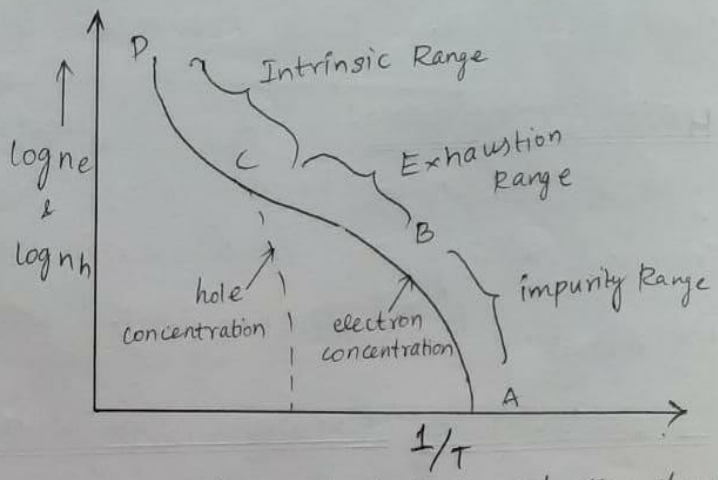
Variation of Carrier Concentration With Temperature

Electron Concentration : At Very low temperature at 0K, 1/T is high, the fermi level will lie exactly in the middle between E_c and E_{d1} and the Carrier Concentration is at the most zero.(A).



Now when the temperature is slowly increased, the donor atom ionised and the electrons move towards conduction band. Hence the carrier concentration increases slowly in the conduction band for electrons; it is called as impurity range.

when the temperature is further increased to reach upto say room temperature, all the donor atoms are ionised and hence the carrier concentration (n_e) increases in the conduction band and reaches to a steady state, it is called exhaustion Range. [shown by curve BC]

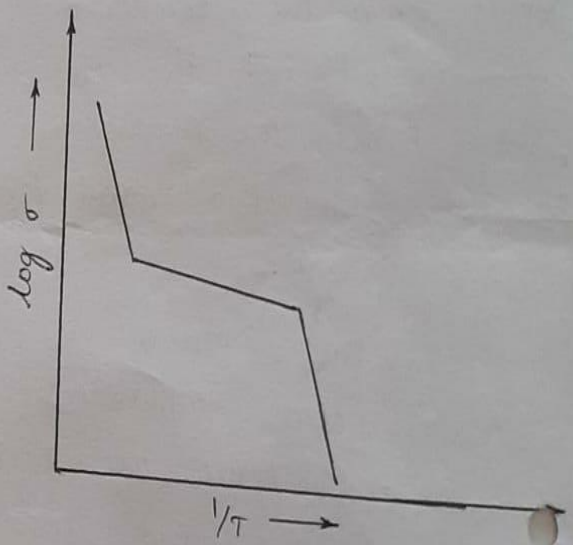
when the temperature is still further increased due to the thermal ionisation, the electrons from the valence band is lifted up to go to the conduction band and hence there is an increase in the carrier concentration. (n_e)

Since the Number of available electrons in donor energy level, is almost exhausted, many number of electron are shifted from Valence band to Conduction band and thus the carrier concentration increase Rapidly, tracing the curve CD, it is known as intrinsic range.

Hole concentration: At 0k electrons concentration is zero in conduction band. Now, when temperature is increased slowly the electrons will move from the donor energy level to Conduction band.

Conductivity of Extrinsic Semiconductor:

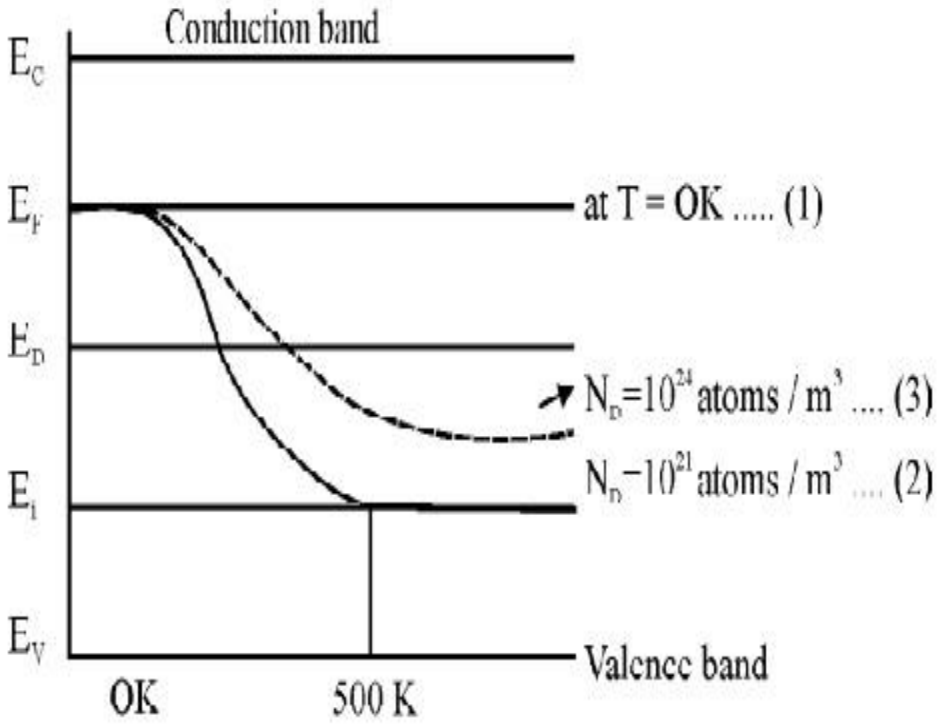
When the temperature is slowly increased from 0k impurity atoms are slowly ionised and goes to conduction band and hence conductivity increases.



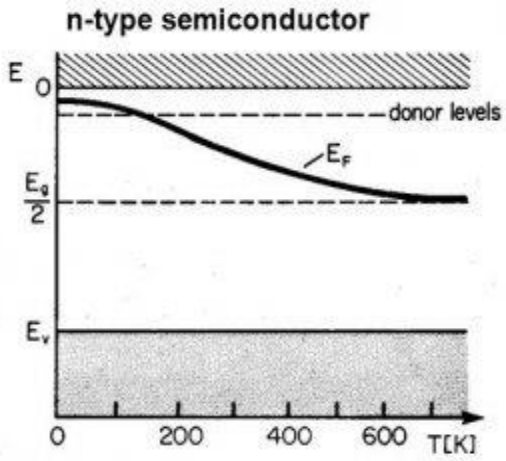
When all the impurities are ionised the mobility of charge carriers decreases slightly and therefore log σ becomes constant (or) may slightly decreases.

VARIATION OF FERMI LEVEL WITH TEMP

- For intrinsic SC (n_i=p_i) and as the temperature increases both n_i and p_i will increase
- Fermi level will remain approximately at the center of the forbidden gap
- This means Fermi level is independent of the temperature
- But in extrinsic SC it is different
- In n-type SC electrons come from two source
  - From donor state- which are easily separated from parent atom and do not vary much as the temperature is increased
  - Intrinsically produced electrons- which increases with increase in temperature
- This shows that *as the temperature rises the material becomes more and more intrinsic and Fermi level moves down closer to intrinsic position (at the center of the forbidden gap)*



Fermi Energy in Doped Semiconductors



At 0K the Fermi energy is located between the new energy band and E_0.

At high temperatures, the Fermi energy approaches the value $E_g/2$, as in intrinsic semiconductors.

Largest differences in electrical properties are expected at low temperatures (< 400K).

In p-type semiconductors, the temperature dependency is reversed