Cambridge IGCSE · Chemistry 0620 · Notes

The Periodic Table

Read online at pastopic.com/cambridge/chemistry-0620/notes/the-periodic-table

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Read first: **Elements, compounds and atomic structure**, **Ionic and metallic bonding**

What you need to know

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

1. **Describe how the Periodic Table is arranged**: in rows called **periods** and columns called **groups**, with the elements in order of increasing **proton number** (atomic number).
2. **Describe the change from metals to non-metals** across a period, from left to right.
3. **Link the group number to the charge on the ions** formed by elements in that group (Group I forms $1+$ ions, Group VII forms $1-$ ions, and so on).
4. **Explain why elements in the same group react in similar ways**: they have the same number of electrons in their outer shell.
5. **Explain how an element's position lets you predict its properties** (metal or non-metal, ion charge, reactivity, state).
6. **Extended only:** identify trends in a group when you are given information (a table of data) about its elements.
7. **Describe the Group I alkali metals** lithium, sodium and potassium as relatively soft metals whose **melting point decreases**, **density increases** and **reactivity increases** down the group.
8. **Predict the properties of other Group I elements** (such as rubidium and caesium) from information about the group.
9. **Describe the Group VII halogens** chlorine, bromine and iodine as **diatomic non-metals** whose **density increases** and **reactivity decreases** down the group.
10. **State what the halogens look like at room temperature and pressure**: chlorine is a pale yellow-green gas, bromine a red-brown liquid, iodine a grey-black solid.
11. **Describe and explain halogen displacement reactions**: a more reactive halogen takes the place of a less reactive one in a halide.
12. **Predict the properties of other Group VII elements** (such as fluorine and astatine) from information about the group.
13. **Describe the transition elements** as metals with **high densities** and **high melting points** that form **coloured compounds** and often act as **catalysts**, both as elements and in their compounds.
14. **Extended only:** describe transition elements as having ions with **variable oxidation numbers**, such as iron(II) and iron(III).

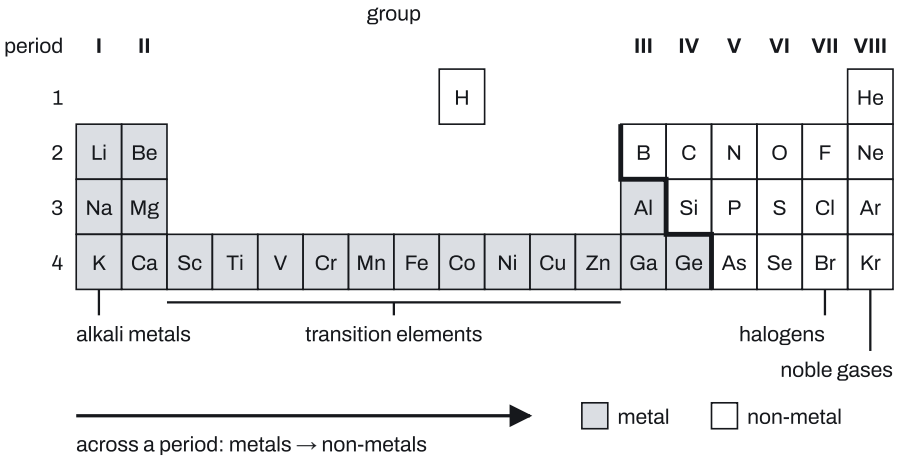
15. **Describe the Group VIII noble gases** as unreactive gases made of single atoms (monatomic), and explain this using their electronic configuration.

Understand it

How the table is arranged

The Periodic Table lists every element in order of **proton number**, the number of protons in one atom (not relative atomic mass). The order is split into rows so that elements that behave alike end up in the same column.

- A **period** is a row. The period number is the **number of occupied electron shells**: sodium, $2,8,1$, has three shells, so it is in Period 3.
- A **group** is a column. For Groups I to VII, the group number is the **number of electrons in the outer shell**: chlorine, $2,8,7$, is in Group VII. Group VIII atoms have a full outer shell (8, or 2 for helium).
- The block between Group II and Group III holds the **transition elements**.
- Hydrogen is not in any group; it sits on its own at the top.



Some groups have names: Group I is the **alkali metals**, Group VII the **halogens**, Group VIII the **noble gases**.

Why a group shares its chemistry

Chemical reactions involve the **outer-shell electrons**. Lithium $(2,1)$, sodium $(2,8,1)$ and potassium $(2,8,8,1)$ each have **one** outer electron, so they all react by losing it to form $1+$ ions, and they all react with water in the same way. Elements in the same **period** do **not** have similar properties: across Period 3, sodium is a reactive metal and chlorine a reactive non-metal.

Metals to non-metals across a period

Metals are on the left and in the middle; non-metals are on the right. Across a period the **metallic character decreases**. In Period 3, sodium, magnesium and aluminium are metals; silicon, phosphorus, sulfur, chlorine and argon are non-metals.

