You have mastered this topic when you can:

1) determine the maximum number of electrons that can be carried by an energy level.
2) define or describe an **ELECTRON CLOUD**, **VALENCE ELECTRON** and **VALENCE ORBIT**.
3) describe the relative location, mass and charge of a **PROTON**, a **NEUTRON** and an **ELECTRON**.
4) define or describe and distinguish between **MASS NUMBER** and **ATOMIC MASS**.
5) determine the **MASS NUMBER** and the number of **NEUTRONS** of an atom.
6) use the periodic table to determine the number of occupied orbits and valence electrons within an atom.
9) use **BOHR'S ATOMIC THEROY** and the periodic table to draw **ORBITAL DIAGRAMS** for the first 38 elements.
7) define the term **ISOTOPE** and explain it in terms of **ATOMIC STRUCTURE** and **ATOMIC MASS**.
8) calculate the number of **PROTONS**, **NEUTRONS** and **ELECTRONS** for an **ISOTOPE** of an element.
9) draw **ORBITAL DIAGRAMS** for **ISOTOPES**.

SUMMARY OF ATOMIC THEORY AS OF 1932

I) **REMEMBER:** Atoms are composed of three different *subatomic particles:* ***protons***, ***neutrons*** and ***electrons***. **MEMORIZE** the information in the **BOLD** highlighted columns in **TABLE 1** given here.

TABLE 1: Summary of Subatomic Particles

Subatomic Particle	**Location**	Actual Mass (g)	**Relative Mass (u)**	Actual Charge (C = coulombs)	**Relative charge**
Proton = p^+	**nucleus**	1.673×10^{-24} g	**1 u**	$+1.602 \times 10^{-19}$ C	**1+**
Neutron = n	**nucleus**	1.675×10^{-24} g	**1 u**	0	**0**
Electron = e^-	**orbits**	9.109×10^{-28} g	**0 u**	-1.602×10^{-19} C	**1-**

A) The Actual Mass of each ***subatomic particle*** is so incredibly small that they are not useful for everyday calculations, as a result, chemists created a more useful unit based on the **Relative Mass** of the ***subatomic particles***, the unified **atomic mass unit = u**. Study the above table. **NOTICE** that the Actual Mass of one ***proton*** is so close to the Actual Mass of one ***neutron*** that chemists consider their **Relative Masses** to be equal at 1 u. The Actual Mass of one ***electron*** is so incredibly small compared to the Actual Mass of one ***proton*** or one ***neutron*** that it's **Relative Mass** is defined as 0 u. Relatively speaking, an ***electron's*** mass is non-existent and thus is not included in the ***atom's mass***.

B) **Required Practice 1:** Answer these questions on your own paper. **{Answers are on page 5.}**

1. Which subatomic particles that have the same mass.
2. Which subatomic particle(s) reside in the nucleus?
3. Which subatomic particle(s) has essentially no mass?
4. Which subatomic particles make up the mass of the atom?
5. List the subatomic particles in order of increasing ***actual*** atomic mass.

II) **MASS NUMBER**

A) Chemists recognize that the ***mass*** of an atom is comprised of the total number of ***protons*** and ***neutrons*** found in the atom's ***nucleus***. As a result, chemists created the concept of **MASS NUMBER**. An element's **MASS NUMBER**, symbolized **A**, is the total number of ***protons*** and ***neutrons*** found in the ***nucleus*** of its atoms. The ***mass number*** is determined using the ***ATOMIC MASS***, which is found on your periodic table under each element's name. The ***mass number*** is not the same value as the ***atomic mass*** that appears on your periodic table. The **ATOMIC MASS**, symbolized $\mathbf{A_r}$, is the relative average mass of an element expressed in **u** = ***atomic mass units***. To determine the ***mass number*** (**A**) for an atom of an element, round the element's ***atomic mass*** ($\mathbf{A_r}$) to the nearest whole number.

e.g. Boron's ***atomic mass*** is $A_r = 10.81$ u $\therefore$ its ***mass number*** is A = 11
Aluminum's ***atomic mass*** is $A_r = 26.98$ u $\therefore$ its ***mass number*** is A = 27.

