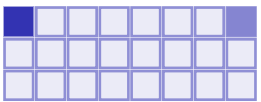
Chemical Periodicity

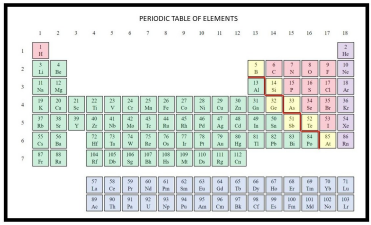
A-Level Chemistry ▪ Topic 9

A-Level Chemistry



What we will cover

1. Atomic radius
2. Melting point & structure
3. Oxidation numbers
4. Oxides: acid–base
5. Amphoteric Al_2O_3
6. Chlorides with water



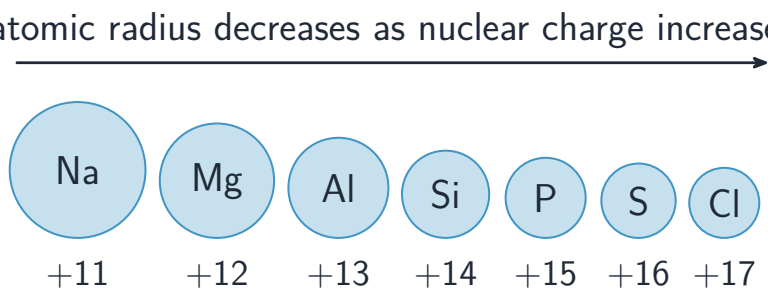
properties repeat in periods

1 Physical properties

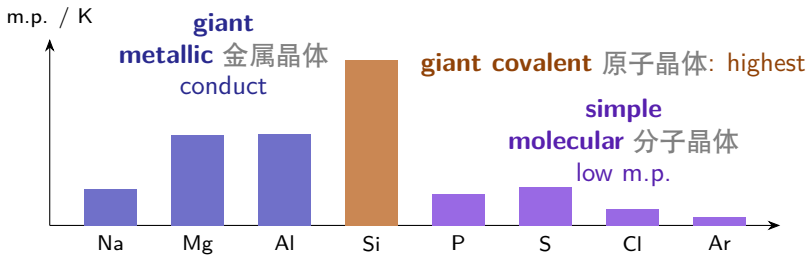
Atomic radius across Period 3

Periodicity 周期性: properties repeat across each **period** 周期.

> **Atomic radius** 原子半径 decreases across Period 3 – the rising **nuclear charge** 核电荷 pulls the same outer shell inwards.



Melting point and structure



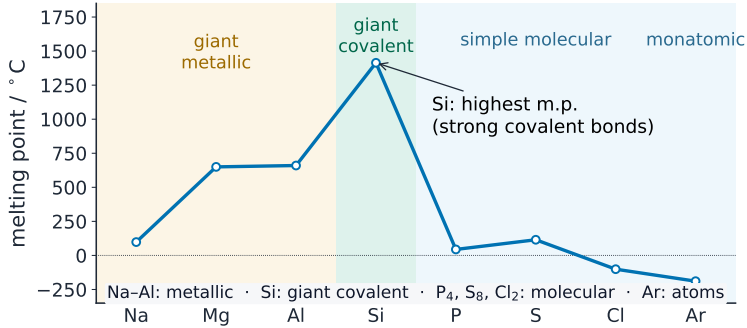
Melting point **peaks at silicon**: breaking a giant covalent lattice needs the most energy.

The Period 3 physical trends

atomic radius	decreases across the period – more nuclear charge, same **valence shell** 价层
ionic radius 离子半径	positive ions are small; from P^{3-} onwards the negative ions are larger
electrical conductivity 导电性	high for Na, Mg, Al – delocalised electrons – and almost zero from Si onwards
melting point	rises Na to Al, peaks at the **giant molecular** 巨型分子 Si, then collapses for the simple molecules
the collapse	name **van der Waals' forces** 范德华力 when you explain it – that is the marking point
the classic error	"the covalent bonds are weak". They are not: it is the *forces between molecules* that break

Na reacts fast with cold water, Mg only very slowly: reactivity with water falls across the period.

Melting point and structure, in detail



Melting point peaks at silicon:

Na, Mg, Al – **giant metallic** 金属晶体, and they conduct.

Si – **giant covalent** 原子晶体, the highest melting point of the period.

2 Chemical properties

Oxidation numbers

Na_2O	MgO	Al_2O_3	P_4O_{10}	SO_3
$+1$	$+2$	$+3$	$+5$	$+6$

The **oxidation number** 氧化数 rises across the period – it equals the **valence** 价层 electrons used in bonding. The chlorides show the same $+1$ to $+5$ rise.

