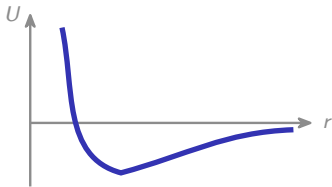


Compound Structure and Properties

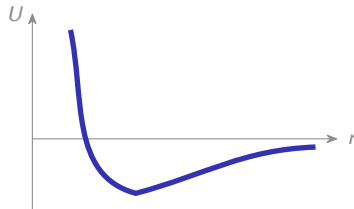
AP Chemistry ■ Unit 2

AP Chemistry



What we will cover

- 1 Types of chemical bonds
- 2 Bond energy and length
- 3 Ionic solids
- 4 Metals and alloys
- 5 Lewis diagrams and resonance
- 6 VSEPR and hybridization



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

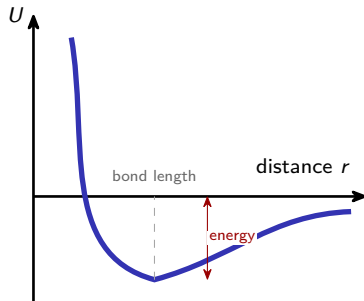
Bond energy

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) $\Rightarrow$ shorter and stronger.



3

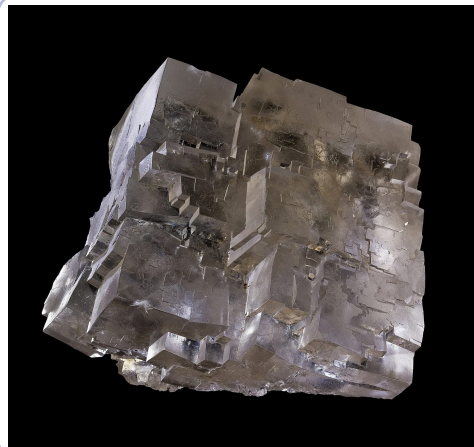
Ionic solids

Ionic solids

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

- higher charges + smaller ions $\Rightarrow$ 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

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

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



6

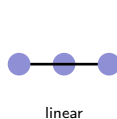
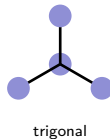
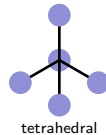
VSEPR

VSEPR and hybridization

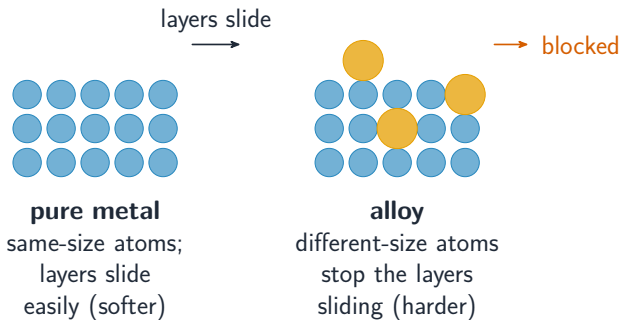
VSEPR 价层电子对互斥理论: electron domains push as far apart as possible.

- 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.

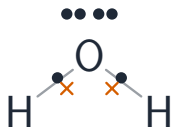


Structure of Metals and Alloys



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

Lewis Diagrams



H_2O : 2 bonding pairs
+ 2 lone pairs

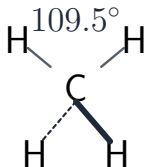


N_2 : triple bond
(3 shared pairs)

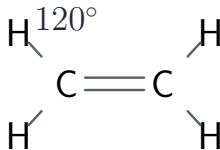
• electron from one atom
× electron from the other

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

VSEPR and Bond Hybridization



sp³: 4 single bonds
tetrahedral



sp²: 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



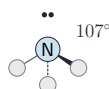
linear
CO₂



trigonal planar
BF₃



tetrahedral
CH₄



pyramidal
NH₃



bent
H₂O



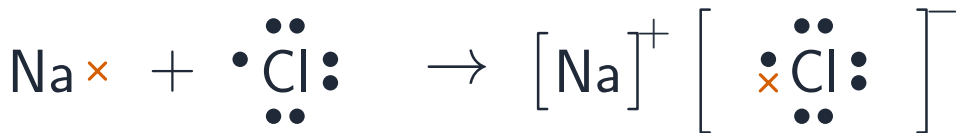
trig. bipyramidal
PF₅, 120° & 90°



octahedral
SF₆, 90°

Count electron domains on the central atom: 2 linear (180°), 3 trigonal planar (120°), 4 tetrahedral (109.5°). Lone pairs squeeze bond angles: water is 104.5°.

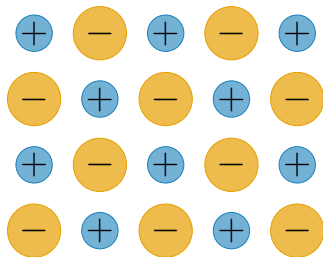
Ionic bonding: electrons transferred



sodium gives its outer electron (×) to chlorine

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

Structure of Ionic Solids



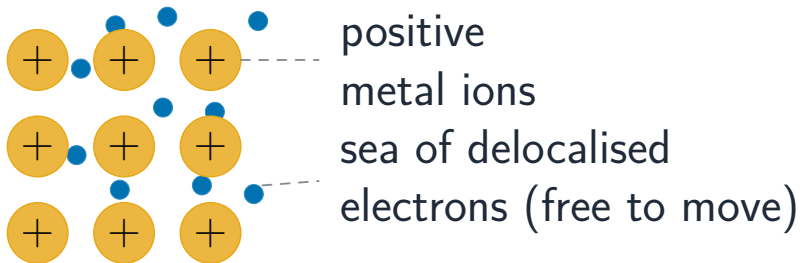
— Cl^- ion

+ Na^+ ion

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

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

Metallic bonding: a sea of electrons



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

Δ EN 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

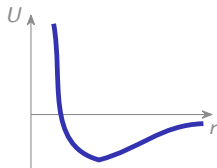
4

Shape

VSEPR: 2/3/4 domains $\rightarrow$ linear/trigonal/tetrahedral

Check yourself

- 1 A large electronegativity difference gives which bond type?
- 2 Going single $\rightarrow$ double $\rightarrow$ 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