Cambridge IGCSE · Chemistry 0620 · Notes

Properties and uses of metals and alloys

Read online at **pastopic.com/cambridge/chemistry-0620/notes/properties-uses-and-alloys**

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Read first: **Ionic and metallic bonding**

What you need to know

By the end of this topic you should be able to:

1. **Compare the physical properties of metals and non-metals**: how well they conduct heat (thermal conductivity) and electricity (electrical conductivity), whether they can be hammered into shape (malleability) and drawn into wires (ductility), and their melting and boiling points.
2. **Describe the general chemical properties of metals**: how they react with dilute acids, with cold water and steam, and with oxygen.
3. **Explain the uses of metals from their physical properties**, including:
   - aluminium for making aircraft, because it has a low density;
   - aluminium for overhead electrical cables, because it has a low density and conducts electricity well;
   - aluminium for food containers, because it resists corrosion;
   - copper for electrical wiring, because it conducts electricity well and is ductile.
4. **Describe an alloy as a mixture of a metal with other elements**, including brass (copper and zinc) and stainless steel (iron with other elements such as chromium, nickel and carbon).
5. **State that alloys can be harder and stronger than the pure metals**, which makes them more useful.
6. **Explain the uses of alloys from their physical properties**, including stainless steel for cutlery, because it is hard and resists rusting.
7. **Pick out an alloy from diagrams** of the arrangement of atoms.
8. **Extended only:** explain, using structure, why alloys can be harder and stronger than the pure metals: the atoms of different sizes stop the layers sliding over each other.

The order of reactivity of metals (including putting metals in order from experimental results), rusting and how to prevent it are in the next topic, Reactivity series and corrosion. Extracting metals from their ores is in Extraction of metals.

Understand it

Metals and non-metals: physical properties

A **physical property** is something you can observe or measure without turning the substance into a new one: how it conducts, how it behaves when hammered, when it melts. Metals share a set of physical properties that most non-metals don't have.

Property	Typical metal	Typical non-metal
Thermal conductivity	good: heat passes through quickly	poor (an insulator)
Electrical conductivity	good, as a solid **and** when molten	poor; does not conduct (graphite is the exception)
Malleability	malleable: hammers into a new shape without breaking	brittle as a solid: it shatters or crumbles
Ductility	ductile: can be pulled out into a wire	not ductile
Melting and boiling points	usually high	usually low (many are gases at room temperature)
Appearance and sound	shiny when freshly cut; rings when struck (sonorous)	dull; not sonorous
Density	usually high	usually low

These are **general** properties. There are exceptions on both sides, so learn the pattern and the main exceptions:

- Mercury is a metal that is liquid at room temperature, and Group I metals such as sodium and potassium are soft, with low melting points and low densities. They still conduct electricity and heat and are still malleable, so they are still metals.
- Diamond (a form of carbon) is a non-metal with a very high melting point, and graphite is a non-metal that conducts electricity. So a high melting point on its own does **not** prove that an element is a metal.

Extended only: these properties come from metallic bonding (see Ionic and metallic bonding). A metal is a lattice of positive ions in a "sea" of delocalised electrons. The electrons are free to move, so they carry charge (electricity) and energy (heat) through the metal. The layers of ions can slide over each other without the bonding breaking, so the metal bends and stretches instead of shattering.

Metals: general chemical properties

A **chemical property** describes how a substance reacts to form new substances. Metals react in the same few ways; how fast depends on how reactive the metal is.

- **With dilute acids:** many metals react to give a **salt and hydrogen**. You see fizzing, and the metal gets smaller. metal + hydrochloric acid → metal chloride + hydrogen, for example $\mathrm{Mg + 2HCl \rightarrow MgCl_2 + H_2}$. With dilute sulfuric acid the salt is a sulfate. The least reactive metals, such as copper, do not react with dilute acids; the Reactivity series topic covers which metals react and how fast.
- **With cold water:** only the most reactive metals react, to give a **metal hydroxide and hydrogen**, for example $\mathrm{Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2}$. The hydroxide makes the water alkaline.
- **With steam:** some less reactive metals, such as magnesium, barely react with cold water but react with steam to give a **metal oxide and hydrogen**: $\mathrm{Mg + H_2O \rightarrow MgO + H_2}$.
- **With oxygen:** many metals burn or tarnish in air to form a **metal oxide**, for example $\mathrm{2Ca + O_2 \rightarrow 2CaO}$. Metal oxides are basic oxides.

