Group 1

4.1.2.5 · Atomic structure and the periodic table · revision notes

The alkali metals in Group 1: their reactions with oxygen, chlorine and water, why they react in similar ways, and why they get more reactive down the group. Expect observations, balanced equations and 'explain the trend' questions, which are very common.

Key facts

- Group 1 = alkali metals: one outer electron; form 1+ ions
- metal + water → metal hydroxide + hydrogen
- $2Na + 2H_2O \rightarrow 2NaOH + H_2$
- $4Na + O_2 \rightarrow 2Na_2O$
- $2Na + Cl_2 \rightarrow 2NaCl$
- Reactivity increases down the group
- Down the group: outer electron further from nucleus → weaker attraction → lost more easily
- Soft, low density, low melting point; stored under oil

Notes

The alkali metals

- Group 1 contains lithium (Li), sodium (Na), potassium (K), rubidium (Rb), caesium (Cs) and francium (Fr).
- They all have **one electron in their outer shell**, which gives them similar chemical properties.
- In reactions each atom loses its outer electron to form an ion with a **1+** charge, e.g. Na^+. Their compounds are ionic.
- They are soft metals that can be cut with a knife, with low densities: lithium, sodium and potassium float on water. Their melting points are low and decrease down the group.
- They react quickly with oxygen and water in the air, so they are stored under oil. A freshly cut surface is shiny but soon tarnishes.

Reactions with water

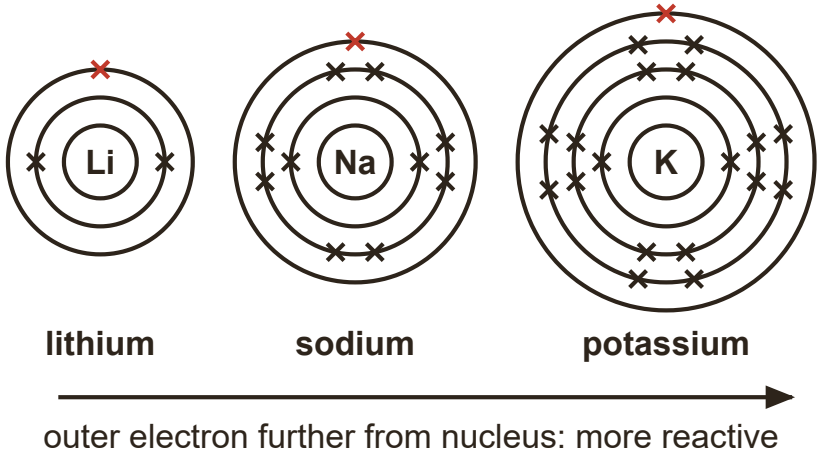
- metal + water → metal hydroxide + hydrogen, e.g. $2Na + 2H_2O \rightarrow 2NaOH + H_2$
- The hydroxide dissolves to form an **alkaline** solution: universal indicator turns blue or purple.
- Lithium floats and fizzes steadily. Sodium fizzes rapidly, melts into a ball and moves around on the surface. Potassium reacts even more vigorously and a lilac flame is seen.
- In each case the metal gets smaller and disappears as it reacts.

Reactions with oxygen and chlorine

- With oxygen they form metal oxides: $4Li + O_2 \rightarrow 2Li_2O$; $4Na + O_2 \rightarrow 2Na_2O$; $4K + O_2 \rightarrow 2K_2O$.
- Heated in oxygen they burn to leave a white solid oxide: lithium with a red flame, sodium with an orange-yellow flame, potassium with a lilac flame.
- With chlorine they react vigorously to form metal chlorides, which are white solids: $2Na + Cl_2 \rightarrow 2NaCl$.
- Hot, silvery sodium burns in green chlorine gas with a bright yellow flame, and white sodium chloride forms.
- Each of these reactions is more vigorous going down the group.

Why reactivity increases down the group

- Going down the group the atoms have more shells, so the outer electron is **further from the nucleus**.
- The attraction between the nucleus and the outer electron is **weaker**.



Down Group 1 the outer electron (red) is further from the nucleus, so it is lost more easily.

- So the outer electron is **lost more easily**, and the metal is more reactive.
- Use the trend to predict: rubidium and caesium react with water even more violently than potassium, forming rubidium hydroxide and caesium hydroxide.

