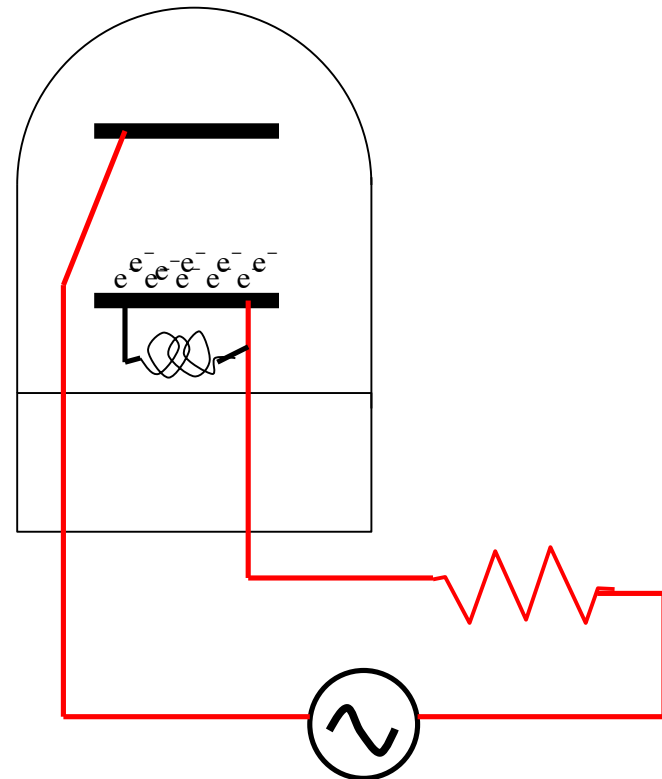


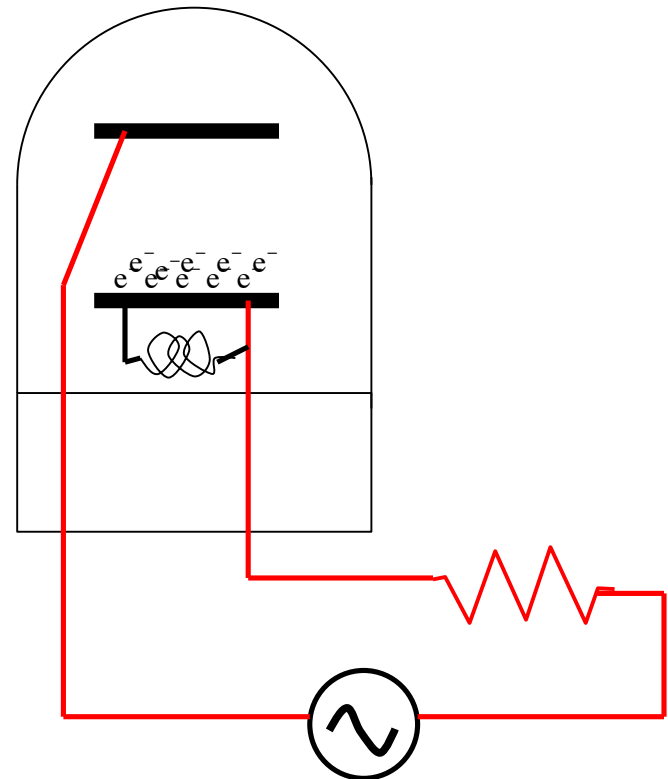
VACUUM TUBES

This tube acts as a **half-wave rectifier**.



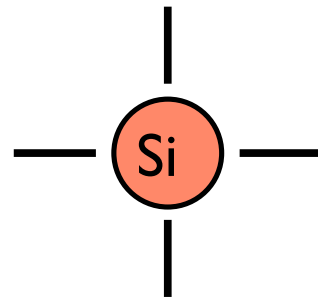
VACUUM TUBES

This tube acts as a half-wave rectifier. It turns **AC** into **DC**.

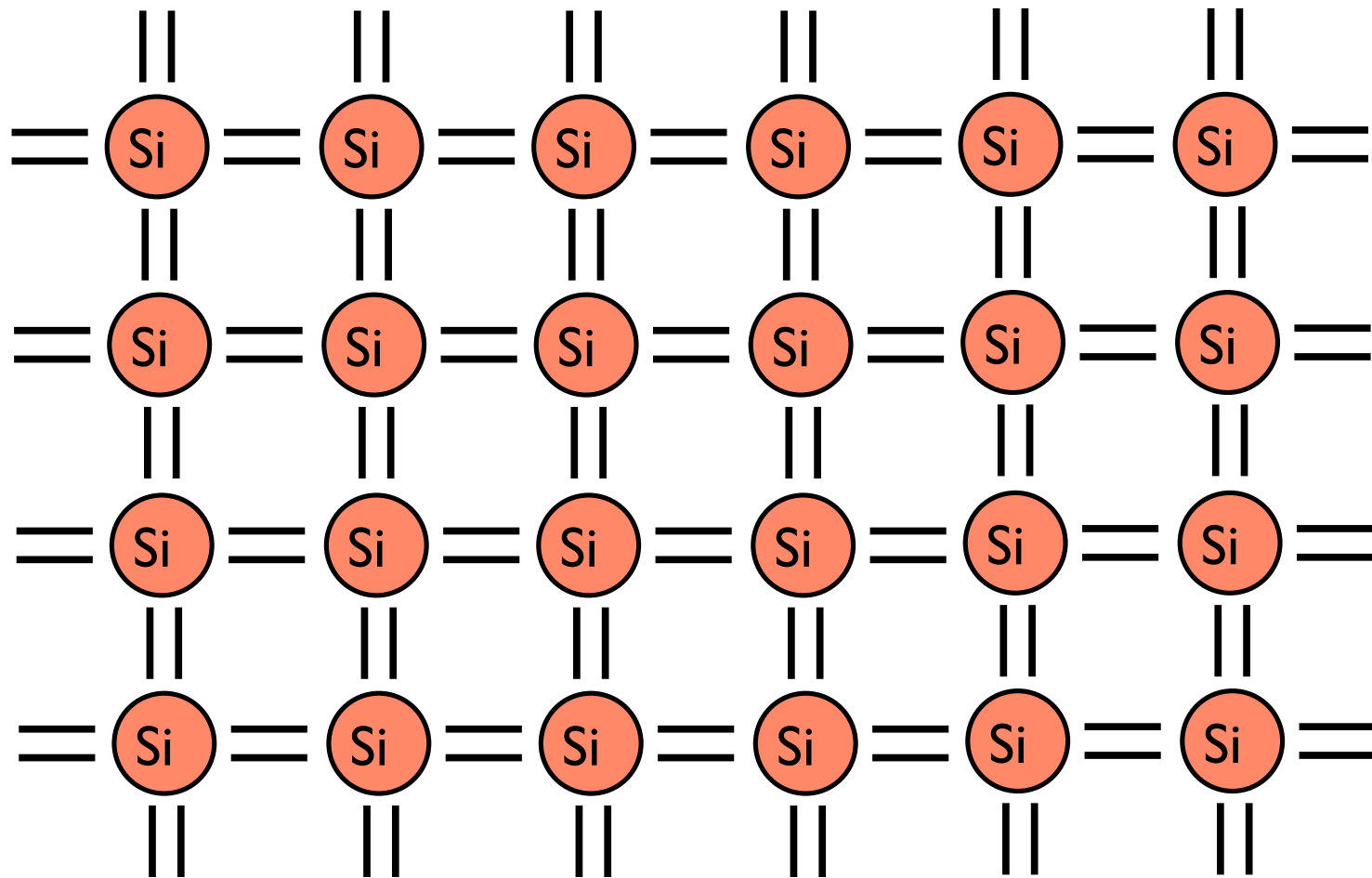


SEMI-CONDUCTING DEVICES

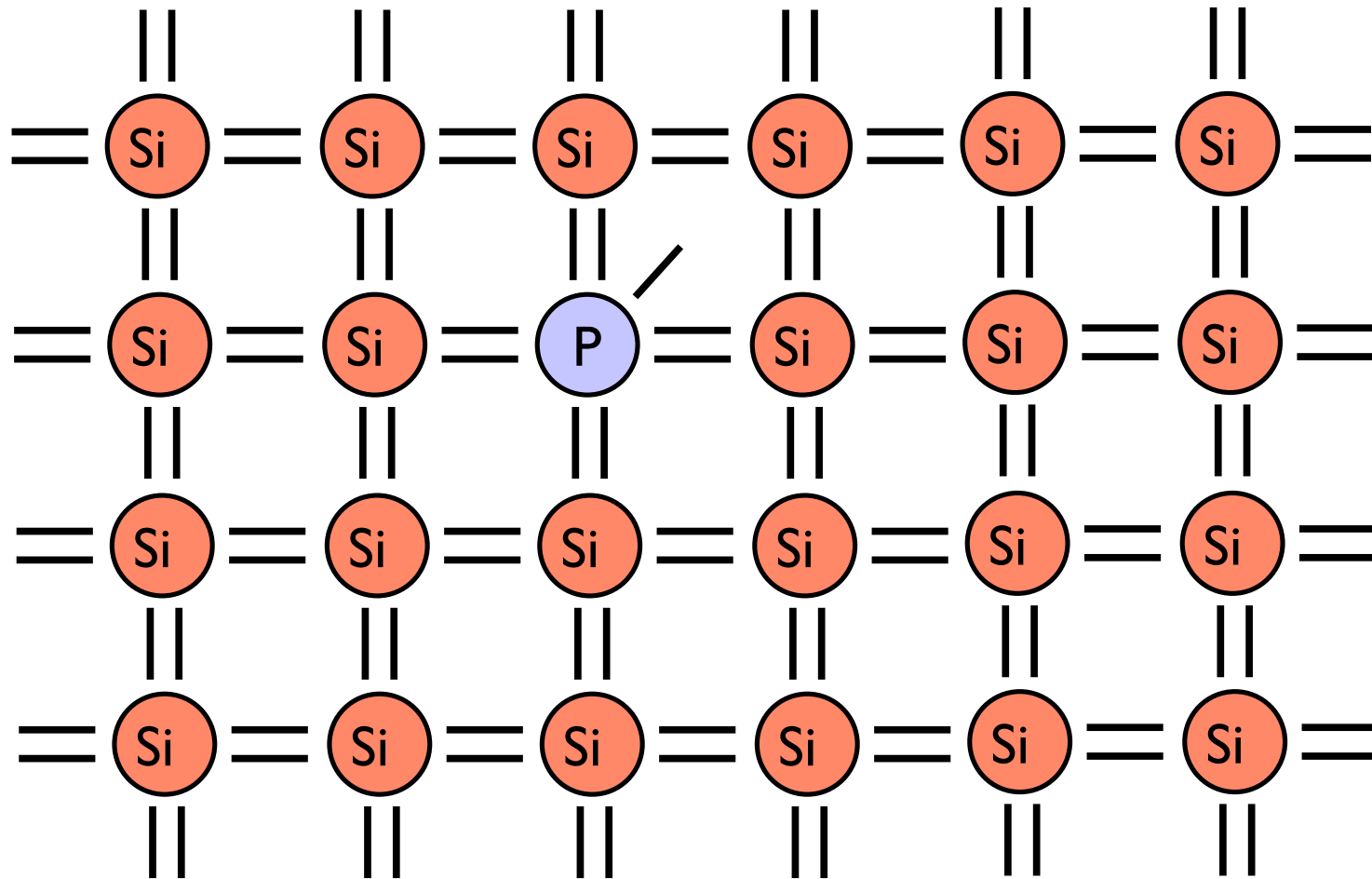
A silicon atom has four valence electrons. For our purposes, those four electrons will be schematically characterized as shown below.