In every one of these reactions the metal atoms lose electrons and become positive ions in the product.

Is it a metal or a non-metal?

Questions often describe an unknown element with a few clues. No single clue settles it, so sort **every** clue:

Points to a metal	Points to a non-metal
conducts electricity as a solid	does not conduct electricity as a solid
conducts heat well (a good thermal conductor), for example used for saucepans	a poor conductor of heat
flattens or bends when hammered (malleable)	shatters or crumbles when hammered (brittle)
a shiny or silver-coloured solid	made of small molecules, for example diatomic, like $\mathrm{O_2}$
reacts with dilute acid, cold water or steam to give hydrogen	forms an oxide that is a gas, or one whose atoms share electrons
forms a basic oxide	forms an acidic oxide

One non-metal clue makes the element a non-metal, even if it also has a metal clue. Graphite conducts electricity, but it shatters when hammered, so it is a non-metal. The element is a metal when it has a metal clue and **no** non-metal clue.

Three traps:

- **Not** reacting with dilute acid is not a non-metal clue: copper, silver and gold are metals that don't react. So "reacts with dilute acid **and** conducts" rules out graphite (a non-metal) and copper (no reaction), leaving a metal such as iron.
- A high melting point on its own proves nothing (diamond). It counts only with a metal clue, such as "a silver solid with a very high melting point".
- A shiny solid that conducts heat and electricity could be a metal **or an alloy**. It is not an ionic compound: those conduct only when molten or dissolved.

Uses come from properties

When a question asks why a metal is used for something, the answer is the **property the job needs**, not just any true fact about the metal. Think about what the object has to do.

Use	What the job needs	Metal	Property that explains the use
Aircraft bodies	light, so less fuel is needed to lift it	aluminium	**low density**
Overhead power cables	light, so the pylons can hold long spans; carries current	aluminium	**low density** and **good electrical conductivity**
Food containers, drinks cans	must not react with food or damp air	aluminium	**resists corrosion**
Electrical wiring	carries current; bends into thin wire	copper	**good electrical conductivity** and **ductile**
Cutlery (knives, forks, spoons)	keeps its edge and shape; must not rust in wet, salty food	stainless steel	**hard** and **resists rusting**

Copper is actually a better electrical conductor than aluminium. It is not used for overhead cables because copper is about 3.3 times as dense (8.96 g/cm^3 against 2.7 g/cm^3), so a long hanging cable would be far too heavy. Overhead cables often have a **steel core** inside the aluminium: the steel adds strength so the cable doesn't stretch or snap.

Why aluminium resists corrosion is explained in Reactivity series and corrosion; here you need only the fact and the use.

Watch out for true properties that don't explain the use. Aluminium conducts heat and electricity, but neither is the reason it is used for food containers. Iron is almost 3 times as dense as aluminium, so it is never the answer for aircraft.

Alloys

Pure metals are often too soft for everyday objects. An **alloy** is a **mixture of a metal with other elements**. The other elements can be metals (as in brass) or non-metals (such as the carbon in steel).

The alloys you must know:

Alloy	Made of	Useful because
Brass	copper and zinc	harder and stronger than pure copper; does not corrode easily
Stainless steel	iron with chromium, nickel and carbon	hard; resists rusting (used for cutlery)

Because an alloy is a **mixture**, not a compound:

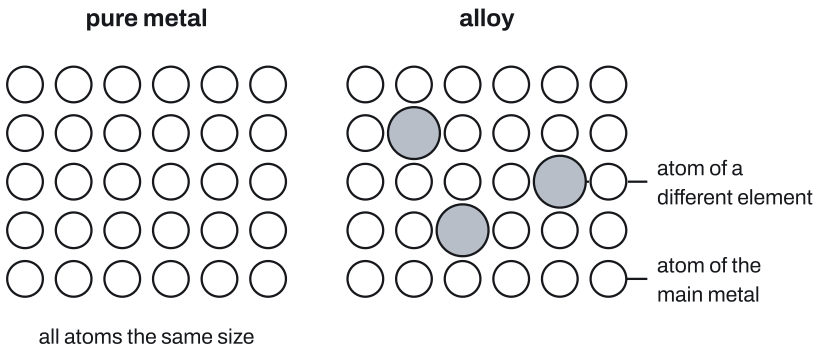
- the elements are **not chemically combined**, and there is no fixed formula;

- the amounts can vary (brass can have more or less zinc), and changing them changes the properties;
- it still has metallic properties: an alloy **still conducts** heat and electricity and is still shiny and malleable enough to be shaped.

