Lecture 1

MATERIALS USED IN ELECTRONICS

INSULATORS, CONDUCTORS, AND SEMICONDUCTORS

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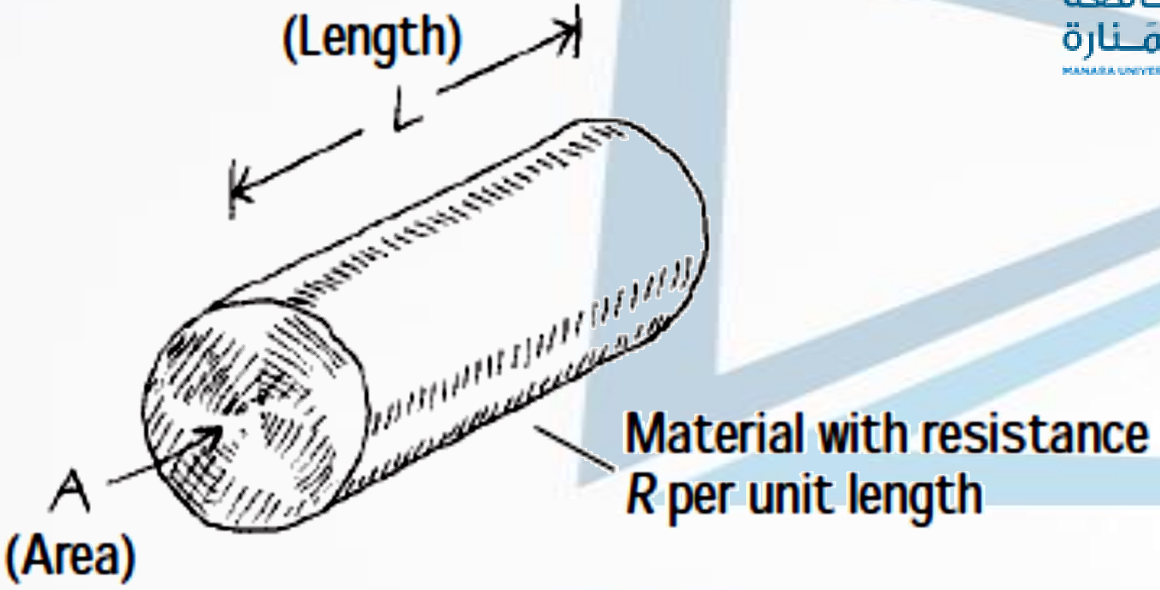
Insulators: **An insulator is a material that does not conduct electrical current under normal conditions. Most good insulators are compounds rather than single-element materials and have very high resistivity's. Valence electrons are tightly bound to the atoms; therefore, there are very few free electrons in an insulator. Examples of insulators are rubber, plastics, glass, mica, and quartz.**

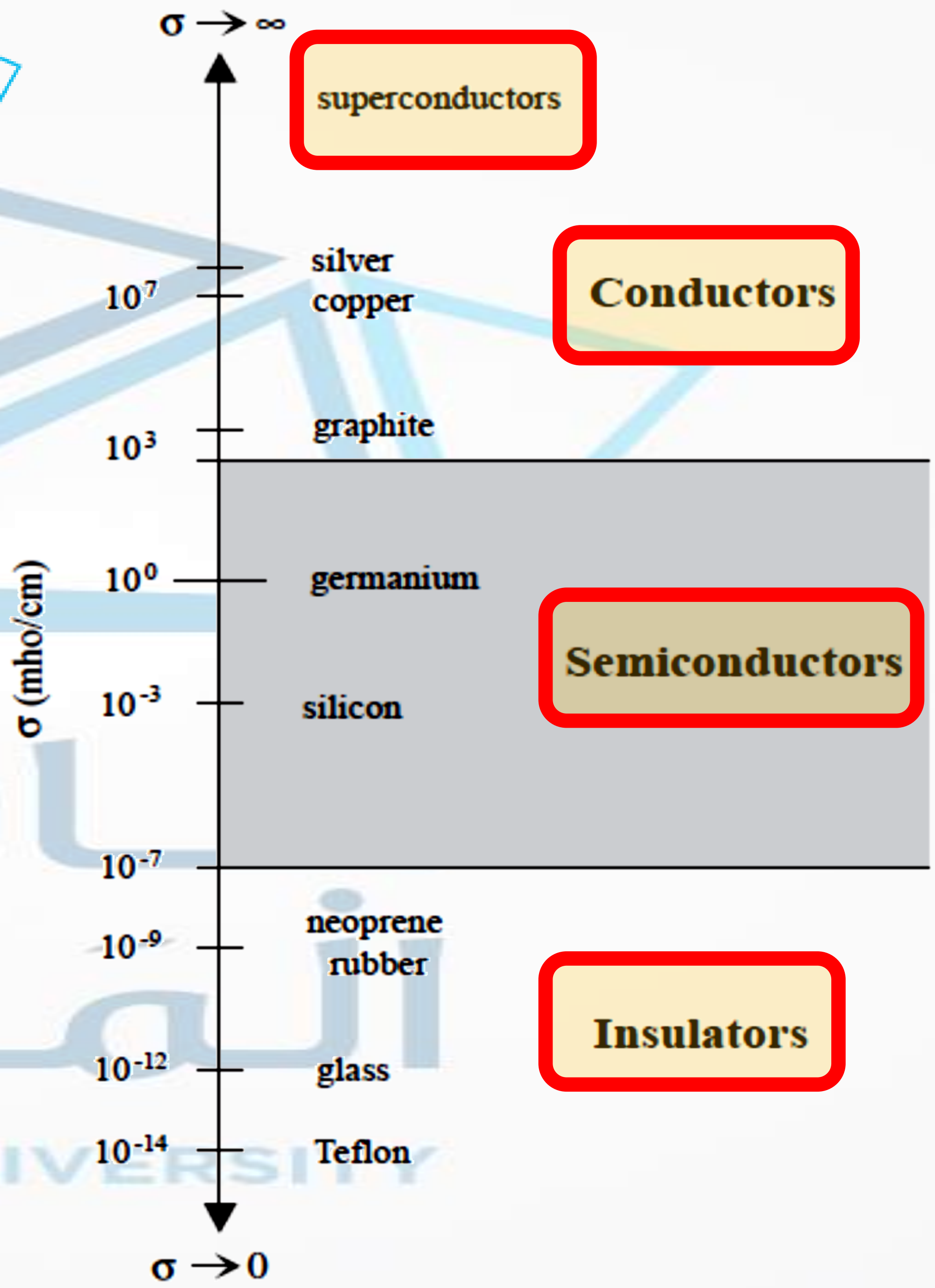
Conductors: **A conductor is a material that easily conducts electrical current. Most metals are good conductors. The best conductors are single-element materials, such as copper (Cu), silver (Ag), gold (Au), and aluminum (Al), which are characterized by atoms with only one valence electron very loosely bound to the atom. These loosely bound valence electrons become free electrons. in a conductive material the free electrons are valence electrons.**

