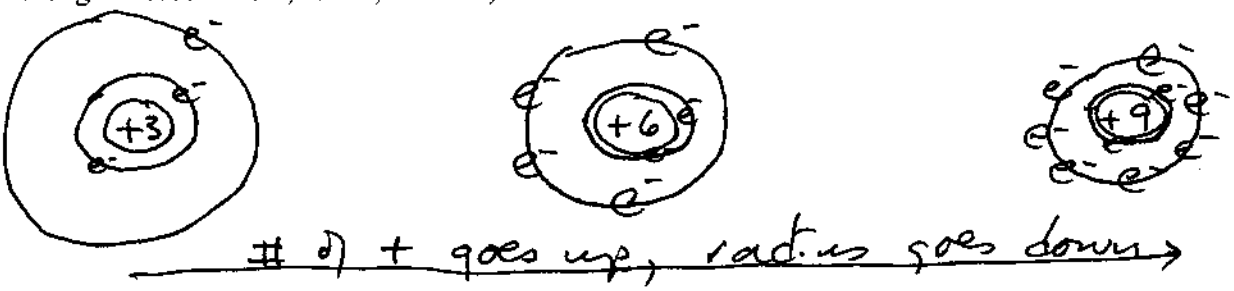
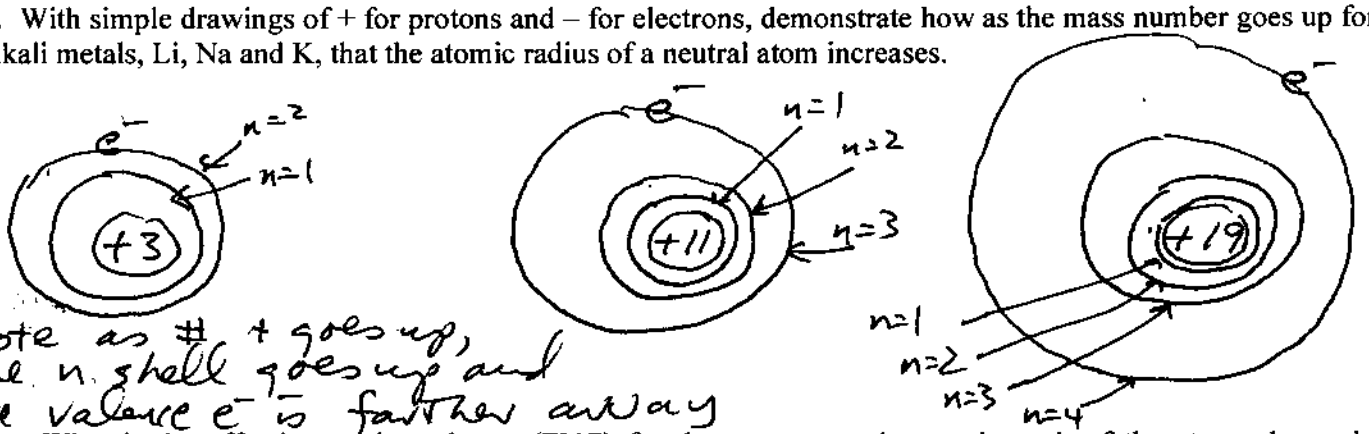
CH301 Fall 2006 Worksheet 3: Periodic Table Trends

1. With simple drawings of + for protons and – for electrons, demonstrate how as the mass number goes up along the second row, for Li, C and F, that the atomic radius of a neutral atom decreases.



of + goes up, radius goes down →

2. With simple drawings of + for protons and – for electrons, demonstrate how as the mass number goes up for alkali metals, Li, Na and K, that the atomic radius of a neutral atom increases.



note as # + goes up, the n shell goes up and the valence e⁻ is farther away

3. What is the effective nuclear charge (ENC) for the outermost electron in each of the atoms drawn in questions 1 and 2.