Metals react by **losing** electrons. Elements on the left have only one, two or three outer electrons and lose them readily, so they are the most metallic. Elements on the right have nearly full outer shells and tend to **gain** electrons instead.

Metals conduct electricity, are malleable and ductile, and have **basic** oxides. Non-metals are poor conductors (graphite is the exception), are brittle when solid, and usually have **acidic** oxides.

Group number and ion charge

An atom gains or loses electrons until it has a full outer shell. So the group number tells you the charge on the ion:

Group	I	II	III	IV	V	VI	VII	VIII
Outer electrons	1	2	3	4	5	6	7	8 (full)
Ion charge	$1+$	$2+$	$3+$	usually no ion	$3-$	$2-$	$1-$	no ion

Metals (Groups I to III) lose electrons and form **positive** ions. Non-metals in Groups V to VII gain electrons and form **negative** ions. For example Na^+ and F^- both have the electronic configuration $2,8$, the same as neon.

Using position to predict

If you know where an element is, you can predict a lot about it without having met it:

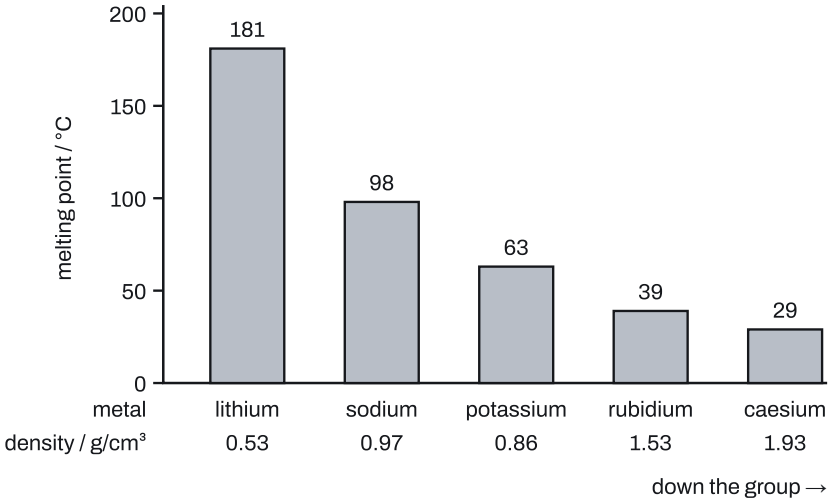
- **Left or right?** Left and middle: metal, forms positive ions, basic oxide. Right: non-metal, negative ions, acidic oxide.
- **Which group?** It behaves like the other members, and follows the group's trends.
- **How far down?** Apply the trend. An element below potassium in Group I is **more** reactive; an element below iodine in Group VII is **less** reactive and denser.

Group I: the alkali metals

Lithium, sodium and potassium are **relatively soft** metals: they can be cut with a knife, showing a shiny surface that quickly goes dull in air. They have **low densities** (lithium, sodium and potassium float on water) and **low melting points** for metals. Like other metals they conduct electricity and heat and are malleable. They are stored under oil to keep air and water away.

Down the group:

- **melting point decreases**;
- **density increases** (in general: potassium is slightly less dense than sodium);
- **reactivity increases**.



Reaction with cold water. Each metal gives a metal **hydroxide** (an alkali) and **hydrogen**:

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

What you see gets more violent down the group:

Metal	What you see
Lithium	floats, fizzes steadily, slowly gets smaller
Sodium	floats, melts into a ball, moves around on the surface, fizzes quickly, gets smaller and disappears; may burn with a yellow-orange flame
Potassium	as sodium but faster; bursts into a lilac flame; may pop or explode

The solution is **alkaline** (about pH 12 to 14), so universal indicator turns blue or purple. Rubidium and caesium react even more violently (explosively).

Reaction with oxygen. Group I metals burn to form oxides such as $\mathrm{Na_2O}$: $4\mathrm{Na} + \mathrm{O_2} \rightarrow 2\mathrm{Na_2O}$. These oxides dissolve in water to form alkalis.

Group II behaves in the same way, less vigorously. Calcium, $2{,}8{,}8{,}2$, **sinks** in cold water, fizzes steadily, gets smaller and gives a cloudy white solid (calcium hydroxide, which is only slightly soluble); the products are calcium hydroxide and hydrogen. Calcium burns in oxygen: $2\mathrm{Ca} + \mathrm{O_2} \rightarrow 2\mathrm{CaO}$. Reactivity increases down Group II too, so barium reacts faster than calcium.

