

2.1 Ionic, covalent and metallic bonding

Name: _____ Class: _____ Date: _____

Total: 44 marks

KEY WORDS ionic bond • covalent bond • lattice

Objective

Explain ionic, covalent and metallic bonding, draw dot-and-cross diagrams, and deduce ion charges. Original questions for spec statements 4.2.1.1–4.2.1.5.

1 Key knowledge and worked examples

- **Ionic bonding:** metal atoms **lose** outer electrons → positive ions; non-metals **gain** → negative ions. Opposite charges attract – a **giant lattice** held by electrostatic forces in all directions. Group charges: Group 1 → +1, Group 2 → +2, Group 6 → -2, Group 7 → -1; the ions have **noble-gas** electronic structures.
- **Covalent bonding:** non-metal atoms **share pairs of electrons**. Dot-and-cross for H_2 , Cl_2 , O_2 , N_2 , HCl , H_2O , NH_3 , CH_4 ; a line = one single bond.
- **Metallic bonding:** giant lattice of positive ions with **delocalised electrons** free to move through the whole structure – strong electrostatic attraction gives the bond.

Model limitations: dot-and-cross shows only outer electrons; ball-and-stick suggests gaps between atoms; 2D diagrams of 3D giant structures show only a fragment.

Worked example (3 marks). Describe what happens when sodium reacts with oxygen.

Each sodium atom loses its one outer electron, forming Na^+ ; each oxygen atom gains two electrons, forming O^{2-} ; the oppositely charged ions attract in a giant ionic lattice – sodium oxide, Na_2O , with both ions holding noble-gas structures.

2 Practice

2.1 Give the charge on the ion formed by (a) calcium; (b) sulfur.

[2]

2.2 How many electrons are shared in a molecule of nitrogen, N₂? [1]

2.3 Why do metals conduct electricity? [2]

2.4 Draw outer-electron dot-and-cross diagrams for H₂, Cl₂, O₂ and N₂. Include every lone pair. [8]

3 Exam-style questions

3.1 Draw a dot and cross diagram to show the bonding in magnesium chloride, showing outer shell electrons only. State the formula. [4]

3.2 Explain the difference between a covalent bond and an ionic bond, in terms of electrons. [4]

3.3 Give two limitations of using ball-and-stick diagrams to represent a giant ionic structure. [2]

3.4 Draw outer-electron dot-and-cross diagrams for HCl, H₂O, NH₃ and CH₄. Explain one limitation of using these flat drawings. [9]

3.5 A stated representative lattice region contains 6 Mg²⁺ and 12 Cl⁻ ions. Deduce its simplest formula and check charge balance. Explain why an arbitrary edge fragment could give a misleading ratio. [4]

Solutions

2.1 (a) Ca^{2+} ; (b) S^{2-} .

2.2 Six – a triple bond shares three pairs.

2.3 The outer electrons are delocalised/free to move through the whole structure; they carry charge through the metal.

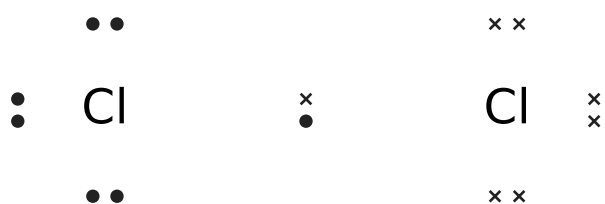
2.4

H-H: outer electrons only



2 outer electrons; each shared pair has one dot and one cross.

Cl-Cl: outer electrons only



14 outer electrons; each shared pair has one dot and one cross.

O-O: outer electrons only



12 outer electrons; each shared pair has one dot and one cross.

N-N: outer electrons only

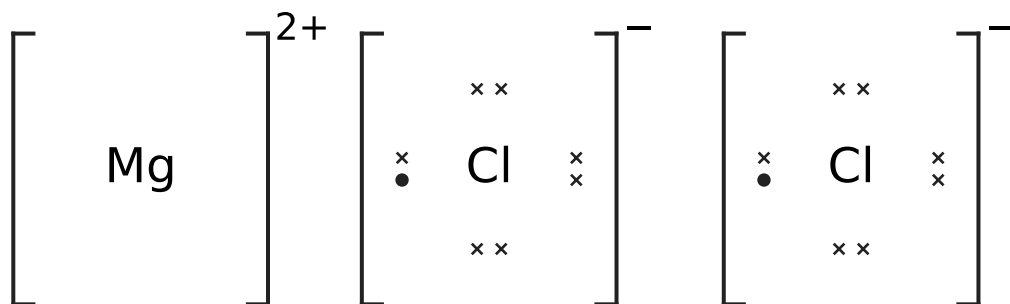


10 outer electrons; each shared pair has one dot and one cross.

For each molecule award one mark for the correct shared pairs and one for complete remaining outer electrons (2 each). H₂: one pair, no lone pairs; Cl₂: one pair and three lone pairs per Cl; O₂: two shared pairs and two lone pairs per O; N₂: three shared pairs and one lone pair per N.

3.1

MgCl₂: one Mg²⁺ and two Cl⁻ ions



Each chloride: seven crosses + one magnesium dot.
Mg²⁺ has configuration 2,8; its old third shell is empty.

