Alloys as useful materials

4.10.3.2 · Using resources · revision notes

What alloys are, why they are harder than pure metals, the alloys named in the specification and their uses, and how the purity of gold is measured in carats. This is in GCSE Chemistry only, not in Combined Science. Expect recall of alloys and uses, carat calculations and questions where you interpret data about an unfamiliar alloy on Paper 2.

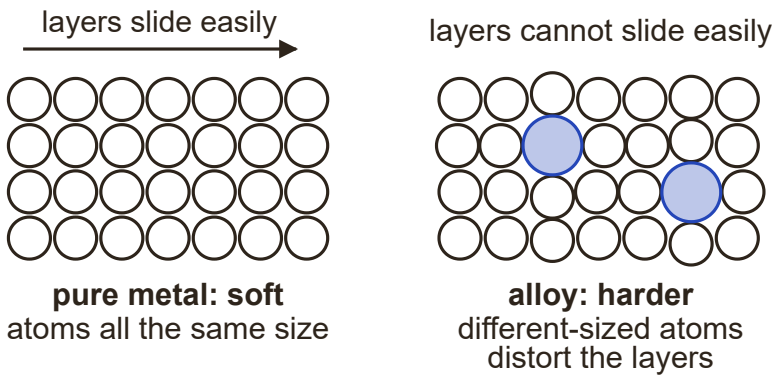
Key facts

- Alloy = mixture of a metal with other elements; harder than the pure metal
- Brass = copper + zinc (musical instruments, door handles)
- High carbon steel: strong but brittle (cutting tools); low carbon steel: soft, easily shaped (car bodies)
- Aluminium alloys: low density (aircraft)
- Bronze = copper + tin (statues, medals, bells)
- Steel = iron + carbon (+ other metals)
- Stainless steel: contains chromium and nickel; hard, resists corrosion (cutlery)
- 24 carat = 100% gold; 18 carat = 75% gold; % gold = carats ÷ 24 × 100

Notes

Why alloys are useful

- Most metals in everyday use are **alloys**: mixtures of a metal with other elements, usually other metals (or carbon, in steel).
- In a pure metal the atoms are all the same size, arranged in layers that can slide over each other easily, so pure metals are soft.
- In an alloy, atoms of different sizes **distort the layers**, making it more difficult for them to slide. So alloys are **harder** than pure metals.



Atoms of a different size make it harder for the layers to slide.

Alloys to know

- **Bronze** = copper + tin. Hard and resistant to corrosion: statues, medals, bells.
- **Brass** = copper + zinc. Hard, resistant to corrosion and gold-coloured: musical instruments such as trumpets, door handles, taps and plumbing fittings.
- **Gold** used for jewellery is usually an alloy with silver, copper and zinc, which makes it harder.
- **Aluminium alloys** have a **low density**: aircraft, bicycle frames.

Steels

- **Steels** are alloys of iron that contain specific amounts of carbon and other metals.
- **High carbon steel** is strong but brittle: cutting tools such as chisels and drill bits.
- **Low carbon steel** is softer and more easily shaped: car body panels, wire, food cans.
- **Stainless steels** contain chromium and nickel. They are hard and resistant to corrosion: cutlery, sinks, surgical instruments.

Carats

- The proportion of gold in a gold alloy is measured in **carats**. **24 carat is 100%** gold (pure gold) and **18 carat is 75%** gold.
- Percentage of gold = carats ÷ 24 × 100. For example, 9 carat gold is 9 ÷ 24 × 100 = 37.5% gold.
- Pure gold is too soft for everyday jewellery, so lower-carat alloys are used. They are harder and cheaper.

How to answer each type of question

Recall alloys, their metals and uses

1 to 3 marks | **Grade 4**

1. Learn the metals in each named alloy: bronze, brass, steels, gold alloys.
2. Give a use that matches a property of the alloy.
3. If asked to explain a use, name the property that makes the alloy suitable.

Example. (a) Name the **two** metals in brass. (1 mark)
(b) Give **one** use of stainless steel and the property that makes it suitable for that use. (2 marks)

Model answer.

