CHEM 120 Spring 2017

Introduction to Inorganic Chemistry

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TR 10:00-12:00

Contact me trough phone or e-mail if you have questions

Online Tests on Following days

March 24, 2017: Test 1 (Chapters 1-3)
April 7, 2017 : Test 2 (Chapters 4-5)
April 28, 2017: Test 3 (Chapters 6,7 &8)
May 12, 2017 : Test 4 (Chapters 9, 10 &11)
May 15, 2017: Make Up Exam: Chapters 1-11)

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Internal Structure of an Atom

Subatomic Particle

- A very small particle that is a building block for atoms.

Return to TOC

Internal Structure of an Atom

Three Types of Subatomic Particles

- The atom contains:
  - *Electrons* – found outside the nucleus; possesses a negative electrical charge; smallest mass.
  - *Protons* – found in the nucleus; positive charge equal in magnitude to the electron's negative charge.
  - *Neutrons* – found in the nucleus; no charge; virtually same mass as a proton.

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Internal Structure of an Atom

Charge and Mass Characteristics

Table 3.1 Charge and Mass Characteristics of Electrons, Protons, and Neutrons

	Electron	Proton	Neutron
Charge	-1	$+1$	0
Actual mass (g)	9.109×10^{-28}	1.673×10^{-24}	1.675×10^{-24}
Relative mass (based on the electron being 1 unit)	1	1837	1839

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Internal Structure of an Atom

- The nucleus is:
  - Small compared with the overall size of the atom.
  - Extremely dense; accounts for almost all of the atom's mass.
  - Positively charged center of an atom.

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Internal Structure of an Atom

Charge Neutrality of an Atom

- An atom as a whole is electrically neutral (no net electrical charge).

# of Protons = # of Electrons

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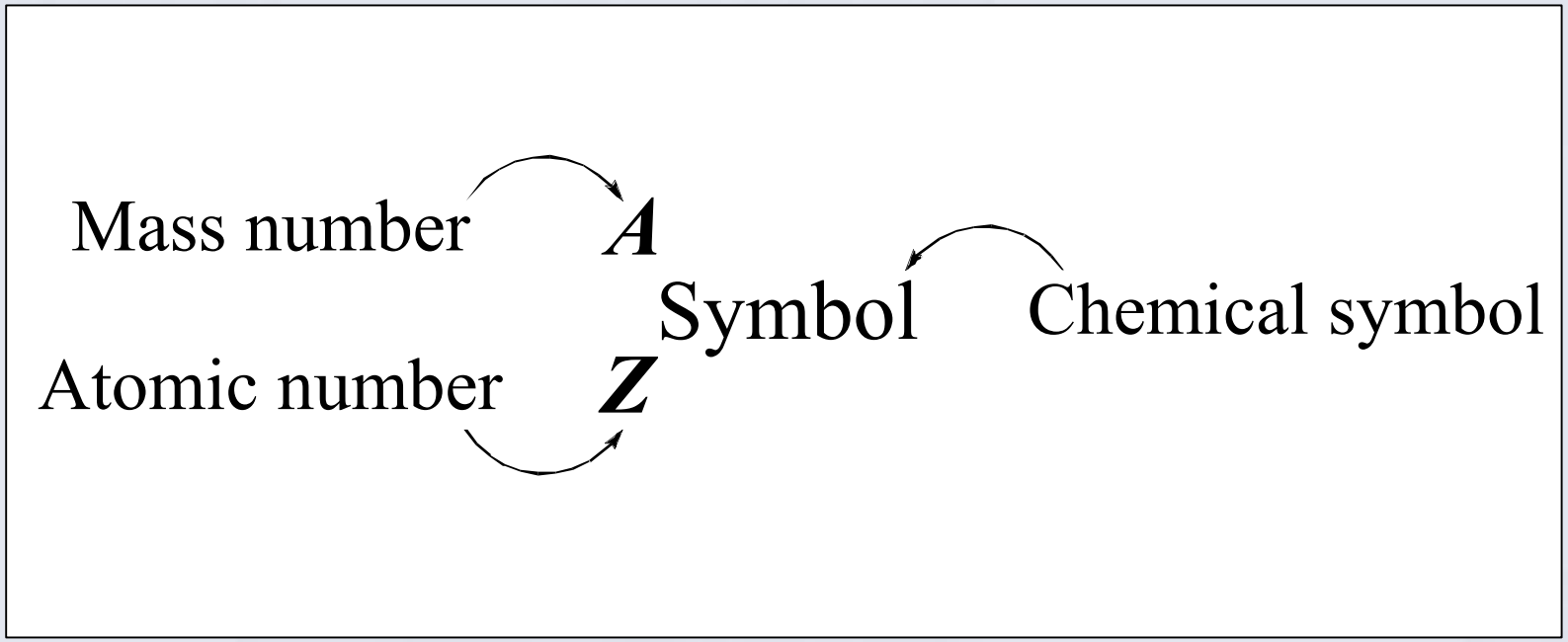
Atomic Number and Mass Number

- Atomic Number (Z) – # of protons in the nucleus of an atom.
- Mass Number (A) – sum of the # of protons and the # of neutrons in the nucleus of an atom.

Atomic Number and Mass Number

Complete Chemical Symbol Notation



$$^{23}_{11}\mathrm{Na}$$

Atomic Number and Mass Number

Element

- A pure substance in which all atoms present have the same atomic number.
- All atoms with the same atomic number have the same chemical properties and are atoms of the same element.

Isotopes and Atomic Masses

Isotopes

- Atoms of an element that have the same number of protons and the same number of electrons but different numbers of neutrons.
- Show almost identical chemical properties; chemistry of atom is due to its electrons.
- Physical properties are often slightly different because they have different masses.
- In nature most elements contain mixtures of isotopes.

