

Exercise walk-through

Covalent bonding and coordinate (dative covalent) bonding ■ 3.4

eXercise

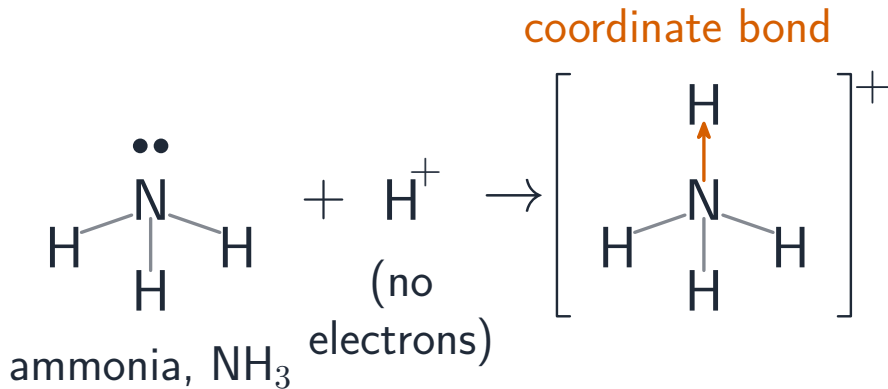
You must be able to

- define covalent and coordinate bonding and describe an expanded octet
- describe σ and π bonds (single, double, triple) and $sp/sp^2/sp^3$ hybridisation
- define bond energy and bond length and relate them to reactivity

Method — Covalent and coordinate bonds

Covalent bonding is the electrostatic attraction between the nuclei of two atoms and a **shared pair** of electrons. Period 3 atoms can **expand the octet** (e.g. SO , PCl , SF). A **coordinate (dative)** bond is a covalent bond where **both** electrons come from one atom.

Method — Covalent and coordinate bonds

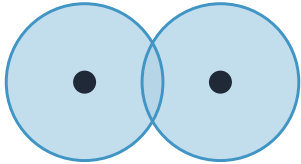


Ammonia's lone pair forming a bond to H to make the ammonium ion

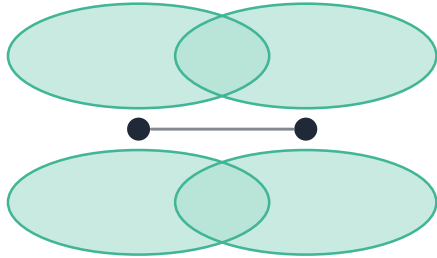
Method — σ and π bonds

Hybridisation mixes orbitals: sp (linear), sp^2 (e.g. CH_2 , planar), sp^3 (e.g. CH_4 , tetrahedral). **Bond energy** = energy to break one mole of a bond (gas); a shorter bond is usually stronger (triple > double > single).

Method — σ and π bonds



σ bond:
head-on overlap



π bond: sideways overlap
of p orbitals

Practice 2.1 ■ 1 mark

Define a **coordinate (dative covalent) bond**.

Solution 2.1

Method: Covalent and coordinate bonds

Worked steps

a covalent bond in which both shared electrons come from the same atom **B1**.

Practice 2.2 ■ 2 marks

State how many σ and π bonds are in a nitrogen molecule, N_2 (triple bond).

Solution 2.2

Method: σ and π bonds

Worked steps

1 σ bond and 2 π bonds **B1** *each*.

Exam-style 3.1 ■ 1 mark

A double bond consists of:

- A** two σ bonds
- B** one σ bond and one π bond
- C** two π bonds
- D** one σ bond and two π bonds

Solution 3.1

Method: σ and π bonds

- A two σ bonds
- B one σ bond and one π bond 
- C two π bonds
- D one σ bond and two π bonds

Worked steps

B. A double bond is one σ plus one π bond.

Exam-style 3.2 ■ 1 mark

Which molecule contains an atom with an expanded octet?

A CH

B NH

C SF

D H O

Solution 3.2

Method: Covalent and coordinate bonds

A CH

B NH

C SF



D H O

Worked steps

C. SF has six bonds around sulfur — an expanded octet.

Exam-style 3.3 ■ 2 marks

- (a) Describe how a coordinate bond forms when ammonia reacts with H^+ to form NH_4^+ .
- (b) Explain why a $\text{C}\equiv\text{C}$ triple bond is shorter and stronger than a $\text{C}=\text{C}$ double bond.

Solution 3.3

Method: σ and π bonds

Worked steps

- (a) the lone pair on the nitrogen atom is donated to the H⁺ ion (M1); both electrons come from N, forming the fourth N–H (coordinate) bond (A1).
- (b) a triple bond has more shared electron pairs, so a greater attraction pulling the nuclei closer (M1); the shorter bond is harder to break — higher bond energy (A1).

Exam-style 3.4 ■ 2 marks

Explain, in terms of σ and π bonds, the bonding in an ethene molecule, C_2H_4 .

Solution 3.4

Method: Covalent and coordinate bonds

Worked steps

each C–H and the C–C σ bond form by direct (head-on) overlap **M1**; the C=C also has a π bond from sideways overlap of p orbitals above and below **A1**.