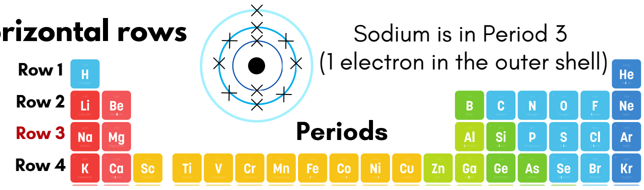
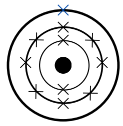
C1.2 The Periodic Table

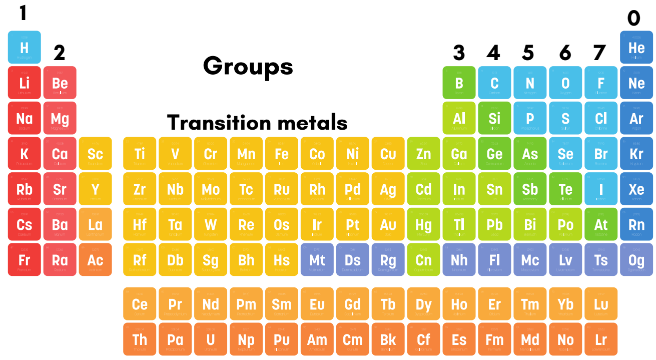
The Structure of the Periodic Table

Periods
- Named for the regular intervals at which properties repeat, a result of electron arrangement.
- Elements are arranged in order of increasing atomic number
- Horizontal rows
- Show the number of electron shells an atom has
- Numbered 1 – 7 (e.g., elements in Period 3 have three shells)



Groups
- Vertical columns
- Numbered 1–7 & 0 (0 instead of Group 8)
- Show the number of outer electrons





How Electronic Structure Relates to the Periodic Table

Subatomic Particle	Relative Mass	Example: Chlorine (2, 8, 7)
Number of shells	Period number	3 - Period 3
Number of electrons in outer shell	Group number	7 outer electrons - Group 7
Total number of electrons	Atomic number	17

Elements in the same group have similar chemical properties because they have the same number of valence (outer shell) electrons.

Metals vs. Non-Metals

Metals: Left and centre of the table.
Non-Metals: Right-hand side.
Metalloids: Border between metals and non-metals.

Property	Metals	Non-Metals
Electrical Conductivity	Good conductor	Poor conductor
Heat Conductivity	Good conductor	Poor conductor
Appearance	Shiny	Dull
Density	High	Low
Malleability	Malleable	Brittle
Bonding	Lose electrons (form positive ions)	Gain/share electrons (form negative ions)

Development of the Periodic Table

Early Attempts

Scientists originally arranged elements by atomic weight.

- This method led to errors because isotopes were not known.
- Some elements ended up in the wrong groups.

Dmitri Mendeleev

Contribution

- Arranged elements by atomic weight while maintaining group properties.
- Left gaps for undiscovered elements, predicting their properties.
- Grouped elements with similar chemical properties for better classification.
- Recognised periodic trends, forming the basis for the modern periodic table.

Limitations

- Ordered by atomic weight instead of atomic number, causing misplacements.
- Lacked knowledge of isotopes, affecting atomic weight ordering accuracy.
- Couldn't fully explain periodic trends due to limited understanding of subatomic particles.
- Some elements were mis grouped due to incomplete knowledge and missing elements.

The Modern Periodic Table

The discovery of protons, neutrons, and electrons led to:

- Ordering elements by atomic number (not weight).
- Fixing incorrect placements (e.g., Tellurium & Iodine).
- Explanation of "pair reversals" due to isotopes.

In Mendeleev's Periodic Table, Iodine (I) was ordered before Tellurium (Te). The modern table orders them by atomic number, placing Iodine (53 protons) after Tellurium (52 protons).

52	53
Te	**I**
Tellurium	Iodine
127.6	126.90447

C1.2 Groups in the Periodic Table

Group 0: Noble Gases

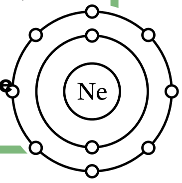
Properties

- Non-flammable and do not easily form compounds.
- Full outer shell of electrons → Very stable and unreactive (inert)
- Exist as monatomic gases (single atoms).

Why are Noble Gases Unreactive?

Their outermost shell is full (Helium: 2 electrons, others: 8 electrons).

Since they do not need to gain, lose, or share electrons, they do not readily react.



