet. To identify a chemical, use its label and safety data sheet; colour and smell are unreliable.

pH and other hazards

- A solution with pH below 7 is acidic, and a solution above 7 is basic.
- pH leaves out other hazards printed on the label.
- A conducting solution contains mobile charged particles, so conductivity helps you classify it; naming the exact chemical takes more tests.
- A corrosive pictogram or hazard statement changes how a product is handled, stored, and cleaned up.

Key terms

acid

A substance that produces hydronium ions in water in the Grade 10 model.

base

A substance that produces hydroxide ions or accepts protons in the Grade 10 model.

pH

Logarithmic measure related to hydronium-ion concentration in an aqueous solution.

conductivity

Ability of a material or solution to carry electric current.

Key terms

Workplace Hazardous Materials Information System (WHMIS)

Canadian system for communicating workplace chemical hazards through labels, pictograms, and safety data sheets.

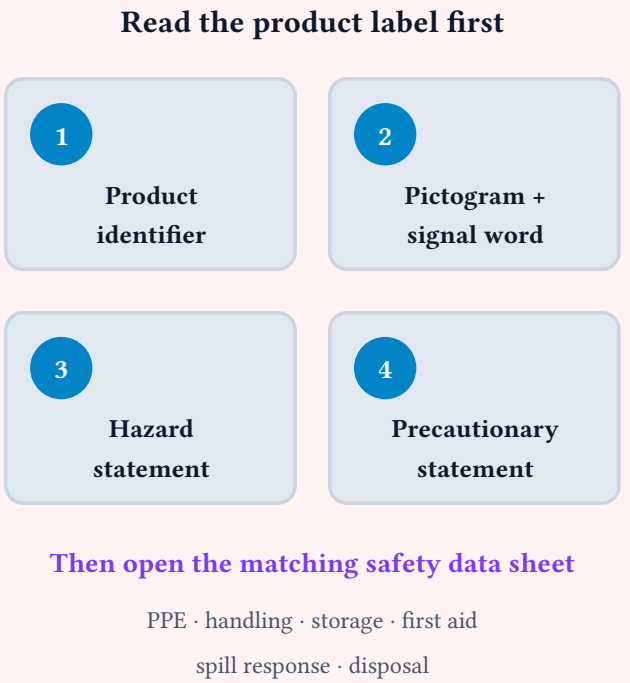
safety data sheet

Document describing a product's hazards, handling, storage, emergency, and disposal information.

Safety

Safety gate before chemical testing

- Identify the product and teacher-approved procedure before opening or testing a chemical.
- Read the container label first; use the safety data sheet for protective equipment, storage, first aid, spill response, and disposal.
- If the label, container, or conditions differ from the approved procedure, stop and notify the teacher.



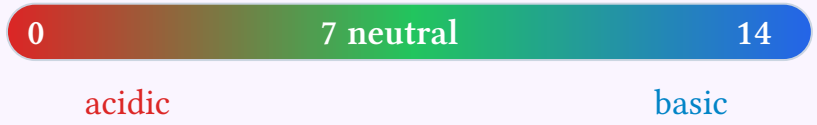
Classifying solutions by pH

- Hydrochloric acid, HCl(aq), has pH below 7 and conducts because ions are present after ionization in water.
- Sodium hydroxide, NaOH(aq), has pH above 7 and conducts because the ionic solid dissociates into mobile ions.
- Sodium chloride, NaCl(aq), can conduct while remaining near neutral, so pH is the test that decides acid or base.



pH scale

- The midpoint of the classroom pH scale is 7. Acids sit below it, and bases sit above it.
- To decide how dangerous a bottle is, use the label and safety data sheet. The pH number is only one clue.
- Concentration, the amount you have, and the safety data sheet still decide how you handle it.



erational Grade 10: acids below 7, bases above 7 in aqueous soluti

Societal hazards

- Hazard depends on the substance, its concentration, and how someone is exposed.
- A strong acid and a concentrated solution are two separate descriptions.
- Labels and safety data sheets say how to store, handle, and dispose of a product.
- Alcohol, nicotine, heavy metals, strong acids, and flammable gases each need their own procedure.