Semiconductors:

A semiconductor is a material that is between conductors and insulators in its ability to conduct electrical current.

- A semiconductor in its pure (intrinsic) state is neither a good conductor nor a good insulator.
- Single-element semiconductors are antimony (Sb), arsenic (As), astatine (At), boron (B), polonium (Po), tellurium (Te), silicon (Si), and germanium (Ge).
- The single-element semiconductors are characterized by atoms with four valence electrons. Silicon is the most commonly used semiconductor.
- Compound semiconductors such as gallium arsenide, indium phosphide, gallium nitride, silicon carbide, and silicon germanium are also commonly used.





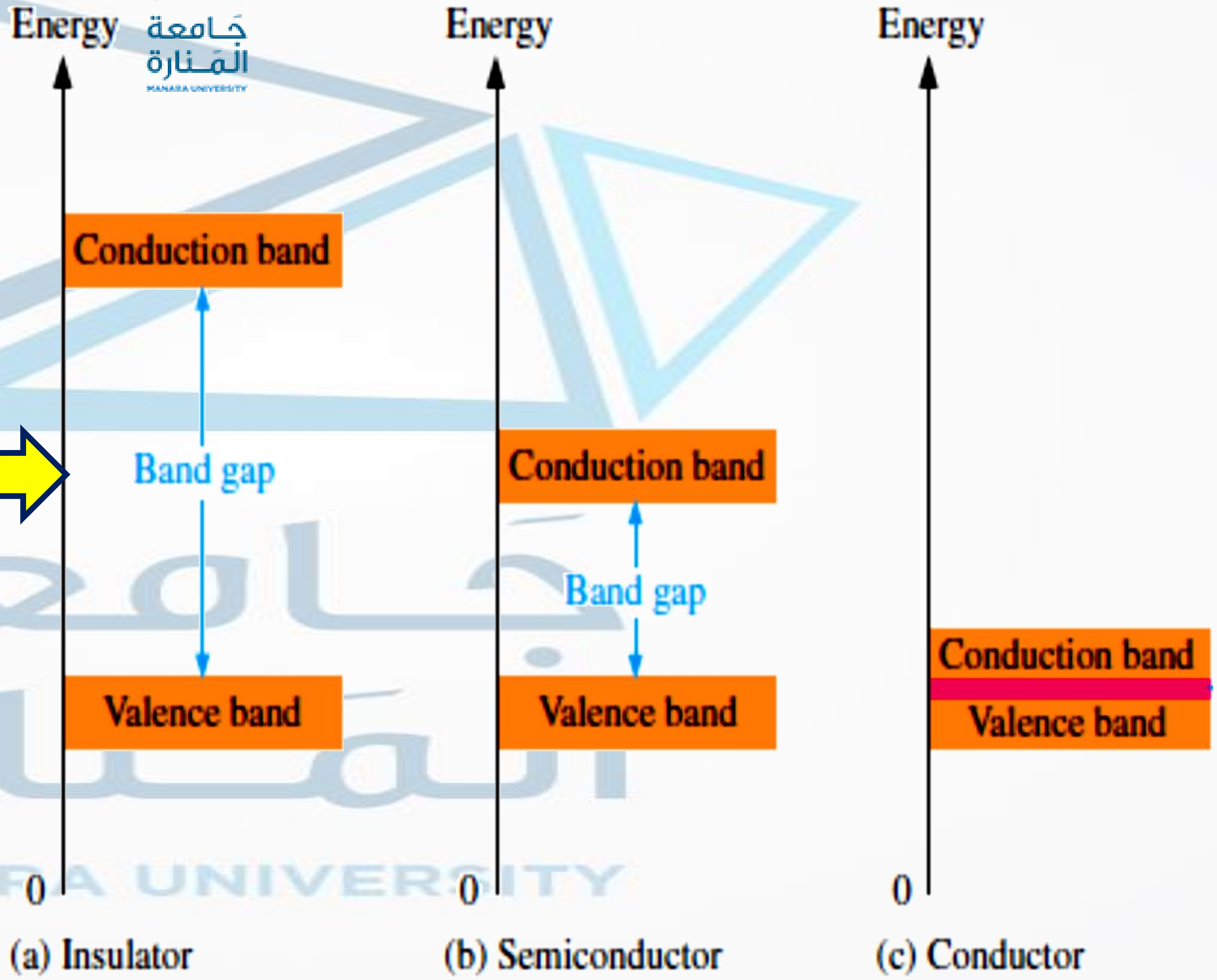
$$\rho = R\frac{A}{L} \quad \text{(Resistivity ohm·cm)}$$