Isotopes and Atomic Masses

Two Isotopes of Sodium

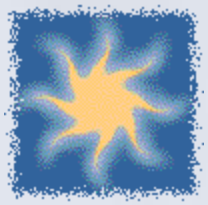
$^{23}_{11}Na$

- Number of Protons = 11
- Mass number = 23
- Number of Neutrons = 12

$^{24}_{11}Na$

- Number of Protons = 11
- Mass number = 24
- Number of Neutrons = 13

Isotopes and Atomic Masses



Exercise

A certain isotope X contains 23 protons and 28 neutrons.

- What is the mass number of this isotope?

- Identify the element.

Isotopes and Atomic Masses

Exercise

A certain isotope X contains 23 protons and 28 neutrons.

- What is the mass number of this isotope?

  51

- Identify the element.

  Vanadium

Isotopes and Atomic Masses

Atomic Masses

- Elements occur in nature as mixtures of isotopes.
- Carbon = 98.89% ^{12}C
  1.11% ^{13}C
  ~~<0.01% ^{14}C~~
- Calculated average mass for the isotopes of an element expressed on a scale where $^{12}_{6}C$ serves as the reference point.

Isotopes and Atomic Masses

Average Atomic Mass for Carbon

98.89% of 12 amu + 1.11% of 13.0034 amu =

(0.9889)(12 amu) + (0.0111)(13.0034 amu) =

12.01 amu

Isotopes and Atomic Masses

Exercise

An element consists of 62.60% of an isotope with mass 186.956 amu and 37.40% of an isotope with mass 184.953 amu.

- Calculate the average atomic mass and identify the element.

(62.60% of 186.956 amu + 37.40% of 184.953)/100

(0.6260)(186.956 amu) + (0.0111)(184.953 amu)
= 186.207 amu

Isotopes and Atomic Masses

Exercise

An element consists of 62.60% of an isotope with mass 186.956 amu and 37.40% of an isotope with mass 184.953 amu.

- Calculate the average atomic mass and identify the element.

  Average Atomic Mass = 186.207 amu

  The element is rhenium (Re).

The Periodic Law and the Periodic Table

- *Periodic Law* – When elements are arranged in order of increasing atomic number, elements with similar chemical properties occur at periodic (regularly recurring) intervals.
- *Periodic Table* – Tabular arrangement of the elements in order of increasing atomic number such that elements having similar chemical properties are positioned in vertical columns.

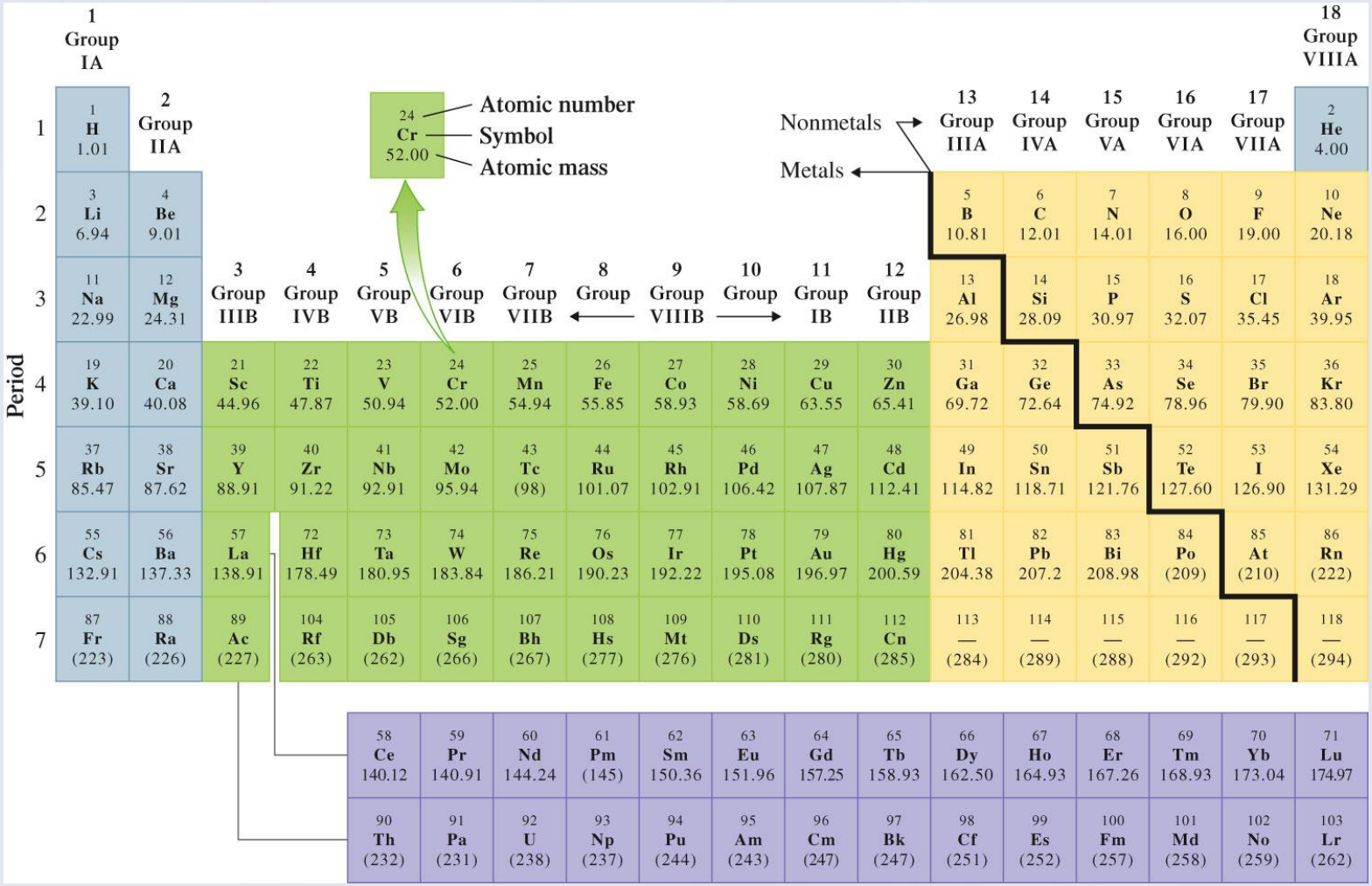
The Periodic Law and the Periodic Table

The Periodic Table

- *Periods* – horizontal rows of elements
- *Groups* – elements in the same vertical columns; have similar chemical properties