Classifying three evidence cards

- Sample A: pH 2, high conductivity, clear solution: classify the aqueous behaviour and state the evidence.
- Sample B: pH 7, high conductivity, clear solution: explain why pH decides acid or base, while conductivity only shows that ions are present.
- Sample C: pH 11, low but measurable conductivity: classify the aqueous behaviour without guessing the product identity.

Acid and base safety

- Classify a conducting solution with pH 2 using the Grade 10 acid/base model.
- Explain what you need besides pH to judge whether a product is safe to handle.
- Name the two product-specific sources to consult before using a classroom chemical.

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Science 10

Unit A: Energy and matter in chemical change

Polarity and solubility

Oil and water

- After shaking, oil forms droplets in water and then separates back into a layer on top.
- Oil floats because it is less dense than water, and polarity explains why the liquids fail to mix.
- Water is polar and cooking oil is mostly non-polar, so their particle attractions favour separation.

Molecular polarity

- Water is polar because its bent molecule has a partially negative oxygen side and partially positive hydrogen sides.
- Hydrogen bonds are attractions between neighbouring polar molecules; the covalent bonds inside one water molecule are a separate, stronger link.
- Call a substance soluble only for a named solvent and conditions.
- Sodium nitrate is soluble in water under typical classroom conditions.

Key terms

polar

Having an uneven distribution of electrical charge.

hydrogen bond

Attraction involving a partially positive hydrogen and an electronegative atom on another particle.

soluble

Able to dissolve to an appreciable extent in a stated solvent and condition.

insoluble

Dissolving only to a very small extent in a stated solvent and condition.

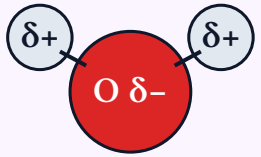
Key terms

like dissolves like

Guideline that substances with similar polarity tend to dissolve one another.

From bond polarity to water's properties

- Oxygen attracts shared electrons more strongly than hydrogen, so each O-H bond has partial charges.
- Water's bent shape keeps the bond dipoles from cancelling, making the whole molecule polar.
- Attractions between neighbouring water molecules require energy to disrupt, helping explain water's high heat capacity and evaporative cooling.



hape → polar molecule; explains cohesion and many solubility pa

Solubility charts as evidence

- Identify the cation and anion in the proposed ionic compound.
- Locate the ion combination on the approved chart and check any listed exception.
- Use the chart to assign aqueous or solid state; trust the chart over the idea that “all ionic compounds dissolve.”

Solubility chart check

1. Name cation and anion
2. Find the pair on the chart

$Ag^+ + Cl^-$

→ **insoluble (exception)**

Check listed exceptions before deciding

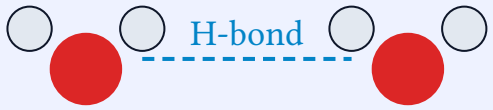
Precipitate prediction

- Mix $AgNO_3(aq)$ and $NaCl(aq)$: list Ag^+, NO_3^-, Na^+, and Cl^- before predicting new ion pairs.
- Ion exchange gives possible products $AgCl$ and $NaNO_3$; the solubility chart identifies $AgCl$ as relatively insoluble.
- Write $AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$, then verify atoms and charge are accounted for.



Water and energy transfer

- Equal energy input usually produces a smaller temperature change in water than in many other common substances.
- Part of the transferred energy disrupts attractions between water molecules before their average motion increases greatly.
- In lakes and organisms, this behaviour moderates temperature; evaporation can remove energy with escaping water molecules.



δ+ on H attracted to δ− on O of neighbouring molecule

Polarity and solubility retrieval check

- Explain why oil floating on water and oil staying separate from water require two different ideas.
- Use the solubility chart to predict whether AgCl forms when $AgNO_3(aq)$ and NaCl(aq) mix.
- State what else you need, besides conductivity, to identify dissolved ions or judge whether something is toxic.