Group VII: the halogens

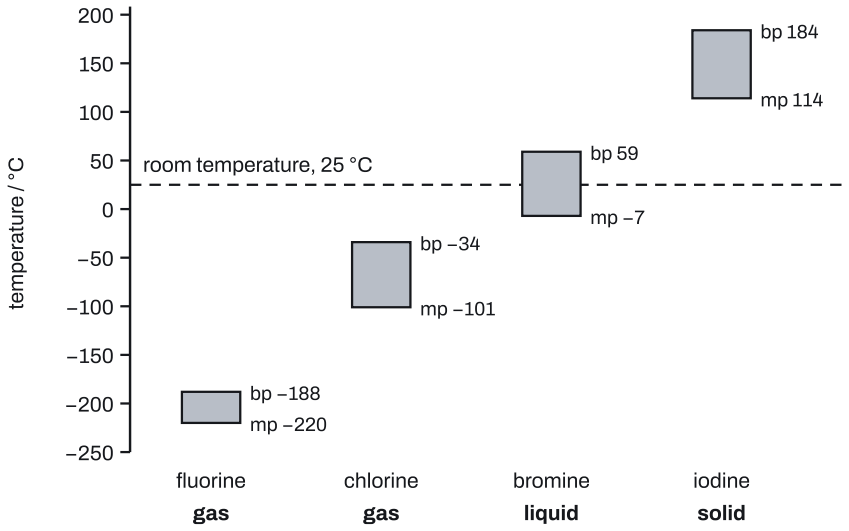
Chlorine, bromine and iodine are **non-metals** made of **diatomic** molecules: $\mathrm{Cl_2}$, $\mathrm{Br_2}$, $\mathrm{I_2}$. Down the group:

- **density increases**;

- **reactivity decreases** (fluorine, at the top, is the most reactive);
- the colour gets **darker** and the melting and boiling points **increase**, so the state changes from gas to liquid to solid.

Halogen	Appearance at r.t.p.
Chlorine, $\mathrm{Cl_2}$	pale yellow-green **gas**
Bromine, $\mathrm{Br_2}$	red-brown **liquid**
Iodine, $\mathrm{I_2}$	grey-black **solid**

Reading the state from melting and boiling points. Below its melting point a substance is a **solid**; between its melting and boiling points it is a **liquid**; above its boiling point it is a **gas**.



Halogen displacement reactions

A **more reactive** halogen **displaces** a less reactive halogen from a solution of its halide (a compound containing $\mathrm{Cl^-}$, $\mathrm{Br^-}$ or $\mathrm{I^-}$ ions). The order is chlorine > bromine > iodine.

$$\text{chlorine} + \text{potassium bromide} \rightarrow \text{potassium chloride} + \text{bromine}$$

$$\mathrm{Cl_2(aq) + 2KBr(aq) \rightarrow 2KCl(aq) + Br_2(aq)}$$

The colourless solution turns **orange** as bromine forms. When iodine forms instead (chlorine or bromine added to an iodide) the solution turns **brown**.

Added	to potassium chloride	to potassium bromide	to potassium iodide
Chlorine	—	reacts: orange (bromine)	reacts: brown (iodine)
Bromine	no reaction	—	reacts: brown (iodine)
Iodine	no reaction	no reaction	—

No reaction happens when the halogen added is **less reactive** than the one in the halide: iodine cannot displace bromine or chlorine.

Extended only: the potassium ions do not change, so the ionic equation leaves them out: $\mathrm{Cl_2} + 2\mathrm{Br^-} \rightarrow 2\mathrm{Cl^-} + \mathrm{Br_2}$. Each chlorine atom **gains** an electron (it is reduced; chlorine is the oxidising agent) and each bromide ion **loses** an electron (it is oxidised). A more reactive halogen gains electrons more readily.

Transition elements

The transition elements (the middle block, such as iron, copper, nickel, chromium and manganese) are all **metals**. Compared with Group I metals they:

- have **high densities** (iron 7.9 g/cm³, against sodium's 0.97);
- have **high melting points** (iron over 1500 °C, against sodium's 98 °C);
- form **coloured compounds** (copper(II) sulfate is blue, iron(III) oxide is red-brown); the **compounds** are coloured, not the metals;
- often act as **catalysts**, as elements (iron in making ammonia) and as compounds (manganese(IV) oxide decomposing hydrogen peroxide).

They are also harder and stronger than Group I metals and do not react with cold water. Like all metals they conduct electricity, are malleable and form basic oxides and soluble salts, so those properties do **not** tell them apart from Group I.

Extended only: transition elements form ions with **variable oxidation numbers**: the same element can form more than one ion. Iron forms iron(II), $\mathrm{Fe^{2+}}$, as in FeO and $\mathrm{FeCl_2}$, and iron(III), $\mathrm{Fe^{3+}}$, as in $\mathrm{Fe_2O_3}$ and $\mathrm{FeCl_3}$. Copper forms copper(I) in $\mathrm{Cu_2O}$ and copper(II) in CuO. The Roman numeral gives the oxidation number. A Group I metal always forms only a $1+$ ion.

Group VIII: the noble gases

Helium, neon, argon, krypton and xenon are **unreactive** gases that exist as **single atoms** (they are **monatomic**: He, Ne, Ar, not $\mathrm{He_2}$). The reason is their **full outer shell** of electrons: neon $2,8$, argon $2,8,8$. With a full outer shell there is nothing to gain by losing, gaining or sharing electrons, so the atoms do not bond to each other or to other atoms. Helium has only **2** outer electrons, but that is its first shell full, so "full outer shell" is the right description for every noble gas; "8 outer electrons" is not true for helium.

