

States of matter

A-Level Chemistry 9701 · Topic 4 revision notes

Everything from the 3 lessons of this topic on a few pages: the key idea of each lesson, the diagram to remember, the points to learn and the traps examiners set. Read it, cover it, test yourself.

1. Ideal gases and $pV = nRT$

2. The liquid state

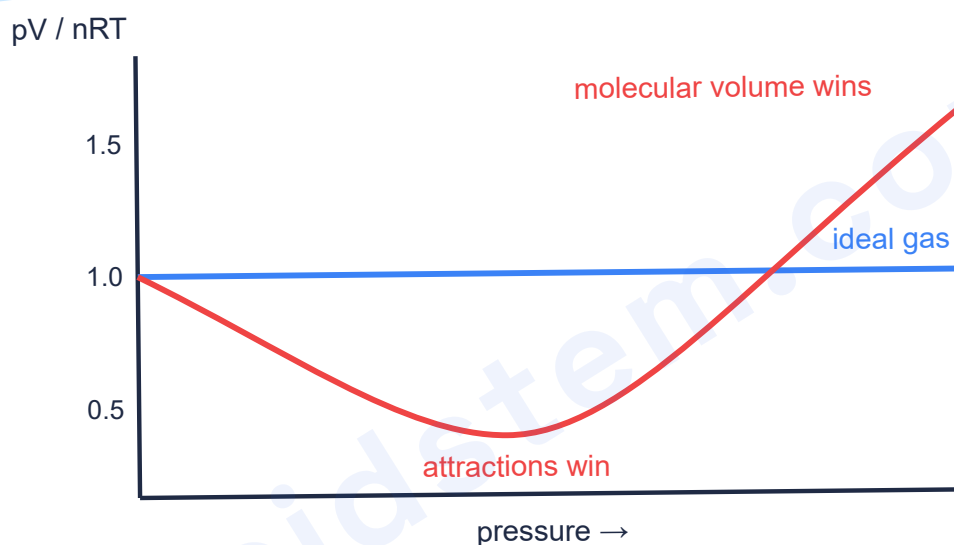
3. Lattice structures and properties

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1 Ideal gases and $pV = nRT$

Syllabus 4.1

An **ideal gas** obeys $pV = nRT$ exactly. The kinetic model assumes the molecules are in rapid random motion, have **negligible volume** compared with the container, have **no intermolecular forces**, and collide elastically. Real gases behave most ideally at **low pressure and high temperature**, where the molecules are far apart and move fast. In $pV = nRT$ use SI units: p in Pa, V in m^3 , T in K and $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$. Rearranged with $n = m \div M$, the equation gives $M = mRT \div pV$, a way to find M_r of a gas or volatile liquid.



a real gas matches the ideal line only at low pressure

Fig. 1: how far a real gas strays from ideal behaviour as the pressure rises

SI units every time.

- ✓ p in Pa, V in m^3 , T in K.
- ✓ $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$.
- ✓ $M = mRT \div pV$ with m in g gives g mol^{-1} .
- ✓ **Ideal:** low pressure, high temperature, weak forces.

Watch out!

Keep M in g mol^{-1} by leaving the mass in grams. And check your answer is sensible: an M_r of 0.058 or 58 000 for a simple liquid means a volume or pressure was not converted. A temperature in $^{\circ}\text{C}$ instead of K is the other classic slip.

2 The liquid state

Syllabus 4.2

In a liquid the particles are **close together but disordered**, moving randomly and sliding past each other while intermolecular forces still hold them. Melting overcomes only some of those forces, but vaporisation separates the particles completely, so the enthalpy change of vaporisation is much larger than that of fusion (water: 41 against 6.0 kJ mol⁻¹). In a closed container, evaporation and condensation reach a **dynamic equilibrium**; the pressure of the vapour then is the **vapour pressure**. It rises with temperature, and a liquid **boils** when its vapour pressure equals the external pressure.

