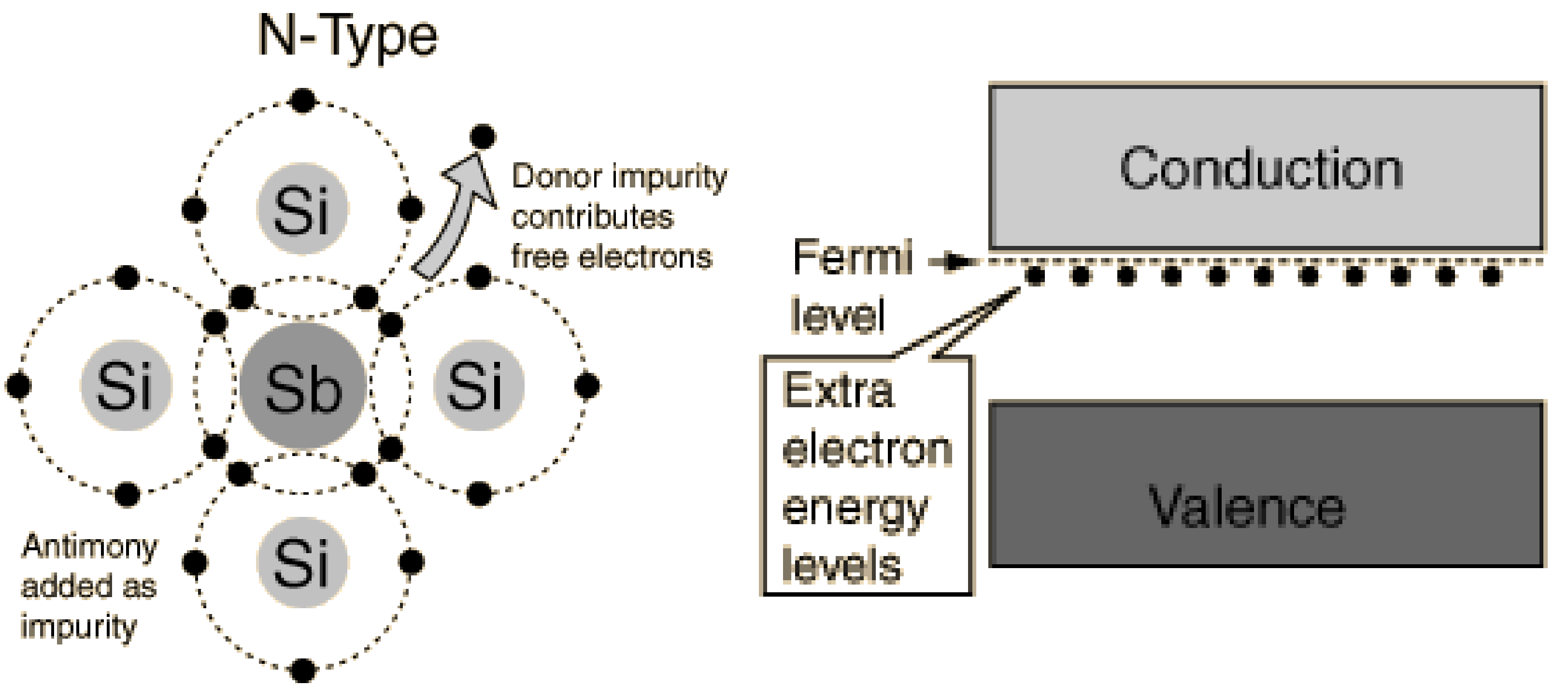
