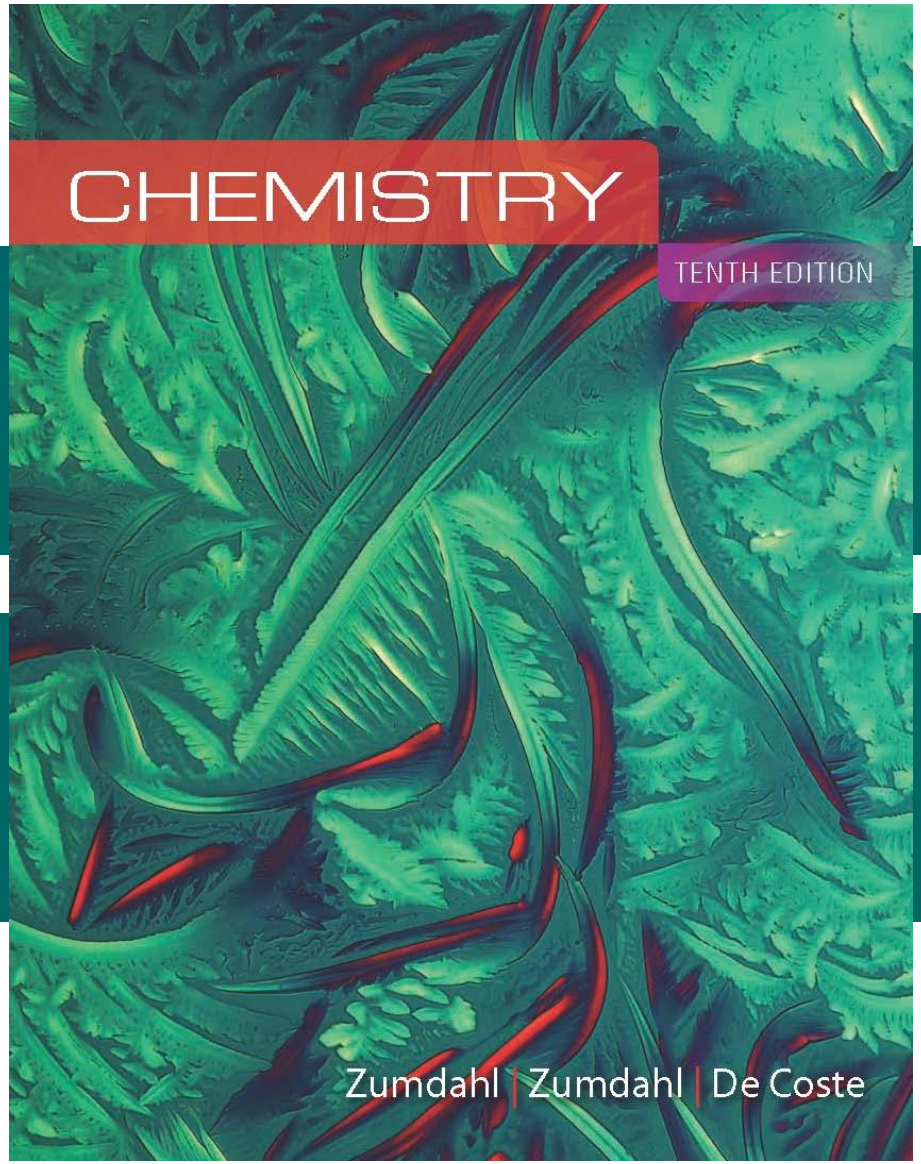


Chapter 2

Atoms, Molecules, and Ions

Chapter 2
Table of Contents

Antoine Lavoisier

- Said measurement is essential to chemistry.
- Verified the law of conservation of mass
  - **Law of conservation of mass**: Mass is neither created nor destroyed in a chemical reaction

Joseph Proust

- **Law of definite proportion**: A given compound always contains exactly the same ratio of elements by mass

John Dalton's Law of Multiple Proportions

- When two elements form a series of compounds, the ratios of the masses of the second element that combine with 1 g of the first element can always be reduced to small whole numbers (H_2O & H_2O_2)

Dalton's Atomic Theory

- Element are made up of tiny particles called atoms
- Atoms of a given element are identical
  - Atoms of different elements are different in some fundamental way

