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EB Education Revision Guide

How to work with Transition Metals and Alloys

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Transition Metals

What are the properties of transition metals?

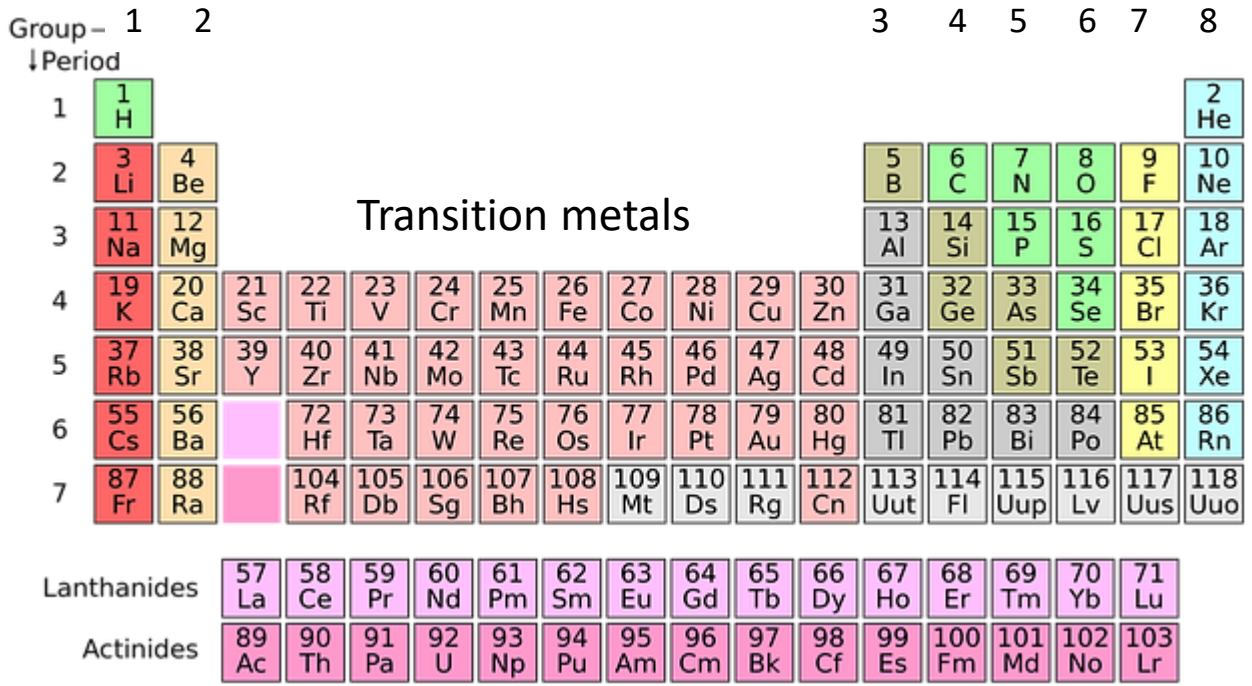
Transition metals are found in the middle of the periodic table.

Many common metals, like iron, copper and gold, are transition metals.

Transition metals all have the typical properties of metals.

These are:

- High melting and boiling points (except mercury which is a liquid at room temperature).
- Hard, strong, shiny and malleable and ductile.
- Conductors of heat and electricity
- High densities
- and sonorous (make a ding when hit) [you don't need to be able to explain this one though]



Properties and structure

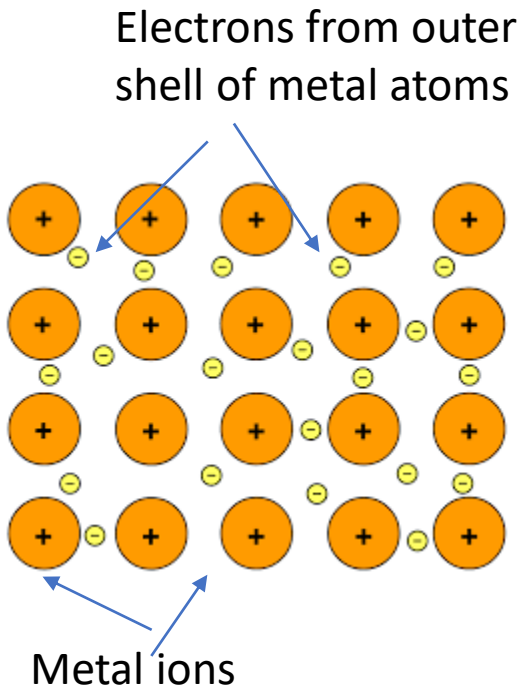
Why do metals have these properties?

- **High melting/boiling points**

The electrostatic forces between positive metal ions and the delocalised electrons which surround them are very strong. This means a lot of energy is needed to break these bonds, so they are generally shiny solids at room temperature.

- **High densities**

The ions in the metallic structure are packed close together.



- **Conduct electricity and heat**

They can conduct electricity because delocalised electrons can move and carry charge (electrical current). They can conduct heat because the ions are closely packed together, and the electrons can carry kinetic energy through the lattice.

