

Chemical periodicity of elements in Period 3

A-Level Chemistry 9701 · Topic 9 revision notes

Everything from the 3 lessons of this topic on a few pages: the key idea of each lesson, the diagram to remember, the points to learn and the traps examiners set. Read it, cover it, test yourself.

1. Period 3: physical properties

2. Period 3: oxides and chlorides

3. Chemical periodicity of other elements

1 Period 3: physical properties

Syllabus 9.1

Across Period 3 the nuclear charge rises while electrons enter the same shell, so shielding is almost constant: the **atomic radius decreases**, and **first ionisation energy** and **electronegativity** generally increase. **Melting point** depends on structure: it rises from Na to Al as metallic bonding strengthens, peaks at **silicon** (giant covalent), then drops sharply for the simple molecular P_4 , S_8 , Cl_2 and monatomic Ar. **Conductivity** rises from Na to Al (more delocalised electrons); Si is a semiconductor and the rest are insulators.

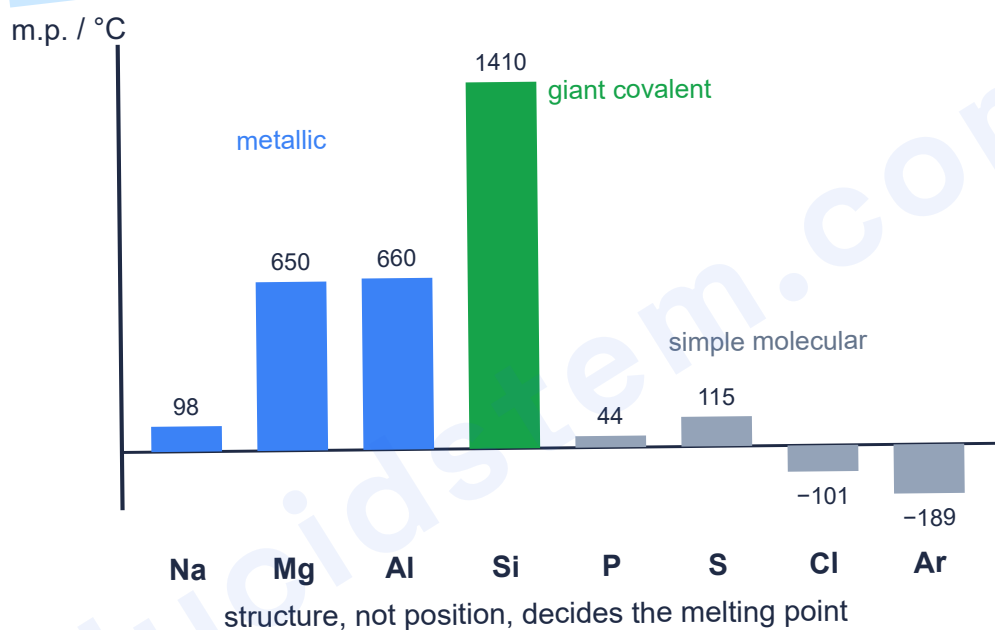


Fig. 1: melting points of the Period 3 elements, coloured by structure

Nuclear charge up, shielding the same.

- ✓ **Radius** down; **IE** and **electronegativity** up.
- ✓ **IE dips** at Al (3p) and S (paired 3p).
- ✓ **m.p.:** metallic rising, Si peak, simple molecular low.
- ✓ **Conductivity:** Na < Mg < Al; Si semiconductor.

Watch out!

Silicon's high melting point is due to its **giant covalent** structure, not to being a metal. And the fall from sulfur to chlorine to argon in melting point is about **intermolecular forces** between small molecules or atoms; no covalent bonds are broken when P, S or Cl_2 melt.

