

Ceramics, polymers and composites

4.10.3.3 · Using resources · revision notes

How glass and clay ceramics are made, why the conditions used to make poly(ethene) change its properties, how thermosoftening and thermosetting polymers differ in structure, and what composites are. This is in GCSE Chemistry only, not in Combined Science. Expect recall, structure-based explanations and questions where you compare data to select a material on Paper 2.

Key facts

- Soda-lime glass: sand + sodium carbonate + limestone
- Clay ceramics (pottery, bricks): shape wet clay → heat in a furnace
- HD poly(ethene): lower temperature and pressure, catalyst → mostly unbranched chains, high density
- Thermosetting: covalent cross-links between chains → does not melt when heated
- Borosilicate glass: sand + boron trioxide; higher melting point
- LD poly(ethene): very high pressure, trace of oxygen → branched chains, low density
- Thermosoftening: no cross-links, weak intermolecular forces → melts when heated
- Composite = matrix (binder) + reinforcement (fibres or fragments)

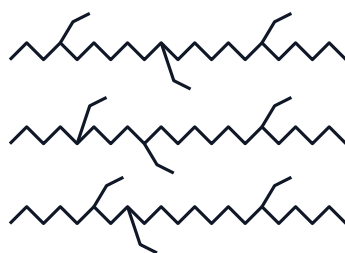
Notes

Glass and clay ceramics

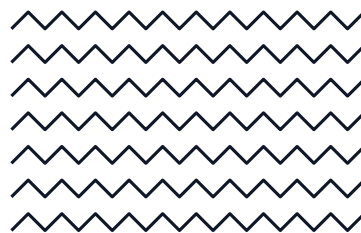
- Most glass is **soda-lime glass**, made by heating a mixture of **sand, sodium carbonate and limestone**.
- **Borosilicate glass** is made from **sand and boron trioxide**. It melts at a higher temperature than soda-lime glass, so it is used for ovenware and laboratory glassware.
- **Clay ceramics**, including pottery and bricks, are made by shaping wet clay and then heating it in a furnace.
- Glass and clay ceramics are hard but brittle, and are good insulators.

LD and HD poly(ethene)

- The properties of a polymer depend on **which monomers** it is made from and the **conditions** under which it is made.
- Low density (LD) poly(ethene)** is made from ethene at a very high pressure, with a trace of oxygen. Its chains are highly branched, so they cannot pack closely: lower density, softer and more flexible (e.g. carrier bags, cling film).
- High density (HD) poly(ethene)** is made from ethene at a lower temperature and pressure, using a **catalyst**. Its chains are mostly unbranched, so they pack closely: higher density, stronger, more rigid, and softens at a higher temperature (e.g. milk bottles, pipes).



LD: branched chains
cannot pack closely



HD: unbranched chains
pack closely: higher density

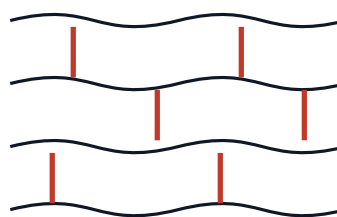
Branches keep LD chains apart, so LD poly(ethene) is less dense and softer.

Thermosoftening and thermosetting polymers

- Thermosoftening** polymers are separate polymer chains held together by weak **intermolecular forces**. On heating these forces are overcome, the chains slide past each other and the polymer **melts**, so it can be remoulded. Example: poly(ethene).
- Thermosetting** polymers have strong covalent **cross-links** between the chains. The cross-links hold the chains in place, so the polymer does **not melt** when heated (it chars at very high temperatures). Example: melamine.



thermosoftening: separate chains
melts when heated



thermosetting: cross-links
does not melt

Strong covalent cross-links hold thermosetting chains in place.

Composites

- Most **composites** are made of two materials: a **matrix** (or **binder**) surrounds and binds together fibres or fragments of the other material, the **reinforcement**.



matrix (binder) surrounds and holds the fibres
e.g. fibreglass: glass fibres in a polymer resin

The composite combines the strength of the fibres with the properties of the matrix.

- Examples: **reinforced concrete** (steel rods in concrete); **fibreglass** (glass fibres in a polymer resin); **carbon fibre** composites (carbon fibres in a polymer resin); **wood** (cellulose fibres in a natural matrix called lignin).
- A composite combines the useful properties of its parts: concrete is strong when squashed but weak when stretched, and the steel rods make reinforced concrete strong when stretched too.

Don't lose marks

- ✗ Saying thermosetting polymers have 'strong intermolecular forces'. They have covalent cross-links between the chains.
- ✗ Saying covalent bonds break when a thermosoftening polymer melts. Only the weak intermolecular forces between chains are overcome.
- ✗ Saying LD and HD poly(ethene) are made from different monomers. Both are made from ethene; the conditions and catalyst differ.
- ✗ Mixing up the matrix and the reinforcement: the matrix surrounds and binds; the reinforcement is the fibres or fragments.
- ✗ Choosing a material from data without saying why the others are unsuitable.

More tips

Memory tricks

- Soda-lime glass = 'SSL': Sand, Sodium carbonate, Limestone.
- BOROSilicate glass contains BOROn trioxide.
- LD = lots of branches, loosely packed; HD = hardly any branches, densely packed.
- Thermo-SETTING: once set, it stays set (cross-links). Thermo-SOFTENING: softens every time it is heated.
- In a composite, the reinforcement gives strength and the matrix is the glue that holds it together.

Exam technique

- Structure-based 'explain' questions need a chain of three links: structure → forces or bonds → property.
- In data questions, quote numbers with units and compare them, e.g. 'density 1.5 g/cm^3 , lower than glass at 2.5 g/cm^3 '.
- Learn at least one composite with its matrix and reinforcement named: reinforced concrete and fibreglass are the safest.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Name the raw materials for soda-lime glass

Sand, sodium carbonate and limestone, heated together.

Grade 4

Describe how clay ceramics are made

Wet clay is shaped and then heated in a furnace, e.g. to make pottery and bricks.

Grade 4

Name the two parts of a composite

A matrix (binder) surrounds and binds together fibres or fragments of the reinforcement.

Grade 5

Give examples of composites and their parts

Reinforced concrete is steel rods in concrete; fibreglass is glass fibres in a polymer resin.

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