- **Malleable and Ductile**

As the ions are arranged in layers in metals, the layers can slide over each other, making them malleable.

Uses of transition metals

Why are they useful?

The properties of transition metals make them very useful.

Some examples are:

- Gold and silver

These are used for jewellery because they are shiny and malleable.

- Titanium

This is often used in aircrafts as it is very strong, and light.

- Copper

This can be used for water pipes as it is malleable and corrosion resistant. It is also used in electrical wiring as it is a good electrical conductor and ductile.

Uses of transition metals

- **Catalysts**

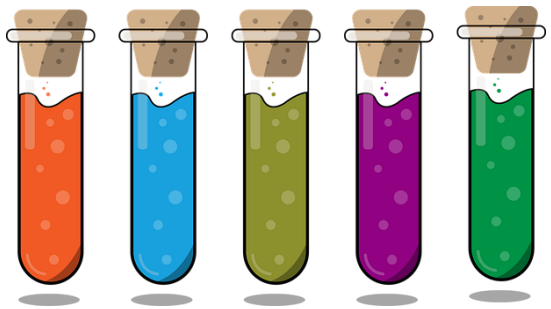
Transition metals and their compounds make good catalysts.

Catalysts speed up chemical reactions without being used up.

- Iron is the catalyst used in the Haber process to make ammonia.
- Iron(III) oxide is a catalyst used to make hydrogen by reacting carbon monoxide and steam together
- Vanadium pentoxide (V_2O_5) is the catalyst used for making sulphuric acid

- **Coloured Compounds**

Transition metal compounds are very colourful. The colour that they are depends on what transition metal ions they contain.



Compounds containing Fe^{2+} ions are often light green, those containing Fe^{3+} ions are often orange/brown

Compounds containing Cu^{2+} ions are often blue

TOP TIP:
You do not need to learn all the colours but you do need to know some that have been outlined here!

Alloys

What is an alloy?

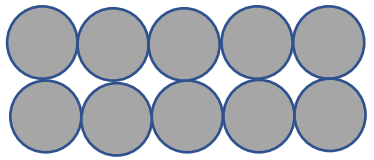
Sometimes the properties of pure metals are not what is needed. When this is the case, **alloys** can be used.

An alloy is a mixture of two or more elements, where at least one element is a metal.

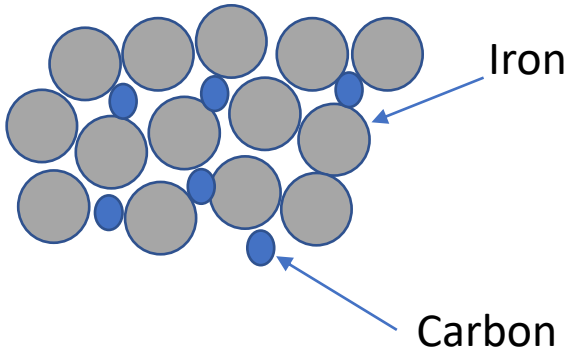
Pure metals are malleable because the layers can slide over each other. This can mean that the pure metals are not strong enough for certain uses.

As different elements have different sized atoms, when another element, for example carbon (or it could be another metal) is added to a particular metal, such as iron, the smaller carbon atoms do not allow the iron layers to slide over each other. This makes the alloy stronger.

Many metals used today are alloys. Alloys can now be designed for particular uses, with specific properties fit for the purpose of the alloy.



Iron atoms are all the same size, so the layers can slide over each other



Alloys

Some common alloys you may have heard of are:

- **Brass made of copper and zinc**

Brass is more malleable than bronze. It is used for door fittings and water taps, where lower friction is required.

- **Bronze made of copper and tin**

Bronze is harder than copper. It is used to make statues, medals and ornaments.

- **Gold alloys**

Zinc, copper and silver can be added to gold to make it stronger. It is used to make jewellery. Pure gold is 24 carat. How many carats a piece of jewellery is, shows how much gold is in it, so 18 carats means 18 out of 24 parts of the alloy are pure gold.

- **Cast iron made of iron, carbon and silicon**

This is used for making metal structure such as bridges, or heavy-duty cookware, as it is much stronger than pure iron.

Non transition metals can also make alloys.

- **Aluminium alloys**

Aluminium is low density, so useful for making aircraft. However pure aluminium is not strong enough, and so small amounts of other metals are alloyed with it to increase its strength.

- **Magnalium made of aluminium and magnesium**

When small amounts of magnesium (around 5%) are added to aluminium, the resulting alloy is stronger, lighter and corrode less easily than pure aluminium.

It is used for making parts for cars and aeroplanes.

If larger amounts of magnesium are added (around 50%), then it becomes much more reactive and burns brightly, so it can be used in fireworks.

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Alloys

Alloys of iron called steels are frequently used instead of pure iron. Steels are made by adding small amounts of carbon to pure iron, and sometimes other metals as well.

What properties the steel has depends upon the amount of carbon and other elements added to the iron.

Steels are usually harder and stronger than iron.

In addition to this, steel is much less likely to rust than iron.

