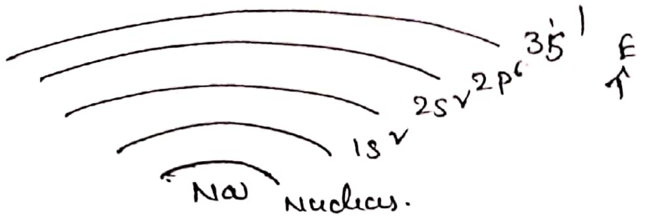
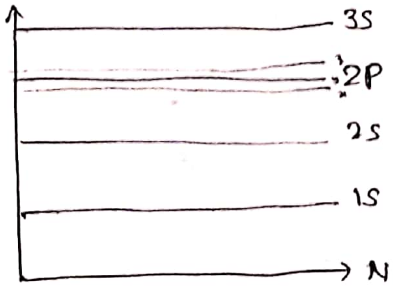
Energy band formation in solids

In an isolated atom

Na – $1s^2 2s^2 2p^6 3s^1$

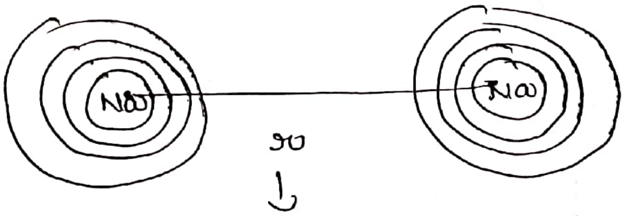




A convenient way of represent ation of energy of orbits is called energy level diagram.

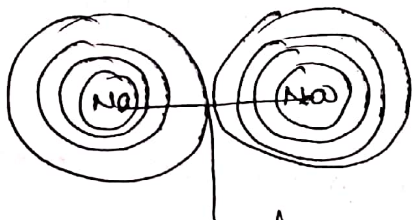
when we consider two atoms

far from each other – No effect on one another



interatomic spacing is high

But in reality, in solids they are very close to eachother



overlapping of orbits occurs

B'coz +ve ion core of one atom attracts the e^- cloud of other atom vice versa.

↓

disturbance occurs

↓

That disturbance is called perturbation.

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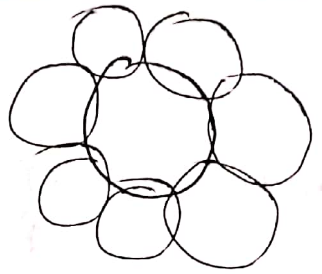
for example if we consider one Na atom cy closely surrounded with other 10 Na atoms then.

first → outermost e⁻s are/ orbits are effected.



(3s)

10 Na atoms → 10 energy levels.

they grouped into bands

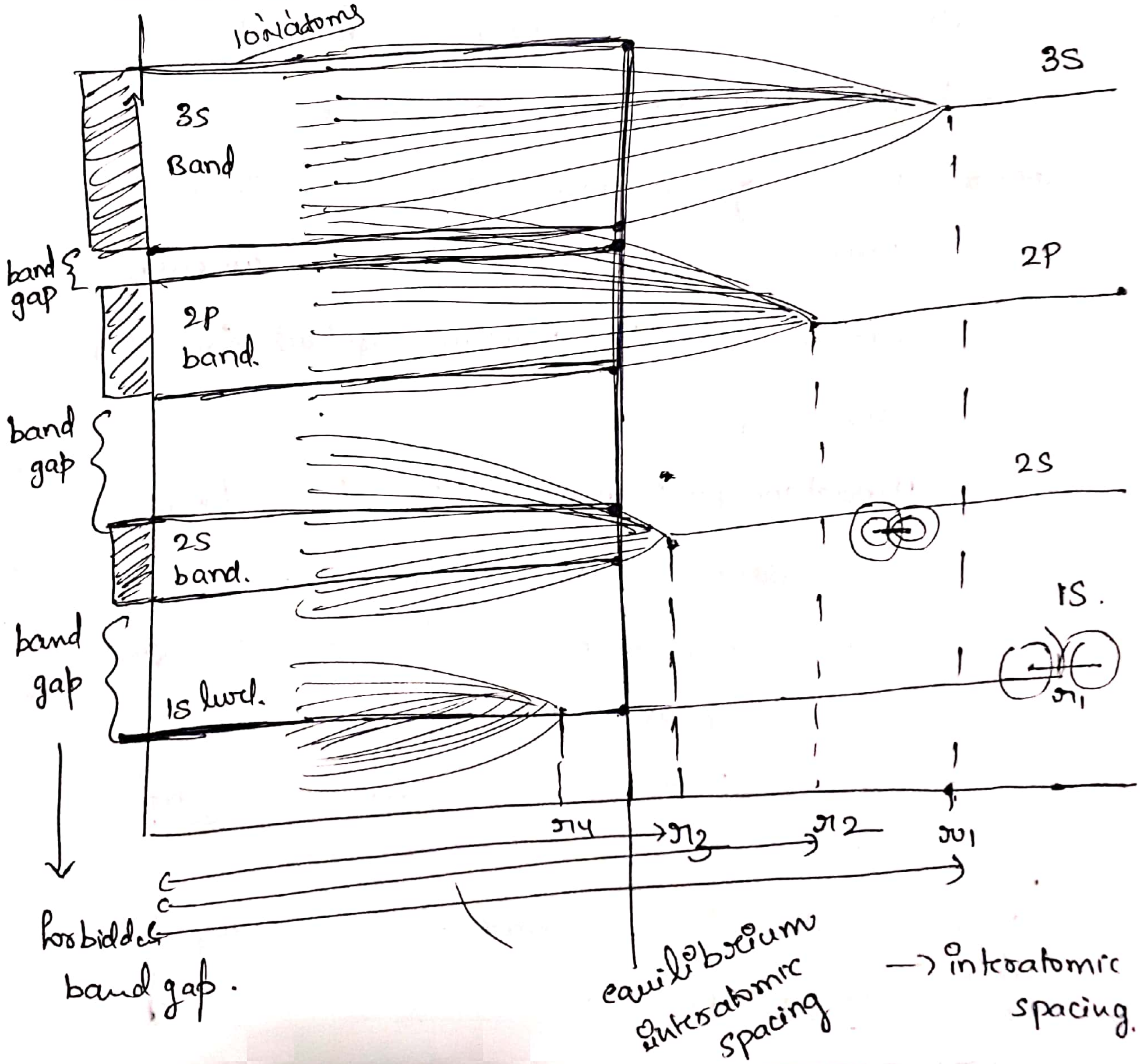
If they are very very close then → 2p levels effected
(attraction cy more)