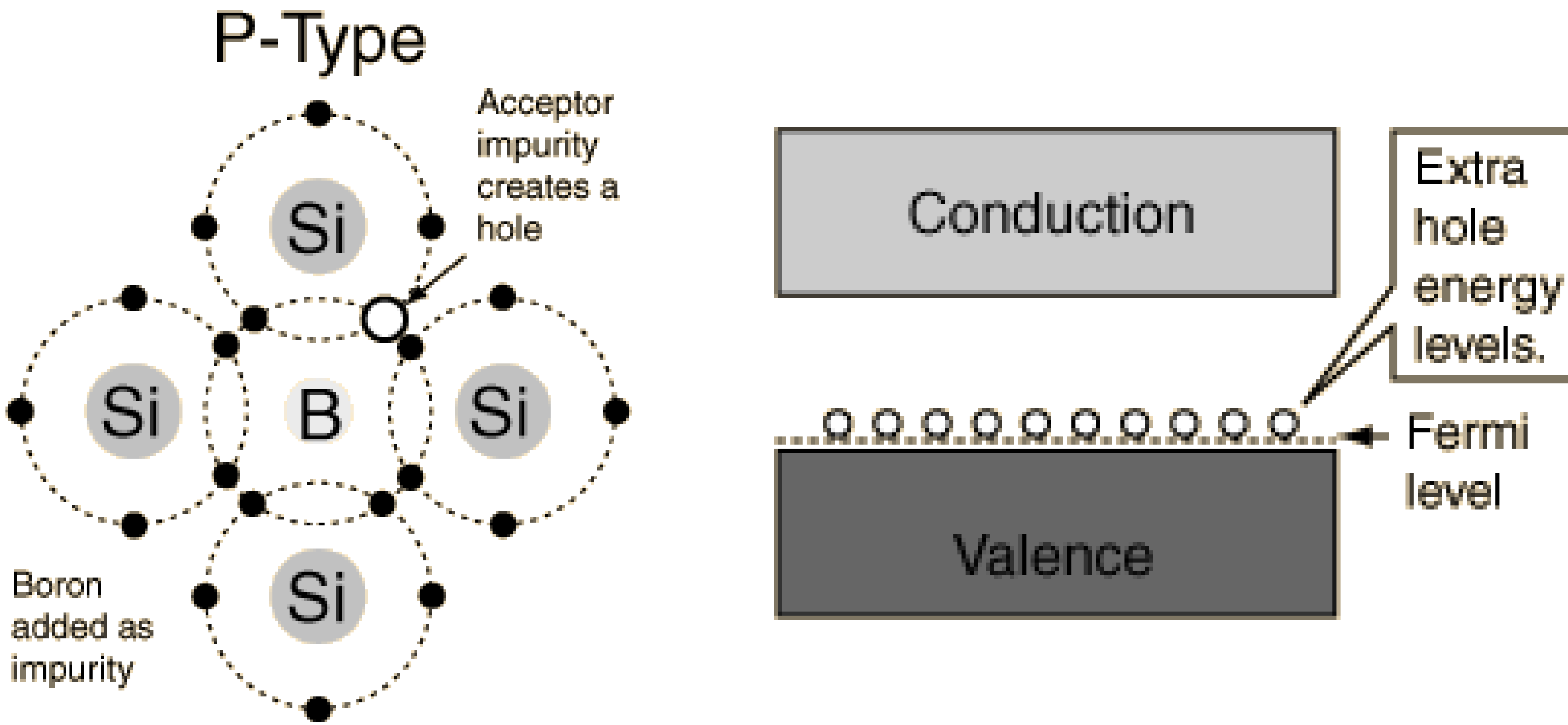
N-Type Semiconductor



