أوراق عمل مراجعة القسم الأول Configuration Electronic منهج انسباير

Electronic Configuration

Ground-State Electron Configuration

Overview

- **Electron configuration**: The arrangement of electrons in an atom.
- Electrons arrange themselves to minimize the atom's energy, resulting in the **ground-state electron configuration** — the most stable, lowest-energy arrangement.
- Three key principles govern electron arrangement:
    1. **Aufbau principle**
    2. **Pauli exclusion principle**
    3. **Hund's rule**

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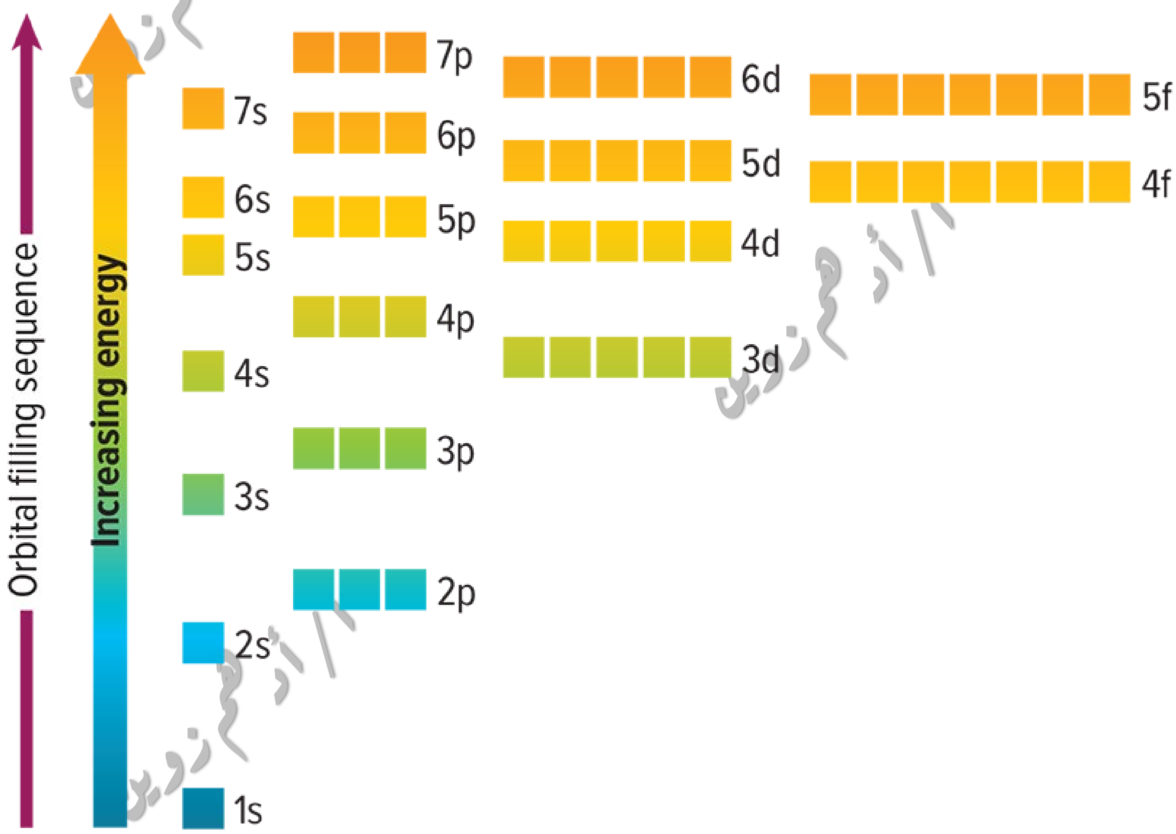
1. **The Aufbau Principle**



Aufbau principle

Feature	Example
All orbitals related to an energy sublevel are of equal energy.	All three 2p orbitals are of equal energy.
In a multi-electron atom, the energy sublevels within a principal energy level have different energies.	The three 2p orbitals are of higher energy than the 2s orbital.
In order of increasing energy, the sequence of energy sublevels within a principal energy level is s, p, d, and f.	If $n = 4$ then the sequence of energy sublevels is 4s, 4p, 4d, and 4f.
Orbitals related to energy sublevels within one principal energy level can overlap orbitals related to energy sublevels within another principal level.	The orbital related to the atom's 4s sublevel has a lower energy than the five orbitals related to the 3d sublevel.

