Section 5.1
History of the Periodic Table

Objectives:

• Explain the roles of Mendeleev and Moseley in the development of the periodic table.
• Describe the modern periodic table.
• Explain how the periodic law can be used to predict the physical and chemical properties of elements.
• Describe how the elements belonging to a group of the periodic table are interrelated in terms of atomic number.
Section 5.2
Electron Configuration and the Periodic Table

Objectives:

• Locate and name the 4 blocks of the periodic table. Explain the reasons for these names.

• Discuss the relationship between configurations and group numbers.

• Describe the locations in the periodic table and the general properties of the alkali metals, the alkaline-earth metals, the halogens, noble gases, actinide series and lanthanide series.
Chapter 5
The Periodic Law
**PERIODIC TABLE OF THE ELEMENTS**

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(1) Pure Appl. Chem., 73, No. 4. 667-683 (2001)
Relative atomic mass is shown with five significant figures. For elements with no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.

However, three such elements (H, Pa, and U) do have a characteristic terrestrial isotopic composition, and for these an atomic weight is tabulated.

Editor: Aditya Varshney (aditya@nci.gov.in)
Section 5.1
History of the Periodic Table

• The first “periodic table” was created by Dmitri Mendeleev in 1860’s.
• He noticed that when elements were arranged in order of increasing atomic mass, certain similarities in their chemical properties appeared at regular intervals.
• He predicted the existence of elements not yet discovered.
Mendeleev’s table as published in 1869, with many gaps and uncertainties
In 1911, Henry Moseley recognized relationships and patterns in properties if elements were arranged according to increasing number of protons – atomic number.

Periodic law = states that the physical and chemical properties of the elements are periodic functions of their atomic numbers.

Elements with similar properties fall in the same column or group.
Types of Elements

• Periodic Table is broadly divided into *metals* and *nonmetals*.

• A stair-step line divides metals and nonmetals on the table.
PERIODIC TABLE OF THE ELEMENTS

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(1) Pure Appl. Chem., 73, No. 4, 687-693 (2001)
Relative atomic mass is shown with five significant figures. For elements having no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element. However, three such elements (Th, Pa and U) do have a characteristic terrestrial isotopic composition, and for these their atomic weights are tabulated.

Editor: Aditya Vardhan (advvr@netcfrx.com)
Metals

- Left of stair-step line
- Shiny, metallic luster
- Good conductors of heat and electricity.
- At room temperature – most are solids (Hg is liquid)
- Malleable – can be hammered or rolled into sheets
- Ductile – can be drawn into a fine wire
- Have tensile strength – resist breaking when pulled
Non-Metals

- Right of stair-step line
- Many are gases at room temperature: nitrogen, oxygen, fluorine, chlorine
- Bromine is liquid at room temperature
- Some are solids at room temperature: carbon, phosphorus, selenium, sulfur, iodine
- Solid non-metals are usually brittle – not malleable and ductile
- Poor conductors of heat and electricity.
### Periodic Table of the Elements

**Period 1**
- **Group 1A**
  - H: Hydrogen
- **Group 2A**
  - Li: Lithium
  - Be: Beryllium
- **Group 3A**
  - B: Boron
- **Group 4A**
  - N: Nitrogen
- **Group 5A**
  - P: Phosphorus
- **Group 6A**
  - S: Sulfur
- **Group 7A**
  - Cl: Chlorine
- **Group 8A**
  - Ne: Neon

**Period 2**
- **Group 1A**
  - Na: Sodium
  - Mg: Magnesium
- **Group 2A**
  - Ca: Calcium
- **Group 3A**
  - Sc: Scandium
- **Group 4A**
  - Ti: Titanium
  - V: Vanadium
- **Group 5A**
  - Cr: Chromium
  - Mn: Manganese
  - Fe: Iron
- **Group 6A**
  - Co: Cobalt
  - Ni: Nickel
  - Cu: Copper
- **Group 7A**
  - Zn: Zinc
  - Ga: Gallium
  - Ge: Germanium
- **Group 8A**
  - As: Arsenic
  - Se: Selenium
  - Br: Bromine
  - Kr: Krypton

