

3.4 Covalent bonding and coordinate (dative covalent) bonding

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS coordinate bond 配位键 • bond energy 键能 • hybridisation 杂化 • bond length 键长
 • covalent bonding 共价键

Objective

Build the skills to answer exam questions on **covalent and coordinate bonding** — **covalent bonds** 共价键, **coordinate (dative)** 配位 bonds, **σ and π bonds** σ 和 π 键, **hybridisation** 杂化, and bond energy/length.

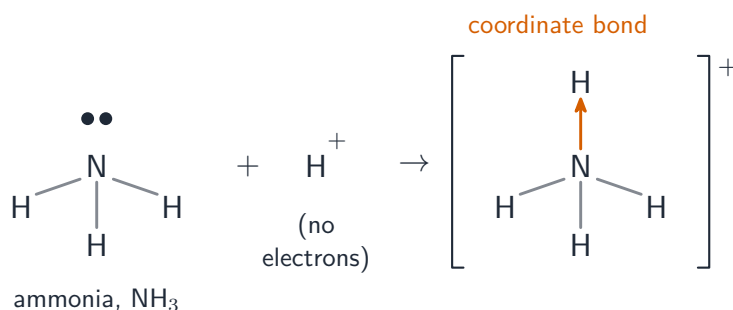
You must be able to:

- 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

1 Worked examples

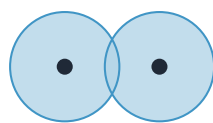
■ Covalent and coordinate bonds

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_2 , PCl_5 , SF_6). A **coordinate (dative)** bond is a covalent bond where **both** electrons come from one atom.

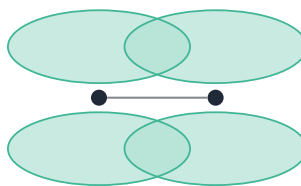


A coordinate bond: N's lone pair forms the fourth N-H bond, both electrons coming from N $\rightarrow NH_4^+$

■ σ and π bonds



σ bond:
head-on overlap



π bond: sideways overlap
of p orbitals

σ = head-on overlap; π = sideways p-orbital overlap. Single = 1σ ; double = $1\sigma + 1\pi$;
triple = $1\sigma + 2\pi$

Hybridisation mixes orbitals: sp (linear), sp^2 (e.g. C_2H_4 , 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).

2 Practice

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 Exam-style questions

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
-

3.2 Which molecule contains an atom with an expanded octet? [1]

- **A** CH_4
 - **B** NH_3
 - **C** SF_6
 - **D** H_2O
-

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]

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

Solutions

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

2.2 1 σ bond and 2 π bonds.

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

3.2 C. SF_6 has six bonds around sulfur — an expanded octet.

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.

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.