Bonding & Structure of Elements

03/09/25 Chemistry

Context

- The position of elements on the periodic table determines their reactivity and hence properties in terms of reactivity & structure.
- This is because the periodic table is arranged in terms of valence electrons, increasing from left to right (with the exception of the transition metals).

Definitions

- Metals - to the ~~right~~ left of the stepped line are metallic elements, typically conductors of heat & electricity, ductile and malleable.
- Non-metals - to the right of the stepped line are non-metallic elements, usually worse conductors of heat & electricity, often unmalleable when solid or gaseous at room temperature.
- Metallic lattices - form between metallic atoms and are defined as the electrostatic force of attraction. High melting & boiling points.
- Covalent network - a potentially infinite formation of atoms covalently bonded. Very high melting & boiling points
- Covalent molecules - discrete formations of covalently bonded atoms separate from one another. Low melting and boiling points.
- Ionic lattices - potentially infinite crystalline lattice formed out of positive and negative ions.

Technique

- Metallic elements: Lithium, Beryllium, Sodium, Magnesium, Aluminium, Potassium, Calcium
- Covalent networks: Boron, Carbon (when in the form of graphite or diamond), Silicon
- Covalent molecules: Hydrogen, Carbon (in the form of fullerene), Nitrogen, Oxygen, Fluorine, Phosphorous, Sulphur, Chlorine
- Monatomic: Helium, Neon, Argon

in the first 20 elements

Thing to Remember

- Carbon can be both molecular and network. It is only molecular in the form of Buckminsterfullerene, or fullerene for short.

Trends in the Periodic Table

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Context

- There are three new trends in the Periodic Table that you need to know for Higher. These three are closely linked and generally all revolve around the structure of the electron orbitals in an atom.

Definition

- Covalent radius - half the distance between the nuclei of two bonded atoms.
- First ionisation energy - the energy required to remove one mole of electrons from one mole of gaseous atoms.
- Electronegativity - a measure of the attraction/affinity an atom in a bond has for the electrons involved in that bond.
- Nuclear charge - how strong the charge of an atomic nucleus is, e.g. how many protons does it have.
- Screening effect - an effect by which electrons are less affected by the nuclear charge as they are further away and there are more occupied electron shells between them.

Equations

- First ionisation energy - $E_{(g)} \rightarrow E^{+}_{(g)} + e^{-}$

Technique

- Covalent radius decreases across a period as the increased nuclear charge holds electrons tighter. It increases down a group as there are more occupied electron shells and the screening effect is greater.
- Electronegativity increases across a period as the covalent radius is smaller and the nuclear charge is greater so bonding electrons are attracted more. It decreases down a group due to the increased covalent radius and the screening effect of the occupied inner electron shells.

- First ionisation energy increases across a period as the greater nuclear charge means it takes more energy to remove an electron. It decreases down a group as the electron being removed is further away from the nucleus due to occupied inner electron shells and is therefore more screened.
- A question that commonly comes up is e.g. why is the third ionisation energy of Magnesium so much higher than the second?
- As the third removed electron is part of a full shell it is closer to the nuclear charge and less screened by inner electron shells than the second electron, so it takes less energy to remove.

Thing to Remember

- Use the words 'nuclear charge', 'inner electron shells' and 'screening effect'!