

The Periodic Table: chemical periodicity

A-Level Chemistry

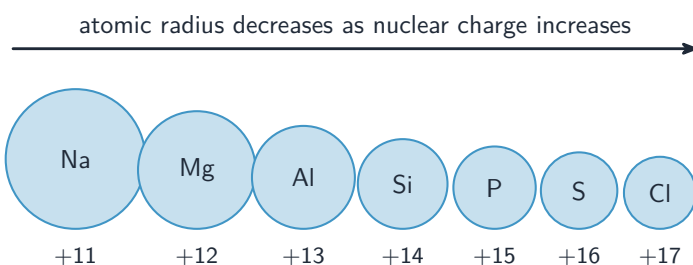
Physical properties across Period 3

PERIODIC TABLE OF ELEMENTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	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
5	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
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn						
	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			
	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 a regular pattern across each period of the table.

Periodicity means that properties repeat in a regular pattern as you go across each **period** of the Periodic Table. Period 3 (Na to Ar) is the standard example.



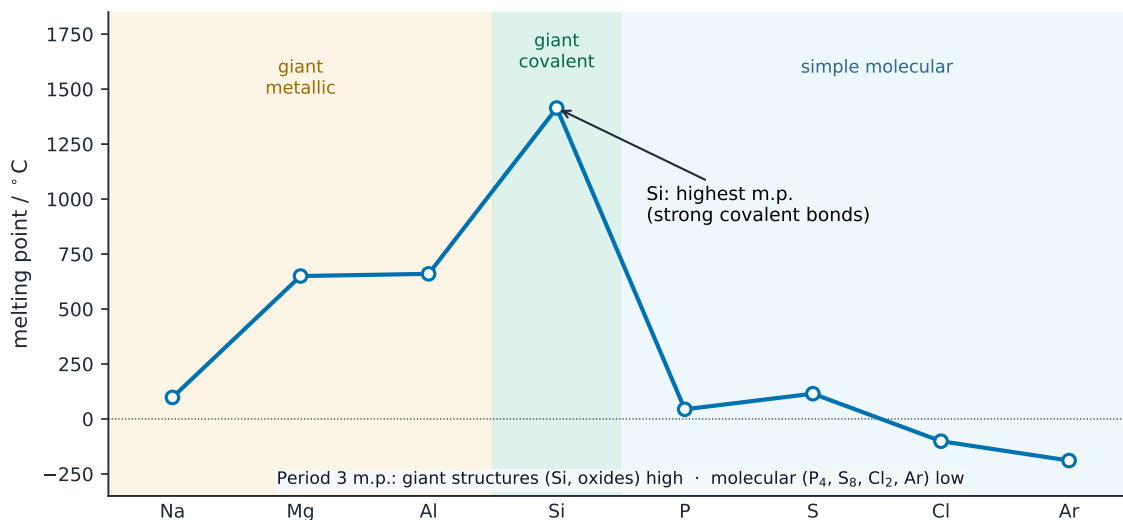
Atomic radius decreases across Period 3: the rising nuclear charge pulls the same outer shell inwards

Property	Trend across Period 3
atomic radius	gets smaller (more nuclear charge pulls the same shell in)
ionic radius	positive ions are small; from P^{3-} onwards the negative ions are larger
melting point	rises to a peak at silicon, then falls sharply
electrical conductivity	high for Na, Mg, Al; almost zero from Si onwards

The melting point and conductivity follow from the structure and bonding:

- **Na, Mg, Al** are **giant metallic** . Melting points rise (Na → Al) because each atom gives more delocalised electrons and the ions get smaller, so the bonding is stronger. They conduct well.
- **Si** is **giant molecular** (giant covalent). It has the highest melting point, because strong covalent bonds must be broken. It barely conducts.
- **P, S, Cl, Ar** are **simple molecular** (or single atoms). Their melting points are low, because the only forces that break are the weak **van der Waals' forces** **between** the molecules - the strong covalent bonds **inside** each molecule are never broken at all. They do not conduct.

Name **van der Waals' forces** when you explain that drop: it is the marking point, and "the covalent bonds are weak" is the error that loses it. Melting S_8 pulls whole molecules apart from each other; it does not touch a single S-S bond. Their sizes still follow the molecule: S_8 melts higher than P_4 because it is bigger, with more electrons and so stronger van der Waals' forces, while Ar (a single atom) is lowest of all.

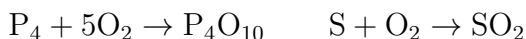
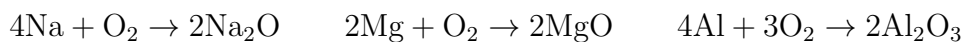


Melting point across Period 3 peaks at silicon (giant covalent); it is high for the metals and low for the simple molecular elements

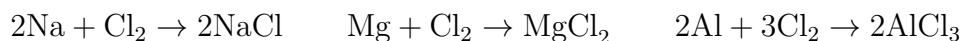
Chemical properties across Period 3

■ Reactions with oxygen, chlorine and water

With **oxygen**:



With **chlorine**:



With **water** (only Na and Mg react):



Sodium reacts fast; magnesium reacts only very slowly with cold water.