$$\sigma = \frac{1}{\rho} \quad \text{(Conductivity mho/cm)}$$

$$\text{mho} = \frac{1}{\text{ohm}} = \frac{1}{\Omega} = \mho$$

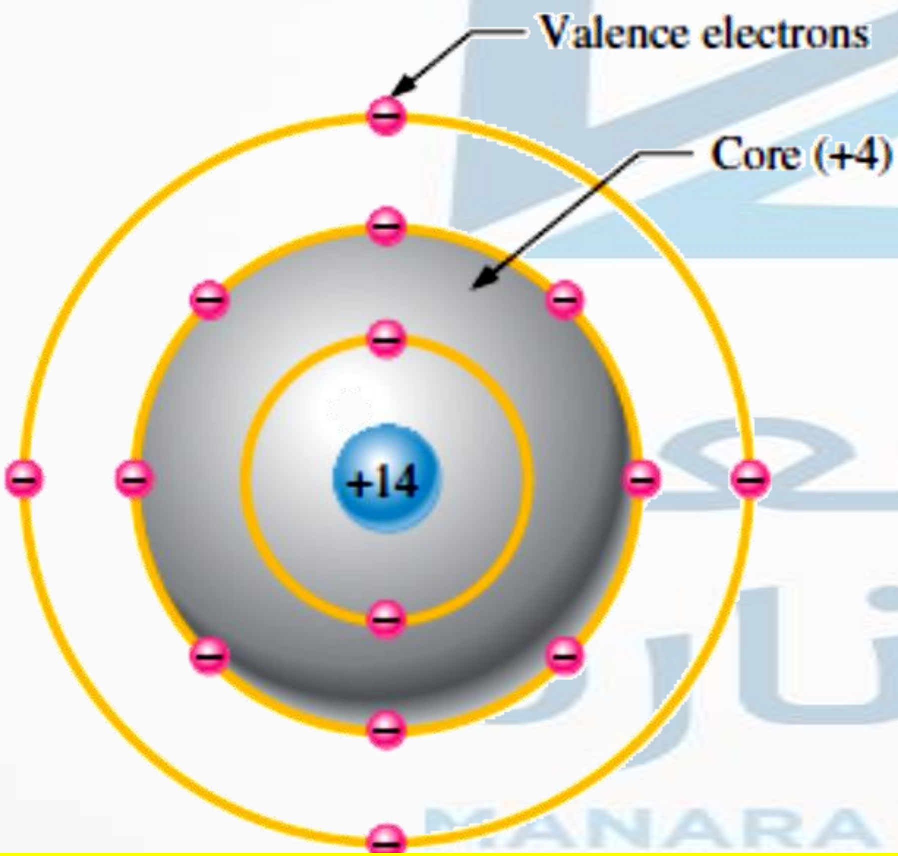
BAND GAP

The difference in energy between the **valence band** **and the** **conduction band** **is called an *energy gap* or band gap.**



