

Atoms, Molecules, and Ions

A foundation for understanding matter — from subatomic particles to compounds.

INSTRUCTOR

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FOUNDATIONS

Matter, Elements, and Atoms

01

Matter

Anything that has mass and occupies volume — the physical substance of the universe.

02

Elements

The simplest form of matter; cannot be broken down chemically into simpler substances.

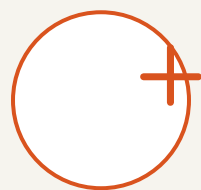
03

Atoms

The smallest unit of an element that retains its identity in a chemical reaction.

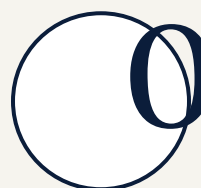
ATOMIC STRUCTURE

Subatomic Particles



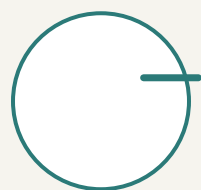
Protons

Positive charge · in the nucleus



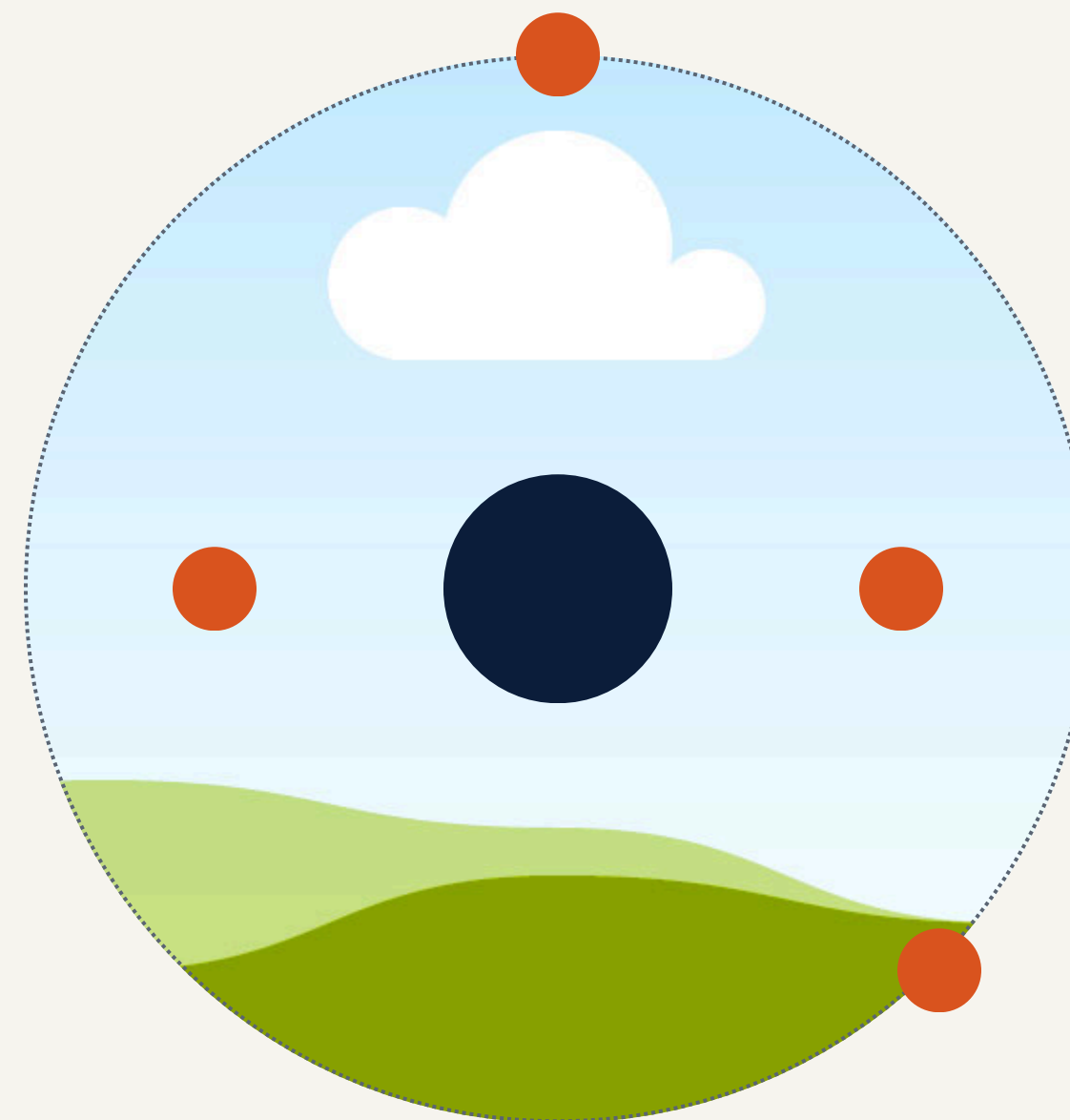
Neutrons

No charge · in the nucleus



Electrons

Negative charge · orbit the nucleus



ATOMIC STRUCTURE

Atomic Number & Mass Number

Atomic Number (Z)

Equal to the number of protons in the nucleus. Defines the element.