Alloys can be **harder and stronger** than the pure metals they are made from. Many are also more **resistant to corrosion**. That is why alloys are often **more useful** than the pure metal: a brass tap stays in shape, and a stainless-steel knife doesn't bend or rust.

Recognising an alloy from a diagram

In a diagram of atoms, a pure metal is drawn as identical circles in neat rows. An alloy is drawn as the same rows with **some circles of a different size** (usually a different shading) mixed in among them.



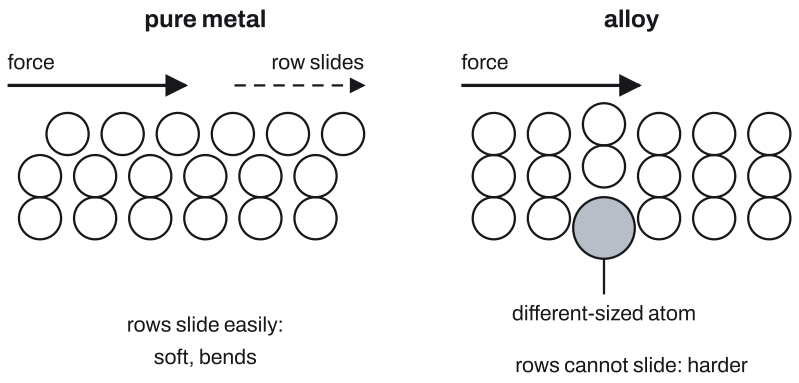
How to tell the options apart in a multiple-choice diagram question:

- **One kind of atom** in a regular pattern: a pure metal (an element).
- **Mostly one kind of metal atom with a few different-sized atoms** scattered in a lattice: an **alloy**.
- **Two kinds of particle joined in small groups** (molecules): a compound, not an alloy.
- **Two kinds of particle alternating in a perfect, fixed pattern**: a compound with a fixed formula, such as an ionic lattice.
- **Separate molecules spread out**: a gas or a simple molecular substance.

Why alloys are harder (Extended)

Extended only: in a pure metal all the atoms are the same size, so they sit in regular layers. When a force pushes on the metal, one layer slides easily over the next, and the metal bends or changes shape: it is soft.

In an alloy, the atoms of the added element are a **different size**. They distort the regular layers, so the layers can **no longer slide over each other** easily. More force is needed to change the shape, so the alloy is **harder and stronger**.



This is about the **layers of atoms** and **different-sized atoms**. It is not about "intermolecular forces" (metals have no molecules), and not simply "because carbon is hard".

Key facts and formulas

"Given" means the exam paper prints it. "Learn it" means you must remember it. Chemistry 0620 has no formula sheet, so everything here must be learned.

Formula	Status
Metals: good thermal and electrical conductors, malleable, ductile, usually high melting and boiling points	Learn it
Non-metals: poor conductors (except graphite), brittle as solids, usually low melting and boiling points	Learn it
metal + dilute acid → salt + hydrogen, e.g. $\mathrm{Mg + 2HCl \rightarrow MgCl_2 + H_2}$	Learn it
reactive metal + cold water → metal hydroxide + hydrogen, e.g. $\mathrm{Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2}$	Learn it
metal + steam → metal oxide + hydrogen, e.g. $\mathrm{Mg + H_2O \rightarrow MgO + H_2}$	Learn it
metal + oxygen → metal oxide (a basic oxide), e.g. $\mathrm{2Ca + O_2 \rightarrow 2CaO}$	Learn it
Aluminium: aircraft (low density); overhead cables (low density, good electrical conductor); food containers (resists corrosion)	Learn it
Copper: electrical wiring (good electrical conductor, ductile)	Learn it
Alloy = a **mixture** of a metal with other elements	Learn it

Formula	Status
Brass = copper + zinc	Learn it
Stainless steel = iron + chromium, nickel and carbon; cutlery (hard, resists rusting)	Learn it
Alloys can be harder and stronger than the pure metals, so they are more useful	Learn it
Extended only: different-sized atoms → layers can no longer slide over each other → harder, stronger	Learn it

How to do it

In the questions we have tagged for this topic (149 questions, 2021–2025), the types came up this often. 61 of the 149 questions mix more than one type, so the counts add up to 247.