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Science 10

Unit A: Energy and matter in chemical change

Evidence of chemical change

Baking with baking powder

- When baking powder becomes wet, its ingredients react and produce carbon dioxide gas.
- The gas forms bubbles that become trapped in the batter; heating expands the bubbles and helps the baked product rise.
- Gas formation supports a chemical-change claim when the reactants can produce a new gaseous substance; bubbles from boiling alone are a physical change.

Reaction patterns

- Magnesium and oxygen forming magnesium oxide is synthesis; one more complex product forms from simpler reactants.
- Hydrogen peroxide breaking into water and oxygen is decomposition, while methane reacting with oxygen is combustion.
- Zinc displacing copper from a compound is single replacement.
- Two ionic compounds that exchange ions and form a precipitate are double replacement.

Key terms

synthesis

Reaction in which simpler substances combine to form a more complex product.

decomposition

Reaction in which one compound breaks into simpler substances.

combustion

Reaction with oxygen that releases energy; complete hydrocarbon combustion forms carbon dioxide and water.

single replacement

Reaction in which one element replaces another element in a compound.

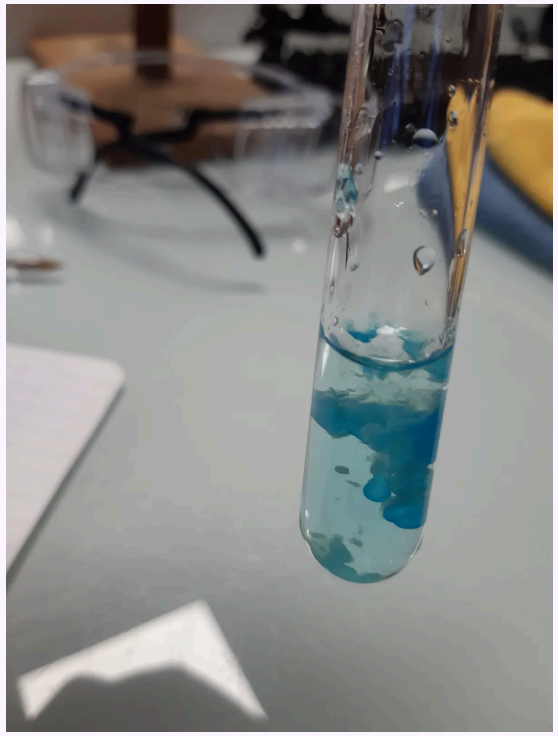
Key terms

double replacement

Reaction in which ions in two compounds exchange partners.

Evidence checklist

- Look for at least one sign that a new substance formed, such as an unexpected gas, a new colour, or a solid appearing.
- A change of state keeps the same chemical formula. Melted ice is still water.



Energy in reactions

- An exothermic reaction releases thermal energy to the surroundings. Many combustions do this.
- Photosynthesis, taken as a whole, absorbs energy, so this course treats it as endothermic.

Five categories

- The five patterns are synthesis, decomposition, hydrocarbon combustion, single replacement, and double replacement.
- Recognize the pattern from how the reactants and products are arranged.

Synthesis: $A + B \longrightarrow AB$

Decomposition: $AB \longrightarrow A + B$

Single replacement: $A + BC \longrightarrow AC + B$

Double replacement: $AB + CD \longrightarrow AD + CB$

Combustion (hydrocarbon): $C_xH_y + O_2 \longrightarrow CO_2 + H_2O$

Reactions in society

- Photosynthesis, respiration, combustion, and decay are chemical changes with different jobs.
- Combustion and respiration both release stored chemical energy. They are separate processes.
- Whether a process helps depends on its products and how people use them; the reaction type is just its name.
- Rate, amount, emissions, and conditions decide the impact.

Classifying equations

- Read the words of the equation before you look for a type.
- Synthesis joins reactants into one product. Decomposition splits one reactant apart.
- Single replacement swaps one element. Double replacement swaps two partners.
- Leave coefficients for the next lesson. This pass is classification only.