**Period 3**
- **Group 1A**
  - K: Potassium
- **Group 2A**
  - Ca: Calcium
  - Mg: Magnesium
- **Group 3A**
  - Sc: Scandium
  - Ti: Titanium
  - V: Vanadium
- **Group 4A**
  - Cr: Chromium
  - Mn: Manganese
  - Fe: Iron
  - Co: Cobalt
- **Group 5A**
  - N: Nitrogen
  - O: Oxygen
  - F: Fluorine
- **Group 6A**
  - P: Phosphorus
  - S: Sulfur
  - Cl: Chlorine
- **Group 7A**
  - Ar: Argon

**Period 4**
- **Group 1A**
  - Rb: Rubidium
  - Cs: Cesium
  - Fr: Francium
- **Group 2A**
  - Sr: Strontium
  - Ba: Barium
  - Ra: Radon
- **Group 3A**
  - Y: Yttrium
  - La: Lanthanum
  - Ac-Lr: Actinide
- **Group 4A**
  - Zr: Zirconium
  - Hf: Hafnium
  - Th: Thorium
  - Pa: Protactinium
- **Group 5A**
  - Nb: Niobium
  - Ta: Tantalum
  - W: Tungsten
  - Re: Rhenium
  - Os: Osmium
  - Ir: Iridium
- **Group 6A**
  - Mo: Molybdenum
  - Tc: Technetium
  - Ru: Ruthenium
  - Rh: Rhodium
  - Pd: Palladium
  - Ag: Silver
  - Cd: Cadmium
  - In: Indium
  - Sn: Tin
  - Sb: Antimony
  - Te: Tellurium
  - I: Iodine
  - Xe: Xenon

**Period 5**
- **Group 1A**
  - Cs: Cesium
  - Fr: Francium
- **Group 2A**
  - Ba: Barium
  - Ra: Radon
- **Group 3A**
  - La: Lanthanum
  - Ce: Cerium
  - Pr: Praseodymium
- **Group 4A**
  - Th: Thorium
  - Pa: Protactinium
  - U: Uranium
  - Np: Neptunium
- **Group 5A**
  - Pu: Plutonium
  - Am: Americium
  - Cm: Curium
- **Group 6A**
  - Br: Bromine
  - K: Krypton
  - Rn: Radon
- **Group 7A**
  - Po: Polonium
  - At: Astatine
  - Rn: Radon

**Period 6**
- **Group 1A**
  - Fr: Francium
  - Ra: Radon
- **Group 2A**
  - Ba: Barium
  - Ra: Radon
- **Group 3A**
  - La: Lanthanum
  - Ce: Cerium
  - Pr: Praseodymium
  - Nd: Neodymium
  - Pm: Promethium
  - Sm: Samarium
  - Eu: Europium
  - Gd: Gadolinium
  - Tb: Terbium
  - Dy: Dysprosium
  - Ho: Holmium
  - Er: Erbium
  - Tm: Thulium
  - Yb: Ytterbium
  - Lu: Lutetium

**Period 7**
- **Group 1A**
  - Fr: Francium
  - Ra: Radon
- **Group 2A**
  - Ba: Barium

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**Note:**
- Relative atomic mass is shown with five significant figures. For elements with no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.
- Elements marked with a * (Th, Pa, and U) do not have a characteristic terrestrial isotopic composition, and for these, atomic weights are tabulated.

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**Editor:** Aditya Vardhan (aditya@encirr.com)
Metalloids

- On stair-step line
- Elements have some characteristics of metals and some characteristics of non-metals.
- All are solids at room temperature
- Less Malleable than metals but not as brittle as nonmetals.
- Some have slight metallic luster
- Semiconductors of electricity –ability to conduct is between metals and nonmetals.
- Used in computers, calculators, digital watches, tv’s and radios
**PERIODIC TABLE OF THE ELEMENTS**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>1A</th>
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**Editor:** Aditya Vardhan (adivar@nclink.com)
GROUP 1, 2
's' BLOCK
ns^{1-2}

Representative elements

Transition element
Group 3-10

'd' BLOCK
(n-1) d^{1-10} ns^{1 or 2}

GROUP 18
Noble gases

Inner Transition element

'f' BLOCK
(n-2) f^{1-14} (n-1) d^{0 or 1} ns^{2}
The $s$-Block Elements: Groups 1 and 2 - Metals

- Elements in Group 1 - alkali metals
  - soft, silvery
  - extremely reactive
  - not found in nature as free elements – only in compounds.
  - They react vigorously with water and most nonmetals.
  - Because they react strongly with moisture in the air, they must be stored in kerosene or oil
  - 1 valence e- in s orbital

- Elements in Group 2 - alkaline-earth metals
  - harder, denser, stronger
  - less reactive than group 1
  - Also too reactive to be found as free elements in nature
  - 2 valence e- in s orbital

- $s$ orbital correlates to period number
  ex: do configuration for sodium  
  do configuration for calcium
The d-Block Elements: Groups 3-12 - Metals

• Groups in this block do not necessarily have identical outer e- configuration.