How to answer each type of question

Give observations for a reaction with water

2 to 3 marks | Grade 4

1. Give things you would see or hear, not the names of products.
2. Give as many separate observations as there are marks.

Example. A small piece of sodium is added to a trough of water containing a few drops of universal indicator.
Give **three** observations.

Model answer. Any three: fizzing / bubbles (1); the sodium floats (1); it melts into a ball (1); it moves around on the surface (1); it gets smaller and disappears (1); the indicator turns blue / purple (1).

Write a balanced equation

1 to 2 marks | Grade 5

1. Write the correct formulae: hydroxides MOH, oxides M_2O, chlorides MCl; hydrogen is H_2, oxygen O_2, chlorine Cl_2.
2. Balance the equation, then count each element on both sides.

Example. Lithium reacts with water to form lithium hydroxide and hydrogen.
Write a balanced symbol equation for this reaction.

Model answer.

$2Li + 2H_2O \rightarrow 2LiOH + H_2$

Correct formulae (1); correctly balanced (1).

Explain why reactivity increases down Group 1

3 marks | Grade 7

1. More shells, so the outer electron is further from the nucleus.
2. Weaker attraction between the nucleus and the outer electron.
3. So the outer electron is lost more easily.

Example. Explain why potassium is more reactive than sodium.
Answer in terms of electrons.

Model answer. A potassium atom has more shells, so its outer electron is further from the nucleus (1). There is weaker attraction between the nucleus and the outer electron (1). So potassium loses its outer electron more easily (1).

Predict the properties of another alkali metal

2 to 3 marks | Grade 5

1. Use the same type of products as sodium or potassium.
2. Use the trend: further down means more reactive.

Example. Rubidium is below potassium in Group 1.
(a) Give the formula of rubidium chloride.
(b) Predict how the reaction of rubidium with water compares with the reaction of potassium with water.
(c) Name the alkaline substance formed when rubidium reacts with water.

Model answer.

(a) RbCl (1)
(b) Rubidium reacts more vigorously / faster / more violently (1)
(c) rubidium hydroxide (1)

Don’t lose marks

- Saying the sodium dissolves. It reacts, gets smaller and disappears.
- Saying the gas made with water is oxygen. It is hydrogen.
- Saying the outer electron is harder to lose down the group. It is easier.
- Writing only 'the atoms get bigger' without linking it to distance, attraction and losing the electron.
- Wrong formulae: Na_2O not NaO; H_2 not H.

More tips

Memory tricks

- Down Group 1: more shells → further away → easier to lose → more reactive.
- Water equation pattern for every alkali metal (M): $2M + 2H_2O \rightarrow 2MOH + H_2$.
- Oxide pattern: $4M + O_2 \rightarrow 2M_2O$. Chloride pattern: $2M + Cl_2 \rightarrow 2MCl$.

Exam technique

- For 'explain the trend', use the three-step chain (distance, attraction, electron lost more easily). Each step is usually a mark.
- Observation questions want what you see or hear (fizzing, moving, melting, a flame), not 'hydrogen is made'.
- Use comparative words: more vigorously, faster, further from the nucleus, weaker attraction.

What each grade needs

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

Grade 3 — **Explain the name 'alkali metals'**
They react with water to form hydroxides that dissolve to give alkaline solutions.

Grade 4 — **Describe their reactions with water**
They float and fizz; sodium melts into a ball; potassium reacts with a lilac flame.

Grade 4 — **State the reactivity trend down Group 1**
Reactivity increases going down the group: lithium, then sodium, then potassium.

Grade 5 — **Write equations for their reactions**
With water, oxygen and chlorine, e.g. $2K + 2H_2O \rightarrow 2KOH + H_2$.

Grade 5 — **Predict properties of rubidium and caesium**
Use the trends: even more vigorous reactions and similar products, e.g. RbOH and RbCl.

Grade 6 — **Explain their similar reactions using electrons**
They all have one electron in their outer shell, which they lose to form 1+ ions.

Grade 7 — **Explain why reactivity increases down Group 1**
The outer electron is further from the nucleus, so it is less strongly attracted and more easily lost.

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