(a) Copper and zinc (both needed) (1)

(b) Cutlery / sinks / surgical instruments (1); it is resistant to corrosion / does not rust (1)

Explain why an alloy is harder than the pure metal

3 marks | Grade 6

1. Describe the pure metal: atoms of the same size in regular layers.
2. Say that the layers slide easily, so the pure metal is soft.
3. Say that in the alloy, atoms of different sizes distort the layers, so they cannot slide as easily.

Example. Pure copper is soft. Bronze is an alloy of copper and tin.
Explain why bronze is harder than pure copper. (3 marks)

Model answer. In pure copper all the atoms are the same size and are arranged in layers that can slide over each other easily (1). In bronze the tin atoms are a different size from the copper atoms (1). This distorts the layers, so it is more difficult for them to slide over each other (1).

Calculate with carats

1 to 3 marks | Grade 5

1. Fraction of gold = carats ÷ 24 (multiply by 100 for a percentage).
2. Mass of gold = fraction of gold × mass of the item.
3. To find the carat from a percentage: percentage ÷ 100 × 24.

Example. A ring is made of 18 carat gold. The ring has a mass of 6.0 g.
(a) Calculate the mass of gold in the ring. (2 marks)
(b) A chain contains 58.3% gold by mass. What carat is the chain? (1 mark)

Model answer.

(a) 18 ÷ 24 = 0.75 (1); 0.75 × 6.0 = 4.5 g (1)
(b) 58.3 ÷ 100 × 24 = 14 carat (1)

Choose an alloy using data

2 to 4 marks **Grade 5**

1. Decide which properties matter most for the use.
2. Quote the relevant values from the data, with units.
3. Rule out the other alloys, giving a reason for each.
4. State your choice clearly.

Example. An engineer needs a material for the frame of a racing bicycle. It must be strong, light and must not corrode. The table gives data about three alloys.

Alloy	Density (g/cm^3)	Strength	Corrodes?
P	7.9	high	no
Q	2.8	high	no
R	2.7	low	no

Which alloy should be used? Explain your choice. (3 marks)

Model answer. Alloy Q (1). It is strong and does not corrode, like P, but its density is much lower (2.8 g/cm^3 compared with 7.9 g/cm^3), so the frame is lighter (1). R has a low density but is not strong enough (1).

Don’t lose marks

- Swapping bronze (copper + tin) and brass (copper + zinc).
- Saying alloys are harder 'because they are mixed'. Explain with different sized atoms distorting the layers so that they cannot slide.
- Calling an alloy a compound. It is a mixture.
- Saying high carbon steel is soft and easily shaped. That is low carbon steel; high carbon steel is strong but brittle.
- Dividing by 100 instead of 24 in carat questions.

More tips

Memory tricks

- Link each alloy to a famous object: bronze statues and medals (copper + tin), brass trumpets (copper + zinc).
- Carats are 24ths: 18 carat = 18/24 = 3/4 = 75%; 12 carat = half; 9 carat = 37.5%.
- More carbon in steel = harder but more brittle.
- Stainless steel has chromium and nickel: it stays shiny because it resists corrosion.

Exam technique

- When asked to explain a use, give the property that makes the alloy suitable, not just the use.
- For unfamiliar alloys, use only the data given and quote the numbers with units.
- In 'why is an alloy harder' answers the key words are layers, different sized atoms, distorted and slide.

What each grade needs

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

Grade 3 — **State what an alloy is**
A mixture of a metal with at least one other element, usually another metal (or carbon, in steel).

Grade 4 — **Name the metals in bronze and brass**
Bronze is copper and tin; brass is copper and zinc.

Grade 4 — **Recall a use for each named alloy**
For example, bronze for statues, brass for musical instruments, stainless steel for cutlery, aluminium alloys for aircraft.

Grade 5 — **Compare high carbon, low carbon and stainless steel**
High carbon steel is strong but brittle; low carbon steel is softer and easily shaped; stainless steel is hard and resists corrosion.

Grade 5 — **Convert between carats and percentage of gold**
24 carat is 100% gold, so percentage of gold = carats ÷ 24 × 100; 18 carat is 75% gold.

Grade 5 — **Choose an alloy using data on properties**
Match properties such as density, strength and resistance to corrosion to the use, quoting the data.

Grade 6 — **Explain why alloys are harder than pure metals**
Atoms of different sizes distort the layers, so the layers cannot slide over each other as easily.

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