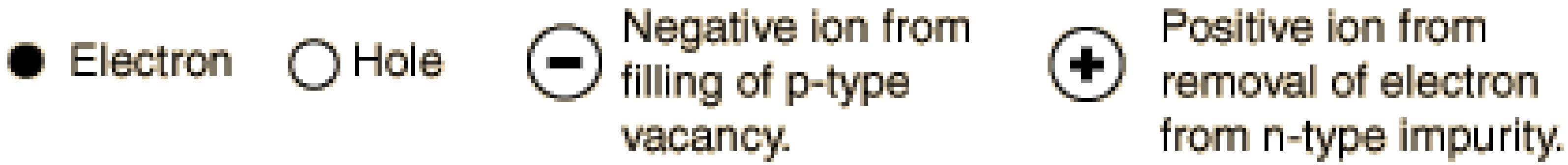
The addition of pentavalent impurities such as antimony, arsenic or phosphorous contributes free electrons, greatly increasing the conductivity of the intrinsic semiconductor. Phosphorous may be added by diffusion of phosphine gas (PH3).

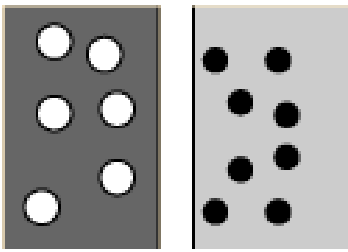
P-Type Semiconductor



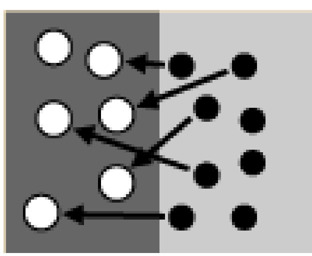
The addition of trivalent impurities such as boron, aluminum or gallium to an intrinsic semiconductor creates deficiencies of valence electrons,called "holes". It is typical to use B_2H_6 diborane gas to diffuse boron into the silicon material.

Depletion Region

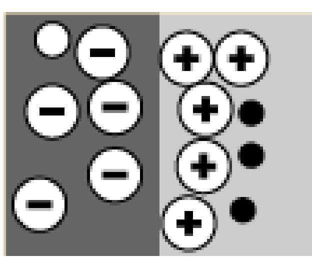




In the p-type region there are holes from the acceptor impurities and in the n-type region there are extra electrons.



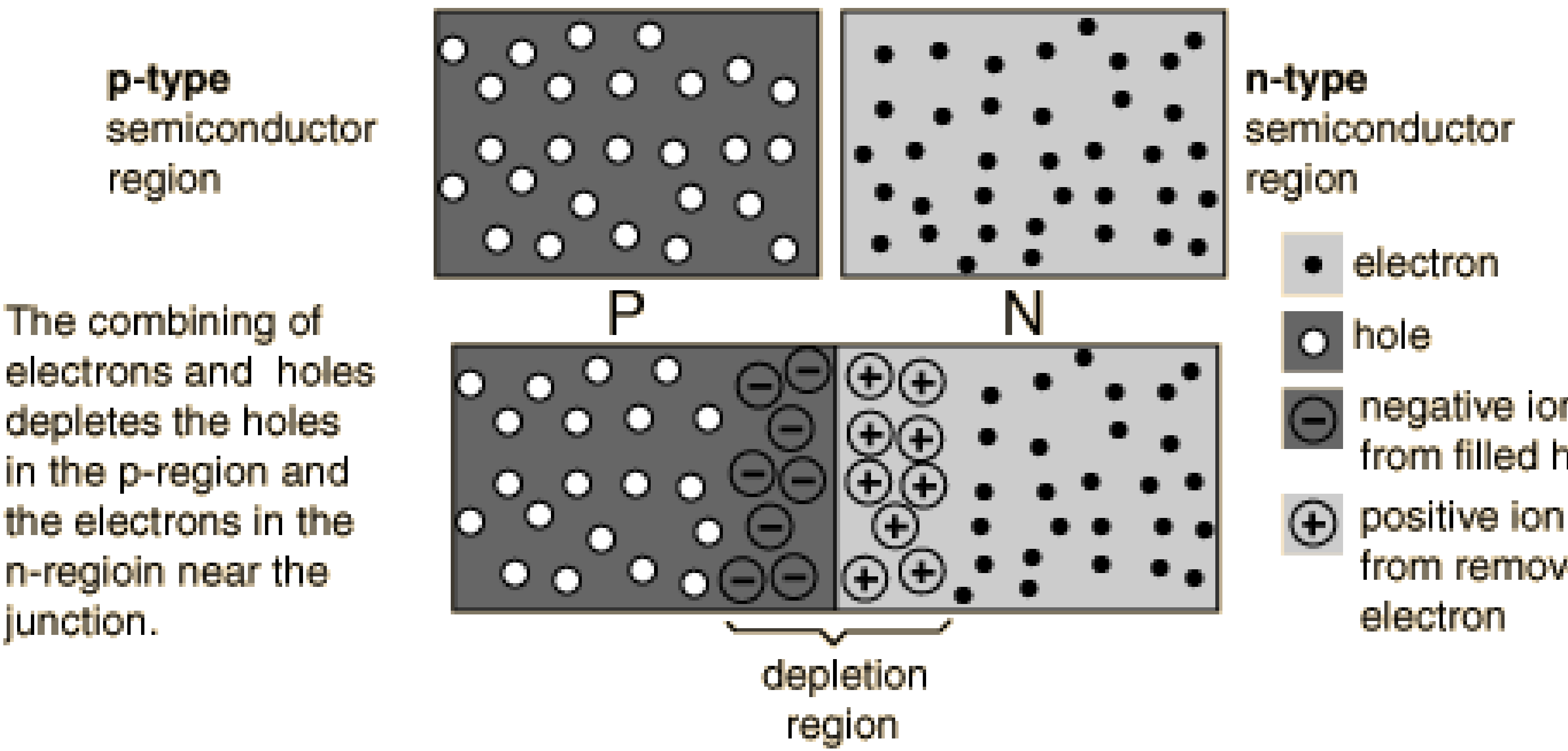
When a p-n junction is formed, some of the electrons from the n-region which have reached the conduction band are free to diffuse across the junction and combine with holes.



