Exercise walk-through

VSEPR and Bond Hybridization ▪ 2.7

eXercise

You must be able to

- count **electron domains 电子域** (bonds + lone pairs) around the central atom
- use **VSEPR 价层电子对互斥** to predict the shape and bond angles
- assign **hybridization** (*sp*, sp^2, sp^3) from the domain count

Method — Count the domains

Electron domains repel and spread as far apart as possible. Count bonding groups (a double/triple bond counts as **one** domain) plus lone pairs on the central atom.

Method — Shape from domains

domains	arrangement	angle
2	linear	180°
3	trigonal planar	120°
4	tetrahedral	109.5°

Lone pairs occupy a domain but are **not** drawn as part of the shape name, so they bend the visible geometry (e.g. water is “bent”).

Method — Lone pairs change the shape name

NH_3 has 4 domains (3 bonds + 1 lone pair): electron geometry tetrahedral, but the **molecular shape** is **trigonal pyramidal**, angle $\approx 107^\circ$ (lone pair squeezes it).

Method — Hybridization from domain count

2 domains $\rightarrow$ *sp*; $3 \rightarrow sp^2$; $4 \rightarrow sp^3$. For CO_2 (2 domains), carbon is *sp*; for CH_4 (4), sp^3.

Practice 2.1 ▪ 1 mark

How many electron domains are around C in CH_4?

Solution 2.1

Method: Lone pairs change the shape name

Worked steps

4 B1.

Practice 2.2 ▪ 2 marks

State the shape and bond angle of CH_4.

Solution 2.2

Method: Lone pairs change the shape name

Worked steps

Tetrahedral, 109.5° B1 B1.

Practice 2.3 ▪ 1 mark

State the hybridization of carbon in CO_2.

Solution 2.3

Method: Hybridization from domain count

Worked steps

sp B1.

Exam-style 3.1 ▪ 1 mark

A central atom with 3 electron domains and no lone pairs has the shape

A linear

B trigonal planar

C tetrahedral

D bent

Solution 3.1

Method: Count the domains

A linear

B trigonal planar ✓

C tetrahedral

D bent

Worked steps

B — 3 domains with no lone pairs is trigonal planar.

Exam-style 3.2 ▪ 1 mark

Consider H_2O.
(a) Count the electron domains on oxygen.
(b) State the molecular shape and approximate bond angle.
(c) State the hybridization of oxygen.

Solution 3.2

Method: Lone pairs change the shape name

Worked steps

(a) 4 (2 bonds + 2 lone pairs) B1. (b) Bent, $\approx 104.5^\circ$ B1 B1. (c) sp^3 B1.

Exam-style 3.3 ▪ 2 marks

Explain why the bond angle in NH_3 (107°) is smaller than in CH_4 (109.5°).

Solution 3.3

Method: Lone pairs change the shape name

Worked steps

NH_3 has one lone pair, which repels more strongly than a bonding pair and pushes the N–H bonds closer together, reducing the angle below the tetrahedral 109.5° M1 A1.