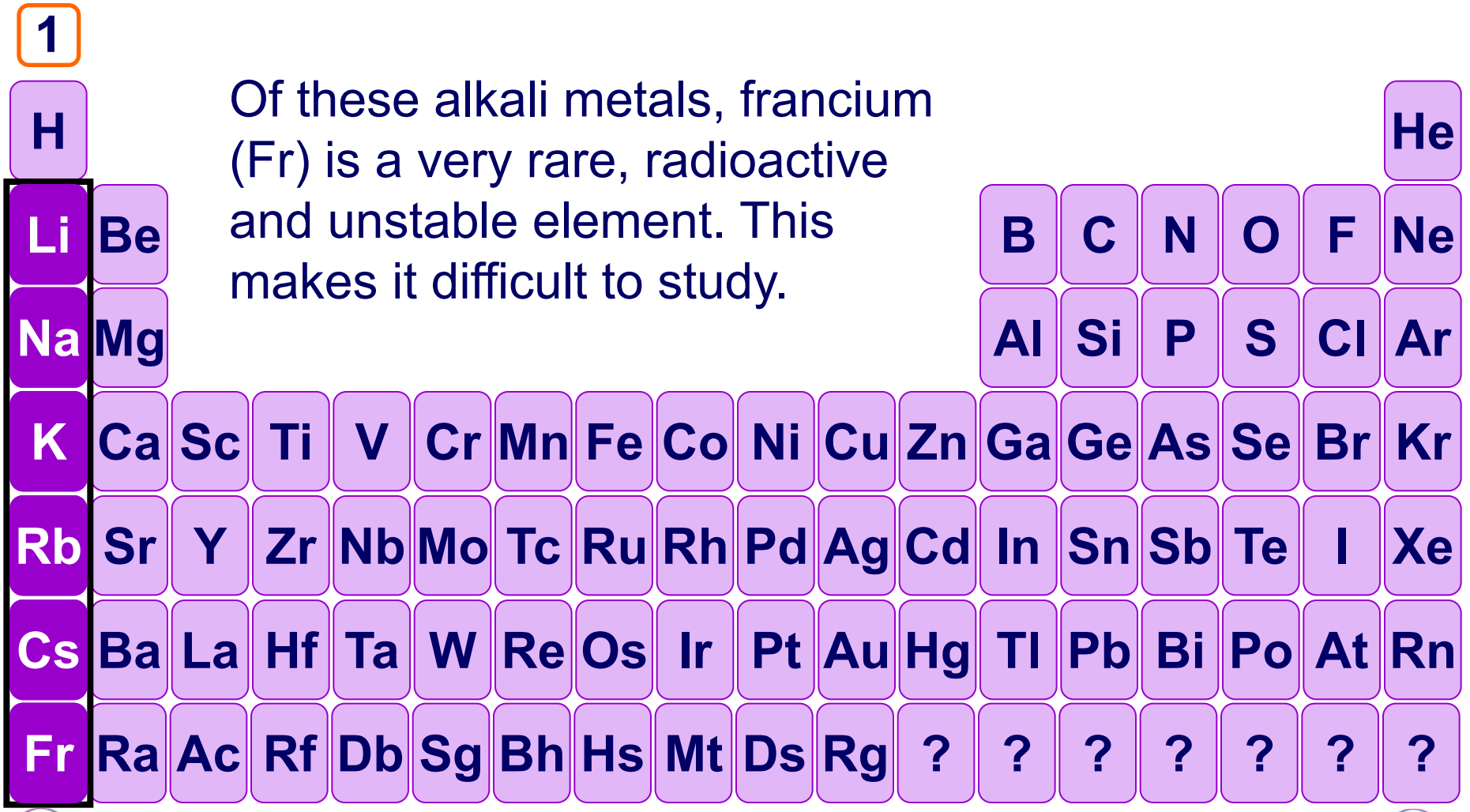
KS4 Chemistry

Alkali Metals

Alkali Metals

Group 1 – the alkali metals

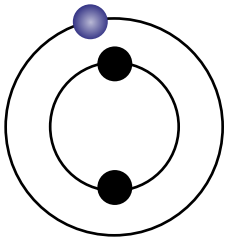
- **Alkali metals** are in group 1 of the periodic table, on the left.