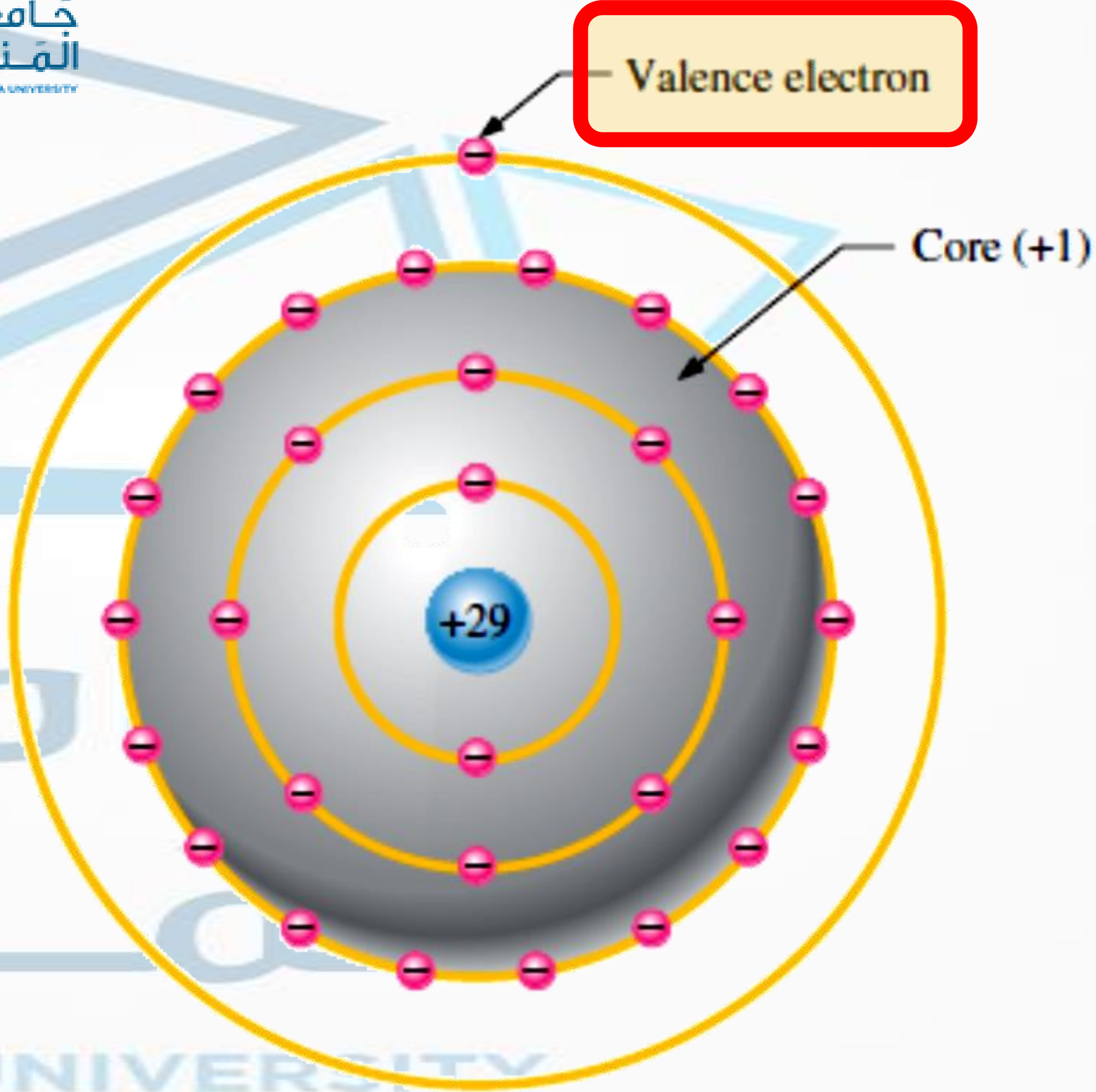
BOHR DIAGRAMS

Semiconductor Atom



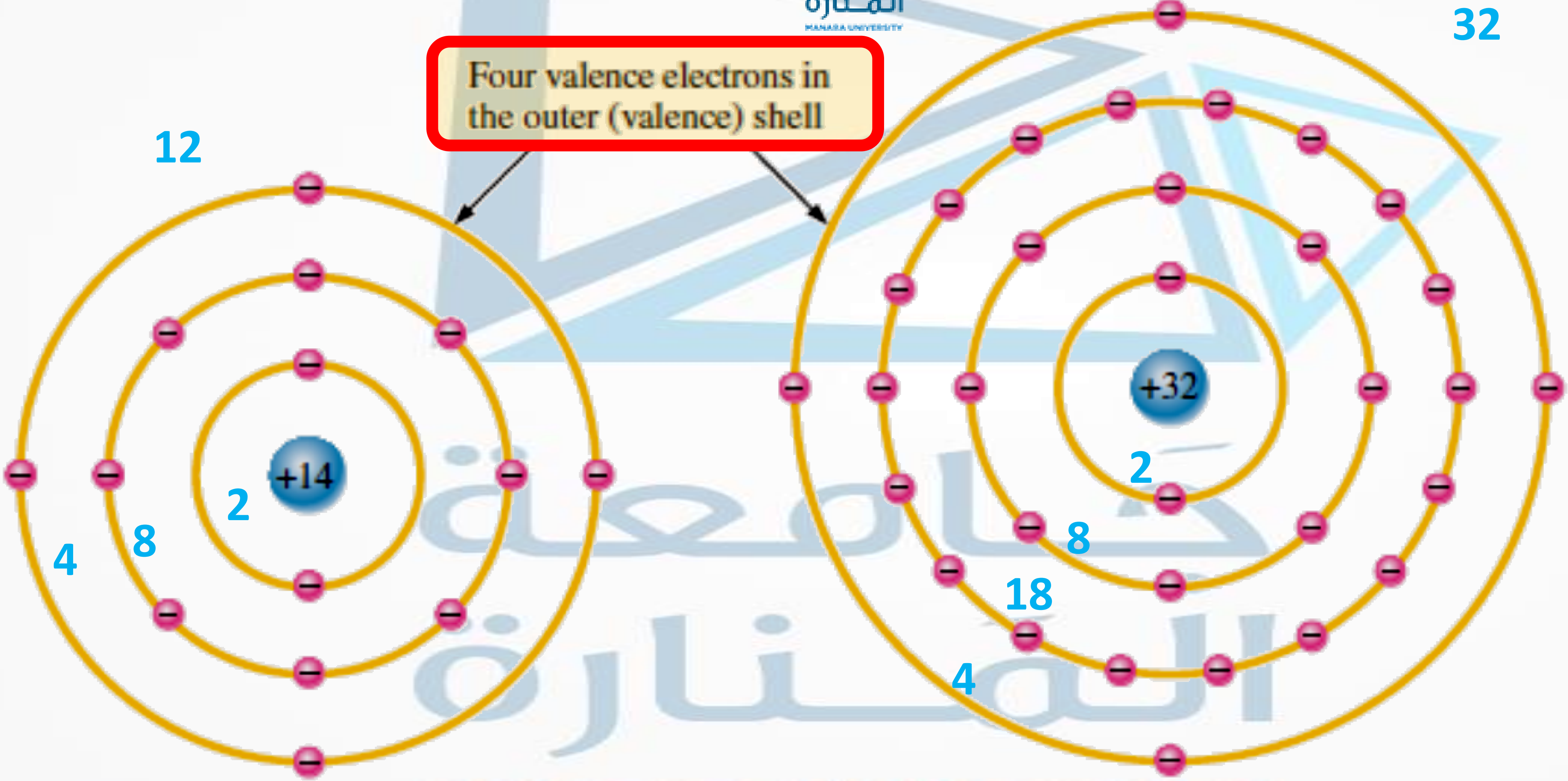
silicon atoms

Conductor Atom



copper atoms