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
Elements are in order of increasing proton number; rows = periods, columns = groups	Learn it

Formula	Status
Period number = number of occupied shells; group number (I to VII) = number of outer electrons	Learn it
Same group → same number of outer electrons → similar chemical properties	Learn it
Across a period: metals → non-metals (metallic character decreases)	Learn it
Ion charges: I $1+$, II $2+$, III $3+$, V $3-$, VI $2-$, VII $1-$	Learn it
Down Group I: melting point decreases, density increases, reactivity increases	Learn it
Group I metal + water → metal hydroxide + hydrogen, e.g. $2\mathrm{Na} + 2\mathrm{H_2O} \rightarrow 2\mathrm{NaOH} + \mathrm{H_2}$	Learn it
Group I metal + oxygen → oxide, e.g. $4\mathrm{K} + \mathrm{O_2} \rightarrow 2\mathrm{K_2O}$	Learn it
Down Group VII: density increases, reactivity decreases	Learn it
Chlorine pale yellow-green gas; bromine red-brown liquid; iodine grey-black solid	Learn it
Halogen + halide: $\mathrm{Cl_2} + 2\mathrm{KBr} \rightarrow 2\mathrm{KCl} + \mathrm{Br_2}$; only a more reactive halogen displaces	Learn it
Extended only: $\mathrm{Cl_2} + 2\mathrm{Br^-} \rightarrow 2\mathrm{Cl^-} + \mathrm{Br_2}$	Learn it
Transition elements: high density, high melting point, coloured compounds, catalysts	Learn it
Extended only: transition elements: variable oxidation numbers, e.g. $\mathrm{Fe^{2+}}$ and $\mathrm{Fe^{3+}}$	Learn it
Noble gases: unreactive, monatomic, full outer shell	Learn it
Below melting point: solid; between melting and boiling point: liquid; above boiling point: gas	Learn it

How to do it

In the questions we have tagged for this topic (366 questions, 2021–2025), the types came up this often. 48 of the 366 questions mix types, so the counts add up to 445.

Question type	Questions
Recall or identify transition element properties	64
Describe trends across a period and how the table is arranged	51
Relate group and period to electrons, shells and ion charge	44
Explain noble gas unreactivity and describe noble gases	44
Recall Group I trends and physical properties	43
Predict a missing value or physical state from a group data table	42
Give halogen colours, states and trends	39
Predict and write halogen displacement reactions	37
Describe Group I (and II) metal reactions with water or oxygen	24
Pick an element from a Periodic Table extract or list	24

Question type	Questions
Compare transition elements with Group I metals	23
Predict an unfamiliar element's properties from its position	10

1. Recall or identify transition element properties (64 questions)

1. **Learn the four Core properties**: high density, high melting point, coloured compounds, catalysts (elements and compounds). **Extended:** variable oxidation numbers.
2. **In a multiple-choice row**, look for "high, high, coloured, yes". Reject any row with low density, low melting point, only white compounds, or poor conductivity.
3. **Picking the transition element from a data table**: choose the one with a melting point of about 1000 °C or more, a density of about 7 g/cm³ or more, and a **coloured** oxide or chloride (green, pink, brown, blue).

For example, a table gives element P: melting point 1320 °C, density 8.1 g/cm³, green chloride. All three fit, so P is a transition element.

Variations you will meet:

- **Paper 3, "give two properties of transition elements that are shown in the table"**: quote the evidence, such as "high density" and "coloured compounds". Say the **compounds** are coloured.
- **Extended: which pair of compounds shows variable oxidation states?** Work out the metal's oxidation number in each: $\mathrm{FeCl_2}$ $(+2)$ and $\mathrm{Fe_2O_3}$ $(+3)$ differ, so that pair does; $\mathrm{Cr_2O_3}$ and $\mathrm{CrBr_3}$ are both $+3$, so they do not.
- **Extended: which property does this equation show?** An ion changing charge ($\mathrm{V^{2+}}$ to $\mathrm{V^{3+}}$, $\mathrm{Cr^{6+}}$ to $\mathrm{Cr^{3+}}$ in dichromate) shows **variable oxidation number**. A metal oxide speeding up a reaction without being used up shows **catalysis**.
- **Which compound is likely to be coloured?** The one containing a transition element, such as $\mathrm{KMnO_4}$ (purple).
- **Which metal colours glass?** A transition element, such as chromium.

2. Describe trends across a period and how the table is arranged (51 questions)

1. **Arrangement**: increasing **proton number** (not nucleon number or relative atomic mass); rows are periods, columns are groups.
2. **Across a period**: outer-shell electrons increase by one each group; the elements change from **metal to non-metal**; metallic character **decreases**.
3. **"Describe how metallic character changes across a period"**: "it decreases (from left to right)".