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2. The Pauli Exclusion Principle

- Each atomic orbital can hold a maximum of **two electrons.**
- These two electrons must have **opposite spins**.
- Electron spin is represented by arrows:
  - Up arrow (↑) = spin in one direction
  - Down arrow (↓) = spin in the opposite direction

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3. Hund's Rule

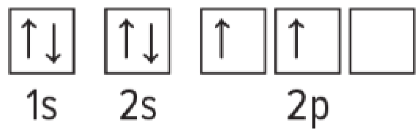
- When electrons occupy orbitals of equal energy (degenerate orbitals), one electron enters each orbital **with the same spin** before any orbital gets a second electron.
- This minimizes electron repulsion and stabilizes the atom.

1. [↑] [ ] [ ]
2. [↑] [↑] [ ]
3. [↑] [↑] [↑]
4. [↑↓] [↑] [↑]
5. [↑↓] [↑↓] [↑]
6. [↑↓] [↑↓] [↑↓]

Representations of Electron Configuration

Orbital Diagrams

- Use boxes to represent orbitals.
- Arrows inside boxes represent electrons and their spins.
- Example for carbon (6 electrons):



Electron Configuration Notation

- Uses principal quantum number and sublevel with superscript for number of electrons.

Element	Atomic Number	Orbital Diagram 1s 2s $2p_x$ $2p_y$ $2p_z$	Electron Configuration Notation
Hydrogen	1	↑	$1s^1$
Helium	2	↑↓	$1s^2$
Lithium	3	↑↓ ↑	$1s^2 2s^1$
Beryllium	4	↑↓ ↑↓	$1s^2 2s^2$
Boron	5	↑↓ ↑↓ ↑	$1s^2 2s^2 2p^1$
Carbon	6	↑↓ ↑↓ ↑ ↑	$1s^2 2s^2 2p^2$
Nitrogen	7	↑↓ ↑↓ ↑ ↑ ↑	$1s^2 2s^2 2p^3$
Oxygen	8	↑↓ ↑↓ ↑↓ ↑ ↑	$1s^2 2s^2 2p^4$

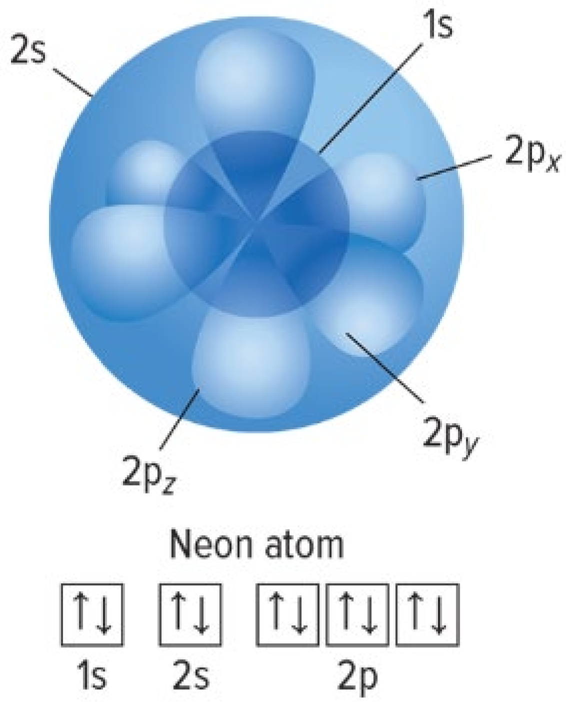
List the sequence in which the following orbitals fill up: 1s, 2s, 3s, 4s, 2p, 3p, 4p, 3d.

a) 1s → 2s → 2p → 3s → 3p → 4s → 3d → 4p

b) 1s → 2s → 3s → 2p → 3p → 3d → 4s → 4p

c) 1s → 2s → 2p → 3s → 3p → 3d → 4s → 4p

d) 1s → 2s → 2p → 3s → 3p → 4p → 4s → 3d



Noble-Gas Notation

- Uses the electron configuration of the previous noble gas in brackets to shorten notation.
- Example for sodium (11 electrons):
- This shows sodium has the same inner configuration as neon plus one electron in 3s.

