

2.2 Bonding, structure and properties

Name: _____ Class: _____ Date: _____

Total: **32 marks****KEY WORDS** intermolecular force • state symbol • alloy

Objective

Link structure to melting point and conductivity for the four structure types, and explain alloys. Original questions for spec statements 4.2.2.1–4.2.2.8.

1 Key knowledge and worked examples

States of matter: melting/freezing at the **melting point**, boiling/condensing at the **boiling point**; particle theory explains them; stronger forces between particles → higher melting and boiling points. State symbols: **(s)**, **(l)**, **(g)**, **(aq)**. (HT) Limits of the model: no forces between the spheres; all particles drawn as solid spheres.

Structure	Melting/boiling point	Conducts?
ionic lattice	high – many strong electrostatic forces to break	only molten or dissolved – ions free to move
small molecules	low – weak intermolecular forces overcome; the covalent bonds do NOT break	no – no mobile ions or delocalised electrons
polymers	solid at room temperature – stronger intermolecular forces between long chains	no
giant covalent	very high – every atom covalently bonded	generally no; graphite and graphene conduct
metals	mostly high – strong metallic bonding	yes – delocalised electrons carry charge; also good thermal conductors

Bigger molecules → stronger intermolecular forces → higher melting/boiling points.

Alloys: in a pure metal the same-sized atoms sit in **layers that slide** – soft, malleable. Adding different-sized atoms **distorts the layers**, so sliding is harder – the alloy is **harder**.

Worked example (3 marks). Explain why chlorine (bp $-34\text{ }^{\circ}\text{C}$) has a much lower boiling point than sodium chloride ($1465\text{ }^{\circ}\text{C}$).

Chlorine is made of small molecules – only weak intermolecular forces between them, so little energy is needed. Sodium chloride is a giant ionic lattice – strong electrostatic forces between oppositely charged ions act in all directions and many must be broken, so much more energy is needed for a far higher boiling point.

2 Practice

2.1 Which forces are overcome when water boils – covalent bonds or intermolecular forces? [1]

2.2 Why does molten sodium chloride conduct electricity but solid sodium chloride does not? [2]

2.3 Give the state symbols for a solid reactant and an aqueous solution. [2]

2.4 At the stated pressure, X melts at $-15\text{ }^{\circ}\text{C}$ and boils at $65\text{ }^{\circ}\text{C}$. Predict its state at $-30\text{ }^{\circ}\text{C}$, $20\text{ }^{\circ}\text{C}$ and $90\text{ }^{\circ}\text{C}$. Explain why the particles do not become larger atoms on heating. [4]

3 Exam-style questions

3.1 Explain why propane is a gas at room temperature but hexane is a liquid, in terms of structure and forces. [4]

3.2 Explain why silicon dioxide has a very high melting point and does not conduct electricity. [4]

3.3 A student says “when iodine crystals are heated, the covalent bonds break, so iodine becomes a gas.” Correct the student. [3]

3.4 A pure metal and an alloy conduct electricity. The alloy is harder. Explain both observations using their structures. [4]

3.5 (*HT*) A sphere-only drawing shows 16 particles close together in a liquid and 22 far apart in a gas, with no particles entering. Identify the counting error, then explain one feature the model omits that is needed to explain boiling energy. [3]

3.6 A solid magnesium strip reacts with aqueous hydrochloric acid. Magnesium chloride remains dissolved and hydrogen gas is collected. Complete the balanced equation with state symbols: $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$. Explain why the salt product uses (aq), rather than (l). [5]
