Properties of metals and alloys

5.2.2.7 · Chemistry · 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

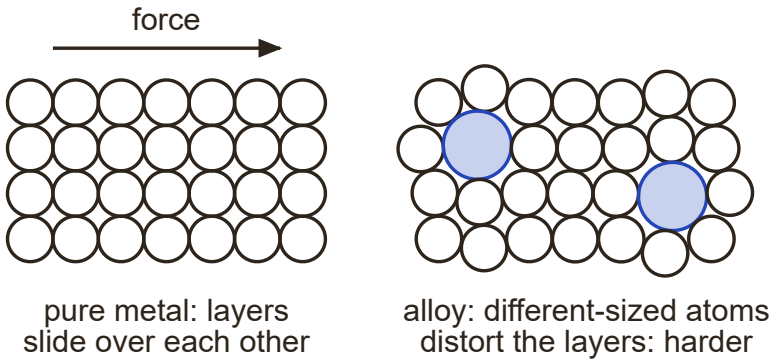
- Metals have **giant structures** with **strong metallic bonding**: strong electrostatic attraction between positive metal ions and delocalised electrons.
- A lot of energy is needed to overcome this attraction, so **most metals have high melting and boiling points**.

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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