Dalton's Atomic Theory (continued)

- Chemical compounds are formed when atoms of different elements combine with each other
  - A given compound always has the same relative numbers and types of atoms
- Chemical reactions involve reorganization of the atoms
  - Atoms themselves are not changed in a chemical reaction

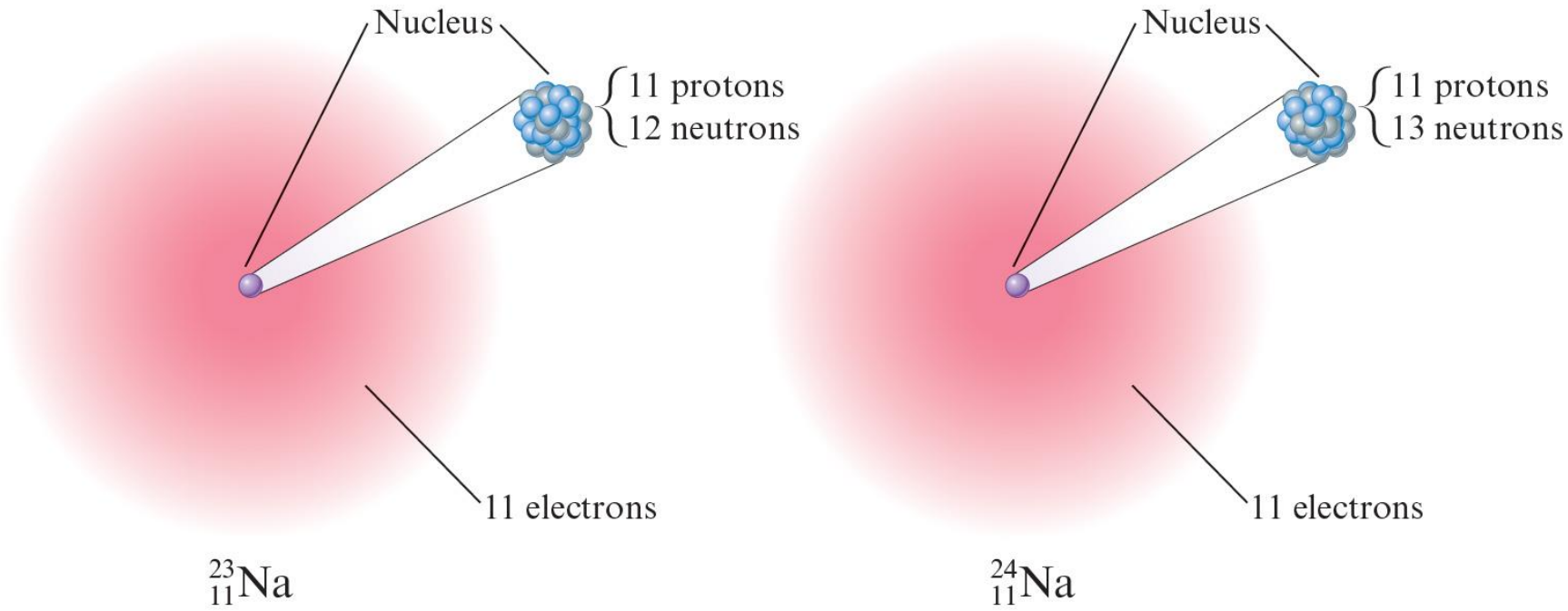
Atomic Structure

- Nucleus is assumed to contain:
  - **Protons**: Positive charge same size as negative charge of electrons
  - **Neutrons**: Same mass as a proton but no charge
- Atoms of different elements, which have different numbers of protons and electrons, exhibit different chemical behavior