" further → 2s "
(attraction more more)

→ 1s "

" " (more ↑

which can be understood from the following diagram.



At 'r_1' interatomic spacing → 3s levels disturbed
(I.d)
& splits into closely formed bands

If I.d decreases further r_2

r_2 ⟶ 2p levels disturbed → 2p band formed

If I.d decreases further r_3.

r_3 ⟶ 2s " → 2s band formed

If I.d decreases further to r_4

r_4 → 1s ⟶ 1s band formed.

But here we have to think one point

~~after~~ Nucleus of one atom attracts the ion core upto particular value only if it increases further both the nucleus repelled & e^- cores also repelled.

Hence at one particular point $F_{att} = F_{rep}$

is called equilibrium point.

i.e formation of bands also possible upto this point only.

after that the band formation is not possible.

$\boxed{\text{width of allowed energy band increases as energy increases}}$

classification of solids from band structure

Depending upon the band structure solids are classified into 3 types

↳ conductors – semiconductors – Insulators

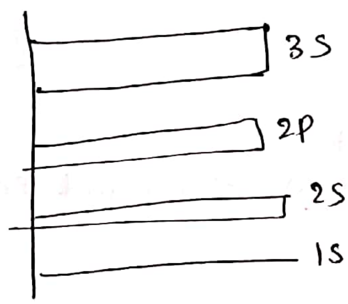
Electrical prop. of materials are the consequence of its electron band structure.

First conductors – Metals – Two diff. types of band structures exist

one for completely filled outer most state / partially filled state.

If we consider atoms in solid

Na – $1s^2 2s^2 2p^6 3s^1$



3s → outermost region / orbit / band valence band may be

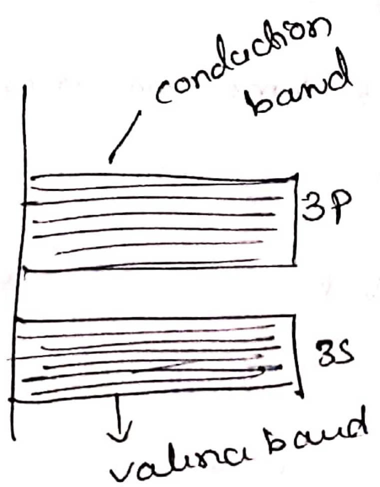
it is completely filled or partially filled.

↓

which contain valence e^- which are loosely bounded to nucleus.

