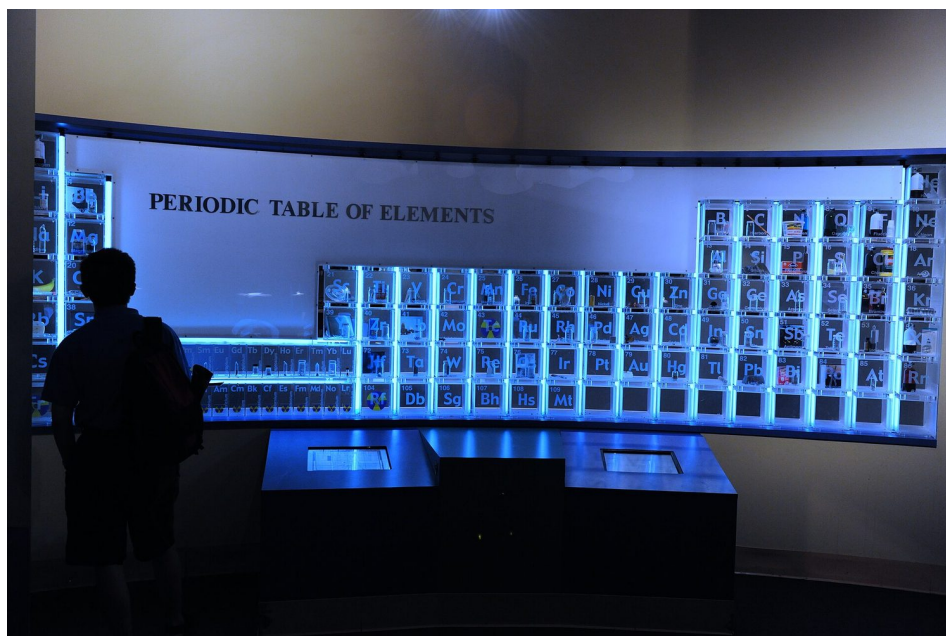


The Periodic Table: chemical periodicity

A-Level Chemistry

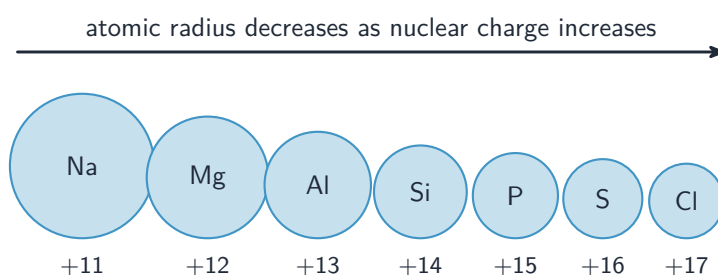
Physical properties across Period 3



Properties repeat in a regular pattern across each period of the table.

Image: Ed Uthman, Houston, Texas, USA, CC BY 3.0 (commons.wikimedia.org)

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



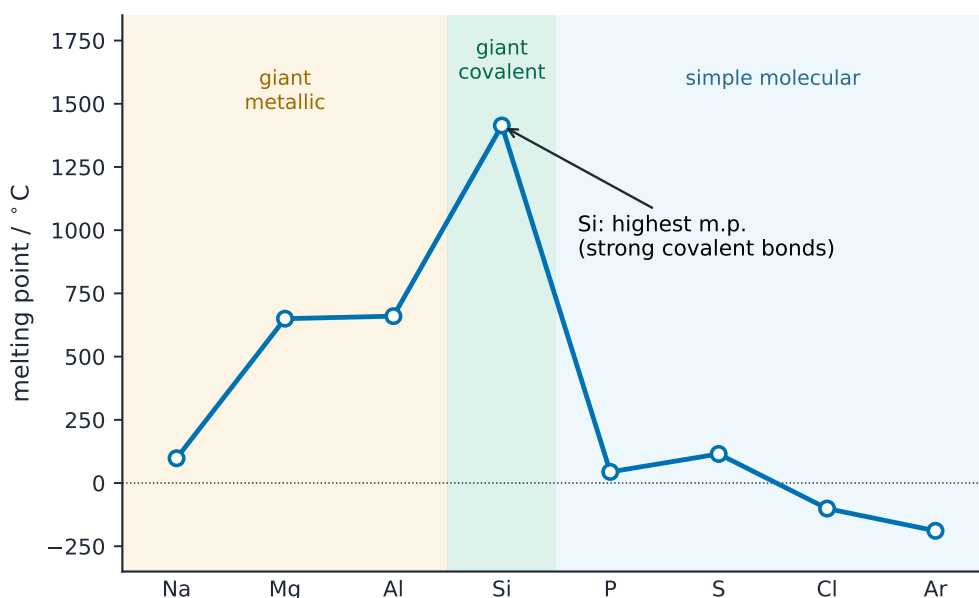
Atomic radius decreases across Period 3: the rising nuclear charge pulls the same outer shell inwards