■ Oxidation number of the oxides and chlorides

The **oxidation number** of the Period 3 element in its oxide or chloride rises across the period, because it equals the number of outer-shell (**valence shell electrons**) the atom uses in bonding:

Oxides	Na ₂ O	MgO	Al ₂ O ₃	P ₄ O ₁₀	SO ₂ / SO ₃
oxidation number	+1	+2	+3	+5	+4 / +6

The chlorides NaCl, MgCl₂, AlCl₃, SiCl₄, PCl₅ show oxidation numbers +1 to +5 in the same way.

■ Oxides with water, and acid–base behaviour

Across the period the **oxides** change from basic to acidic:

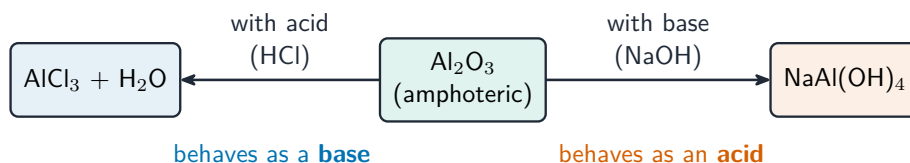
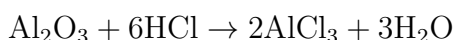
Na ₂ O	MgO	Al ₂ O ₃	P ₄ O ₁₀	SO ₃
basic		amphoteric	acidic	
pH ≈ 14		pH ≈ 7	pH ≈ 0	

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

The Period 3 oxides change from basic (the metals) through amphoteric (Al₂O₃) to acidic (the non-metals)

Oxide	With water	Acid–base nature	Approximate pH
Na ₂ O	Na ₂ O + H ₂ O → 2NaOH	basic	13–14
MgO	MgO + H ₂ O → Mg(OH) ₂	basic	9–10
Al ₂ O ₃	insoluble	amphoteric	7
SiO ₂	insoluble	weakly acidic	7
P ₄ O ₁₀	P ₄ O ₁₀ + 6H ₂ O → 4H ₃ PO ₄	acidic	1–2
SO ₃	SO ₃ + H ₂ O → H ₂ SO ₄	strongly acidic	0–1

Metal oxides (left) are basic; non-metal oxides (right) are acidic. Al₂O₃ and its **hydroxide** Al(OH)₃ are amphoteric – they react with **both** acids and bases:

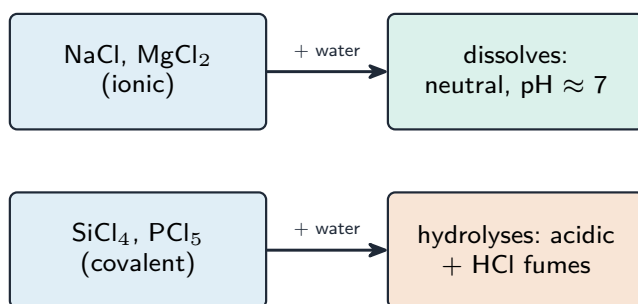


Aluminium oxide is amphoteric – it reacts with acids (behaving as a base) and with bases (behaving as an acid)

■ Chlorides with water

- NaCl and MgCl₂ are ionic. They simply dissolve, giving a near-neutral solution.
- SiCl₄ and PCl₅ are covalent. They undergo **hydrolysis** (react with water) to make acidic solutions and fumes of HCl:





The ionic chlorides just dissolve (neutral); the covalent chlorides react with water (hydrolyse) to give an acidic solution and 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). On the right, the elements are non-metals with high electronegativity, so their oxides and chlorides are covalent and acidic. You can use a chloride's or oxide's properties (melting point, conductivity, effect on water) to suggest whether its bonding is ionic or covalent.

Worked example. Predict the pH when Na_2O , Al_2O_3 and SO_3 are each added to water. Acid-base character follows the **metal to non-metal** change across Period 3. Na_2O is ionic and basic: it dissolves to give NaOH , so the pH is about **13**. SO_3 is covalent and acidic: it reacts to give H_2SO_4 , so the pH is about **1**. Al_2O_3 sits at the changeover - it is **amphoteric** and essentially **insoluble** in water, so the pH stays about **7**. The trap is that last one: amphoteric does **not** mean neutral, it means the oxide reacts with acids **and** with alkalis - it simply does not react with water.

Periodicity of other elements

The same idea works for any group. 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 (P₄, S₈, Cl₂) and monatomic (Ar).
- Oxides go **basic** → **amphoteric** (Al₂O₃) → **acidic** across the period; link to ionic-to-covalent bonding.
- For reactions of oxides/chlorides with water, give the **products and the resulting pH**.