Evidence and reaction retrieval check

- Two clear aqueous solutions form a white solid. Name the evidence of chemical change and the likely reaction category.
- Methane reacts with oxygen to form carbon dioxide and water. Classify the reaction and identify the energy evidence you would expect.
- For each case, name one observation that would make you reconsider your classification.

Image credits

Wikisquack, Un précipité bleu dans une solution aqueuse incolore, CC BY 4.0

Science 10

Unit A: Energy and matter in chemical change

Word equations and balancing

Lavoisier and the balance

- In a closed system, total mass before a chemical reaction equals total mass after, within measurement uncertainty.
- Atoms are rearranged during a reaction. None are created or destroyed.



Same atoms: rearranged, not created or destroyed

aw of conservation of mass ↔ balanced equations ↔ mole ratio

Mass in a closed system

- A closed system keeps all of its matter inside its boundary.
- Its measured mass stays constant during a chemical reaction, within the precision of the balance.
- Lavoisier compared masses before and after reactions in closed containers.

Key terms

reactant

A starting substance in a chemical reaction; written on the left side of an equation.

product

A substance formed in a chemical reaction; written on the right side of an equation.

coefficient

A whole number placed before a formula that multiplies every atom in that formula.

subscript

A number within a chemical formula that states the fixed atom ratio in that substance.

Key terms

conservation of mass

In a closed system, total mass remains constant during physical and chemical changes.

Word equations

- A word equation names substances: methane + oxygen ⟶ carbon dioxide + water.
- A skeleton equation uses correct formulas and states: $CH_4(g) + O_2(g) \longrightarrow CO_2(g) + H_2O(g)$.

Word and skeleton equations

Words: methane + oxygen ⟶ CO_2 + water

$CH_4(g) + O_2(g) \longrightarrow CO_2(g) + H_2O(g)$

Skeleton uses formulas and state symbols

Skeleton and balanced equations

- Keep every chemical formula fixed.
- Choose whole-number coefficients so each element has the same atom count on both sides.

Unbalanced:

$H_2 + O_2 \longrightarrow H_2O$

H: 2 = 2 ✓ · O: 2 ≠ 1 ×

Balanced:

$2\ H_2 + O_2 \longrightarrow 2\ H_2O$

H: 4 = 4 · O: 2 = 2

Coefficients multiply entire formulas: never change subscrip

Combustion of propane

- Skeleton: $C_3H_8 + O_2 \longrightarrow CO_2 + H_2O$.
- Balanced: $C_3H_8 + 5\ O_2 \longrightarrow 3\ CO_2 + 4\ H_2O$.
- Balance carbon first, then hydrogen, then oxygen, and recount every element.

Unbalanced:

$H_2 + O_2 \longrightarrow H_2O$

H: 2 = 2 ✓ · O: 2 ≠ 1 ×

Balanced:

$2\ H_2 + O_2 \longrightarrow 2\ H_2O$

H: 4 = 4 · O: 2 = 2

Coefficients multiply entire formulas: never change subscrip

Practice set

- Synthesis: $Mg + O_2 \longrightarrow MgO$.
- Single replacement: $Zn + HCl \longrightarrow ZnCl_2 + H_2$.
- Double replacement: $NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl$.

Unbalanced:

$H_2 + O_2 \longrightarrow H_2O$

H: 2 = 2 ✓ · O: 2 ≠ 1 ×

Balanced:

$2\ H_2 + O_2 \longrightarrow 2\ H_2O$

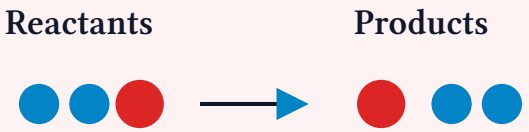
H: 4 = 4 · O: 2 = 2

Coefficients multiply entire formulas: never change subscrip

Safety

Lab conservation demo

- Measure a sealed flask before and after an effervescent reaction at room temperature.
- Keep a reacting sealed container closed and away from heat; follow the teacher's procedure.