The Periodic Law and the Periodic Table

The Periodic Table



The Periodic Law and the Periodic Table

Groups

- Table of common charges formed when creating ionic compounds.

Group	Charge
Alkali Metals (1A)	1+
Alkaline Earth Metals (2A)	2+
Halogens (7A)	1-
Noble Gases (8A)	0

Metals and Nonmetals

Metal

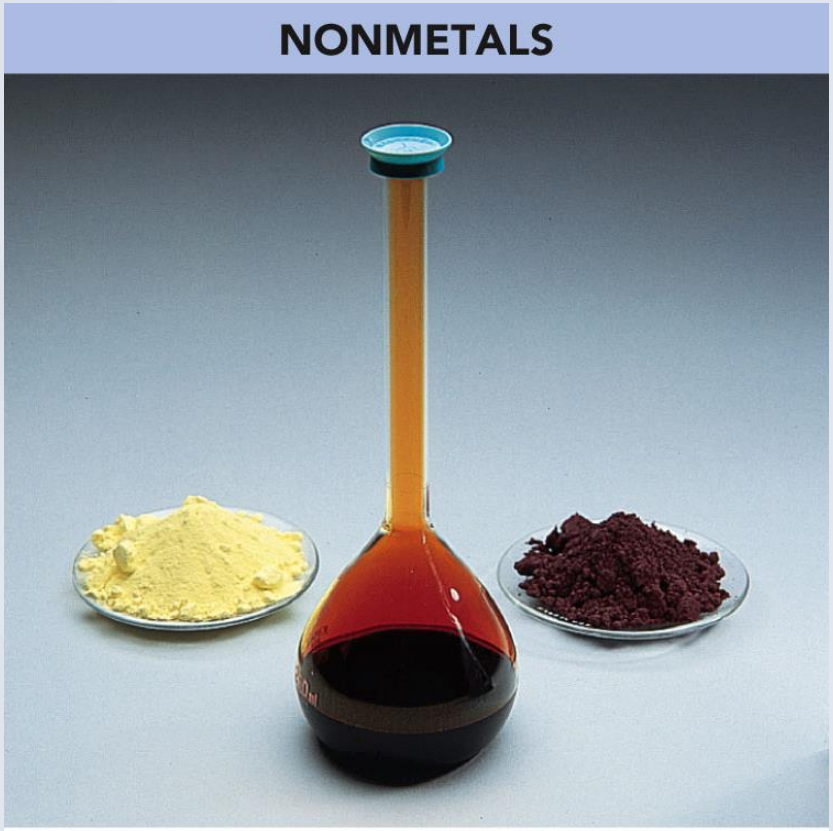
- An element that has the characteristic properties of luster, thermal conductivity, electrical conductivity, and malleability.

a Some familiar metals (clockwise, starting on left) are aluminum, lead, tin, and zinc.

Metals and Nonmetals

Nonmetal

- An element characterized by the *absence* of the properties of luster, thermal conductivity, electrical conductivity, and malleability.



b Some familiar nonmetals are sulfur (yellow), phosphorus (dark red), and bromine (reddish-brown liquid).

