ORIGIN OF BAND GAP (OR) ENERGY GAP

❖ Definition:

❖ The **band gap** is the **energy difference** between the **top of the valence band** and the **bottom of the conduction band** in a solid.

It represents the **minimum energy required** for an electron to move from the valence band to the conduction band, allowing electrical conduction.

$$E_g = E_c - E_v$$

- **Where:** E_g = Band gap energy

  E_c = Energy at the bottom of conduction band

  E_v = Energy at the top of valence band

Origin of Band Gap:

❖ Each atom has discrete and fixed energy levels for its electrons.

❖ When atoms are far apart, their electrons occupy specific, discrete energy levels which do not interact.

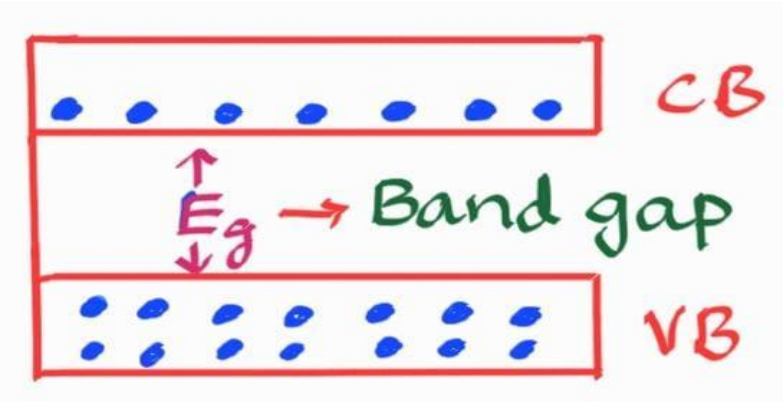
❖ When many atoms come close together to form a solid crystal, their **outer electron orbitals overlap**.

❖ Due to the **Pauli Exclusion Principle**, no two electrons can occupy the same energy state.

❖ Therefore, the discrete atomic levels **split into many closely spaced energy levels**. When the number of atoms is very large (around 10^{23}), these closely spaced levels form **continuous energy bands**.

❖ The **lower energy band** becomes the **valence band**, and the **higher energy band** becomes the **conduction band**.

❖ Between these two bands, there exists a range of **forbidden energy gaps** where no electron states are allowed.This **forbidden region** is called the **band gap** or **energy gap**.



- The size of the band gap depends on the **interatomic distance**, **crystal structure**, and **bonding strength**.
- So,the **band gap originates** from the **splitting of atomic energy levels** when atoms combine to form a solid.

Importance

- The **band gap determines** the electrical behavior of materials:

Conductor: No band gap (bands overlap).

Semiconductor: Small band gap (≈ 0.1–3 eV).

Insulator: Large band gap (> 3 eV).