A-LEVEL CHEMISTRY • EXERCISE SHEET

9.1 Periodicity of physical properties of Period 3

Name: ____________ Class: ________ Date: __________ **Total: 22 marks**

KEY WORDS melting point 熔点 • ionic radius 离子半径 • atomic radius 原子半径 • electrical conductivity 导电性 • period 周期

Objective

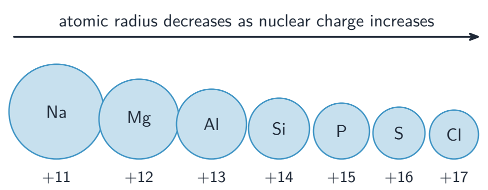
Build the skills to answer exam questions on the **physical properties of Period 3** — the trends in **atomic radius 原子半径**, **melting point 熔点** and **electrical conductivity 导电性**, explained by structure and bonding.

You must be able to:

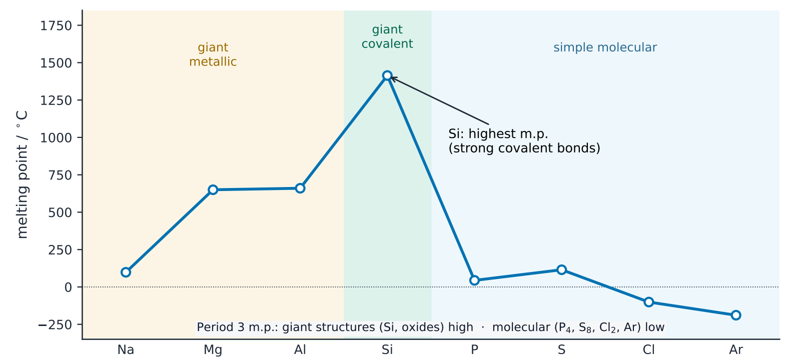
- describe the trends in atomic/ionic radius, melting point and conductivity across Period 3
- explain the melting point and conductivity trends in terms of structure and bonding

1 Worked examples

Trends across Period 3



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



Melting point peaks at silicon (giant covalent); high for the metals, low for the simple molecular elements

- **Na, Mg, Al** — **giant metallic**: m.p. rises (more delocalised electrons, smaller ions); conduct well.
- **Si** — **giant covalent**: highest m.p. (strong covalent bonds); barely conducts.
- **P, S, Cl, Ar** — **simple molecular**: low m.p. (weak forces); do not conduct.

2 Practice

2.1 Describe the trend in atomic radius across Period 3. [1]

2.2 State which Period 3 element has the highest melting point and what type of structure it has. [2]

3 Exam-style questions

3.1 Why do Na, Mg and Al conduct electricity well? [1]

- **A** they are simple molecular
- **B** they have delocalised electrons (giant metallic)
- **C** they have covalent networks
- **D** they have low melting points

3.2 Why does silicon have the highest melting point in Period 3? [1]

- **A** it is a metal
- **B** strong covalent bonds throughout a giant structure must be broken
- **C** it has the most delocalised electrons
- **D** only weak forces hold it together

3.3 Explain why the melting point increases from sodium to aluminium. [3]

3.4 Explain why the melting point of sulfur (S_8) is higher than that of phosphorus (P_4). [2]

3.5 The table gives the melting points of four Period 3 elements.

Element	**Na**	**Al**	**Si**	**S**
Melting point / K	371	933	1687	392

(a) Explain, in terms of structure and bonding, why the melting point rises from Na to Al. [3]

(b) Explain why silicon's melting point is far higher than any of the others. [3]

(c) Sulfur exists as S_8 molecules and phosphorus as P_4. Explain why sulfur's melting point is low, yet higher than that of phosphorus (317 K). [3]

(d) State and explain the trend in atomic radius across Period 3. [3]

Solutions

2.1 it decreases across the period.

2.2 silicon; giant covalent / giant molecular.

3.1 B. Giant metallic structures have delocalised electrons that conduct.

3.2 B. Silicon is a giant covalent structure with strong bonds throughout.

3.3 from Na to Al each atom releases more delocalised electrons ($1 \rightarrow 3$); and the metal ions get smaller with higher charge; so the metallic bonding is stronger, needing more energy to melt.

3.4 sulfur exists as larger S_8 molecules with more electrons than P_4; so it has stronger London (van der Waals) forces, giving a higher melting point.

3.5 (a) All three are metallic lattices of cations in a sea of delocalised electrons; across the period each atom releases more electrons (1, 2, then 3) and the cation charge rises while its radius falls; so the electrostatic attraction between cations and delocalised electrons strengthens and more energy is needed to melt the lattice.
(b) Silicon is a **giant covalent** (macromolecular) lattice; melting means breaking covalent bonds right through the structure, not merely loosening a lattice; covalent bonds are far stronger than the metallic bonding or the intermolecular forces in the neighbouring elements.
(c) Sulfur is **simple molecular**, so only weak induced-dipole (London) forces act between the S_8 molecules and little energy is needed; S_8 has more electrons than P_4; a larger, more polarisable electron cloud gives stronger induced dipoles, hence the higher melting point.
(d) The atomic radius **decreases**; the nuclear charge rises while the added electrons enter the same outer shell; shielding is essentially unchanged, so the outer electrons are pulled in more strongly.