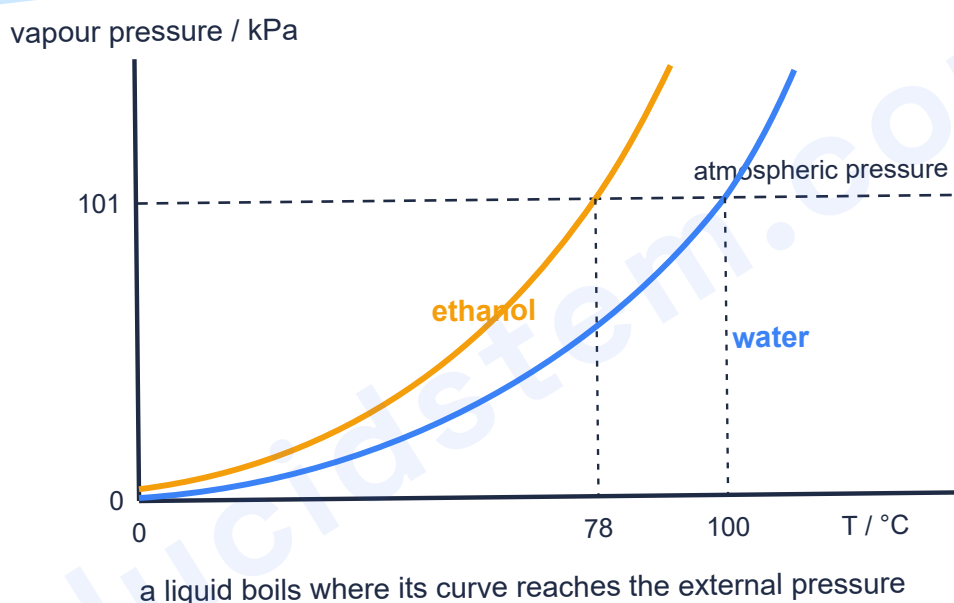


Fig. 1: vapour pressure against temperature for ethanol and water

Boiling is where vapour pressure meets outside pressure.

- ✓ **Liquid:** close, random, mobile particles.
- ✓ **$\Delta H_{\text{vap}} > \Delta H_{\text{fus}}$:** vaporising separates molecules completely.
- ✓ **Vapour pressure:** dynamic equilibrium, rises with T .
- ✓ **Weaker forces:** higher vapour pressure, lower b.p.

Watch out!

Evaporation happens at any temperature, from the surface only; boiling happens at one temperature for a given pressure, throughout the liquid. And when explaining vapour pressure, say the equilibrium is **dynamic**: both processes continue at equal rates, they do not stop.

3 Lattice structures and properties

Syllabus 4.3

A crystalline solid has a regular three-dimensional arrangement of particles called a **lattice**. There are four types: **giant ionic** (NaCl, MgO: ions held by ionic bonds), **giant metallic** (Cu: cations in delocalised electrons), **giant molecular** or covalent (diamond, graphite, graphene, SiO₂: atoms joined by covalent bonds throughout) and **simple molecular** (I₂, ice, C₆₀: molecules held by weak intermolecular forces). To explain a property, name the particles, the force that must be overcome, and how strong it is.

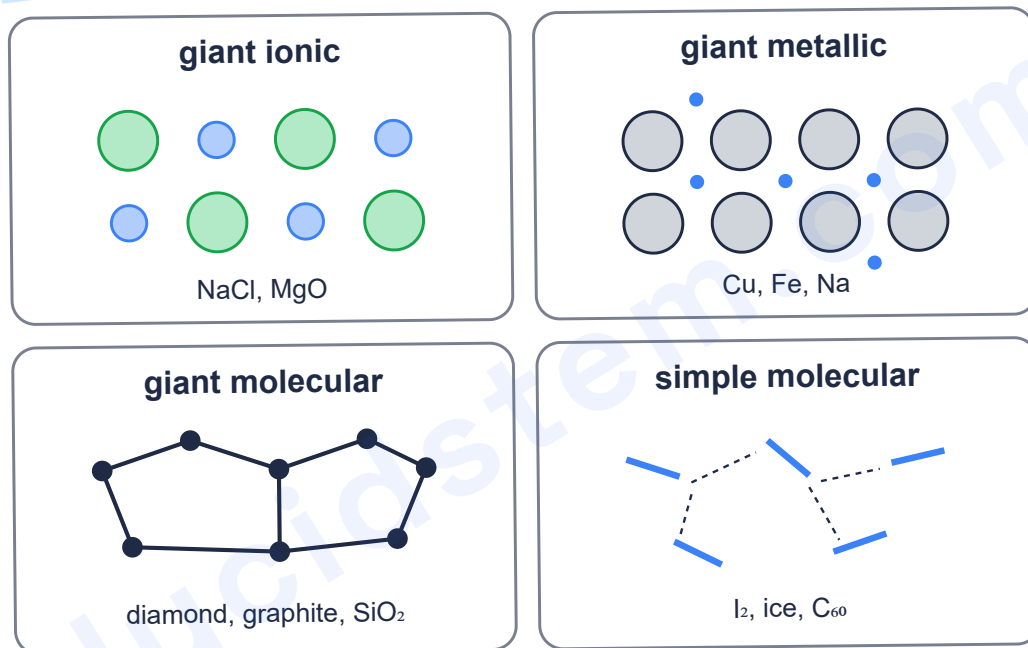


Fig. 1: the four types of lattice

Particles, force, strength.

- ✓ **Giant ionic:** ions, ionic bonds.
- ✓ **Giant metallic:** cations and delocalised electrons.
- ✓ **Giant molecular:** atoms, covalent bonds everywhere.
- ✓ **Simple molecular:** molecules, weak intermolecular forces.

Watch out!

For a giant molecular solid, melting breaks **covalent bonds**; for a simple molecular solid it overcomes only **intermolecular forces**. Mixing these up is the most common error in this section. Graphite conducts through **delocalised electrons**, not ions.