Ch. 8 NOTES ~ PERIODIC PROPERTIES OF THE ELEMENTS

NOTE: Vocabulary terms are in **boldfaced.** Supporting details are in *italics.*

8.1 Notes: Patterns of Behavior

I. Periodic Trends in Atomic Size

A. **atomic radius**—half the distance between two nuclei in a diatomic molecule

1) *diatomic = consisting of two identical atoms*

2) **seven diatomic molecules ("Super Seven"): H_2, N_2, O_2, F_2, $C1_2$, Br_2, I_2**

B. *group trends*

1) *atomic size increases from top to bottom*

2) reason: *adding n #s = adding electrons = adding shells*

C. *periodic trends*

1) *atomic size decreases from left to right*

2) reason: *adding electrons to the same shell pulls the electron clouds in more, as more protons are added to attract more electrons)*

3) "shielding effect" of inner electrons

II. Periodic Trends in *Ionic Size*

A. cations (positive ions)

1) *cations are smaller than their neutral atoms*

2) reason: *electrons have been removed)*

B. anions (negative ions)

1) *anions are larger than their neutral atoms*

2) *electrons have been added*

C. *group trends*

1) *ionic radius increases from top to bottom*

2) reason: reason: *adding n #s = adding electrons = adding shells*

D. *periodic trends*

1) *ionic radius decreases from left to right*

2) reason: *adding electrons to the same shell pulls the electron clouds in more, as more protons are added to attract more electrons*

3) *"shielding effect"* of inner electrons

III. Periodic Trends in Ionization Energy

A. **ionization energy**—the *energy needed to remove an electron* from an atom, in kJ/mol

B. *first ionization energy*—the energy needed to remove the first electron

C. *group trends*

1) *(first) ionization energy decreases from top to bottom*

2) *reason: outermost electron is farther and farther from the nucleus in larger atoms, so it is more easily removed*

D. *periodic trends*

1) *(first) ionization energy increases from left to right*

2) reason: *"nuclear charge" increases; more attraction between electrons and protons*

IV. Periodic Trends in Electronegativity

A. **electronegativity**—the *"greediness" of an atom for electrons* when chemically reacting
B. noble gases do not have electronegativity values
C. electronegativity trends not completely regular
   1) *fluorine = most electronegative element* with a value of 4.0 (smallest anion formed)
   2) cesium = least electronegative element (largest cation formed)
D. *group trends: electronegativity decreases from top to bottom*
E. *periodic trends: electronegativity increases from left to right*
F. chemical bond character is determined by electronegativity differences between the bonding partners

V. Periodic Trends in Electron Affinity

A. *electron affinity (EA)—energy required to add an electron to a gaseous atom*
B. EA hard to determine; trends less clear
C. …but usually increases from left to right and decreases from top to bottom

VI. Periodicity and General Characteristics of the Representative Elements

A. partially filled "shells"
B. patterns

GROUP NUMBER	# VALENCE ELECTRONS	# ELECTRON DOTS	STATUS
Group IA	**1**	**1**	**(has 1 out of 8, missing 7 to be full)**
Group IIA	**2**	**2**	**(has 2 out of 8, missing 6 to be full)**
Group IIIA	**3**	**3**	**(has 3 out of 8, missing 5 to be full)**
Group IVA	**4**	**4**	**(has 4 out of 8, exactly half-full)**
Group VA	**5**	**5**	**(has 5 out of 8, needs 3 more to be full)**
Group VIA	**6**	**6**	**(has 6 out of 8, needs 2 more to be full)**
Group VIIA	**7**	**7**	**(has 7 out of 8, needs 1 more to be full)**
Group VIIIA	**8**	**8**	**(has 8 out of 8, completely full)**