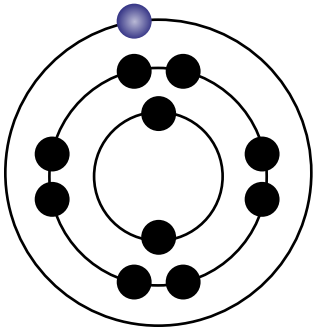
Of these alkali metals, francium (Fr) is a very rare, radioactive and unstable element. This makes it difficult to study.

Electron structure

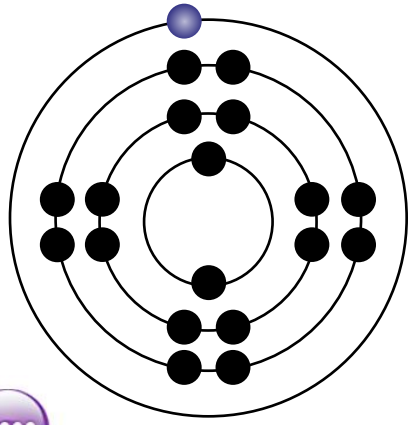
- All alkali metals have 1 electron in their outer shell. This means that:



lithium
2,1



sodium
2,8,1

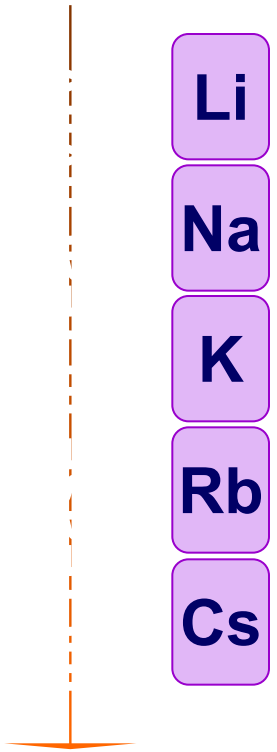


potassium
2,8,8,1

- They can easily obtain a full outer shell by losing 1 electron.
- They all lose their outer shell electron in reactions to form **positive ions** with a +1 charge.
- They have similar physical and chemical properties.

Electron structure and reactivity

- The reactivity of alkali metals increases down the group. What is the reason for this?



- The size of each element's atoms, and the number of full electron shells, increases down the group.
- This means that, down the group, the electron in the outer shell gets further away from the nucleus and is shielded by more electron shells.
- The further an electron is from the positive attraction of the nucleus, the easier it can be lost in reactions.
- This means that reactivity increases as the size of the atom increases.

Reactivity of the alkali metals

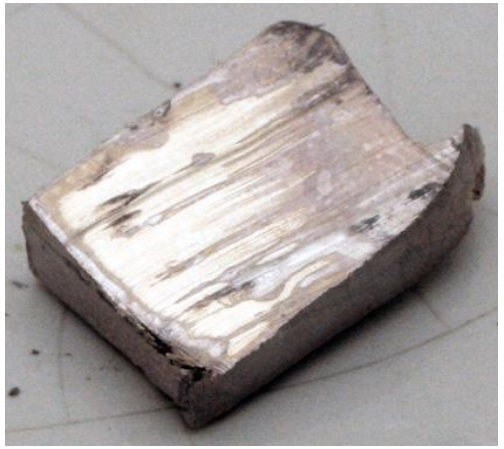
Alkali Metals

General properties

- Alkali metals are different to typical (transition) metals, such as iron and copper. Unlike typical metals, alkali metals:
  - are **soft** and can be cut by a knife – softness increases down the group;
  - have a **low density** – lithium, sodium and potassium float on water;
  - have **low melting and boiling points**.