As silicon atoms would like to have eight valence electrons, each silicon atom can achieve that end by sharing with four other silicon atoms. Such a lattice is shown below.



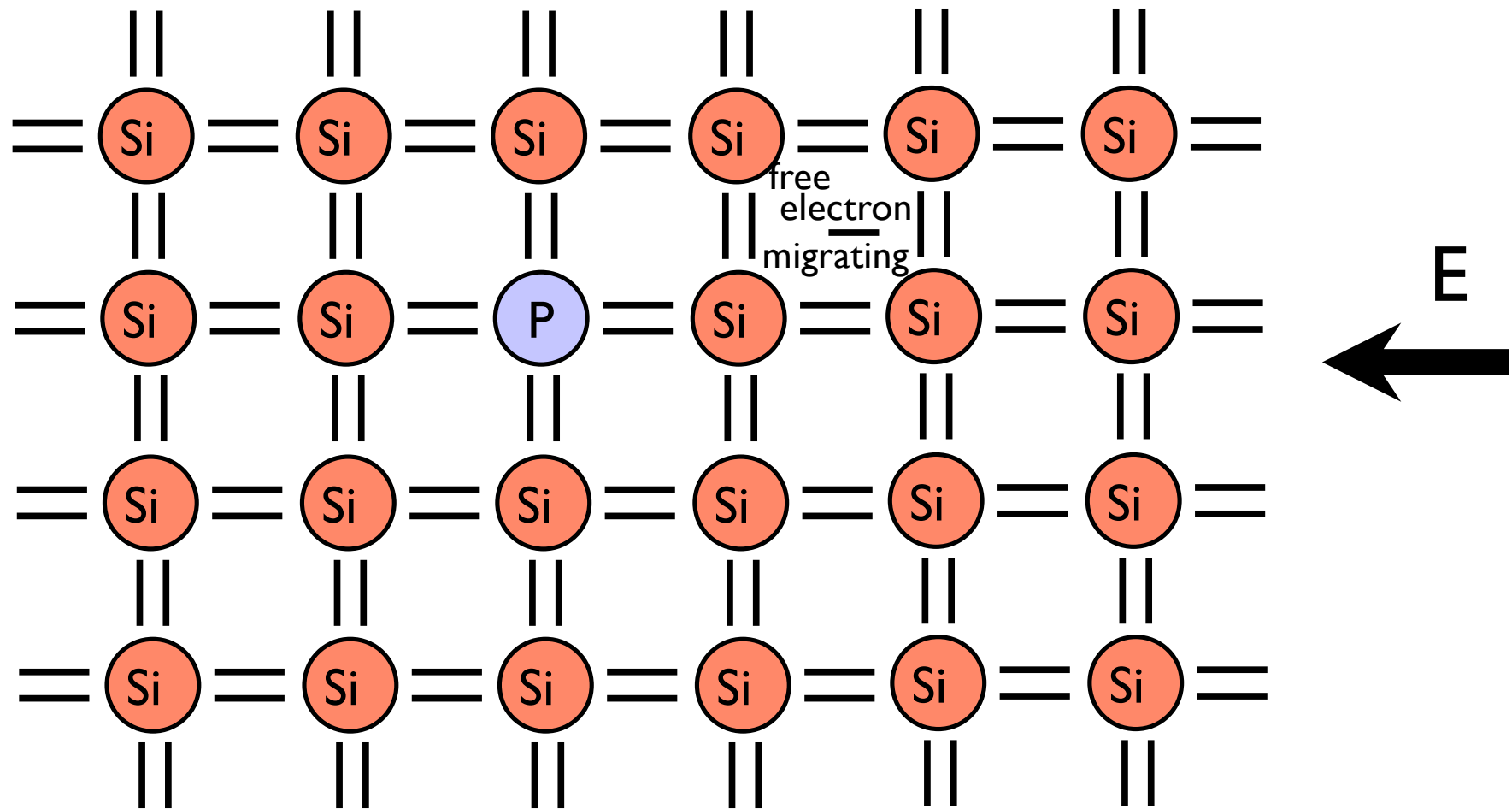
If we placed an impurity in the lattice (this is called “doping”), for instance a phosphorous atom with its five valence electrons, what would happen?



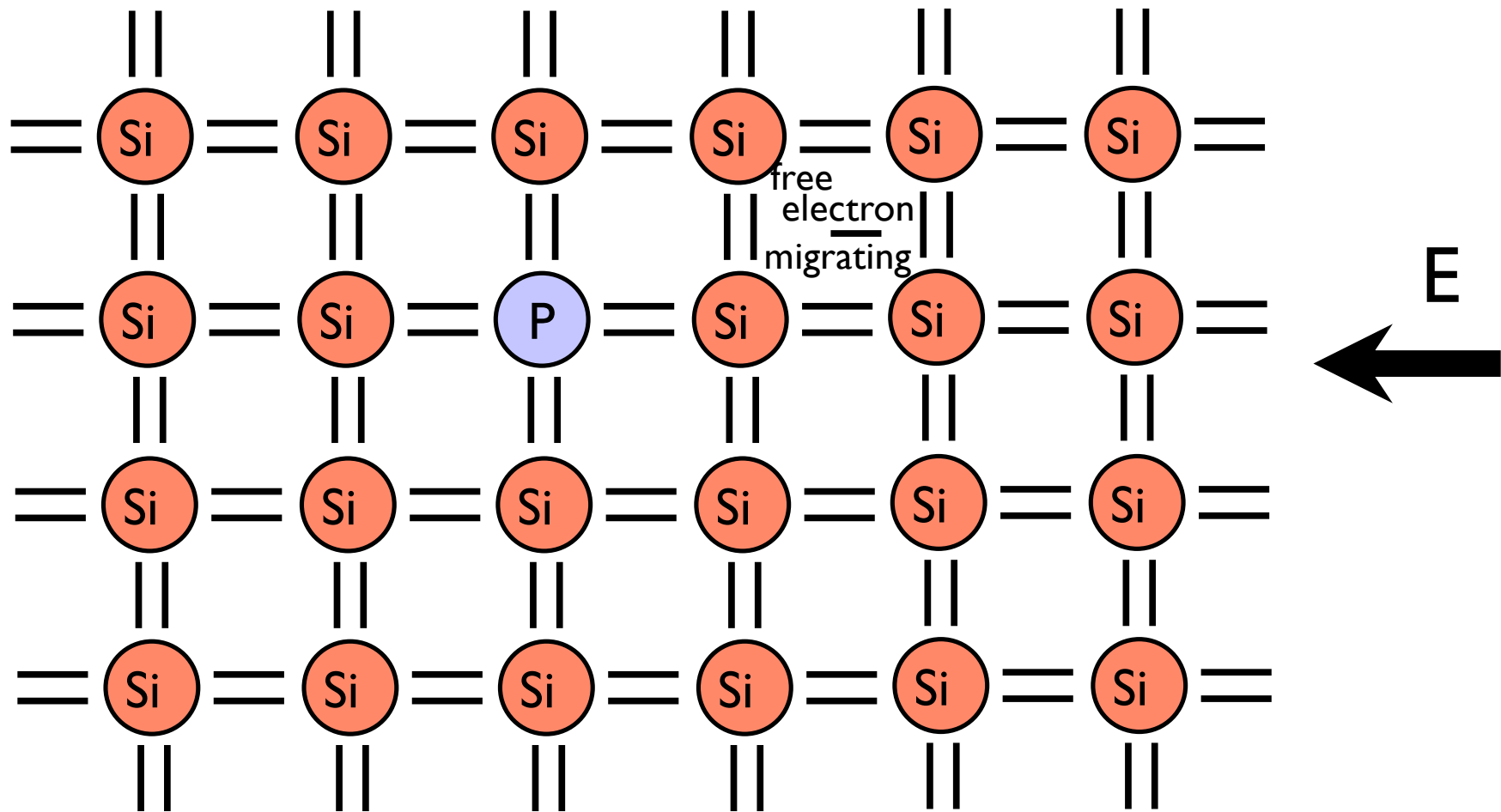
We would end up with a lattice in which there was one electron very loosely bound to the atom it came with. And if we put this structure in an electric field, what then?

And if we put this structure in an electric field, that extra electron could be made to break loose so that it might migrate freely throughout the structure, much like a valence electron does in a **METALLICALLY BONDED** structure.

In other words, we could end up with an *insulating* material that had *metallic* characteristics. Such materials are called SEMI-CONDUCTORS.



