

Materials and Their Properties

Physical properties of Materials

- ▶ Materials have many different physical properties that make them suitable for a range of purposes.
- ▶ Some properties of materials include:
 1. Ability to conduct electricity.
 2. Ability to conduct heat.
 3. Hardness.
 4. Strength.
 5. Density.
 6. Melting point and boiling point.

Examples :

Material	Physical property	Objects made from the material
Copper	Good conductor of electricity	Used in electric cables and wires.
Iron and steel	Hard, strong	Bridges, ships, cars, girders for buildings.
Plastic (PVC)	Low density, strong, resistance to rust	Garden furniture, watering cans.
Gold, platinum and silver	Shiny, unreactive	Jewelleries and ornaments, coins.
Aluminium	Good conductor of heat, low density	Pots and pans, aluminium foil, aircraft parts.

Ceramics and Composites

Ceramics

- Ceramics are hard, non-metallic materials, such as brick, china, and glass.
- Due to their high melting points and thermal resistance, ceramics are used widely as a construction material as well as domestic appliances

Types of Ceramics

1. Glass Ceramics

- Transparent and strong, glass insulates against heat and its transparency makes glass the ideal material for making windows.
- Glass ceramics are also more durable than other materials hence they are better suited for use in windows than plastic.
- Most of the glass produced is soda-lime glass which is made by heating a mixture of limestone, sand and sodium carbonate (soda) until it melts.
- On cooling it solidifies to form glass.
- A variation is borosilicate glass which is made using sand and boron trioxide and has a higher melting point than soda-lime glass

2. Clay Ceramics

- These include brick, china and porcelain.
- These are hardened materials that resist compressive forces.
- Clay is a soft material dug up from the earth which hardens at high temperatures and when it is fired, produces a very strong and hard material.
- This allows bricks to be used to build walls which withstand the weight and pressure of the material bearing downwards on itself

Composites

- **Composites** are **combinations** of two or more materials. One material is used as a **matrix** or binder, surrounding **fibers** of the other. These fibers are known as the **reinforcement** and are added to make the composite **stronger**.
- Common examples include fibre glass and steel reinforced concrete
- Wood is an example of a natural composite as it consists of cellulose fibres held together by an organic polymer mix

Reinforced concrete

- The properties of concrete can be improved by reinforcing it with steel rods or mesh.

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- The compressive strength of concrete is higher than its tensile strength, but the tensile strength of steel is higher than its compressive strength.
- The combination of the two creates a material that is strong in tension and in compression. This allows reinforced concrete to be strong and slightly flexible, which is important when constructing large buildings and structures.

Polymers

- **Polymers** are one of the most wide spread materials used by humanity. They can be produced to have a vast range of properties, from **soft and malleable** like the polymers used in plastic bags, to **hard and brittle** like the polymers used in things like window fittings.
- The **properties of the polymer** will depend on both the **monomers** from which they are produced and the **conditions** under which they are produced.
- For example poly(ethene) will have different properties depending on it's manufacture or conditions:
 1. **Low density poly(ethene)** is produced at a **moderate temperature** and a **high pressure**. Low density poly(ethene) is **flexible** and is used commonly for plastic bags and bottles.
 2. **High density poly(ethene)** is produced at **low temperature and pressure**, and employs a **catalyst** in its production. This yields a more **rigid** polymer that is used for things like water tanks and drain pipes.
- Polymers can also be designed to have more specialist properties. For example **thermosetting** and **thermo-softening** polymers:
 1. **Thermosetting** polymers are ones that **do not soften when heated**. They contain monomers that connect polymer chains which makes the polymer solid more rigid. These connections are known as cross linked.
 2. **Thermo-softening** polymers contain no cross links. These polymers are less rigid and **melt upon heating**.

Alloys

- **Alloys are everyday metals**. This means that they are a **mixture** of two or more metals.
- **Alloys have different properties** depending on the metals that they contain. The different sized atoms disrupt the metal layers making them harder to slide. They will also be harder than pure metals.
- There are some example of alloys which are in everyday use

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1. Common Alloys

- **Bronze is made from copper and tin.** Bronze is an alloy that can be used for decorating ornaments and statues, and it is made from copper and tin.
- **Brass is made from copper and zinc.** Brass is soft, so it can be used for taps. This allows water to flow with less friction. It is an alloy of copper and tin.

2. Gold Alloys

- **Gold can form alloys.** Gold can be mixed with silver, copper and zinc to form an alloy. By forming an alloy, pure gold (which is relatively soft), becomes harder.
- **Gold alloys can be used for jewellery.** The strengthened gold alloy is commonly found in jewellery. It is a very valuable metal.
- **Gold is measured in carats.** Pure (100%) gold is 24 carats, whilst 18 carats means that the alloy contains 75% gold.

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18K Gold

75% gold
25% other metals

Best Color & Quality.
If your budget can stretch
to 18K we recommend it!



10K Gold

41.7% gold
58.3% other metals

Strong & durable with
a Good Color. An excellent
choice for a moderate budget.



14K Gold

58.3% gold
41.7% other metals

Excellent Color. Great
compromise between
quality & price. The most
common choice for our
customers.



9K Gold

37.5% gold
62.5% other metals

Best price. Entry level
gold. At this low Karat the
red color of the Copper mix
begins to come through

Karat Rating	Percentage of Gold Present	Percentage of Other Metals Present
24	100%	none
22	91.6%	8.4%
18	75%	25%
14	58.5%	41.5%
10	41.7%	58.3%

3. Steel Alloys

- ▶ **Steel is an alloy of iron.** It contains carbon and other metals as well as iron.
- ▶ The proportion of **carbon** in a steel alloy can vary.

I. **High carbon steel, contains 0.5 to 2% carbon.** The steel is very strong but brittle. This type of steel can be used to build bridges.

II. **Low carbon steel (0.05 to 0.25% carbon) is soft.** Steel alloys containing a low proportion of carbon is very soft and therefore easily shaped. This type of steel can be used to make cars.

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- **Chromium and nickel resist corrosion.** If the steel alloy contains **chromium** and **nickel**, this means that it is hard and resists corrosion. This type of steel is called stainless steel, usually used to make cutlery.

4. Aluminium Alloys

- **Aluminium alloys are low density.** This means that they are lightweight.
- **Aluminium is used in drinks cans** due to its lightweight but strong nature
- **Duralumin is an alloy containing aluminium,** copper and magnesium. It has a low density but a higher strength in comparison to aluminium alone, so is used in aircraft construction.

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