

Chapter 2 – Atomic Structure and Nomenclature

Section 2 – Periodic Table

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The Periodic Table

The first periodic table was developed by Dimitri Mendeleev in which elements are arranged in a specific order in groups (vertical) and rows (horizontal).

- See a short video here: http://youtu.be/-kUg_KJhcLo
- Here is the best periodic table with videos and history of elements. <http://www.rsc.org/periodic-table>

The First Periodic Table



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Introduction - Mendeleev

In 1830 only 55 elements were known. As time went by and more elements were discovered it was important to arrange them in some order.

In 1869 Dimitri Mendeleev, constructed the first such arrangement in what is now called Periodic Table (PT).

- Initially PT was arranged by mass number. Most elements that were arranged in the same column had similar properties, however some elements did not. Mendeleev moved those elements out of sequence of mass number to fit the trend. It arranged perfectly when PT was arranged according to atomic number.
- Modern PT – Glenn Seaborg improved the old PT after he discovered majority of the lanthanide elements.

Review: Atomic number is the number of protons and mass number is the number of protons and neutrons. We know electrons don't contribute to the mass of the atom. And we will see later that electrons can be given or taken.

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The Periodic Table

| IA | IIA | | | | | | | | | | | | IIIA | IVA | VA | VIA | VIIA | VIIIA | |
|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|-------------------|-------|------------------|
| 1 H 1.008 | | | | | | | | | | | | | | | | | | | 2 He 4.003 |
| 3 Li 6.941 | 4 Be 9.012 | | | | | | | | | | | 5 B 10.81 | 6 C 12.01 | 7 N 14.01 | 8 O 15.99 | 9 F 18.99 | 10 Ne 20.18 | | |
| 11 Na 22.98 | 12 Mg 24.31 | | | | | | | | | | | 13 Al 26.98 | 14 Si 28.09 | 15 P 30.97 | 16 S 32.07 | 17 Cl 35.45 | 18 Ar 39.95 | | |
| 19 K 39.1 | 20 Ca 40.08 | 21 Sc 44.96 | 22 Ti 47.88 | 23 V 50.94 | 24 Cr 51.99 | 25 Mn 54.94 | 26 Fe 55.85 | 27 Co 58.93 | 28 Ni 58.69 | 29 Cu 63.55 | 30 Zn 65.39 | 31 Ga 69.72 | 32 Ge 72.63 | 33 As 74.92 | 34 Se 78.96 | 35 Br 79.9 | 36 Kr 83.8 | | |
| 37 Rb 85.47 | 38 Sr 87.62 | 39 Y 88.91 | 40 Zr 91.22 | 41 Nb 92.91 | 42 Mo 95.94 | 43 Tc 98.81 | 44 Ru 101.1 | 45 Rh 102.9 | 46 Pd 106.4 | 47 Ag 107.9 | 48 Cd 112.4 | 49 In 114.8 | 50 Sn 118.7 | 51 Sb 121.8 | 52 Te 127.6 | 53 I 126.9 | 54 Xe 131.3 | | |
| 55 Cs 132.9 | 56 Ba 137.3 | 57 La 138.9 | 58 Ce 140.1 | 59 Pr 140.9 | 60 Nd 144.2 | 61 Pm 145 | 62 Sm 150.4 | 63 Eu 152 | 64 Gd 157.3 | 65 Tb 158.9 | 66 Dy 162.5 | 67 Ho 164.9 | 68 Er 167.3 | 69 Tm 168.9 | 70 Yb 173 | 71 Lu 175 | | | |
| 87 Fr 223 | 88 Ra 226 | 89 Ac 227 | 90 Th 232 | 91 Pa 231 | 92 U 238 | 93 Np 237.1 | 94 Pu 244.1 | 95 Am 243.1 | 96 Cm [247] | 97 Bk [247] | 98 Cf [251] | 99 Es [252] | 100 Fm [257] | 101 Md [258] | 102 No [259] | 103 Lr [260] | | | |
| | | Lanthanides | | | | | | | | | | | | | | | | | |
| | | Actinides | | | | | | | | | | | | | | | | | |

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Periodic Table Basics

Periodic table is arranged chronologically according to the atomic number, given on the top of the element.

There are vertical **groups** and horizontal **rows** in the PT.

Elements in a group have similar chemical properties, i.e., they behave the same way when treated with certain chemicals.

Rows are not in any particular order except increasing atomic number.

Main group elements are groups 1-8 (I-VIII).

Transition metals are in the middle.

Lanthanides and Actinides are the bottom two rows written below the periodic table.