Element	Atomic Number	Complete Electron Configuration	Electron Configuration Using Noble Gas
Sodium	11	$1s^2 2s^2 2p^6 3s^1$	$[Ne]3s^1$
Magnesium	12	$1s^2 2s^2 2p^6 3s^2$	$[Ne]3s^2$
Aluminum	13	$1s^2 2s^2 2p^6 3s^2 3p^1$	$[Ne]3s^2 3p^1$
Silicon	14	$1s^2 2s^2 2p^6 3s^2 3p^2$	$[Ne]3s^2 3p^2$
Phosphorus	15	$1s^2 2s^2 2p^6 3s^2 3p^3$	$[Ne]3s^2 3p^3$
Sulfur	16	$1s^2 2s^2 2p^6 3s^2 3p^4$	$[Ne]3s^2 3p^4$
Chlorine	17	$1s^2 2s^2 2p^6 3s^2 3p^5$	$[Ne]3s^2 3p^5$

Exceptions to Predicted Configurations

- Some elements (e.g., chromium and copper) have electron configurations that differ from the aufbau prediction due to increased stability of half-filled or fully filled d orbitals.
- **Correct configurations:**
  - Chromium:
    $[Ar]3d^5 4s^1$
  - Copper:
    $[Ar]3d^{10} 4s^1$

Valence Electrons

- Electrons in the **outermost principal energy level**.
- Determine chemical properties and bonding behavior.
- Example: Sulfur (16 electrons) has valence electrons in 3s and 3p orbitals:

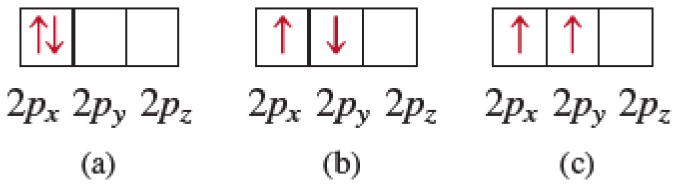
  $3s^2 3p^4$
- Sulfur has 6 valence electrons.

Electron-Dot Structures (Lewis Dot Structures)

- Represent valence electrons as dots around the element's symbol.
- Place one dot on each side before pairing.
- Example for sulfur (6 valence electrons):

Element	Atomic Number	Electron Configuration	Electron-Dot Structure
Lithium	3	$1s^2 2s^1$	Li·
Beryllium	4	$1s^2 2s^2$	·Be·
Boron	5	$1s^2 2s^2 2p^1$	·Ḃ·
Carbon	6	$1s^2 2s^2 2p^2$	·Ċ· (with a dot below)
Nitrogen	7	$1s^2 2s^2 2p^3$	·N̈· (with a dot below)
Oxygen	8	$1s^2 2s^2 2p^4$	:Ö· (with a dot below)
Fluorine	9	$1s^2 2s^2 2p^5$	:F̈· (with two dots below)
Neon	10	$1s^2 2s^2 2p^6$	:N̈e: (with two dots below)

Notes



None of the three arrangements violates the Pauli exclusion principle

But (a) and (b) it violates Hund’s rule, Which of the following elements has **no unpaired electrons** in its ground-state configuration?

a) Boron (B)

b) Neon (Ne)

c) Iron (Fe)

d) Selenium (Se)

How many **unpaired electrons** does a manganese (Mn) atom have in its ground state?

a) 2

b) 3

c) 5

d) 0

Which element's electron configuration ends with $\mathbf{4p^4}$ and has 2 unpaired electrons?

a) Selenium (Se)

b) Krypton (Kr)

c) Cadmium (Cd)

d) Phosphorus (P)

Why does neon (Ne) have **0 unpaired electrons**?

a) Its outermost p orbitals are half-filled.

b) Its outermost s orbitals are empty.

c) Its 2p orbitals are fully filled with paired electrons.

d) It only has one electron in the 1s orbital.

Which of the following has the **greatest number of unpaired electrons** in its ground state?

a) Scandium (Sc)

b) Iron (Fe)

c) Manganese (Mn)

d) Cadmium (Cd)

The symbol [Kr] represents

A) $4s^2 4p^6$.

B) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^6$.

C) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$.

D) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10}$

An element in its ground-state electron configuration has **4 electrons in the 4p orbitals**. Which of the following statements **cannot** describe the electron configuration of this atom?

A) The element has 2 unpaired electrons.

B) The element is selenium (Se), atomic number 34.

C) The element's configuration ends with $4p^4$.

D) All 4p orbitals are fully filled

Which orbital-filling diagram violates the Pauli exclusion principle?

A)
[Ar] ↑↓ (4s) ↑ ↑ ↑ ↑ __ (3d)

B)
[Ar] ↑↑ (4s) ↑ ↑ ↑ ↑ __ (3d)

C)
[Ar] ↑ (4s) ↑ ↑ ↑ ↑ ↑ (3d)

D)
[Ar] ↑↓ (4s) ↑↓ ↑ ↑ __ __ (3d)

Which orbital-filling diagram violates Hund's rule?

A)
[Ar] ↑↓ (4s) ↑ ↑ ↑ ↑ __ (3d)

B)
[Ar] ↑↑ (4s) ↑ ↑ ↑ ↑ __ (3d)

C)
[Ar] ↑ (4s) ↑ ↑ ↑ ↑ ↑ (3d)

D)
[Ar] ↑↓ (4s) ↑↓ ↑ ↑ __ __ (3d)

Which orbital-filling diagram represents the ground state of oxygen?

A)
[He] ↑ (2s) ↑↓ ↑↓ ↑ (2p)

B)
[He] ↑↑ (2s) ↑↓ ↑ ↑ (2p)

C)
[He] ↑↓ (2s) ↑↓ ↑ ↑ (2p)

D)
[He] ↑↓ (2s) ↑↓ ↑↓ __ (2p)

Which orbital-filling diagram represents the ground state of vanadium?

A)
[Ar] ↑↓ (4s) ↑ ↑ ↑ _ _ (3d)

B)
[Ar] ↑↑ (4s) ↑ ↑ ↑ _ _ (3d)

C)
[Ar] ↑ (4s) ↑ ↑ ↑ ↑ _ (3d)

D)
[Ar] ↑↓ (4s) ↑↓ ↑ _ _ _ (3d)

Which orbital-filling diagram represents the anomalous ground state of chromium?

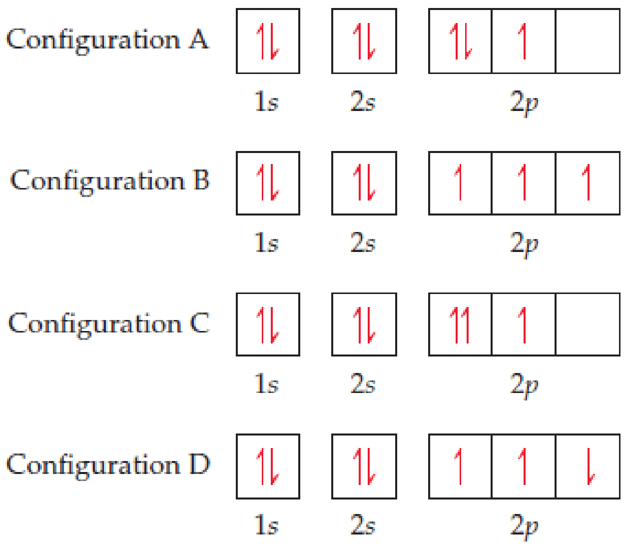
A)
[Ar] ↑↓ (4s) ↑ ↑ ↑ ↑ _ (3d)

B)
[Ar] ↑↑ (4s) ↑ ↑ ↑ ↑ _ (3d)