1) **alkali metals—Group IA; Group 1**
   Group IA has 1 valence electron (1/8, missing seven to be full)
   a) **Li, Na, K, Rb, Cs, Fr**
   b) *good conductors*
   c) *soft, silver-white*
   d) *not found in elemental form naturally*
   e) *react violently with water to form bases (alkali)*
   f) *uses of sodium: Na in NaCl;*, NaOH used in paper-making and soap-making; *NaOH in "lye" in oven and drain cleaners; Na^+ ion is important to our bodies*
   g) *uses of potassium: K in KOH (hydroxide cleaners); in fertilizer; K^+ ion is important to our bodies*

2) **alkaline earth metals—Group IIA; Group 2**
   Group IIA has 2 valence electrons (2/8, missing six to be full)
   a) **Be, Mg, Ca, Sr, Ba, Ra**
   b) *obtained from mining mineral ores*
   c) *not found in elemental form naturally*

d) *some react with water, but less violently than the alkali metals*
e) uses of magnesium and beryllium: alloys
f) uses of beryllium: nuclear weapons
g) *uses of calcium ion and magnesium ion: important to our bodies*
h) uses of strontium: pyrotechnics

3) **Group IIIA; Group 13 (aluminum group)**

Group IIIA has 3 valence electrons (3/8, missing five to be full)

a) **B, Al, Ga, In, Tl**
b) Al is the most useful member of the group; does not react with water
c) *uses of aluminum: alloys— Al_2O_3 as a gritty powder; water purification; fabric dyeing; aluminum cans, siding, and foil; paper manufacture; in deodorants; $Al(OH)_3$ in antacids*
d) uses of boron: in $Na_2B_4O_7 * 10H_2O$ borax (water softener and cleaner) and H_3BO_3 boric acid (contact lens cleaner and roach insecticide)
e) uses of gallium: GaAs (gallium arsenide) used in some semiconductors

4) **Group IVA; Group 14 (carbon group)**

Group IVA has 4 valence electrons (4/8, exactly half-full)

a) **C, Si, Ge, Sn, Pb**
b) *uses of carbon: graphite, diamond, organic compounds*
c) *uses of silicon: (in many minerals); SiO_2 in sand; semiconductors; microchips; glass photocells*
d) uses of germanium: photocells
e) uses of tin and lead: alloys (solder Pb + Sn; bronze = Cu + Sn); leaded gasoline
f) uses of tin: foil, metal can coating

5) **Group VA; Group 15 (nitrogen group)**

Group VA has 5 valence electrons (5/8, needs three more to be full)

a) ***N, P, As, Sb, Bi***
b) *uses of nitrogen: needed by plants; nucleic acids (DNA and RNA); liquid N_2 for low temps; TNT; ammonia (NH_3)*
c) *uses of phosphorus: phosphate $(PO_4)^{3-}$;ATP; nucleic acids; fertilizer*; red P used in matches
d) uses of arsenic: GaAs (gallium arsenide) used in some semiconductors
e) uses of antimony: alloys with Pb and other metals

6) **chalcogens—Group VIA; Group 16 (oxygen group)**

Group VIA has 6 valence electrons (6/8, needs two more to be full)

a) **O, S, Se, Te, Po**
b) *uses of oxygen: atmospheric gas O_2; in water (H_2O); product of photosynthesis; ozone O_3; hydrogen peroxide (H_2O_2); in bleach – sodium hypochlorite (NaClO); in sulfuric acid (H_2SO_4)*
c) *sulfur: S_8, SO_2, SO_3; H_2SO_3, H_2SO_4…*
d) uses of selenium: photoelectric cells; photocopying

