Chemical Bonding

Ionic (electrovalent) Bonding

Typical ionic compounds are formed when metals in groups 1 and 2 such as sodium and magnesium, react with non-metals in groups 6 and 7.

- Electrons are transferred from metal to non-metal
- Electrons are transferred until noble-gas configuration is achieved.
- E.g lithium oxide, magnesium fluoride, sodium chloride, hydrogen fluoride

Properties of Ionic Compounds
- Hard crystalline substances
- High melting and boiling points
- Soluble in water and other polar solvents
- Do not conduct electricity as solids as ions are not free moving
- Can conduct electricity as liquid or aqueous as ions are free moving

Covalent Bonding
- Sharing of electrons
- To achieve noble gas configuration
- 1 pair of shared electrons is known as a single bond.
- Electrons which are not shared form lone pairs

Number of covalent bonds usually formed by some non-metals

Element	Symbol	Number of covalent bonds usually formed
Hydrogen	H	1
Chlorine	Cl	1
Oxygen	O	2
Sulfur	S	2
Nitrogen	N	3
Carbon	C	4

Properties of simple molecular substances

- Covalent bonds that hold atoms together within simple molecular substances are strong. Molecules do not readily break up into atoms.
- Are usually gases or liquids at room temperature
- Do not conduct electricity as solids, liquids or in solution because they have no ions or electrons to carry electric charge.

Properties of giant molecular substances

- Billions of atoms linked together by covalent bonds
- Very strong covalent bonds
- Hard solids
- Have very high melting points
- Do not usually conduct electricity
- Are insoluble in polar and non-polar solvents.

Dative covalent bonds (coordinate bonds)

- Electrons that are not involved in bonding are lone pairs.
- Lone pairs are “donated” to other atoms which are electron deficient, forming a dative covalent bonds.
- **A = electron rich**
- **B = electron deficient**

A and B share A’s electrons.

Metallic Bonding

Close packing of metal atoms

- This close packing allows metal atoms in one layer to get as close as possible to those in adjacent layers above and below forming a giant structure of closely packed atoms.
- Each atom touches 12 other atoms altogether; 6 in the same layer, 3 in the layer below and 3 above.
- This is described as a **giant lattice**.

Sea of Delocalized electrons

- Electrons in the outer shell of each atom can drift through the whole lattice structure.
- These outer shell electrons which are free to move and are shared by several atoms, are described as **delocalized.**

Therefore a metal can be seen as giant lattices of positive ions with electrons moving around and between them in a 'sea or cloud' of 'delocalized' negative charge. The strong electrostatic forces between the cations and the sea of delocalized electrons bind the metal structure strongly together as a single unit.

As a result of these strong forces between atoms, metals :

- Have high melting and boiling points
- Have high densities
- Are good conductors of heat and electricity (free moving electrons)
- Are malleable

Electronegativity

Electronegativity of a particular element is a measure of its pull on electrons relative to other atoms.

- Elements like chlorine and oxygen, which have a stronger pull on shared electrons in a covalent bond than elements such as hydrogen have higher values of electronegativity.
- In a polar O – H bond, there is a delta- charge on the O and a delta+ charge on the H atom
- Can be measured using the Pauling Scale
- Increases across a period and up a group.

- Fluorine is the most EN element.

Intermolecular Forces

Permanent Dipole attractions

Polar molecules with permanent dipoles have pd-pd intermolecular interactions. The delta+ charge on one molecule tends to attract the delta- charge on other molecules and vice versa. These attractions between polar molecules are called permanent dipole interactions.

Induced Dipole attractions

Non-polar molecules with no permanent dipole have instantaneous dipole – induced dipole interactions.

- Electrons in atoms and molecules are in continual motion.
- At any particular moment, the electron charge cloud around the molecule will not be perfectly symmetrical.
- There will be more negative charge on one side of the molecule than on the other.
- The *instantaneous electric dipole* which induces dipoles in neighboring molecules.
- Positive dipoles will tend to induce negative dipoles and vice versa.

As the size of the molecule increases, the number of constituent electrons increases. As a result, the induced dipole attractions between molecules become stronger. This explains why the boiling points increase down Group 0 and Group VII.

Hydrogen Bonding

Nitrogen, oxygen and fluorine are the three most EN elements.
H atom has no inner shell of electrons, the single proton in its nucleus is exceptionally 'bare' and very attractive to any lone pair of electrons on another H_2O.

Requirements:

- A H atom bonded to a highly electronegative atom (F, O or N)
- An unshared pair of electrons on a second electronegative atom.
- Any molecule with H directly bonded to F, O or N will have Hydrogen Bonding (intermolecular)