Metals and Nonmetals

Selected Physical Properties of Metals and Nonmetals

Table 3.3 Selected Physical Properties of Metals and Nonmetals

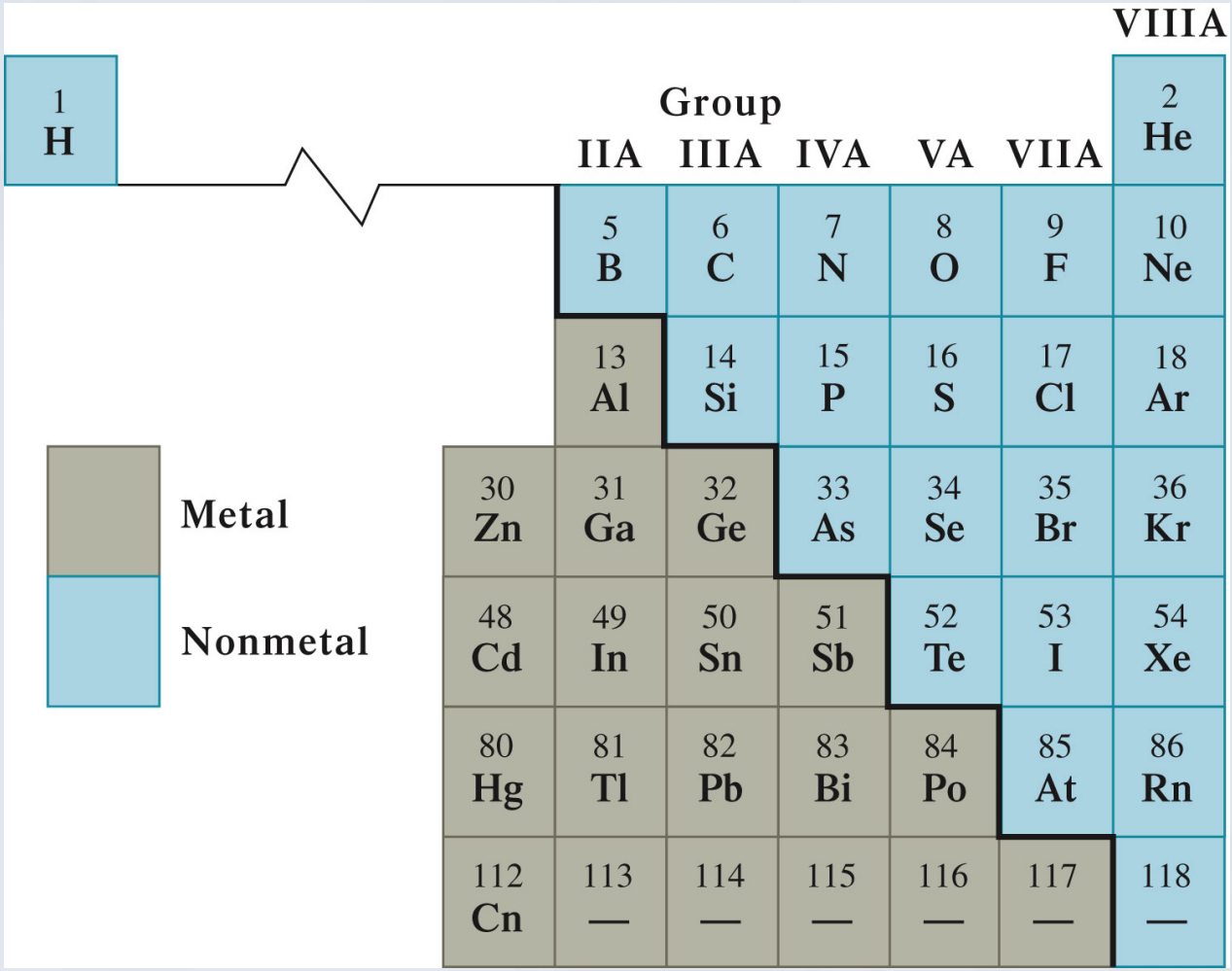
Metals	Nonmetals
1. High electrical conductivity that decreases with increasing temperature	1. Poor electrical conductivity (except carbon in the form of graphite)
2. High thermal conductivity	2. Good heat insulators (except carbon in the form of diamond)
3. Metallic gray or silver luster*	3. No metallic luster
4. Almost all are solids†	4. Solids, liquids, or gases
5. Malleable (can be hammered into sheets)	5. Brittle in solid state
6. Ductile (can be drawn into wires)	6. Nonductile

*Except copper and gold.

†Except mercury; cesium and gallium melt on a hot summer day (85°F) or when held in a person's hand.

Metals and Nonmetals

Dividing Line Between Metals and Nonmetals



Electron Arrangements Within Atoms

Electron Shells

- A region of space about a nucleus that contains electrons that have approximately the same energy and that spend most of their time approximately the same distance from the nucleus.
- Electrons that occupy the first electron shell are closer to the nucleus and have a lower energy than electrons in the second electron shell.

Electron Arrangements Within Atoms

Electron Subshells

- A region of space within an electron shell that contains electrons that have the same energy.

Subshell	Number of Electrons
s	2
p	6
d	10
f	14

Electron Arrangements Within Atoms

Electron Orbitals

- A region of space within an electron subshell where an electron with a specific energy is most likely to be found.
- An electron orbital can accommodate a maximum of 2 electrons.

