Ch 5

The Periodic Law

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.

Development of the Periodic Table

- In the 1700s, Lavoisier compiled a list of all the known elements of the time.
  - There were _____ elements organized into _____ categories

Lavoisier's Table of Simple Substances (most of them)	
	Light, heat, inflammable air
	Au, Co, Cu, Sn, Fe, Mg, Hg, Au, Pb, Zn, W, Ni, At
	S, P, Charcoal
	Chalk, Magnesia, Clay, Siliceous earth

Development of the Periodic Table

- The 1800s brought large amounts of information and scientists needed a way to organize knowledge about elements.
- One of the largest was the agreement on _____
  - This allowed one scientists results to be reproduced

Mendeleev and Chemical Periodicity

- _____took all the known elements and placed their info on cards
  - He moved these cards around and looked for _____
  - He noticed that when the elements were arranged by increasing _____, their properties repeated every _____
    - It repeated _____
- This is eventually where the "Periodic" Table name comes from

Mendeleev and Chemical Periodicity

- _____ arranged the elements by increasing _____ but also arranged them into _____
  - Each element in the column has _____
  - Mendeleev actually predicted where missing elements would be placed!!
- This was called the periodic table of elements!

The missing elements…

Predicted elements	Element and year discovered	Properties	Predicted properties	Observed properties
Ekaaluminum	gallium 1875	density of metal	6.0 g/mL	5.96 g/mL
		melting point	low	30°C
		oxide formula	Ea_2O_3	Ga_2O_3
Ekaboron	scandium 1877	density of metal	3.5 g/mL	3.86 g/mL
		oxide formula	Eb_2O_3	Sc_2O_3
		solubility of oxide	dissolves in acid	dissolves in acid
Ekasilicon	germanium 1886	melting point	high	900°C
		density of metal	5.5 g/mL	5.47 g/mL
		color of metal	dark gray	grayish white
		oxide formula	EsO_2	GeO_2
		density of oxide	4.7 g/mL	4.70 g/mL
		chloride formula	$EsCl_4$	$GeCl_4$

Mendeleev and Chemical Periodicity

- The fact that Mendeleev predicted there were missing elements and the properties they would have persuaded scientists to accept his table.
- But… there were still 2 questions
  1. _____
     _____
  2. _____
     _____

Mendeleev and Chemical Periodicity

- Mendeleev's table was not completely correct. ☹
- After several new elements were discovered and the _____ were determined more accurately, several elements did _____

Moseley and the Periodic Table

- _____ rearranged the table by increasing _____(not _____ _____), and resulted in a clear periodic pattern.
- Periodic repetition of chemical and physical properties of the elements when they are arranged by increasing atomic number is called _____.
- Moseley's work led to the definition of _____ and the use of it to _____

The Modern PT

- **The Periodic Table** is an arrangement of the elements in order of their _____ so that elements with similar _____ fall in the same _____.
  - Where are the following?
    - Groups, Periods, Families
    - Metals, NM, Metalloids

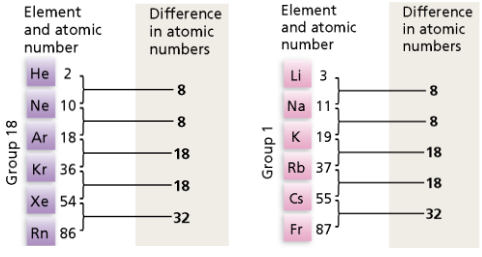
Noble Gases

- Sir William Ramsey discovered the first _____ in 1868, Ar.
  - The noble gases were difficult to find because _____
  - Eventually all of the gases were discovered
- This discovery is important because he proposed a new group to the PT and placed it between _____

Lanthanides and Actinides

- The transition elements are divided into _____ and _____.
- The two sets of inner transition metals are called the _____(____ - ____) and _____ (_____ - _____) and are located at the bottom of the periodic table.

Periodicity of Atomic #'s



Electron Config and the PT

Section 5.2

Objectives

- **Explain** the relationship between electrons in sublevels and the length of each period of the periodic table.
- **Locate** and name the four blocks of the periodic table. Explain the reasons for these names.
- **Discuss** the relationship between group 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, and the noble gases.

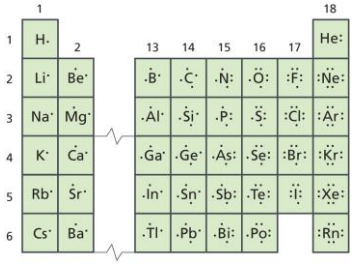
Periods are determined by e^- config.