Variations you will meet:

- **Pick the metal, the most metallic element, or the element that conducts** from an outline of the table: go furthest **left** (and down).
- **Pick the most reactive non-metal**: top right, but not Group VIII (fluorine's position).

- **Which set shows metal → non-metal?** A set going left to right across one period, such as sodium → silicon → chlorine.
- **"Which statement is not correct?"** Watch for "elements in the same **period** have similar properties" (false) and "arranged by relative atomic mass" (false).
- **Extended: why metallic character rises from right to left**: elements on the left lose their outer electrons more readily.
- **The element on the left of a period forms a basic oxide**; the one on the right an acidic oxide.

3. Relate group and period to electrons, shells and ion charge (44 questions)

1. **Write the electronic configuration** from the proton number (shells hold 2, 8, 8, then 2 for the first 20 elements).
2. **Group** = number of outer electrons; **period** = number of shells.
3. **Ion charge** from the group: I to III lose electrons ($1+$, $2+$, $3+$); V to VII gain ($3-$, $2-$, $1-$).
4. **"Explain why silicon is in Group IV" (in terms of electronic configuration)**: "it has 4 electrons in its outer shell". One sentence earns the mark.

Variations you will meet:

- **From an ion to a group**: X^{2+} comes from Group II; Y^{-} from Group VII; Z^{2-} from Group VI.
- **"Why do elements L and M have similar chemical properties?"**: same number of electrons in the **outer shell** (not the same number of shells, protons or neutrons).
- **Three configurations from the same group**: the last number is the same, e.g. $2{,}1$, $2{,}8{,}1$, $2{,}8{,}8{,}1$.
- **The connection between the number of shells and the period**: they are equal.
- **Extended: the noble gas with the same configuration as an ion**: Br^{-} has gained one electron, so it matches krypton; Na^{+} matches neon.

4. Explain noble gas unreactivity and describe noble gases (44 questions)

1. **"Explain why argon is unreactive"**: "it has a **full outer shell** (of electrons)". For any noble gas other than helium, "8 outer electrons" is also accepted.
2. **"What is meant by monatomic?"**: "it exists as **single atoms**".
3. **Describe them**: Group VIII, unreactive, monatomic, gases.

Variations you will meet:

- **Multiple choice**: "they all have eight outer electrons" is **false** because of helium; "they are diatomic" is false; "they react with Group I" is false.
- **Pick the noble gas configuration** from electron diagrams or proton/electron numbers: a full outer shell (2; $2{,}8$; $2{,}8{,}8$), with electrons equal to protons for an atom.
- **Pick monatomic unreactive gases** from particle diagrams: separate single circles, not pairs.
- **From boiling points**: a noble gas is a liquid at a temperature between its melting and boiling points (see type 6).

5. Recall Group I trends and physical properties (43 questions)

1. **Down the group**: melting point **decreases**, density **increases**, reactivity **increases**.
2. **Physical properties**: soft, low density, low melting point, good conductors of heat and electricity, malleable, shiny when cut.
3. **Name**: Group I = **alkali metals**.

Variations you will meet:

- **Identify a Group I element from data**: low melting point, low density, reacts with cold water, white compounds.
- **Use two clues to pin one down**: "higher melting point than caesium and lower density than sodium" means lithium (or potassium: check the numbers given).
- **Which Group I metal is least reactive / has the highest melting point?** Lithium, at the top. Most reactive: at the bottom (caesium, or potassium among Li, Na, K).
- **Order by reactivity**: top is least, so caesium > rubidium > potassium > sodium > lithium.
- **Mixed Group I and Group VII trends**: reactivity **increases** down Group I but **decreases** down Group VII, while density increases down both.

6. Predict a missing value or physical state from a group data table (42 questions)

1. **Find the trend** in the column: going up or down the group?
2. **Missing value in the middle**: give a value **between** its neighbours. For the element at the end: continue the trend beyond the last value.
3. **Physical state at a temperature**: compare the temperature with the melting and boiling points:
   - below the melting point → **solid**;
   - between them → **liquid**;
   - above the boiling point → **gas**.
4. **Always give the reason** with the numbers: "liquid, because 900 °C is between the melting point and the boiling point".

For example, antimony melts at 631 °C and boils at 1587 °C. At 900 °C it is a liquid, because 900 is between 631 and 1587.

Variations you will meet:

- **"Describe the trend in melting point"**: say whether it increases or decreases, and which way you are going: "decreases down the group".
- **A reaction column** ("reacts slowly", "reacts quickly", ...): predict the next one as **more** (Group I) or **less** (Group VII) vigorous, with detail such as "explodes".
- **Other columns** (atomic radius, hardness, boiling point, colour): the question's own data gives the trend; just continue it.
- **Noble gas or Group II tables**: same method; Group II follows the same trends as Group I.

7. Give halogen colours, states and trends (39 questions)

1. **Learn the three**: chlorine **pale yellow-green gas**, bromine **red-brown liquid**, iodine **grey-black solid**. Each colour and each state usually scores a mark.
2. **Trends down Group VII**: density increases, reactivity decreases, colour darkens, melting and boiling points increase.
3. **Name**: Group VII = **halogens**; they are **diatomic** non-metals.