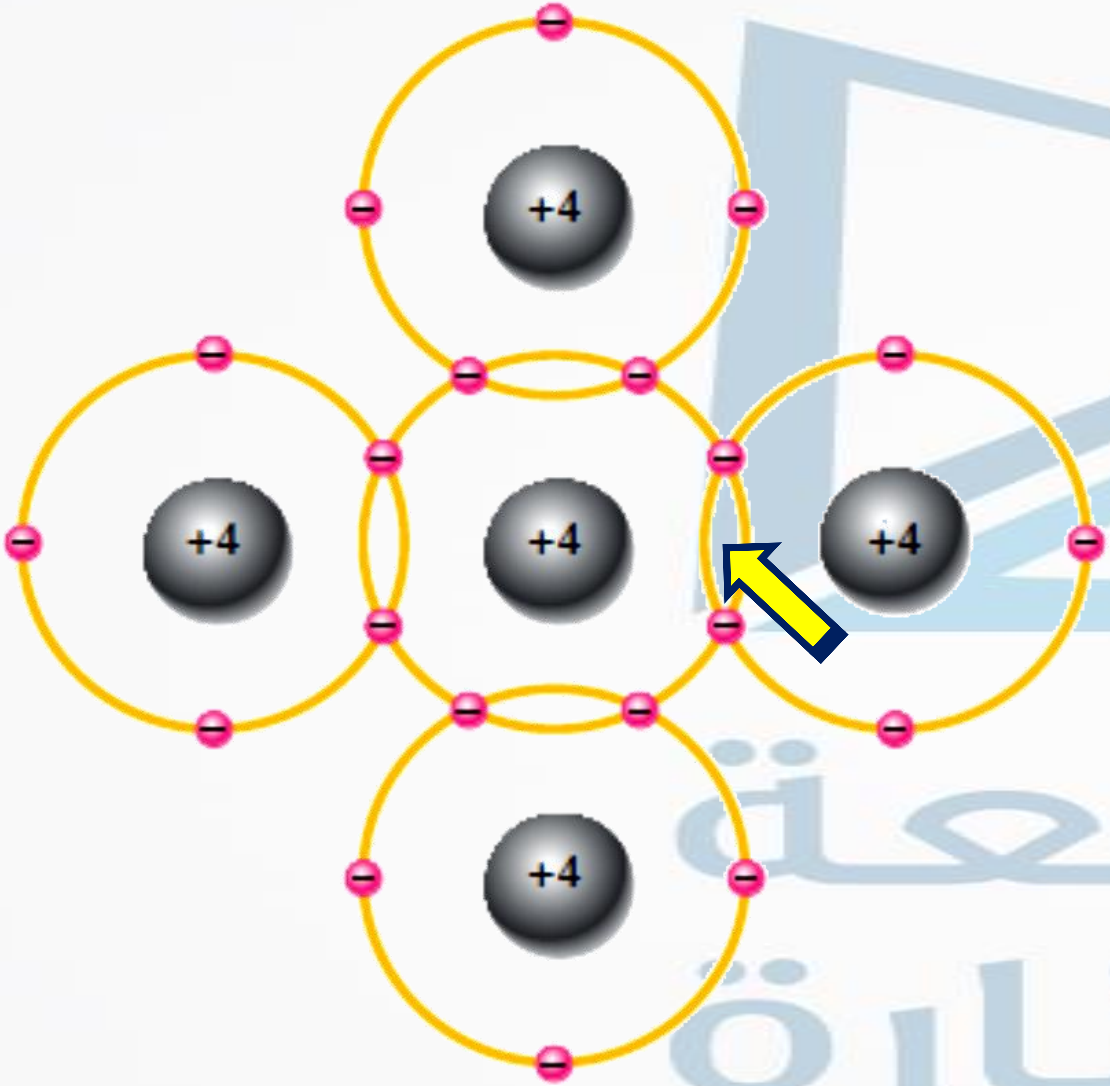
DIAGRAMS OF THE SILICON AND GERMANIUM ATOMS.

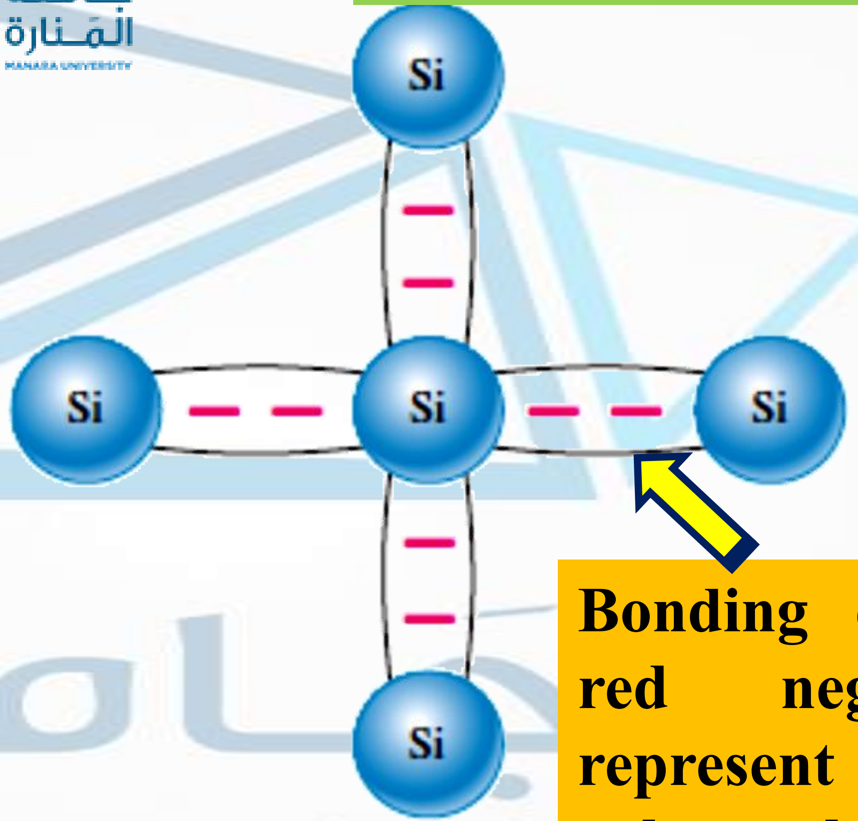


silicon atom

Germanium atom

COVALENT BONDS IN SILICON.



