NAME\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ NOTES: UNIT 2 ATOMIC STRUCTURE (PART 2)

AND BOND TYPES

Unit 2 (Part 1) Basic Atomic Structure (Goals, Reading, Practice)

**For this section of Unit 2, you need to master the following ideas about Atomic Theory:**

⮊ atomic theory influencing bond theory via the idea of electronegativity

⮊ the role of valence electrons in reaction chemistry

⮊ that the ion(s) of an element behave differently than the atom of the element (Big Idea 3)

⮊ the interpretation of a ground state configuration and excited state configuration

⮊ the relationship between basic electron configuration, atomic number and the organization of the periodic

table of the elements

I) First, some vocabulary …

A) Atom vs. Element

1) You can think of an element as an aggregation of only one type of atom. **The key is that all**

**the atoms have the same # of protons** (same atomic number). There may be millions of

these atoms all bonded to each other ... but because every atom is of identical atomic number,

the whole mass is classified as an element!

atom element

(a group of atoms of the

same atomic number)

Try using the analogy: **atom is to element as a** brick **is to** brick wall**.**

1 atom represents the whole element, like 1 brick

describes the basic properties of a brick wall

**GIMME’ A METAPHOR**

j0233413

Question: How is a string of pearls like atoms and elements?

What assumption do we make about each individual pearl?

Question: Create an analogy in which a lawn is analogized to an element.

What assumption must be made regarding each blade of grass?

B) Electronegativity: \*The tendency of an atom to attract the electrons of a bond to itself.

1) Metals tend to lose electrons to nonmetals (Thus metals tend to have a much lower

electronegativity relative to nonmetals.

2) Nonmetals can bond with metals …. BUT(!) nonmetals can bond with other nonmetals.

a) This is where electronegativity really has an impact upon our ability to predict and

to explain various phenomenon.

Table

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<http://www.chem.ucla.edu/~harding/IGOC/E/electronegativity.html>

3) Fluorine is the most electronegative element. This means that when an atom of fluorine

bonds to another atom, the atom of fluorine tends to gain or draw the electrons of the bond

to its own nucleus.

4) Generally, we can use the ***electronegativity difference*** to predict the TYPE of bond. There

are exceptions …. but as a rule of thumb…..

Box and whisker chart

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<https://www.chegg.com/homework-help/questions-and-answers/question-already-answered-signs-blue-answer-question-asked-identify-polar-covalent-bond-le-q32854403>

5) Thus, we can begin to investigate at least three different types of bonds. Two are some type

of covalent bond. The third type is the ionic bond.

Check out: <https://slideplayer.com/slide/6612620/> up to and including slide 12 of 20… Do no go

beyond slide 12 for our purposes of developing the idea of identifying bond type.

a) Nonpolar Covalent Bond:

* a type of bond of shared electrons, in which the electronegativity difference is between 0 and 0.4
* Very often the bond is between \*2 nonmetal atoms of very closely aligned electronegativities. Neither atom has a nuclear force that can dominate and take the electrons

* C-H bonds and C – C bonds are excellent examples.

H H H

| | |

H – C – C – C – H

| | |

H H H

* Diatomic elements, such as O2 and Cl2 are excellent examples.

b) Polar Covalent Bonds

* a type of bond of shared electrons, in which the electronegativity difference is between 0.4 and 1.8
* Very often the bond is between \*2 nonmetal atoms of rather different electronegativities. One of the atoms of the bond will have sufficient nuclear strength to attract the electrons of the bond towards itself.
* An easy (and possibly too simplified) means of identifying a polar covalent bond is to note that one tends to exist between TWO DIFFERENT NONMETALS (with the exception of C – H bonds)
* Example: NH3
* Example: HCl
* Example: CO2
* Example: H2O

c) Ionic Bonds: Electrons are NOT shared. Electrons are \*transferred from one species

to another.

* The action of transferring electrons creates IONS
* The opposite charges of the resulting ions create the bonding attraction
* Ionic bonds (between ions) are electrostatic attractions

A picture containing text, book

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* Most often, the electronegativity difference is greater than 1.8
* The easiest (and possibly oversimplified means) of identifying an ionic bond is one which exists between a \*metal ion and nonmetal ion

C) Depending upon the date of publication of these notes, there are roughly 118 element

represented on the Periodic Table, and they are divided into:

18 vertical columns (called families or groups),

7 horizontal periods and

2 related series.

1) The elements are organized based upon \*increasing atomic number.

