

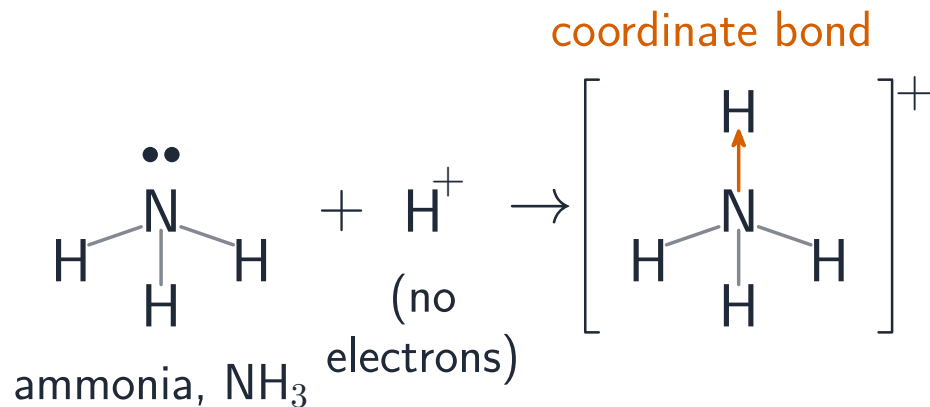
Exercise walk-through

3.4

Covalent bonding and coordinate (dative covalent) bonding

A-Level Chemistry

Covalent and coordinate bonds



A **covalent bond** is a shared pair of electrons.

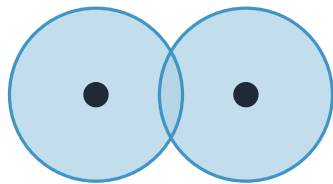
In a **coordinate bond** (dative) **both** electrons come from one atom – e.g. N's lone pair makes NH_4^+ .

Sigma and pi bonds

Covalent bonds form when **orbitals** overlap:

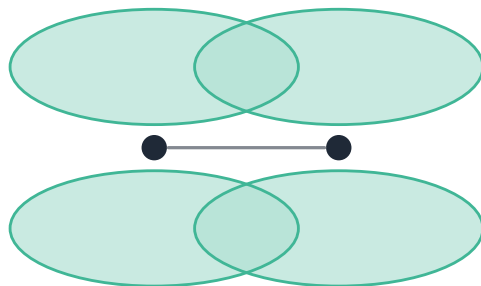
- a **sigma bond** σ – head-on **overlap**
- a **pi bond** π – sideways p-orbital overlap

Double = $1\sigma + 1\pi$; triple = $1\sigma + 2\pi$. **Hybridisation** : sp , sp^2 , sp^3 .



σ bond:

head-on overlap



π bond: sideways overlap
of p orbitals

Bond energy and bond length

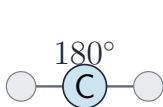
- **bond energy** is the energy needed to break one mole of a particular covalent bond in the gas state.
- **bond length** is the distance between the centres of the two bonded atoms.

Shapes of molecules

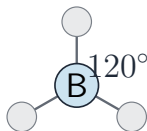
VSEPR theory : electron pairs push apart as far as possible.

A **lone pair** repels harder than a bonding pair, squeezing the **bond angle** ($\sim 2.5^\circ$ each) – so NH_3 is 107° , H_2O 104.5° .

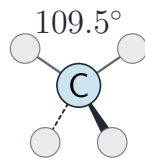
Shapes of molecules, in detail



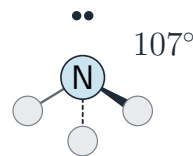
linear
CO2



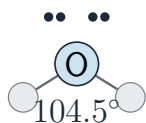
trigonal planar
BF3



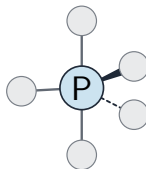
tetrahedral
CH4



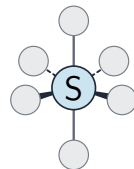
pyramidal
NH3



bent
H2O



trig. bipyramidal
PF5, 120° & 90°



octahedral
SF6, 90°

The seven shapes from VSEPR theory; the lone pairs on NH3 and H2O push harder, squeezing the bond angle below 109.5°

Exercises 2.1·3.1

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

[1]

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

[2]

3.1 A double bond consists of:

[1]

☐

A two σ bonds

B one σ bond and one π bond

C two π bonds

D one σ bond and two π bonds

Exercises 2.1·3.1

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

[1]

2.1

- a covalent bond in which both shared electrons come from the same atom

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

[2]

2.2

- 1 σ bond and 2 π bonds

3.1 A double bond consists of:

[1]

☐

A two σ bonds

B one σ bond and one π bond

C two π bonds

D one σ bond and two π bonds

3.1 B

- A double bond is one σ plus one π bond

Exercise 3.2

3.2 Which molecule contains an atom with an expanded octet?

[1]

☐

A CH_4

B NH_3

C SF_6

D H_2O

Exercise 3.2

3.2 Which molecule contains an atom with an expanded octet?

[1]

☐

A CH₄

B NH₃

C SF₆

D H₂O

3.2 C

- SF₆ has six bonds around sulfur – an expanded octet

Exercise 3.3

3.3 (a) Describe how a coordinate bond forms when ammonia reacts with H^+ to form NH_4^+ . [2]

(b) Explain why a $\text{C}\equiv\text{C}$ triple bond is shorter and stronger than a $\text{C}=\text{C}$ double bond. [2]

Exercise 3.3

3.3 (a) Describe how a coordinate bond forms when ammonia reacts with H^+ to form NH_4^+ . [2]

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3.3

(a)

- the lone pair on the nitrogen atom is donated to the H^+ ion; both electrons come from N, forming the fourth N–H (coordinate) bond

(b)

- a triple bond has more shared electron pairs, so a greater attraction pulling the nuclei closer; the shorter bond is harder to break – higher bond energy

Exercise 3.4

3.4 Explain, in terms of σ and π bonds, the bonding in an ethene molecule, C_2H_4 . [2]

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3.4

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