PROPERTIES OF COVALENT COMPOUNDS

Covalent Compounds
- Simple Covalent / Molecular
  - Polar
  - Non-polar
- Giant Covalent
  - Giant Covalent Lattices
    - graphite
    - diamond
    - SiO_2

SIMPLE MOLECULAR

Solids	Liquids	Gases
- I_2, S_8, P_4	- Br_2	- SO_2, CO_2, Cl_2, F_2, N_2, O_2, CH_4
- waxy solids, ie. higher alkanes	- CCl_4	- water vapour
- ice	- Hexane	
	- CH_3CH_2OH	
	- H_2O	

Structure : Simple Molecular (lattice)
Bonding : Covalent
Intermolecular force : ID-ID, PD-PD, H-bonds
(depends on the molecule)

General Properties :
- low melting points and low boiling points / volatile
  ↳ weak intermolecular forces are easily broken
- Usually gases, liquids, or soft solids
- Non-conductors of electricity in the solid + liquid states
  ↳ But can conduct in the aqueous state (ie. HCl)
  ↳ they are non-conductors because they do not have mobile / free electrons to carry the charge.

but in water $HCl(aq) \longrightarrow \underbrace{H^+ + Cl^-}_{\text{ions carry charge}}$

- The non-polar molecules are soluble in non-polar solvents as they have similar inter-molecular forces.

ie.

Oil (hydrocarbon) $\xrightarrow{\text{dissolve}}$ in Hexane (non-polar)
ID - ID   ID - ID

ie.

Paint thinner (non polar) ⟶ removes paint (non-polar)
ID - ID   ID - ID

- The polar molecules are soluble in polar solvents

ie. CH_3CH_2OH is soluble in water ⟶ because they can form hydrogen bonds with each other

Typical Non-polar Solvents
- CCl_4
- CH_2Cl_2
- Benzene (C_6H_6)
- Hexane

* HCl gas is a non-conductor, as there are no free electrons.
But HCl (aq) has ions to carry the charge, so aqueous HCl will conduct electricity.

- When questions ask to compare melting points → always do it in reference to structure, bonding, and intermolecular forces

		Melting Points:
Ar (g)	ID - ID	- 189°
HCl (g)	PD - PD	- 115°
H_2O (s)	H-bonds	0°C
I_2 (s)	ID - ID	114°C
$C_{12}H_{22}O_{11}$ (s) ↳ sucrose	H-bonds (very strong)	185°C

Q. Compare the melting points of these two.
The M.P of I_2 is greater because the instantaneous dipole - induced dipoles are stronger than the Hydrogen bonds (in ice). This is because I_2 has a larger Mr, and therefore more polarisable electrons and stronger ID - ID forces.

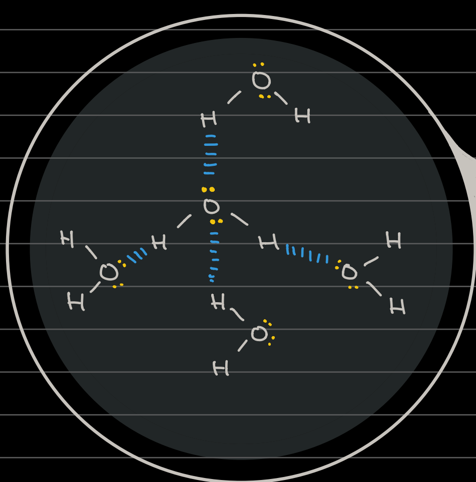
WATER (liquid vs. solid)

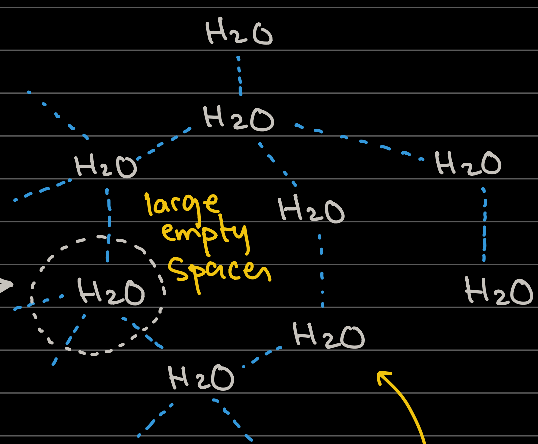
Ice

Q. Why is ice less dense than water? → Main question that we have to answer

Ice:

Tetrahedral Arrangement





- Ice has a open, fixed hexagonal arrangement of water molecules
- Large spaces within ice give the solid state a lower density
- Therefore, ice floats on water

Water:
- Liquid water also has intermolecular H-bonding
- But in water, there are no fixed hexagonal rings ↱ dimers, trimers, tetramers, etc.
↳ they are fluctuating rings made up of any number of H_2O molecules, but they are very unstable (ie. they keep forming and then breaking

immediately after, repeatedly)

GIANT COVALENT

Relevant Examples:
- Graphite
- Diamond
- SiO_2

Simple Molecule:
- C_{60} → discussed with giant covalent because it's an allotrope of carbon
  ↳ aka. "Buckminster Fullerene"
  ↳ member of the "fullerenes"
  "Bucky Ball"

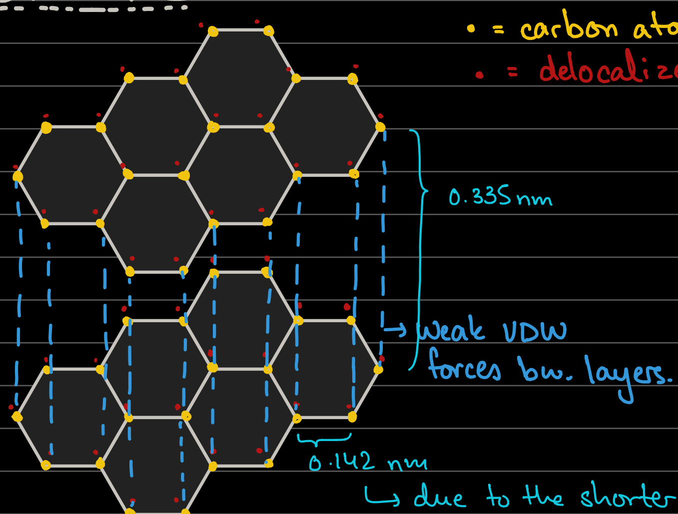
+ Allotropes: Two or more different forms of the same element in the same physical state but having a different atomic arrangement

3 Allotropes of Carbon (all solids)
1. Graphite
2. Diamond
3. C_{60}

	Graphite	Diamond	C_{60}
Density	$2.27\ g/cm^3$	$3.51\ g/cm^3$	$1.65\ g/cm^3$
Hardness	soft + slippery	hardest known substance	soft / slippery
Colour	Shiny black	transparent	black solid / purple in solution
Electrical Conductivity	Good conductor of electricity	Non conductor	Conducts some what - low conductivity

GRAPHITE

• = carbon atom
• = delocalized electrons



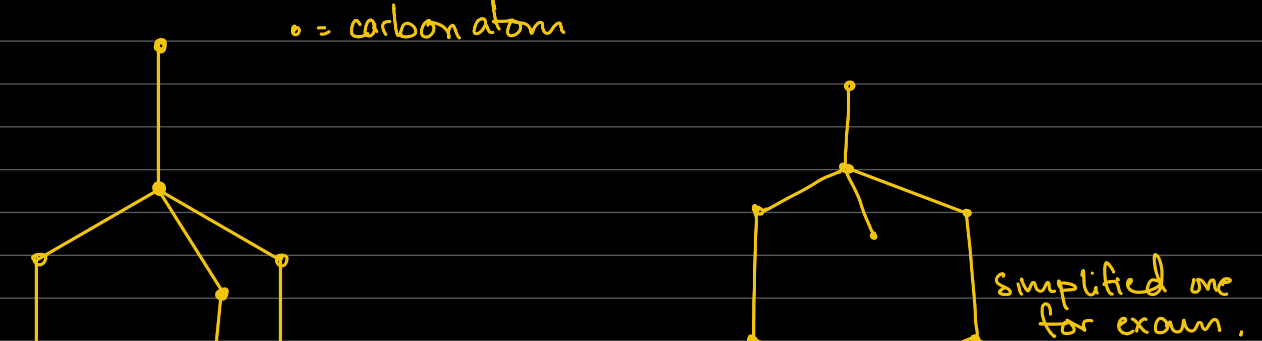
↳ due to the shorter C-C bond length, this bond is much stronger than the intermolecular force between the layers.