Variations you will meet:

- **Most reactive halogen**: fluorine (top). **Densest**: the one lowest down.
- **Identify a halogen from its melting and boiling points**: a liquid at room temperature is bromine (melts below 25 °C, boils above it).
- **Which halogens are gases at r.t.p.?** Fluorine and chlorine.
- **The halide ions** are chloride, bromide, iodide ($\mathrm{Cl^-}$, $\mathrm{Br^-}$, $\mathrm{I^-}$).

8. Predict and write halogen displacement reactions (37 questions)

1. **Compare reactivity**: is the halogen added **above** the halogen in the halide (chlorine > bromine > iodine)?
2. **Yes**: it displaces it. Write the word equation by swapping the halogens: chlorine + sodium iodide → sodium chloride + iodine.
3. **Observation**: colourless to orange (bromine forms) or to brown (iodine forms).
4. **No**: "no reaction, because iodine is **less reactive than bromine**". Compare the two **halogens**.

Variations you will meet:

- **Balance the symbol equation**: $\mathrm{Cl_2 + 2NaI \rightarrow 2NaCl + I_2}$. The halogen is diatomic, so the halide needs a 2.
- **Which mixtures react?** Tick each pair where the halogen is higher in the group than the halide's halogen.
- **Extended: ionic equation**: $\mathrm{Br_2 + 2I^- \rightarrow 2Br^- + I_2}$ (state symbols (aq) if asked). **Which species is oxidised?** The halide ion (it loses electrons). **Oxidising agent?** The halogen.
- **Extended: unfamiliar halogens**: astatine is below iodine, so it displaces none of the others; fluorine displaces all of them.
- **Multiple-choice trap**: "chlorine displaces **bromide**" is wrong wording; chlorine displaces **bromine** (from bromide ions).

9. Describe Group I (and II) metal reactions with water or oxygen (24 questions)

1. **Observations** (give what you **see**, 2 or 3 of these): floats, moves around, melts into a ball, fizzes (bubbles), gets smaller and disappears, flame (lilac for potassium, yellow-orange for sodium), heat given out.
2. **Products**: metal hydroxide + hydrogen.
3. **Equation**: $\mathrm{2K + 2H_2O \rightarrow 2KOH + H_2}$ (add state symbols on Paper 4 if asked).

4. **pH of the solution**: above 7 (alkaline), such as pH 12 or 13.

Variations you will meet:

- **Calcium (Group II)**: it **sinks**, fizzes, gets smaller, forms a white solid; products calcium hydroxide and hydrogen.
- **Reaction with oxygen**: $4\mathrm{Na} + \mathrm{O_2} \rightarrow 2\mathrm{Na_2O}$; $2\mathrm{Ca} + \mathrm{O_2} \rightarrow 2\mathrm{CaO}$.
- **Why stored under oil?** To stop it reacting with air (oxygen) and water.
- **Melting of the metal** (sodium turning into a ball) is a physical change inside a chemical reaction.

10. Pick an element from a Periodic Table extract or list (24 questions)

1. **Read each clue as a position**: "forms a $2-$ ion" → Group VI; "has a full outer shell" → Group VIII; "is in Period 3 and forms a $1-$ ion" → chlorine; "has three electron shells and two outer electrons" → magnesium; "is a transition element" → middle block.
2. **Write only the symbol** (one mark each). Each symbol may be used more than once.

Variations you will meet:

- **Clues from other topics**: a red flame test (lithium), extracted from bauxite (aluminium), present in diamond (carbon), electrical wiring (copper). Check the other topic notes for these.
- **Extended**: an element with an amphoteric oxide; an element with oxidation number 0 (any uncombined element).

11. Compare transition elements with Group I metals (23 questions)

1. **Physical differences** (use comparative words): transition elements have a **higher density**, a **higher melting point** (and boiling point), and are **harder / stronger**.
2. **If one difference is given in the question, don't repeat it.**
3. **Extended: chemical differences**: transition elements form **coloured compounds**, have **variable oxidation numbers**, act as **catalysts**, and do not react with cold water; Group I metals form white compounds with a single $1+$ ion.

Variations you will meet:

- **"Pick two properties that show how copper is similar to Group I metals"**: good electrical conductor, forms soluble salts, forms basic oxides. **Different**: variable oxidation states, coloured compounds, catalyst.
- **Multiple choice**: "shown by transition metals but not Group I": coloured compounds. Conductivity and malleability are shared by all metals.

12. Predict an unfamiliar element's properties from its position (10 questions)

1. **Place it**: which group, and above or below the elements you know?

2. **Apply each trend in turn**: state, colour, density, reactivity, melting point.

For example, astatine is below iodine: a **dark (black) solid**, **denser** than iodine, **less reactive**, and it **cannot displace** iodine from iodides. Barium is below calcium in Group II: it reacts **faster** with water and is **denser**.