Isotopes

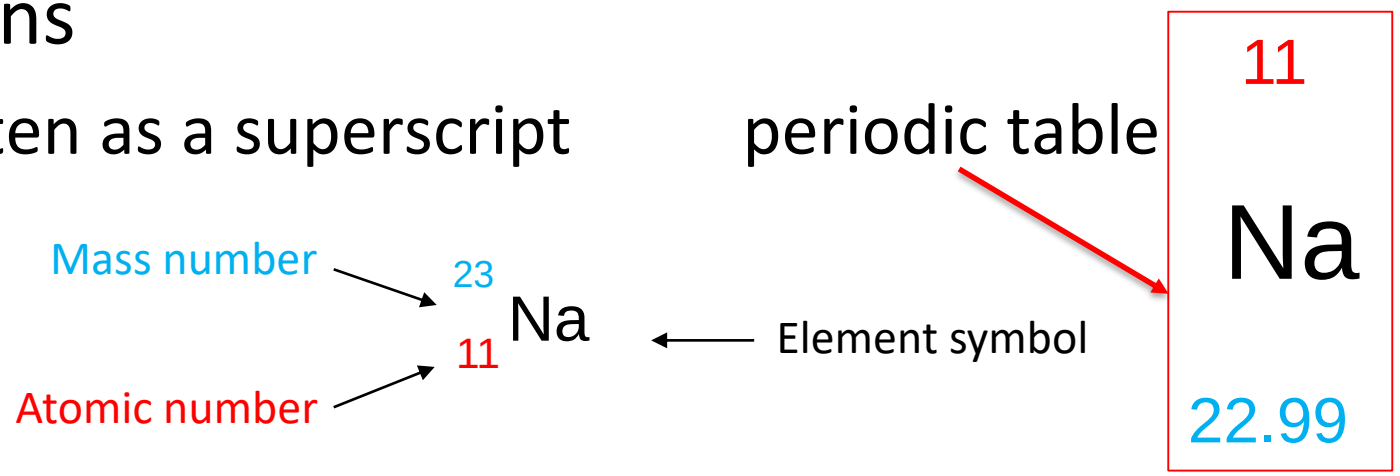
- Atoms with the same number of protons but different numbers of neutrons
- almost identical chemical properties
- Most elements are mixtures of isotopes

Figure 2.15 - Two Isotopes of Sodium



Identifying Isotopes

- **Atomic number** (*Z*): Number of protons
  - Written as a subscript
- **Mass number** (*A*): Total number of protons and neutrons
  - Written as a superscript



Interactive Example 2.2 - Writing the Symbols for Atoms

- Write the symbol for the atom that has an atomic number of 9 and a mass number of 19
  - How many electrons and how many neutrons does this atom have?

Interactive Example 2.2 - Solution

- The atomic number 9 means the atom has 9 protons (& 9 electrons for neutral atom)
  - This element is called fluorine, symbolized by F
  - The atom is represented as follows:

$$^{19}_{9}\mathrm{F}$$

    - The atom is called fluorine nineteen

Exercise

- How many protons and neutrons are in the nucleus of each of the following atoms?
  - In a neutral atom of each element, how many electrons are present? End class 9/5W

1. ^{79}Br **35 p, 44 n, 35 e**
2. ^{81}Br **35 p, 46 n, 35 e**
3. ^{239}Pu **94 p, 145 n, 94 e**
4. ^{133}Cs **55 p, 78 n, 55 e**

Chemical Bonds

- Forces that hold atoms together in compounds
- **Covalent bond**: Formed by sharing electrons

Ion

- Atom (atoms) with positive or negative charge
  - **Cation**: Positive ion formed by losing electrons
  - **Anion**: Negative ion formed by gaining electrons
- **Ionic bonding**: Force of attraction between oppositely charged ions

ionic vs covalent

Ionic compounds – metal with nonmetal combine two elements on opposite side of periodic table ex: $NaCl$, K_2S

Covalent compounds – nonmetal with nonmetal, combine two elements close together on periodic table ex: CO_2, PCl_3

Ion Formation - Example

- Sodium chloride
  - Formed when a neutral Cl and Na react
  - Electron is transferred from a Na atom to a Cl atom