Filling a hole makes a negative ion and leaves behind a positive ion on the n-side. A space charge builds up, creating a depletion region which inhibits any further electron transfer unless it is helped by putting a forward bias on the junction.

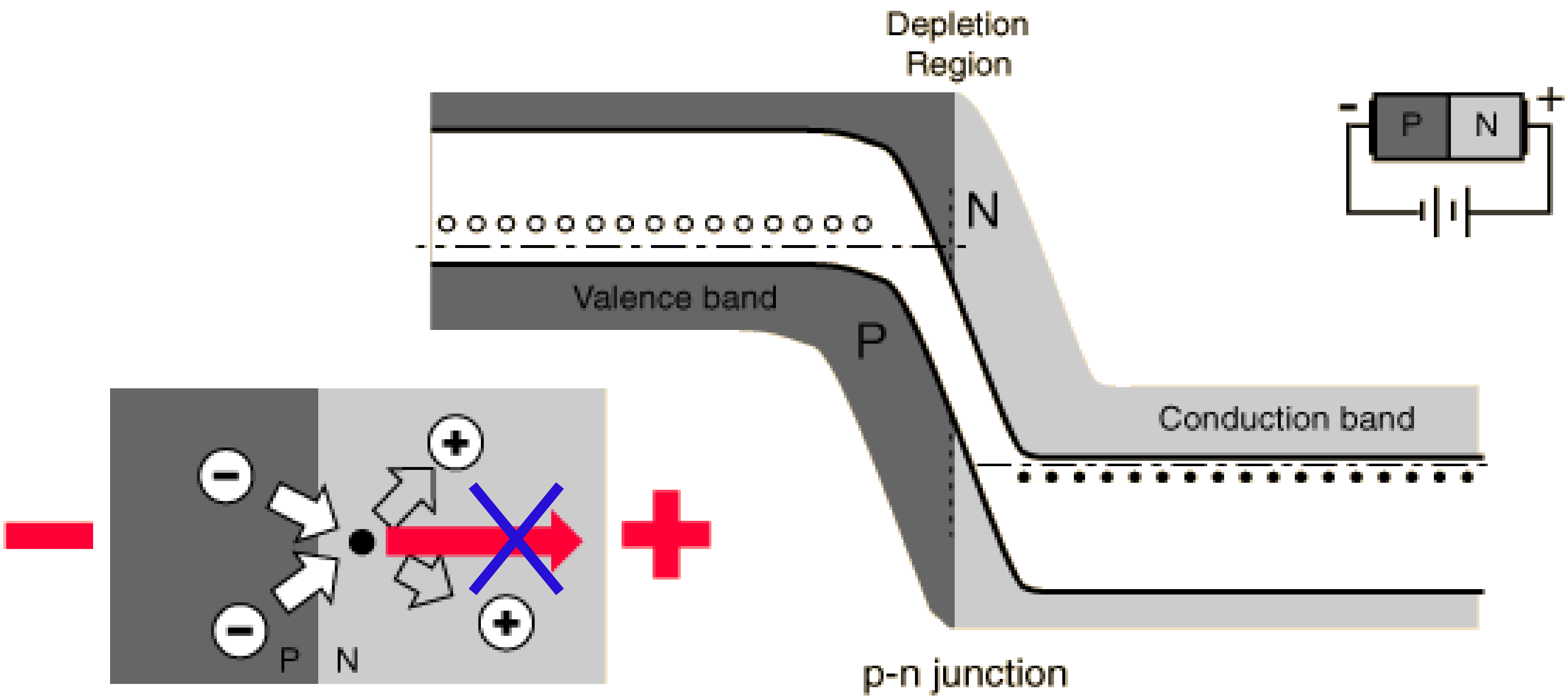
Depletion region

When a p-n junction is formed, some of the free electrons in the n-region diffuse across the junction and combine with holes to form