However, alkali metals do share a few properties with typical metals, because:

- they are **good conductors** of heat and electricity;
- they are **shiny** – this is only seen when they are freshly cut.



Trends in density

- The alkali metals generally become more dense down the group, but the trend is not perfect because potassium is less dense than sodium.

Element	Density (g/dm^3)
lithium	0.53
sodium	0.97
potassium	0.86
rubidium	1.53
caesium	1.87

Water has a density of 1 g/dm^3. Lithium, sodium and potassium are all less dense than water and so will float.

Trends in melting point

- The melting point of alkali metals decreases down the group.

Element	Melting point (°C)
lithium	181
sodium	98
potassium	64
rubidium	39
caesium	28

Melting points are lower than for typical (transition) metals, because alkali metals only have 1 electron in their outer shell. Not much energy is needed for this electron to be lost.

Alkali Metals

Reactions with air

- All alkali metals react with air to form **metal oxides**. This produces a layer of dull oxide on the surface of the metal, called **tarnish**.

The speed with which alkali metals react with air increases down the group:

- lithium – tarnishes slowly;
- sodium – tarnishes quickly;
- potassium – tarnishes very quickly.

Why are alkali metals stored in **oil**?

The oil prevents them from reacting with air and tarnishing.

Equations for reaction with air

- The reaction between an alkali metal and air is an example of an **oxidation** reaction:

lithium + oxygen → lithium oxide

$4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$

What are the word and chemical equations for the reaction of sodium and air?

sodium + oxygen → sodium oxide

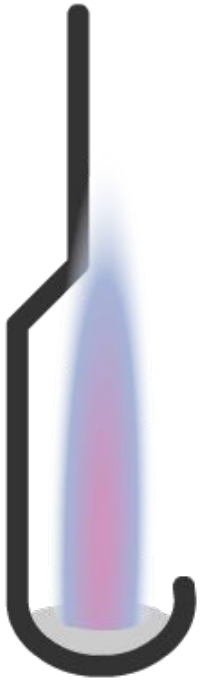
$4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$

Flame colour

- When alkali metals are heated and added to a jar of oxygen, they burn fiercely with a coloured flame.

