Topics Lists: ChemActivity 3-6 (only through 5) & Periodic Table Basics

****DO NOT ONLY RELY ON THIS STUDY GUIDE****

I. ChemActivity 3: Coulombic PE (potential Energy)

- Model 1: Two Charged Particles Separated by a Distance "d"
  - Notes:
    - The potential energy (V) of two stationary charged particles is given by the equation listed below, where q1 and q2 are the charge on the particles and d is the separation of the particles (in pm) and k is a positive-valued proportionality constant.
      1) $V = \frac{kq_1q_2}{d}$
      2) 1pm= 10^-12 m
  - CTQ's
    - 1. Assuming that q1 and q2 remain constant, what happens to the magnitude of V if the separation, d, is increased? Smaller, decreases
    - 2. If the two particles are separated by an infinite distance (that is d= infinity), what is the value of v? Approaches/is zero
    - 3. If d is finite, and the particles have the same charge (that is q1=q2), is V>0 or is V<0? Explain your answer. V>0, because the number must be positive.
    - 4. If q or an electron is -1…
      (a) What is q for a proton? 1+
      (b) What is q for a neutron? 0
      (c) What is q for the nucleus of a C atom? 6+
    - 5. Recall that a H atom consists of a proton as the nucleus and an electron outside of the nucleus. Is the PE, V, of a H atom a positive or negative number? Explain. Negative because a positive times a negative must be negative.
      - ✷ The PE of the interaction between a proton and electron will always be negative.
- Model 2: IE (ionization energy)
  - Notes:
    - The IE is the amount of energy needed to remove an electron from an atoms and move it infinitely far way.
    - IE is usually measure in Joules
  - CTQ's (see table 1 pg 18, in packet for the table references)
    - 6. Do you expect the PE of the hypothetical atoms in Table 1 to be positive or negative numbers? Explain. Negative, because the opposite charges cause negative numbers.
    - 7. Without using a calculator, predict what trend (if any) you expect for the values of V for these hypothetical atoms. From A to Z the V will increase in magnitude or get more negative.
    - 8. Calculate the Potential energies of the hypothetical atoms to complete table 1. Use the value k= 2.31*10^-16 J*pm.
      1) Just use the PE equation

- 9. What is the relationship between IE and V for these hypothetical atoms? They are directly proportional, but opposite in sign.
- 10. Which of the following systems will have the large IE? Explain.
  (a) An electron at a distance of 500pm from a nucleus with a charge +2
  (b) An electron at a distance of 700pm from a nucleus with a charge +2

  (a) would be the correct answer because it is close to the nucleus, therefore harder to remove.

- 11. Which of the following system will have the larger IE? Explain.
  (a) An electron at a distance d1 from a nucleus with a charge +2
  (b) An electron at a distance d1 from a nucleus with a charge +1

  (a) because it has a stronger attractive force

- 12. How many times is the larger of the two IEs from CQT 11? Show your work
  $\frac{kq_1q_2}{d}$ $vs.$ $\frac{k2q_1q_2}{d}$ so the second is two times larger.
- 13. Consider a H atom and a He ion, He+. Which of these do you expect to have the larger IE? Explain. He+ because it has more protons for the same number of electrons, it has a higher charge for the same distance.

II. ChemActivity 4: The Shell Model (I) (ok so I got lazy and am just typing up notes you would need for the objectives list… sorry!)
- Objective 1: Explain how experimental ionization energies prove the existence of electron shells
  - The numbers for the ionization energies drop once you start a new row on the periodic table. Based on the first couple values you would expect the values to continue to increase but actually they go down then back up. Which tells us that the distance increases, therefore proving the existence of electron shells.
- Objective 2: be able to use the CPE equation to rationalize/explain changes in IE data
  - The distance, when you add the second electron shell increase, therefore the IE would go down. However as you get a larger charge with the same distance (the 2nd shell) you see an increase in the IE. This is based on the direct relationship between charge and IE and the indirect relationship between distance and IE.
- Objective 3: Definition
  - Cation: a positively charges species
  - Ionization Energy: the minimum energy required to remove an electron from a gaseous atom of that element.
  - First Ionization Energy: The energy required to remove the outmost/ electron from the atom. Corresponds to the smallest amount of energy that a bombarding electron needs to be able to knock off one of the atom’s electrons.
  - Shell: ummm I don’t really know how to explain it in simplistic terms so its um a shell.