Question type	Questions
Link a use of aluminium or copper to its properties	42
Define or recognise an alloy	33
State the typical physical properties of metals	29
Chemical properties: metals with acids, water, steam and oxygen	25
Name the metals in an alloy	23
Give a use of a steel and the property behind it	22
Put metals in order of reactivity from observations	20
Pick the alloy from a diagram of atoms	14
Why alloys are more useful than pure metals	14
Decide whether an element is a metal from clues	10
Compare a transition metal with a Group I metal	9
Why alloys are harder, in terms of structure (Extended)	6

1. Link a use of aluminium or copper to its properties (42 questions)

1. **Ask what the object must do**: be light, carry current, not react with food, stand heat.
2. **Match that need to the property** from the table in "Understand it".
3. **Check each property is the right way round** for that metal: aluminium has a *low* density, copper is *highly* ductile and a *good* conductor.

4. **Check the property really explains the use.** A true fact about the metal that the job doesn't need is wrong.

Variations you will meet:

- **Multiple choice with rows** of metal, property and use. Reject any row with a property the wrong way round ("aluminium, high density"; "copper, low ductility"; "copper, poor conductor of heat"), a use given to the wrong metal (copper or iron for aircraft), or a reason that doesn't fit the use ("aluminium for food containers because it conducts electricity").
- **Aircraft**: aluminium, because it has a **low density** and is **strong**. Mark schemes accept "resists corrosion" as well, but never "conducts".
- **Overhead cables**: aluminium has a **low density** and **conducts electricity**. The steel core makes the cable **stronger**; the steel is not there to conduct or to stop corrosion.
- **"Which statements explain why aluminium, not copper, is used for cables?"** Only the lower density. "Copper is a better conductor" is true but is a reason *against* aluminium, and "aluminium is more reactive" doesn't explain the use.
- **Copper wiring**: good electrical conductor **and ductile**. "State one other reason" after conductivity is given: ductile.
- **Pans and cooking pans** (copper or aluminium): a **good conductor of heat** and a **high melting point**. Electrical conductivity and density are not the reason.
- **"Give two physical properties that explain…"**: give properties only (low density, conducts electricity), not uses or chemical facts.
- **A company needs a metal with a list of properties** (low density, resists corrosion, conducts): aluminium. Iron is dense and rusts; sodium and magnesium are too reactive.

2. Define or recognise an alloy (33 questions)

1. **Definition:** "a **mixture** of a metal with other elements". The word *mixture* is essential, and so is *metal*.
2. **Given the definition, name the term:** "alloy".

Variations you will meet:

- **Multiple-choice statements.** An alloy is a mixture, not a compound and not a single element. It is not a coating of one metal on another (that is plating or galvanising). It **still conducts electricity**. Alloys can contain non-metals: steel contains carbon and is still an alloy.
- **An unfamiliar alloy**, such as gold mixed with a little copper, or iron with a little tungsten. It is still an alloy, still a mixture, and still conducts. The pure metal it came from has its atoms in **ordered layers**.
- **"Give two characteristics of a mixture"**: its parts are not chemically combined; the amounts can vary; its parts keep their own properties; they can be separated by physical methods.

3. State the typical physical properties of metals (29 questions)

1. **List properties from the metals column** of the table: malleable, ductile, good thermal conductor, good electrical conductor, high melting point, high boiling point, shiny, sonorous, high density.

2. **Don't repeat what the question has already given.** If it says "metals are malleable and ductile. State three other properties", choose from the rest.
3. **Give physical properties only.** "Reacts with acid" or "forms positive ions" is chemical and scores nothing here.

Variations you will meet:

- **"Which property is true of all metals?"** (multiple choice): conducting electricity (as a solid and when molten) and heat, and being malleable. "Low density", "hard", "high melting point" and "reacts with dilute acid" are not true of every metal.
- **Name the property from a description**: "can be drawn into wires" is ductile; "can be hammered into shape" is malleable.
- **Extended:** what happens to the particles when a metal is hammered: the layers of ions **slide** over each other.
- **"Give one physical property of Group I metals that differs from most metals"**: lower density, lower melting point, or softer.

