The Periodic Table

Prentice Hall *Physical Science* – Chapter 5

History – Search for Order

- Lavoisier (1789) grouped the then-known elements into categories: metals, nonmetals, gases and earths
- Mendeleev (1860's) found a way to organize the elements while playing the card game solitaire
  - Organized elements based on
    - Mass
    - Properties (especially interactions with O_2 and H_2)
  - Key was to break elements into rows
    - Mass increases across a row (left to right)
    - Mass increases down a column
    - Elements with similar properties in same column, similar to a "suit" in a deck of cards

Mendeleev's Prediction

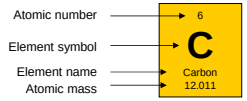
- Not all elements were discovered when Mendeleev put together the first periodic table.
- Mendeleev left spaces where undiscovered elements should have been, and predicted that those elements existed and what their properties would be.
- When those elements were later discovered (example: Ga, similar to Al, MP=29.7ºC, d=5.91 g/cm^3), his predictions were very accurate and proved how useful the periodic table was.

The Periodic Law

- Elements are arranged by increasing atomic number
- Row = ***Period***
  - Recall that atomic number = # of p^+ = # of e^- for a neutral atom
  - As number of electrons increase, more energy levels and orbitals are occupied
  - Number of elements per period varies because number of available orbitals increases from energy level to energy level
- Column = ***Group***
  - Elements within a group have similar:
    - chemical properties
    - electron configurations
  - Electron configurations determine chemical properties
- This pattern of repeating properties is the ***periodic law***
- ***www.webelements.com***

Atomic Mass

- Mass of atom in grams is small – not very useful compared to the large samples we work with
- Scientists chose the carbon-12 atom as a standard, and assigned it 12 atomic mass units (amu)



- 1 amu = 1/12 of the mass of a carbon atom
- Why is the atomic mass of carbon 12.011 instead of 12?
  - Atomic mass depends on the distribution of an element's isotopes
  - ***Weighted averages*** are used to calculate an element's atomic mass:
    - 98.93% is carbon-12, while 1.07% is carbon-13
    - For carbon, the atomic mass is found by the following calculation:

$$\text{Atomic Mass} = \frac{98.93}{100} \times 12\text{amu} + \frac{1.07}{100} \times 13\text{amu} = 12.011\text{amu}$$

Classes of Elements

- Elements are classified 3 different ways on the Periodic Table:
  - State at room temperature (solid, liquid or gas)
  - Naturally occuring or not
  - General properties (metals, nonmetals, metalloids)
- Metals (blue boxes in Figure 7)
  - Majority of elements are metals
  - Good conductors of electricity and heat
  - Solids at room temperature (except for mercury)
  - Many are malleable and ductile
  - Transition metals: groups 3 through 12

Classes of Elements (cont'd)

- Nonmetals (yellow boxes in Figure 7)
  - Poor conductors of electricity and heat
  - Many are gases at room temperature. (those that are solid are typically brittle.)
- Metalloids (green boxes in Figure 7)
  - Properties fall between those of metals and nonmetals
  - Electrical conductivity changes with temperature
- Across a period from left to right, elements properties generally transition from metallic to nonmetallic

Valence Electrons

- ***Valence electron***: an electron in the highest occupied energy level of an atom
- Elements in a group have similar properties because they have the same number of valence electrons.

Alkali Metals

- Group 1A, or 1
- Have 1 valence e^-
- Reactivity increases from *TOP* to *BOTTOM*
- *Includes Li, Na, K, Rb, Cs, Fr*
- Note that H is NOT a metal!

Alkaline Earth Metals

- Group 2A, or 2
- Have 2 valence e^-
- *Include Be, Mg, Ca, Sr, Ba, Ra*
- Magnesium plays important role in photosynthesis, and is found in chlorophyll
- Calcium is important for bones and teeth

The Boron Family

- Group 3A, or 13
- Have 3 valence e^-
- *Includes B, Al, Ga, In, Tl*
- Aluminum is most abundant metal in Earth's crust

The Carbon Family

- Group 4A, or 14
- Have 4 valence e^-
- *Includes C, Si, Ge, Sn, Pb*
- Except for water, most of the compounds in living things contain carbon
- Silicon is 2nd most abundant element in Earth's crust (after Oxygen)

The Nitrogen Family

- Group 5A, or 15
- Have 5 valence e^-
- *Includes N, P, As, Sb, Bi*
- Nitrogen and phosphorus are often contained in fertilizers

The Oxygen Family

- Group 6A, or 16
- Have 6 valence e^-
- *Includes O, S, Se, Te, Po*
- Oxygen is most abundant element in Earth's crust

The Halogens

- Group 7A, or 17
- Have 7 valence e^-
- *Includes F, Cl, Br, I, At*
- Highly reactive nonmetals, with reactivity decreasing from top to bottom
- Fluorine is most reactive nonmetal

Noble Gases

- Group 8A, or 18
- Have 8 valence e^- (except He has 2)
- *Includes He, Ne, Ar, Kr, Xe, Rn*
- Colorless, odorless and extremely *unreactive*