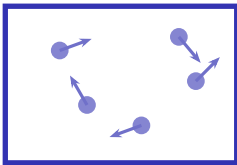


States of Matter

A-Level Chemistry ■ Topic 4

A-Level Chemistry



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



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 of-
ten $\Rightarrow$ higher p

Ideal gases

An **ideal gas** 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).

The ideal gas equation

$$pV = nRT$$

Worked example

0.50 mol at 27 °C, 100 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: °C → K (+273), volume → m³. From

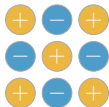
$$n = m/M: M = \frac{mRT}{pV} \text{ gives the molar mass .}$$



Quartz



The four structures



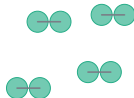
giant ionic

NaCl: high m.p.,
conducts when molten



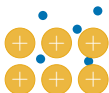
giant covalent

diamond, SiO₂: very
high m.p., insulating



simple molecular

I₂, ice: low m.p.,
weak forces between



giant metallic

copper: high m.p.,
conducts (solid + molten)

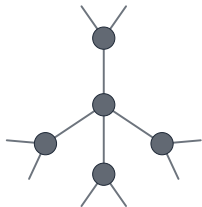
Four structures of a crystalline solid:

- **giant ionic** – lattice of ions
- **simple molecular** – small molecules
- **giant molecular** – covalent network
- **giant metallic** – ions in an electron sea

Diamond and graphite

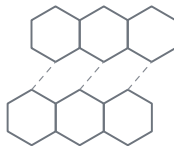
Two giant covalent forms of carbon:

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



diamond

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



weak forces

graphite

layers slide; spare
electrons let it conduct

Physical properties

giant ionic – 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** ; **conductivity** needs mobile ions or delocalised electrons.

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

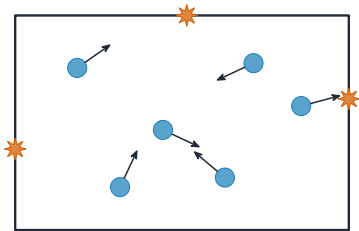
Giant molecular



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.

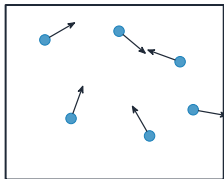
Where gas pressure comes from



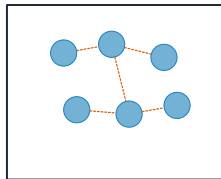
fast particles collide with the walls; the many pushes make the **pressure**

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** and T in **kelvin**

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

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

giant molecular

diamond, graphite, **silicon(IV) oxide** , **fullerene** – 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** , and no **electrical conductivity** 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.



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

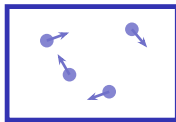
4

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