Type of Steel	Properties and Uses
Low carbon steel (0-1 – 0.3% carbon)	Easily shaped Used to make car body panels
High carbon steel (0.22 – 2.5% carbon)	Very strong, brittle Construction
Stainless steel (chromium, and sometimes nickel)	Corrosion-resistant, strong Used to make cutlery, washing machines, dishwashers

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Your turn:

1. There are many different uses of metals. Duralumin can be made by melting copper and aluminium together. What is duralumin?
   Put a X in the correct box.

A. an ore ☐
B. an element ☐
C. an alloy ☐
D. a halogen ☐

Two useful properties of metals are their malleability and ability to conduct electricity.
Explain how the structure of metals provides these properties.

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The periodic table has many metallic elements in it. Which row of the table shows two transition metals, and two metals that are in Group 2?

	Transition metals	Group 2
A	Magnesium and copper	Potassium and calcium
B	Zinc and Nickel	Iron and Magnesium
C	Chromium and Manganese	Beryllium and Magnesium
D	Titanium and Sodium	Calcium and Strontium

Your turn:

2. Metals have different uses.
Give an example of what the metals below are used for and why.

a) Gold

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b) Copper

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3. Pure metals can be made into alloys.
Explain what an alloy is, and why alloying can help increase the strength of pure metals. (diagrams can be used)

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Your turn:

4. Many coins are made of a mixture of different metals.

1 cent coin is made of steel, and coated with copper

1 euro coin.
The silver coloured centre is made of an alloy containing copper and nickel
The gold coloured outside is made of an alloy containing copper, zinc and nickel

a) Explain why there is a copper coating on the 1 cent coin.

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b) Using the compositions of the silver and gold part of the 1 euro coin, suggest which metal causes the alloy to become gold-coloured.

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Your turn:

5. The table below shows the properties of four different metals.

Metal	Cost of 1 kg/£	Density /gcm^{-3}	Relative strength	Resistance to corrosion	Electrical conductivity
Copper	5	8.92	high	good	very good
Gold	33000	19.3	low	excellent	excellent
Silver	620	10.5	low	very good	excellent
Aluminium	1	2.70	high	good	good

Using the data provided in the table, explain some uses of each metal, relating their use to their individual properties.

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Answers:

1. There are many different uses of metals. Duralumin can be made by melting copper and aluminium together. What is duralumin?
   Put a X in the correct box.

A. an ore ☐
B. an element ☐
C. an alloy ☒ X
D. a halogen ☐

Two useful properties of metals are their malleability and ability to conduct electricity.
Explain how the structure of metals provides these properties.

Delocalised electrons can flow so they can conduct electricity. Layers of same sized atoms can slide over each other, so they are malleable

The periodic table has many metallic elements in it. Which row of the table shows two transition metals, and two metals that are in Group 2?

	Transition metals	Group 2
A	Magnesium and copper	Potassium and calcium
B	Zinc and Nickel	Iron and Magnesium
C X	Chromium and Manganese	Beryllium and Magnesium
D	Titanium and Sodium	Calcium and Strontium

Answers:

2. Metals have different uses.
Give an example of what the metals below are used for and why.

a) Gold

Gold can be used for jewellery:
It is malleable
It is shiny
It does not corrode
It is unreactive

b) Copper

Copper can be used for water pipes as it is malleable and corrosion resistant. It is also used in electrical wiring as it is a good electrical conductor and ductile.

3. Pure metals can be made into alloys.
Explain what an alloy is, and why alloying can help increase the strength of pure metals.

In pure metal the atoms are all the same size and the layers can slide over each other
In the alloy the second metal atoms added are larger
This disrupts the layers, and prevents the layers sliding

Answers:

4. Many coins are made of a mixture of different metals.

1 cent coin is made of steel, and coated with copper

1 euro coin.
The silver coloured centre is made of an alloy containing copper and nickel
The gold coloured outside is made of an alloy containing copper, zinc and nickel

a) Explain why there is a copper coating on the 1 cent coin.

Steel rusts/corrodes, copper does not

b) Using the compositions of the silver and gold part of the 1 euro coin, suggest which metal causes the alloy to become gold-coloured.

Zinc

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Answers:

5. The table below shows the properties of four different metals.

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Aluminium	1	2.70	high	good	good

Using the data provided in the table, explain some uses of each metal, relating their use to their individual properties.

Copper:

1) good conductor of electricity so can be used in electrical wires/cables, electromagnets
2) corrosion resistant so can be used in water pipes, roofing, coins, musical instrument

Gold:

1) excellent resistance to corrosion, valuable, low strength so can be used for jewellery, coins
2) excellent conductor of electricity so can be used in electronic devices, circuit boards

Aluminium:

1) low density, strong and corrosion resistant so can be used in aeroplanes, cars, bikes
2) low density, conducts electricity, corrosion resistant so can be used in overhead electricity cables
3) low density, corrosion resistant so can be used for foil, cans, food packaging, saucepans

Silver:

1) very good resistance to corrosion, valuable, low strength so can be used for jewellery, cutlery and coins
2) excellent conductor of electricity so can be used for electronic devices, circuit boards

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