

1.3 Bonding and structure

Name: _____ Class: _____ Date: _____ **Total: 18 marks**

KEY WORDS dot-and-cross • lone pair • polar molecule
• giant lattice • covalent character

Objective

Practise Topic 3: ionic, covalent and metallic bonding; dot-and-cross diagrams; VSEPR shapes and angles; polarity; giant and molecular lattices; polarising power and covalent character.

1 Key knowledge and worked examples

■ The shape table

Pairs (bonding + lone)	Shape	Angle
2	linear	180°
3	trigonal planar	120°
4	tetrahedral	109.5°
4 (3+1 lone)	trigonal pyramidal	107°
4 (2+2 lone)	bent	104.5°
6	octahedral	90°

Lone pairs repel MORE than bonding pairs – this reduces bond angles relative to the ideal arrangement. The amount is not a fixed rule: it depends on the molecule.

■ Polar molecule test

Polar BONDS + dipoles that do NOT cancel. CO₂ linear → cancels → non-polar. H₂O bent → polar. SF₆ octahedral → cancels. SF₄ (one lone pair) → polar.

■ Worked example: melting-point reasoning

MgO (2852 °C) vs NaCl (801 °C): both ionic lattices; Mg²⁺/O²⁻ carry double the charge and Mg²⁺ is smaller, so the lattice attraction is much stronger – higher energy needed to separate the ions.

■ Covalent character

A small, highly charged cation polarises the anion's electron cloud: MgCl₂ more covalent than NaCl; AlCl₃ so polarised it becomes molecular. 100% ionic and 100% covalent are idealisations.

2 Practice

2.1 Draw a dot-and-cross diagram for ammonia showing outer electrons only. [2]

2.2 Name the shape of and bond angle in the ammonium ion, NH₄⁺. [2]

2.3 Explain why metals conduct electricity when solid but ionic compounds do not. [2]

3 Exam-style questions

3.1 Draw dot-and-cross diagrams for BF₃ and NH₃, name the shape of each, and explain the difference in bond angle. [5]

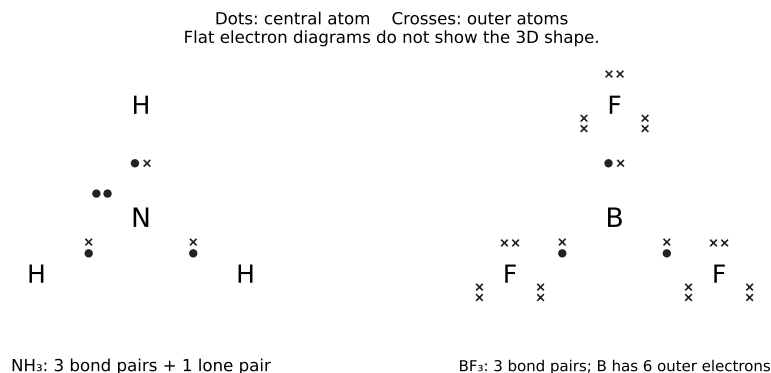
3.2 Explain why the melting temperature of magnesium oxide is much higher than that of magnesium chloride. [3]

3.3 The boiling temperatures of the hydrogen halides rise from HCl to HBr to HI, but HF is anomalously high. Explain both patterns. [4]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 The completed ammonia electron diagram is shown below.



2.2 Tetrahedral; 109.5°.

2.3 Metals have delocalised electrons free to move and carry charge; in ionic solids the ions are fixed in the lattice – the charge carriers cannot move until molten or dissolved.

3.1 Use the completed electron diagrams above. Show all three lone pairs on each F. BF₃: three bonding pairs around B, no lone pair – trigonal planar, 120°. NH₃: three bonding pairs + ONE lone pair – trigonal pyramidal, ~107°. The lone pair repels more strongly, squeezing the bonding pairs together.

3.2 O²⁻ has double the charge of Cl⁻; the Mg²⁺–O²⁻ attraction is therefore much stronger than Mg²⁺–Cl⁻; more energy is needed to overcome the lattice attraction, so the melting temperature is higher. (Also accept O²⁻ smaller than Cl⁻.)

3.3 HCl → HI: permanent dipole-dipole forces weaken as electronegativity falls, but London forces grow with molecule size and electron count; London dominates, so boiling temperature rises. HF forms hydrogen bonds – much stronger than both other forces – so its boiling temperature is far above the trend.