

# 3 Chemical bonding – Part 2

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

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English                    | 中文        | Write it 3 times (English) |       |       |
|----------------------------|-----------|----------------------------|-------|-------|
| covalent bond              | 共价键       | _____                      | _____ | _____ |
| VSEPR theory               | 价层电子对互斥理论 | _____                      | _____ | _____ |
| lone pair                  | 孤对电子      | _____                      | _____ | _____ |
| bonding pair               | 成键电子对     | _____                      | _____ | _____ |
| bond angle                 | 键角        | _____                      | _____ | _____ |
| linear                     | 直线形       | _____                      | _____ | _____ |
| tetrahedral                | 四面体形      | _____                      | _____ | _____ |
| pyramidal                  | 三角锥形      | _____                      | _____ | _____ |
| bent                       | 角形        | _____                      | _____ | _____ |
| dipole                     | 偶极        | _____                      | _____ | _____ |
| polar                      | 极性        | _____                      | _____ | _____ |
| intermolecular forces      | 分子间作用力    | _____                      | _____ | _____ |
| London (dispersion) forces | 伦敦色散力     | _____                      | _____ | _____ |
| permanent dipole           | 永久偶极      | _____                      | _____ | _____ |
| Hydrogen bonding           | 氢键        | _____                      | _____ | _____ |

| English       | 中文 | Write it 3 times (English) |
|---------------|----|----------------------------|
| boiling point | 沸点 | _____                      |

## Recall

From Part 1 you know a **covalent bond** 共价键 is a shared pair of electrons. Here we work out the **shape** of a molecule and the weak forces **between** molecules.

- The shape decides many of a substance's properties.
- Weak forces between molecules explain melting and boiling points.

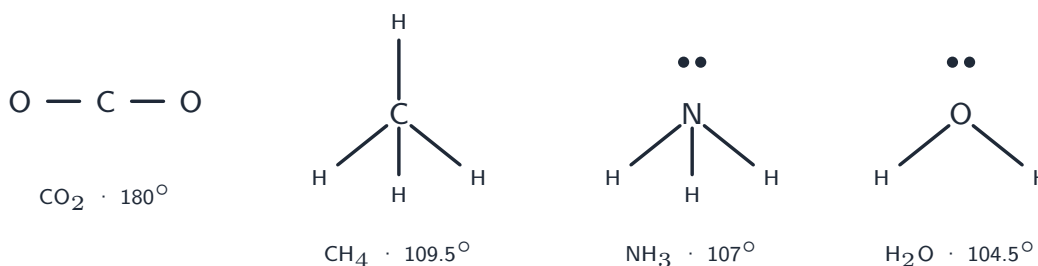
## New ideas

Read these first, then do the Practice.

### ■ 1 Shapes of molecules (VSEPR)

To find a shape, use **VSEPR theory** 价层电子对互斥理论: the electron pairs around the central atom push as far apart as possible. A **lone pair** 孤对电子 pushes harder than a **bonding pair** 成键电子对, squeezing the **bond angle** 键角.

| Molecule         | Shape                   | Angle  |
|------------------|-------------------------|--------|
| CO <sub>2</sub>  | <b>linear</b> 直线形       | 180°   |
| CH <sub>4</sub>  | <b>tetrahedral</b> 四面体形 | 109.5° |
| NH <sub>3</sub>  | <b>pyramidal</b> 三角锥形   | 107°   |
| H <sub>2</sub> O | <b>bent</b> 角形          | 104.5° |



### ■ 2 Polarity and dipoles

When atoms of different electronegativity bond, the electrons sit closer to the more electronegative atom. One end is slightly negative ( $\delta^-$ ) and the other slightly positive ( $\delta^+$ ) — a **dipole** 偶极. If the dipoles do not cancel, the molecule is **polar** 极性.

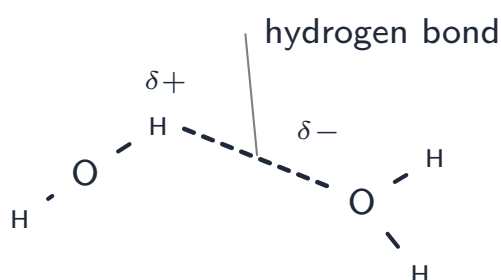
### ■ 3 Van der Waals' forces

These are the weak **intermolecular forces** 分子间作用力 *between* molecules:

- **London (dispersion) forces** 伦敦色散力 — brief dipoles from moving electrons; act between **all** molecules and get stronger with **more electrons**.
- **permanent dipole** 永久偶极 forces — between molecules that are always polar.

### ■ 4 Hydrogen bonding

**Hydrogen bonding** 氢键 is a strong special case: it forms when H is bonded to **N, O or F** and is attracted to a lone pair on an N, O or F atom nearby. It gives water its high **boiling point** 沸点, and makes ice **less dense** than water (so ice floats).



**Watch out:** hydrogen bonding only happens when H is bonded to N, O or F. A C–H bond does *not* hydrogen bond, so molecules like methane have only weak van der Waals' forces.

## Practice

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Try these in order.

**3.1** What does VSEPR theory say about the electron pairs around a central atom? [1]

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**3.2** State the shape and bond angle of (a)  $\text{CH}_4$ , (b)  $\text{CO}_2$ . [2]

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**3.3**  $\text{NH}_3$  has a smaller bond angle than  $\text{CH}_4$ . Explain why. [2]

**3.4** What is a *dipole*? [1]

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**3.5** London forces get stronger with more electrons. Explain what this means for boiling point down a group of similar molecules. [2]

**3.6** State the three elements (bonded to hydrogen) that allow hydrogen bonding. [1]

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**3.7 Challenge.** Water ( $\text{H}_2\text{O}$ ) boils at a much higher temperature than hydrogen sulfide ( $\text{H}_2\text{S}$ ), even though sulfur sits just below oxygen. Explain why. [2]

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