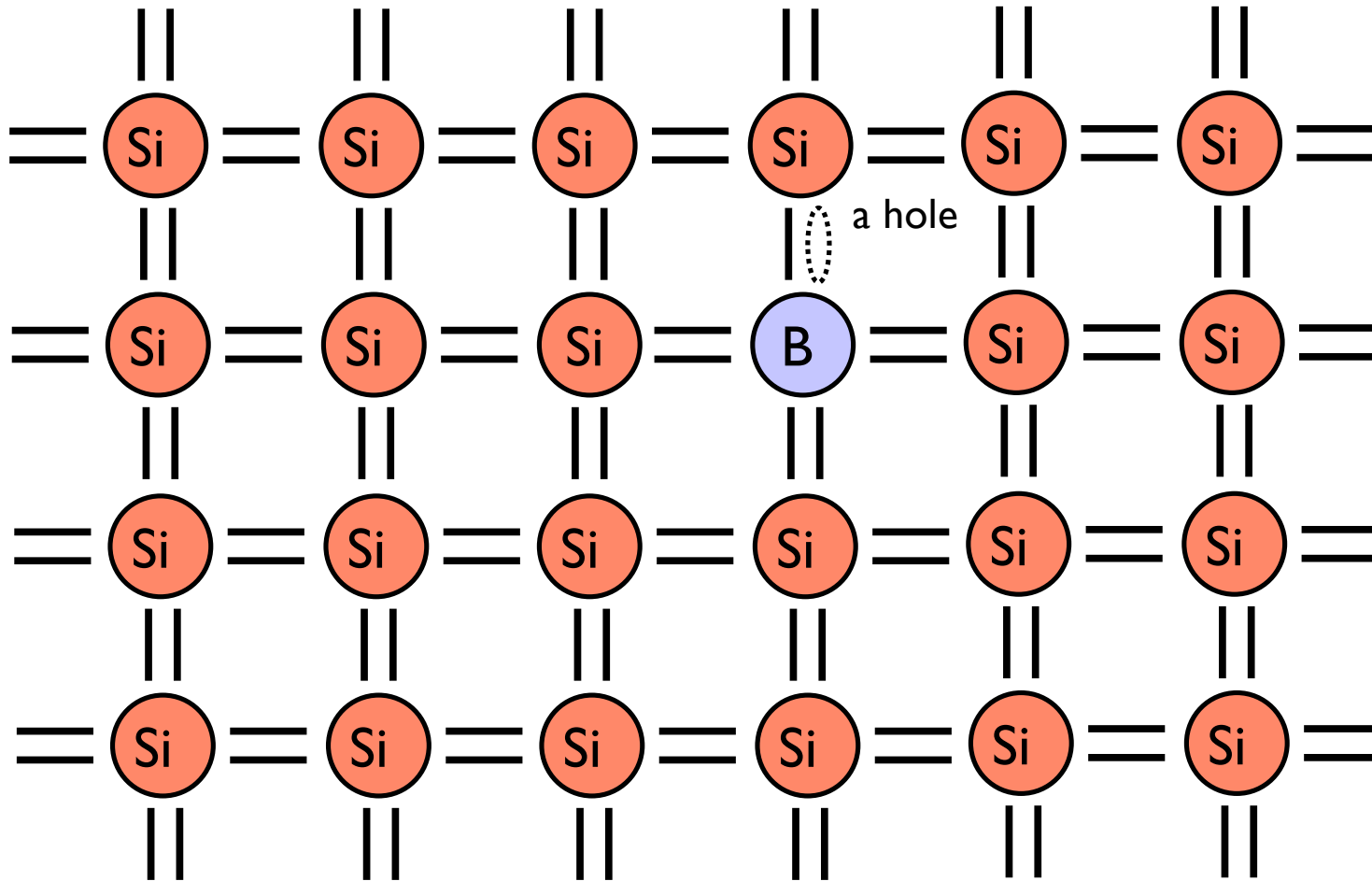
More specifically, as the migrating entity is an negatively charged electron, this is called an “n-type” semiconductor.



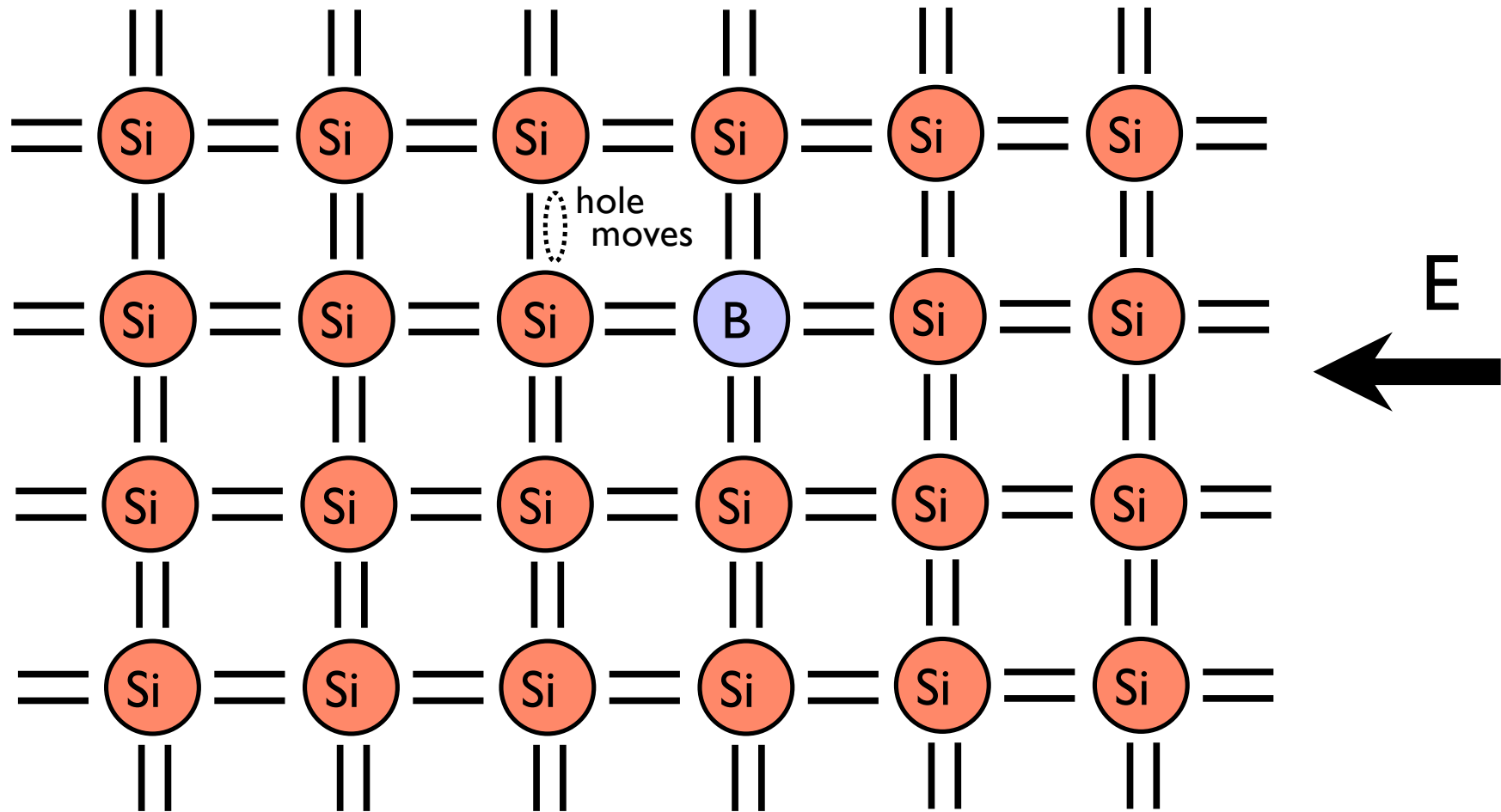
N-type semi-conductors are said to have “electron conduction.”

If the impurity had been a boron atom with its three valence electrons, the situation would have been a little different. In that case, there would have been a “hole” in the lattice where an electron should go (as far as the silicon is concerned) but in which there is no electron.

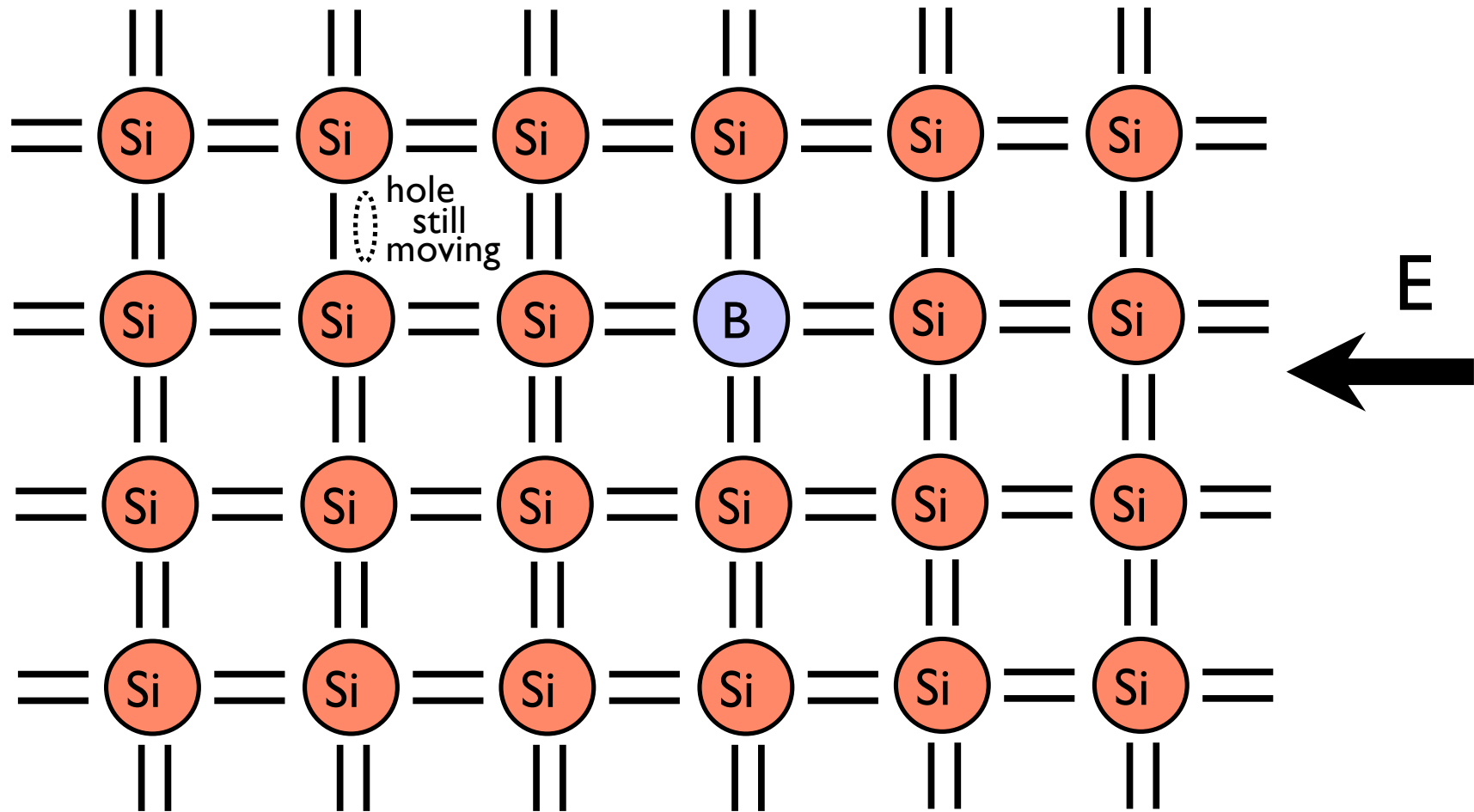
That situation is shown below.



