8.1 Outline

- History of the periodic table
- Effective nuclear charge
- Sizes of atoms and ions
- Trends in ionization energies
- Trends in electron affinities

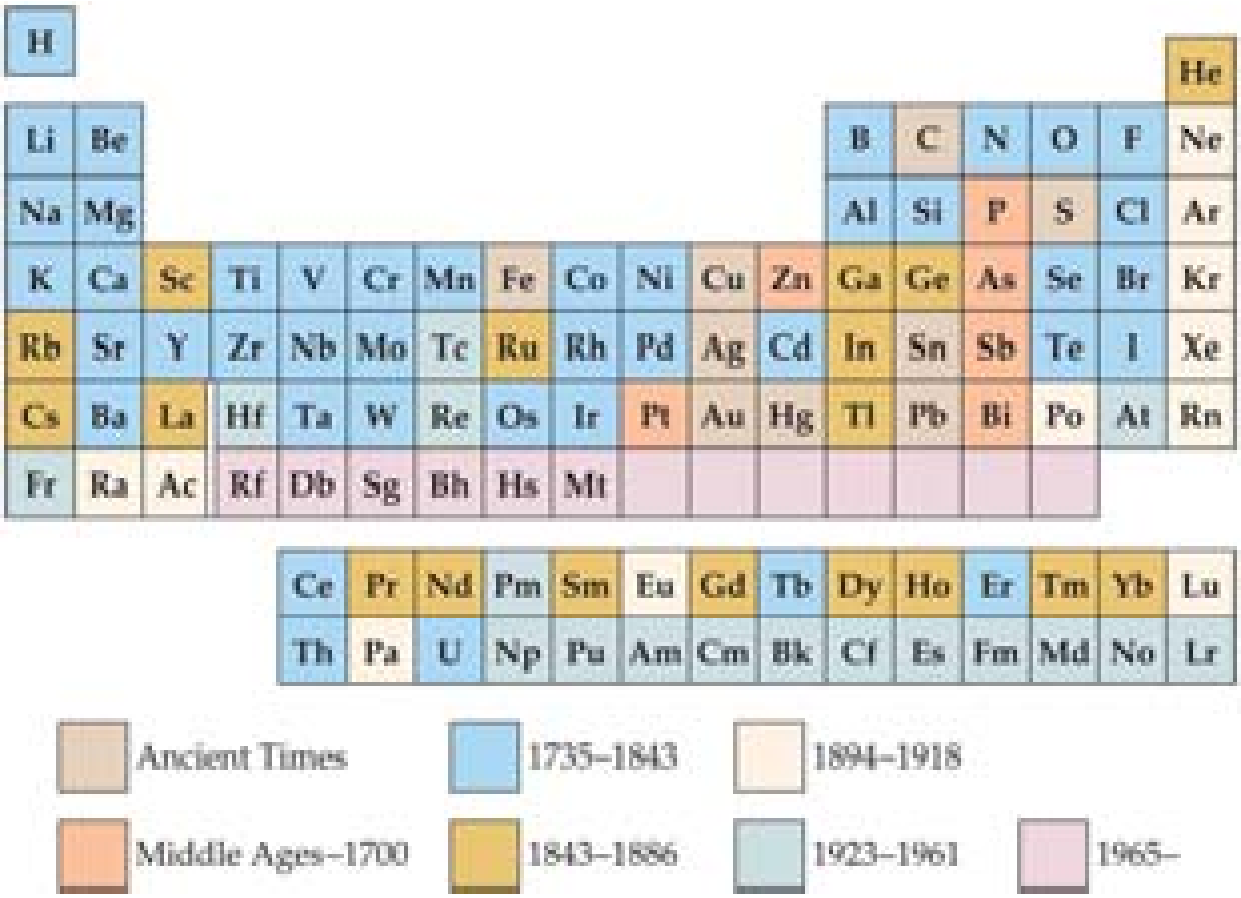

Figure 8.1: Discovery Dates of the Elements

8.2 Development of the Periodic Table

- Mendeleev's insistence that elements with similar properties be listed in the same group lead him to leave several blanks in the periodic table.
- For example, Mendeleev predicted some properties of now what is called Germanium based on the fact that it is in the same group as Silicon. Silicon was discovered almost 100 years before that of Germanium!

- Once germanium was discovered, its observed properties matched exceptionally well with Mendeleev's predictions (see the table on the next slide).

Table 8.1: Comparison of the Properties of Eka-Silicon ("under" silicon) Predicted by Mendeleev with the Observed Properties of Germanium

Property	**Mendeleev's Predictions for Eka-Silicon (made in 1871)**	**Observed Properties of Germanium (discovered in 1886)**
Atomic weight	72	72.59
Density (g/cm^3)	5.5	5.35
Specific heat (J/g×K)	0.305	0.309
Melting point (°C)	High	947
Color	Dark gray	Grayish white
Formula of oxide	XO_2	GeO_2
Density of oxide (g/cm^3)	4.7	4.70
Formula of chloride	XCl_4	$GeCl_4$
Boiling point of chloride (°C)	A little under 100	84

Periodic law 1860–1870's (Mendeleev and Meyer) – A periodic repetition of physical and chemical properties occurs when the elements are arranged in order of increasing atomic *weight [number]*

