You have mastered this topic when you can:

1) relate stability of the **NOBLE GASSES** to electron arrangement within the atom.
2) relate the charge of **MONATOMIC METAL** and **NON-METAL IONS** to numbers of electrons lost or gained.
3) state the electron gain or loss requirements for elements in **GROUPS** 1, 2, 3, 13, 14, 15, 16 & 17 to attain stability.
4) draw **ORBITAL DIAGRAMS** for **MONATOMIC IONS**.

THE PERIODIC TABLE, OBSERVABLE PROPERTIES & ATOMIC THEORY

I) **EXPLAINING THE SIMILAR *OBSERVABLE PROPERTIES* OF ELEMENTS WITHIN A *GROUP***

A) How is it possible for different elements within a ***group*** to share similar ***observable properties***, in particular their chemical reactivity? The answer lies in the structural similarities of each atom within the ***group***.

1) ***NOBLE (INERT) GASSES*:** Draw ***orbital diagrams*** of the atoms of the first four ***noble gasses*** in the space below then answer the questions that follow. The maximum number of ***electrons*** allowed in each ***orbit*** is determined by the pattern: ______________________________.

helium **neon** **argon** **krypton**

a) Is the ***valence shell*** full or not full? ______________________________.

b) Are these atoms reactive or non-reactive? ______________________________.

c) What is the relationship between your answers to questions **a & b**? ______________________________

______________________________.

2) ***ALKALI METALS*:** Draw ***orbital diagrams*** of the atoms of the first four ***alkali metals*** in the space below then answer the questions that follow. The maximum number of ***electrons*** allowed in each ***orbit*** is determined by the pattern: ______________________________.

lithium **sodium** **potassium** **rubidium**

a) Is the ***valence shell*** full or not full? ______________________________.

b) Are these atoms reactive or non-reactive? ______________________________.

c) What is the relationship between your answers to questions **a & b**? ______________________________

______________________________.

d) All ***alkali metals*** lack ***full valence orbits*** *and thus all are reactive*. ***THIS IS AN EXTREMELY IMPORTANT RELATIONSHIP!*** When the ***valence shell*** of an atom is not full the atom is not stable, and thus it is reactive. ***Alkali metals*** are reactive because they lack a ***full valence orbit***. In fact, they are extremely reactive elements because each of their atoms has only one ***valence electron***, which means each has an atomic structure that is very close to having a ***full valence orbit*** '(***nobility'***). If an ***alkali metal*** lost its lone ***valence electron***, its ***valence orbit*** would then be full just like the ***valence orbit*** in a ***noble gas*** atom. That is exactly what occurs. The unstable ***alkali metal*** atoms lose their one ***valence electron*** in order to obtain a new ***full valence orbit*** thus becoming ***stable*** and "***noble***": **e.g.** Consider the ***alkali metal*** lithium.

Unstable lithium **Stable lithium**

i) Calculate the charge on the ***unstable*** lithium atom and the ***stable*** lithium particle you drew at the bottom of the previous page. The ***unstable*** lithium atom has $3p^{+}$ and $3e^{-}$ therefore it is *neutral*. This means it is called a ***lithium atom*** which is symbolized **Li**. The ***stable*** lithium particle has $3p^{+}$ and $2e^{-}$ therefore it has a *positive 1 charge* and is now called a ***lithium ion*** which is symbolized $\mathbf{Li^{1+}}$. **REMEMBER:** An ***ion*** is a positively or negatively charged particle.

3) ***ALKALINE EARTH METALS*****:** Draw ***orbital diagrams*** of the atoms of the first four ***alkaline earth metals*** in the space below then answer the questions that follow. The maximum number of ***electrons*** allowed in each ***orbit*** is determined by the pattern: ____.

beryllium **magnesium** **calcium** **strontium**

a) Is the ***valence shell*** full or not full? ____.

b) Are these atoms reactive or non-reactive? ____.

c) What is the relationship between your answers to questions **a & b**? ______________________________

____.

d) All ***alkaline earth metals*** lack ***full valence orbits*** *and thus all are reactive*. ***THIS IS AN EXTREMELY IMPORTANT RELATIONSHIP!*** When the ***valence shell*** of an atom is not full the atom is not stable, and thus it is reactive. ***Alkaline earth metals*** are reactive because they lack a full ***valence orbit***. In fact, they are very reactive elements because each of their atoms has two ***valence electrons***, which means each has an atomic structure that is close a ***full valence orbit*** '(***nobility'***). If an ***alkaline earth metal*** lost its two ***valence electrons***, its new ***valence orbit*** would be full just like the ***valence orbit*** in a ***noble gas*** atom. That is exactly what occurs. The unstable ***alkaline earth metal*** atoms lose their two ***valence electrons*** in order to obtain a new ***full valence orbit*** thus becoming ***stable*** and "***noble***": **e.g.** Consider the ***alkaline earth metal*** beryllium found at the top of the next page.