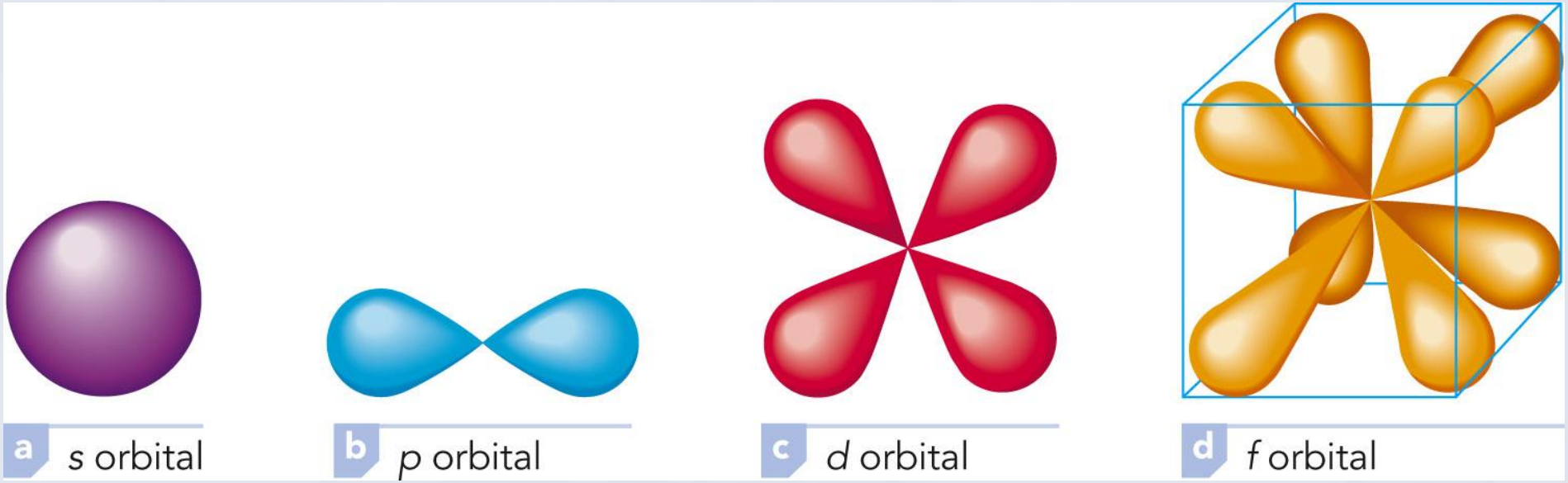
Electron Arrangements Within Atoms

Electron Orbitals

Subshell	Number of Orbitals
s	1
p	3
d	5
f	7

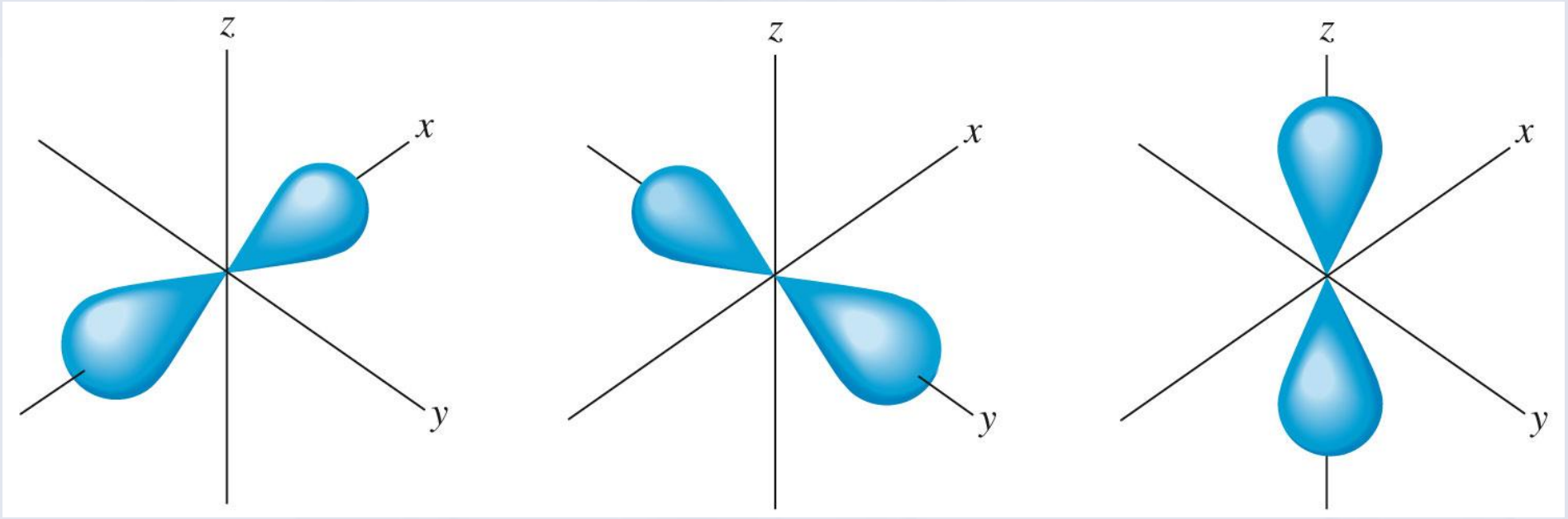
Electron Arrangements Within Atoms

Electron Orbitals



Electron Arrangements Within Atoms

Orbitals Within the Same Subshell Differ in Orientation



Electron Arrangements Within Atoms

Electron Spin

- As an electron “moves about” within an orbital, it spins on its own axis in either a clockwise or a counterclockwise direction.
- When two electrons are present in an orbital, they always have opposite spins.

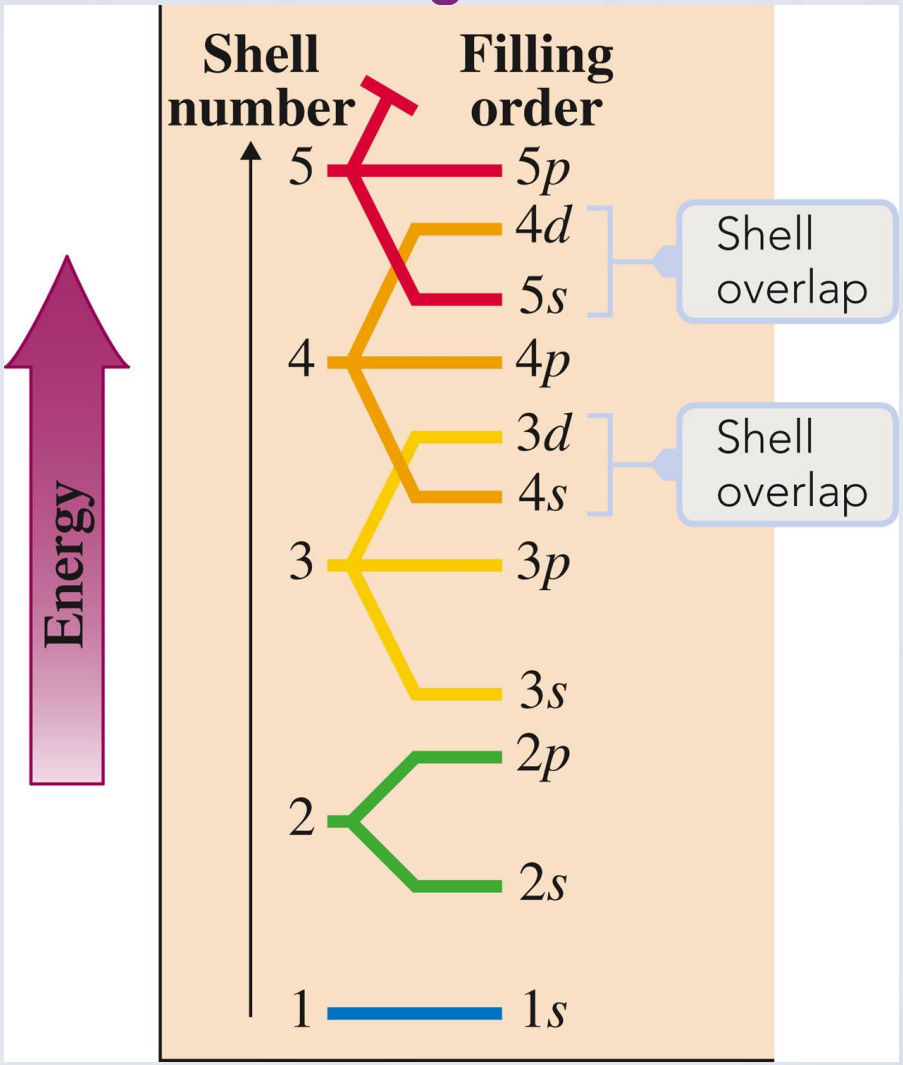
Electron Configurations and Orbital Diagrams

