Periodic Table Trends in Element Properties

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The Periodic Table

Quick Historical Review

Mendeleev in 1850 put together the first comprehensive periodic table. It was based on atomic weights. Small errors were evident.

In 1910 Mosley discovered how to determine atomic number using x-rays. It was then realized that the properties of elements are actually periodic functions of their atomic numbers. This is the statement of modern periodic law.

The Schrodinger equation allows us to see that the periodic table is really arranged by electron configuration.

The Structure of the Table (Review)

Periods - horizontal rows, numbered from top to bottom

- Be able to identify the lanthanide and actinide series of elements. Collectively they both belong to the "rare earths".

Groups - vertical columns, numbered in several ways: using A and B designations or by numbers

Names of Groups to know -

- Alkali Metals – IA or column 1
- Alkaline Earth Metals – IIA or column 2
- Transition Metals - IIIB – IIB or columns 3-12
- Chalcogens - VI A or column 16
- Halogens – VIIA or column 17
- Noble Gases – VIIIA or column 18

Another way to divide the table

- Metals - have a tendency to lose electrons in bonding, good electrical and thermal conductivity; elements on the left side of the table
- Nonmetals - have a tendency to gain electrons in bonding, usually have poor electrical and thermal conductivity; elements on the upper right of the table
- Metalloids - have properties between metals and nonmetals, reside along the “stairstep”

General Trends seen from electron configurations

As we go down a family

1. The outermost electrons are farther from the nucleus
2. The inner electrons shield the outermost ones from the nucleus.
3. The atom gets larger
4. The outermost electrons are more likely to be lost.
5. Reactivity as a metal increases.

As we go across a period

1. The outermost electrons are about the same distance from the nucleus
2. There is very little additional shielding.
3. The atom gets smaller
4. The outermost electrons are held more tightly.
5. Reactivity as a nonmetal increases.

Summary of trends

1. Size increases as we go down a family and decreases across a period
2. Ionization energy (define) increases as we go across a period and decreases as we go down a family.
3. Metallic behavior increases diagonally toward francium at the bottom left. Nonmetallic behavior increases diagonally toward fluorine at the top right. Metal ions are smaller than metal atoms. Nonmetal ions are larger than nonmetal atoms.
4. Electron affinity (define) increases as we go across and decreases as we go down
5. Electronegativity (define) increases as we go across and decreases as we go down.

Prediction of Oxidation numbers

The driving force for elements to lose or gain electrons can be calculated from quantum theory in a very complex way. The results can be summarized very simply:

Elements would like to have 8 electrons in their outermost energy level (highest n value). This means that elements try to get a s^2p^6 configuration in their highest n value energy level. This is the *octet rule*.

Many transition metals also lose some of their “d” electrons in addition to the electrons needed to satisfy the octet rule.

Terms

Valence electrons – electrons in the outermost energy level

Core electrons – all nonvalence electrons

Representative elements – also called the main group elements – those in column 1, 2, 13, 14, 15, 16, and 17 where we are filling the “s” and “p” sublevels.

To summarize the prediction of oxidation numbers:

1. Alkali metals +1
2. Alkaline earth metals +2
3. Transition elements - lose the “s” and then some or all of the “d” electrons, difficult to predict
4. Boron family +3 but Tl is +1, +3
5. Carbon family usually +4 but Sn and Pb are +2,+4
6. N family is -3 but all can also exhibit +3, +5 in nonmetal compounds
7. O family is -2 to Po; these elements can also exhibit +4 and +6 in nonmetal compounds
8. Halogens are -1, but in compounds with nonmetals can exhibit +5 and + 7

9. Lanthanide and Actinide series - most common is +3 but others are possible

Electron configurations of ions

The loss of the outermost "s" and "p" electrons by many metals or the gain of "p" electrons by nonmetals to get a full octet means that they will have the same electron configuration as atoms of a noble gas.

The term isoelectronic is used to refer to atoms or ions that have the same electron configuration. Na^{+}, Mg^{+2}, Al^{+3}, O^{-2}, and F^{-1}, are all isoelectronic with Ne.