7) **halogens—Group VIIA; Group 17**

Group VIIA has 7 valence electrons (7/8, needs one more to be full)

a) **F, Cl, Br, I, At**
b) *F is the most reactive*

c) *found as* **diatomic molecules**, *not elemental:* F_2, Cl_2, Br_2, I_2
d) *commonly found as ions in a salt*
e) *hydrogen has characteristics of Group IA and VIIA; often listed in both places*
f) *uses of fluorine: NaF or* SnF_2 *"fluoride"*
g) *uses of chlorine—*$CaC1_2$ *(Damp Rid),* $NaCl$, Cl^- *(chloride) ion in the body; water purification*
h) *uses of iodine:* I^- *(iodide) ion in the body; ion put into table salt;* antibacterial cleaner
i) uses of bromine: silver bromide (AgBr) film coating

8) **Noble Gases—Group VIIIA / 0; Group 18**
Group VIIIA has 8 valence electrons, completely full)
a) **He, Ne, Ar, Kr, Xe, Rn**
b) *inert; inactive; valence is full*
c) they do not form compounds unless chemically "forced" (example: XeO_3)
d) uses: Ne/Kr/Xe signs, He balloons, welding atmosphere Ar and He, Ar in light bulbs

8.2 Notes: Transition Elements

VII. Properties of the Transition Elements
A. **transition elements** – "B" groups; 3-12
1) general characteristics
a) metals
b) form multiple charges for ions
c) the majority occurs naturally
d) all solids at room temperature—except for mercury (Hg) which is a liquid (uses of mercury: thermometers and barometers)

2) **Iron Triad**
a) **Fe, Co, Ni: iron, cobalt, nickel**
b) magnetic
c) *uses of iron: main component of steel (building material);* Fe^{2+} *ion in hemoglobin and myoglobin*
d) uses of cobalt: alloyed with iron and nickel, used in jet turbines; steels; electroplating; Co salts used for blue paint color pigments
e) uses of nickel: stainless steel

3) **Platinum "Group"**
a) **Ru, Rh, Pd, Os, Ir, Pt**
b) ruthenium, rhodium, palladium, osmium, iridium, platinum
c) uses of platinum: jewelry; wire; electric contacts; dentistry; missile cones; jet fuel nozzles

4) **Coinage Metals**
a) **Cu, Ag, Au**
b) copper, silver, gold

5) **Chromium (Cr)**
    a) alloyed with Fe in steel
    b) jet engine alloys
    c) plating as corrosion retardant
    d) used as a catalyst
    e) green coloring in glass

6) **Zinc (Zn)**
    a) uses of Zn: brass (Zn alloyed with copper); dry batteries; light coinage (US and Canadian pennies)
    b) uses of ZnO— zinc oxide: paint and rubber manufacturing; cosmetics; plastics; flooring materials; drying body powder; soap
    c) uses of ZnS—zinc sulfide: X-ray and TV screens, fluorescent lighting

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VIII. **<u>Inner Transition Elements: Lanthanide and Actinide series</u>**

A. also called **inner transition metals** or **Rare Earth metals**

B. two "footnotes" at the bottom of the periodic table

C. **Cerium (Ce)**
    1) uses for Ce: alloy "misch metal" for lighter flint; alloy with Mg for jet engines
    2) uses for Ce compounds: polishing glass; decolorizing glass; self-cleaning ovens

D. **Neodymium (Nd)** used to decolorize or add color to glass

E. **Nd and Praseodymium (Pr)** used to make welding mask glass

F. *Radioactive elements*
    a) **Uranium (U-235)**, used in nuclear fission
    b) **Plutonium (Pu-239)**, used in nuclear reactor fuel

G. **Americium (Am-241)** used in smoke detectors

H. **Californium (Cf-252)** *used in cancer radiation therapy*

SUMMARY OF TRENDS
(remember, trends are generalizations)

INC = increases DEC = decreases

	TOP to BOTTOM	LEFT to RIGHT
ATOMIC SIZE	**INC**	**DEC**
IONIZATION ENERGY	**DEC**	**INC**
ELECTRO-NEGATIVITY	**DEC**	**INC**
ELECTRON AFFINITY	**DEC**	**INC**

IONIC SIZE **cation (+) < neutral atom**
anion (-) > neutral atom