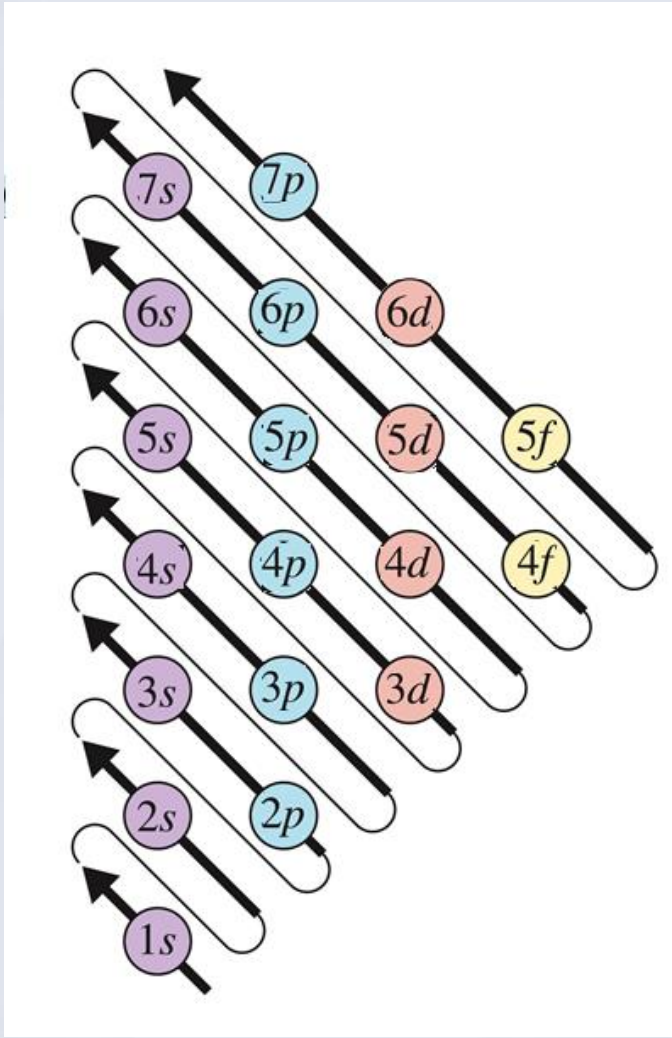
Rules for Assigning Electrons to Various Shells, Subshells, and Orbitals

1. Electron subshells are filled in order of increasing energy.
2. Electrons occupy the orbitals of a subshell such that each orbital acquires one electron before any orbital acquires a second electron. All electrons in such singly occupied orbitals must have the same spin.
3. No more than two electrons may exist in a given orbital – and then only if they have opposite spins.

