Metals and non-metals

4.1.2.3 · Atomic structure and the periodic table · revision notes

Where metals and non-metals are in the periodic table, how their properties differ, and how their atomic structure explains this: metals react to form positive ions, non-metals do not. Questions often give data or properties and ask you to classify an element and explain why.

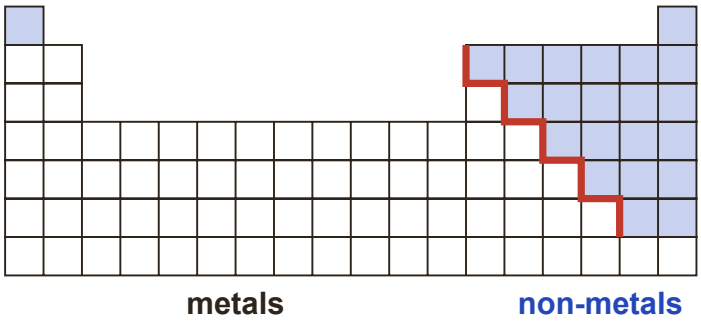
Key facts

- Metal: an element that reacts to form positive ions
- Metals: left and bottom; non-metals: right and top
- Non-metals: dull, poor conductors, brittle, low melting point
- Metals lose outer electrons; non-metals gain or share electrons
- Non-metal: an element that does not form positive ions
- Metals: shiny, conductors, malleable, usually high melting point
- Metal oxides are basic; non-metal oxides are usually acidic

Notes

Where they are

- Most elements are **metals**.
- Metals are found to the **left** and towards the **bottom** of the periodic table. Non-metals are found towards the **right** and the **top**.



Metals: left and bottom. Non-metals (shaded): top right, plus hydrogen.

- Elements that react to form **positive ions** are metals. Elements that do not form positive ions are non-metals.

Typical properties

- Metals: shiny, usually high melting and boiling points, good conductors of heat and electricity, malleable (can be hammered into shape), ductile (can be drawn into wires).
- Non-metals: dull, low melting and boiling points (many are gases at room temperature), poor conductors, brittle when solid.
- Metals form positive ions, and their oxides are **basic** (they react with acids).
- Non-metals form negative ions or share electrons, and their oxides are usually **acidic** (those that dissolve in water form acidic solutions).
- These are typical properties, not rules: Group 1 metals are soft with low melting points, mercury is a liquid, and carbon (a non-metal) has a very high melting point and, as graphite, conducts electricity.

Explaining with electrons

- Metal atoms usually have only a few electrons (1, 2 or 3) in their outer shell. In reactions they lose these electrons to form positive ions.
- Non-metal atoms usually have 4 to 7 outer electrons. In reactions they gain electrons to form negative ions, or share electrons.
- Across a period the atomic number, and so the number of outer electrons, increases, so the elements change from metals on the left to non-metals on the right.
- Down a group the outer electrons are further from the nucleus and are lost more easily, so elements become more metallic. In Group 4, carbon is a non-metal but tin and lead are metals. Grade 8+ only

How to answer each type of question

Classify an element from its properties 2 to 3 marks **Grade 5**

1. Decide which properties point to a metal and which to a non-metal.
2. Give your answer.
3. Quote the evidence from the question for each reason.

Example. Element **X** melts at 44 °C, does not conduct electricity, and forms an oxide that dissolves in water to give a solution of pH 2.
Is **X** a metal or a non-metal? Give **two** reasons for your answer.

Model answer. Non-metal. Any two reasons: it does not conduct electricity (1); its oxide is acidic, pH 2 (1); it has a low melting point (1).

Use electronic structure to decide metal or non-metal

2 marks | Grade 6

1. Count the outer electrons.
2. 1 to 3 outer electrons: usually lost to form positive ions, so usually a metal. 5 to 7: gained, so a non-metal.

Example. An element has the electronic structure 2,8,2.
Explain whether the element is a metal or a non-metal.

Model answer. Metal (1), because it has 2 outer electrons, which it loses to form a positive (2+) ion (1).

Compare the properties of a metal and a non-metal

2 to 3 marks | Grade 5

1. Pick properties that differ: conductivity, melting point, appearance, malleability.
2. Write each point about both elements, with a comparative word.

Example. Compare the physical properties of magnesium and sulfur.

Model answer. Magnesium conducts electricity but sulfur does not (1). Magnesium has a higher melting point than sulfur (1). Magnesium is shiny and malleable, but solid sulfur is dull and brittle (1).

Don’t lose marks

- Saying all metals have high melting points and densities. Group 1 metals have low melting points and low densities.
- Saying non-metals form positive ions.
- Classifying from one property only: graphite conducts electricity but carbon is a non-metal.
- Using 'strong' to mean 'hard' or 'high melting point'. Use the exact property.

More tips

Memory tricks

- Picture a staircase line running roughly from boron down to astatine: metals are to its left, non-metals to its right.
- Metals lose electrons; non-metals gain or share them.
- Oxide test: basic oxide → metal; acidic oxide → non-metal.

Exam technique

- When classifying, use the evidence in the question and say which property points to which answer.
- For 'compare', write about both elements using comparative words (higher, better conductor).
- The definition examiners look for: metals react to form positive ions.

What each grade needs

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

Grade 3

Locate metals and non-metals in the table

Metals are on the left and towards the bottom; non-metals are on the right and towards the top.

Grade 4

Define metals by the ions they form

Elements that react to form positive ions are metals; elements that do not are non-metals.

Grade 4

Compare physical properties of metals and non-metals

Metals are usually shiny, high melting, malleable conductors; non-metals are usually dull, brittle, low melting and poor conductors.

Grade 5

Compare the oxides of metals and non-metals

Metal oxides are basic; non-metal oxides are usually acidic.

Grade 5

Classify an element using data

Use melting point, conductivity, appearance and the type of oxide as evidence.

Grade 7

Explain properties using electronic structure

Metal atoms have few outer electrons, which they lose; non-metal atoms gain or share electrons.

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