↓

The band which contains these e^-s → valence band



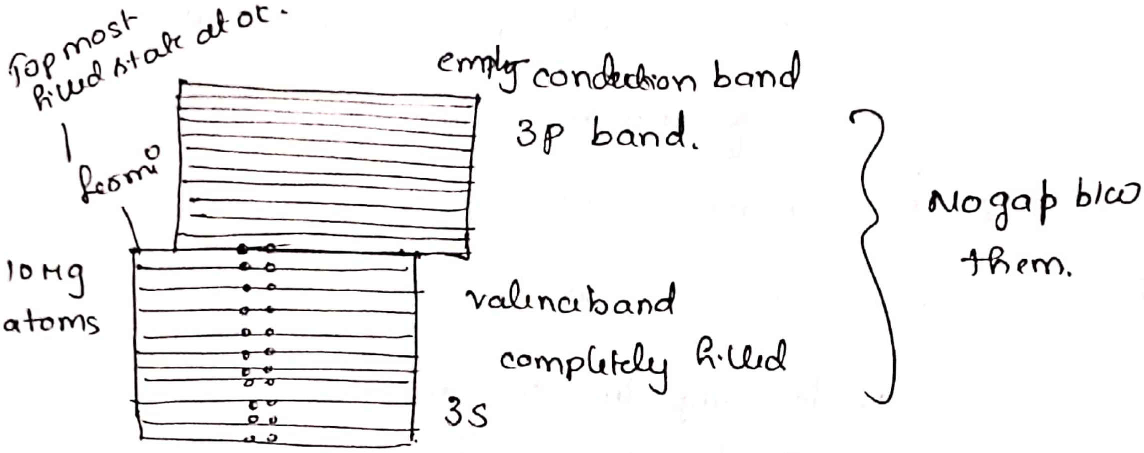
Above this 3s orbit → 3p orbit is there which is close to 3s level in which no e^-s are present → i.e it is empty

→ It is known as conduction band

Metals (OK) / conductors

~~Structure~~. Mg — $1s^2 2s^2 2p^6 \underline{3s^2}$ (12) (completely filled shells)

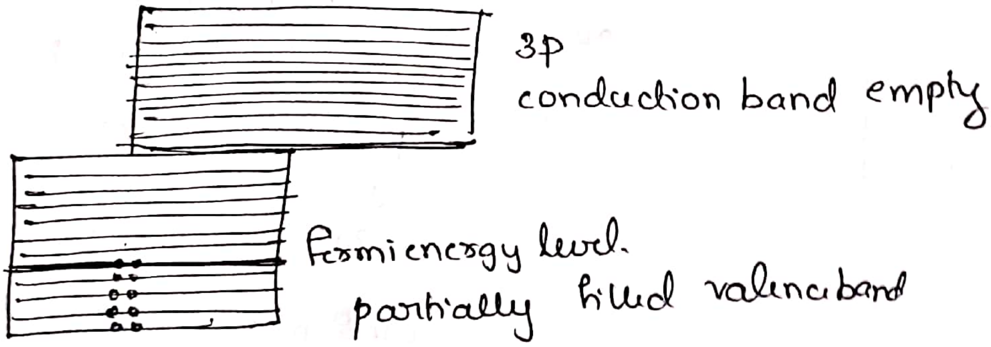
Here outermost band is completely filled.



For small energy (room temp) → e^- moves to CB

Now — $1s^2 2s^2 2p^6 \underline{3s^1}$ → partially filled.

Cu — — $4s^1$



Now → gap is there in b/w fermi energy level & conduction band.

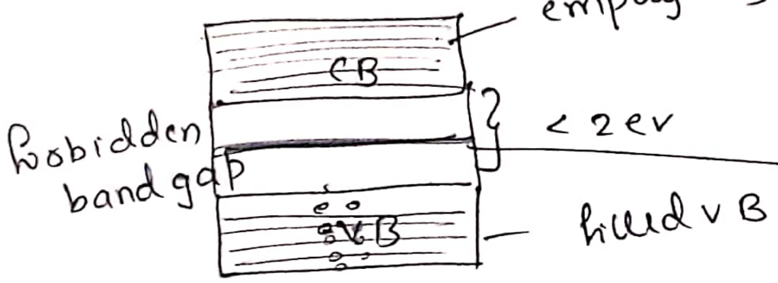
~~But~~ ~~e~~ In general e^- need some more energy to reach CB then only conduction possible

But In partially filled valence band case

If e^- crossed fermi energy level they can participate in conduction.

Semiconductors

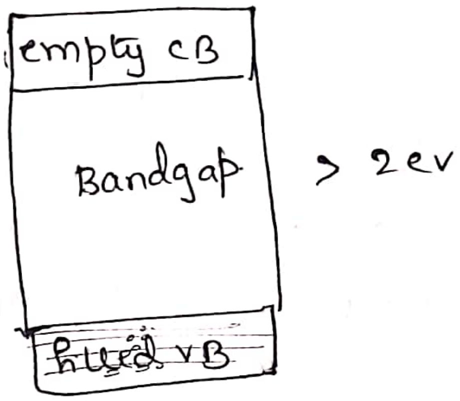
In these type of materials the band gap is < 2ev



e⁻ bound in covalent bonds

fermi energy level lies in b/w VB & CB.

Insulators → band gap is > 2ev



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