- **lithium** burns with a **red** flame

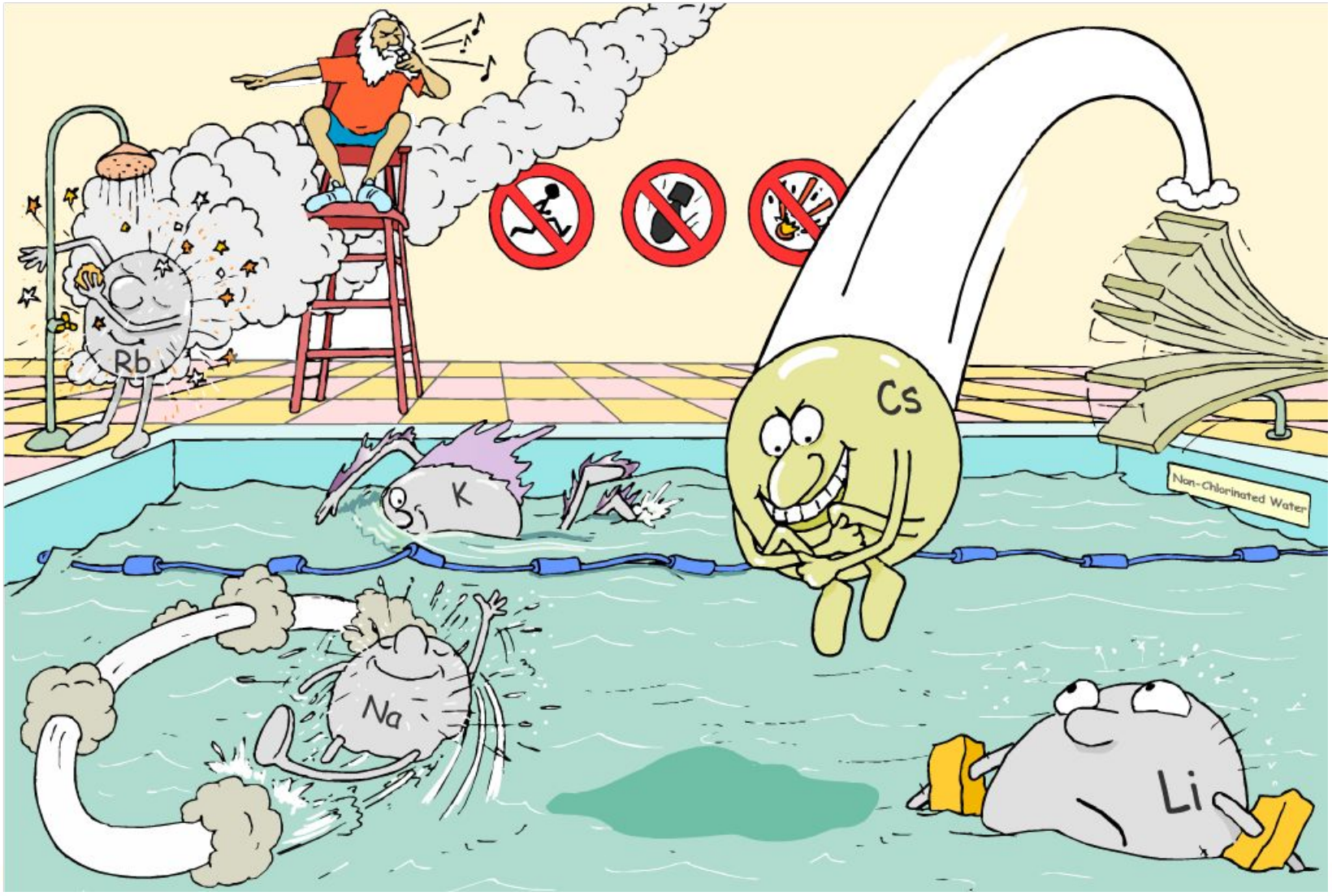
- **sodium** burns with an **orange** flame



- **potassium** burns with a **lilac** flame

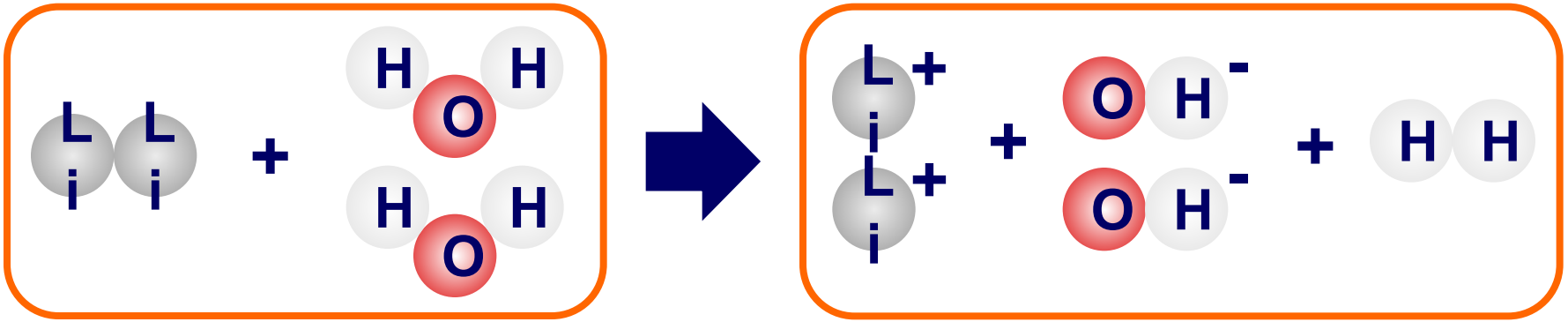
Alkali metals and water

- How do alkali metals react with water?