Mass Number (A)

The total count of protons + neutrons in the nucleus.

Neutral Atom

Number of electrons equals the number of protons.

ATOMIC NOTATION



mass number (A)

atomic number (Z)

element symbol

VARIATIONS

Isotopes

Atoms of the same element with equal numbers of protons but different numbers of neutrons. Isotopes behave alike chemically yet differ in mass.

Carbon-12



PROTONS

6

NEUTRONS

6

Stable · 98.9% natural abundance

Carbon-14



PROTONS

6

NEUTRONS

8

Radioactive · used in dating

CHARGED SPECIES

Ions: Cations and Anions

+ Cation

Positively charged ion formed by the LOSS of one or more electrons.



— Anion

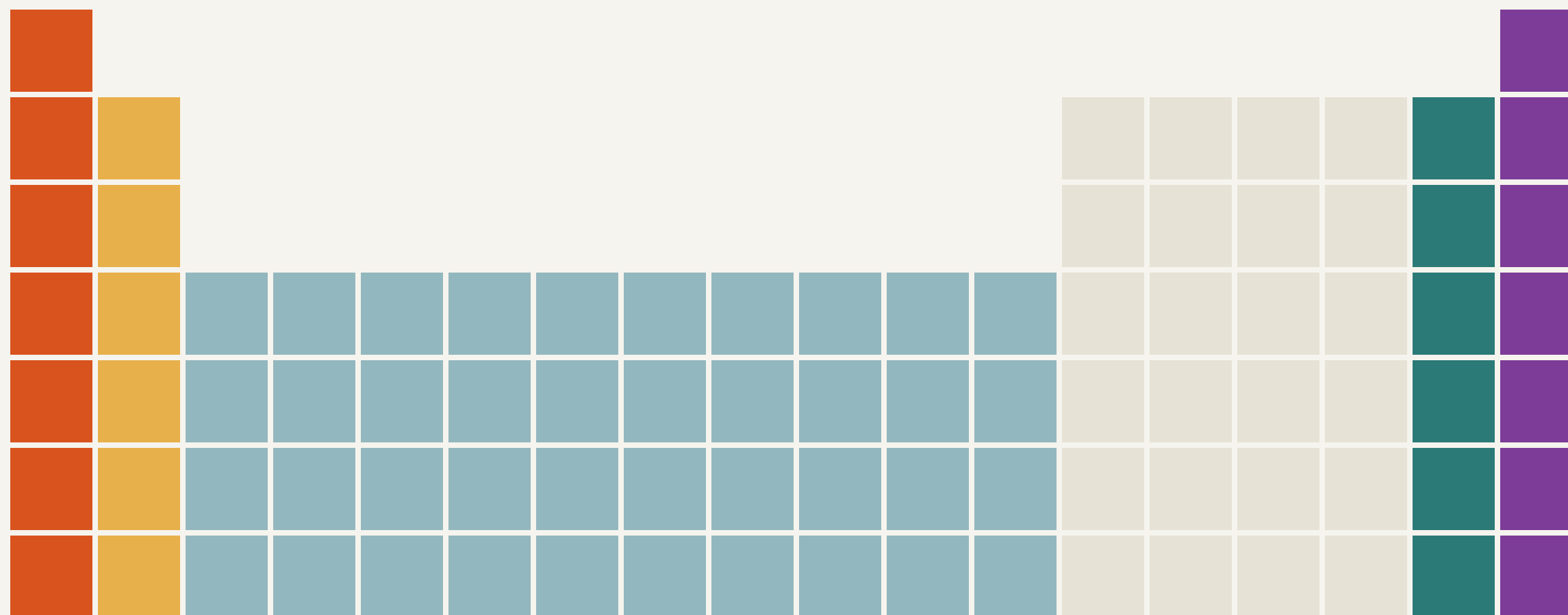
Negatively charged ion formed by the GAIN of one or more electrons.



MAP OF THE ELEMENTS

The Periodic Table

7 periods (rows) · 18 groups (columns). Elements are arranged by increasing atomic number and share properties within a group.



- Group 1 · Alkali Metals
- Group 2 · Alkaline Earth
- Groups 3–12 · Transition
- Group 17 · Halogens
- Group 18 · Noble Gases

CLASSIFICATION

Metals, Metalloids, Nonmetals

Metals

Good conductors of heat and electricity · malleable · ductile · lustrous.

EXAMPLES

Fe · Cu · Al

Metalloids

Show intermediate properties between metals and nonmetals · semiconductors.

EXAMPLES

Si · Ge · As

Nonmetals

Poor conductors · brittle when solid · often gaseous at room temperature.

