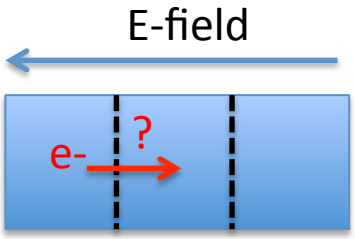
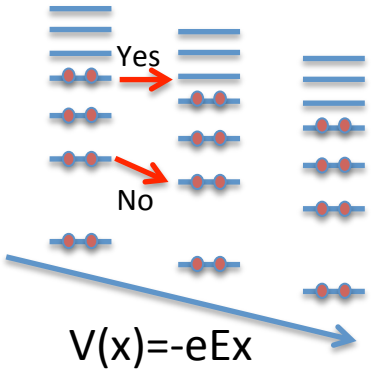
Only electrons close to the Fermi level participate to conduction (qualitative argument)

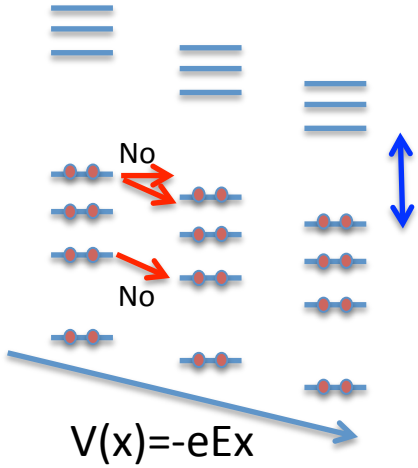
An electron can only jump into an empty level (Pauli repulsion).
Further, he can only go down in energy or "go up" into a level located within k_BT.
Remember that k_BT << Fermi energy.



If there is a large energy gap between the highest occupied energy level and the lowest unoccupied level, conduction is impossible.



Metal !!



Energy gap between occupied and unoccupied levels:

k_BT = 25 meV (room temperature)
Silicium gap = 1.2 eV (semiconductor)
Diamond gap = 5.5 eV (insulator)

Semiconductor or Insulator !!

Experimental specific heat (Kittel, Chapter 6, Free Electron Fermi gas)

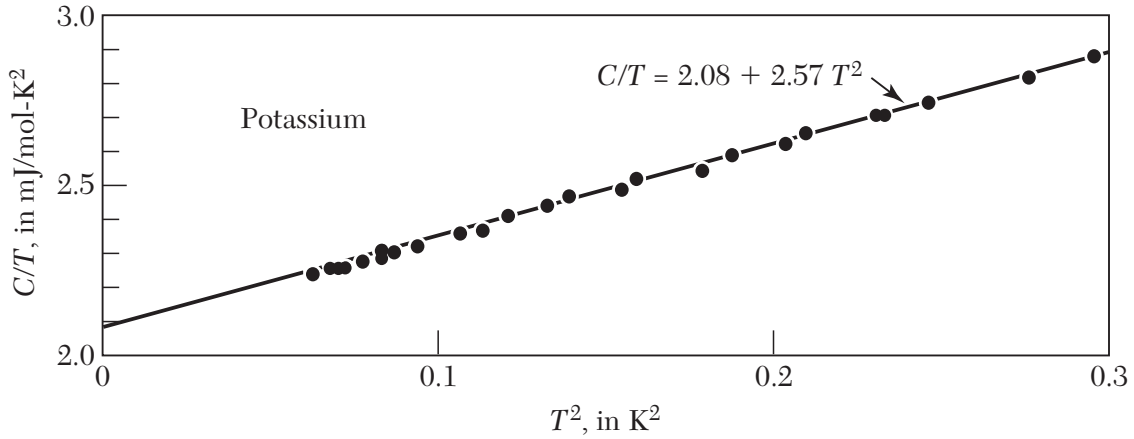


Figure 9 Experimental heat capacity values for potassium, plotted as C/T versus T^2. (After W. H. Lien and N. E. Phillips.)

Fermi-Dirac distribution (Kittel, Chapter 6)