1) **REMEMBER:** The ***atomic mass*** and the ***mass number*** are not the same thing!!

2) A question may have entered your mind: If all the ***mass*** of an ***atom*** is found within its ***nucleus*** which is composed of ***protons*** and ***neutrons***, and the ***mass*** of each ***proton*** and each ***neutron*** is 1 u, and it is not possible for a fraction of a ***proton*** or ***neutron*** to exist, how is it possible that the ***atomic masses*** recorded on the periodic table are not whole numbers? The answer lies in the existence of **IOSTOPES**. Most elements are composed of two or more *varieties* of atoms called ***IOSTOPES***. We will discuss ***isotopes*** later in this Topic.

B) **CALCULATING THE NUMBER OF *NEUTRONS* IN AN *ATOM'S NUCLEUS***

1) **RECALL** that an atom's ***mass number***, **A**, is the sum of its ***protons*** and ***neutrons***, and that it's number of ***protons*** is given by its atomic number, **Z**.

i.e. A = (# of p^+) + (# of n) = Z + (# of n).

a) Since **A = Z + (# of *n*)**, subtracting **Z (# of p^+)** from **A** (the ***mass number***) gives the number of ***neutrons*** **(# of *n*)**. Use the formula given below to calculate the number of ***neutrons*** in an atom's ***nucleus***. **MEMORIZE IT!!**

of *n* = MASS NUMBER – ATOMIC NUMBER → $\boxed{n = A - Z}$

REMEMBER: Round the *atomic mass* recorded on the periodic table to the nearest whole number to determine the *mass number* of an element.

b) **SAMPLE PROBLEMS:**

i) Determine the number of ***neutrons*** in an atom of fluorine.

A_r = 19.00 u and Z = 9 ∴ ***n* = A – Z = 19 – 9 = 10 *n*** Fluorine's nucleus has 10 neutrons.

ii) How many ***neutrons*** do atoms of lithium contain?

A_r = 6.939 B 7 u and Z = 3 ∴ ***n* = A – Z = 7 – 3 = 4 *n*** Lithium's nucleus has 4 neutrons.

c) **Required Practice 2:** Answer this question on your own paper. **{Answers are on page 5.}**

1. Determine the number of neutrons in these elements: sodium, carbon, neon, chlorine, calcium, bromine, krypton, tungsten, osmium & lead.

III) **ORBITAL DIAGRAMS ARE DRAWINGS OF ATOMS USING *BOHR'S ATOMIC THEORY***

A) The periodic table is organized to reflect the structure of the atoms of an element in that the number of each horizontal row gives the maximum number of ***occupied orbits*** found within the atoms of the elements within each row. An ***occupied orbit*** contains at least one ***electron***.

1) The relationship between row number and the number of ***occupied orbits*** found in the atoms within each row of the periodic table is illustrated in **TABLE 2** given here.

TABLE 2: Relationship between each periodic table row and the number of ***occupied orbits***

Row	Number of ***occupied orbit***s		Row	Number of ***occupied orbit***s
1	1		4	4
2	2		5	5
3	3		6	6

a) <u>**On your periodic table, number both sides of each row 1 to 7 from top to bottom.**</u> **REMEMBER:** The row number indicates the number of ***occupied orbits*** found in the atoms within each row.

2) ***Electrons*** fill ***orbits*** from ***low-energy levels*** to ***high-energy levels***, inside out, according to the pattern outlined in **TABLE 3** given below. **RECALL** that **n =** ***principle quantum number***, which is the number assigned to a particular ***orbit***. The ***principle quantum number*** is reflected in the periodic table in that the number assigned to each row corresponds to the outermost ***occupied orbit*** in the atoms of the elements within that row, thus the row number is also the ***principle quantum number*** for the outmost occupied orbit.

