Phys 570

Lecture #5

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Chapter 7: Energy Bands
Introduction

❑ The free electron model of metals gives us good insight into the heat capacity, thermal conductivity, electrical conductivity, magnetic susceptibility, and electrodynamics of metals.

❑ But the model fails to help us with other large questions:

➢ *the distinction between metals, semimetals, semiconductors, and Insulators*

➢ *the occurrence of positive values of the Hall coefficient*

➢ *the relation of conduction electrons in the metal to the valence electrons of free Atoms*

➢ *many transport properties, particularly magnetotransport*

❑ Hence, we need to modify Fermi Electron Model to be able to answer these puzzles. We will see that little modification is just adequate.
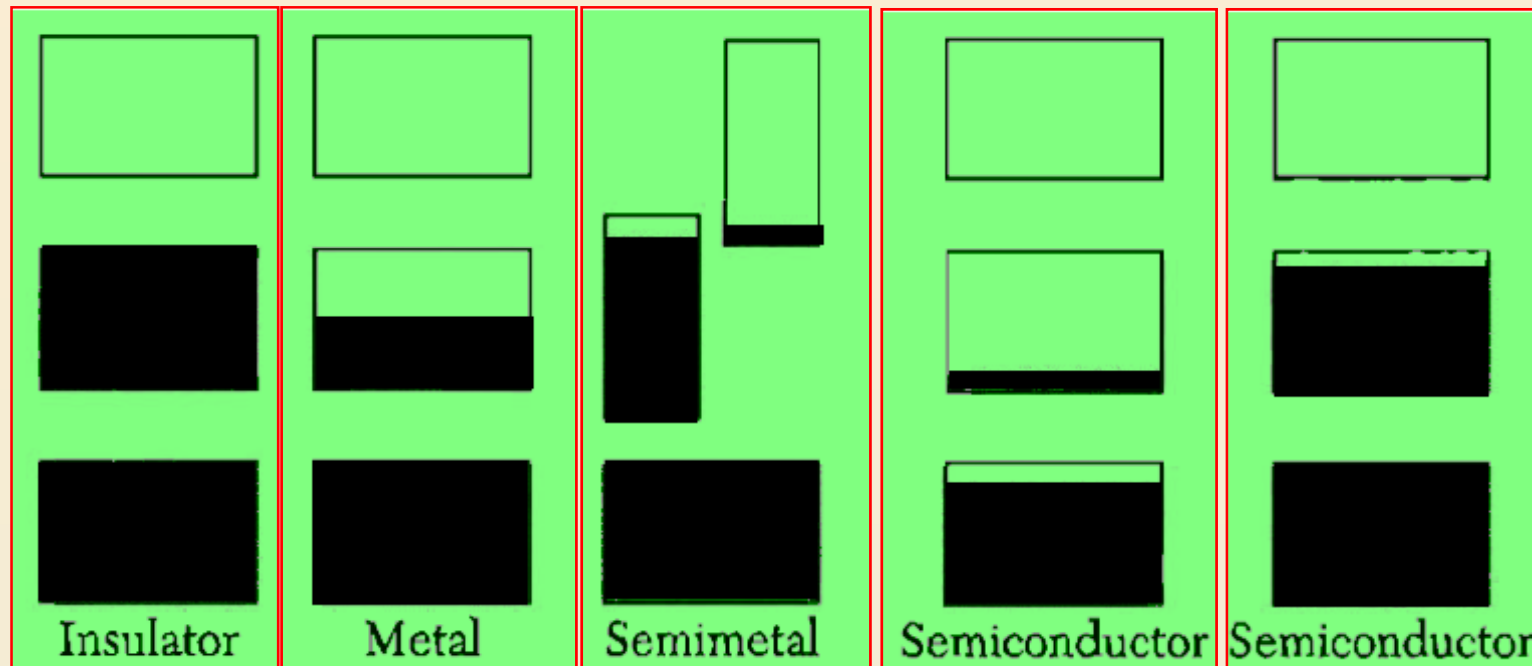
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❑ The difference between a good conductor and a good insulator is striking. The electrical resistivity of a pure metal may be as low as 10^{-10} Ω.cm at 1 K, apart from the possibility of superconductivity.

❑ The resistivity of a good insulator may be as high as 10^{22} Ω.cm.

❑ This range of 10^{32} may be the widest of any common physical property of solids.

❑ Every solid contains electrons. The important question for electrical conductivity is how the electrons respond to an applied electric field.

❑ electrons in crystals are arranged in energy bands.

❑ Bands are separated by band gaps (Forbidden Regions)

❑ Source of bands come from the interaction of the conduction electron waves with the ion cores of the crystal

❑ Insulator: if the allowed energy bands are either filled or empty, for then no electrons can move in an electric field.

❑ Metal if one or more bands are partly filled.

❑ Semiconductor or a semimetal if one or two bands are slightly filled or slightly empty.

Insulator   Metal   Semimetal   Semiconductor   Semiconductor

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❏ To modify the Free Electron Model; we will assume that electron is not totally free. It has to respect the periodicity of the crystal.

❏ This will directly lead to the important result: band gap.

❏ Also; we introduce the concept of effective mass of electron *m** *which may be larger or* smaller than the free electron mass, or may even be negative.

❏ Negative and Positive effective mass can directly explain for +tive Hall coefficient.