Unstable beryllium **Stable beryllium**

i) Calculate the charge on the ***unstable*** beryllium atom and the ***stable*** beryllium particle. The ***unstable*** beryllium atom has $4p^+$ and $4e^-$ therefore it is *neutral*. This means it is a ***beryllium atom*** and is symbolized **Be**. The ***stable*** beryllium particle has $4p^+$ and $2e^-$ therefore it has a *positive 2 charge* and is now called a ***beryllium ion*** which is symbolized $\mathbf{Be^{2+}}$. **REMEMBER:** An ***ion*** is a positively or negatively charged particle.

3) ***HAOGENS*: ** Draw ***orbital diagrams*** of the atoms of the first four ***halogens*** in the space below then answer the questions that follow. The maximum number of ***electrons*** allowed in each ***orbit*** is determined by the pattern: ____.

fluorine **chlorine** **bromine** **iodine**

a) Is the ***valence shell*** full or not full? ______________________________.

b) Are these atoms reactive or non-reactive? ______________________________.

c) What is the relationship between your answers to questions **a & b**? ______________________________
____.

d) All ***halogens*** lack ***full valence orbits*** *and thus all are reactive*. ***THIS IS AN EXTREMELY IMPORTANT RELATIONSHIP!*** When the ***valence shell*** of an atom is not full the atom is not stable, and when an atom is not stable it is reactive. ***Halogens*** are reactive because they lack a ***full valence orbit***. In fact, they are extremely reactive elements because each of their atoms has seven ***valence electrons***, which means each has an atomic structure that is very close to a ***full valence orbit*** **'(*nobility'*)**. If a ***halogen*** atom gained one ***valence electron***, its ***valence orbit*** would then be full just like the ***valence orbit*** in a ***noble gas*** atom. That is exactly what occurs. The ***unstable halogen*** atoms gain one ***valence electron*** to obtain a new ***full valence orbit*** thus becoming ***stable*** and "***noble***": **e.g.** Consider the ***halogen*** Fluorine.

Unstable fluorine **Stable fluorine**

i) Calculate the charge on the ***unstable*** fluorine atom and the ***stable*** fluorine particle. The ***unstable*** fluorine atom has $9p^+$ and $9e^-$ therefore it is *neutral*. This means it is called a ***fluorine atom*** and is symbolized **F**. The ***stable*** fluorine particle has $9p^+$ and $10e^-$ therefore it has a *negative 1 charge* and is now called a ***fluoride ion***, which has the symbol $\mathbf{F^{1-}}$. **REMEMBER:** An ***ion*** is a positively or negatively charged particle.

B) **Required Practice 1:** Answer these questions on your own paper. **{Answers are on page 6.}**

1. Draw orbital diagrams for the unstable and stable forms of the first four elements of groups 1, 2, 15 & 16. Label each orbital diagram with its name and symbol then classify each as an atom or ion.
2. What do the atoms of the elements within each group have in common?
3. Explain why elements within a group share similar properties.
4. Define and explain the difference between atoms and ions.

II) Elements are chemically reactive because their atoms lack ***full valence orbits*** making them ***unstable***. ***The closer the valence shell of an atom is to being full - the more reactive is the atom.*** ***Alkali metals*** have ***1 valence electron***, which makes them more reactive than ***alkaline earth metals***, which have ***2 valence electrons***. ***Halogens*** have ***7 valence electrons***, which makes them more reactive than elements found in ***group 16*** which have ***6 valence electrons***. ***Atoms become stable by gaining or losing enough valence electrons to create a full valence shell.*** When an atom becomes stable by gaining or losing ***electrons***, it forms a charged particle called an ***ION***. **REMEMBER:** ***IONS are positively or negatively charged particles.***

A) **MONATIOMIC IONS are particles consisting of a single atom having a positive or negative charge.**

e.g. Li^{1+}, Be^{2+}, Sc^{3+}, F^{1-}, O^{2-}, P^{3-}

1) **NOTICE** that each ***ion*** has a unique charge. The charge on an ***ion*** is called its **VALENCE**.

2) *Names of non-metal ions always* ____________________. ← **MEMORIZE THIS!!**

a) **e.g.** ox**ide**, fluor**ide**, sulph**ide**, phosph**ide**, brom**ide**, etc.

3) **Predicting the number of *valence electrons* and the charge of *monatomic ions*.** The periodic table is designed to help you predict the atomic structure of each of its elements, thus it will help you predict the number of ***valence electrons*** in the atoms of elements within each ***group***. As shown in **TABLE 1** below, ***the last digit of the number at the top of groups*** **1**, **2**, **3**, 1**3**, 1**4**, 1**5**, 1**6**, 1**7** & 1**8** is equal to the number of ***valence electrons*** found in the atoms of the elements within each ***group***.

e.g. TABLE 1: Relationship between the ***group*** number and the number of ***valence electrons***.

Group #	# of ***Valence e***$^-$
1	***1***
2	***2***
3	***3***
1***3***	***3***
1***4***	***4***
1***5***	***5***
1***6***	***6***
1***7***	***7***
1***8***	***8***

a) **i.e.** Scandium is in ***group* 3** and it has ***3 valence electrons***. Oxygen is located in ***group*** 1***6*** and it has ***6 valence electrons***.