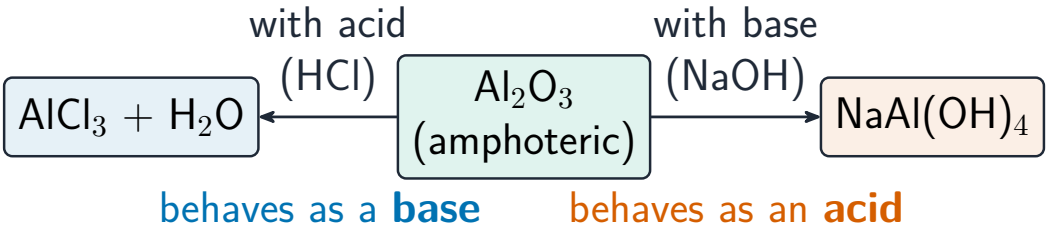
Oxides: acid–base behaviour

Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_3
basic		**amphoteric**	**acidic**		
Na_2O: alkaline solution MgO: sparingly soluble		insoluble in water; reacts with acids and strong bases	insoluble; reacts with hot alkali	react with water to form acids	

An insoluble oxide has no meaningful “solution pH” of its own.

Amphoteric aluminium oxide

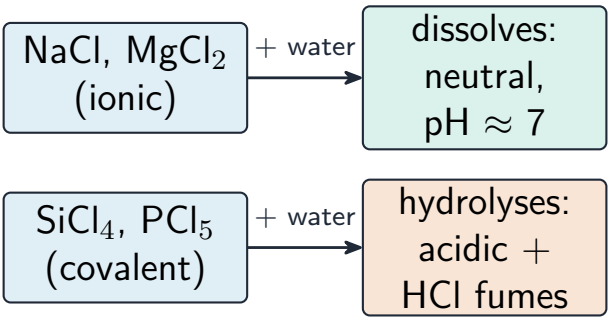
Al_2O_3 and its **hydroxide** 氢氧化物 $Al(OH)_3$ react with both acids and bases. **Aluminium oxide** 氧化铝 is **amphoteric** 两性 – it reacts with both acids and bases. With acid it behaves as a base; with base it behaves as an acid.



Chlorides with water

The chlorides undergo **hydrolysis** 水解 – they react with water – giving acidic solutions and fumes of HCl.

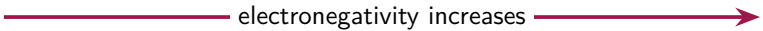
- ionic chlorides (NaCl, $MgCl_2$) just dissolve – near-neutral
- covalent chlorides ($SiCl_4$, PCl_5) **hydrolyse** 水解 – acidic + HCl fumes



Explaining the trends

The trends follow from the change in bonding as **electronegativity 电负性** rises across Period 3.

	Na, Mg	**Al**	**Si**	**P, S**
oxide bonding	ionic	ionic, covalent character	giant covalent	simple molecular
oxide in water	basic	**amphoteric**	weakly acidic, insoluble	acidic
chloride	ionic, neutral	covalent, hydrolyses	covalent, hydrolyses	covalent, hydrolyses



Low electronegativity on the left gives **ionic, basic** oxides; high on the right gives **covalent, acidic** ones.

Periodicity of other elements

If you know the pattern down a group and across a period, you can:

predict: from position to properties

a Group 1 element ⇒ a reactive metal forming a $+1$ ion

deduce: from properties to position

physical and chemical data ⇒ likely group and identity

Exam tips

- Always pair the **trend with its reason**: atomic radius falls across Period 3 (rising nuclear charge, similar shielding).
- Explain the **melting-point pattern** by structure: giant metallic (Na→Al), giant covalent (Si, highest), then simple molecular (P_4, S_8, Cl_2) and monatomic (Ar).
- Oxides go **basic → amphoteric (Al_2O_3) → acidic** across the period; link to ionic-to-covalent bonding.
- For reactions of oxides/chlorides with water, give the **products and the resulting pH**.

3 Recap

Worked example – melting points across Period 3

Explain why the melting point rises Na → Al, peaks at Si, then falls sharply at P.

- Na, Mg, Al: giant metallic. Charge goes $+1 \rightarrow +3$ and more electrons delocalise, so attraction grows.
- Si: giant covalent. Many strong covalent bonds must break ⇒ the peak.
- P: simple molecular (P_4). Only weak **induced-dipole forces** 诱导偶极力 break.
- So the drop is giant → simple, not a change in bond strength.

Melting point follows the structure, not the atom. Giant (metallic or covalent) ⇒ high; simple molecular ⇒ low.

Topic 9 – key takeaways

1 Radius

decreases across the period

2 Melting point

peaks at silicon (giant covalent)

3 Oxides

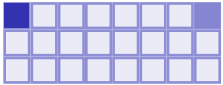
basic $\rightarrow$ amphoteric $\rightarrow$ acidic

4 Chlorides

ionic dissolve; covalent hydrolyse

Check yourself

1. Which Period 3 element has the highest melting point?
2. Which oxide is amphoteric?
3. Is Na_2O acidic or basic?
4. What do covalent chlorides do in water?



Answers **1.** silicon **2.** Al_2O_3 **3.** basic **4.** hydrolyse to an acidic solution