$$\text{Cation formation: } Na \longrightarrow Na^+ + e^-$$

$$\text{Anion formation: } Cl + e^- \longrightarrow Cl^-$$

Ionic Solids

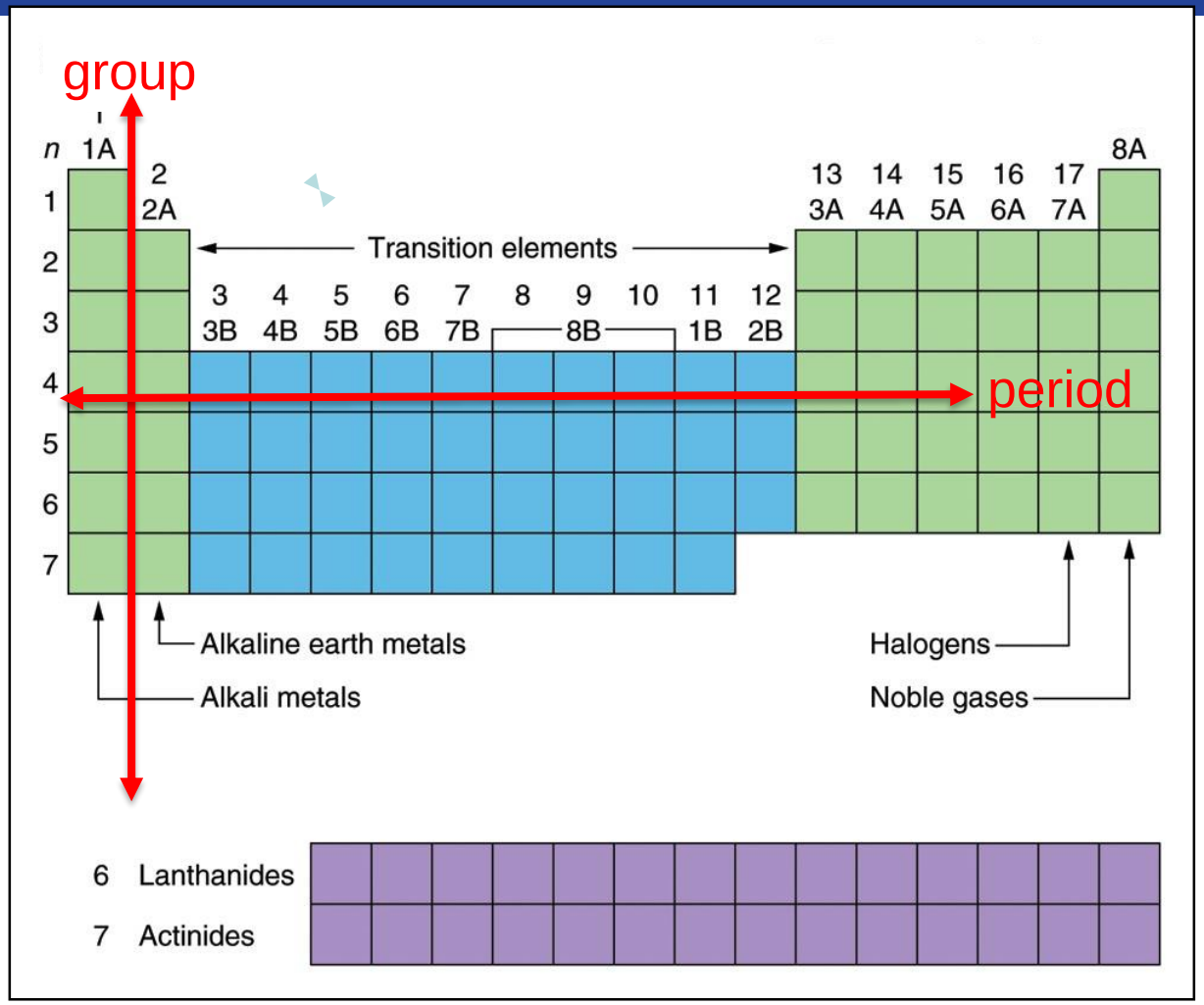
- Solids containing oppositely charged ions
- Can consist of:
  - Simple ions
    - Example - Sodium chloride (NaCl)
  - **Polyatomic ions**: Contain many atoms
    - Example - Ammonium nitrate (NH_4NO_3) contains ammonium ions (NH_4^+) and nitrate ions (NO_3^-)

Section 2.6
Molecules and Ions

- likely charge for below elements ?
- likely charge group 1A to 3A = + group #
- likely charge: group 5A to 7A = group # - 8)

group 2A, +2	a. Ra	Loses 2 e^- to form Ra^{2+}
group 3A, +3	b. In	Loses 3 e^- to form In^{3+}
group 5A, 5 - 8	c. P	Gains 3 e^- to form P^{3-}
group 6A, 6 - 8	d. Te	Gains 2 e^- to form Te^{2-}