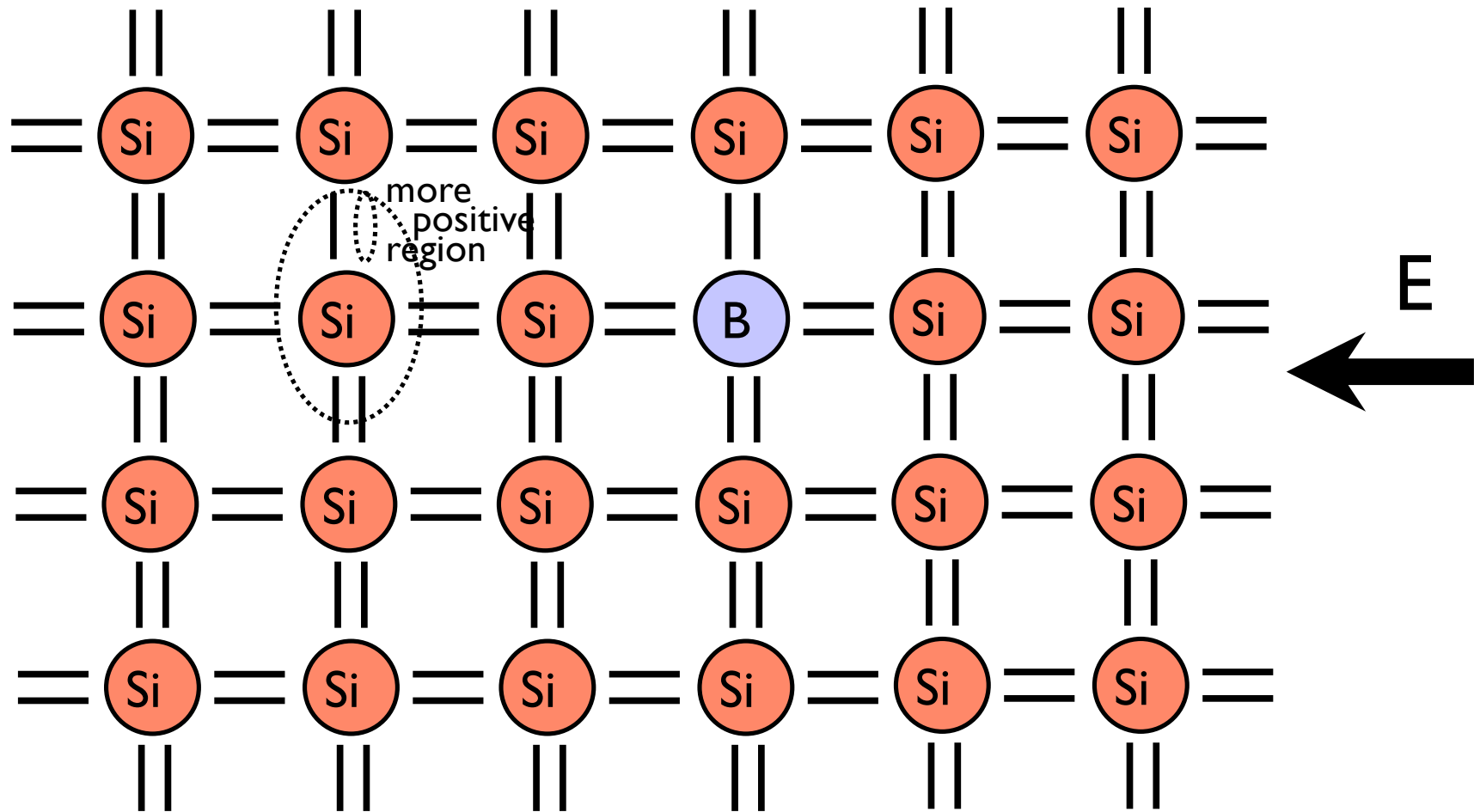
If we applied an electric field that that situation, a valence electrons to the left would migrate to the right to fill the hole leaving a hole behind.



This process continues with the hole migrating through the material just as a valence electron migrates through a conductor.



When a silicon atom hosts a hole, it will be more electrically positive than normal (there is one less electron in the valence shell).



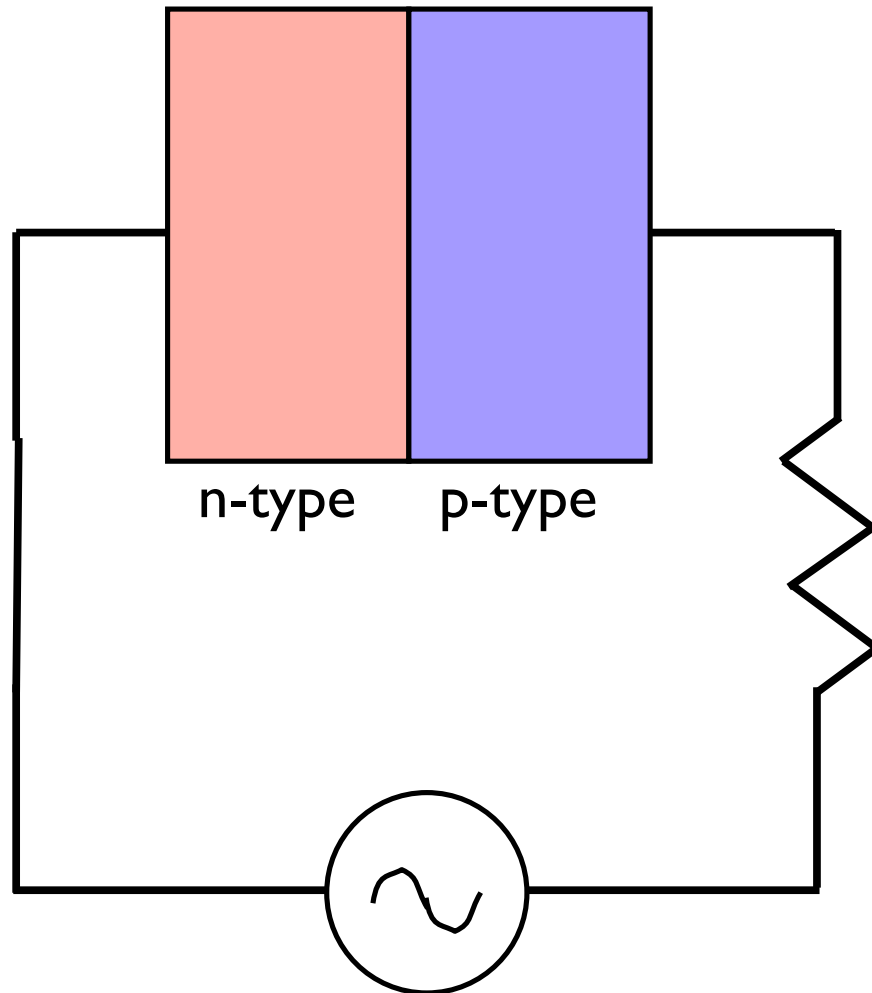
In other words, it is as though POSITIVE charge is migrating through the structure the way electrons migrate through a conductor.

Materials that are doped in this way are called “p-type” semi-conductors.