4. Chemical properties: metals with acids, water, steam and oxygen (25 questions)

1. **Metal + dilute acid → salt + hydrogen.** Name the salt from the acid: hydrochloric → chloride, sulfuric → sulfate, nitric → nitrate, ethanoic → ethanoate. So strontium + hydrochloric acid → strontium chloride + hydrogen. "Salt and water" is wrong: that is what a metal oxide gives.
2. **Metal + cold water → metal hydroxide + hydrogen** (reactive metals). The solution is alkaline, pH above 7.
3. **Metal + steam → metal oxide + hydrogen.**
4. **Metal + oxygen → metal oxide**, and metal oxides are **basic**.

Variations you will meet:

- **Which named metals react with dilute acid?** Zinc, magnesium, iron and sodium do; copper does not. So "reacts with dilute acid" is true of those four but not of all metals.
- **Group I metals and water from a table**: name the gas (hydrogen) and the solution (potassium + water → potassium hydroxide), predict the pH (above 7) and predict more vigorous fizzing further down the group.
- **Balance an equation** with oxygen: $4\mathrm{Na} + \mathrm{O_2} \rightarrow 2\mathrm{Na_2O}$.
- **Iron and steam**: $3\mathrm{Fe} + 4\mathrm{H_2O} \rightleftharpoons \mathrm{Fe_3O_4} + 4\mathrm{H_2}$. The reaction is reversible, so the box takes $\rightleftharpoons$.
- **"Is this metal oxide acidic or basic?"** Basic, because it is the oxide of a metal (calcium oxide, iron(III) oxide, copper(II) oxide).
- **Complete an equation for a metal burning**, such as iron forming $\mathrm{Fe_3O_4}$: $3\mathrm{Fe} + 2\mathrm{O_2} \rightarrow \mathrm{Fe_3O_4}$.
- **Metals form positive ions** (they lose electrons). "Gain electrons" or "negative ions" is wrong.

5. Name the metals in an alloy (23 questions)

1. **Brass**: copper and zinc.

2. **Stainless steel**: mainly iron, with chromium and nickel (and carbon). If asked for the metals other than iron, give chromium and nickel; carbon is not a metal.
3. **Steel**: mainly iron, with carbon. Iron is the main component.
4. **"A mixture of a metal with other elements such as brass is called…"**: an alloy.

Variations you will meet:

- Common wrong options for brass are tin, nickel, chromium, iron and aluminium.
- **"Which pairs can form an alloy?"** At least one must be a metal: magnesium and aluminium, iron and carbon, copper and zinc can; nitrogen and oxygen cannot.
- **Pick the substance from a list**: "a mixture of copper and zinc" is brass; "added to iron to make stainless steel" is nickel (Ni) or chromium.

6. Give a use of a steel and the property behind it (22 questions)

1. **Stainless steel**: cutlery (also a chemical plant). "Utensils" or "cooking" is too vague.
2. **Why**: it is **hard** and **resists rusting** (corrosion). Not "it is a pure metal", "it conducts electricity" or "it has a high melting point".

Variations you will meet:

- **"One reason for using stainless steel instead of pure iron for cutlery"**: harder, or more resistant to rusting.
- **A table of steels** with their carbon content and properties: read off the row asked for, or pick the one that is hard and does not corrode for cutlery. A steel that corrodes, or is soft, is wrong for cutlery.
- **Mild steel** (older papers only): car bodies and machinery.

7. Put metals in order of reactivity from observations (20 questions)

These parts sit in the same questions as this topic, but ranking metals from observations belongs to Reactivity series and corrosion: use the method in that note.

8. Pick the alloy from a diagram of atoms (14 questions)

1. Look for **one kind of metal atom in regular rows** with **a few atoms of a different size** mixed in (the first diagram in "Understand it").
2. Reject one kind of atom only (pure metal), small groups joined together (molecules), and two particles alternating in a perfect pattern (an ionic compound such as sodium chloride).

Variations you will meet:

- **Pick both the pure metal and the alloy** from pairs of diagrams.
- **A labelled diagram for brass**: it must show copper **and zinc** atoms, not iron.

- **"Which kind of substance is shown?"** (for example cupronickel, copper and nickel atoms mixed): an alloy, not a compound or an isotope.

9. Why alloys are more useful than pure metals (14 questions)

1. **Give a comparison**: the alloy is **harder**, **stronger**, or **more resistant to corrosion** than the pure metal.
2. **Use the comparative word.** "It conducts electricity" is true of the pure metal too, so it is not a reason.