• **Transition elements** = act as a transition from the highly reactive metals to the less reactive metals

• Pd, Pt, and Au among the least reactive of all elements.

• **Ex:** do configuration for copper
The f-Block Elements: Lanthanides and Actinides - Metals

• Located under the d-block elements

• **LANTHANIDES**
  – 14 elements
  – At. Numbers 58-71

• **ACTINIDES**
  – 14 elements
  – At. Numbers 90-103
  – radioactive.
  – First 4 actinides are found in nature; the others are lab-made. i.e. synthetic
The p-Block Elements: Groups 13-18 – Metals and Non-metals

• Main group elements = s- and p-block elements
• The total number of e- in the highest occupied level is equal to the group number minus 10.

• Ex: do electron configuration for sulfur

• Properties vary greatly, but most closely associated with non-metal properties.
• Includes the 6 metalloids (B, Si, Ge, As, Sb, Te) - semiconductors
• Groups 13-16 are known by the top member of each group (ex. Carbon family = Group 14).
More on p-block elements

• Group 17 = **halogens**
  – Halogens are 1 e- short of octet and are most reactive nonmetals.
  – React with metals to form salts.
  – **Ex:** do electron configuration for chlorine

• Group 18 – **noble gases**
  – 1894 Ar was discovered.
  – It and the other noble gases were previously unknown because they are non-reactive.
  – 1895 He was discovered.
  – These discoveries led to a new group being added to the table.
  – **Ex:** do electron configuration for argon
Noble Gases

- Group 18
- Generally unreactive
- Gases at room temperature
Argon is one of the most widely used gases, not just for science, but also in lighting and other applications. Neon signs were developed when Georges Claude, a French chemist, came up with a long lasting cathode design. Contrary to the name, many of the colors produced for neon displays use a mixture of argon with a little mercury as the working gas. Different colors are achieved by using colored glass as well as fluorescent materials to coat the inside of the tube.
Types of Electron Configurations

3. Noble Gas Notation – abbreviates part of the electron configuration by using the Noble Gas Symbol just prior to the element and adds the rest of the electron configuration

Magnesium 12e-

Mg = [Ne] 3s^2
Complete Noble-Gas Notations for the following elements:

S
Ca
Rb
Li
O
Al
Elements that are Exceptions to some of the groupings/blocks: H and He

• These are the simplest and most abundant elements.

  H = 76% of mass of universe
  He = 23% of mass of universe

  – H does not share the properties of Group 1.
  – H properties are unique.
  – He has same e- configuration as Group 2, but is part of group 18.
May 6, 1937, German rigid airship *Hindenburg* (dirigible) caught fire and was destroyed within one minute while attempting to dock with its mooring mast at *Lakehurst Naval Air Station* in *New Jersey*. Of the 97 people on board, 35 people died in addition to one fatality on the ground.

Hydrogen is incredibly explosive (Hindenburg disaster). More explosive than natural gas.
He atom
Practice

1. Which element has the noble gas configuration of \([\text{Xe}]6s^2\)?

2. Which element is more reactive: Sr or Na?
1. Write the electron configuration notation for Cl.

2. What is its highest occupied energy level (principal quantum number)?

3. How many total electrons does it have in that highest energy level?

4. How does this compare to its group number?
1. In which block is the element Calcium?
2. In which block is the element Ar?
3. In which period is the element Iron?
4. What is the group number for phosphorus?
5. In which block in the element Copper?
6. What would be the highest energy level for electrons in an atom of sulfur?
7. What is the atomic number of sodium?
8. Do the electron configuration notation for manganese.
9. Do the noble gas configuration for arsenic.
10. In which period is the element Ag?
11. What is the best way to define a metal?
12. In what block on the Periodic Table is Nickel?
13. Describe the properties of a metalloid.
14. What are elements in Group 18 called?
15. What is the purpose of the stair-step line on your Periodic Table?
16. How can you use the Periodic Table to determine the number of valence electrons in a p-block element?
17. What do we call the Group I elements?
18. What do we call the Group 2 elements?
19. What do we call the Group 17 elements?
20. What is another name for the D-block elements?