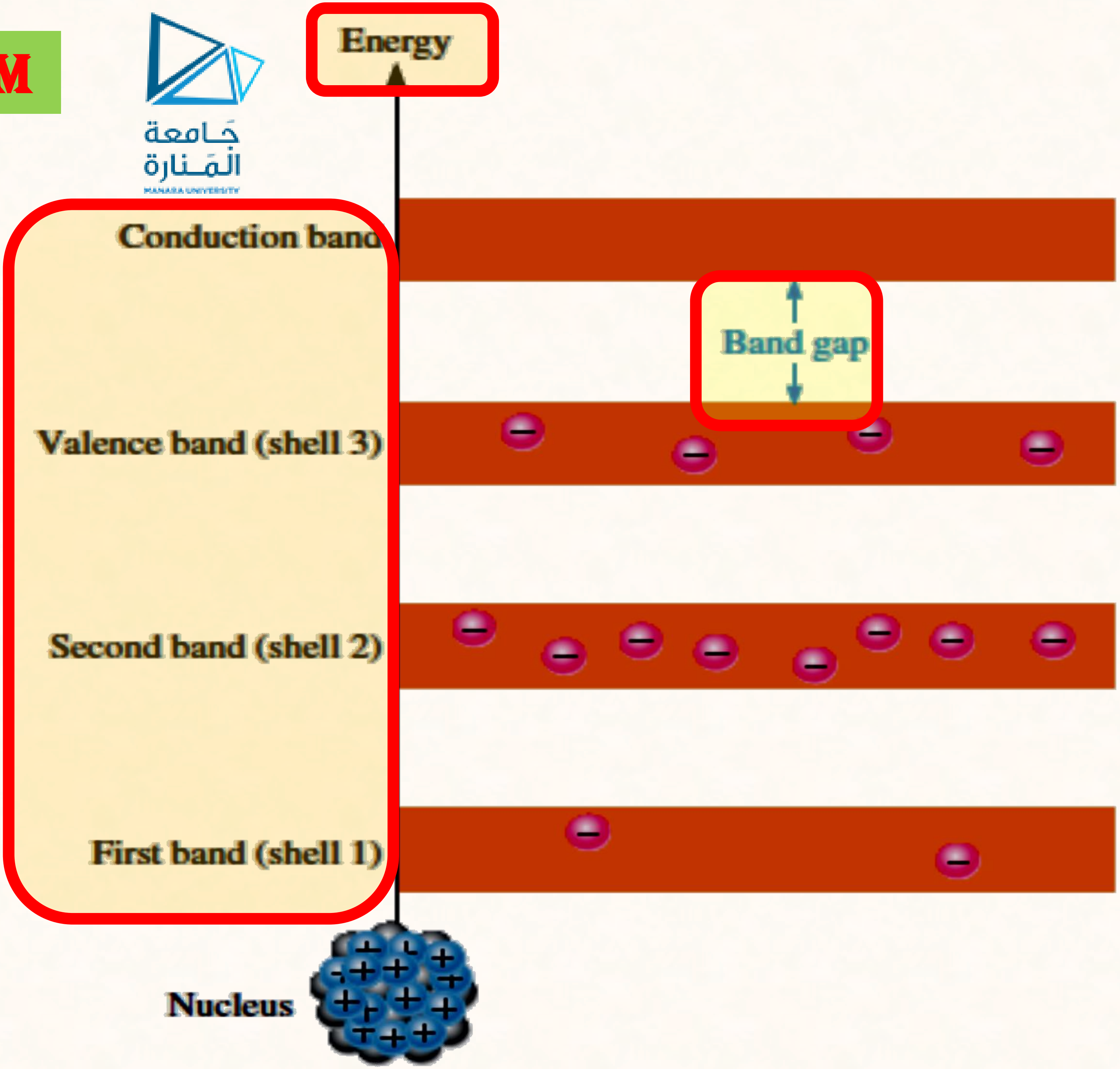


Bonding diagram. The red negative signs represent the shared valence electrons.

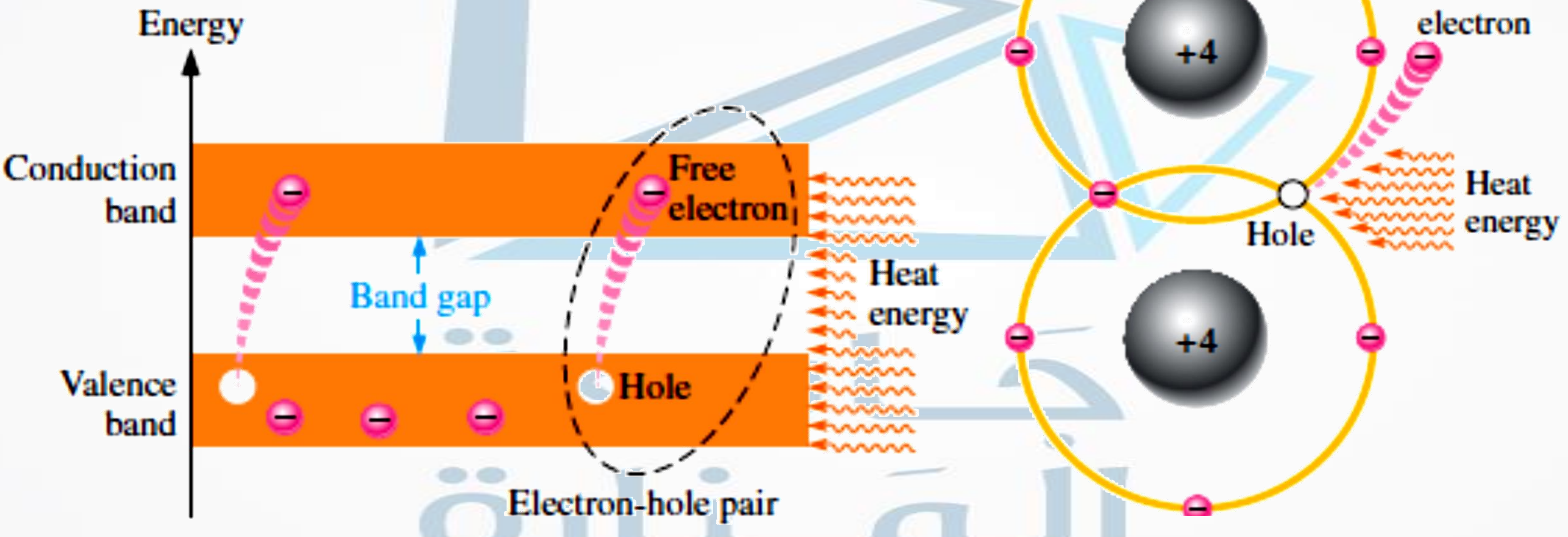
The center silicon atom shares an electron with each of the four surrounding silicon atoms, creating a covalent bond with each.

ENERGY BAND DIAGRAM

- Energy band diagram for an unexcited atom in a pure (intrinsic) silicon crystal.
- There are no electrons in the conduction band.