The Periodic Table – Divided into Periods and Groups

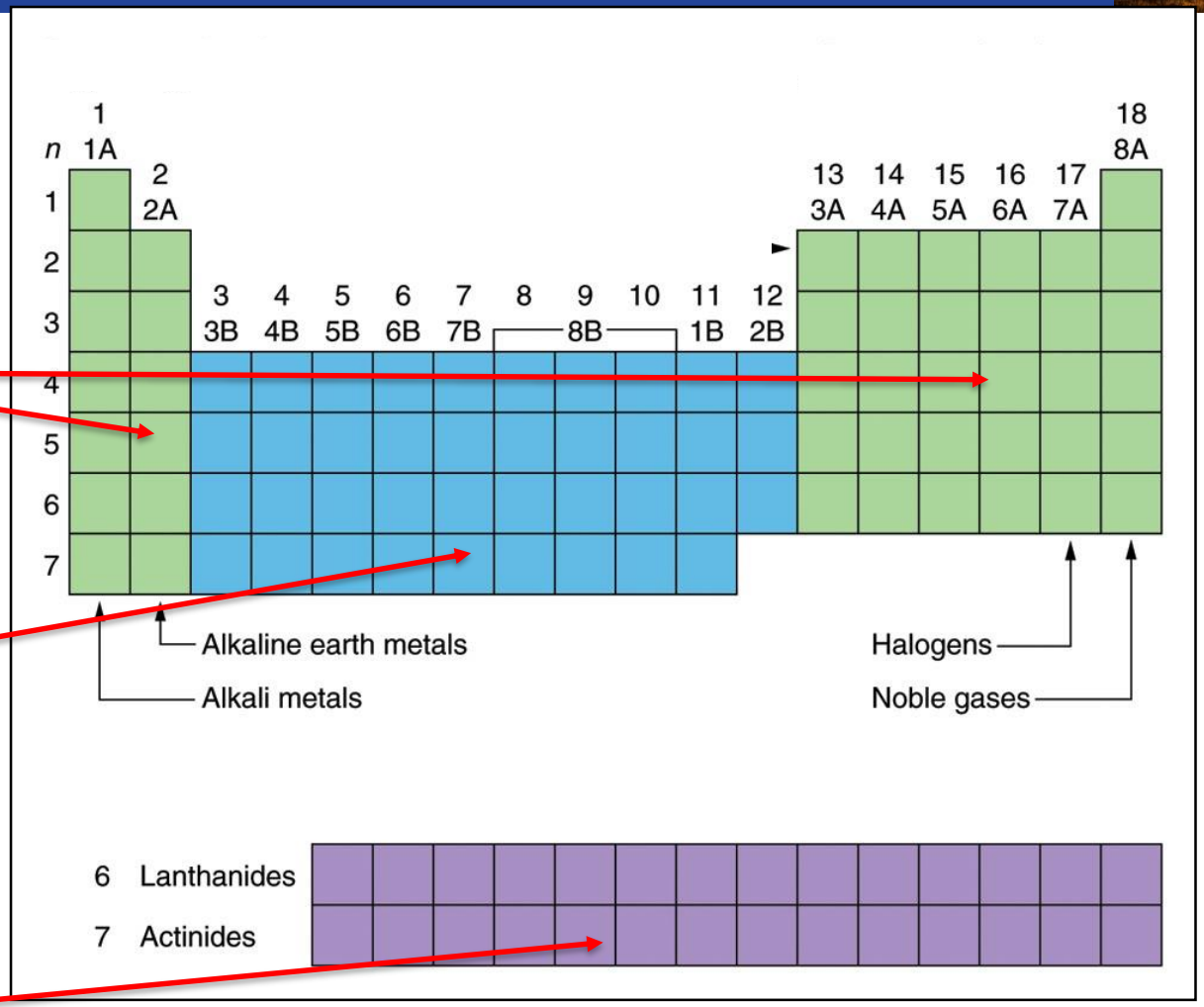


One Way to Classify