Electron Configurations and Orbital Diagrams

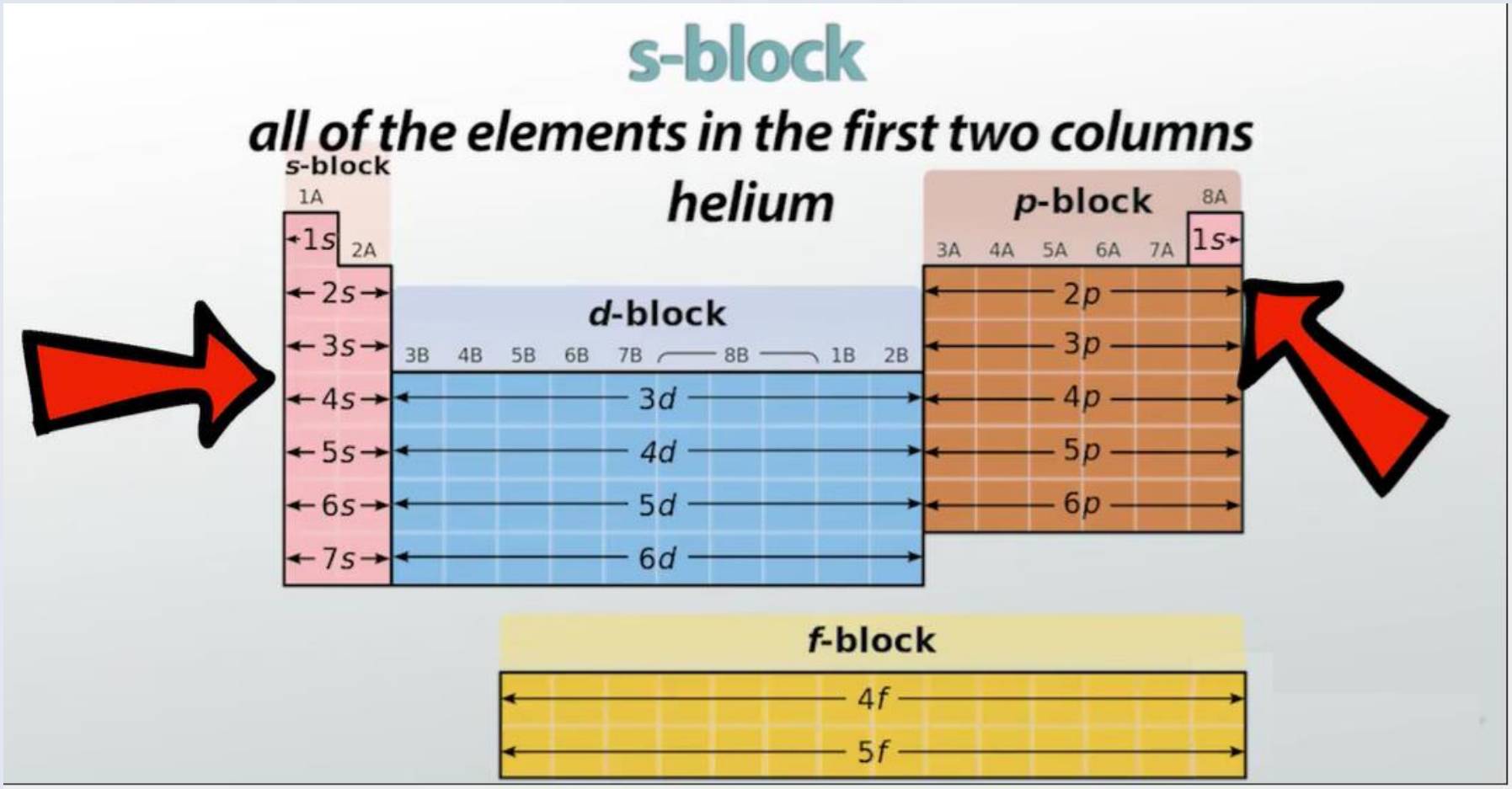
Electron Configurations





Electron Configurations and Orbital Diagrams

Electron Configurations



Electron Configurations and Orbital Diagrams

Electron Configurations

- A statement of how many electrons an atom has in each of its electron subshells.
- An oxygen atom as an electron arrangement of two electrons in the 1*s* subshell, two electrons in the 2*s* subshell, and four electrons in the 2*p* subshell.

Oxygen: $1s^2 2s^2 2p^4$

Electron Configurations and Orbital Diagrams

Orbital Diagrams

- A notation that shows how many electrons an atom has in each of its occupied electron orbitals.

Oxygen: $1s^2 2s^2 2p^4$

Oxygen: 1*s* 2*s* 2*p*

Electron Configurations and Orbital Diagrams

Exercise

Determine the expected electron configurations for each of the following.

a) S

b) Ba

Electron Configurations and Orbital Diagrams

Exercise

Determine the expected electron configurations for each of the following.

a) S

$1s^2 2s^2 2p^6 3s^2 3p^4$

b) Ba

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2$

The Electronic Basis for the Periodic Law and the Periodic Table

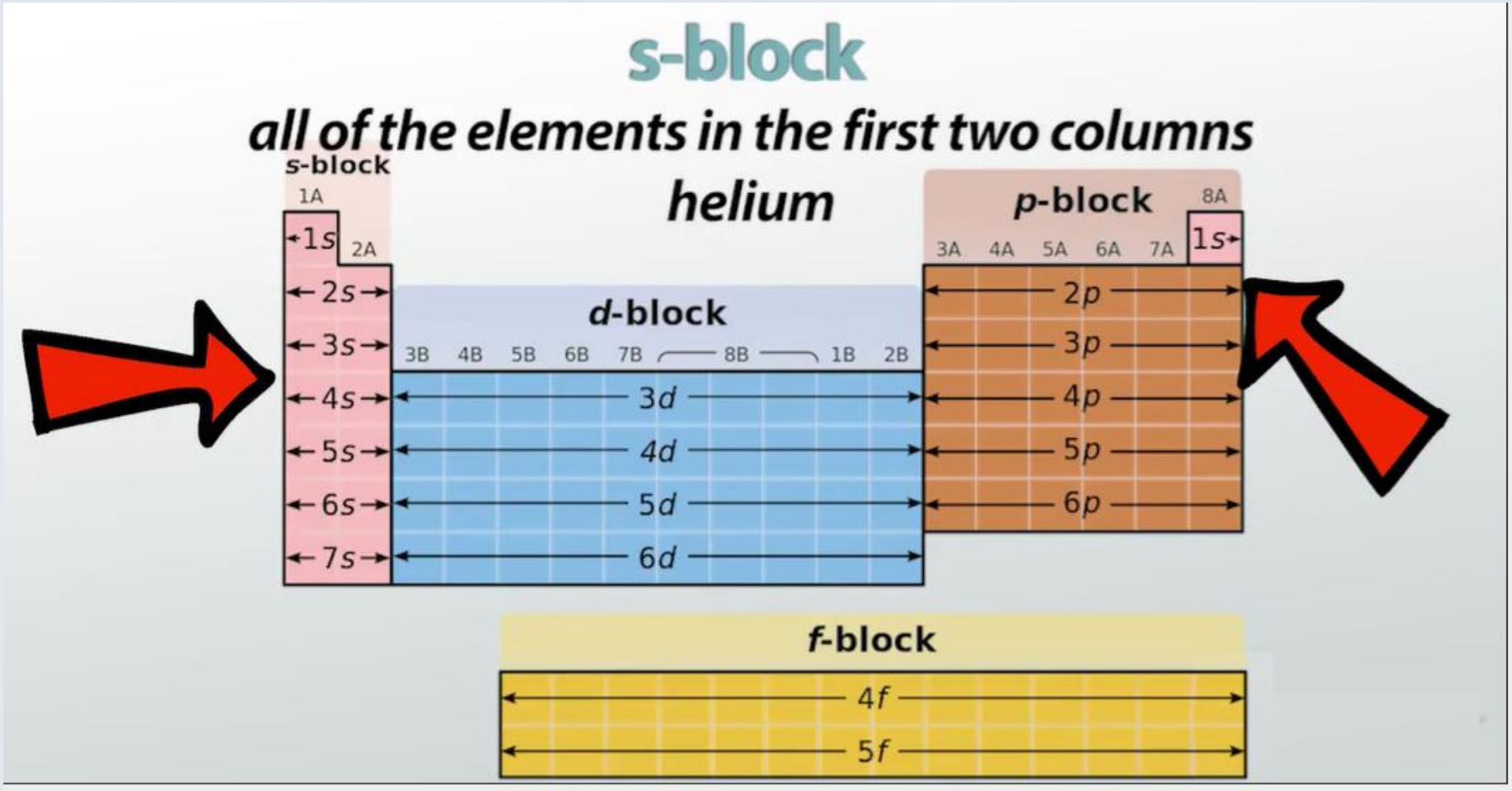
- The electron arrangement in the outermost shell is the same for elements in the same group.
- This is why elements in the same group have similar chemical properties.
  - Group 1A – very reactive