Same atoms: rearranged, not created or destroyed

aw of conservation of mass ↔ balanced equations ↔ mole ratio

Review

- Translate: hydrogen + oxygen ⟶ water.
- Balance the skeleton equation and verify both atom counts.
- Count the atoms of each element on both sides before you call the equation balanced.

Unbalanced:

$H_2 + O_2 \longrightarrow H_2O$

H: 2 = 2 ✓ · O: 2 ≠ 1 ×

Balanced:

$2\ H_2 + O_2 \longrightarrow 2\ H_2O$

H: 4 = 4 · O: 2 = 2

Coefficients multiply entire formulas: never change subscrip

Industrial equations

- Electrolysis: $2\ H_2O(l) \longrightarrow 2\ H_2(g) + O_2(g)$.
- The coefficients show twice as many hydrogen molecules as oxygen molecules.
- Industrial decisions also consider electricity source, gas storage, cost, and worker safety.

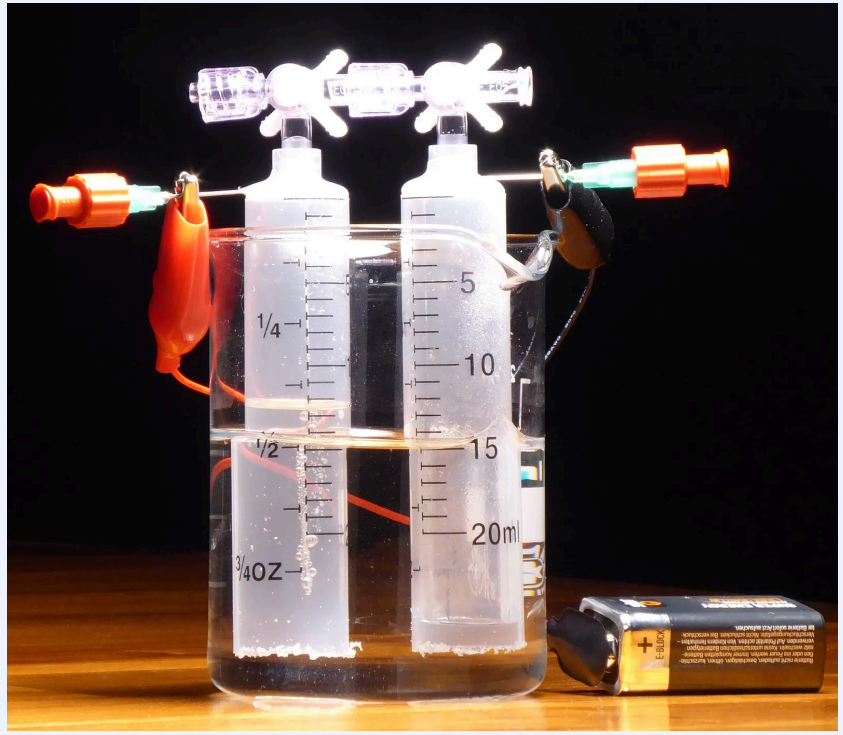


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Science 10

Unit A: Energy and matter in chemical change

Predicting products and balancing

Predicting products

- Iron placed in copper(II) sulfate solution can form iron(II) sulfate and solid copper because iron is above copper in the activity series.
- The prediction tells the chemist what colour, solid product, and hazards to expect before mixing substances.
- After predicting correct formulas, coefficients are adjusted so every element has the same atom count on both sides.

Products and solubility

- Because iron is above copper in the activity series, the prediction is $Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$.
- For two aqueous ionic compounds, exchange the ions and check the solubility chart.
- Write a precipitate only when a product is relatively insoluble.
- For complete hydrocarbon combustion, predict carbon dioxide and water, then balance carbon, hydrogen, and oxygen.

