Palestine Technical University-Kadoorie PTUK
Faculty of Engineering and Technology

Course Name:

Electronics (12120205)

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Course Outline

Chapter.1

Introduction to Electronics

CHAPTER OUTLINE

CHAPTER OBJECTIVES

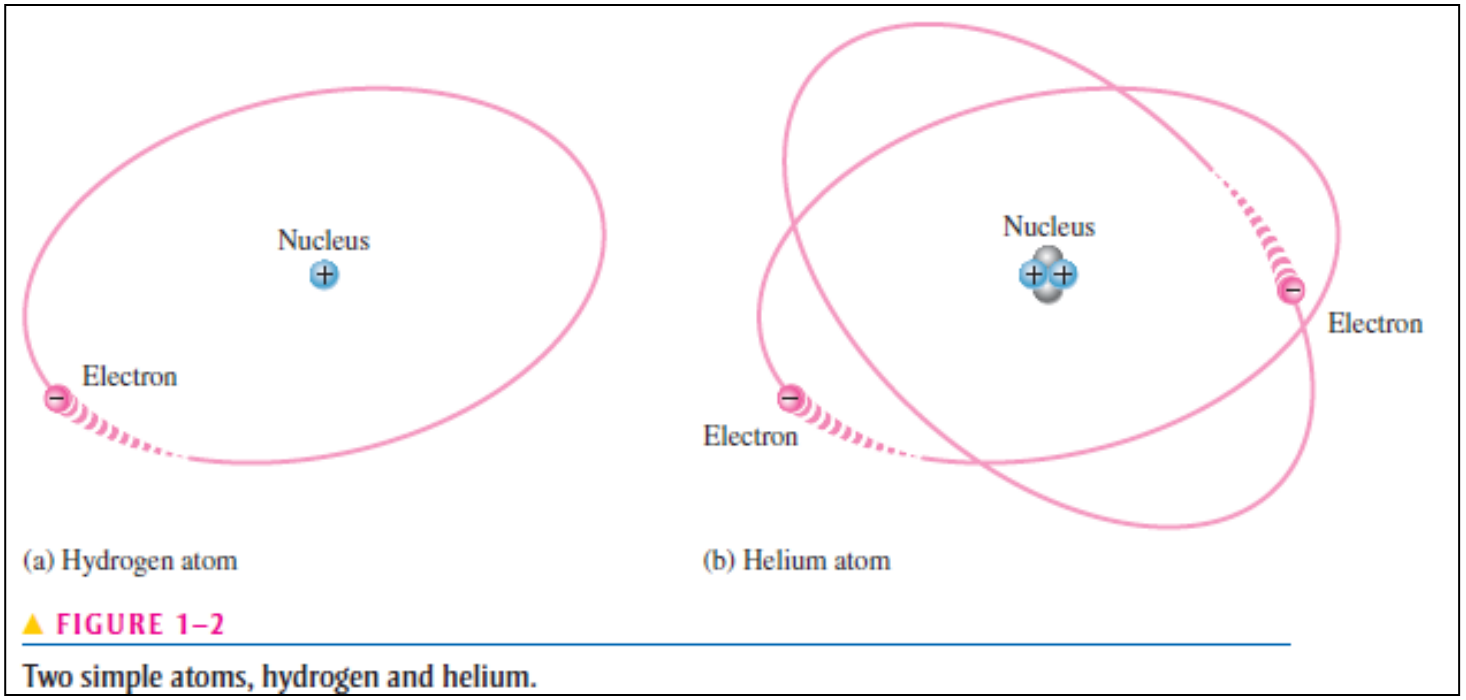
- Describe the structure of an atom
- Discuss insulators, conductors, and semiconductors and how they differ
- Describe how current is produced in a semiconductor
- Describe the properties of *n*-type and *p*-type semiconductors
- Describe how a *pn* junction is formed

INTRODUCTION

Electronic devices such as diodes, transistors, and integrated circuits are made of a semiconductive material. To understand how these devices work, you should have a basic knowledge of the structure of atoms and the interaction of atomic particles. An important concept introduced in this chapter is that of the *pn* junction that is formed when two different types of semiconductive material are joined. The *pn* junction is fundamental to the operation of devices such as the solar cell, the diode, and certain types of transistors.

1-1: The Atom

- All matter is composed of atoms; all atoms consist of electrons, protons, and neutrons except normal hydrogen, which does not have a neutron.
- **An atom**: is the smallest particle of an element that retains the characteristics of that element.
- **Atomic number :** equals the number of protons in the nucleus, which is the same as the number of electrons in an electrically balanced (neutral) atom.



▲ FIGURE 1–2
Two simple atoms, hydrogen and helium.

Bohr model

- electrons orbits the nucleus at a certain distance.(orbit)
- electrons near the nucleus have less energy.
- each orbit correspond to a certain energy level.
- The orbits are grouped **into energy levels** known as **Shells**.
- For most practical purposes in electronics, the Bohr model suffices and is commonly used because it is easy to visualize.