B) The ***valence*** is the number located at the top right corner of each box on the Periodic Table.

1) The ***valence*** of a ***metal*** atom indicates the number of ***valence electrons*** it has, the number of ***valence electrons*** it will give and the resulting charge on the ***monatomic ion*** that is formed. **e.g.** The ***valence*** for scandium is 3+. This means that an unstable scandium atom has 3 ***valence electrons*** that it gives to a needy atom when it forms a stable scandium ***ion*** = Sc^{3+}. On the next page, draw ***orbital diagrams*** for Sc and Sc^{3+} to confirm this.

scandium atom **scandium ion**

a) Study the ***valence*** for all of the ***metals***, what do they have in common? The ***valence*** *for all* ***metals*** *is positive, this means that all* ***metal atoms*** *will give their* ***valence electrons*** *to a needy atom and become positively charged* ***metal ions***.

i) Some ***metals*** have one ***valence***, while others have more than one. This is possible because the actual structure of the atom is flexible, it allows for several stable electron arrangement variations for the atoms found in groups 4 through 12, ***transition metals***. ***Metals*** in groups 1, 2 and 3 have one ***valence*** and are called **UNIVALENT**. Many ***transition metals,*** groups 4 through 12, have more than one ***valence*** and are called **MULTIVALENT**. *Your periodic table shows two* ***valences*** *for* ***multivalent metals****, however they often have three or more. Your periodic table shows only the two most common* ***valances***. **REMEMBER:** *There are often more than two* ***valences*** *for* ***multivalent metals***.

2) The ***valence*** of a ***non-metal*** atom indicates the number of ***electrons*** required to fill its ***valence shell***, the number of ***electrons*** gained by its ***valence orbit*** and the resulting charge on the ***monatomic ion*** it becomes. **e.g.** The ***valence*** for nitrogen is 3-. This means that an unstable nitrogen atom must gain 3 ***electrons*** to form a stable ***Nitride ion*** = N^{3-}. In the space provided at the top of the next page, draw ***orbital diagrams*** for N and N^{3-} to confirm this.

nitrogen atom **nitrogen ion**

b) Study the ***valence*** for all of the ***non-metals***, what do they have in common? *The* ***valence*** *for all non-metals is negative. This means that all non-metals atoms will gain* ***electrons*** *to fill their* ***valence orbits*** *turning them into negatively charged non-metals* ***ions***.

III) **DRAWING *ORBITAL DIAGRAMS* FOR *MONATOMIC IONS***

A) ***Monatomic Metal ions*** have a positive charge because they give their ***valence electrons*** to needy atoms. To calculate the number of electrons the ***monatomic metal ion*** has, you must subtract the ***valence*** from the ***atomic number*** (Z).

1) **SAMPLE PROBLEM:** Calculate the number of each subatomic particle in the ***monatomic metal ion*** aluminum: Al^{3+}.

2) **Required Practice 2:** Answer this question on your own paper. **{Answers are on page 6.}**

1. Calculate the number of protons, neutrons and electrons then draw orbital diagrams for these metal ions.
   a. B^{3+} b. Na^{+} c. Sr^{2+} d. Y^{3+}

B) ***Monatomic Non-Metal ions*** have a negative charge because they gain ***valence electrons*** from atoms that need to give ***valence electrons*** away. To calculate the number of electrons the ***monatomic non-metal ion*** has, you must subtract the ***valence*** from the ***atomic number***, Z.

1) **SAMPLE PROBLEM:** Calculate the number of each subatomic particle in the ***monatomic non-metal ion*** O^{2-}.

2) **Required Practice 3:** Answer this question on your own paper. **{Answers are on page 6.}**

1. Calculate the number of protons, neutrons and electrons and draw orbital diagrams for these monatomic non-metal ions.
   a) N^{3-} c) P^{3-} d) S^{2-} d) Cl^{-}

ANSWERS TO THE REQUIRED PRACTICE

Required Practice 1 from page 4

1. See your teacher. **2.** Elements within a group have the same number of valence electrons. **3.** Elements within a group share similar observable properties because they have the same number of valence electrons. **4.** See the table below.

	Atom	Ion
Definition →	Fundamental particle of an element	A positively or negatively charged particle
Differences ↓	Neutral in charge Has equal numbers of protons and electrons Valence shell not full Is unstable and reactive	Has a positive or negative charge Has different numbers of protons and electrons Valence shell full Is stable and non-reactive

Required Practice 2 from page 4

1.

	p^+	n	e^-		p^+	n	e^-
a.	5	6	2	**b.**	11	12	10
c.	38	50	36	**d.**	39	50	36

Required Practice 3 from page 5

1.

	p^+	n	e^-		p^+	n	e^-
a.	7	7	10	**b.**	15	16	18
c.	16	16	18	**d.**	17	18	18

BE SURE YOU ARE PREPARED FOR MEMORY CHALLENGE-1 ON T1 – T7!!