

Chemical Periodicity

A-Level Chemistry ■ Topic 9

A-Level Chemistry

- 5 Amphoteric Al_2O_3
- 6 Chlorides with water

properties repeat in periods

1

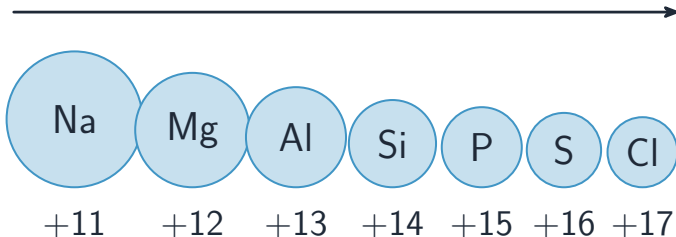
Physical properties

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

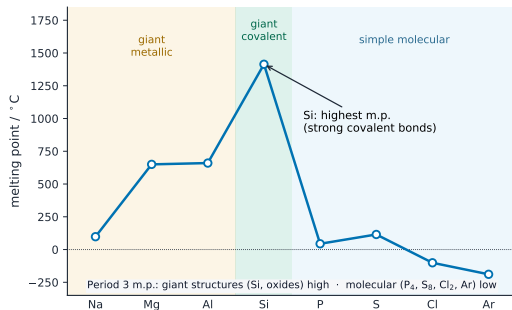
name van der Waals' forces 范德华力 when you explain it – that is the marking point

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



+1



+2



+3



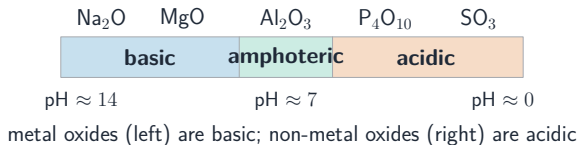
+5



+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



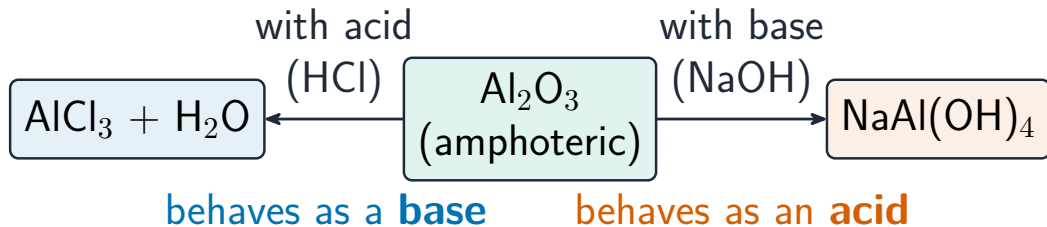
The oxides change across the period:

- 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 $\text{Al}(\text{OH})_3$ react with acids and bases.

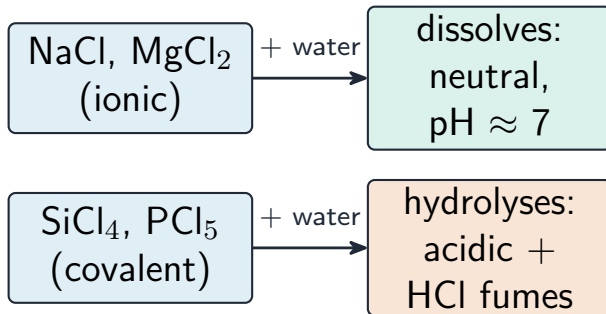
Aluminium oxide 氧化铝 is **amphoteric** 两性 – it reacts with **both** acids and bases. With acid it behaves as a base; with base it behaves as an acid.



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**.

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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 → +3 and more electrons delocalise, so attraction grows.
- Si: **giant covalent**. Many strong covalent bonds must break ⇒ the peak.
- P: **simple molecular** (P₄). 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

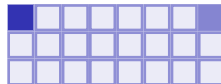
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Chlorides

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