- The length of each period (# of elements) is determined by the _____ _____
- The periodic table is divided into four blocks, the __, __, __, and __ blocks. The name of each block is determined by the electron sublevel being filled in that block.

Quick Activity

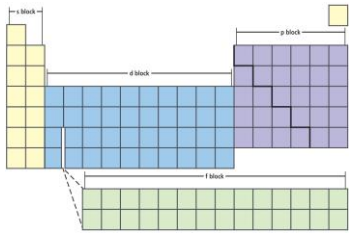
- Write the e^- config for Mg, Ca, F, and Cl
  - Compare them
  - What do you notice?
  - What would you expect Sr's or I's e^- config to look like?

Organizing Elements by Electron Configuration



The s-, p-, d-, and f-Block Elements

- The shape of the periodic table becomes clear if it is divided into blocks representing the atom's energy sublevel being filled with valence electrons.



The s-, p-, d-, and f-Block Elements

- s-block elements consist of group __ and __, and the element _____.
- Group __ elements have a partially filled s orbital with ____electron.
- Group __ elements have a completely filled s orbital with ____ electrons.

The s-, p-, d-, and f-Block Elements

- After the s-orbital is filled, valence electrons occupy the _____.
- Groups 13-18 contain elements with completely or partially filled _____.

The s-, p-, d-, and f-Block Elements

- The d-block contains the _____ metals and is the _____ block.
- There are exceptions, but d-block elements usually have filled outermost s orbital, and filled or partially filled d orbital.
- The five d orbitals can hold ____ electrons, so the d-block spans _____groups on the periodic table.

The s-, p-, d-, and f-Block Elements

- The _____ contains the inner transition metals.
- f-block elements have filled or partially filled outermost s orbitals and filled or partially filled 4f and 5f orbitals.
- The 7 f orbitals hold ____ electrons, and the inner transition metals span _____ groups.

Examples

- e^- config can determine period
  - Boron: $1s^2\ 2s^2\ 2p^1$
    - The highest occupied NRG level is 2p
      - So, Boron is in the p block
  - You try…
    - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$
      - Which block is the element located?
      - What is the identity of the element?
    - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^7$
      - Which block is the element located?
      - What is the identity of the element?

Quick Activity

- Get a partner
  - 1 student chose an element for the PT
  - The other student identifies the highest occupied NRG level
- You have 1 minute…GO

Sample Problems

a. Without looking at the periodic table, identify the group, period, and block in which the element that has the electron configuration [Xe]$6s^2$ is located.

b. Without looking at the periodic table, write the electron configuration for the Group 1 element in the third period.

S-block Elements: Groups 1 & 2

- These elements are chemically reactive, some extremely reactive!
- _____ are all the elements in group 1 except _____, and are very reactive.
  1. _____
  2. _____
  3. _____
  4. _____

H and He

- H is located in G1 but _____ properties with G1
  - In fact, it does not share props with any groups
- He in in G18 but has 2 valence e^-, like G2
  - It is in G18 because it has a _____ and is _____

S-block Elements: Groups 1 & 2

- _____are in group 2, and are also _____.
  1. _____
  2. _____
  3. _____
  4. _____

d-block Elements: Groups 3-12

- Max of ___ orbitals and _____ e^-
- Consist of transition metals
- _____– metals in groups 3-12
  1. _____
  2. _____

p-block elements: Groups 13-18

- _____ – are elements in Groups 1,2,13-18
  - The total # of e^- in the highest occupied NRG level is (Group # - 10)
    - i.e. C has 4 (14-10)
  - The properties of the elements _____
    - Metals, Metalloids, Nonmetals, Noble Gases

p-block elements: Groups 13-18

- _____– elements in group 17
  - – React vigorously with _____
    - NaCl
  - – This is because they are _____
  - – _____ found freely in nature
    - Except Bi

f-block: Lanthanide and Actinides

- Not much else to say

Electron Config and Periodic Props

Section 5.3

Objectives

- **Define** *atomic* and *ionic radii, ionization energy, electron affinity,* and *electronegativity.*
- **Compare** the periodic trends of atomic radii, ionization energy, and electronegativity, and state the reasons for these variations.
- **Define** *valence electrons,* and state how many are present in atoms of each main-group element.
- **Compare** the atomic radii, ionization energies, and electronegativities of the *d*-block elements with those of the main-group elements.