2) We will concern ourselves with the Main Group elements (Groups 1,2,13-18). We will do a little

work with the Transition Metal Elements (Groups 3 -11), and group 12

D) A somewhat arbitrary means of categorizing the elements is based upon the activity of the

outermost electrons (the most loosely held electrons ....and those most likely to participate in

making new bonds) .... the \* valence electrons

Val*a*nce curtain ... While not spelled the same, I like to think of this curtain, being so named, because it is the "outermost" drape .... the furthest from the window (metaphorically, the nucleus)

& the last to be put on (configured) and the first to be taken off. How does this metaphor work for you? Do you have any questions?

<http://oxbowherald.com/writing/blog/with-valances-for-windows-all-you-need-is-your-imagination>

1) Based upon the activity of valence electrons, there are **4** broad categories of elements

a) Metals are elements which lose electrons in a chemical reaction, when reacted with

nonmetals. (Metals become oxidized when reacted with nonmetals.)

i) loss of electrons = \*oxidation

ii) oxidized species become \*more positive in charge, due to a loss of negative

electrons. e.g. 0 to +2 or +2 to +5

iii) You may sometimes hear that fossil fuels are oxidized when combusted in

oxygen. This is generally accurate, as the carbon atoms of the fossil fuel(s)

lose electrons to oxygen, and form carbon dioxide. The carbon of CO2 is

in a +4 oxidation state … a more positive state, then carbon is in the original

fuel.

This holds true as well, for glucose … It is oxidized biochemically, in that

carbon atoms become more positive.

iv) In the case of metals, you will often hear that a metal (such as iron) has been

oxidized (**or rusted**) in the presence of oxygen or some other nonmetal.

In this case, iron atom loses electrons and becomes a +3 or +2 ion.

v) Oxidation does NOT require oxygen … but derives the name from oxygen.

vi) The key is to grasp that oxidation is a loss of electrons, and many atoms can

become oxidized …. BUT(!) Metal atoms, in the presence of nonmetals are

especially vulnerable to this sort of electron activity.

b) Metalloids (or Semimetals) blend the characteristics of metals and nonmetals & are

elements with properties which fall between the extremes of metallic and

nonmetallic properties. They are associated with the "staircase" of the

periodic table and this staircase separates metals and nonmetals, as well.

c) Nonmetals ***tend*** to gain electrons in a chemical reaction especially when reacted with

a species of lesser electronegativity, like a metal or even another nonmetal.

(Nonmetals tend to become reduced.)

i) Gain of electrons = \*reduction

ii) a reduced species becomes \*more negative, due to the gain of negative

electrons.

iii) fluorine is the most readily (easily) reduced element … followed by oxygen.

It is very common for oxygen to change its electron configuration by gaining

2 more electrons from some other atom. Oxygen, **in compounds** is often a

-2 species.

d) Noble Gases often seen as a subset of the nonmetals, these elements tend to neither

gain nor lose electrons under normal Earth-like conditions. That, is,

under normal Earth-like conditions, noble gases tend not bond to other

species, and you won’t find them in many compounds. There are a few

exceptions …but not many.

3) Elements tend to interact in such a way as to stabilize their valence electron levels, and

lower their overall energy.

a) For first-year students we could look at these reactions, as an attempt to reach 8

valence electrons. This is called the OCTET RULE. However, it is just a guideline

and not always accurate. Let’s just say that often (but not always,) a atom will

react to that it ends up with 8 valance electrons … or as close as possible. (more later)

b) Metals tend to Lose Electrons when reacting with nonmetals by Oxidation (LEO) and

the metal atom becomes a positive species.

c) Nonmetals tend to Gain Electrons when reacting with metals by Reduction (GER), and the nonmetal atom becomes a more negative species (due to a gain of electrons)



c) LEO says GER

<http://bananaoilmovies.wordpress.com/2010/11/05/a-farewell/>

**Relative Locations of the 4 Categories of Elements Found on the Periodic Table**

**Non -**

**Metals Noble**

**Gases**

**Metals**

**Metalloids**

**Metals**

II) Electron Configuration: We believe that electrons are ordered from low levels of energy to

higher levels of energy, which correspond statistically to probable locations of the

electrons from the nucleus.

A) According to Bohr:

1) electrons are organized outside of and around the nucleus

2) electrons are found at specific distances from the nucleus. These distances are

called energy shells (K – Q) or principal energy levels (1 – 7). (vocabulary term!!!)

![j0237628](data:None;base64,) 3) \* there are 7 principal energy levels, some with electrons of a quantized energy

Picture it!

