C2 – Bonding, structure, and the properties of matter

Formation of Ions

- **Ions** = a charged particle made when atoms lose or gain electrons
- **Positive ion** = atom has lost electrons
- **Negative ion** = atom has gained electrons.

Metals form **positive ions**
Non-metals form negative ions

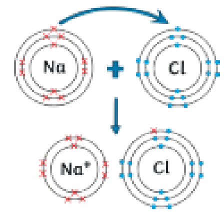
Group	Ions	Example
1	+1	Li → Li^+ + e^-
2	+2	Ca → Ca^{2+} + $2e^-$
6	-2	O + $2e^-$ → O^{2-}
7	-1	Br + e^- → Br^-

Lost electrons (groups 1 and 2)

Gained electrons (groups 6 and 7)

Ionic Bonding

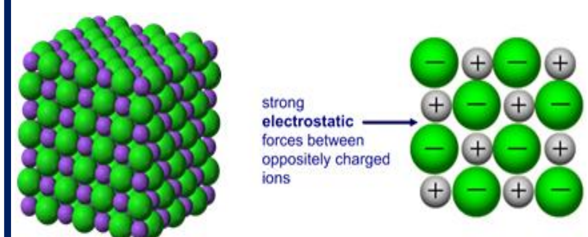
- Between a metal and non-metal.
- Metals give electrons to non-metals so both have a full outer shell.
- **Electrostatic force of attraction** between positive and negative ions.



E.g. Sodium loses one electron to become Na^+. Chlorine gains one electron to become Cl^-. The two ions attract to form sodium chloride.

Ionic compounds

- Form **giant lattices, as the attraction between ions acts in all directions**

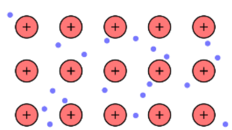


Properties of Ionic Compounds

- **High melting point** – lots of energy needed to overcome electrostatic forces.
- **High boiling point**
- **Cannot conduct electricity as solid** – ions cannot move
- **Conducts electricity when molten or dissolved** – ions are free to move.

Metallic Bonding

- Happens in **metals only.**
- Positive metal ions surrounded by **sea of delocalised electrons (can move).**
- Ions tightly packed in rows.

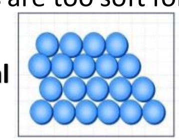


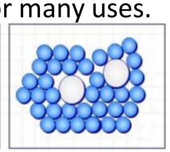
- Strong **electrostatic forces of attraction** between positive ions and negative electrons.

Alloys

- **Alloys** = mixture of two or more metal atoms
- Pure metals are too soft for many uses.

Pure Metal





Alloy

Pure metal:

- Atoms same size
- Layers slide
- Softer

Alloy:

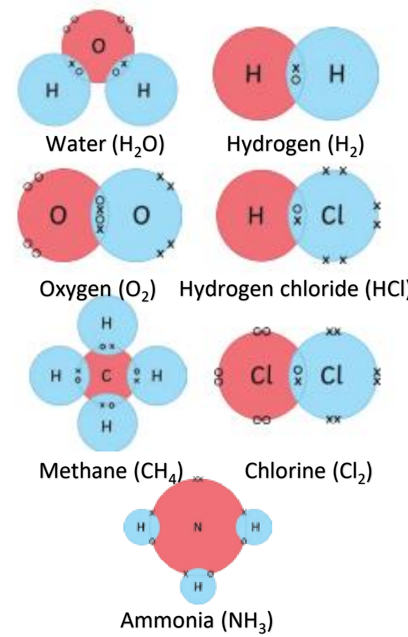
- Different sized atoms
- Layers cannot slide
- Stronger

Covalent Bonding

- **Covalent bonding** = sharing a pair or pairs of electrons for a full outer shell.
- Between **non-metals only.**

Dot and cross diagrams

- Show the bonding in simple molecules.
- Uses the outer shell of the atoms
- Crosses and dots used to show electrons
- You should be able to draw the following:



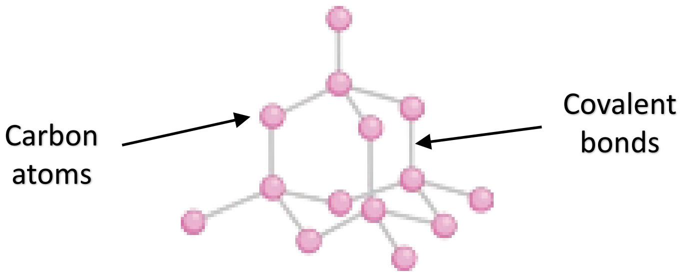
Simple Covalent Molecules

- Form when all atoms have full outer shells so bonding stops
- Examples are the molecules shown above.
- Have **low melting and boiling points**
- Due to **weak intermolecular forces**
- Do not conduct electricity

C2 – Bonding, structure, and the properties of matter

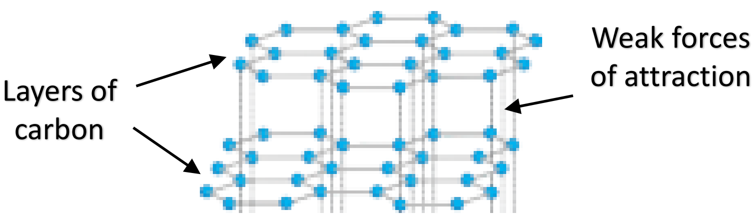
Giant Covalent Structure – Diamond

- Each carbon atom **covalently** bonded to **four** others.
- Forms a giant structure
- This makes diamond **strong** → a lot of **energy** needed to break lots of strong covalent bonds.
- **Does not conduct electricity** – has no free electrons.



Giant Covalent Structure – Graphite

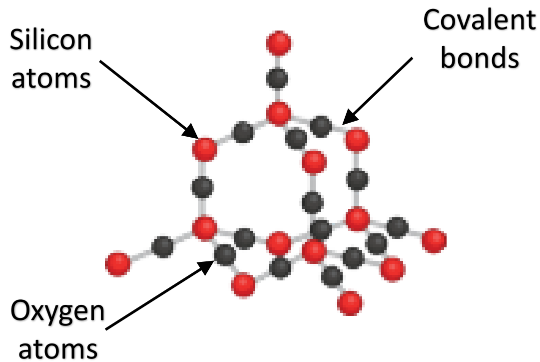
- Layers of **carbon** arranged in **hexagons.**
- Each carbon bonded to **three** other carbons.
- Leaves **one delocalised electron** → moves to carry electrical charge **throughout structure.**



- Layers held together by **weak forces**
- Layers can **slide** over each other easily
- Makes graphite **soft/slippery** → good lubricant.
- Has **high melting point** as has many strong covalent bonds.

Silicon Dioxide

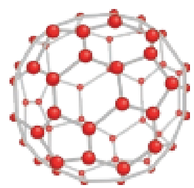
- Similar structure to diamond
- Giant covalent structure.
- Lots of **strong covalent bonds**.
- These require lots of **energy** to break.
- High melting and boiling points.



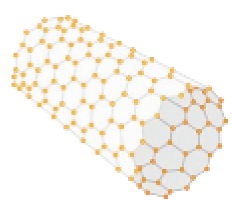
Fullerenes and Nanotubes

- Molecules of carbon shaped into hollow tubes or balls.
- Used to **deliver drugs into body**

Buckminsterfullerene
Formula = C_{60} →

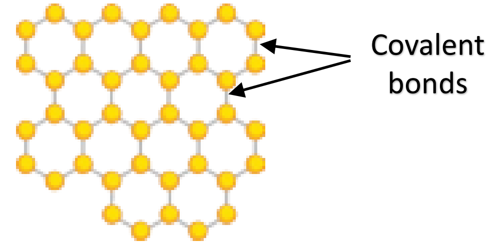


- **Carbon nanotubes** = long narrow tubes
- Can conduct electricity
- Can strengthen materials without adding weight.
- Used in electronics and nanotechnology.