PT Trends

- Many properties of the elements tend to change in a predictable way
- As you move across periods or up/down groups you will notice trends

Atomic Radius

- _____ is a periodic trend influenced by electron configuration.
- For metals, atomic radius is _____ between adjacent nuclei in a crystal of the element.
- _____ may be defined as one-half the distance between the nuclei of identical atoms that are bonded together.

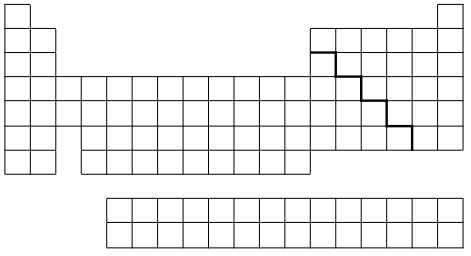
Atomic Radius

- There is a general _____ in atomic radius from left to right
  - Caused by _____ positive charge in the nucleus.
- The outside _____ are attracted the _____ nucleus
- More protons =

Atomic Radius

- Atomic radius generally _____ as you move down a group.
- The outermost orbital size _____ down a group, making the atom _____.
- More NRG levels =

Atomic Radius



Practice

- Which has the largest atomic radii? Smallest?
  - Li, O, C, F
- Why?

Practice

- Which has the larges atomic radii? Smallest?
  - Sr, Be, Ca, Ba
- Why?

Valence Electrons

- _____– an electron in the outer NRG level of an atom.
- These electrons are available to be _____, _____, or _____
- Discuss
  - Group # and v e^-
  - Ion formation in groups

e^- dot notation

- Each element has valence electrons, the e^- in the _____ NRG level
  - Examples on board
- The energy level of an element's valence electrons indicates the _____ on the periodic table in which it is found.
- The number of valence electrons for elements in groups 13-18 is _____ than their group number.

Ionization NRG

- _____– an atom or group of atoms bonded that have a positive or negative charge
- _____– any process that results in the formation of an ion

Ionization NRG

General Equation for Ion Production

Element + NRG → Ion^{+1} + e^-

This is the Production of an electron. It does not mean the addition of an electron.

- Ion Example (Na^+, O^{-2})
  - How many electrons did Sodium lose? Oxygen?

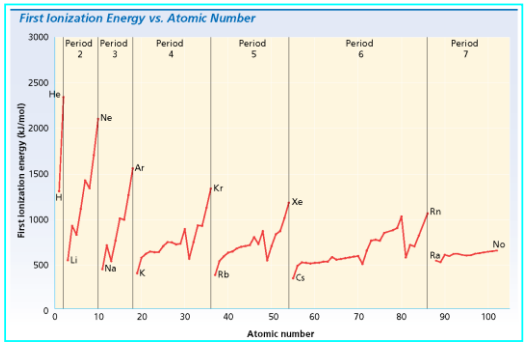
Ionization NRG

- _____– The NRG required to remove 1 e^- from an atom
  - This may happen _____than once for an atom
    - First Ionization NRG, Second Ionization NRG…
- Removing the second electron requires _____ energy, and is called the second ionization energy (IE_2).
- Each successive ionization requires _____energy, but it is not a steady _____.

Ionization NRG

- In general, ionization energies of the main-group elements _____ across each period.
  1. _____
  2. _____
- Among the main-group elements, ionization energies generally _____down the groups.
  1. _____
  2. _____

Ionization NRG



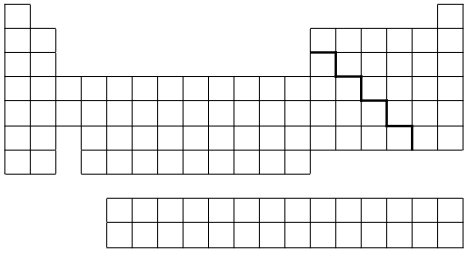
Ionization NRG

Table 6.5 Successive Ionization Energies for the Period 2 Elements

Element	Valence Electrons	Ionization Energy (kJ/mol)*								
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Li	1	520	7300							
Be	2	900	1760	14,850						
B	3	800	2430	3660	25,020					
C	4	1090	2350	4620	6220	37,830				
N	5	1400	2860	4580	7480	9440	53,270			
O	6	1310	3390	5300	7470	10,980	13,330	71,330		
F	7	1680	3370	6050	8410	11,020	15,160	17,870	92,040	
Ne	8	2080	3950	6120	9370	12,180	15,240	20,000	23,070	115,380

* mol is an abbreviation for mole, a quantity of matter.