Variations you will meet:

- **An alloy you haven't met** (pewter compared with tin, magnalium compared with magnesium): the same answer, harder or stronger.
- **"Suggest two reasons"** (brass taps rather than pure zinc): harder, stronger, more resistant to corrosion.
- **Multiple choice:** alloys are *not* easier to hammer into shape, easier to extract or cheaper, and do not contain atoms all of the same size. Adding zinc to copper makes brass **harder**; coating iron with zinc (galvanising) is to **stop corrosion**.

10. Decide whether an element is a metal from clues (10 questions)

1. **Sort every clue** into the metal or non-metal column of the clue table in "Understand it". Metal clues: conducts electricity, **conducts heat well** (so it is used for saucepans), malleable, shiny, gives hydrogen with an acid, water or steam, forms a basic oxide.
2. **One non-metal clue makes it a non-metal**, even if it also conducts. An element that conducts but shatters when hammered is a non-metal (like graphite).
3. **It is a metal when it has a metal clue and no non-metal clue.**

Variations you will meet:

- **Flow charts** ("does it react with water to give hydrogen?", "does it conduct?", "does it break when hammered?"): judge each end point by every answer on its path. Reacts with water to give hydrogen: metal. Doesn't conduct: non-metal. Conducts but breaks: non-metal. Conducts and doesn't break: metal.
- **"Reacts with dilute acid and conducts"**: iron, not copper (no reaction with dilute acid) and not graphite (a non-metal).
- **A shiny solid that conducts heat and electricity** could be a metal or an alloy, not an ionic compound or a non-metal.
- **Compare a metal with a non-metal**, such as potassium and sulfur: the metal has the higher thermal conductivity and the non-metal is the less malleable (it is brittle), even though potassium is a soft metal.
- **A data table**: the metal is the one that **conducts when solid**. Elements that don't conduct and have low melting points are non-metals made of small molecules. One that conducts only when liquid is an ionic compound.

11. Compare a transition metal with a Group I metal (9 questions)

The details are in The Periodic Table; here you need the physical differences.

1. The transition metal (iron, nickel, cobalt, silver, copper) has a **higher melting point**, a **higher density** and is **harder and stronger**. Group I metals are soft, with low densities and low melting points.
2. Write each point as a comparison: "cobalt has a higher density than lithium".
3. Both conduct electricity, are malleable and form basic oxides, so these are **not** differences.

12. Why alloys are harder, in terms of structure (6 questions, Extended)

Extended only. Write the linked points:

1. An alloy contains atoms of **different sizes**.
2. These **disrupt the regular layers** of metal atoms.
3. So the **layers cannot slide over each other** easily, which makes the alloy harder and stronger.

Variations you will meet:

- **Multiple choice**: pick the option with "layers cannot easily slide". Reject "intermolecular forces are stronger" (a metal has no molecules), "carbon is a very hard substance", "the carbon atoms bond strongly", and "larger atoms slide more easily".
- You may draw a labelled diagram as part of the answer: rows of equal circles with one larger circle breaking the rows.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **M1** method mark: for a correct method, even if the numbers slip.
- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

Example 1

The table shows some properties of four elements, E, G, J and L.

Element	Melting point / °C	Conducts electricity as a solid	When hammered	Density / g/cm^3
E	1455	yes	flattens	8.9
G	44	no	crumbles	1.8
J	660	yes	flattens	2.7
L	3550	no	crumbles	3.5

(a) Which **two** elements are metals? Give **two** pieces of evidence from the table. **[3]**

(b) A student says L must be a metal because it has a very high melting point. Explain why the student is wrong. **[1]**

(c) Suggest which element is better for making overhead electricity cables. Explain your answer. **[2]**

(d) State **two** physical properties typical of metals that are not shown in the table. **[2]**

(a) E and J. **B1**

They conduct electricity as solids **B1**, and they flatten when hammered, so they are malleable **B1**.

(b) L does not conduct electricity and it crumbles (it is brittle), so it is a non-metal. A high melting point alone doesn't prove an element is a metal. **B1**

(c) J. **B1** It conducts electricity **and** has a low density (2.7 g/cm^3; E is about 3.3 times as dense), so the cable is light. **B1**

(d) Any two of: ductile; good conductor of heat; shiny; sonorous. **B1 B1** (Not a high boiling point: it goes with the melting point already in the table.)

Example 2

A pure metal, R, is soft. Different amounts of element Y are mixed with R. The hardness of each mixture is measured.