2 Period 3: oxides and chlorides

Syllabus 9.2

Across Period 3 the bonding in the oxides and chlorides changes from **ionic** (Na, Mg) to **covalent** (Si, P, S). The oxides go from **basic** (Na_2O , MgO) through **amphoteric** (Al_2O_3) to **acidic** (SiO_2 , P_4O_{10} , SO_2 , SO_3). Ionic chlorides dissolve to give neutral or near-neutral solutions; covalent chlorides are **hydrolysed** by water, producing HCl and strongly acidic solutions. The highest oxidation number in the oxides and chlorides equals the **number of outer electrons**.

oxide

Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_3
14	9	–	–	2	1
basic		insoluble: Al_2O_3 amphoteric, SiO_2 acidic		acidic	

chloride

NaCl	MgCl_2	AlCl_3	SiCl_4	PCl_5
7	6.5	3	2	2
dissolve		hydrolyse, giving HCl		

approximate pH in water: basic on the left, acidic on the right

Fig. 1: approximate pH of the oxides and chlorides in water

Ionic and basic to covalent and acidic.

- ✓ **Oxides:** Na_2O , MgO basic; Al_2O_3 amphoteric; rest acidic.
- ✓ **Insoluble:** Al_2O_3 and SiO_2 ; test with acid and alkali.
- ✓ **Covalent chlorides** hydrolyse, giving HCl.
- ✓ **Max oxidation number** = outer electrons.

Watch out!

Aluminium oxide and silicon dioxide are **insoluble** in water, so they do not change its pH; their acid-base character is shown by their reactions with acids and alkalis. And AlCl_3 is not neutral in water: the small, highly charged Al^{3+} ion polarises water molecules, releasing H^+ .

3 Chemical periodicity of other elements

Syllabus 9.3

The trends seen in Period 3 recur in every period. To place an unknown element, use several clues together: the **formulae** of its oxide and chloride give its oxidation number and so its group; **successive ionisation energies** jump after the last outer electron; a very high melting point and non-conducting behaviour point to a **giant covalent** structure; oxide and chloride behaviour with water (basic, amphoteric, acidic, hydrolysed) shows where it sits between metal and non-metal.

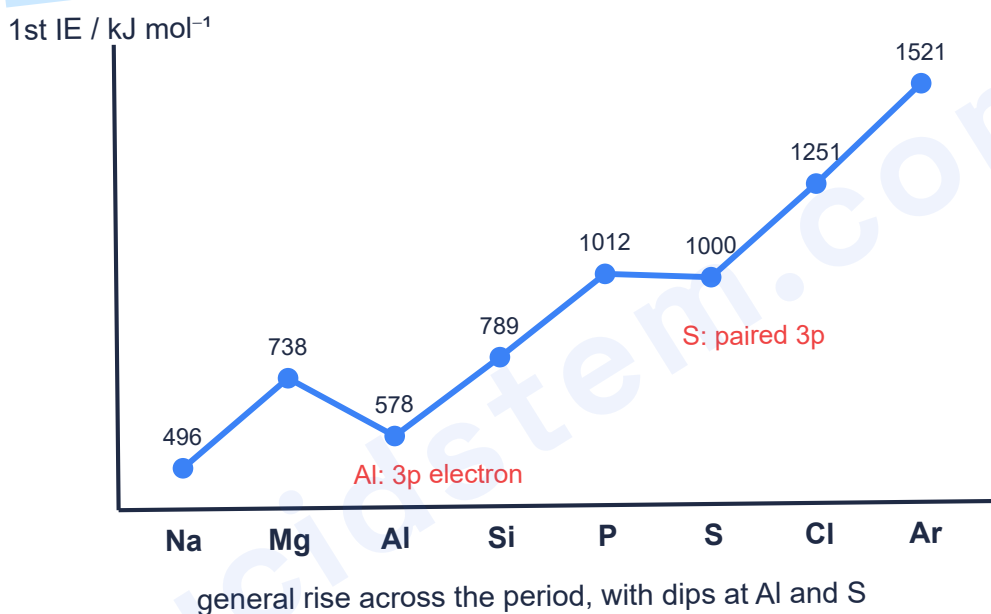


Fig. 1: first ionisation energies across Period 3

Combine clues; never rely on one.

- ✓ **Formulae** give the oxidation number and group.
- ✓ **Ionisation energy jump** gives the number of outer electrons.
- ✓ **Structure** from melting point and conductivity together.
- ✓ **Oxide/chloride with water** shows metal or non-metal.

Watch out!

Do not base an identification on a single property. Melting point alone cannot separate a strong metal from a giant covalent solid; combine it with conductivity, oxide behaviour and ionisation energy data. And remember that the dips in first ionisation energy (at Groups 13 and 16) repeat in every period.