the Periodic Table

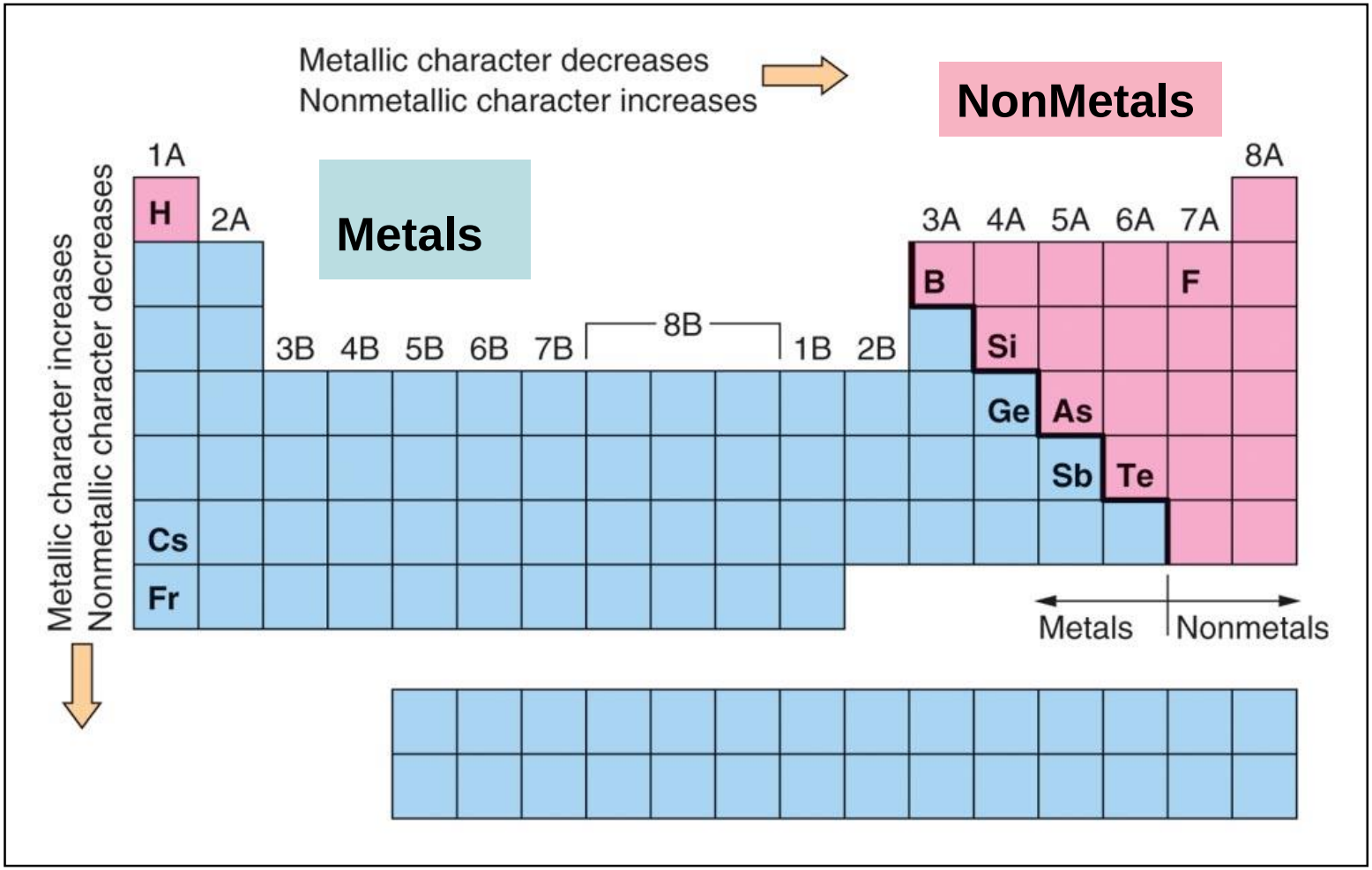
Representative Elements (green) (main group elements)