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Names of Groups in the Periodic Table

- Some groups have names, some don't; the ones without names are referred to as group numbers (III-VI).
- Groups I-VIII labeled below are called the main group elements.
- Note: metalloids are not a group but some elements in the middle of the PT.

The diagram shows a periodic table with the following group labels and corresponding colors:

- Alkali Metals (I):** Orange box, points to group I.
- Alkaline Earth Metals (II):** Green box, points to group II.
- Transition Metals:** Purple box, points to the d-block.
- Metalloids:** Grey box, points to the diagonal line of elements.
- Halogens:** Blue box, points to group VII.
- Noble Gases/Elements (VIII):** Pink box, points to group VIII.

The main groups are labeled I, II, III, IV, V, VI, VII, and VIII at the top of the table.

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Analyzing the Periodic Table

- The PT is divided into metals, metalloids and nonmetals.
- Metals on the left, nonmetals on the right and in the middle are metalloids.
- Hydrogen is a unique element: it is a nonmetal even though its on metal side.

| Metals | Metalloids | Nonmetals |
|--|---|---|
| <ul style="list-style-type: none"> • Hard. • Shiny, lustrous. • Malleable. • Good conductors of heat and electricity. • Give electrons to form cations. | <p>Can behave like a metal or nonmetal depending on the conditions.</p> | <ul style="list-style-type: none"> • Vary in color. • Not shiny. • Poor conductors. • Brittle. • Group VII and VIII are all nonmetals. • Gain electrons to form anions. |

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Elements and Symbols

Elements are represented by alphabets, one or two, the first is always capital and second is always small case. Chemical formulas and equations are written in symbol format.

- Some names of elements are the first letter of the element e.g., H for Hydrogen and He for Helium,
- Some symbols are based on the original name which could be in Greek or Latin e.g. Na for Sodium (Natrium) and K for Potassium (Kalium).
- Names of elements can be based on names of people (Mt - Meitnerium for Lise Meitner, the Noble Prize winner for chemistry); planets (U - Uranium for Uranus) and country (Am - Americium for USA).
- Visit the website (*given earlier also*) <http://www.rsc.org/periodic-table> to learn about the discovery, names etc. of the elements.
- I will recommend that as a chemistry student it is good to know elements 1-20 by heart. Other key elements to know are all of group I, II, VII, VIII, transition metal row 1.

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Solved Problem: Symbols and groups

Write the symbol or name of the element given in the table below and write which group or section of the periodic table they belong to.

| Element | Symbol | Group | Metal or nonmetal |
|-----------|--------|-------|-------------------|
| Bromine | | | |
| | Ag | | |
| Potassium | | | |
| | Cu | | |
| Neon | | | |

| Element | Symbol | Group | Metal or nonmetal |
|---------------|-----------|-------------------------|-------------------|
| Bromine | <i>Br</i> | <i>Halogens</i> | <i>Nonmetal</i> |
| <i>Silver</i> | Ag | <i>Transition metal</i> | <i>Metal</i> |
| Potassium | <i>K</i> | <i>Alkali metal</i> | <i>Metal</i> |
| <i>Copper</i> | Cu | <i>Transition metal</i> | <i>Metal</i> |
| Neon | <i>Ne</i> | <i>Noble gas</i> | <i>Nonmetal</i> |

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Solved Problem: Determining number of particles in an atom.

Answer the following questions about the elements given and determine the number of particles asked in that question.

| Element | Protons | Electrons | Neutrons | Element | Protons | Electrons | Neutrons |
|----------------------|---------|-----------|----------|----------------------|-----------|-----------|-----------|
| | 50 | | | <u>Tin</u> | 50 | <u>50</u> | <u>69</u> |
| Chlorine -37 | | | | Chlorine -37 | <u>17</u> | <u>17</u> | <u>20</u> |
| Al ³⁺ ion | | | | Al ³⁺ ion | <u>13</u> | <u>10</u> | <u>14</u> |
| As ³⁻ ion | | | | As ³⁻ ion | <u>33</u> | <u>36</u> | <u>42</u> |

Notes for answering these questions.

1. Make sure you don't answer in decimal points since particles exist as a whole number and not as fractions.
2. Cations are positively charged. Whatever the charge is indicates that is the number of electrons they have lost. This means that protons are now more than electrons hence the positive charge.
3. Anions are positively charged. Whatever the charge is indicates that is the number of electrons they have gained. This means that electrons are now more than protons hence the positive charge.

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Key Words and Concepts

- Isotopes
- Periodic table
- Metals, metalloids and nonmetals
- Alkali metal, alkaline earth metals, halogens, noble gases, transition metals