

From models to materials

Structure 2.4 · SL and AHL

Why is a racing bike made of carbon fibre?

Choosing a material means choosing a type of bonding.

- Steel is strong but heavy; aluminium **alloy** is lighter.
- Carbon-fibre composite is stronger than steel for its mass.
- This unit: bonding continuum → alloys → polymers.

Three models, one continuum

By electronegativity

Large difference: ionic.

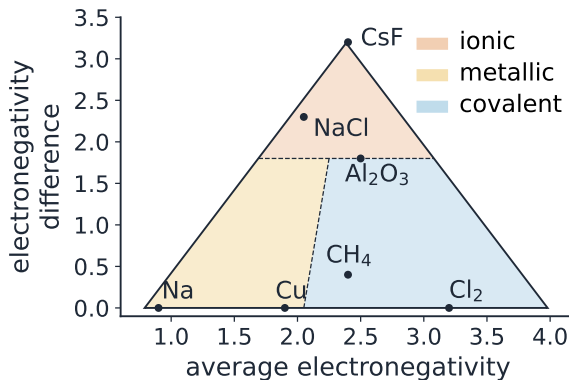
Both high: covalent. Both low: metallic.

Aluminium oxide

Mainly ionic.

Small, highly charged Al^{3+} gives covalent character.

The bonding triangle



The triangle predicts the bonding type, not whether a covalent substance is molecular or a network.

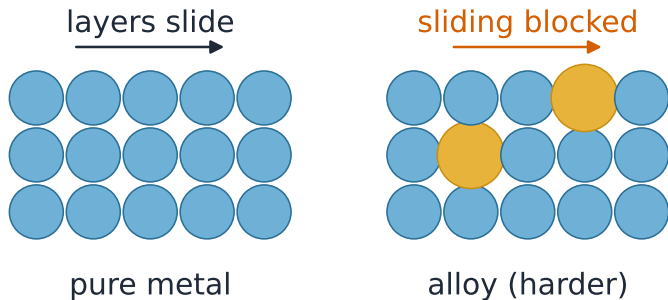
Worked example: MgO

- 1 **Average.** $(1.3 + 3.4)/2 = 2.35$
- 2 **Difference.** $3.4 - 1.3 = 2.1$
- 3 **Region.** The point (2.35, 2.1) lies in the ionic region.

Decision

MgO is mainly ionic, so expect a high melting point and conduction only when molten.

Why alloys are harder



An **alloy** keeps metallic bonding but becomes harder and stronger.

Alloys and their uses

Alloy	Composition	Improved property
steel	iron + carbon	harder, stronger
stainless steel	iron + Cr, Ni	resists corrosion
brass	copper + zinc	harder than copper
duralumin	Al + Cu, Mg	stronger, still light

Polymers are long chains

- Monomers join into a macromolecule with a **repeating unit**.
- Natural (starch, proteins, DNA) or synthetic (plastics).
- Longer, unbranched chains give stronger intermolecular forces.

Polymer a very large molecule made of many repeating units joined in a chain

The price of unreactive plastics

HDPE

Unbranched chains pack closely.

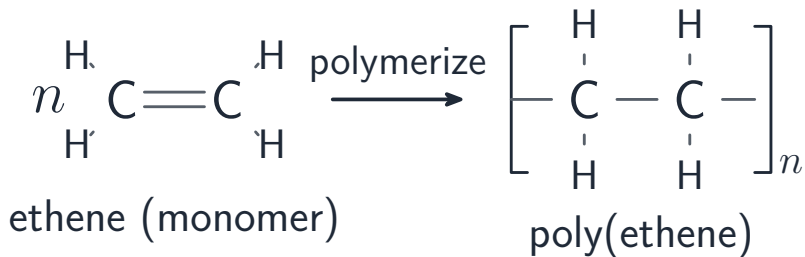
Stronger and denser.

LDPE

Branched chains pack loosely.

Softer and more flexible.

Addition polymerization



The **repeating unit** has the same atoms as the **monomer**, joined by single bonds.

Monomers and repeating units

Monomer	Polymer	Repeating unit
ethene	poly(ethene)	$-\text{CH}_2-\text{CH}_2-$
propene	poly(propene)	$-\text{CH}_2-\text{CH}(\text{CH}_3)-$
chloroethene	PVC	$-\text{CH}_2-\text{CHCl}-$
tetrafluoroethene	PTFE	$-\text{CF}_2-\text{CF}_2-$

Check: find the monomer

Your turn

Which monomer gives the repeating unit $-\text{CH}_2-\text{CH}(\text{CN})-$?

- A. $\text{CH}_3\text{CH}_2\text{CN}$
- B. $\text{CH}_2=\text{CHCN}$
- C. $\text{CH}_2=\text{C}(\text{CN})_2$
- D. $\text{CH}\equiv\text{CCN}$

AHL: Condensation polymerization



every new ester or amide link loses a small molecule (condensation)

PET, nylon-6,6 and Kevlar are condensation polymers; so are proteins and starch.

AHL: Addition against condensation

	Addition	Condensation
monomer	contains C=C	two functional groups
other product	none	H ₂ O or HCl
main chain	C–C only	ester or amide links

Exam tips

Name the bonding first, then explain the property from it.

- Use both triangle coordinates; bonding is a continuum.
- Alloys: different-sized atoms distort the layers.
- Addition unit: $\text{C}=\text{C}$ becomes $\text{C}-\text{C}$, side groups off the chain, n .
- AHL. Name the small molecule lost and the link formed.

Check yourself

Try these

Predict the bonding in NaCl, CH₄ and brass from the bonding triangle.

Explain why steel is harder than pure iron.

Draw the repeating unit of poly(propene).

AHL. Name the monomers and the link in nylon-6,6.