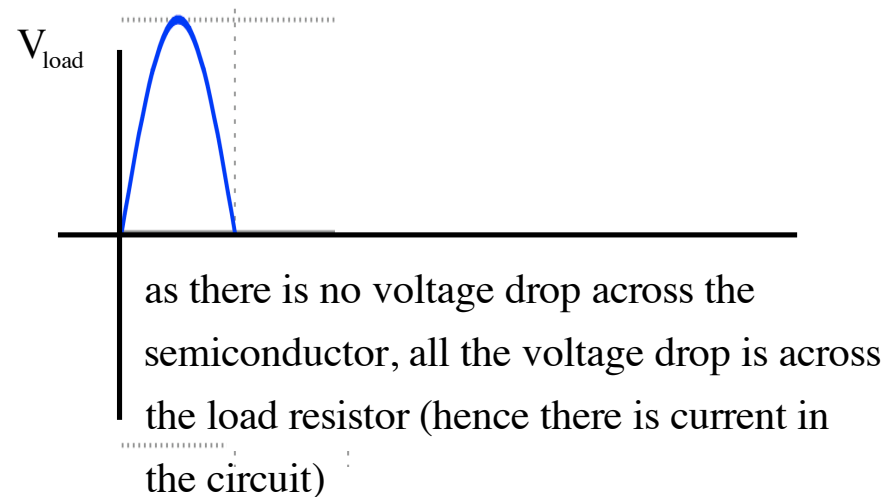
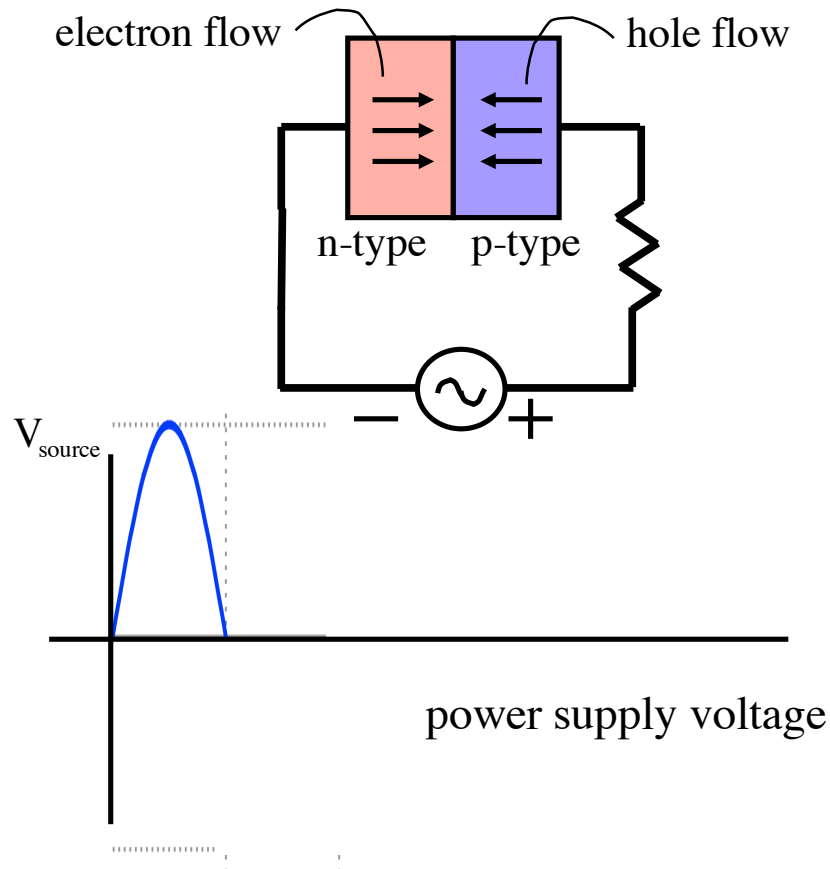
P-type semi-conductors are said to experience “hole conduction.”

In short, when asked on your test what the difference is between an n-type and p-type semiconductor, you will say that n-types have electron conduction and p-types have hole conduction.

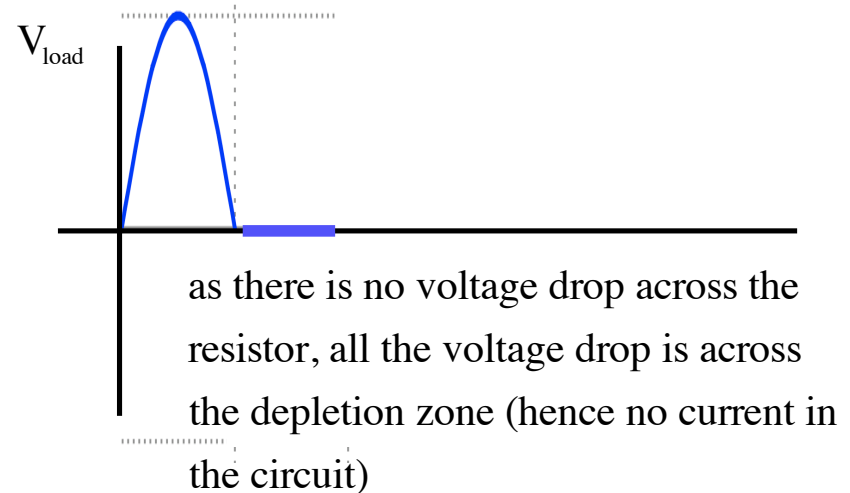
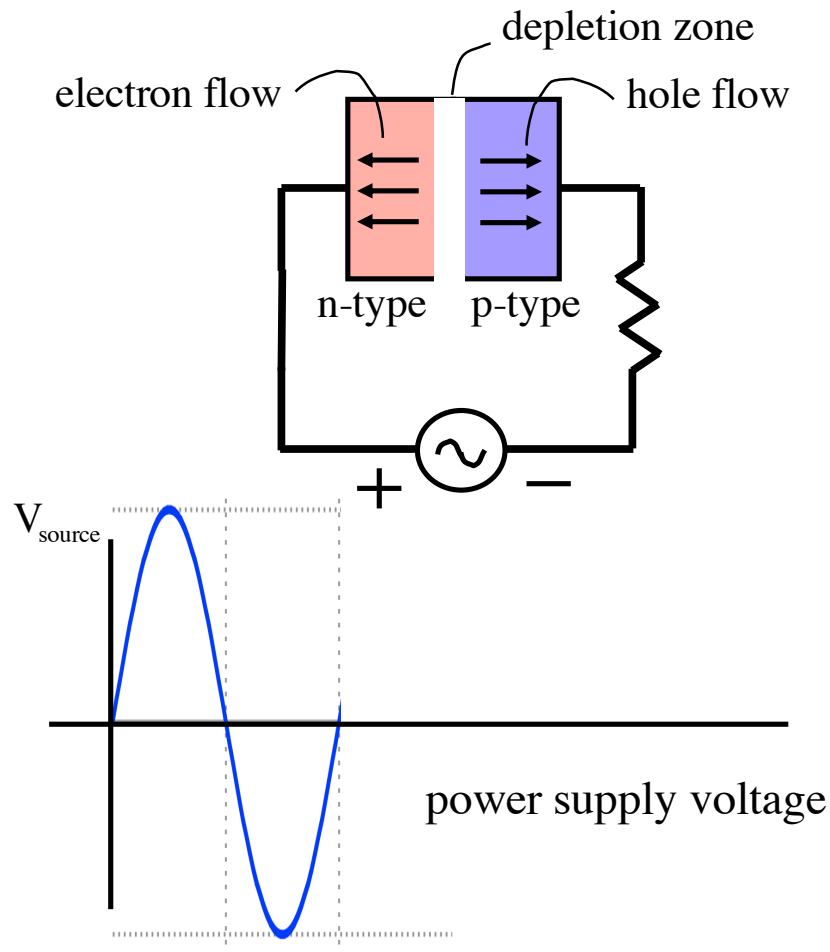
If we “glue” a p-type semi-conductor onto an n-type semi-conductor, we get an interesting device. Consider the following AC circuit.



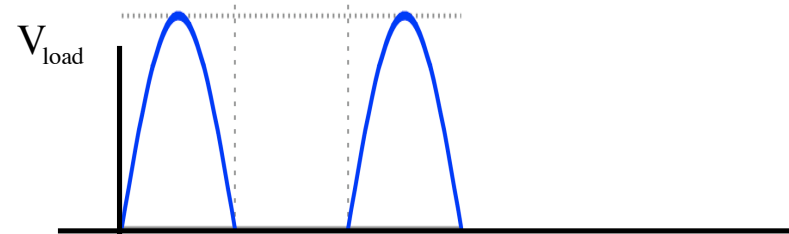
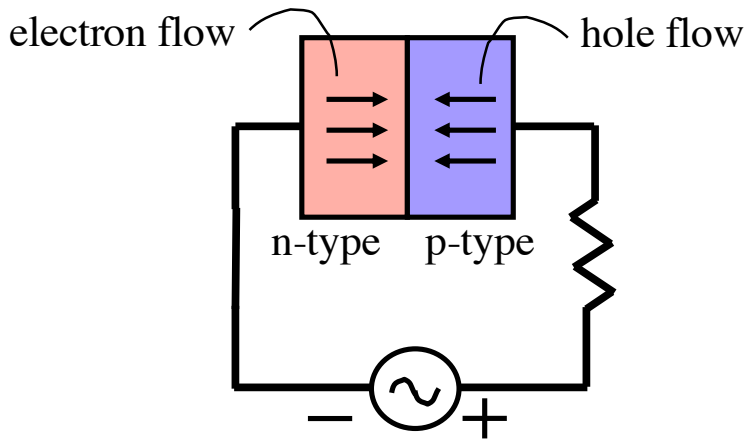
With the polarity shown, the electrons in the n-type semiconductor will move to the right while the holes in the p-type semiconductor will move to the left. Electrons and holes will meet along the boundary between the two semiconductors with the electrons filling in the holes. As it will take little energy to effect this situation, there will be only a tiny potential drop across the semiconductor with almost all of the voltage drop happening across the resistor. As current through a resistor is proportional to the voltage across a resistor, this means there IS a substantial current in the circuit and the output voltage across the load will look as sketched.



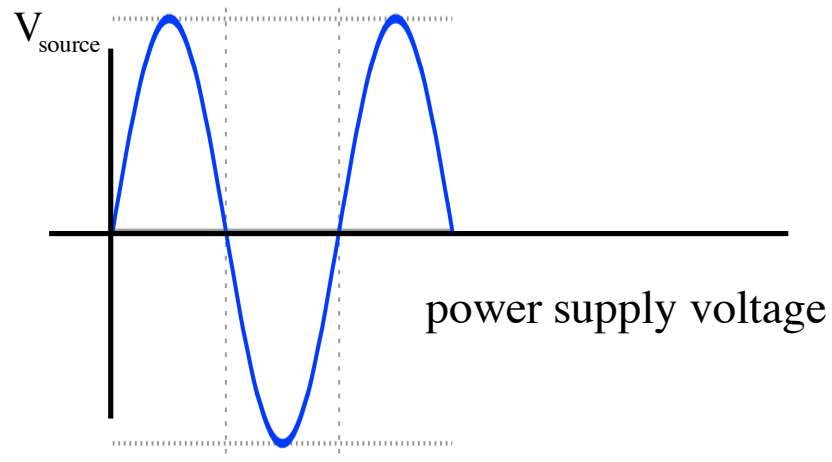
With the polarity change, the electrons in the n-type semiconductor will move to the left while the holes in the p-type semiconductor will move to the right. This will produce a depletion zone at the p-n junction. Acting like a break in the circuit, all the voltage will drop across the junction so that no voltage drop occurs across the resistor. As current through a resistor is proportional to the voltage across a resistor, this means there is **NO** current in the circuit and the output voltage across the load will look as sketched.