EXAMPLES

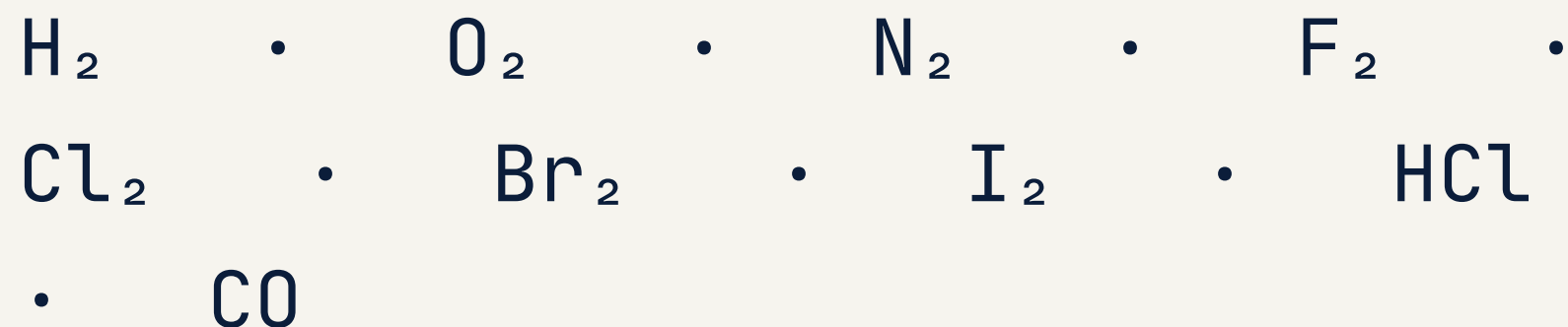
O · N · S

BONDED ATOMS

Molecules: Diatomic & Polyatomic

A molecule is two or more atoms held together by chemical bonds — the smallest independent unit of a compound.

DIATOMIC — TWO ATOMS



POLYATOMIC — THREE OR MORE



Remember the seven diatomic elements: H, N, O, F, Cl, Br, I — plus the mixed diatomics HCl and CO.

COMPOUNDS

Ionic vs. Molecular

Ionic Compounds

METAL + NONMETAL

Formed by the transfer of electrons producing cations and anions held by electrostatic attraction.

EXAMPLES

NaCl · MgO · CaF₂

Molecular Compounds

NONMETAL + NONMETAL

Formed by sharing of electron pairs between atoms — covalent bonds.

EXAMPLES

H₂O · CO₂ · NH₃

IONIC CHARGES

Main-Group Element Charges

GROUP	EXAMPLES	TYPICAL CHARGE
Group 1	Li, Na, K	+1
Group 2	Mg, Ca, Ba	+2
Group 13	Al, Ga	+3
Group 15	N, P, As	-3
Group 16	O, S, Se	-2
Group 17	F, Cl, Br, I	-1

TRANSITION METALS

Variable charges

Indicate the charge in Roman numerals — e.g. Fe(II), Fe(III), Cu(I), Cu(II).

GROUPS OF ATOMS

Common Polyatomic Ions

Ammonium



+1

Hydroxide



-1

Cyanide



-1

Nitrate



-1

Sulfate



-2

Carbonate



-2

Phosphate



-3

Acetate



-1

NOMENCLATURE

Naming Ionic Compounds

- 01 Name the cation first, then the anion.
- 02 For transition metals, indicate the charge with a Roman numeral in parentheses.
- 03 Monoatomic anions end with the suffix -ide (e.g., chloride, oxide).
- 04 Polyatomic anions typically end with -ate or -ite (with common exceptions such as hydroxide).

EXAMPLES

NaCl Sodium chloride

CaBr_2 Calcium bromide

FeCl_3 Iron(III) chloride

K_2SO_4 Potassium sulfate

CONSTRUCTION

Writing Ionic Formulas

- 1** Identify the ions
Aluminum forms Al^{3+} ; oxygen forms O^{2-} .
- 2** Balance the charges
The compound must be electrically neutral overall.
- 3** Cross the charges
Use subscripts to make total positive = total negative.
- 4** Write the formula
Cation first, then anion — with the balancing subscripts.

WORKED EXAMPLE · ALUMINUM OXIDE



↓ cross the charges ↓



Aluminum oxide

PRACTICE PROBLEM · 01

Name this compound.

Iron is a transition metal — its charge must be shown in Roman numerals to remove ambiguity.

GIVEN FORMULA



ANSWER

Iron(III) chloride

Fe^{3+} balances three Cl^- ions → charge in Roman numerals: (III).

Write the formula.

GIVEN NAME

Calcium nitrate

IONS & BALANCE

$\text{Ca}^{2+} + \text{NO}_3^- \rightarrow$ one Ca^{2+} needs two NO_3^-

ANSWER

$\text{Ca}(\text{NO}_3)_2$



RECAP

Summary of Key Concepts

01 Matter & Atoms

Matter is anything with mass and volume; atoms are the smallest chemically active units of elements.

02 Atomic Structure

Protons and neutrons sit in the nucleus; electrons orbit it. Z = protons, A = protons + neutrons.

03 Periodic Table

7 periods, 18 groups organize elements as metals, metalloids, and nonmetals with shared properties.

04 Molecules & Compounds

Atoms bond into molecules and compounds — ionic (metal + nonmetal) or molecular (nonmetal + nonmetal).

05 Ions & Nomenclature

Cations lose electrons; anions gain them. Naming and formulas balance charges to yield neutral compounds.

END OF CHAPTER 02

Thank you.

Questions & discussion welcome.

INSTRUCTOR

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COURSE

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