Key terms

activity series

A ranking used to predict whether one element can replace another in a reaction.

solubility

Maximum amount of a substance that dissolves under stated conditions.

complete combustion

Combustion with sufficient oxygen that produces carbon dioxide and water for a hydrocarbon fuel.

Synthesis and decomposition

- Synthesis has several reactants and one product; establish the product formula before balancing.
- Decomposition has one reactant and multiple products; use the taught reaction family or supplied conditions to identify products.
- Atom counts verify a completed prediction; product identity comes from the reaction pattern.

Synthesis and decomposition

Synthesis: A + B ⟶ AB

Decomposition: AB ⟶ A + B

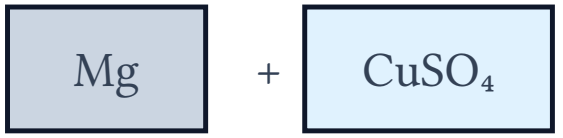
Name the product formula, then balance coefficients

Single replacement

- A free metal replaces a metal ion only when the activity series places the free metal higher.
- Magnesium is above copper, so Mg + $CuSO_4$ ⟶ $MgSO_4$ + Cu is supported.
- Copper is below magnesium, so Cu + $MgSO_4$ is recorded as no reaction under the stated conditions.

Single replacement

Mg + $CuSO_4$ ⟶ $MgSO_4$ + Cu



Mg is higher on the activity series than Cu

Double replacement and combustion

- Double replacement: exchange ions, write charge-balanced formulas, then use the solubility chart to decide whether a precipitate supports reaction.
- Complete hydrocarbon combustion: predict CO_2 and H_2O, then balance carbon, hydrogen, and oxygen in that order.
- These pathways use different evidence and should be checked in separate panels.

Synthesis: $A + B \longrightarrow AB$

Decomposition: $AB \longrightarrow A + B$

Single replacement: $A + BC \longrightarrow AC + B$

Double replacement: $AB + CD \longrightarrow AD + CB$

Combustion (hydrocarbon): $C_xH_y + O_2 \longrightarrow CO_2 + H_2O$

Full workflow

- Classify Mg + $AgNO_3$ as possible single replacement, then use the activity series to test the prediction.
- Write $Mg(NO_3)_2$ and Ag from ion identity and charge balance before adding coefficients.
- Balance and verify: $Mg + 2AgNO_3 \longrightarrow Mg(NO_3)_2 + 2Ag$.

Four prediction stations

- Station 1: synthesis and decomposition: identify the family, establish products, then balance.
- Station 2: single replacement: include one supported reaction and one no-reaction decision.
- Stations 3 and 4: double replacement with chart evidence, then complete hydrocarbon combustion.

Product-prediction retrieval check

- Predict and balance the products for magnesium reacting with oxygen.
- Use the activity series to decide whether copper replaces zinc in zinc sulfate.
- For sodium chloride mixed with silver nitrate, predict products and identify any precipitate.

Science 10

Unit A: Energy and matter in chemical change

The mole and conservation of mass

The mole

- A dozen always means 12 objects; one mole always means 6.022×10^{23} representative particles.
- Individual atoms and molecules are too small to count directly, so chemists count moles by measuring a sample's mass.
- About 18.02 g of water is one mole of water molecules because water's molar mass is about 18.02 g/mol.

Amount and number of particles

- A 0.50 mol water sample contains about 3.011×10^{23} water molecules because amount is multiplied by Avogadro's number.
- Each water molecule contains three atoms, so 0.50 mol of water molecules contains about 9.033×10^{23} atoms in total.
- In a balanced reaction, coefficients compare amounts in moles, for example, 2 mol hydrogen reacts with 1 mol oxygen.