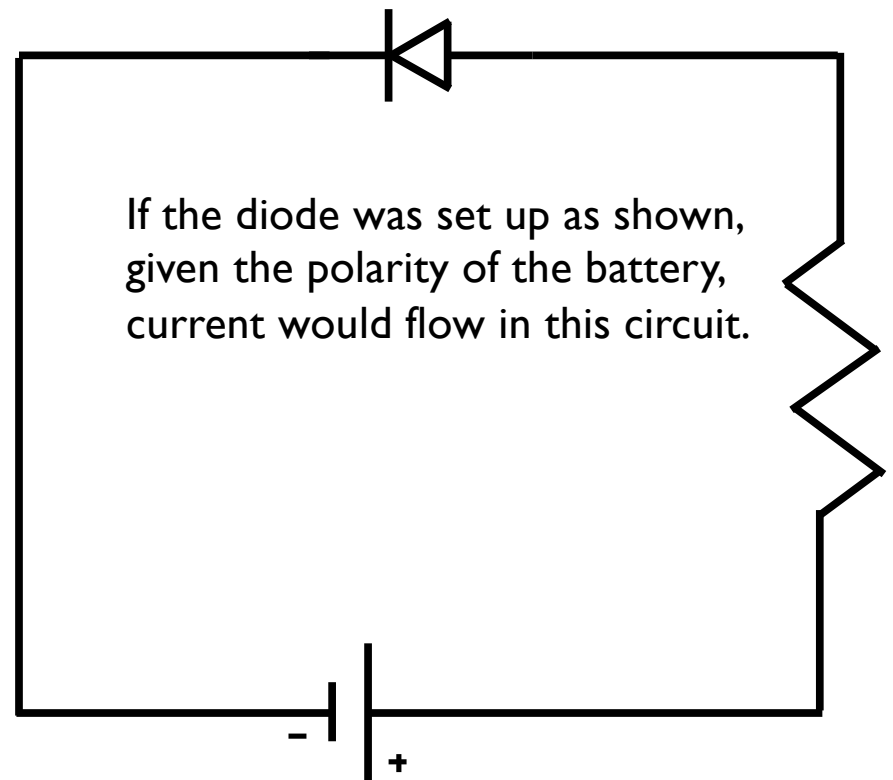
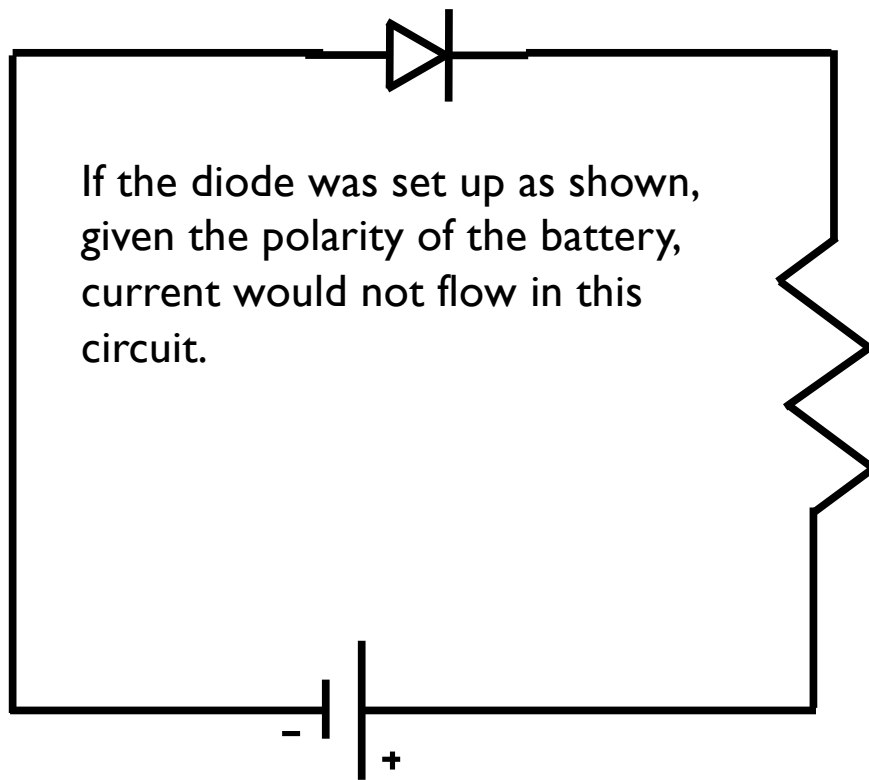
When the power supply cycles back, the depletion zone goes away, all the voltage drop occurs across the resistor which means we again have current in the circuit. In short, this device is designed to turn AC into DC or, in a DC circuit, restrict the direction current can flow in the circuit.



again, no voltage drop across the semiconductor, all the voltage drop is across the load resistor (hence there is current in the circuit)--what this device does is turn AC into DC . . .

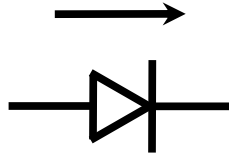


This device is called “a diode.” It’s symbol is shown in the two circuits sketched below. Diodes only allow current to flow in one direction with the arrow making up the diode’s symbol identifying the direction in which current can flow in the circuit.



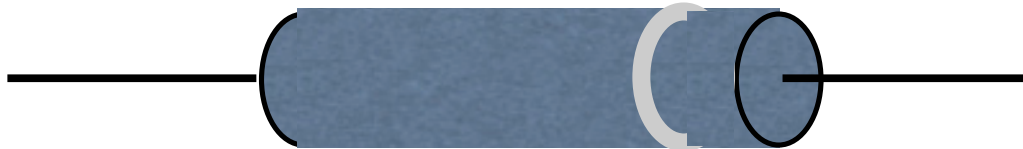
Shown a little differently:

current can flow this way

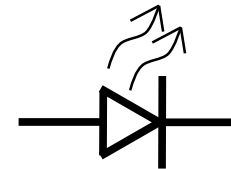


current cannot flow this way

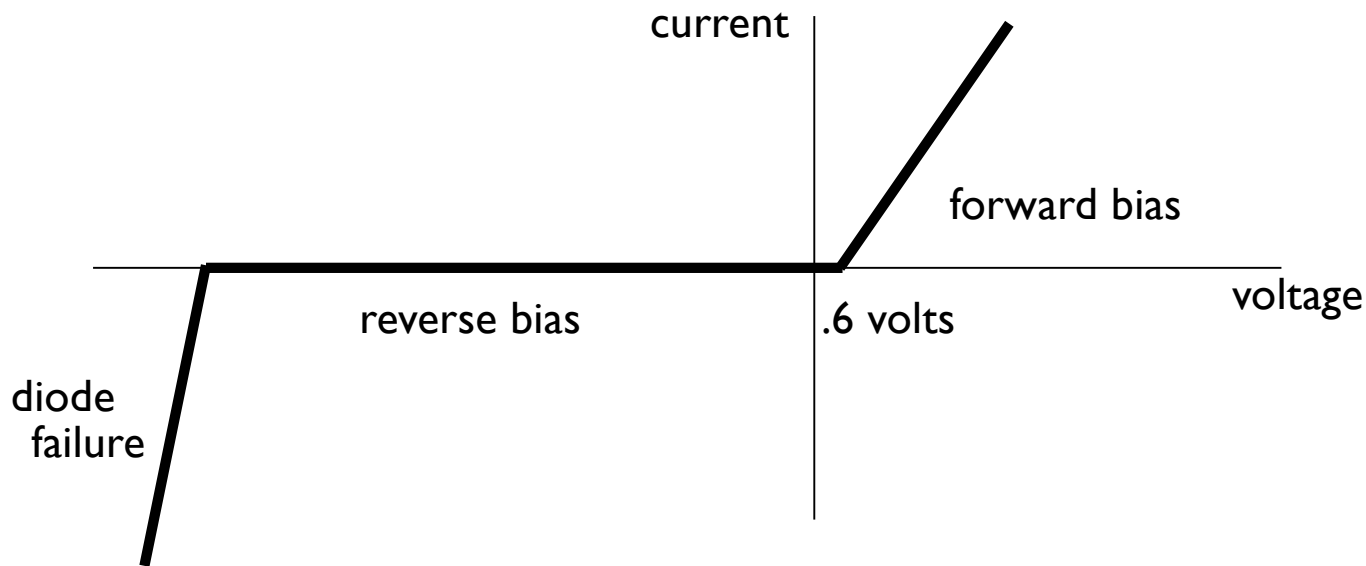
Physically, diodes look like resistors but with only one band, usually silver, at one end.



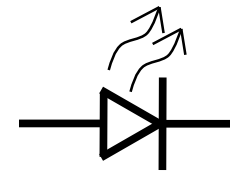
And when the transitions produce light, we get a light-emitting diode (LED) whose circuit symbol is:



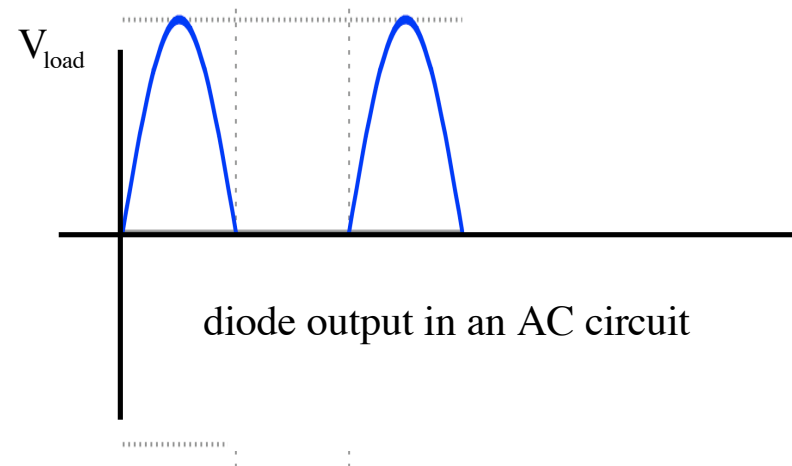
The current characteristic for a diode is shown below.