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III. ChemActivity 5: The Shell Model (II)

- Effect of core electrons on valence electrons interaction with the nucleus
  - Valence Electrons: the electrons in the outermost shell of an atom.
  - Core Electrons: Electrons in shells closer to the nucleus.
  - Direct Quote from Packet: "Of particular interest is the repulsion of the valence electron by the two inner-shell electrons [for Li atom]. This dramatically decreases the overall force of attraction pulling the valence electron toward the nucleus. (AKA electron shielding)
  - The outer-shell valence electrons experience the charge of the core rather than the full charge of the nucleus.
- Core Charge Calculations
  - Number of protons – number of core electrons = core charge
  - The nucleus plus the inner shells of electrons constitute the core of the atom and the net overall charge on the core is called the core charge.
- Difference between core charge and effective nuclear charge ($\mathrm{Z_{eff}}$)
  - Core charge is a simplified version of $\mathrm{Z_{eff}}$ and doesn't take into account inner-shell electron repulsion and the movement of electrons.
  - The overall resulting charge action on a valence shell electron is known as the effective nuclear charge, and it is generally less than the core charge.
- Relationship of an atom's position on the periodic table with core charge, number of valence electrons, and valence shell.
  - Core Charge
    - Elements in the same group have the same core charge.
    - Core charge increases as you go across a period.
  - Number of Valence Electrons
    - Elements in the same group have the same number of valence electrons.
    - The number of valence electrons increases as you go across a period.
  - Valence Shell
    - Elements in the same period have the same size valence shell.
    - The size of the valence shell (i.e. the distance the valence shell is from the nucleus) increases as you go down a group.

IV. Periodic Table Basics

- Definitions
  - Nucleus: The central part of the atom containing neutrons and protons.
  - Proton: A positively charged particle in the atom which doesn't change and therefore can be used to ID an element.
  - Neutron: A neutral particle in the atom which changes and therefore cannot be used to ID an element.
  - Electron: A negatively charged particle in the atom which changes and therefore cannot be used to ID an element.

- Atomic Mass: The mass of the nucleus.
- Atomic Number: Equal to the number of protons an element has.
- Ion: A charged atom.
- Anion: A negatively charged atom which has gained electrons.
- Cation: A positively charged atom which has lost electrons.
- Isotope: An atom with a different number of neutrons, and therefore a different atomic mass than the neutral version of the same element.

o Periodic Table: Know Location
- Common properties of metals
  - Good conductors of electricity
  - Good conductors of heat
  - Ductile: ability to be drawn into a thin wire
  - Malleable: Bendable
  - Shiny (sometimes)
  - Lose electrons
- Common properties of non-metals (basically just the opposite of metals)
  - Poor conductors of electricity
  - Poor conductors of heat
  - Gain electrons
- Main Group Elements
  - Main-group elements: the former "A" group elements of the periodic table.
  - Alkali Metals- group 1
  - Alkaline Earth Metals- group 2
  - Halogens- group 7
  - Noble Gases- group 8
- Transition metals/elements: groups 3-12
  - Less predictable properties.
- Metals: Right of stair step
- Non-metals: left of stair step
- Metalloids: directly on the stair step
  - Properties of metals and non-metals
  - Many are semi-conductors (an element that has conductivity that changes based on temperature- controllable conductivity)
- Lanthanides: Period 6 (#57-71)
- Actinides: Period 7 (#89-103)

o Other Objective Notes
- Chemical Symbol: ${}^{131}_{54}Xe$
  - Element Abbreviation
  - Atomic Mass
  - Atomic Number

- Isotope Symbol: Carbon-14
  - Element
  - Mass
- The atomic masses found on the periodic table are always decimals because they are a combination of all of the common isotope masses more or less averaged.

Determine. . .	How you find it. . .	Example. . . Li (Lithium)
Protons	Atomic number	3
Neutrons	Mass (rounded) – atomic number	4
Electrons	If neutral, equal to atomic number	3
Metal vs. Non- Metal	Left or right of stair step	Metal
Group name	Know the names!!!!	Alkali Metal

V. Electronic Structure of Atoms

- Definitions:
  - Valence Electrons: the electrons in the outermost shell of an atom. Do participate in chemical reactions (s and p are the only sublevels we consider valence for now)
  - Core Electrons: Electrons in shells closer to the nucleus. Electrons that don't participate in chemical reactions.
- Objective List Notes
  - The electrons structure of an atom determine its chemical properties (how it reacts)
  - Energy Levels/shells = PERIOD
  - Sublevels/subshells = BLOCK (see below)
    - "s" block: groups 1 and 2
    - "d" block: groups 3-12
    - "p" block: groups 13-18
    - "f" block: Lanthanides {Period 6 (#57-71)} and Actinides {Period 7 (#89-103)}
  - Sublevel Information
    - "s": holds 2 electrons and contains 1 orbital
    - "p": holds 6 electrons and contains 3 orbitals
    - "d": holds 10 electrons and contains 5 orbitals
    - "f": holds 14 electrons and contains 7 orbitals
    - Each orbital can hold 2 electrons (duh)
  - Electron Configuration
    - Long-hand:
      1) Determine the number of electrons in the atom
      2) Locate the element on periodic table to find the ending energy level and subshell
      3) You must fill all energy/sub-levels before moving to the next
      4) Use periods and blocks to know the filling order.
    - Short-hand:

1) Find atom, go up 1 period from the atom and all the way to the right/end of the period
2) Write noble gas you found in brackets
3) Start writing electron configuration as usual from beginning of the period the atom is found in.

- Noble gases end with completely full energy levels and subshells. The fact that they have full shells makes them very stable. All elements want to be stable so they attempt to add or lose electrons until they have full shells.
- Since noble gases are full we can use them to represent the core electrons of other atoms.
- Elements in the same group have the same number of valence electrons and the same chemical properties.