Uses

- **Helium**: Balloons, cooling superconductors (lighter than air, non-flammable)

- **Argon**: Used in welding (inert atmosphere)

- **Neon**: Lights (glows when electricity passes through)
- **Xenon and Krypton**: Flash photography, car headlights

Group	Key Features	Trends in Reactivity
Group 0 (Noble Gases)	Unreactive, full outer shell, low boiling points	No trend (inert gases)
Group 1 (Alkali Metals)	Very reactive, soft, low density, low melting points	Increases down the group
Group 7 (Halogens)	Reactive non-metals, form -1 ions, diatomic	Decreases down the group

Trends in Physical Properties

Boiling points increase down the group due to larger atom size and mass, resulting in stronger intermolecular forces that require more energy to overcome.

Element	Boiling Point (˚C)
Helium (He)	-269
Neon (Ne)	-246
Argon (Ar)	-186
Krypton (Kr)	-153
Xenon (Xe)	-108
Radon (Rn)	-61

Group 1: Alkali Metals

Properties

- Soft metals that can be cut with a knife
- Low melting points; decrease down the group.
- Low density (Lithium, Sodium, and Potassium are less dense than water).
- 1 electron in outer shell → Very reactive

Trends in Physical Properties

Reactivity increases down a group due to additional electron shells, which position outer electrons further from the nucleus. This distance weakens the attraction from the nucleus, making it easier to lose outer electrons and thus increasing reactivity.

Element	Density	Melting Point (˚C)	Reactivity
Lithium (Li)	0.53 g/cm³	181˚C	Least reactive
Sodium (Na)	0.97 g/cm³	98˚C	More reactive
Potassium (K)	0.86 g/cm³	63˚C	Even more reactive
Rubidium (Rb)	1.53 g/cm³	39˚C	Highly reactive
Caesium (Cs)	1.93 g/cm³	28˚C	Extremely reactive
Francium (Fr)	Unstable	~27˚C	Most reactive (rare and radioactive)

Reactions of Halogens

With Metals → Forms ionic metal halides (salts).
Equation: Metal + Halogen → Metal Halide
Example: $2Na + Cl_2 \rightarrow 2NaCl$ (sodium chloride).

With Hydrogen → Forms hydrogen halides (covalent)
Equation: $H_2 + X_2 \rightarrow 2HX$
Example: $H_2 + Cl_2 \rightarrow 2HCl$ (hydrogen chloride)

Displacement Reactions: A more reactive halogen displaces a less reactive halogen from its salt solution
Reactivity Order: $Cl_2 > Br_2 > I_2$.
Examples:
$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$
- Chlorine displaces bromine

$Br_2 + 2KI \rightarrow 2KBr + I_2$
- Bromine displaces iodine

Reactions of Alkali Metals

With Water → Produces hydrogen gas & a metal hydroxide (alkaline solution).
Equation: $2M\ (s) + 2H_2O\ (l) \rightarrow 2MOH\ (aq) + H_2\ (g)$
Observations:
- Lithium: Fizzes gently, moves slowly.
- Sodium: More vigorous, forms a ball, dissolves faster.
- Potassium: Violent reaction, lilac flame, may explode

With Oxygen → Forms metal oxides.
Equation: $4M\ (s) + O_2\ (g) \rightarrow 2M_2O\ (s)$
Observation: Forms a dull oxide coating when exposed to air.

With Chlorine → Forms metal chlorides (white solids).
Equation: $2M\ (s) + Cl_2\ (g) \rightarrow 2MCl\ (s)$
Observation: The reaction becomes more vigorous down the group.

Group 7: Halogens

Properties

- Can be toxic and are highly reactive.
- Non-metals with 7 electrons in the outer shell.
- Exist as diatomic molecules (e.g., Cl_2, Br_2).
- Reactivity decreases down the group.

Trends in Physical Properties

Melting and boiling points increase down the group due to larger atoms leading to stronger intermolecular forces, which require more energy to overcome.

Element	State at Room Temperature	Colour	Boiling Point (˚C)
Fluorine (F_2)	Gas	Pale yellow	-188˚C
Chlorine (Cl_2)	Gas	Green	-35˚C
Bromine (Br_2)	Liquid	Red-brown	59˚C
Iodine (I_2)	Solid	Dark grey	184˚C
Astatine (At_2)	Solid	Black	302˚C

Reactivity decreases down the group due to:
- Increased electron shells, placing the outer shell further from the nucleus.
- Weaker attraction for an extra electron.
- Fluorine is the most reactive; iodine and astatine are the least reactive.