negative ions. In so doing they leave behind positive ions at the donor impurity sites.



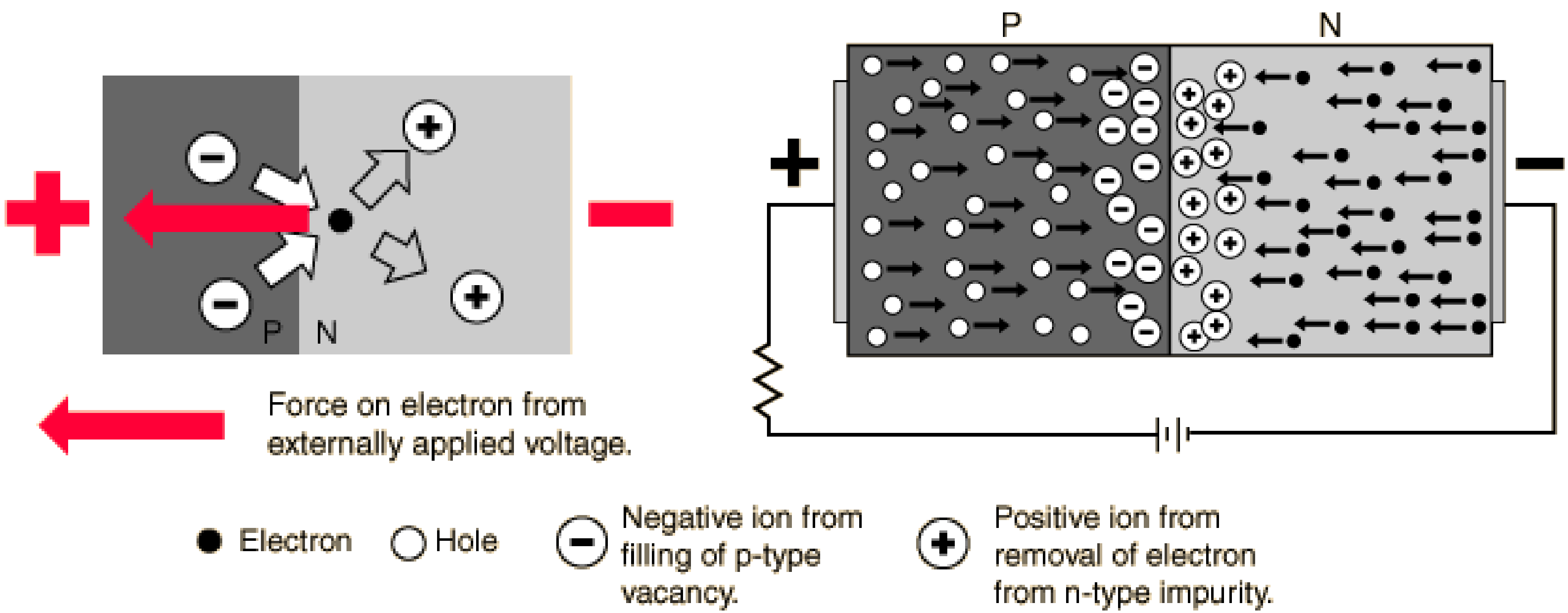
Reverse Biased Conduction of p-n junction

To reverse-bias the p-n junction, the p side is made more negative, making it "uphill" for electrons moving across the junction. The conduction direction for electrons in the diagram is right to left, and the upward direction represents increasing electron energy.