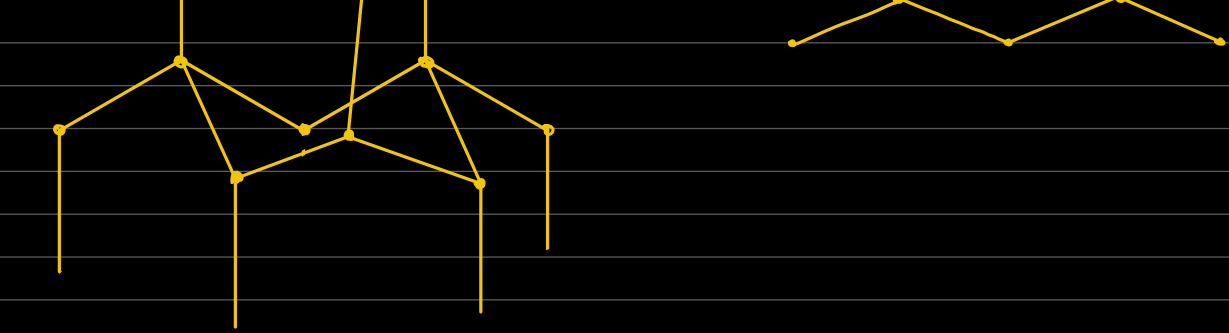
- Graphite has a giant covalent structure, made up of flat layers of carbon atoms arranged hexagonally
- The flat sheets are stacked together, and are connected by weak van der waal's forces of attraction.
- within each layer, each C atom is bonded covalently to 3 other C atoms
- The fourth valence electron is available for pi bonding between adjacent carbon atoms, resulting in delocalization throughout the layer.
- The delocalized mobile electrons allow graphite to conduct electricity only in the plane of the sheet (horizontally)

Properties of Graphite (Structure + Bonding)

1. High melting point / boiling point
   - A large amount of energy is required to break the strong covalent bonds between carbon atoms held in the giant covalent lattice.
2. Good conductor of electricity
   - Because it has delocalized electrons to conduct within hexagonal layer
3. Insoluble in all solvents
   - In both polar and non-polar solvents. As the solvent molecules cannot penetrate the graphite lattice due to the presence of strong covalent bonds within the layers
4. Soft and Slippery
   - The van der waal's forces between the layers are relatively weak and are easily broken
     ↳ Graphite is also used as a lubricant for this reason

DIAMOND





- Each C atom is bonded covalently to 4 other carbon atoms in a virtually endless array
- There are strong C-C single covalent bonds throughout the lattice
- The electrons are 'localised', so diamond does not conduct electricity [No free electrons]
- Diamond has a 3D covalent network of interlocking hexagons

→ Simple Molecular Structure

C_{60} - BUCKMINSTER FULLERENE

↳ "Fullerenes"

C_{60} C_{70} C_{120}

- Discovered originally in soot
- Hollow, spherical
- Each C is bonded covalently to 3 other carbons, and they are arranged in hexagonal + pentagonal rings
- 12 pentagons, 20 hexagons
- Some delocalization of electrons - but less than graphite
  ↳ weak conductor

Properties

- It sublimes at ~600°C - it has weak VDW forces bw. the molecules.
- It is relatively soft (VDW forces)
- Somewhat soluble in non-polar solvents like benzene and methyl-benzene → forms a violet solution

Graphene :
- A flat layer / sheet of carbon atoms
- Hexagonal
- One atom thick
- very light layer