Semiconductors follow the E equation $(h^2k^2)/(8pi^2m)$
Direct Band Gap Semiconductors;
They have the same K Value for the CB Minimum, and VB Maximum.
For an electron to fall from a filled state in CB, to a hole in VB, energy has to be released. This energy is released in the form of a photon, therefore emitting light whilst lowering the energy, and keepin the K value unchanged.
These types of semiconductors are used for light sources such as LEDs and Lasers due to their light emitting properties. Examples of these semiconductors are GaAs, GaP, and InP.
Indirect Band Gap Semiconductors;
They have the different K Values for the CB Minimum, and VB Maximum.
For an electron to fall from a filled state in CB, to a hole in VB, energy has to be released. In this case, as the K value is different, a phonon is released in order to reach the K value of the VB maximum, and a photon is then released to lower the Energy as well.
These types of semiconductors are not used for light sources such as LEDs and Lasers, as efficiency is less. More energy is required to emit light in comparison to Direct Band Gap Semiconductors. Examples of these semiconductors are Si, Ge
NOTE: Direct are compounds, Indirect and elemental. Direct has a higher energy gap, whereas indirect has a lower energy gap.
Chalcogen Semiconductors
Oxygen Family. Examples are S, Se, and Te. An example of the semiconductor is As_2Se_3. They are photosensitive, and therefore are used as Photoconductors.
When light is incident upon Chalcogen Semiconductors, it causes electrons to be excited, and therefore jump from the VB to the CB, and thereby conductivity increases.
As conductivity increases in Selenium (Se) when light is incident upon it, it is used in Xerography/Photocopying.
1. Selenium platen is positively charged by the corona wire
2. The light removes the positive charge from the paper, other than the dark regions, therefore creating a positive-negative image on the paper itself
3. The toner particles are negatively charged, and therefore are attracted to the positively charged image
4. A new sheet of paper, positively charged by the corona wire, attracts the toner particles
5. The toner particles then fuse to the paper itself after heating, and excess toner is removed.
The Selenium platen can be used multiple times.
Non-elemental Semiconductors
Non-Stoichiometric Compounds
In a perfect crystal, all atoms would be in their correct lattice position, however this only occurs at absolute zero (0K). Above 0K, defects in the lattice structure arise.
Another type of defect that is found are point defects. These are defects in the lattice at isolated atomic positions. These may occur due to the presence of a foreign atom at a particular location in the lattice, or a vacancy where there should normally be an atom. Point defects have effects on the chemical and physical properties of the solid.
Transition Metal Oxides are an example of these.

There are two types of Defects i.e Stoichiometric/Intrinsic (Schottky and Frenkel Defects), and Non-Stoichiometric/Extrinsic Defects(Metal Excess due to anion vacancies or interstitial cation, or Metal Deficiency due to cation vacancies or interstitial anion).

Stoichiometric/Intrinsic Defects

Schottky Defects are a pair of vacant sites; an anion, and cation vacancy. To compensate for these vacancies, there are two extra atoms at the surface of the crystal. There must be an equal number of anion and cation vacancies, in order to preserve electrical neutrality in the structure. The size of the cation should be similar to the size of the anion. These types of defects are found in NaCl, KBr, and CsCl. These give rise to Cation and Anion Intrinsic Semiconductors.

Frenkel Defects are displaced atoms found in an interstitial site in the lattice which is normally empty. As cations are small, they can fit in the interstitial sites, therefore showing cation lattice defects, and vice versa for anions.CaF_2 has an anion Frenkel Defect, in which F^- occupies the interstitial sites. Another example is Na_2O (Na^+ interstitial). These give rise to Cationic Intrinsic Semiconductors.

Both of these effects can occur at the same time if the energy required for both is similar. The crystals thereby conduct electricity due to the movement of ions from filled, to vacant positions. This phenomenon is called “intrinsic semiconduction”.

Extrinsic Non-Stoichiometric/Extrinsic Defects

Extrinsic defects exhibit ionic conduction, which is also referred to as “fast ion conductors”.

In these defects, the ratio of ions is not equal. (E.g., $Fe_{0.9}$)These defects occur in addition to Stoichiometric/Intrinsic Defects. There are 4 types, i.e;

Metal excess due to anion vacancies

Vacant anion site which is occupied by an electron. This occurs along with the Schottky defect. Excess electron sites are known as F-centres, which have higher color intensity.

Metal excess due to interstitial cations

Extra cation in an interstitial location in the lattice. This occurs along with the Frenkel defect.

Metal deficiency due to cation vacancies

Absence of cation at lattice sites, therefore causing the metal to have a higher charge.There is therefore an excess of electrons.

Metal deficiency due to interstitial anions.

Additional anions at interstitial sites. As the crystal has a complete lattice with no vacancy, it can not compensate for the interstitial anion. This is theoretical as anions are large, therefore cannot occupy interstitial sites.

Non-Stoichiometric defects with a metal excess use normal conduction (n-type), and metal deficiency use positive conduction (p-type).

There are two mechanisms of conduction in Non-Stoichiometric semiconductors;

Vacancy mechanism, in which an ion jumps from its normal position on the lattice to a nearby vacancy, and interstitial mechanism, which is similar to the first, however it jumps to an adjacent interstitial site.

Cation Deficiency = P-Type. Less cations, more holes.

Cation Excess = N-Type. More cations, out of which some move to interstitial sites, and then $2e^-$ also moves to interstitial sites to maintain electrical neutrality.

Transition Metal Oxides have Molecular Orbits crystalize into ionic cubic lattice structures, like NaCl. TiO and VO are metallic conductors, however the rest are semiconductors.

Quantum Dots are what semiconductors look like when grouped together (approximately a thousand atoms). They exhibit properties similar to bulk semiconductors, and isolated molecules. They can be made from both elemental, and compound semiconductors.
As Quantum Dots are photoactive, when they absorb energy, they emit light as well. The color of the light that they emit is based on the radius of the core. As the core size increases, the wavelength of the light decreases, for example 7 to 2 nm is Blue to Red.