All diodes give off energy when they are in forward bias. Some do this in the optical range. These are called “light emitting diodes,” or LED’ s. The symbol for an LED is shown to the right where the arrows, usually shown wavy, are meant to denote radiation leaving the device.



A single diode in an AC circuit will generate DC (i.e., a situation in which all of the current flowing in the circuit proceeds in one direction only), but there are two problems with the DC it does produce.



- a.) First, it is wasteful in the sense that you lose half your power.
- b.) Second, it is lumpy (versus the linear, straight-line voltage one would expect for a DC source).

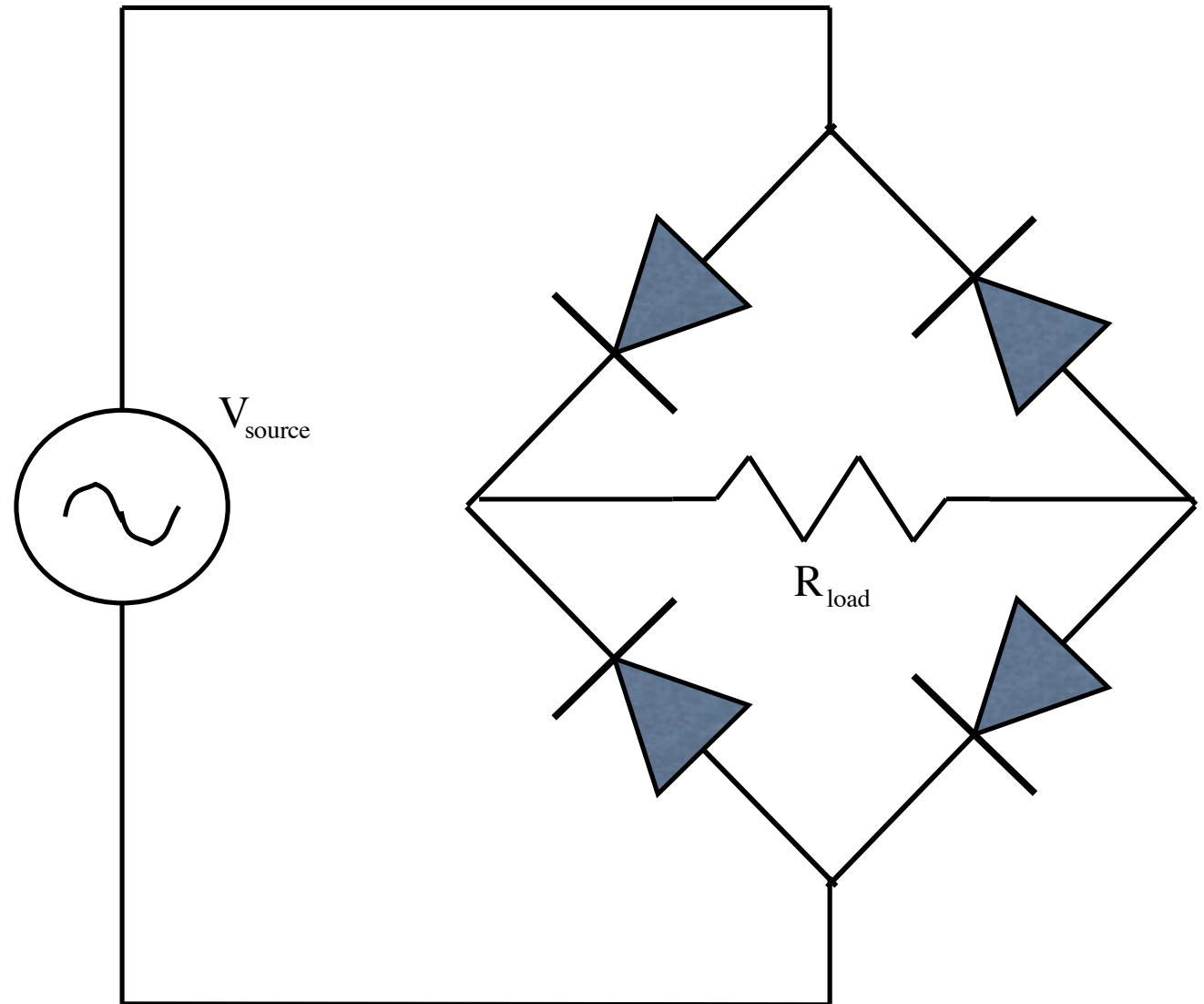
The solution to these two problems follows:

The Diode Bridge:

Follow the current path when the AC power polarity is as shown.

Note 1: The current at far right node will flow downward instead of upward because current always flows from higher voltage to lower, and flowing upward would violate that stricture.

Note 2: The left side of the load resistor is electrically positive.

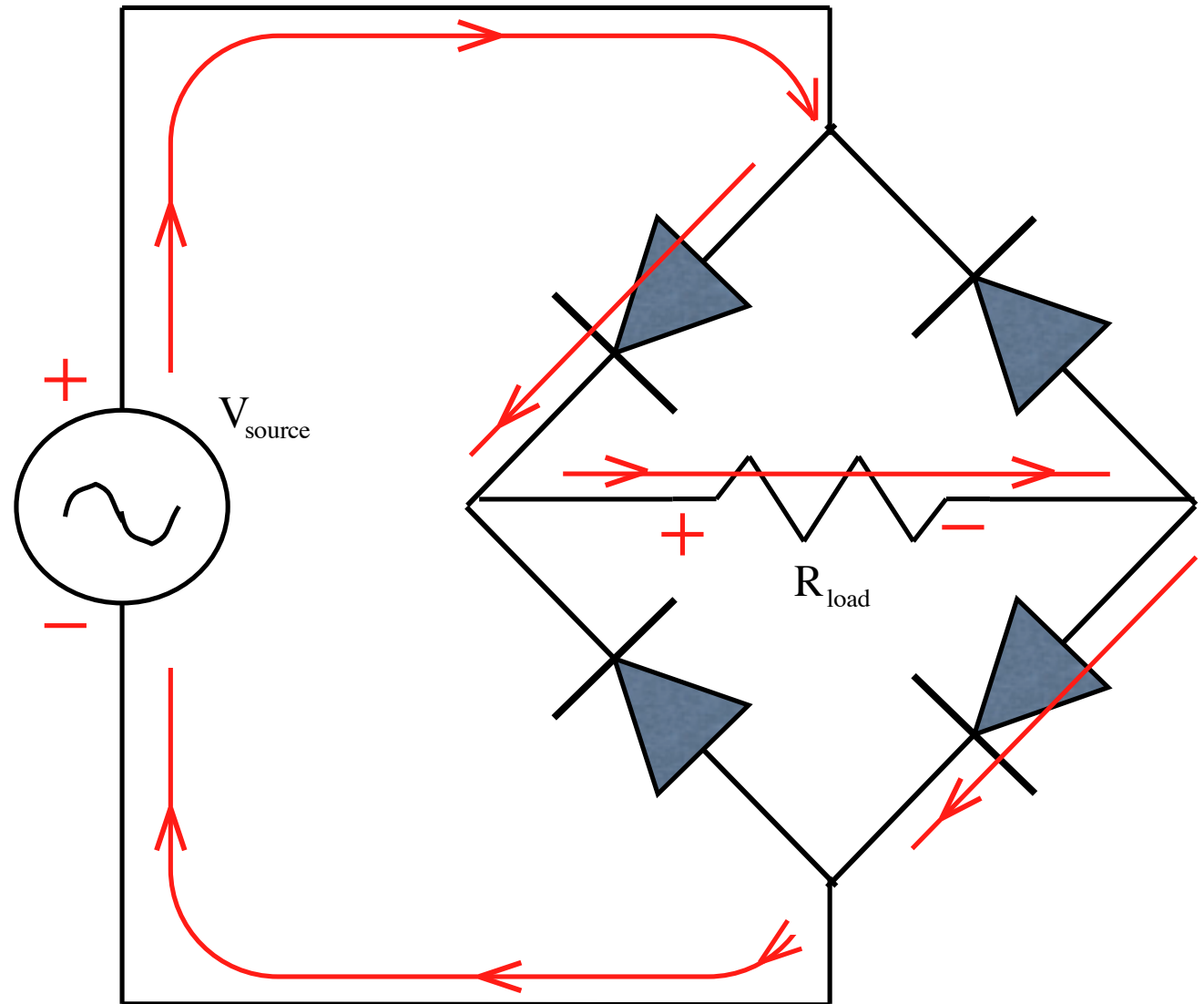


The Diode Bridge:

Follow the current path when the AC power polarity is as shown.

