

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

PERIODIC TABLE OF ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
87 Fr	88 Ra		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

properties repeat in periods

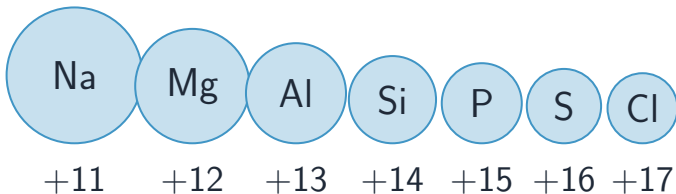


Atomic radius across Period 3

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

Atomic radius decreases across Period 3 – the rising **nuclear charge** pulls the same outer shell inwards.

atomic radius decreases as nuclear charge increases



Melting point and structure

Melting point peaks at silicon:

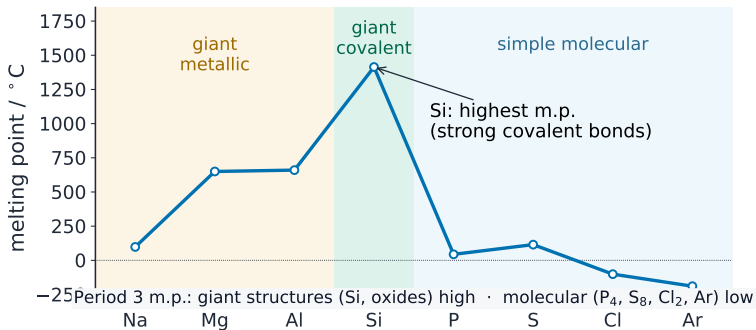
- Na, Mg, Al – **giant metallic** , conduct
- Si – **giant covalent** , highest m.p.
- P, S, Cl, Ar – **simple molecular** , low m.p.

The Period 3 physical trends

atomic radius	decreases across the period – more nuclear charge, same valence shell
ionic radius	positive ions are small; from P^{3-} onwards the negative ions are larger
electrical conductivity	high for Na, Mg, Al – delocalised electrons – and almost zero from Si onwards
melting point	rises Na to Al, peaks at the giant molecular Si, then collapses for the simple molecules
the collapse	name van der Waals' forces 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** , and they conduct.

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



Oxidation numbers

Na₂O

+1

MgO

+2

Al₂O₃

+3

P₄O₁₀

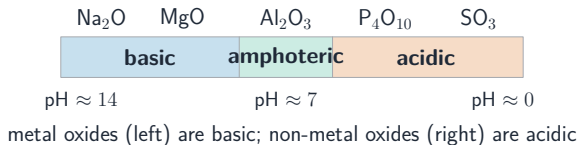
+5

SO₃

+6

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

Oxides: acid–base behaviour

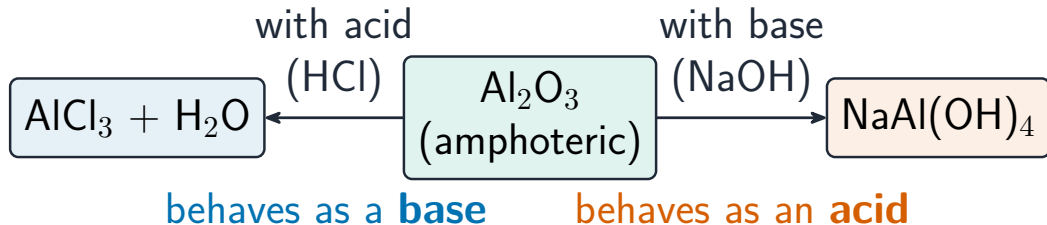


The oxides change across the period:

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

Amphoteric aluminium oxide

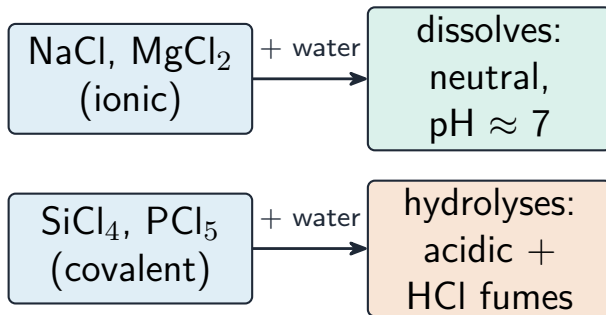
Al_2O_3 and its **hydroxide** $\text{Al}(\text{OH})_3$ react with **both** acids and bases. **Aluminium oxide** is **amphoteric** – it reacts with **both** acids and bases. With acid it behaves as a base; with base it behaves as an acid.



Chlorides with water

The chlorides undergo **hydrolysis** – 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** – acidic + HCl fumes



Explaining the trends

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

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**.



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** 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

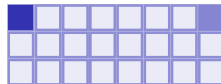
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Chlorides

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