Reactions with water

- All alkali metals react readily with water. The reaction becomes more vigorous down the group, and creates a lot of heat.



This reaction creates **alkaline** **hydroxide** ions. This is why the group 1 elements are called the alkali metals.

The reaction also produces a gas that can be ignited by a lighted splint. What is this gas?

Reactivity of alkali metals with water

Reaction of lithium with water

- Lithium is the least reactive of the alkali metals. When added to water, it fizzes and moves around slowly across the surface of the water.

lithium + water □ lithium hydroxide + hydrogen

$2Li(s) + 2H_2O(l) \square 2LiOH(aq) + H_2(g)$

Reaction of sodium with water

- When added to water, sodium fizzes more than lithium, and moves quickly across the surface of the water. The sodium melts as it reacts, and it becomes spherical and shiny, like a ball bearing. The hydrogen sometimes catches fire because of the heat from the reaction.

What is the equation for this reaction?

sodium + water □ sodium hydroxide + hydrogen

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

Reaction of potassium with water

- When added to water, potassium burns with a lilac flame and the hydrogen catches fire immediately. The potassium moves across the surface of the water very quickly. Like sodium, it melts with the heat of the reaction.

What is the equation for this reaction?

potassium + water → potassium hydroxide + hydrogen

$$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$$

Reaction of alkali metals and chlorine

- Alkali metals burst into flame when heated and added to chlorine. They form **metal chlorides**:

lithium + **chlorine** □ **lithium chloride**

2Li(s) + **Cl_2**(g) □ **2LiCl**(s)

What are the word and chemical equations for the reaction of sodium and chlorine?

sodium + **chlorine** □ **sodium chloride**

2Na(s) + **Cl_2**(g) □ **2NaCl**(s)

True or false?

Alkali Metals

Uses of lithium

- Lithium and its compounds are used in:
  - **batteries** – elemental lithium is used in non-rechargeable batteries. Lithium compounds are used in **lithium-ion** batteries, which are rechargeable.
  - **alloys** – with other metals, such as aluminium, copper and manganese, for use in aircraft parts.
  - **medical treatment – lithium carbonate** is sometimes used to treat mental illnesses such as depression.
  - **submarines and space vehicles – lithium hydroxide** is used to absorb carbon dioxide from the air.

Uses of sodium

- Elemental sodium is used in:
  - **street lights** – sodium vapour gives them their yellow glow.
  - **nuclear reactors** – used as a coolant due to its good conductivity and low melting point.

- Sodium compounds are in many household products:
  - **sodium chloride** – table salt
  - **sodium hydrogencarbonate** – bicarbonate of soda
  - **sodium hydroxide** – oven cleaner

Uses of potassium

- Potassium compounds are used in:
  - **fertilizers** – potassium is an essential element for plants. It is usually added as a chloride, sulfate, nitrate or carbonate.
  - **fireworks and explosives** – as potassium nitrate and potassium chlorate.
  - **food preservation** – as potassium nitrate.

Alkali Metals

Glossary

- **alkali metal –** An element that belongs to group 1 of the periodic table.
- **hydroxide –** The alkali produced by the reaction between an alkali metal and water. It is a compound ion with a charge of -1.
- **metal chloride –** The solid produced when an alkali metal is burned in chlorine gas.
- **metal oxide –** The solid produced when an alkali metal reacts with air.
- **oxidation –** The process by which a substance reacts with oxygen to produce an oxide.
- **tarnish –** Discolouration of metal after exposure to air caused by the formation of an oxide on the surface.

Anagrams

Completing alkali metal equations

Comparing reactivity with water

Multiple-choice quiz