

The Periodic Table

Organizing the Elements

How did chemists begin to organize the known elements?

- 1700:
 - Only 13 elements had been identified
 - Knew more elements existed but they couldn't be isolated from compounds
- 1765-1775:
 - 5 more elements were discovered
 - Included hydrogen, nitrogen, and oxygen
- How would chemists know when all elements had been discovered?

J.W. Dobereiner

- 1829:
 - Published classification system for the elements based on properties
 - Grouped known elements into **triads** (set of 3 elements)
 - ie: Chlorine, bromine, & iodine
 - Unfortunately, not all the known elements could be grouped into triads



- Dobereiner noted a pattern within the triads he could form:
 - If he added the atomic mass of the outer two elements of the triad, their average mass was equal to that of the inner element in the triad

| Atomic Mass (1850) | | Atomic Number | |
|--------------------|--|---------------|--|
| Li 7 | } $\rightarrow \frac{7 + 39}{2} = 23$ | Li 3 | } $\rightarrow \frac{3 + 19}{2} = 11$ |
| Na 23 | | Na 11 | |
| K 39 | | K 19 | |
| Ca 40 | } $\rightarrow \frac{40 + 137}{2} = 88.5$ | Ca 20 | } $\rightarrow \frac{20 + 56}{2} = 38$ |
| Sr 87 | | Sr 38 | |
| Ba 137 | | Ba 56 | |
| P 31 | } $\rightarrow \frac{31 + 122}{2} = 76.5$ | P 15 | } $\rightarrow \frac{15 + 51}{2} = 33$ |
| As 75 | | As 33 | |
| Sb 122 | | Sb 51 | |
| S 32 | } $\rightarrow \frac{32 + 128}{2} = 80$ | S 16 | } $\rightarrow \frac{16 + 52}{2} = 34$ |
| Se 78 | | Se 34 | |
| Te 128 | | Te 52 | |
| Cl 35.5 | } $\rightarrow \frac{35.5 + 127}{2} = 81.25$ | Cl 17 | } $\rightarrow \frac{17 + 53}{2} = 35$ |
| Br 80 | | Br 35 | |
| I 127 | | I 53 | |

| | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|--|--|--|----|--|
| H | | | | | | | | | | | He | |
| Li | Be | B | C | N | O | F | Ne | | | | | |
| Na | Mg | Al | Si | P | S | Cl | Ar | | | | | |
| K | Ca | Ga | Ge | As | Se | Br | Kr | | | | | |
| Rb | Sr | In | Sn | Sb | Te | I | Xe | | | | | |
| Cs | Ba | Tl | Pb | Bi | Po | At | Rn | | | | | |

- While Dobereiner's triads were a good start to classifying the elements, it had its disadvantages:
 - At the time, he could only identify 3 triads
 - A large number of existing elements at the time could not be grouped into triads

Dmitri Mendeleev

1869:

- Considered the properties of the elements as well as their atomic masses when organizing.
- Created cards for each elements and began to lay them out in a form of “chemistry solitaire”
- Not all the elements were known at the time so Mendeleev had to leave blank spaces for those elements not yet discovered



Mendeleev's Periodic Table of 1871¹

| | I --- R ₂ O | II --- RO | III --- R ₂ O ₃ | IV RH ₄ RO ₂ | V RH ₃ R ₂ O ₃ | VI RH ₂ RO ₃ | VII RH R ₂ O ₇ | VIII --- RO ₄ |
|----|------------------------------|-----------------|---|--|---|--|--|---|
| 1 | H 1 | | | | | | | |
| 2 | Li 7 | Be 9.4 | B 11 | C 12 | N 14 | O 16 | F 19 | |
| 3 | Na 23 | Mg 24 | Al 27.3 | Si 28 | P 31 | S 32 | Cl 35.5 | |
| 4 | K 39 | Ca 40 | ? 44 | Ti 48 | V 51 | Cr 52 | Mn 55 | Fe, Co, Ni, Cu 56, 59, 59, 63 |
| 5 | Cu 63 | Zn 65 | ? 68 | ? 72 | As 75 | Se 78 | Br 80 | |
| 6 | Rb 85 | Sr 87 | ? Yt 88 | Zr 90 | Nb 94 | Mo 96 | ? 100 | Ru, Rh, Pd, Ag 104, 104, 106, 108 |
| 7 | Ag 108 | Cd 112 | In 113 | Sn 118 | Sb 122 | Te 125 | I 127 | |
| 8 | Cs 133 | Ba 137 | ? Di 138 | ? Ce 140 | ? 140 | ? 140 | ? 140 | ? , ? , ? , ? |
| 9 | ? 140 | ? 140 | ? 140 | ? 140 | ? 140 | ? 140 | ? 140 | |
| 10 | ? 140 | ? 140 | ? Er 178 | ?? La 180 | Ta 182 | W 184 | ? 184 | Os, Ir, Pt, Au 195, 197, 198, 199 |
| 11 | Au 199 | Hg 200 | Tl 204 | Pb 207 | Bi 208 | ? 208 | ? 208 | |
| 12 | ? 208 | ? 208 | ? 208 | Th 231 | ? 231 | U 240 | ? 240 | |

- While Mendeleev did not make the first periodic table, his was the first to gain wide acceptance.
- Was a “true” periodic table since it arranged elements according to periodicity of chemical and physical properties.

The Modern Periodic Table

- Take a minute to look at your copies of the Periodic Table
- Compare it to Mendeleev’s Periodic table on the previous slide.
 - How are they similar?
 - How are they different?
 - What do you think are the advantages and disadvantages of Mendeleev’s organization?

The Modern Periodic Table

- In a periodic table based on mass, Iodine should come before Tellurium. (Mendeleev broke this rule)
- Proton not yet discovered during Mendeleev's time.
- In 1913, Henry Moseley determined the atomic number for each known element
- Modern Periodic Table is organized based on atomic number

- Properties of element within a period change as you go across (left → right).
- The arrangement of the elements has importance consequence which we will explore in the next few lessons.

What are the three broad classes of element?

• Metals

- About 80% of the known elements are metals
- Good conductors of heat and electricity
- High luster or shine
- Solids at room temperature (except Hg)
- Ductile (can be made into wires)
- Malleable (can be hammered into thin sheets)

• Nonmetals

- Most are gases at room temperature
- However, some are solids (sulfur, phosphorus)
- Bromine is a liquid
- Generally poor conductors
- Tend to be brittle when solid (graphite)

| | | | | |
|-----------------|------------------|-------------------|----------------------|----------------------|
| | | | | 2 He 4.00 |
| 6 C 12.01 | 7 N 14.01 | 8 O 16.00 | 9 F 19.00 | 10 Ne 20.18 |
| | 15 P 30.97 | 16 S 32.07 | 17 Cl 35.45 | 18 Ar 39.95 |
| | | 34 Se 78.96 | 35 Br 79.90 | 36 Kr 83.80 |
| | | | 53 I 126.90 | 54 Xe 131.29 |
| | 1 H 1.01 | | 85 At (209.99) | 86 Rn (222.02) |

• Metalliods

- Has properties similar to both metals and nonmetals
- Reactivity depends on the element with which they react
- Intermediate conductors
- Good semiconductors

