

1.3.2 Electron diagrams, coordinate bonds and shape

Name: _____ Class: _____ Date: _____ **Total: 27 marks**

KEY WORDS coordinate bond • lone pair • bond dipole

Objective

Complete electron diagrams and use electron-pair repulsion, ion migration and polarity evidence. Keep electron origin separate from three-dimensional shape.

1 Key knowledge and worked examples

■ Count electrons before drawing

CO_2 has $4 + 2 \times 6 = 16$ outer electrons. Four shared pairs form its two double bonds; the remaining eight electrons are lone pairs on oxygen. N_2 has ten outer electrons: six in its triple bond and one lone pair on each N.

Coordinate bonding uses a pair supplied by one donor. NH_4^+ has $5 + 4 - 1 = 8$ outer electrons. In Al_2Cl_6 , six chlorines and two aluminium atoms supply 48 outer electrons. Each bridging chlorine bonds to both aluminium atoms.

■ Predict shape and then polarity

Count electron regions around the central atom; a multiple bond is one region. CO_2 is linear, so its equal opposing C–O dipoles cancel. H_2O is bent, so its O–H dipoles do not cancel. A flat electron diagram alone does not show these spatial arrangements.

2 Practice

2.1 Draw a dot-and-cross electron diagram for sodium chloride, showing each ion's outer shell, brackets and charges. [3]

2.2 Draw complete outer-electron dot-and-cross diagrams for CO_2 and N_2 , including every lone pair. [5]

2.3 In an aqueous ion-migration demonstration, a coloured cation moves toward the negative electrode. Explain what this shows and why movement in solution differs from solid ionic material. State one limitation of using conductivity alone to conclude a substance is ionic. [3]

3 Exam-style questions

3.1 Draw complete outer-electron diagrams for NH_4^+ and Al_2Cl_6 , distinguishing the origins of electrons in coordinate bonds. [6]

3.2 Give the shape and typical bond angle(s) for BeCl_2 , BCl_3 , NH_4^+ , gaseous PCl_5 and SF_6 . Explain why the double bonds in CO_2 do not make it a four-region tetrahedral molecule. [6]

3.3 A charged rod deflects a thin water jet more strongly than a cyclohexane jet. Explain how this supports a polarity comparison. Why can a molecule containing polar bonds still have no permanent overall dipole? Give an example. [4]

Solutions

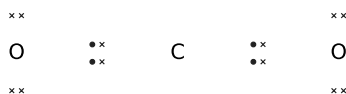
Original guidance. Accept consistent swapped dot/cross conventions and equivalent complete diagrams.

2.1



NaCl: bracketed ions; only each ion's outer shell shown.

CO₂: dots from C; crosses from O



Two shared pairs per C–O bond; two lone pairs per O.

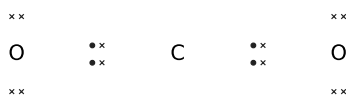
Award Na⁺ and Cl[−] charges/brackets, eight outer electrons on each ion, and chloride's gained electron distinguished from its seven original outer electrons. Only the upper panel answers this item.

2.2



NaCl: bracketed ions; only each ion's outer shell shown.

CO₂: dots from C; crosses from O



Two shared pairs per C–O bond; two lone pairs per O.

N₂: dots from left N; crosses from right N

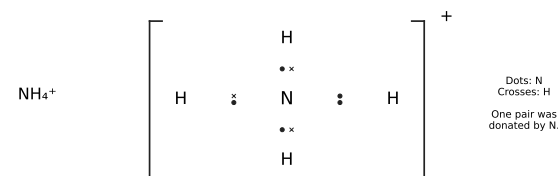


Three shared pairs and one lone pair per atom: ten outer electrons.

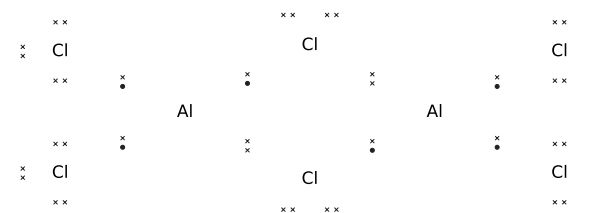
CO₂: two shared pairs per C–O bond and two lone pairs on each O, consistent electron origins. N₂: three shared pairs, one lone pair per N with consistent electron origins.

2.3 The migration supports the presence of mobile positively charged particles attracted to the negative electrode. Solid ionic lattices hold ions in fixed positions; solution permits movement. Metals and graphite can also conduct through mobile electrons, so conductivity alone does not identify the charge carriers or uniquely prove ionic bonding.

3.1



Al₂Cl₆: dots from Al; crosses from Cl



Each bridging Cl donates a pair to the other Al. All 48 outer electrons are shown.

NH₄⁺: four shared pairs/no N lone pair, one pair supplied entirely by N, bracket/+ and eight-electron total. Al₂Cl₆: two bridging chlorines, one donor pair from each bridge to the other aluminium, all terminal/bridge lone pairs and 48-electron total.

3.2 BeCl₂ linear 180°; BCl₃ trigonal planar 120°; NH₄⁺ tetrahedral 109.5°; gaseous PCl₅ trigonal bipyramidal 90°/120°; SF₆ octahedral 90°. CO₂ has two electron regions, because each double bond counts as one; the regions arrange linearly.

3.3 Water has a permanent molecular dipole and interacts with the charged rod's field; non-polar cyclohexane lacks a permanent overall dipole, so the observations support the comparison. In a symmetrical molecule, bond-dipole vectors can cancel, as in CO₂ or

BCl_3 . The deflection comparison is qualitative and does not alone determine every bond or molecular structure.