Ionization NRG



Practice

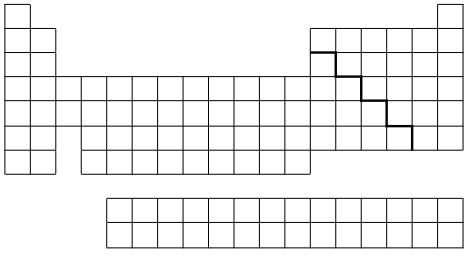
Electron Affinity

- What do you have an affinity for?
  - Sports ?, Cars ?, Family?, Job ? Make up ?
  - So, what does affinity mean?
- _____ – the NRG change that occurs when an e^- is acquired by a neutral atom
  - The larger the _____ number the _____ affinity there is for an electron
  - A "____" are too difficult to establish

Electron Affinity

- Electron affinity generally _____ across periods.
  1. _____
- Electron affinity generally _____ down groups.
  1. _____

Electron Affinity



Ionic Radius

- _____– a positive ion
  - Ex.?
- _____ formation results in a _____ in atomic radius
- _____– a negative ion
  - Ex.?
- _____ formation results in a _____ in atomic radius

Ionic Radius

- When atoms lose electrons and form positively charged ions, they always become smaller for two reasons:
  1. _____
     _____
  2. _____
     _____

Ionic Radius

1. The loss of a valence electron can leave an empty outer orbital resulting in a small radius.

   - _____ electrons are attracted to the same positive charge

   - Now there is more _____ charge than _____ charge

   - smaller radius

Ionic Radius

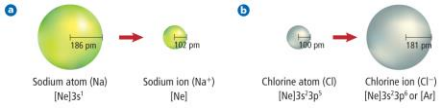
2. Electrostatic repulsion decreases allowing the electrons to be pulled closer to the radius.

   - _____ electrons means less _____ repulsion

   - smaller radius

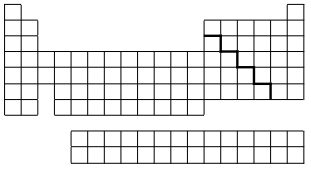
Ionic Radius

- When atoms gain electrons, they can become _____ , because the addition of an electron _____ electrostatic repulsion.



Ionic Radius

- The ionic radii of positive ions generally _____ from left to right.
- The ionic radii of negative ions generally _____ from left to right, beginning with group 15 or 16.



Ionic Radius

- Both positive and negative ions _____ in size moving _____ a group.

Li	Be
Na	Mg
K	Ca
Rb	Sr
Cs	Ba

B	C	N	O	F
Al	Si	P	S	Cl
Ga	Ge	As	Se	Br
In	Sn	Sb	Te	I
Tl	Pb	Bi		

Draw in the relative sizes

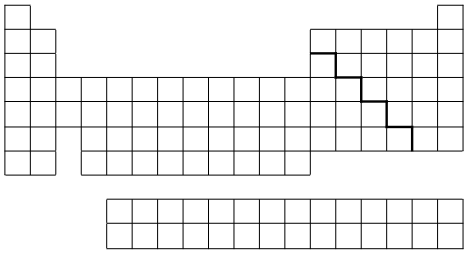
Electronegativity

- The _____ states that atoms tend to gain, lose or share _____ in order to acquire a _____ set of _____ valence electrons.
- The _____ rule is useful for predicting what types of ions an element is likely to form.

Electronegativity

- The _____ of an element indicates its relative ability to _____ electrons in a chemical bond.
- _____ _____ down a group and _____ left to right across a period.
- Electronegativity – ability to attract an electron
- Higher electronegativity =

Electronegativity



Electronegativity vs others learned

- Electronegativity is a relationship between atoms in cmpds
- Electron Affinity and Ionization are properties of isolated atoms

Electronegativity decreases down a group

A. True
B. False

The Higher electronegativity the …

A. Higher the attraction of electrons
B. Higher the repulsion of electrons
C. Both
D. Neither

Ionization NRG increases across the PT.

A. True
B. False

The higher the ionization NRG the…

A. Harder it is to remove a proton
B. Easier it is to remove a proton
C. Harder it is to remove an electron
D. Easier it is to remove an electron
E. More than 1 of the above
F. None of the above