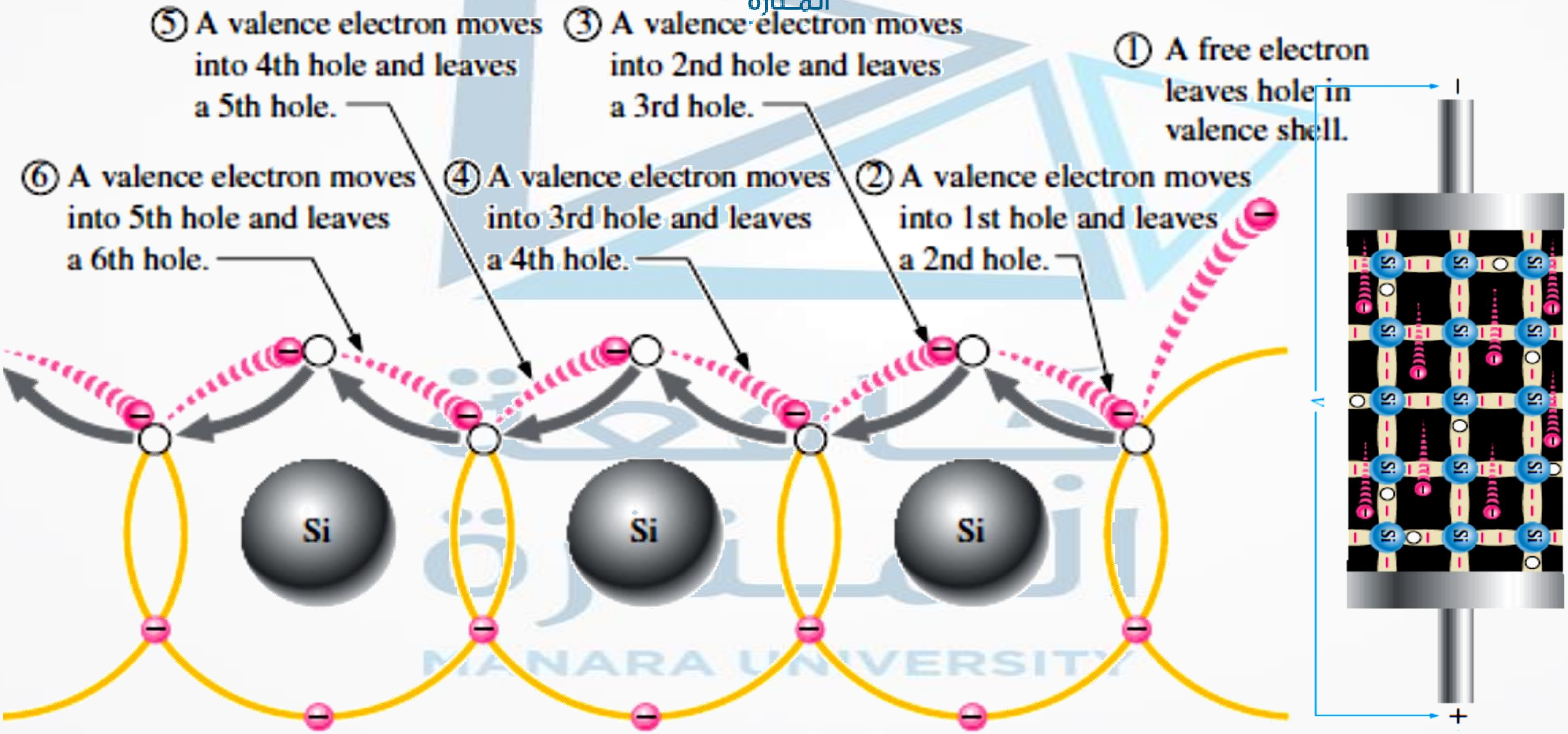


CONDUCTION ELECTRONS AND HOLES

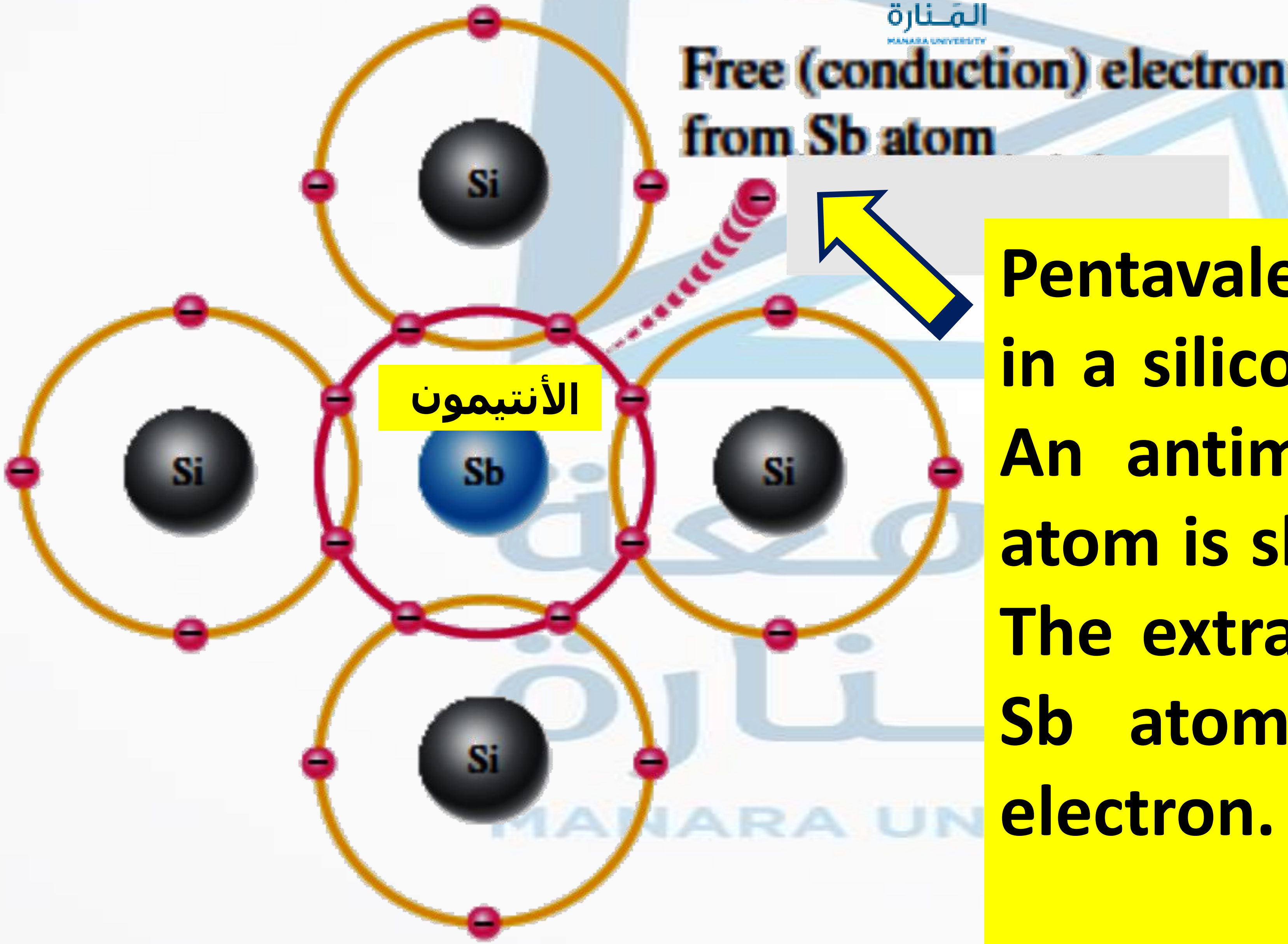


Creation of electron-hole pairs in a silicon crystal. Electrons in the conduction band are free electrons.

ELECTRON AND HOLE CURRENT

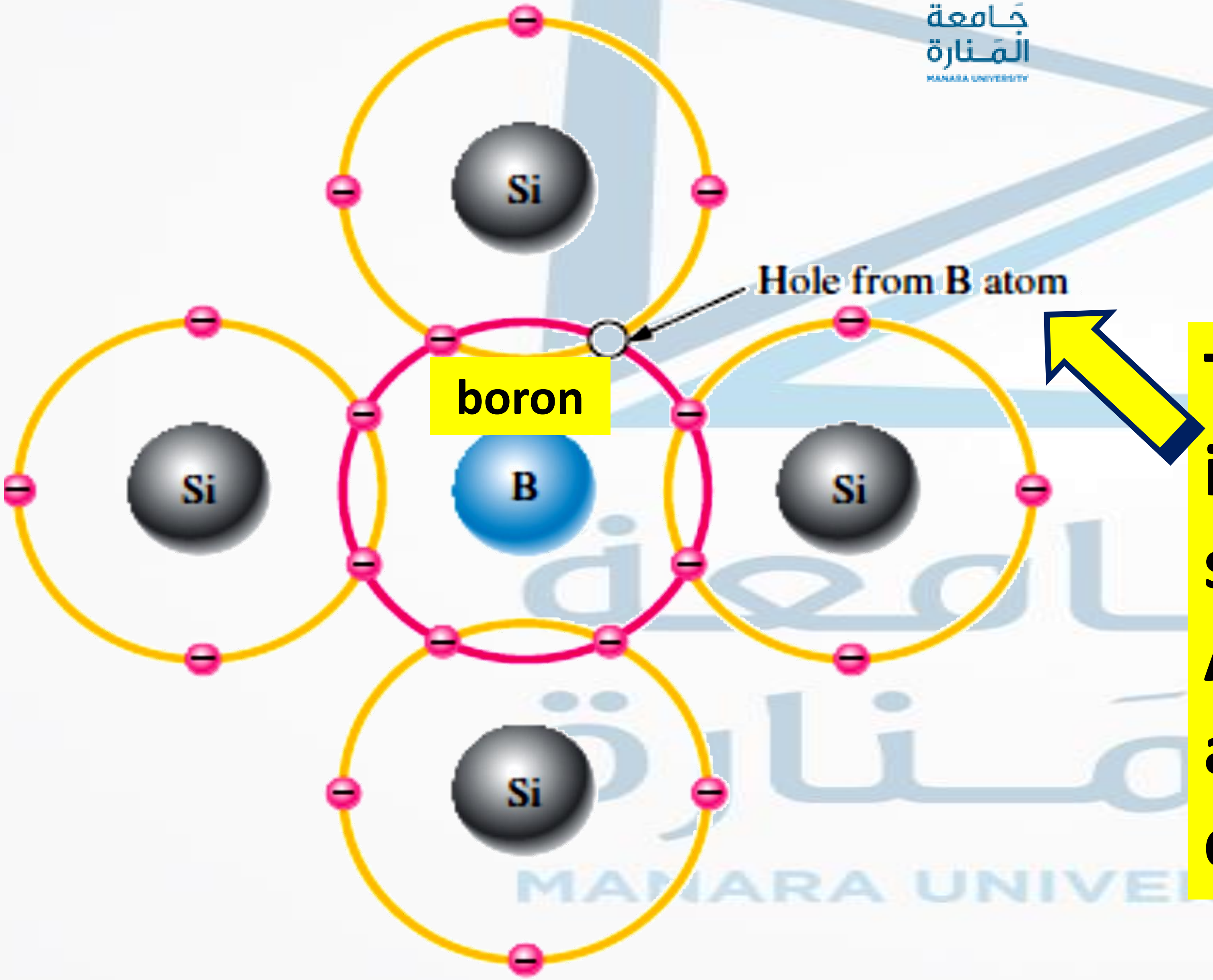


N-TYPE SEMICONDUCTOR



Pentavalent impurity atom in a silicon crystal structure. An antimony (Sb) impurity atom is shown in the center. The extra electron from the Sb atom becomes a free electron.

P-TYPE SEMICONDUCTOR



Trivalent impurity atom in a silicon crystal structure.

A boron (B) impurity atom is shown in the center.