Key terms

mole

The International System of Units (SI) amount unit: 6.022×10^{23} representative particles. (mol)

Avogadro's number

The number of representative particles in one mole: 6.022×10^{23} per mole. (N_a)

molar mass

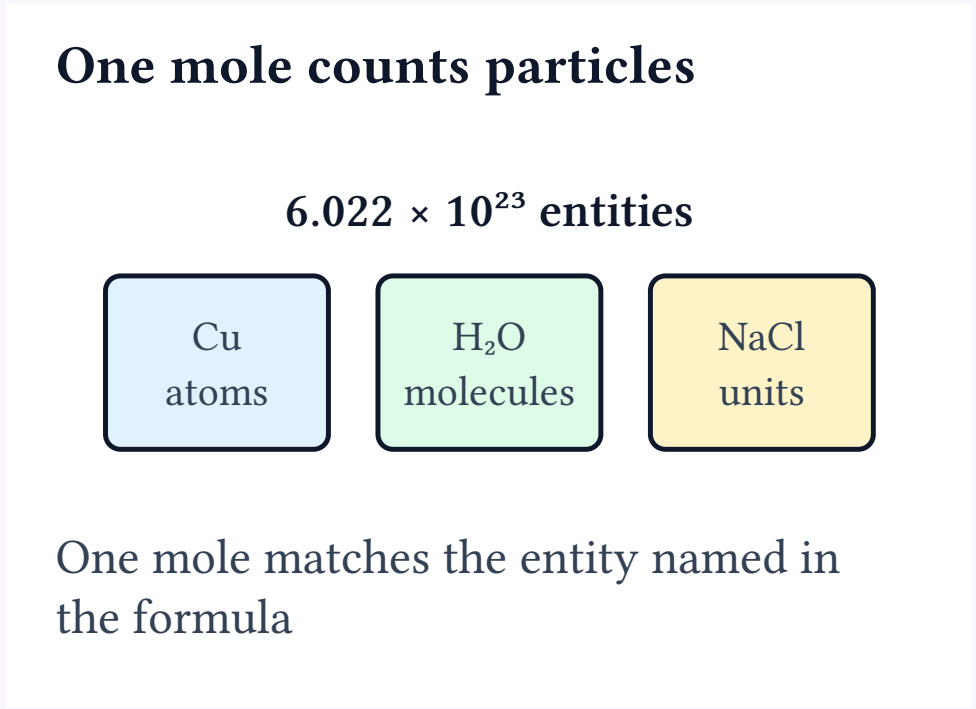
The mass of one mole of a substance, usually measured in grams per mole.

coefficient

A whole number placed before a chemical formula that multiplies every atom in that formula.

What one mole counts

- One mole contains 6.022×10^{23} specified representative entities.
- Use atoms for elements such as copper, molecules for substances such as water, and formula units for ionic compounds such as sodium chloride.
- A numerical particle answer is incomplete unless the entity and unit are named.



Molar mass

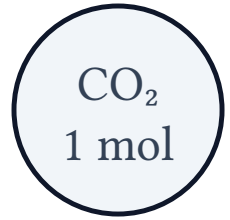
- For CO_2, add one carbon atomic mass and two oxygen atomic masses.
- Calculation: 12.01 g/mol + 2(16.00 g/mol) = 44.01 g/mol.
- A coefficient changes the amount of CO_2 present; the molar mass of CO_2 stays the same.

