

Exercise walk-through

Shapes of molecules ■ 3.5

eXercise

You must be able to

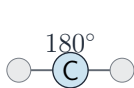
- state and explain the shapes and bond angles of the standard molecules
- predict the shapes of analogous molecules and ions
- explain the effect of lone pairs on bond angle

Method — VSEPR theory

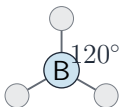
Electron pairs around the central atom repel and push as far apart as possible. A **lone pair** 孤对电子 repels more than a **bonding pair**, squeezing the bond angle by about 2.5° each.

molecule	shape	angle
CO	linear	180°
BF	trigonal planar	120°
CH	tetrahedral	109.5°
NH	pyramidal	107°
H O	bent	104.5°
PF	trigonal bipyramidal	120° & 90°
SF	octahedral	90°

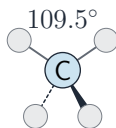
Method — VSEPR theory



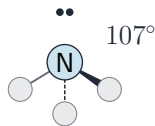
linear
CO2



trigonal planar
BF3



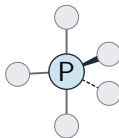
tetrahedral
CH4



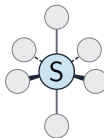
pyramidal
NH3



bent
H2O

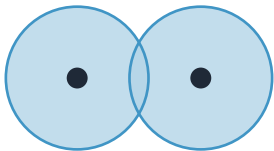


trig. bipyramidal
PF5, 120° & 90°

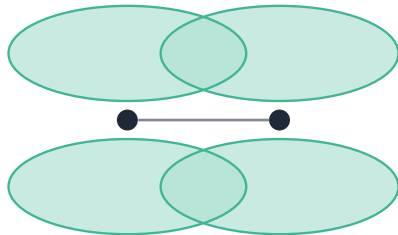


octahedral
SF6, 90°

Method — VSEPR theory



σ bond:
head-on overlap



π bond: sideways overlap
of p orbitals

Bonding pairs set the shape; sigma and pi bonds

Practice 2.1 ■ 2 marks

State the shape and bond angle of a methane molecule, CH₄.

Solution 2.1

Method: VSEPR theory

Worked steps

tetrahedral **B1**; 109.5° **B1**.

Practice 2.2 ■ 1 mark

State the shape of an ammonia molecule, NH_3 .

Solution 2.2

Method: VSEPR theory

Worked steps

pyramidal (trigonal pyramidal) **B1**.

Exam-style 3.1 ■ 1 mark

What is the bond angle in a carbon dioxide molecule, CO ?

A 104.5°

B 109.5°

C 120°

D 180°

Solution 3.1

Method: VSEPR theory

A 104.5°

B 109.5°

C 120°

D 180°



Worked steps

D. CO is linear, 180° .

Exam-style 3.2 ■ 1 mark

Why is the bond angle in water (104.5°) smaller than in methane (109.5°)?

- A** water has more bonds
- B** the two lone pairs on oxygen repel more, squeezing the angle
- C** oxygen is bigger than carbon
- D** water has a double bond

Solution 3.2

Method: VSEPR theory

- A water has more bonds
- B the two lone pairs on oxygen repel more, squeezing the angle** 
- C oxygen is bigger than carbon
- D water has a double bond

Worked steps

- B. Oxygen's two lone pairs repel more, squeezing the angle.

Exam-style 3.3 ■ 2 marks

- (a) Using VSEPR theory, explain the shape of a BF_3 molecule.
- (b) Predict the shape and bond angle of an NH_4^+ ion.

Solution 3.3

Method: VSEPR theory

Worked steps

- (a) boron has 3 bonding pairs and no lone pairs (M1); they repel equally to a trigonal planar shape, 120° (A1).
- (b) tetrahedral (M1); 109.5° (4 bonding pairs, no lone pairs) (A1).

Exam-style 3.4 ■ 2 marks

Explain why ammonia (107°) has a smaller bond angle than methane (109.5°).

Solution 3.4

Method: VSEPR theory

Worked steps

ammonia has one lone pair on nitrogen (M1); the lone pair repels the bonding pairs more strongly, squeezing the angle from 109.5° to 107° (A1).