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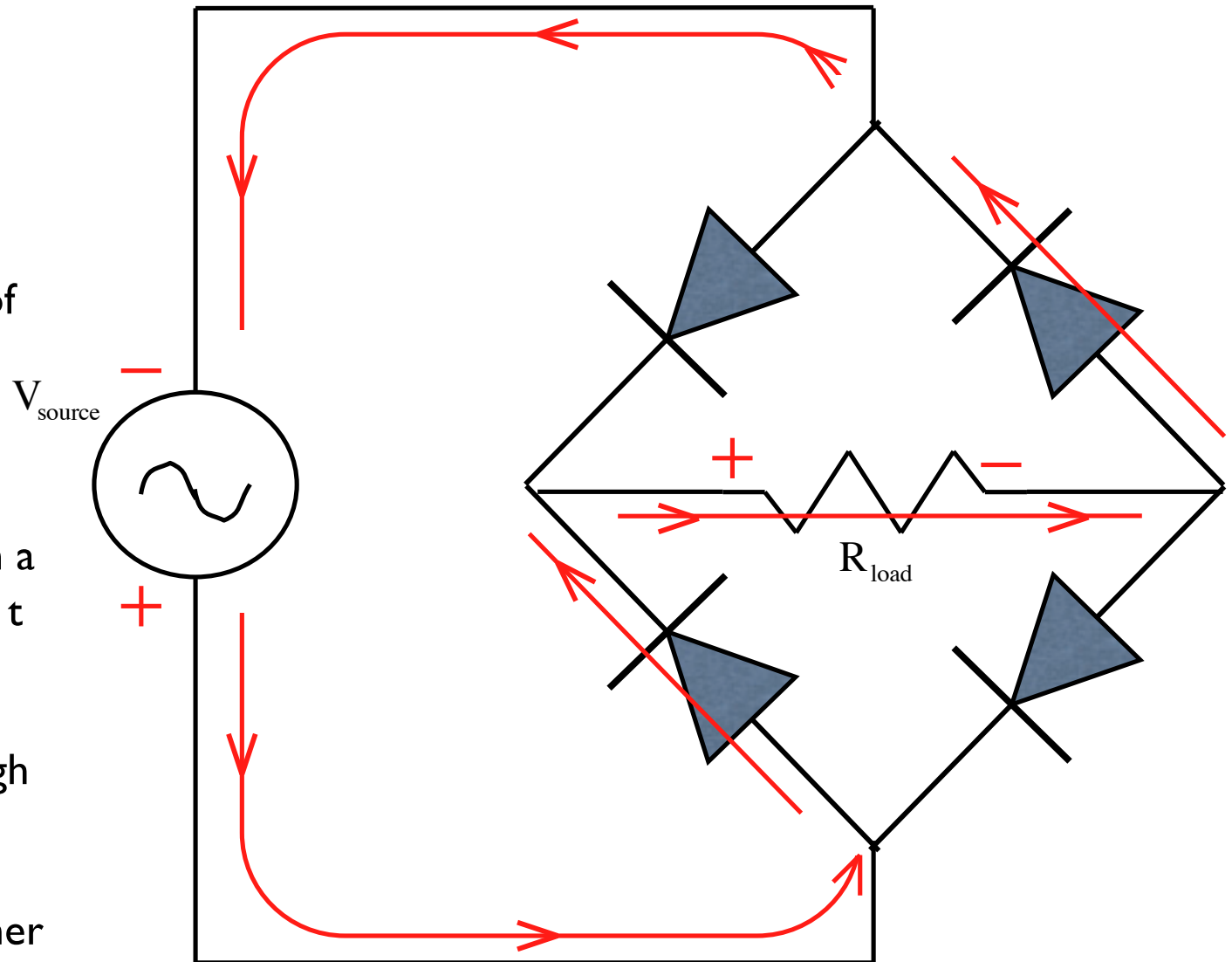
Note 2: The left side of the load resistor is electrically positive.



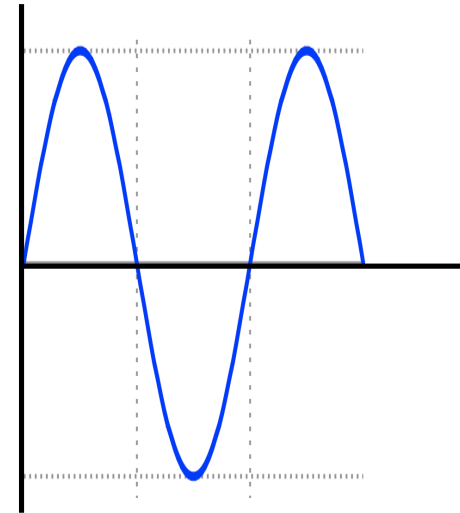
Follow the current path when the AC power polarity switches as shown.

Note 1: The left side of the load resistor is STILL electrically positive.

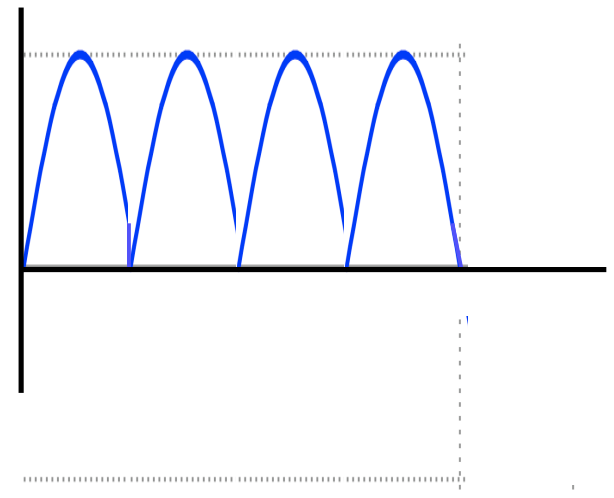
Note 2: Evidently, with a diode bridge it doesn't matter what polarity there is across the AC source, current through the load resistor ALWAYS flows in the same direction. In other words, we've taken AC and turned it into DC.



The net result? From an AC power supply input of:



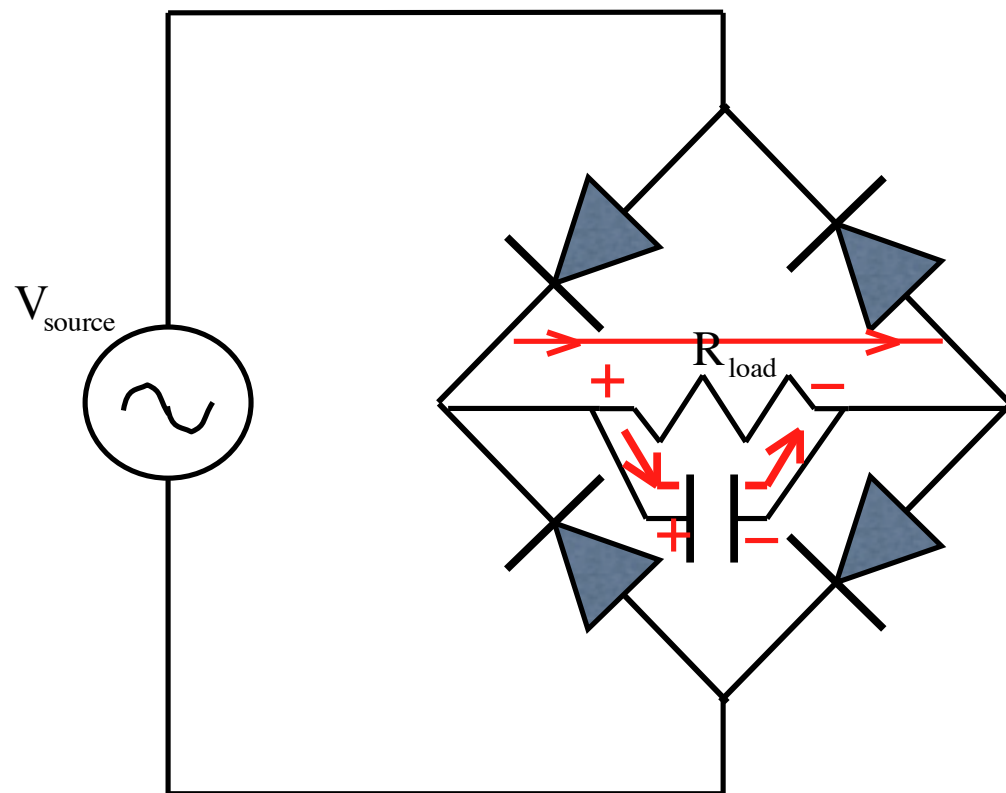
we get a DC load resistor output that looks like:



So much for flipping the AC signal so that no power is lost in the process. How do we make the lumpy DC into flat-line, linear DC? It's done by putting a capacitor across the load resistor terminals.

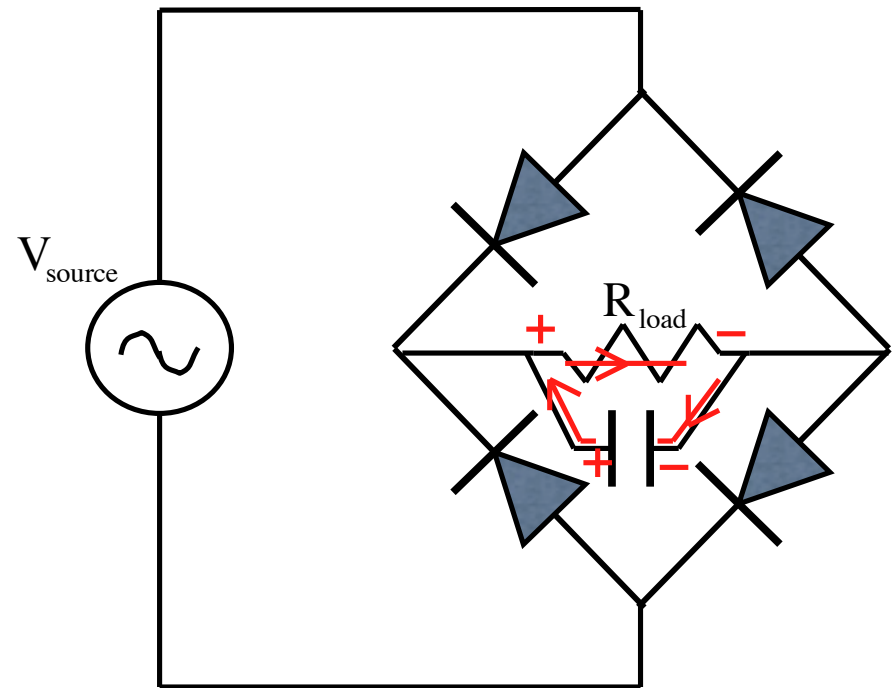
How does this work?

a.) As the voltage across the load resistor increases due to the voltage increase across the AC power supply, the voltage across the capacitor also increases.



b.) As the voltage across the power supply decreases, the voltage across the load resistor also begins to decrease but not as fast as normal. Why? Because the charged capacitor, which is in parallel with the resistor and, hence, must have the same voltage as the resistor, is still charged. It responds to the attempted voltage drop across the resistor by beginning to discharge through the resistor. In doing so, it keeps the resistor's voltage artificially high.

c.) This buoying of voltage across the resistor continues until the duty cycle across the resistor and capacitor begins to again charge up the capacitor and the whole cycle starts over again.



The capacitor discharges across the resistor as the AC power supply's voltage begins to drop. This keeps the voltage across the resistor and the current through the load resistor artificially high until the AC source can again push the cap's voltage back up to its maximum again.

The end result is that our lumpy DC load voltage

gets smoothed out

and ends up looking like:

Called *ripple*, this effect is exaggerated in the sketch. It is usually no more than 2% to 5% of the amplitude of the voltage, so the actual waveform looks to the naked eye like:

