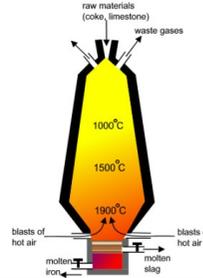


Materials and their properties

Metals and Alloys

A: Metal is a naturally occurring material and is mined from the ground in the form of ore. The raw metal is then extracted from the ore through a combination of crushing, smelting or heating with the addition of chemicals and huge amounts of electrical energy. Most metals can be recycled, saving natural resources and limiting the amount of materials imported from abroad.

Metals can be categorised into two groups: **ferrous** and **non-ferrous** metals.



B: Alloys

Metals in their pure form can be useful for many purposes, but it is often desirable to adjust their mechanical and physical properties in order to produce a more suitable material for a particular application.

An **alloy** is a material that is produced by combining two or more elements together to produce a new material with refined properties.

Alloys too can be categorised as ferrous alloys or non-ferrous alloys, depending on the main pure metal they contain.

Metal	Characteristics and uses of alloys
Brass: non-ferrous alloy	Composition: alloy of copper (65%) and zinc (35%). Strong and ductile, casts well, corrosion resistant, conductor of heat and electricity. Used for musical instruments, plumbing fittings, ornate artefacts, castings, forgings, taps, wood screws.
Stainless steel: ferrous alloy	Composition: alloy of steel including chromium (18%) and nickel (8%). Hard and tough, excellent resistance to corrosion. Used for sinks, cutlery, surgical equipment, home wares.
Duralumin	Composition: alloy of aluminium (90%) copper (4%) magnesium (1%) manganese (0.5 - 1%). Strong, soft and malleable, excellent corrosion resistance, lightweight. Used for aircraft structure and fixings, suspension applications, fuel tanks.
High speed steel: ferrous alloy	Composition: alloy of iron, carbon (>0.6%) and other metals including chromium, tungsten and vanadium. Able to withstand high temperatures created when machining at high speed, keeps its cutting edge well. Used for cutting tools such as drill bits, mill cutters and taps and dies.

C: Ferrous metals

Ferrous metals are those that contain iron. Most are magnetic, which is a useful property when it comes to sorting out metals for recycling. Their carbon content means that most are prone to corrosion in the form of rust when exposed to moisture and oxygen.

Their properties, such as hardness and malleability, are directly related to their carbon content. For example, the more carbon that is found in the metal, the harder and less malleable it is.

A good way of remembering that ferrous metals contain iron is to remember the periodic table symbol for iron. **FE** = iron = **ferrous**.

Metal	Characteristics and uses of ferrous metals
Cast iron	Composition: iron and 3.5% carbon. Hard surface but has a brittle soft core, strong compressive strength, inexpensive. Used for vice, car brake discs, manhole covers.
Low carbon steel (mild steel)	Composition: iron and 0.15-0.35% carbon. Good tensile strength, tough, malleable, poor resistance to corrosion. Use for car bodies, nuts, bolts and screws, RSJs and girders.
High carbon steel (tool steel)	Composition: iron and 0.70-1.4% carbon. Hard but also brittle, less tough, malleable or ductile than medium carbon steel. Used for screwdrivers, chisels, taps and dies.

D: Non-ferrous metals

Non-ferrous metals are those that don't contain iron. The absence of iron makes non-ferrous metals desirable for their malleable properties and for their resistance to corrosion. The majority of them are also not magnetic, which means that they can be used in electronic devices and wiring.

After steel, aluminium is the most widely used metal. Aluminium is produced from alumina, which is extracted from an ore known as bauxite. In addition to heating, several chemicals are used to help the separation process, including caustic soda and lime. The alumina then goes through an electrolysis process from which liquid aluminium is then obtained. All of this processing takes a huge amount of energy, which is why aluminium is so regularly recycled. It takes around 95% less energy to recycle aluminium than to produce the raw material from bauxite.

Metal	Characteristics and uses of non-ferrous metals
Aluminium	Composition: pure metal (often alloyed with copper and manganese depending on application). Lightweight, soft, ductile and malleable, good conductor of heat and electricity, corrosion resistant. Used for aircraft bodies, high-end car chassis, cans, cooking pans, bike frames.
Copper	Composition: pure metal. Extremely ductile and malleable, an excellent conductor of heat and electricity, easily soldered and corrosion resistant. Used for plumbing fittings, hot water tanks, electrical wire.
Zinc	Composition: pure metal. Weak in its pure state, high level of corrosion resistance, low melting point, easily worked. Used as a galvanised coating in crash barriers, corrugated roofing, intricate die cast products.
Tin	Composition: pure metal. Soft, ductile and malleable, low melting point, excellent corrosion resistance. Used for coatings on food and drinks cans, solders.

Materials and their properties

Metals and Alloys

E: Keywords

- Primary source: where materials originate (polymers from oil, timber from trees etc) and the raw material that needs to be converted into a workable form
- Ferrous metals: metals that contain iron
- Non-ferrous metals: metals that do not contain iron
- Alloys: metals that are a mixture of two or more metals
- RSJ: Rolled Steel Joist - a type of beam used in building construction
- Compressive strength:
- Toughness: the ability of a material to absorb an impact without rupturing
- Malleability: the ability of a material for its shape to be permanently changed without the material breaking
- Brittleness: the tendency of a material to break without being significantly distorted or exposed to a high level of stress
- Hardness: the resistance of a material to abrasive wear and tear

F: Video and web-links

- Aluminium recycling: <https://alupro.org.uk/consumers/how-is-aluminium-recycled/>
- Aluminium recycling: <https://www.youtube.com/watch?v=AOpGhAdQFEY>
- Steel manufacturing: <https://www.youtube.com/watch?v=9I7JqonyoKA>
- Steel: <https://www.worldsteel.org/about-steel.html>

Revision Checklist

I know the primary source of materials for producing metals and alloys

I can recognise and characterise different types of metals and alloys

I understand how the physical and working properties of a range of metals and alloys affect their performance

I understand the impact metals and alloys have on the environment

I understand the advantages of recycling aluminium compared to producing the raw material from bauxite

Test yourself

1. Explain the major difference between an alloy and a pure metal.
2. Why is mild steel such a popular material for the construction of buildings and vehicles?
3. Explain why rust can be an issue for structural products made from low carbon steel.
4. What is the chemical symbol for iron?
5. Explain why high speed steel is suitable for the manufacture of drill bits.