Transitional Elements (blue) transition metal elements

Inner Transition Elements (purple) lanthanides & actinides



Metals/Nonmetals in the Periodic Table



Metals and Nonmetals

Metals

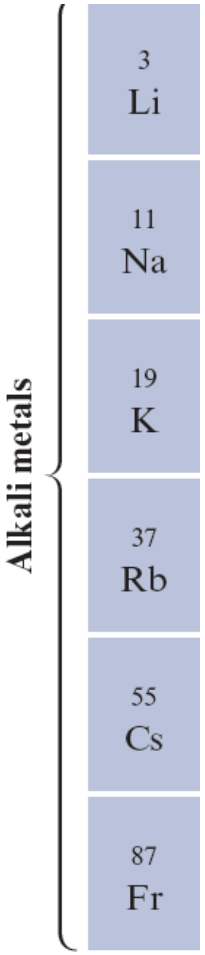
- Efficient conductors of heat and electricity, malleable, and ductile
- Have a lustrous appearance
- Tend to lose electrons to form positive ions

Nonmetals

- Lack the physical properties that characterize metals
- Tend to gain electrons in reactions with metals to form negative ions
- Often bond to each other by forming covalent bonds

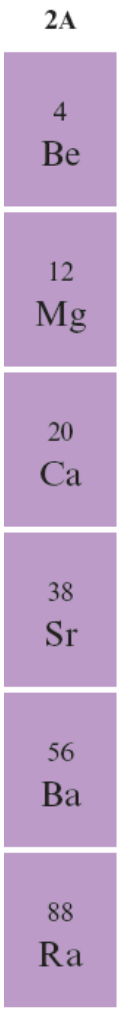
Structure of the Periodic Table: Groups or Families

- Elements in the vertical columns with similar chemical properties
- **Alkali metals**
  - Members of Group 1A
  - Very active elements that readily form ions with a 1+ charge when they react with nonmetals



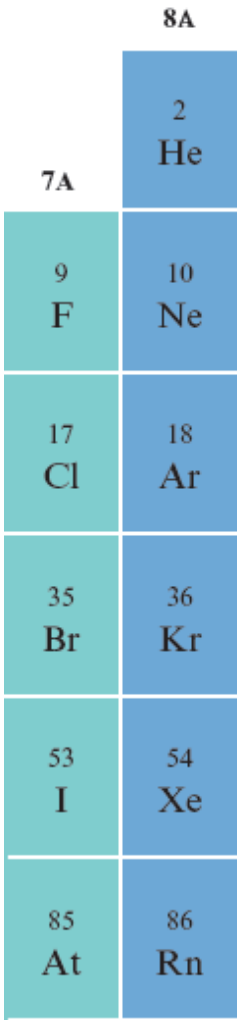
Structure of the Periodic Table: Groups or Families
(continued 1)

- **Alkaline earth metals**
  - Members of Group 2A
  - Form ions with a 2+ charge when they react with nonmetals



Structure of the Periodic Table: Groups or Families
(continued 2)

- **Halogens**: Members of Group 7A
  - Form diatomic molecules
  - React with metals to form salts containing ions with a 1– charge (exception - Astatine)
- **Noble gases**: Members of Group 8A
  - Exist under normal conditions as monatomic gases
  - Have little chemical reactivity



Binary Compounds

- Composed of two elements
- Include covalent and ionic compounds
  - **Binary ionic compounds**: Contain a cation, which is written first in the formula, and an anion

Naming Binary Ionic Compounds (Type I)

- Cation is always named first and the anion second
- Monatomic cation takes its name from the name of the parent element
- Monatomic anion is named by taking the root of the element name and adding -ide

Table 2.3 - Common Monatomic Cations and Anions

Cation	Name	Anion	Name
H^+	Hydrogen plus ide	H^-	Hydride
Li^+	Lithium	F^-	Fluoride
Na^+	Sodium	Cl^-	Chloride
K^+	Potassium	Br^-	Bromide
Cs^+	Cesium	I^-	Iodide
Be^{2+}	Beryllium	O^{2-}	Oxide
Mg^{2+}	Magnesium	S^{2-}	Sulfide
Ca^{2+}	Calcium	N^{3-}	Nitride
Ba^{2+}	Barium	P^{3-}	Phosphide
Al^{3+}	Aluminum		

Interactive Example 2.3 - Naming Type I Binary Compounds

- Name each binary compound
  a. CsF
  b. $AlCl_3$
  c. LiH

Interactive Example 2.3 - Solution

a. CsF is cesium fluoride
b. $AlCl_3$ is aluminum chloride
c. LiH is lithium hydride end 9/7F END EXAM I

- Notice that, in each case, the cation is named first and then the anion is named