TABLE 3: Relationship between ***principle quantum number***, row number and possible number of ***electrons*** in each ***occupied orbit***. **MEMORIZE THIS TABLE!!**

Row	# of ***occupied orbit***s	n	Maximum # of ***electrons***	Possible # of ***electrons***
1	1	1	2	0, 1 or 2
2	2	2	8	0, 1, 2, 3, 4, 5, 6, 7 or 8
3	3	3	8 or 18	0, 1, 2, 3, 4, 5, 6, 7, 8 or 18
4	4	4	8 or 18 or 32	0, 1, 2, 3, 4, 5, 6, 7, 8 ,18 or 32
OUTER MOST OCCUPIED ORBIT			**8**	**1, 2, 3, 4, 5, 6, 7 or 8**

a) We now have enough information to draw **ORBITAL DIAGRAMS**, ***Bohr models*** of atoms.

B) **USE THESE STEPS TO DRAW ORBITAL DIAGRAMS FOR ATOMS**

(1) Determine the number of protons, electrons and neutrons.
(2) Draw the nucleus with the appropriate number of protons and neutrons.
(3) Determine and draw the number of occupied orbits.
(4) Place electrons in orbits from inside out, according to the 2, 8, 8 or 18, 8 or 18 or 32 pattern.

1) SAMPLE PROBLEMS: Draw ***orbital diagrams*** for these elements.

Lithium	**Fluorine**	**Aluminum**	**Selenium**	**Xenon**
$p^+ =$	$p^+ =$	$p^+ =$	$p^+ =$	$p^+ =$
$e^- =$	$e^- =$	$e^- =$	$e^- =$	$e^- =$
$n =$	$n =$	$n =$	$n =$	$n =$

2) ***Important Terminology***.

a) ***The VALENCE ORBIT is the outermost occupied orbit. Electrons found in the valence orbit are called VALENCE ELECTRONS.*** **REMEMBER:** ***The valence orbit can never hold more than 8 electrons.***

3) **Required Practice 3:** Answer these questions on your own paper. **{Answers are on page 5.}**

1. Draw orbital diagrams for sodium, carbon, neon, chlorine, calcium, bromine and krypton.
2. How many valence electrons does each atom have?

ISOTOPES

I) When naturally occurring samples of an element are analyzed, they are usually found to consist of two or more *variations* of its atom. *Variations* of the same kind of atom are called **ISOTOPES**. ***ISOTOPES are atoms of the same element that have different numbers of neutrons thus they have different atomic masses.*** **[MEMORIZE THIS DEFINITION!!]** This means ***isotopes*** of an element have the *same number of* ***protons***, the *same number of* ***electrons***, ***different number of neutrons*** and ***different atomic masses***. **REMEMBER:** The number of ***protons*** identifies which element the atom belongs to: **i.e.** As long as an atom has 11 ***protons*** it will always be sodium, regardless of the number of ***neutrons*** found in its ***nucleus***. **TABLE 4** illustrates the similarities and differences between the isotopes of chlorine and hydrogen.

e.g. TABLE 4: Chlorine has these two ***isotopes***. Hydrogen has these three ***isotopes***.

	chlorine-35	chlorine-37		hydrogen-1	hydrogen-2	hydrogen-3
$p^+ = e^-$	17	17		1	1	1
n	18	20		0	1	2
mass number	35 u	37 u		1 u	2 u	3 u

II) **CHEMISTS IDENTIFY *ISOTOPES* OF ELEMENTS USING TWO METHODS, MEMORIZE BOTH METHODS!!**

A) The **first** identification method includes the ***isotope's mass number*** (**A**) with its name or symbol.

e.g. Chlorine-35 or Cl-35 ; Chlorine-37 or Cl-37
Hydrogen-1 or H-1 ; Hydrogen-2 or H-2 ; Hydrogen-3 or H-3

B) The **second** identification method is called ***SYMBOLISM***. ***Symbolism*** uses the element's symbol with the ***isotope's mass number*** (**A**) to its ***UPPER LEFT*** and its ***atomic number*** (**Z**) to its ***LOWER LEFT***.

i.e. ${}^{A}_{Z}X$ where X = element's symbol; A = ***mass number*** of isotope; Z = element's ***atomic number***

e.g. TABLE 5: The ***isotopes*** for chlorine are described using ***symbolism***.