Property	Trend across Period 3
atomic radius 原子半径	gets smaller (more nuclear charge pulls the same shell in)
ionic radius 离子半径	positive ions are small; from P^{3-} onwards the negative ions are larger
melting point 熔点	rises to a peak at silicon, then falls sharply
electrical conductivity 导电性	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** 金属晶体. 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** 原子晶体 (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** 分子晶体 (or single atoms). Their melting points are low, because the only forces that break are the weak **van der Waals' forces** 范德华力 **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 S₈ pulls whole molecules apart from each other; it does not touch a single S-S bond. Their sizes still follow the molecule: S₈ melts higher than P₄ because it is bigger, with more electrons and so stronger van der Waals' forces, while Ar (a single atom) is lowest of all.

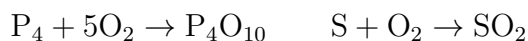
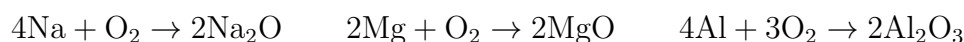


Melting point across Period 3 peaks at silicon (giant covalent); it is high for the metals and low for the simple molecular elements

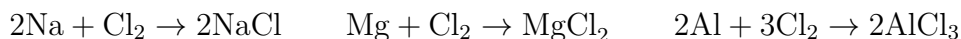
Chemical properties across Period 3

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** 氧化数 of the Period 3 element in its oxide or chloride rises across the period, because it equals the number of outer-shell (**valence shell** 价层) **electrons** 电子 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** 氧化物 change from basic to acidic:

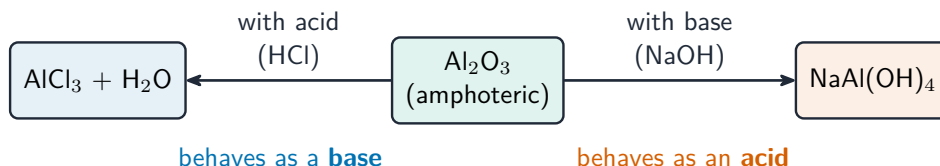
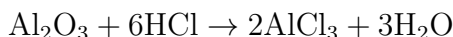
Na ₂ O	MgO	Al ₂ O ₃	P ₄ O ₁₀	SO ₃
basic		amphoteric	acidic	
pH ≈ 14		pH ≈ 7	pH ≈ 0	

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 两性	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

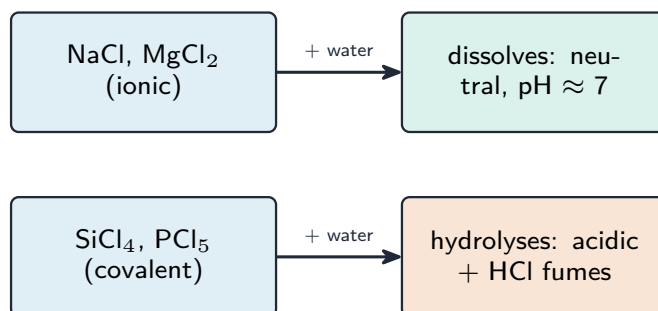
Metal oxides (left) are basic; non-metal oxides (right) are acidic. Al_2O_3 and its **hydroxide** 氢氧化物 $\text{Al}(\text{OH})_3$ are amphoteric—they react with **both** acids and bases:



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

Chlorides with water

- NaCl and MgCl_2 are ionic. They simply dissolve, giving a near-neutral solution.
- SiCl_4 and PCl_5 are covalent. They undergo **hydrolysis** 水解 (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** 电负性. 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 ($\text{Na} \rightarrow \text{Al}$), giant covalent (Si , highest), then simple molecular (P_4 , S_8 , Cl_2) and monatomic (Ar).
- Oxides go **basic** $\rightarrow$ **amphoteric** (Al_2O_3) $\rightarrow$ **acidic** across the period; link to ionic-to-covalent bonding.
- For reactions of oxides/chlorides with water, give the **products and the resulting pH**.