

## 3.5 Shapes of molecules

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Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

**Total: 11 marks**

**KEY WORDS** vsepr theory 价层电子对互斥理论 • bond angle 键角 • tetrahedral 四面体形  
• trigonal planar 平面三角形 • lone pair 孤对电子

### Objective

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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:**

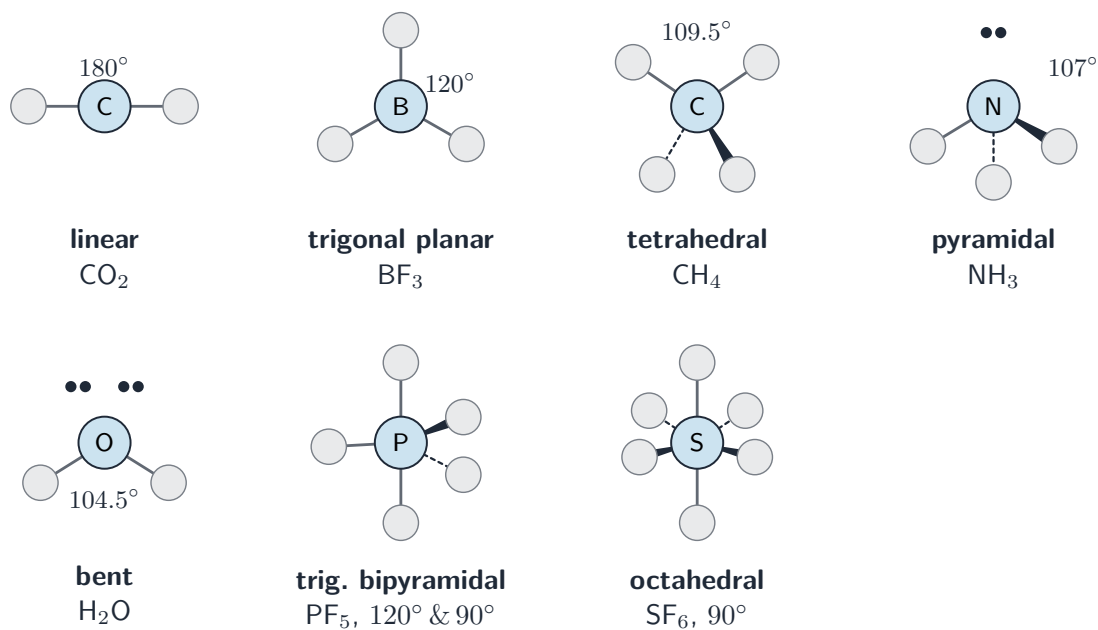
- state and explain the shapes and bond angles of the standard molecules
- predict the shapes of analogous molecules and ions
- explain the effect of lone pairs on bond angle

### 1 Worked examples

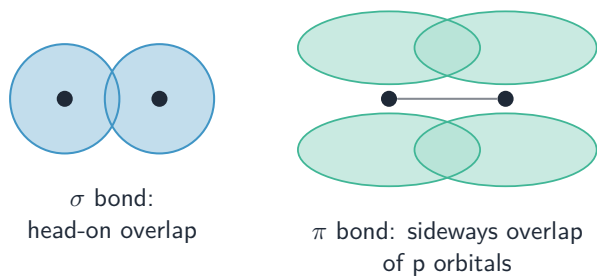
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#### ■ VSEPR theory

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  $2.5^\circ$  each.



*The seven shapes; lone pairs on NH<sub>3</sub> and H<sub>2</sub>O squeeze the angle below 109.5°*



*Bonding pairs set the shape; sigma and pi bonds*

| molecule         | shape                | angle      |
|------------------|----------------------|------------|
| CO <sub>2</sub>  | linear               | 180°       |
| BF <sub>3</sub>  | trigonal planar      | 120°       |
| CH <sub>4</sub>  | tetrahedral          | 109.5°     |
| NH <sub>3</sub>  | pyramidal            | 107°       |
| H <sub>2</sub> O | bent                 | 104.5°     |
| PF <sub>5</sub>  | trigonal bipyramidal | 120° & 90° |
| SF <sub>6</sub>  | octahedral           | 90°        |

## 2 Practice

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**2.1** State the shape and bond angle of a methane molecule,  $\text{CH}_4$ . [2]

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**2.2** State the shape of an ammonia molecule,  $\text{NH}_3$ . [1]

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## 3 Exam-style questions

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**3.1** What is the bond angle in a carbon dioxide molecule,  $\text{CO}_2$ ? [1]

|   |   |
|---|---|
| A | B |
| C | D |

**A**  $104.5^\circ$

**B**  $109.5^\circ$

**C**  $120^\circ$

**D**  $180^\circ$

**3.2** Why is the bond angle in water ( $104.5^\circ$ ) smaller than in methane ( $109.5^\circ$ )? [1]

|   |   |
|---|---|
| A | B |
| C | D |

**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  $\text{BF}_3$  molecule. [2]

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(b) Predict the shape and bond angle of an  $\text{NH}_4^+$  ion. [2]

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**3.4** Explain why ammonia ( $107^\circ$ ) has a smaller bond angle than methane ( $109.5^\circ$ ). [2]

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