Variations you will meet:

- **A made-up element** "Ox" that is a diatomic, non-conducting element forming a $1-$ ion: Group VII.
- **Selenium below sulfur** (Group VI): similar chemical properties because of the same number of outer electrons.

Worked examples

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

- **B1** mark for a correct result on its own, with no method needed.

Example 1

Some information about Group I elements is shown.

Element	Melting point / °C	Density / g/cm^3	Reaction with cold water
lithium	181	0.53	fizzes steadily
sodium	98	0.97	fizzes quickly, melts into a ball
potassium		0.86	
rubidium	39	1.53	

(a) Predict the melting point of potassium. **[1]**

(b) Rubidium boils at 688 °C. Deduce the physical state of rubidium at 50 °C. Give a reason. **[2]**

(c) Describe what you would see when a small piece of sodium is added to a large trough of cold water. Give **three** observations. **[3]**

(d) Write the symbol equation for the reaction of sodium with water. **[2]**

(e) Explain why sodium and potassium have similar chemical properties. **[1]**

(a) Any value between 39 and 98 °C, for example 63 °C. **B1** (It must fit the trend: melting point decreases down the group.)

(b) Liquid **B1**, because 50 °C is between its melting point (39 °C) and its boiling point (688 °C). **B1**

(c) Any three: floats; melts into a ball; moves around on the surface; fizzes; gets smaller and disappears. **B1 B1 B1**

(d) $2\mathrm{Na} + 2\mathrm{H_2O} \rightarrow 2\mathrm{NaOH} + \mathrm{H_2}$. **B1** for the correct formulas, **B1** for balancing.

(e) Both have one electron in their outer shell. **B1**

Example 2

Some properties of the halogens are shown.

Halogen	Melting point / °C	Boiling point / °C	Colour at r.t.p.
fluorine	−220	−188	pale yellow
chlorine	−101	−34	
bromine	−7		red-brown
iodine	114	184	grey-black

(a) Complete the table for the colour of chlorine. **[1]**

(b) Predict the boiling point of bromine. **[1]**

(c) Deduce the physical state of iodine at 150 °C. Give a reason. **[2]**

(d) Aqueous chlorine is added to colourless aqueous potassium bromide.

(i) State the colour of the solution at the end. **[1]**

(ii) Write a word equation for the reaction. **[1]**

(e) Explain why there is no reaction when aqueous iodine is added to aqueous potassium bromide. **[1]**

(f) **Extended.** Write the ionic equation for the reaction in (d), and name the species that is oxidised. **[3]**

(a) Pale yellow-green. **B1**

(b) Any value between -34 and 184 °C, for example 59 °C. **B1**

(c) Liquid **B1**; 150 °C is above the melting point (114 °C) and below the boiling point (184 °C). **B1**

(d)(i) Orange (or yellow-orange). **B1**

(d)(ii) chlorine + potassium bromide → potassium chloride + bromine. **B1**

(e) Iodine is less reactive than bromine, so it cannot displace it. **B1**

(f) $\mathrm{Cl_2} + 2\mathrm{Br^-} \rightarrow 2\mathrm{Cl^-} + \mathrm{Br_2}$ **B1** for the species, **B1** for balancing. Bromide ions are oxidised (each loses an electron). **B1**

Example 3

Element Q is a metal. It melts at 1538 °C, has a density of 7.87 g/cm³ and forms green and red-brown compounds. Sodium melts at 98 °C and has a density of 0.97 g/cm³.

(a) State which part of the Periodic Table Q is in. Give **two** reasons from the information. **[3]**

(b) Give **two** ways, other than density, in which the physical properties of Q differ from those of sodium. **[2]**

(c) State **one** chemical property of transition elements not mentioned in the information. **[1]**

(d) **Extended.** Q forms two chlorides, $\mathrm{QCl_2}$ and $\mathrm{QCl_3}$. Give the oxidation number of Q in each, and name the property of transition elements this shows. **[3]**

(a) The transition elements **B1**. Any two of: high melting point; high density; forms coloured compounds. **B1** **B1**

(b) Q has a **higher** melting point **B1**; Q is **harder** (or stronger), or has a higher boiling point. **B1** ("Sodium has a low density" repeats the given property and does not score.)

(c) It (or its compounds) can act as a catalyst. **B1**

(d) $\mathrm{QCl_2}$: $+2$ **B1**; $\mathrm{QCl_3}$: $+3$ (each chloride ion is -1) **B1**. Variable oxidation numbers. **B1**

Example 4

An atom of element X has the electronic configuration $2,8,8,2$.

(a) State the group and the period of X. **[2]**

(b) State whether X is a metal or a non-metal, and give the charge on its ion. **[2]**

(c) Give the formula of the chloride of X. **[1]**

(d) Strontium is below X in the same group. Predict how the reaction of strontium with cold water compares with that of X. **[1]**

(e) **Extended.** Astatine is below iodine in Group VII. Predict its state at room temperature, and whether it reacts with aqueous potassium iodide. Explain your answer. **[3]**

(a) Group II **B1** (two outer electrons); Period 4 **B1** (four shells).

