7.12 Electron Configurations of Atoms

- Electron configurations can be deduced from the positions of elements in the periodic table:
  - Valence shell principal quantum numbers equal period numbers (F → 2nd period, n=2)
  - All elements in a period have the same noble-gas core configurations ([He], [Ne], [Ar], …)
  - All elements in a group have analogous valence shell electron configurations (F → [He]2s^22p^5; Cl → [Ne]3s^23p^5; all halogens → ns^2np^5)
- The filling order of the orbitals can be obtained from the periodic table.

Fig. 7.31

- The ns, np, (n-1)d and (n-2)f orbitals are filled in the nth period.

- The ns orbitals are filled before the (n-2)f and (n-1)d orbitals, but are written after them.
  Sc → noble gas core [Ar] → (K, Ca) 4s^2 → (Sc) 3d^1
  ⇒ [Ar]4s^23d^1 → [Ar]3d^14s^2

Example: Write the electron configuration of osmium, Os.

Os is in the 6th period → valence shell n=6
Previous noble gas is Xe → noble-gas core is [Xe]
After Xe → 2 ns, 14 (n-2)f, and 6 (n-1)d elements
⇒ [Xe]4f^14d^66s^2

7.13 Electron Configurations of Ions

- Cations:
  - For p- and s-elements electrons are lost first from the np subshell followed by the ns subshell.
  - For d-elements electrons are lost first from the ns subshell followed by the (n-1)d subshell.

Example: Write the electron configurations of Pb^{2+} and Pb^{4+}.

Pb → [Xe]4f^14d^106s^2
Pb^{2+} → [Xe]4f^14d^106s^2
Pb^{4+} → [Xe]4f^14d^{10}

- Anions:
  - Electrons are added until a noble-gas configuration is reached.

Example: Write the electron configurations of the nitride and oxide ions.

N → [He]2s^22p^3
N^{3-} → [He]2s^22p^6 → [Ne]
O → [He]2s^22p^4
O^{2-} → [He]2s^22p^6 → [Ne]

- Exceptions to the building-up principle:
  - Half-filled d and f subshells have exceptional stability.
  - Completely filled d and f subshells have exceptional stability.

Example: Write the electron configuration of gold, Au.

valence shell n=6 noble-gas core [Xe]
After Xe → 2 6s, 14 4f, and 9 5d elements
⇒ [Xe]4f^14d^106s^2
7.14 Electronic Structure and the Periodic Table

- The table is divided into s, p, d, and f blocks named by the last occupied subshell being filled.
- **Valence electrons** – electrons in the highest occupied principal shell and in partially filled subshells of lower principal shells.
- **Main groups** – s and p elements
  - Group 1 ns\(^1\), Group 2 ns\(^2\), Group 13 ns\(^2\)np\(^1\), ..., Group 18 ns\(^2\)np\(^6\)
- **Secondary groups** – d elements
  - Group 3 (n-1)d\(^1\)ns\(^2\), ..., Group 12 (n-1)d\(^10\)ns\(^2\)

- The number of valence electrons equals the group # (group # - 10 for p-elements)

**Example:** Write the valence electron configurations of groups 7 and 15.

**Group 7** → 7 valence electrons, d-elements
2 s-electrons and 5 d-electrons
⇒ (n-1)d\(^5\)ns\(^2\)

**Group 15** → 15-10=5 valence electrons, p-elements
2 s-electrons and 3 p-electrons
⇒ ns\(^2\)np\(^3\)

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7.15 Atomic Radius

- Half of the distance between the centers of two neighboring atoms
  - Metals - in the solid phase
  - Nonmetals - in molecules (covalent radius)

- **Atomic radii** increase down a group and decrease from left to right across a period.

**Example:** Compare the sizes of Ge, Sn, and Se.
Sn is below Ge ⇒ Sn > Ge
Ge is to the left of Se ⇒ Ge > Se