

# Halfgeleiders

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## Intrinsic

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### Assumptions

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- Fermi-Dirac distribution
- Density of States
- Maxwell-Boltzmann approximation for Fermi-Dirac distribution if  $E - E_F > 3kT$
- Charge neutrality:  $n = p$

### Conclusions

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- $n = N_C \exp\left(\frac{E_F - E_C}{kT}\right)$
- $p = N_V \exp\left(\frac{E_V - E_F}{kT}\right)$
- $n_i \triangleq n = p$
- $n = p \Rightarrow E_F = E_i \triangleq \frac{E_C + E_V}{2} + \frac{kT}{2} \ln\left(\frac{N_V}{N_C}\right)$

## Extrinsic

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### Assumptions

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- $n = N_D$  (n-type)
- $p = N_A$  (p-type)
- Charge neutrality:  $n + N_A = p + N_D$

### Conclusions

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- $n = N_D = N_C \exp\left(\frac{E_F - E_C}{kT}\right) \Rightarrow E_F - E_C = kT \ln\left(\frac{N_D}{N_C}\right)$  (n-type)
  - $p = N_A = N_V \exp\left(\frac{E_V - E_F}{kT}\right) \Rightarrow E_V - E_F = kT \ln\left(\frac{N_A}{N_C}\right)$  (p-type)
  - $n = N_C \exp\left(\frac{E_F - E_C}{kT}\right) = N_C \exp\left(\frac{E_F - E_i + E_i - E_C}{kT}\right) = n_i \exp\left(\frac{E_F - E_i}{kT}\right)$
  - $p = N_V \exp\left(\frac{E_V - E_F}{kT}\right) = N_V \exp\left(\frac{E_V - E_i + E_i - E_F}{kT}\right) = n_i \exp\left(\frac{E_i - E_F}{kT}\right)$
  - $n \cdot p = n_i \exp\left(\frac{E_F - E_i}{kT}\right) \cdot n_i \exp\left(\frac{E_i - E_F}{kT}\right) = n_i^2$
  - $n_n = \frac{N_D - N_A}{2} + \frac{\sqrt{(N_D - N_A)^2 + 4n_i^2}}{2} \approx N_D - N_A$  (n-type)
  - $p_p = \frac{N_A - N_D}{2} + \frac{\sqrt{(N_A - N_D)^2 + 4n_i^2}}{2} \approx N_A - N_D$  (p-type)
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## Formularium

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