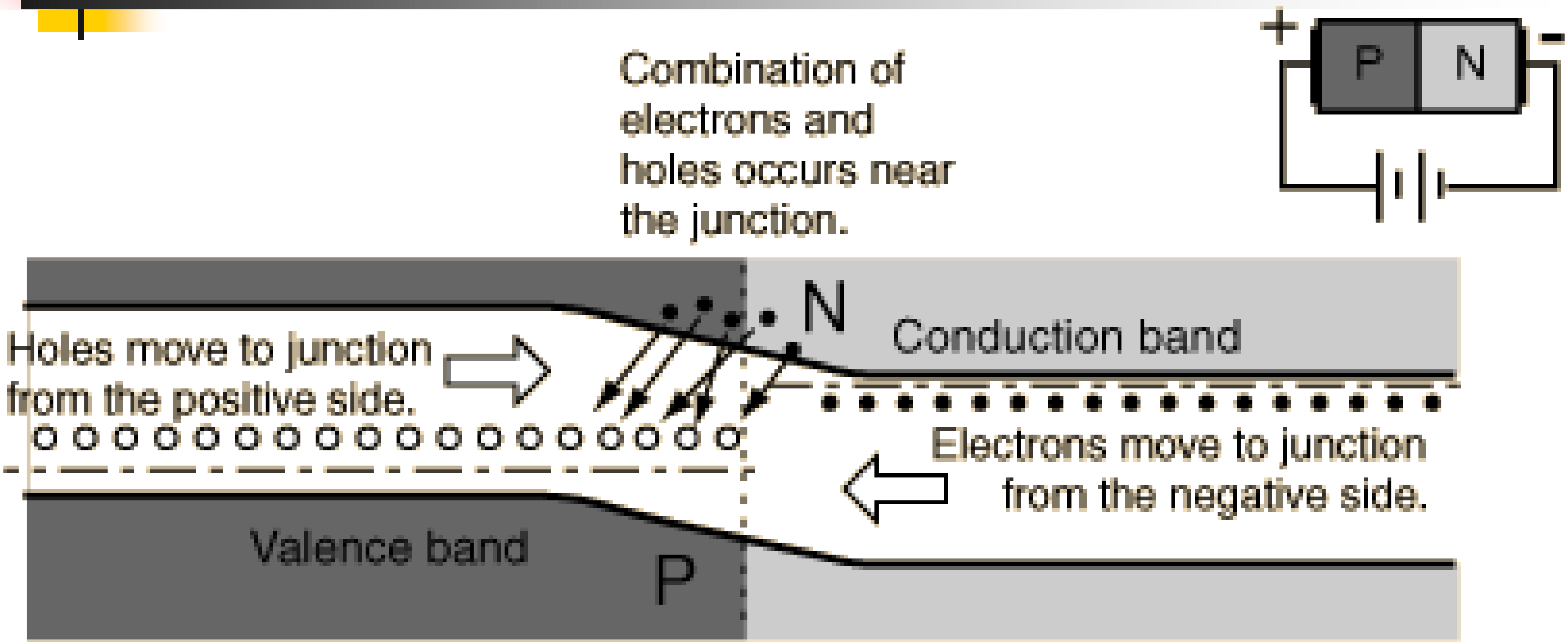


Forward Biased Conduction of p-n junction

The forward current in a p-n junction when it is forward-biased (illustrated below) involves electrons from the n-type material moving leftward across the junction and combining with holes in the p-type material. Electrons can then proceed further leftward by jumping from hole to hole, so the holes can be said to be moving to the right in this process.



Forward Biased Conduction of p-n junction



p-n junction

When the p-n junction is forward biased, the electrons in the n-type material which have been elevated to the conduction band and which have diffused across the junction find themselves at a higher energy than the holes in the p-type material. They readily combine with those holes, making possible a continuous forward current through the junction