chlorine-35	chlorine-37
${}^{35}_{17}Cl$	${}^{37}_{17}Cl$

e.g. TABLE 6: The ***isotopes*** for hydrogen are described using ***symbolism***.

hydrogen-1	hydrogen-2	hydrogen-3
${}^{1}_{1}H$	${}^{2}_{1}H$	${}^{3}_{1}H$

C) **Required Practice 4:** Answer these questions on your own paper. **{Answers are on page 5.}**

1. Determine the number of protons, neutrons and electrons for these isotopes.
   a. oxygen-18 b. Li-6 c. C-12 d. uranium-235 e. U-237 f. C-14

III) **DRAWING *ORBITAL DIAGRAMS* FOR *ISOTOPES***

A) **USE THESE STEPS TO DRAW ORBITAL DIAGRAMS FOR ISOTOPES.**

(1) Determine the number of protons, electrons and neutrons.
(2) Draw the nucleus with the appropriate number of protons and neutrons.
(3) Determine and draw the number of occupied orbits.
(4) Place electrons in orbits from inside out, according to the 2, 8, 8 or 18, 8 or 18 or 32 pattern.

1) **SAMPLE PROBLEMS:** Draw ***orbital diagrams*** for these elements.

Li-6	**Li-7**	**Ca-40**	**Ca-42**
$p^+ =$	$p^+ =$	$p^+ =$	$p^+ =$
$e^- =$	$e^- =$	$e^- =$	$e^- =$
$n =$	$n =$	$n =$	$n =$

2) **Required Practice 5:** Answer these questions on your own paper. **{Answers: See your teacher.}**

1. Draw orbital diagrams for boron-10, boron-11, chlorine-35, chlorine-37, magnesium-24 & magnesium-25.

ANSWERS TO THE REQUIRED PRACTICE

Required Practice 1 from page 1

1. Chadwick discovered the neutron, which has a relative mass of 1 u, a relative charge of 0 and is found in the nucleus. **2.** Bohr's theory states that the energy levels are concentric spheres rather than the solar system's circular orbits. Bohr's theory has neutrons while his solar system does not. **1.** Protons and Neutrons. **2.** Protons and Neutrons. **5.** Electron. **4.** Protons and Neutrons. **5.** Electron, proton, neutron.

Required Practice 2 from page 2

1. Na: 12 **C:** 6 **Ne:** 10 **Cl:** 18 **Ca:** 20 **Br:** 45 **Kr:** 48 **W:** 110 **Os:** 114 **Pb:** 125

Required Practice 3 from page 3

1. See your teacher. **2. Na:** 1 **C:** 4 **Ne:** 8 **Cl:** 7 **Ca:** 2 **Br:** 7 **Kr:** 8

Required Practice 4 from page 4

1.	p^+	e^-	n		p^+	e^-	n		p^+	e^-	n
a.	8	8	10	**b.**	3	3	3	**c.**	6	6	6
d.	92	92	143	**e.**	92	92	145	**f.**	6	6	8

ASSIGNMENT

At the top of your assignment, please print **"T4 – Applications of the Bohr Model, your LAST then First name, block and date**. Show all your work for questions requiring calculations; marks will not be awarded for final answers only. Complete these questions in the order given here. *[Marks indicated in italicized brackets.]*

1. Determine the maximum number of electrons that can be carried by the sixth orbit. Show all work. *[2]*

2. What subatomic particles are responsible for the mass of an atom? *[1]*

3. What is the mass number of an atom having 14 protons and 13 neutrons. *[1]*

4. An atom has 15 protons and a mass number of 31.
   a. What is its atomic number? *[0.5]*
   b. What element is it? *[0.5]*
   c. Calculate the number of neutrons. *[1]*

5. An atom has Z = 15 and A = 130. Another atom has Z = 14 and A = 30. Are they atoms of the same element? Justify your answer *[2]*

6. **Name** and draw orbital diagrams for these elements. *[10]*
   1. Mg 2. Cl 3. P-31 4. Z = 53

[18 marks in total]