# Properties of metals and alloys

4.2.2.7 · Bonding, structure and the properties of matter · revision notes

Why most metals have high melting points and can be bent and shaped, and why alloys are harder than pure metals. Expect 2 to 4 mark 'explain' questions, often with diagrams of the layers of atoms in a pure metal and in an alloy.

### Key facts

- Metals: giant structures, strong metallic bonding → most have high melting points
- Alloy = mixture of a metal with other elements (usually other metals)
- Brass = copper + zinc; bronze = copper + tin; steel = iron + carbon (and often other metals)
- Pure metal: same-sized atoms in layers that slide over each other → can be bent and shaped (soft)
- Alloy: different-sized atoms distort the layers → layers can't slide easily → harder

## Notes

### High melting points

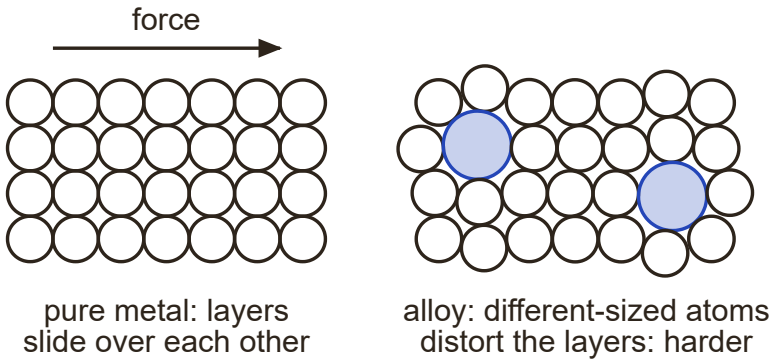
- Metals have **giant structures** with **strong metallic bonding**: strong electrostatic attraction between positive metal ions and delocalised electrons.
- A lot of energy is needed to overcome this attraction, so **most metals have high melting and boiling points**.

### Pure metals can be bent and shaped

- In a pure metal, all the atoms are the **same size** and are arranged in regular **layers**.
- When a force is applied, the **layers can slide over each other**, so the metal changes shape instead of breaking.
- So pure metals can be **bent and shaped**, but many are **too soft** for many uses. For example, pure iron and pure gold are too soft for most tools and jewellery.

## Alloys are harder

- An **alloy** is a mixture of a metal with other elements, usually other metals. Examples: brass (copper and zinc), bronze (copper and tin), steel (iron with carbon and often other metals).
- The atoms of the added elements are a **different size** from the atoms of the main metal.
- These different-sized atoms **distort the layers**, so it is much harder for the layers to slide over each other.




The larger atoms (blue) stop the layers sliding easily.

- So alloys are **harder** than pure metals, which makes them more useful for many purposes.

## Alloy calculations

- Percentage by mass: mass of one metal = (its percentage ÷ 100) × mass of alloy. E.g. 8.40 g of bronze with 12.5% tin is 87.5% copper: 0.875 × 8.40 = 7.35 g of copper.
- Percentage of atoms = number of that kind of atom ÷ total number of atoms × 100. E.g. 2 tin atoms with 23 copper atoms: 2 ÷ 25 × 100 = 8% tin atoms.

## How to answer each type of question

**Explain why a pure metal can be bent and shaped** 2 marks **Grade 5**

1. Say the atoms are arranged in layers.
2. Say the layers can slide over each other.

**Example.** Explain why gold can be hammered into thin sheets.

**Model answer.** Gold atoms are arranged in layers (1). The layers can slide over each other (1).

**Explain why a metal has a high melting point** 3 marks **Grade 5**

1. Name the structure: giant metallic structure.
2. Describe the bonding: strong electrostatic attraction between positive ions and delocalised electrons.
3. Say a lot of energy is needed to overcome it.

**Example.** Iron melts at 1538 °C.
Explain why iron has a high melting point.

**Model answer.** Iron has a giant metallic structure (1). There is strong electrostatic attraction between the positive ions and the delocalised electrons (strong metallic bonds) (1). A lot of energy is needed to overcome this attraction (1).

**Explain why an alloy is harder than a pure metal** 3 marks **Grade 5**

1. Pure metal: atoms of the same size in regular layers that slide easily.
2. Alloy: atoms of a different size distort the layers.
3. So the layers cannot slide over each other as easily.

**Example.** Pure copper is too soft to make coins. Some coins are made from an alloy of copper and nickel.
Explain why the alloy is harder than pure copper.

**Model answer.** In pure copper, all the atoms are the same size and are arranged in layers that can slide over each other (1). In the alloy, the nickel atoms are a different size from the copper atoms, so the layers are distorted (1). This makes it more difficult for the layers to slide over each other (1).

## Don’t lose marks

- Saying alloys are harder because they have stronger bonds. The key idea is that different-sized atoms distort the layers so they can't slide.
- Saying the layers in an alloy cannot slide at all. They slide less easily.
- Saying pure metals bend because metallic bonds are weak. The bonds are strong; the layers slide.
- Calling an alloy a compound. It is a mixture.
- Forgetting to say that the atoms in the alloy are of different sizes.

## More tips

### Memory tricks

- Pure = neat rows = slide = soft. Alloy = bumpy rows = stuck = hard.
- Different size is the key phrase in every alloy answer.
- Picture a tray of identical marbles: the rows roll past each other easily. Add a few bigger marbles and the rows jam.

### Exam technique

- Describe both structures: the pure metal (regular layers that slide) and the alloy (different-sized atoms, distorted layers).
- If a diagram is given, refer to it, e.g. 'the larger atoms in the alloy disrupt the layers'.
- Use the words 'layers' and 'slide': these are what mark schemes look for.

## What each grade needs

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

**Grade 3**

**State that pure metals can be bent and shaped**

The atoms in a pure metal are arranged in layers.

**Grade 4**

**Define an alloy**

A mixture of a metal with other elements, usually other metals.

**Grade 5**

**Explain why most metals have high melting points**

Giant structures with strong metallic bonding need a lot of energy to overcome.

**Grade 5**

**Explain why pure metals are soft**

The layers of atoms can slide over each other easily.

**Grade 5**

**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.

**Grade 5**

**Interpret diagrams of pure metals and alloys**

Regular layers of identical atoms compared with layers disrupted by atoms of a different size.

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