Graphene

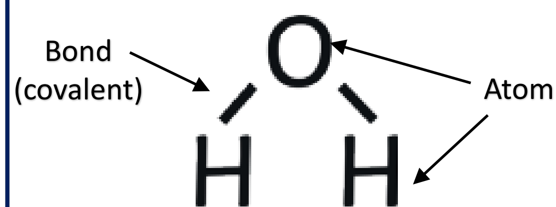
- Graphene = one layer of graphite.
- Very strong → lots of strong covalent bonds.

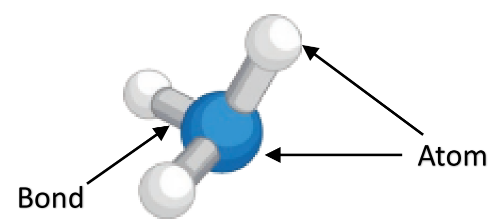


- Each carbon bonded to three others.
- One **free delocalised electron** → can move to **carry electrical current** throughout **the structure.**

Molecular models

- There are different ways to show a molecule other than dot and cross diagrams.

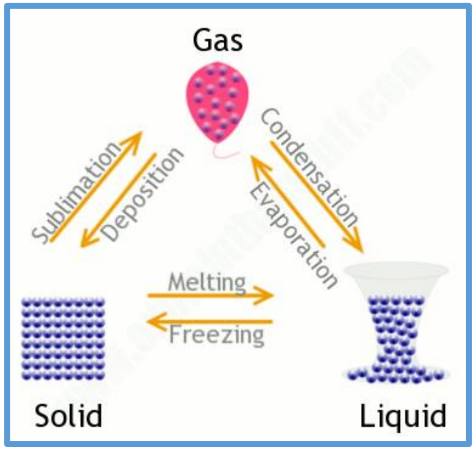




3D model

C2 – Bonding, structure, and the properties of matter

States of Matter
- Three states of matter: **solid, liquid & gas.**
- To change state, **energy** must be **transferred**.

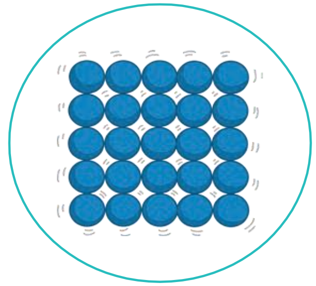


- When heated, particles **gain energy**.
- **Attractive forces** between particles begin breaking when melting or boiling points are reached
- **Amount of energy** needed to change state depends on how strong forces are.

Gas
- Randomly arranged.
- Particles **move quickly** – all directions.
- Highest **amount** of **kinetic energy.**

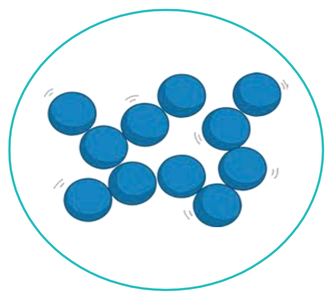
- Gases **are able to flow** – fill containers
- **Can be compressed as there is space between particles**

Solid
- **Regular** pattern (rows and columns)
- Particles **vibrate** in a **fixed position**.
- Particles have **low amount of kinetic energy.**



- Have a **fixed shape** – cannot flow because of strong forces of attraction between particles
- **Cannot be compressed** – particles close together.

Liquid
- Particles **randomly** arranged and touching.
- Particles can **move around.**
- **Greater amount** of **kinetic energy** than solid



- Liquids **able to flow** – take shape of containers.
- **Cannot be compressed** – particles are close together and cannot be pushed closer

State symbols
- States of matter shown in chemical equations:
- Solid **(s)**
- Liquid **(l)**
- Gas **(g)**
- Aqueous **(aq)**
- **Aqueous** solutions = substance dissolved in water.

Identifying Physical State of Substances
- If the temperature is **lower** than a substance's melting point – substance is **solid**.
- If the temperature is **between** the melting point and boiling point – substance is **liquid**.
- If the temperature is **higher** than the boiling point – substance is a **gas.**

Limitations of Particle Model (HT)
- No chemical bonds are shown.
- Particles shown as solid spheres – not the case, particles are mostly empty space like atoms.
- The diagrams don't show any of the forces between particles
- The diagrams are unable to show the movement of the particles.