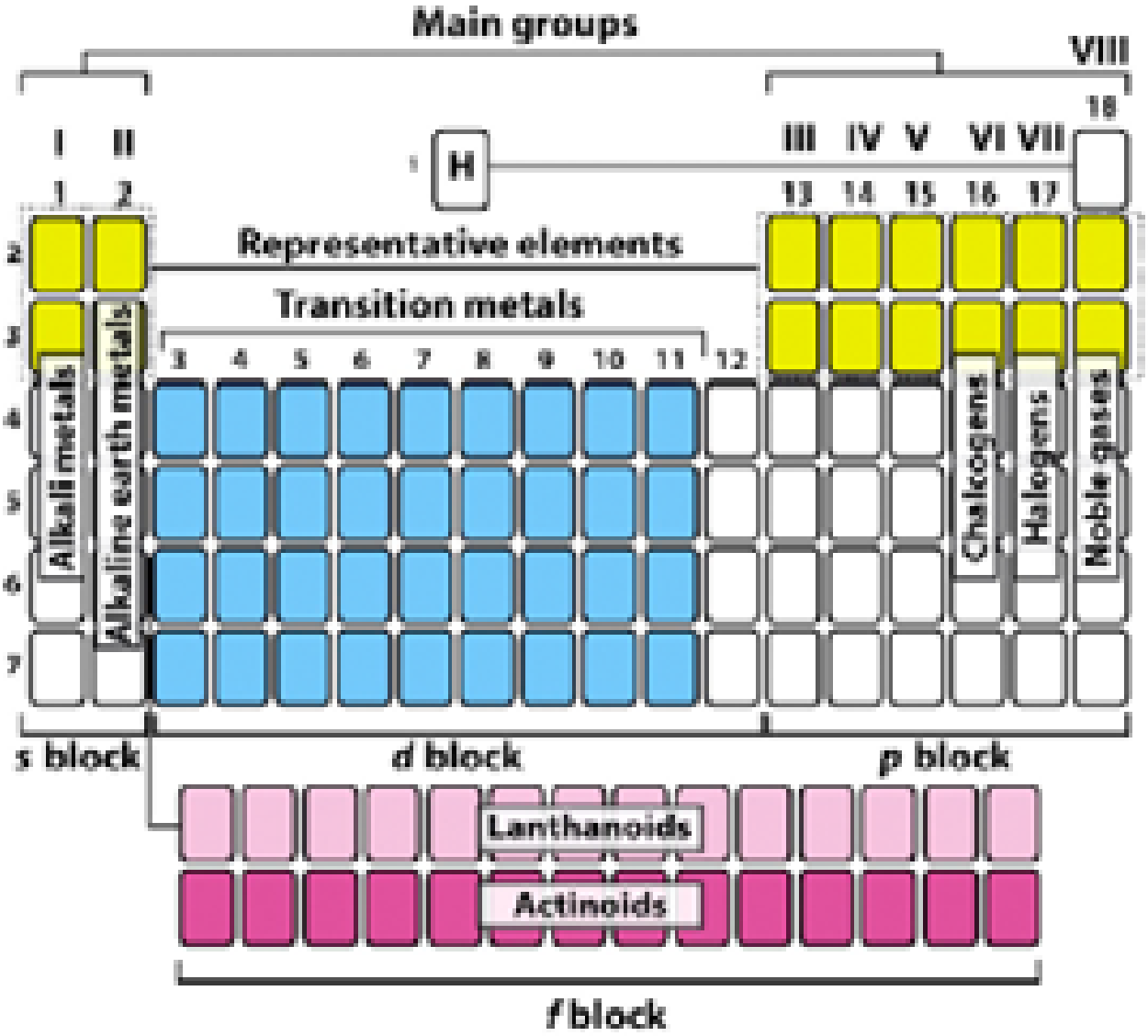

Figure 8.2

8.3 Ordering by Atomic Weight

Inconsistencies in ordering by atomic weight:

- Co (58.93 amu; $Z = 27$) and Ni (58.69 amu; $Z = 28$)
- Ar (39.95 amu; $Z = 18$) and K (39.10 amu; $Z = 19$)
- Te (127.60 amu; $Z = 52$) and I (126.90 amu; $Z = 53$)

However, all of the above are correctly ordered by atomic number, Z (i.e., the number of protons).

8.4 Development of Periodic Table

- Elements in the same group generally have similar chemical properties.
- However, physical properties are not necessarily similar.
- For example, even though Oxygen and Sulfur are in the same group (6A), Oxygen is a colorless gas, while Sulfur is a yellow solid under normal conditions.

8.5 But why do elements in the same group have similar properties?

8.6 Trends in First Ionization Energies

- As one goes down a group, less energy is required to remove the first electron.
  - For atoms in the same group, Z_{eff} is essentially the same, but the valence electrons are farther from than ...
- Generally, as one goes across a row/period, it becomes more difficult to remove an electron.
  - As you go from left to right $\rightarrow$ Z_{eff} increases!

Account for the decrease in ionization energy in going from nitrogen (N) to oxygen (O) despite the increase in effective nuclear charge (Z_{eff}).

8.7 Electron Affinity

Electron affinity is the energy change accompanying the addition of an electron to a gaseous atom:

$$\mathsf{Cl(g)} + \mathsf{e^-} \longrightarrow \mathsf{Cl^-(g)} \qquad E_a = -349\frac{\text{kJ}}{\text{mol}}$$

Energy is typically released when an electron is added to a gaseous atom. The process is said to be exothermic, so the energy has a negative sign associated with it.

The electron affinity of lithium is a negative value, whereas the electron affinity of Beryllium is a positive value. Use electron configuration to account for this observation.