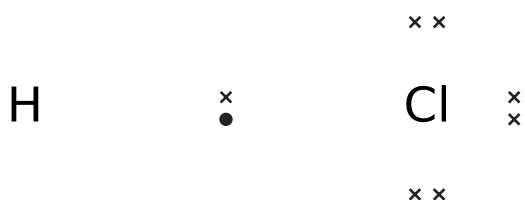
Mg (2,8,2) loses two electrons → Mg²⁺, configuration 2,8; the former third shell is empty; each chlorine atom gains one electron → two Cl⁻ with eight outer electrons, dots and crosses distinguished; correct ratio – one Mg²⁺ to two Cl⁻; formula MgCl₂.

3.2 Covalent – non-metal atoms share one or more pairs of electrons; the shared pair attracts both nuclei, bonding the atoms in a molecule. Ionic – a metal transfers electrons to a non-metal; forming oppositely charged ions held together by electrostatic attraction in a lattice.

3.3 Any two: it suggests there are spaces/gaps between the ions, but the lattice is touching; it shows bonds as sticks, whereas the force is electrostatic attraction; only a tiny fragment of a giant structure can be drawn; the real 3D arrangement is flattened into 2D.

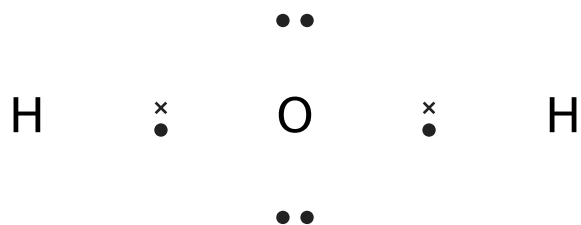
3.4

H-Cl: outer electrons only



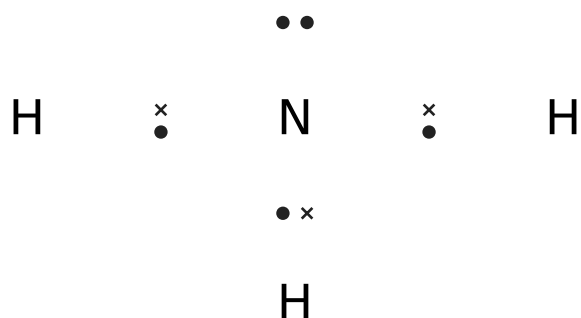
8 outer electrons; each shared pair has one dot and one cross.

water: dots from O; crosses from H



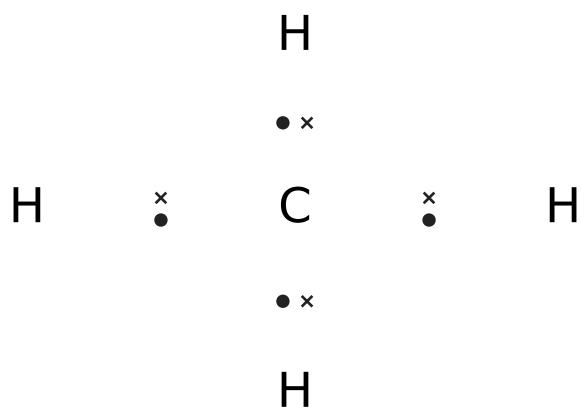
Flat electron model: positions do not establish the 3D shape.

ammonia: dots from N; crosses from H



Flat electron model: positions do not establish the 3D shape.

methane: dots from C; crosses from H



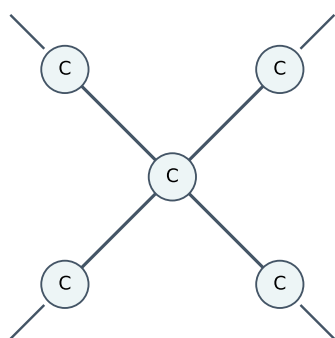
Flat electron model: positions do not establish the 3D shape.

For each molecule award one mark for the correct shared pairs and one for complete remaining outer electrons (2 each). HCl: one shared pair and three Cl lone pairs; H₂O: two shared pairs and two O lone pairs; NH₃: three shared pairs and one N lone pair; CH₄: four shared pairs, no lone pairs. A flat drawing does not fully show 3D arrangement, particle size or forces (any one, B1).

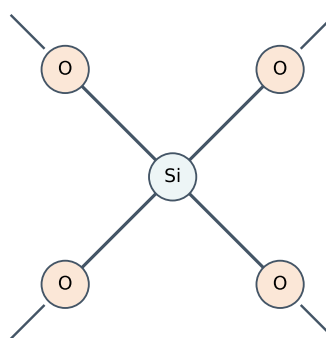
3.5 Reduce Mg:Cl = 6:12 to 1:2, giving MgCl₂. Charge check: $+2 + 2(-1) = 0$. The giant lattice continues beyond the pictured region; an arbitrary cut can omit/shared-count boundary ions unevenly, so use the stated representative region or repeat pattern.

3.6 Molecular formula C₂H₆O: two C, six H and one O. The polymer answer is $[-CH_2-CH_2-]_n$: two bonded carbon groups with single backbone bonds, two hydrogens per carbon, continuation bonds across both brackets and n. For the diamond sketch, use the left network projection below: central C joined to four C neighbours with continuation beyond the fragment. A molecule is a finite separate particle, whereas a giant network has covalent connections continuing throughout the structure.

Local coordination projections; bonds continue into giant 3D structures



Diamond: four C neighbours



Silica: four O neighbours;
each O bridges to another Si

2D projection does not show actual bond angles. Silica oxygens are shared: SiO₂ overall.