Percentage of Y by mass	**0**	**2**	**5**	**8**	**12**
Hardness (arbitrary units)	40	58	75	88	94

(a) The mixtures of R and Y are alloys. State what is meant by the term alloy. **[2]**

(b) Describe how the hardness changes as the percentage of Y increases. **[2]**

(c) Calculate the percentage increase in hardness when 8% of Y is added to pure R. **[2]**

(d) **Extended only.** Explain, in terms of structure, why the alloys are harder than pure R. **[3]**

(e) The alloys still conduct electricity. Explain why this is expected. **[1]**

(a) A mixture **B1** of a metal with other elements **B1**.

(b) The hardness increases as more Y is added **B1**. It rises quickly at first (18 units for the first 2%) and then levels off (only 6 units from 8% to 12%) **B1**.

(c) Increase $= 88 - 40 = 48$. **M1**

$$\text{percentage increase} = \frac{48}{40} \times 100 = 120\%$$

A1

(d) The atoms of Y are a different size from the atoms of R **B1**. They disrupt the regular layers of R atoms **B1**, so the layers can no longer slide over each other easily **B1**.

(e) An alloy is a mixture, not a compound: the metal R is still there with its metallic properties, so it still conducts. **B1**

Example 3

The table gives information about five materials, T, U, V, X and Z. All five are ductile.

Material	Density / g/cm^3	Strength	Corrodes in damp air?	Electrical conductivity
T	2.7	medium	no	good
U	7.9	high	yes	fair
V	8.0	high	no	fair
X	8.9	low	no	very good
Z	4.5	high	no	poor

(a) A company makes the frame of a racing wheelchair. The frame must be light, strong and must not corrode. Which material should it use? Explain why the other materials are less suitable. **[3]**

(b) U is strong and cheap. Explain why U is not suitable for making forks. **[1]**

(c) Which material is best for the wires inside a phone charger? Give **two** reasons. **[2]**

(a) Z. **B1** It is strong, does not corrode and has the lowest density of the strong materials. **B1** U corrodes; V is almost twice as dense; T and X are not strong enough. **B1**

(b) U corrodes in damp air (it rusts), and forks are washed and touch wet food. **B1**

(c) X **B1**: it has the best electrical conductivity and it is ductile, so it can be drawn into thin wire. **B1**

Example 4

Metal M forms ions with a $2+$ charge. M reacts slowly with cold water and quickly with steam, and it burns in air to form a white solid.

(a) Name the products when M reacts with dilute hydrochloric acid, and write a balanced symbol equation for the reaction. **[3]**

(b) Write a balanced equation for M burning in oxygen. **[2]**

(c) Write a balanced equation for the reaction of M with steam. **[1]**

(d) The white solid from (b) is a metal oxide. State whether it is an acidic or a basic oxide. **[1]**

(a) M chloride **B1** and hydrogen **B1**.

$$\mathrm{M} + 2\mathrm{HCl} \rightarrow \mathrm{MCl_2} + \mathrm{H_2}$$

B1 (the $2+$ ion needs two chloride ions, so $\mathrm{MCl_2}$).

(b)

$$2\mathrm{M} + \mathrm{O_2} \rightarrow 2\mathrm{MO}$$

B1 for MO, **B1** for balancing.

(c) With steam a metal forms its oxide and hydrogen:

$$\mathrm{M} + \mathrm{H_2O} \rightarrow \mathrm{MO} + \mathrm{H_2}$$

B1

(d) Basic, because it is the oxide of a metal. **B1**

Common mistakes

- **Writing "compound" in the definition of an alloy.** Examiners see "a compound of metals", "metal molecules" or "metals chemically combined" every year. An alloy is a **mixture**; the word must be there.
- **Being too vague in the definition.** "A mixture of elements" is not enough: say "a mixture of a **metal** with other elements".
- **Giving a use when a property is asked for, or a property when a use is asked for.** Read the command: "state a use" wants an object (cutlery), "suggest a property" wants a property (hard, resists rusting).
- **Vague uses.** "Utensils", "cooking" and "machines" do not score for stainless steel; "cutlery" does.
- **Giving a property that the pure metal also has.** "Brass conducts electricity" is not a reason brass is more useful than copper. Use a comparison: harder, stronger, more resistant to corrosion.
- **Getting brass wrong.** Brass is copper and zinc, not copper and tin, nickel or iron.
- **Pairing properties.** "Conducts heat" and "conducts electricity" are often counted as **one** property, and so are "high melting point" and "high boiling point". When asked for three properties, pick from different groups: for example malleable, good conductor, high melting point.
- **Chemical instead of physical properties.** "Reacts with acid" or "forms positive ions" is not a physical property.
- **Comparing without the comparative word.** "Iron is dense" doesn't compare; write "iron has a **higher** density than sodium". Both conduct and both are malleable, so these are not differences between them.
- **Claiming properties that only some metals have**, such as "magnetic" or "rusts" (only iron and a few others). A property "of all metals" must really apply to every metal.
- **Calling an element a metal from one clue.** Graphite conducts but is a non-metal, because it shatters when hammered. Check every clue: one non-metal clue decides it.
- **Extended: "intermolecular forces" in the alloy explanation.** Metals are not made of molecules. Write about **different-sized atoms** and **layers that cannot slide**.

How to get the marks

- **"State what is meant by an alloy"**: "a mixture of a metal with other elements". On a two-mark version, one mark is for *mixture* and one for *a metal with other elements*.
- **"State" and "name"** need a short answer, not an explanation: "copper and zinc", "cutlery", "alloy".
- **"Suggest"** means use what you know on something new: an unfamiliar alloy is still harder or stronger than its pure metal; an unfamiliar use needs the property that the job needs.
- **"Describe"** a trend in data: say which way it goes (increases), then any change in the pattern (quickly at first, then levels off), quoting numbers.
- **"Explain"** (Extended, alloy hardness): the three linked points, different-sized atoms, layers disrupted, layers cannot slide. A labelled diagram can help but the key words must be there.
- **Uses**: give the use **and** the matching property if both are asked, for example "overhead cables, because aluminium has a low density and conducts electricity".
- **Lists**: when a question gives "any two from" or asks for "three other properties", write exactly that many and don't repeat any already given in the question. Extra wrong answers can cancel right ones.
- **Multiple choice**: check every part of a row. One wrong direction (high for low) makes the whole row wrong.
- **Calculations** from data (percentage change): show the subtraction, then divide by the **starting** value and multiply by 100.

Quick check

1. Which of these is an alloy? (A) pure zinc; (B) zinc oxide; (C) a mixture of zinc with a little copper; (D) iron coated with zinc. Explain your choice, and name the alloy that is made of copper and zinc.
2. A question says "Metals are good conductors of electricity." State **three other** physical properties of metals.
3. Copper conducts electricity better than aluminium. Explain why aluminium is still used for overhead power cables, and why these cables often have a steel core.
4. Four solid elements are described. W conducts electricity but shatters when hit with a hammer. X is a silver solid that reacts with dilute hydrochloric acid to give hydrogen. Y does not conduct electricity. Z reacts with steam to give hydrogen. Which of them are metals?
5. **Extended only.** A pure metal bends easily. When 3% of an element with larger atoms is mixed in, the metal becomes much harder. Explain this.

Answers

1. C. An alloy is a mixture of a metal with other elements. A is a pure metal (one element), B is a compound (chemically combined) and D is a coating, not a mixture. Copper and zinc make brass.
2. Any three of: malleable; ductile; good conductor of heat; high melting point (or high boiling point); shiny; sonorous. (Not "conducts electricity", which was given.)
3. Aluminium has a much lower density (2.7 g/cm^3 against 8.96 g/cm^3), so a long hanging cable is light enough for the pylons, and it still conducts electricity well. The steel core adds strength so the cable does not stretch or snap.
4. X and Z. X is a silver solid and gives hydrogen with an acid; Z gives hydrogen with steam; neither has a non-metal clue. W shatters, so it is a non-metal even though it conducts (like graphite). Y does not conduct, so it is a non-metal.
5. The added atoms are a different size from the metal atoms, so they disrupt the regular layers. The layers can no longer slide over each other easily, so the alloy is harder than the pure metal.

Past questions to try

- **0620/33/M/J/25 Q8**: recognise an alloy from diagrams, a property of an unfamiliar alloy, and physical properties of metals (parts (c) and (d)).
- **0620/31/O/N/25 Q6**: the metals in stainless steel and one of its uses (part (b)).
- **0620/43/O/N/23 Q5**: Extended, explain in terms of structure why an alloy is harder (part (c)).
- **0620/13/M/J/23 Q23**: a flow chart that sorts four elements into metals and non-metals.