(b) Metal **B1**; $2+$ **B1** (it loses its two outer electrons).

(c) $\mathrm{XCl_2}$ (X is calcium, so $\mathrm{CaCl_2}$). **B1**

(d) Strontium reacts faster (more vigorously), because reactivity increases down Group II. **B1**

(e) Solid **B1** (melting point increases down the group, and iodine is already a solid). No reaction **B1**, because astatine is less reactive than iodine, so it cannot displace it. **B1**

Common mistakes

- **Comparing a halogen with a halide.** "Chlorine is more reactive than bromide" does not score. Compare the halogens: "chlorine is more reactive than **bromine**". Examiners report this every year.
- **Getting the halogen colours wrong.** Chlorine is not "yellow" or "colourless"; bromine is red-brown, not orange (orange is its solution); iodine is grey-black, not purple.
- **Saying the transition elements themselves are coloured.** It is their **compounds** that are coloured.
- **Loose comparisons of metals.** "Sodium has a high melting point" or "sodium is denser" are backwards. "Transition elements are not malleable" is wrong; they are **less** malleable. Rusting and magnetism apply only to iron (and a few others), so they are not general transition element properties.
- **Only one difference when two are asked.** Plan two separate properties before writing.
- **Explaining noble gases vaguely.** "Because it's a noble gas" or "it has no free electrons" earns nothing; write "a full outer shell". Don't say helium has 8 outer electrons.
- **Forgetting potassium in the density trend.** Density increases down Group I in general, but a multiple-choice option giving the trend as "decreases" is still wrong.
- **Describing products instead of observations.** "Hydrogen is produced" is not something you see; "fizzing" is.
- **Group I and Group VII forming a covalent bond.** A Group I metal and a halogen form an **ionic** compound: the metal atom loses one electron and the halogen atom gains it.
- **Writing "it" in comparisons.** Name the element: "copper has a higher melting point than sodium".
- **Stating the state without a reason, or with the wrong comparison.** Say which of the melting and boiling points the temperature is above or below.

How to get the marks

- **"Explain why … is in Group V" (in terms of electronic configuration)**: "it has 5 electrons in its outer shell". Mention electrons and the outer shell.
- **Colour and state questions** are two marks: give both, using the exact colours above.
- **"Deduce the physical state … Give a reason"**: one mark for the state, one for the comparison with the melting or boiling point.
- **Predicting a value**: stay between the neighbouring values (or beyond the last one), and in the right direction.
- **Observations**: give as many different ones as there are marks; each must be something you could see, hear or feel.
- **Displacement**: "the halogen added is **more** (or less) reactive than the halogen in the salt". For a colour change, give the final colour (and the starting colour if asked "from … to …").
- **Comparisons** need comparative words: higher, lower, harder, denser.
- **"Describe the trend"**: say what happens and which direction, e.g. "melting point decreases down the group".
- **"Predict"** or **"suggest"**: use the trend in the question's data; any answer that fits the trend scores.

- **Multiple choice with statements**: test every part; one false half makes the option wrong.

Quick check

1. An element has the electronic configuration $2,8,5$. State its group, its period and the charge on its ion.
2. Which of these mixtures react? For each that does, state the final colour of the solution. (a) aqueous bromine + potassium iodide, (b) aqueous iodine + sodium chloride, (c) aqueous chlorine + sodium iodide.
3. Of lithium, sodium and potassium, which has the highest melting point, and which reacts most vigorously with water?
4. Explain why argon is unreactive. Helium has only two electrons in its outer shell; why is it also unreactive?
5. **Extended.** Give the oxidation number of iron in $\mathrm{FeSO_4}$ and in $\mathrm{Fe_2(SO_4)_3}$. Which property of transition elements does this show?

Answers

1. Group V (5 outer electrons), Period 3 (3 shells). It gains 3 electrons, so its ion has a $3-$ charge.
2. (a) Reacts: bromine is more reactive than iodine; the solution turns brown (iodine). (b) No reaction: iodine is less reactive than chlorine. (c) Reacts: brown (iodine).
3. Lithium has the highest melting point; potassium reacts most vigorously.
4. Argon has a full outer shell (8 electrons), so it does not gain, lose or share electrons. Helium's only shell holds 2 electrons, so its outer shell is also full.
5. $+2$ in $\mathrm{FeSO_4}$ (sulfate is $2-$); $+3$ in $\mathrm{Fe_2(SO_4)_3}$ (three sulfates, $6-$, shared by two iron ions). Variable oxidation numbers.

Past questions to try

- **0620/32/O/N/25 Q5**: Core, group from configuration, state from data, bromine, sodium with water.
- **0620/42/M/J/25 Q5**: the alkali metals and their trends.
- **0620/42/F/M/25 Q3**: the halogens, including displacement.
- **0620/43/O/N/25 Q5**: copper compared with Group I metals.