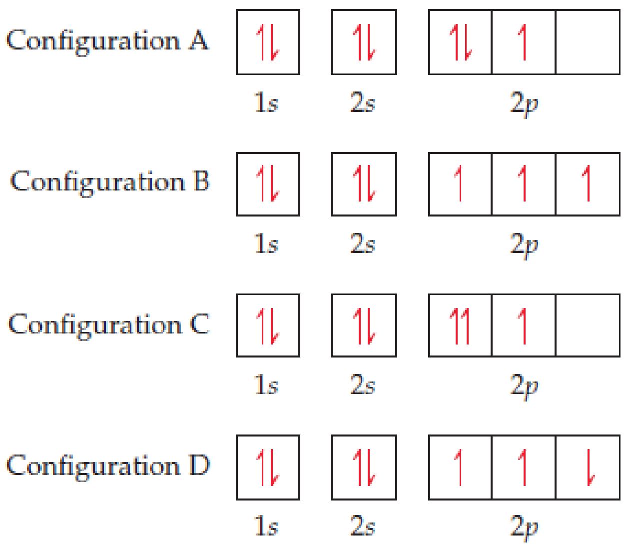
C)
[Ar] ↑ (4s) ↑ ↑ ↑ ↑ ↑ (3d)

D)
[Ar] ↑↓ (4s) ↑↓ ↑ ↑ _ _ (3d)

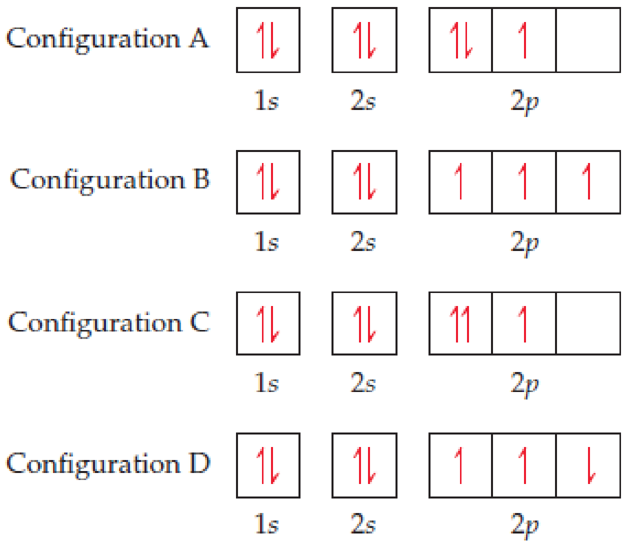
Four possible electron configurations for a nitrogen atom are shown here, but only one schematic represents the correct configuration for a nitrogen atom in its ground state.



Four possible electron configurations for a nitrogen atom are shown here, Which configurations violate the Pauli exclusion principle?



Four possible electron configurations for a nitrogen atom are shown here, Which configurations violate Hund's rule?



Which of the following is the correct electron-dot structure for **magnesium (Mg)**, atomic number 12

A	·Mg·
B	·Mg
C	·Ṁg·
D	·Ṃ̇g·

Which is the correct electron-dot structure for **xenon (Xe)**, atomic number 54?

A	
B	
C	
D	

A chlorine atom in its ground state has a total of seven electrons in orbitals related to the atom's third energy level. How many of the seven electrons occupy p orbitals? How many of the 17 electrons in a chlorine atom occupy p orbitals?

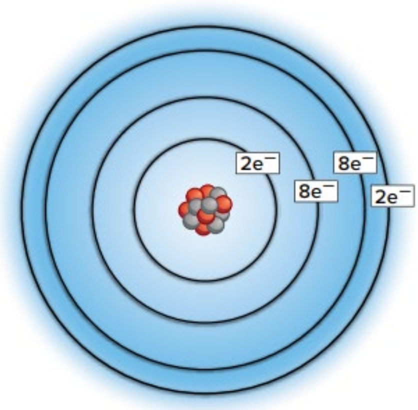
A) 3 in n=3; 10 in the atom

B) 5 in n=3; 11 in the atom

C) 2 in n=3; 7 in the atom

D) 4 in n=3; 12 in the atom

Use the figure below to answer the following questions



How many valence electrons does an atom of this element have?

A) 2 B) 8 C) 10 D) 20

What is the atom's electron-dot structure?

A	
B	
C	
D	

Which is the correct electron-dot structure for an atom of selenium?

a. 

b. 

c. 

d. 

What is the highest energy level (n) that is occupied in Helium (He)?

A) n = 2
B) n = 1
C) n = 3
D) n = 4

What is the highest energy level (n) that is occupied in Calcium (Ca)?

A) n = 2
B) n = 3
C) n = 4
D) n = 5