4) electrons nearest the nucleus are lowest in energy. The energy of electrons

\* increases as their position from the nucleus increases.

(potential energy argument)

5) Ground State = \* The electrons arranged in the lowest possible energy levels

a) The “shells” (or principal energy levels) tend to have a rule which predicts the

maximum number of electrons = 2n2, where n is the number of the level, 1,2,3,4 …

b) The rule describes the maximum number of electrons a level may hold … NOT the

the number it MUST hold … Think of this last statement like carrying in a load of

wood, from outside.

c) Octet Rule: A tendency for atoms to lose or gain electrons so that the resulting

species has 8 valence electrons.

This is simply a tendency …. not a hard and fast rule….

e.g) Oxygen atoms tend to gain 2 electrons….to get a valence of 8

O0 2-6 can become O-2 2-8

Na0 2-8-1 can become Na+1 2-8

Ca0 2-8-8-2 can become Ca+2 2-8-8

P0 2-8-5 can become P-3  2-8-8

d) As a general rule, atoms with fewer than 4 valence e- tend to lose electrons

and atoms with more than 4 valence e- tend to gain electrons to complete the octet.

Check out your periodic table or <https://hobart.k12.in.us/ksms/PeriodicTable/energy%20levels.htm>

6) Excited State Electron Configuration: This exists when an inner level electron absorbs

energy from an outside source and moves to a higher energy level.

a) A temporary state

b) When the electron returns to a lower energy level, the loss of potential energy is

converted to some form of electromagnetic spectrum energy. (radio waves,

microwaves, infrared, visible light, ultraviolet, x-ray, or gamma ray)

c) The configuration is NOT found on the periodic table references

d) Example: O: 2-6 O: 2-5-1

ground state excited state

e) Everyday Chemistry: Neon Light Sign

Sunlight

Flashlight

**TRY THIS!!!!!**

1. Use the ground state electron configuration of 2-8-18-6
2. An atom of which element is represented? \* Se or selenium

b) The configuration suggests that this atom has how many valence electrons? \*6

c) Using the octet rule, which generalizes that atoms react in such a way, so as to attain 8 valence

electrons, will this atom tend to gain or lose electrons? \*gain 2 electrons…

2) Use the ground state electron configuration of 2-8-10-2

a) An atom of which element is represented? \* Ti or titanium

b) How many valence electrons does this atom have? \*2

c) Will this atom tend to gain, or to lose electrons, when reacted with another atom, such as oxygen?

\*lose

d) How many principal energy levels hold electrons? \*4

3) Us the ground state electron configuration of 2-5

a) An atom of which element is represented? \* Nitrogen

b) How many valence electrons does this atom have? \*5

c) Will this atom tend to gain, or to lose electrons, when reacted with another atom, such as oxygen?

\*gain

d) How many principal energy levels hold electrons? \*2

We have seen the effect of ions and excited state in lab…. Think about the flame tests and the application to fireworks, or just the blue-green color of the copper sulfate we have used.

Other applications can include:

**Here is a neat application …Why is water “blue”?**

## Light attenuation in water

Shortwave radiation emitted from the sun wavelengths in the visible spectrum of light that range from 360 nm (violet) to 750 nm (red). When the sun’s radiation reaches the sea-surface, the shortwave radiation is attenuated by the water, and the intensity of light decreases exponentially with water depth. The intensity of light at depth can be calculated using the Beer-Lambert Law.

In clear open waters, visible light is absorbed at the longest wavelengths first. Thus, red, orange, and yellow wavelengths are absorbed at higher water depths, and blue and violet wavelengths reach the deepest in the water column. Because the blue and violet wavelengths are absorbed last compared to the other wavelengths, open ocean waters appear deep-blue to the eye.

In near-shore (coastal) waters, sea water contains more phytoplankton than the very clear central ocean waters. Chlorophyll-a pigments in the phytoplankton absorb light, and the plants themselves scatter light, making coastal waters less clear than open waters. Chlorophyll-a, absorbs light most strongly in the shortest wavelengths (blue and violet) of the visible spectrum. In near-shore waters where there are high concentrations of phytoplankton, the green wavelength reaches the deepest in the water column and the color of water to an observer appears green-blue or green.

<http://en.wikipedia.org/wiki/Attenuation>

OR…. Check out: The Aurora Borealis: <https://www.youtube.com/watch?reload=9&v=eJV_wlCm6ms>

And: <https://www.youtube.com/watch?v=5wZSt_LNq3U> (covers a little of nuclear fusion as well)