Molar mass of CO_2

C 12.01 g/mol

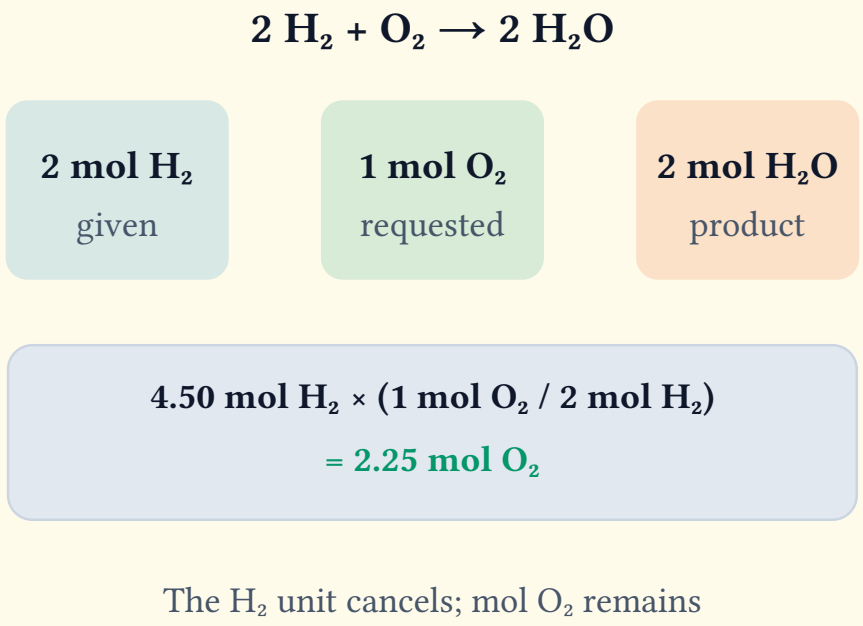
O 16.00 g/mol × 2

12.01 + 2(16.00) = 44.01 g/mol



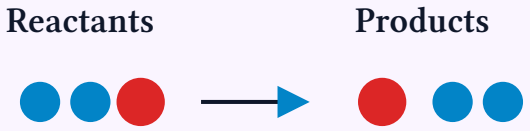
From equation to mole ratios

- In $2H_2 + O_2 \longrightarrow 2H_2O$, the coefficient ratio H_2:O_2:H_2O is 2:1:2.
- For 4.50 mol H_2, multiply by 1 mol O_2 / 2 mol H_2 to obtain 2.25 mol O_2.
- The H_2 unit cancels; the remaining mol O_2 unit identifies the requested substance and amount.



Conservation revisited

- For $2H_2 + O_2 \longrightarrow 2H_2O$, both sides contain 4 mol of H atoms and 2 mol of O atoms.
- The total amount of chemical substances changes from 3 mol of reactants to 2 mol of product; conservation applies to atoms and mass, so substance moles can change.
- Using molar masses gives 4.032 g H_2 + 32.00 g O_2 = 36.032 g H_2O, so total mass is conserved.



Same atoms: rearranged, not created or destroyed

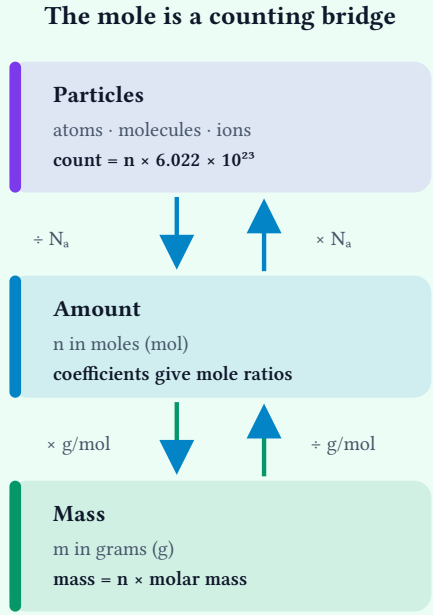
aw of conservation of mass ↔ balanced equations ↔ mole ratio

Calculations

- Mole ratio: 4.0 mol H_2 × (1 mol O_2 / 2 mol H_2) = 2.0 mol O_2.
- Particle count: 0.500 mol NaCl × 6.022×10^{23} formula units/mol = 3.011×10^{23} formula units.
- In each calculation, choose the relationship, show unit cancellation, and name the representative entity.

Directions on the mole map

- Convert 1.2044×10^{24} water molecules to moles of water.
- Convert 0.125 mol water to number of water molecules.
- Before calculating, state whether the map calls for division or multiplication and identify the final unit.



Start from the known quantity; keep units beside every value.

Mole and conservation retrieval check

- Convert 0.25 mol of water molecules to number of molecules.
- Find the molar mass of carbon dioxide from its formula.
- Use $2H_2 + O_2 \longrightarrow 2H_2O$ to find oxygen required for 6.0 mol hydrogen.