Li: $1s^2 2s^1$

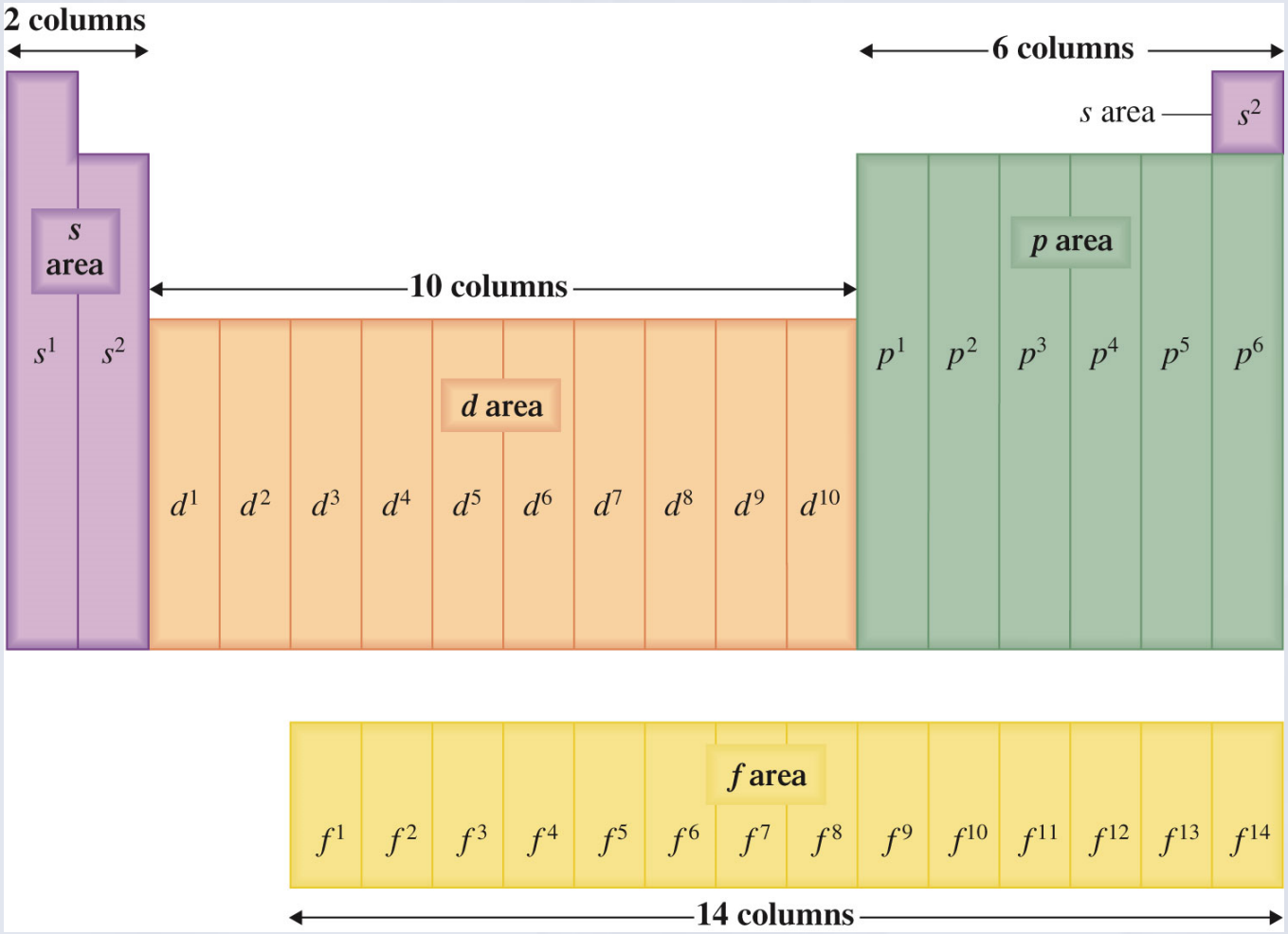
Na: $1s^2 2s^2 2p^6 3s^1$

K: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

Electron Configurations and the Periodic Table



Electron Configurations and the Periodic Table



Distinguishing Electron

- Last electron added to the electron configuration for an element when electron subshells are filled in order of increasing energy.
- This last electron is the one that causes an element's electron configuration to differ from that of an element immediately preceding it in the periodic table.

Classification of the Elements

1. A system based on selected physical properties of the elements, in which they are described as metals or nonmetals.
2. A system based on the electron configurations of the elements, in which elements are described as noble-gas, representative, transition, or inner transition elements.

Classification of the Elements

Classification Scheme on the Periodic Table