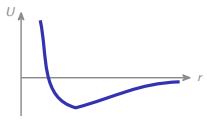
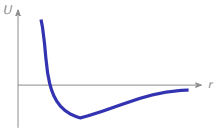
Compound Structure and Properties

AP Chemistry ▪ Unit 2

AP Chemistry



What we will cover



1 Bond types

Types of chemical bonds

A **chemical bond** 化学键 forms by what atoms do with valence electrons:

- **ionic** 离子键 – metal transfers to nonmetal
- **covalent** 共价键 – two nonmetals share
- **metallic** 金属键 – a shared electron sea

Network solids bond in giant lattices

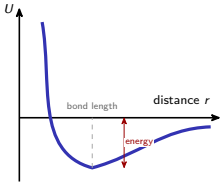
2 Bond energy

Bond energy and length

As two atoms approach, potential energy dips to a well:

- **bond length** 键长 – the distance at the minimum
- **bond energy** 键能 – the depth of the well

> Higher **bond order** 键级 (single→double→triple) ⇒ shorter and stronger.



3 Ionic solids

Ionic solids

Ions pack into a repeating **crystal lattice** 晶格, glued by **Coulombic attraction** 库仑吸引.

- higher charges + smaller ions ⇒ bigger **lattice energy** 晶格能
- high melting points; **brittle** 脆性 (a shifted layer repels)

MgO ($2+/2-$) melts far hotter than NaCl ($1+/1-$).

Ionic solids form ordered lattices

4 Metals

Metals and alloys

The **sea of electrons** 电子海: fixed + ions in a sea of **delocalized electrons** 离域电子. This explains:

- conductivity (electrons drift)
- **malleability** 延展性 (layers slide)
- **luster** 光泽 (electrons reflect light)

Alloys 合金: substitutional (brass) or interstitial (steel) – both harder.

Metals share a sea of delocalised electrons

5 Lewis

Lewis diagrams and resonance

A **Lewis diagram** 路易斯结构式 shows shared **bonds** 共价键 (lines) and **lone pairs** 孤对电子, aiming for an **octet** 八隅规则.

Formal charge picks the best

$$\text{FC} = V - (\text{lone}) - (\text{bonds})$$

Resonance 共振: when several equal structures exist, the real bonds are an average (delocalized).

O ═ C ═ O

O=C=O (linear)

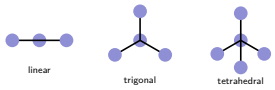
6 VSEPR

VSEPR and hybridization

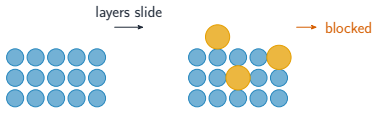
VSEPR 价层电子对互斥理论: electron domains push as far apart as possible.

- 2 domains – *sp* – linear
- 3 – sp^2 – trigonal planar
- 4 – sp^3 – tetrahedral

Lone pairs bend the shape; geometry decides **polarity** 分子极性.



Structure of Metals and Alloys

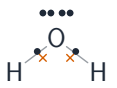


pure metal
same-size atoms; layers slide easily (softer)

alloy
different-size atoms stop the layers sliding (harder)

Different-sized atoms in an alloy stop the layers sliding, so it is harder

Lewis Diagrams



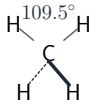
H_2O: 2 bonding pairs + 2 lone pairs

N_2: triple bond (3 shared pairs)

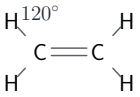
• electron from one atom
× electron from the other

Dot-and-cross diagrams show the bonding pairs and lone pairs in a molecule

VSEPR and Bond Hybridization



sp^3: 4 single bonds tetrahedral

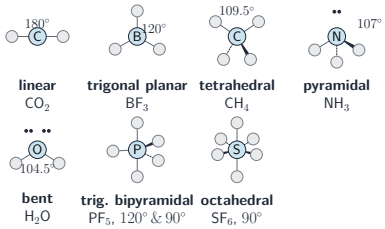


sp^2: 1 double + 2 single planar (flat)

sp: 1 triple bond linear

Hybridisation and shape: sp3 tetrahedral, sp2 planar, sp linear

The common VSEPR shapes and their bond angles



linear CO_2

trigonal planar BF_3

tetrahedral CH_4

pyramidal NH_3

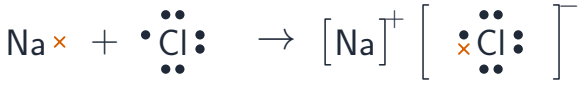
bent H_2O

trig. bipyramidal PF_5, 120° & 90°

octahedral SF_6, 90°

The common VSEPR shapes and their bond angles

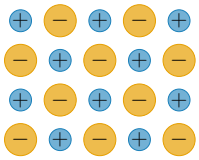
Types of Chemical Bonds, continued



sodium gives its outer electron (×) to chlorine

Ionic bonding: a metal transfers its outer electrons to a non-metal

Structure of Ionic Solids



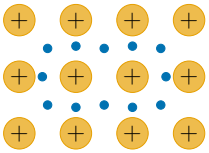
Cl^- ion

Na^+ ion

a regular, repeating 3-D pattern of alternating + and − ions

Ions pack into a giant lattice of alternating positive and negative ions

Structure of Metals and Alloys, continued



'sea' of **delocalised electrons**, free to move and carry charge

positive metal ions in a fixed lattice

Metallic bonding: positive ions in a sea of delocalised electrons

Exam tips

- Decide the bond type from the atoms: **ionic** (metal + non-metal, electron transfer), **covalent** (non-metals, sharing), **metallic** (sea of delocalised electrons).
- An ionic solid conducts only when **molten or dissolved** (ions free to move), never as a solid.
- Draw **Lewis structures** to satisfy the octet (H wants 2), then use **VSEPR** – electron pairs spread as far apart as possible – to predict the shape.

Exam tips (continued)

- **Lone pairs** take up space and push bonds closer, bending the shape (water is bent, ammonia pyramidal).
- A molecule can have polar bonds yet be **non-polar overall** if its symmetry makes the dipoles cancel (CO_2).
- A single bond is 1 **sigma** bond; a double bond is 1 sigma + 1 **pi**, a triple bond 1 sigma + 2 pi. Sigma is stronger than pi, and a pi bond blocks rotation, giving cis/trans **geometric isomers**.

7 Recap

Unit 2 – key takeaways

1 Bond types

ΔEN sets ionic / polar / nonpolar covalent

2 Bond well

depth = energy, minimum = length; order shortens it

3 Structures

ionic lattice; metals a sea of delocalized electrons

4 Shape

VSEPR: 2/3/4 domains → linear/trigonal/tetrahedral

Check yourself

1. A large electronegativity difference gives which bond type?
2. Going single → double → triple, how does bond length change?
3. Why do metals conduct electricity?
4. A central atom with 4 electron domains has what shape?

Answers **1.** ionic **2.** it shortens **3.** delocalized electrons drift **4.** tetrahedral