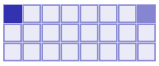
Chemical Periodicity

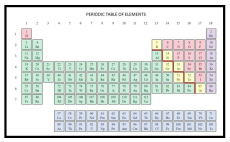
A-Level Chemistry ▪ Topic 9

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.

atomic radius decreases as nuclear charge increases →

Melting point and structure

Melting point peaks at silicon:

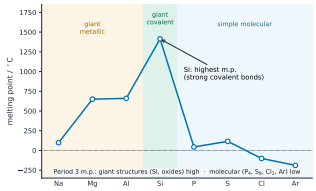
- Na, Mg, Al – **giant metallic** 金属晶体, conduct
- Si – **giant covalent** 原子晶体, highest m.p.
- P, S, Cl, Ar – **simple molecular** 分子晶体, low m.p.

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

Sodium reacts fast with cold water; magnesium only very slowly. Reactivity with water falls sharply across the period as the metals give way to non-metals.

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.

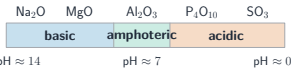
2 Chemical properties

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



pH ≈ 14 pH ≈ 7 pH ≈ 0

metal oxides (left) are basic; non-metal oxides (right) are acidic

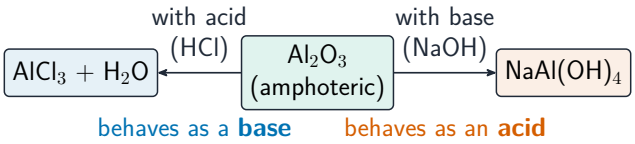
The oxides change across the period:

- metal oxides (Na, Mg) – basic
- Al_2O_3 – **amphoteric** 两性
- non-metal oxides (P, S) – acidic

Amphoteric aluminium oxide

Al_2O_3 and its **hydroxide** 氢氧化物 $Al(OH)_3$ react with acids and bases.

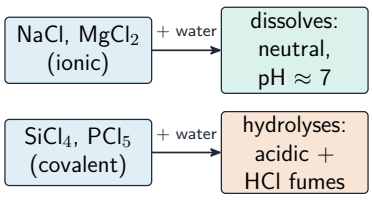
Aluminium oxide 氧化铝 is **amphoteric** 两性 – it reacts with both acids and bases. With acid it behaves as a base; with base it behaves as an acid.



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

These trends follow from the change in bonding and **electronegativity 电负性**.

> On the left, the elements are metals with low electronegativity, so their oxides and chlorides are ionic and basic (or neutral).

Periodicity of other elements

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

- **predict** the properties of an element from its position (for example, a Group 1 element will be a reactive metal forming a $+1$ ion).
- **deduce** the likely position and identity of an unknown element from its physical and chemical properties.

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 $+1 \to +3$ 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.

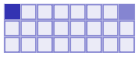
> Melting point follows the structure, not the atom. Giant (metallic or covalent) ⇒ high; simple molecular ⇒ low.

Topic 9 – key takeaways

1. **Radius** — decreases across the period
2. **Melting point** — peaks at silicon (giant covalent)
3. **Oxides** — basic → amphoteric → 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