The max number of electrons in each Shell:

$$N_e = 2n^2$$

where n is the number of the shell.

shell 1	$N_e = 2n^2 = 2(1)^2 = 2$
shell 2	$N_e = 2n^2 = 2(2)^2 = 2(4) = 8$
shell 3	$N_e = 2n^2 = 2(3)^2 = 2(9) = 18$
shell 4	$N_e = 2n^2 = 2(4)^2 = 2(16) = 32$

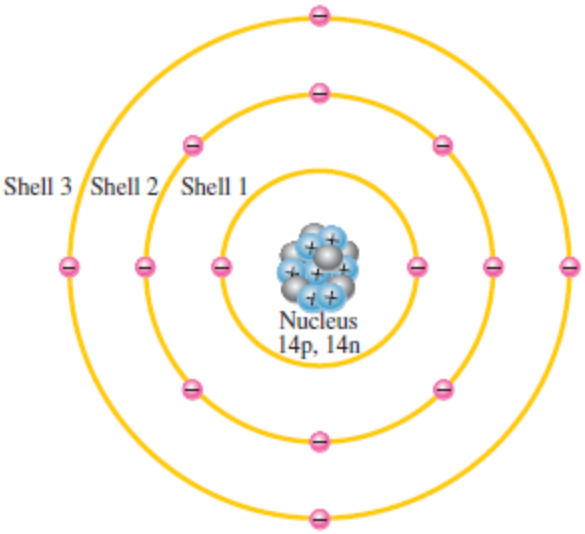


FIGURE 1–4

Illustration of the Bohr model of the silicon atom.

Quantum model

- Bohr model is simple but not complete
- **The quantum model is**
  - more accurate
  - statistical model
  - difficult to visualize
  - like Bohr: has nucleus of neutrons and protons, surrounded by electrons
  - Unlike Bohr: electrons don't exist in precise circular orbits.

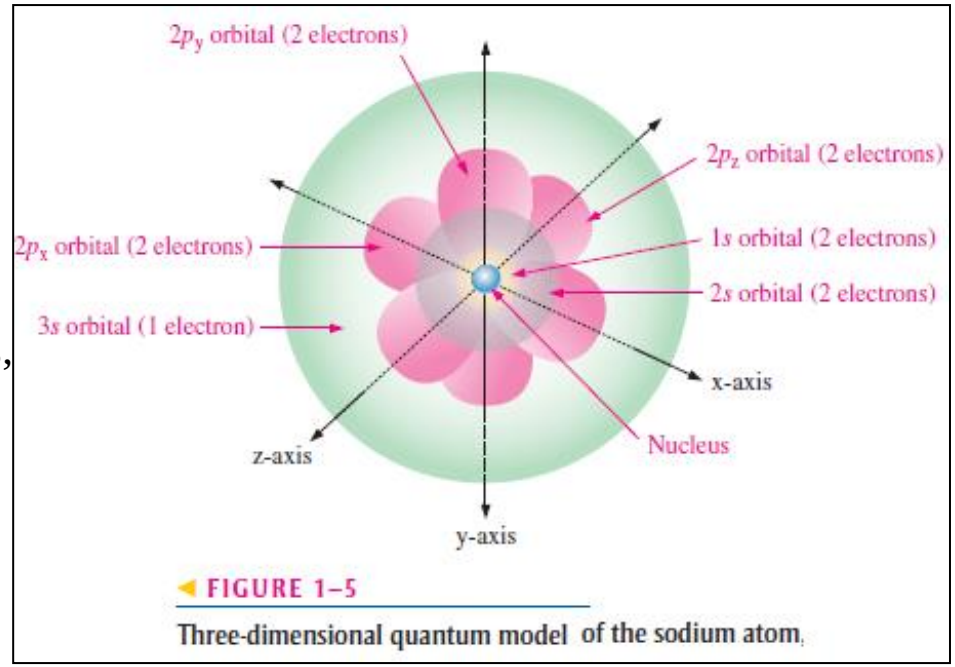


FIGURE 1–5
Three-dimensional quantum model of the sodium atom.

- **Underlying Theories:**

(1) Wave-particle duality: Electrons are thought to exhibit both wave and particle characteristics and velocity of orbiting particle is considered to be its wavelength.

(2) Uncertainty Principle (Heisenberg): It is impossible to determine simultaneously both the position and velocity of an electron with any degree of accuracy or certainty.

➔ **The result of this model produces a concept of atom with probability clouds which are mathematical description of where electrons in atom are most likely.**

Quantum model (cont.)

In quantum model, each shell contains of up to **4 subshells** called **orbitals**.

***s**: hold max of 2e*
***p**: hold max of 6e*
***d**: hold max of 10e*
***f**: hold max of 14e*

▶ TABLE 1–1

Electron configuration table for nitrogen.

NOTATION	EXPLANATION
$1s^2$	2 electrons in shell 1, orbital *s*
$2s^2\ \ 2p^3$	5 electrons in shell 2: 2 in orbital *s*, 3 in orbital *p*

EXAMPLE 1–1

Using the atomic number from the periodic table in Figure 1–3, describe a silicon (Si) atom using an electron configuration table.

NOTATION	EXPLANATION
$1s^2$	2 electrons in shell 1, orbital *s*
$2s^2\ \ 2p^6$	8 electrons in shell 2: 2 in orbital *s*, 6 in orbital *p*
$3s^2\ \ 3p^2$	4 electrons in shell 3: 2 in orbital *s*, 2 in orbital *p*

Valence Electrons

- The outermost shell is known as **Valence Shell** and the electrons are **Valence electrons**

- Electrons in orbit far from nucleus have higher energy and less tightly bounded because of the force of attraction between positive nucleus and negative electron.

Ionization

- **Positive ion**: atom absorbs sufficient energy (ionization energy), valence electron escape from outer shell.

- **Negative ion**: when free electron collides with an atom, and captures, releasing energy.