Li 3 - 2 = 1 C 6 - 2 = 4 F 9 - 2 = 7

Na 11 - 10 = 1

K 19 - 18 = 1

4. What is the ENC for each of the 11 electrons in the ion Al^{+2}.

In n = 1 shell 13 - 0 = 13 for 1s electrons

In n = 2 shell 13 - 2 = 11 for 2s + 2p electrons

In n = 3 shell 13 - 10 = 3 for 3s electrons

5. For the following series of atoms: Cs, K, Mg, Al, P, S, Cl, rank the following properties for smallest or most negative number to largest or most positive number. Assume that only ENC determines the ranking.

atomic radius: Cs > K > Mg > Al > P > S > Cl

ionization energy: Cs < K < Mg < Al < P < S < Cl

electronegativity: Cs < K < Mg < Al < P < S < Cl

electron affinity: Cs < K < Mg < Al < P < S < Cl

metallic character: Cs > K > Mg > Al > P > S > Cl

6. For the series of atoms in question 5, which of the five property rankings would change if secondary effects from filled and half filled shell stability were considered? What are the new rankings for those properties?

For EA, the $p_2 e^- > p_3 e^-$ so Si > P but < S

For IE, the $p_4 e^- < p_3 e^-$ so Si < S < P

note analogy to the reordering of CNO from n=2 row

7. Consider the following groups (columns) on the periodic table:

s1, s2, d1, d2, d3, d4, d5, d6, d7, d8, d9, d10, p1, p2, p3, p4 , p5, p6

and identify islands of stability for which filled and half filled shell stability perturb either Aufbau or ENC and influence electronic configuration or trend. For each of these more stable groups, give a specific example of how that increased stability Example. d5 stability: the electronic configuration of s2d4 becomes s1d5 for Cr.

stable filled subshells: p^6, d^{10}, s^2 stable ½ filled: p^3, d^5, s^1

p^6: noble gases d^{10}: main group metal ions form $d^{10} + s_2 d_{10}$

p^3: EA + IE reordered (see # 6 above)

8. What are the electronic configurations of the following atoms or ions?

a) Ru^{+2} $[Kr]5s^1 4p^5$

b) Ag $[Kr]5s^1 4p^{10}$

c) Si $[Ne]3s^2 3p^2$ (no exception)

d) In^+ $[Kr]5s^2 4d^{10}$

e) In^{+2} $[Kr]5s^1 4d^{10}$

f) In^{+3} $[Kr]4d^{10}$

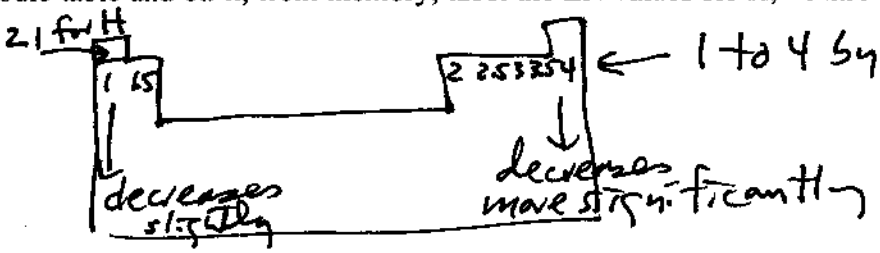
9. Create an isoelectronic series by turning the following atoms into ions and rank them in terms of increasing ionic radius. Sc, K, Ca, Ar, P, S.

	Sc^{+3}	K^+	Ca^{++}	Ar	P^{-3}	$S^=$
#e⁻	18	18	18	18	18	18
#P	21	19	20	18	15	16

so from ENC, ionic radius is $P^{-3} > S^= > Ar > K^+ > Ca^{+4} > Sc^{+3}$

10. Electronegativity (EN)is the most useful trend that you will learn in chemistry—it can be used to explain just about everything with respect to where electrons end up in inter and intramolecular bonding and the properties that result. Consequently it is a good thing to have a rule of thumb quantitative measure of EN values.

a. Construct a crude periodic table and on it, from memory, label the EN values for H, Li through F, the alkali metals and the halogens.



b. From memory, using the EN table you constructed, what are ΔEN for HF, BN, NaCl, CO

ΔEN HF = 4 − 2.1 = 1.9

ΔEN BN = 3 − 2 = 1.0

ΔEN NaCl ≈ 3 − .9 = 2.1

ΔEN CO = 3.5 − 2.5 = 1.0