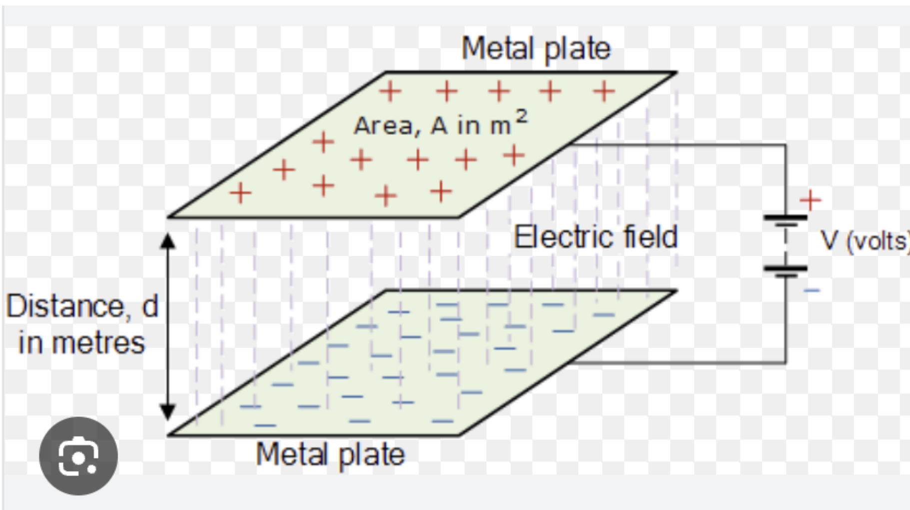
This document describes how electrons move and answers some questions about intrinsic silicon and doped silicon

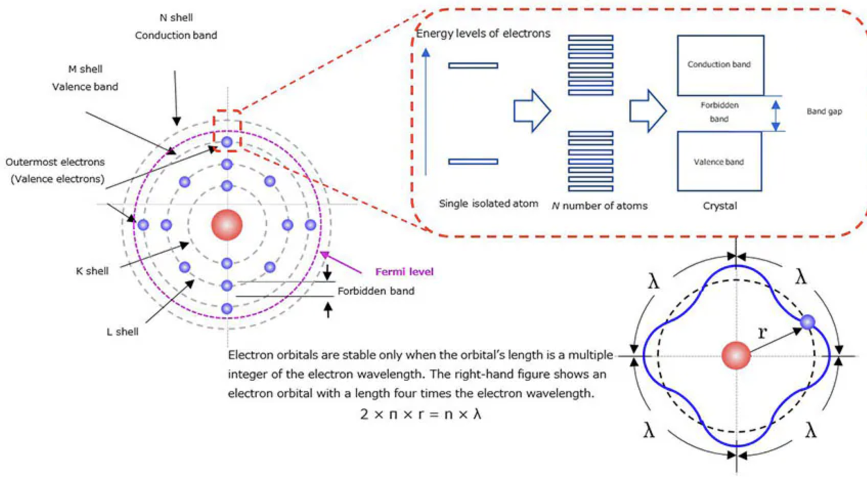
1 From Bohr model to +/- charges in a material

When we evaluate methods and electronic components, we often think about +/- charges flowing in a material, like the image below



but how does that relate to a bohr model? More specifically, how does electrons / holes in a bohr model be to move across atoms?
we know that there are energy bands, in a bohr model, every material has a certain number of valence electrons in its **valence shell**. Silicon has 4, Boron has 3, etc. In order for those electrons move freely, it needs a certain amount of energy in order for it to jump across the forbidden gap and into the conduction band.
Note that the valence shell not the same as the **valence bands**. Electrons in each shell (orbital) has a certain range of energy. Now looking at the range of energy for the electrons in the valence band, there are two important ranges : 1. the valence band 2. the conduction band

2 From Bohr model to +/- charges in a material



3 PN junction

This picture will help visualize things Remember that Lorentz Force Law is given by

$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$$
$$q = charge$$
$$\vec{E} = eletricfield$$
$$\vec{v} = velocity$$
$$\vec{B} = magneticfield$$

We'll just look at the electric field component,

$$\vec{F} = q\vec{E}$$

q is positive for positive charge and negative for negative charge. Following the picture of the pn junction above we set left side to be positive, right side to be negative.

4 How Electrons Flow and Creates Base/Collector Current

Now what we have established DC bias, when a small signal increasing input (voltage or current honestly you can say either) at the base terminal, electrons

are injected at the emitter terminal. Because EBJ is forward biased, electrons at n side(emitter) goes across to the p side(base). Here some electrons are combined with the holes that were already in the base. Every time a hole combines with a electron, new holes needs to be supplied from outside of the base terminal(electrons coming out of the base terminal), thus a base current is present.
Now majority of those electrons in base region will get swept across to collector region, this is because CBJ is reversed biased(looks like the picture of the PN junction), the electric field is pointing from collector to base. Electrons are negative charges, they experience force in the opposite direction of the electric field, thus they go over to collector. The amount of electrons going over to collector is proportional to the amount of electrons that makes it across EBJ from emitter. Which is why the collector current is given by

$$i_c = I_s e^{v_{BE}/V_T} \tag{1}$$

See that equation 1 depends on v_{BE} and not v_{CB}. As long as the collector voltage is higher than the voltage at the base, those electrons will get swept across, doesn't matter the magnitude.