# Group Theory And Electronic Energy Bands In Solids

## J. F Cornwell

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Band theory, in solid-state physics, theoretical model describing the states of electrons, in solid materials, that can have values of energy only within certain specific ranges. The behaviour of an electron in a solid (and hence its energy) is related to the behaviour of all other particles around.Â  Studies of such changes of energy in solids interacting with photons of light, energetic electrons, X-rays, and the like confirm the general validity of the band theory and provide detailed information about allowed and forbidden energies. A variety of ranges of allowed and forbidden bands is found in pure elements, alloys, and compounds . Three distinct groups are usually described: metals, insulators, and semiconductors. The existence of electron energy bands in solids makes it possible to understand this remarkable span [1]. We can begin by considering the energy levels of the individual atoms as they are brought together. When the atoms are far apart, the energy of a particular level is the same for each atom.Â  2. The Bloch Theorem The behavior of an electron in a crystalline solid is determined by studying the appropriate Schrodinger equation. This may be written as. (1). \begin{align} (-\frac{\hbar^2}{2m}\nabla^2 + V(\mathbf{r}))\Psi(\mathbf{r}) = E\Psi(\mathbf{r}) \end{align}. where V(r) is the crystal potential seen by the electron, and $\Psi (\mathbf{r})$ and E are respectively, the state function and the energy of this electron.

Energy bands in solids. When separate atoms bind together in a single system to form a solid, their electronic structure is perturbed by the bonding interaction. For a given structure this change in configuration must satisfy two primary constraints: 1) the Pauli exclusion principle and 2) the periodic lattice potential of the atomic cores.Â  Therefore, discrete atomic levels broaden into a band of levels. Since the typical solid contains ~1022 atoms/cm3 (Si has 5x1022 atoms/cm3), a nearly continuous distribution of energies results. The "shape" of the bands of electron states are determined by the finite size of the solid and the periodic array of potentials contained therein. Sommerfeld proposed in 1928 that free electrons in a solid should behave as a 'particle in a box'.