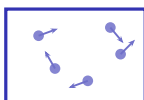


States of Matter

A-Level Chemistry ■ Topic 4

A-Level Chemistry



States of Matter

What we will cover

- 1 Gas pressure
- 2 Ideal gases
- 3 The ideal gas equation
- 4 The four structures
- 5 Diamond & graphite
- 6 Physical properties



boiling changes state

1 The gaseous state

States of Matter
↳ The gaseous state

Gas pressure

Pressure is the force from molecules hitting the walls.

more molecules

more hits per second $\Rightarrow$ higher p

higher T

faster molecules $\Rightarrow$ harder hits

smaller V

hits more often $\Rightarrow$ higher p

States of Matter
↳ The gaseous state

Ideal gases

An **ideal gas** 理想气体 is a model: point particles, no attractions, elastic collisions. Real gases approach it at **low pressure** and **high temperature** (far apart, moving fast).

The model fails when molecules take up a real volume (high p) or attract each other (low T).

States of Matter
↳ The gaseous state

The ideal gas equation

$$pV = nRT$$

Worked example

$$0.50 \text{ mol at } 27^\circ\text{C, } 100 \text{ kPa: } V = \frac{nRT}{p} = \frac{0.50 \times 8.31 \times 300}{1.00 \times 10^5} = 0.0125 \text{ m}^3$$

Convert first: $^\circ\text{C} \rightarrow \text{K}$ (+273), volume $\rightarrow \text{m}^3$. From $n = m/M$: $M = \frac{mRT}{pV}$ gives the **molar mass** 摩尔质量.

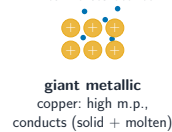
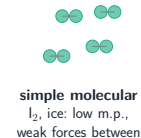
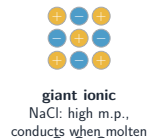


Quartz

2 Structure

States of Matter
└ Structure

The four structures



Four structures of a crystalline solid:

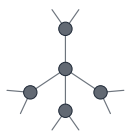
- **giant ionic** 离子晶体 – lattice of ions
- **simple molecular** 分子晶体 – small molecules
- **giant molecular** 原子晶体 – covalent network
- **giant metallic** 金属晶体 – ions in an electron sea

States of Matter
└ Structure

Diamond and graphite

Two giant covalent forms of carbon:

- **diamond** 金刚石 – a rigid 3-D network (very hard)
- **graphite** 石墨 – sliding layers & spare electrons that **conduct**



diamond
every C bonded to 4:
rigid 3D network, very hard



graphite
layers slide; spare
electrons let it conduct

States of Matter
└ Structure

Physical properties

giant ionic 离子晶体 – high m.p.; conducts when molten/dissolved; soluble

simple molecular – low m.p.; does not conduct; low solubility

giant molecular – very high m.p.; no conduction (except graphite); insoluble

giant metallic – high m.p.; conducts (solid & molten); insoluble

Strong forces → high **melting point** 熔点; **conductivity** 导电性 needs mobile ions or delocalised electrons.

States of Matter
└ Structure

Giant metallic



A piece of pure copper metal. The shine, and the way metals conduct and bend, all come from that giant lattice of copper ions sitting in a shared sea of delocalised electrons

States of Matter
└ Structure

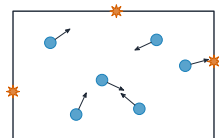
Giant molecular



A real diamond in the rock it grew in. That whole crystal is one giant molecule – a single unbroken network of carbon atoms, each bonded to four others. Breaking it means breaking countless strong covalent bonds, which is why diamond is the hardest natural material

A real diamond in the rock it grew in. That whole crystal is one giant molecule – a single unbroken network of carbon atoms, each bonded to four others.

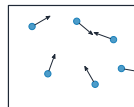
Where gas pressure comes from



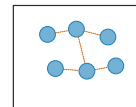
fast particles collide with the walls; the many pushes make the **pressure**

Gas pressure: fast molecules move in all directions and collide with the walls; the many tiny pushes add up to the pressure

Ideal gases, continued



ideal gas (model)
point particles, no forces



real gas: high p , low T
real size + attractions (dashed)

An ideal gas is a model: point particles with no forces between them. A real gas behaves least like this at high pressure and low temperature, when the particles are crowded and their real size and attractions start to matter

The ideal gas equation: what to remember

the equation

$pV = nRT$, with R the **gas constant** 气体常数 and T in **kelvin** 开尔文

its use

work out M_r from the **mass or the density** of a gas: $M_r = \frac{mRT}{pV}$

Every quantity goes in **SI units**: p in Pa, V in m^3 , T in K. Converting cm^3 and $^\circ\text{C}$ is where most marks are lost

Reading a structure from its properties

giant ionic 离子晶体

a huge regular **lattice** 晶格 of positive and negative **ions** 离子 – high melting point, brittle, conducts only when molten or aqueous

giant molecular

diamond, graphite, **silicon(IV) oxide** 二氧化硅, **fullerene** 富勒烯 – very high melting point; only graphite conducts

giant metallic

high melting point, malleable, and conducts as a solid

simple molecular

low melting and **boiling point** 沸点, and no **electrical conductivity** 导电性 at all

You can work **backwards**: from an unknown's melting point, conductivity and solubility, deduce which of the four structures it has. That is the standard question.

Exam tips

- Use **SI units** in $pV = nRT$: pressure in Pa, volume in m^3 ($\text{cm}^3 \times 10^{-6}$), temperature in K ($^\circ\text{C} + 273$).
- State the **ideal-gas assumptions** (negligible molecular volume, no intermolecular forces) and when real gases deviate (high pressure, low temperature).
- Link each property to structure: giant ionic (high m.p., conducts molten), giant covalent (very high m.p.), simple molecular (low m.p.), giant metallic (conducts, malleable).
- Graphite conducts because each carbon has a **delocalised** electron; diamond does not – a favourite comparison.

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Recap

Topic 4 – key takeaways

1 Gas pressure

collisions with the walls add up

2 Ideal gas

$pV = nRT$; zero volume, no forces

3 Structures

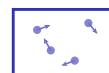
ionic, molecular, covalent, metallic

4 Properties

structure sets m.p., conductivity, solubility

Check yourself

- 1 Write the ideal gas equation.
- 2 When does a real gas behave least ideally?
- 3 Which giant covalent form of carbon conducts?
- 4 When does a giant ionic solid conduct electricity?



Answers 1. $pV = nRT$ 2. high pressure, low temperature 3. graphite 4. when molten or dissolved