

3.5 Shapes of molecules

Name: _____ Class: _____ Date: _____

Total: 11 marks

Objective

Build the skills to answer exam questions on **shapes of molecules** —using **VSEPR theory** 价层电子对互斥理论 to predict shapes and **bond angles** 键角.

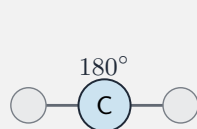
You must be able to:

- 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

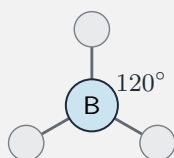
1 Worked examples

■ VSEPR theory

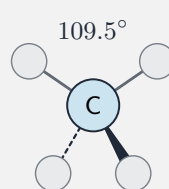
Electron pairs around the central atom repel and push as far apart as possible. A **lone pair** 孤对电子 repels more than a **bonding pair**, squeezing the bond angle by about 2.5° each.



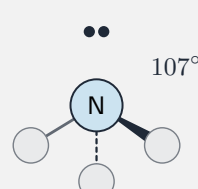
linear
CO2



trigonal planar
BF3



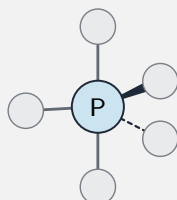
tetrahedral
CH4



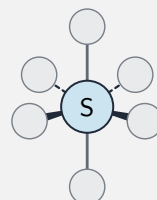
pyramidal
NH3



bent
H2O

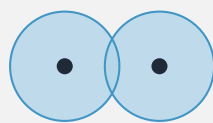


trig. bipyramidal
PF5, 120° & 90°

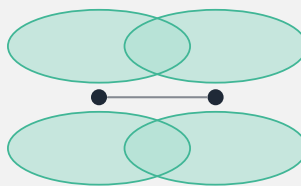


octahedral
SF6, 90°

The seven shapes; lone pairs on NH and H O squeeze the angle below 109.5°



σ bond:
head-on overlap



π bond: sideways overlap
of p orbitals

Bonding pairs set the shape; sigma and pi bonds

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°

2 Practice

2.1 State the shape and bond angle of a methane molecule, CH₄. [2]

2.2 State the shape of an ammonia molecule, NH₃. [1]

3 Exam-style questions

3.1 What is the bond angle in a carbon dioxide molecule, CO₂? [1]

- A 104.5°
- B 109.5°
- C 120°
- D 180°

3.2 Why is the bond angle in water (104.5°) smaller than in methane (109.5°)? [1]

- 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

3.3 (a) Using VSEPR theory, explain the shape of a BF_3 molecule. [2]

(b) Predict the shape and bond angle of an NH_4^+ ion. [2]

3.4 Explain why ammonia (107°) has a smaller bond angle than methane (109.5°). [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **3.5 Shapes of molecules** past-paper sheet in the Library, or try these in **Practice mode**:

- 9701/12 N25 —Q6 (molecular shapes)
- 9701/14 N25 —Q5 (VSEPR)

Solutions

2.1 tetrahedral; 109.5° .

2.2 pyramidal (trigonal pyramidal).

3.1 D. CO is linear, 180° .

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

3.3 (a) boron has 3 bonding pairs and no lone pairs; they repel equally to a trigonal planar shape, 120° .

(b) tetrahedral; 109.5° (4 bonding pairs, no lone pairs).

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