CHAPTER 3 ATOMIC STRUCTURE

OVERVIEW

Chapter 3 begins with Rutherfords's experiment that leads to the nuclear model of the atom of matter and moves chronologically forward to the electronic arrangement, periodic table, and properties of atoms.

INSTRUCTIONS & QUIZ

- **Study** chapter 3 Lecture Notes and multimedia in Laulima Modules
- Do all the learning checks, self-assessment and worksheet.
- Take practice quiz #2 unlimited times (online class)
- Take **actual quiz #2** (online class)
- Do the chap 3 extra credit.

OBJECTIVES

After completing this chapter, you should be able to:

1. Discuss structure of an atom
2. Compare the charge, mass and location of electrons, neutrons, and protons in an atom.
3. Explain the terms atomic number and mass number
4. Understand the meaning of an isotope
5. Determine the number of protons and neutrons in an element given the nuclear symbol.
6. Predict the electron arrangement of any element based on its atomic number or location in periodic table.
7. Identify the major regions of the periodic table are the main group elements and the transition metals.
8. Define a group and a period in the periodic table
9. Name the common groups in the periodic table: alkali metals, alkaline earth's, halogens and noble gases.
10. Describe the influence of valence electrons on chemical reactivity and physical properties.
11. Know the trends in the periodic table: predict whether an element is a metal, nonmetal, or metalloid
12. Write the Lewis symbol of elements.

ORGANIZATION

Chapter 3 – Atomic structure is divided into four sections:

A. Atomic Nucleus
B. Electron Arrangement
C. Periodic Table
D. Valence Electrons & Periodic Table
E. Metals, nonmetals and metalloids
F. Lewis Structures of Atoms

SELF-STUDY/REVIEW QUESTIONS

Use the following questions as a self-assessment tool to help you gauge your understanding of the course material in this Module.

Recall from the previous chapter:

1. The periodic table contains all known elements. **Please tear off the periodic table preceding this page, and use this as your handout whenever you study, or take a quiz. Please do not write anything on the periodic table.**
2. Atoms are the smallest units of an element that have the same properties as the element.

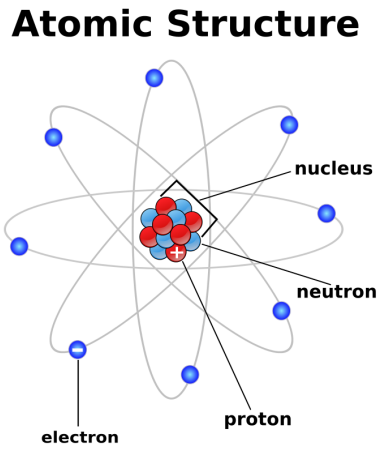
Know the following:

1. An atom is neutral. In an atom, the number of protons is equal to the number of electrons.
2. The protons and neutrons are found in the nucleus. The mass is concentrated in the nucleus.
3. Electrons (are negative) are found outside the nucleus and move in specifically shaped volumes of space called orbitals.
4. The way the electrons are arranged in an atom determines the properties of the atom or element. This is called the electronic configuration of the atom. The pattern in the electronic arrangement of the atom is found in the periodic table.
5. Elements in the same group (vertical column) have the same number of valence electrons and have similar chemical properties.
6. When valence electrons are lost or gained, atoms become ions.
7. Metal elements have the tendency to lose valence electrons while nonmetals have the tendency to gain valence electrons.
8. Know the following terms:

Key terms:

alkali metals
alkaline earth metal
atomic number
electron configuration
electrons
groups
halogens
Lewis symbol
isotopes
main group elements
mass number
metals
neutron
noble gases
nonmetals
nucleon number
nucleons
nucleus
orbital
periods
proton
shell
subshell
transition elements
valence electrons

Chapter 3 Atomic Structure



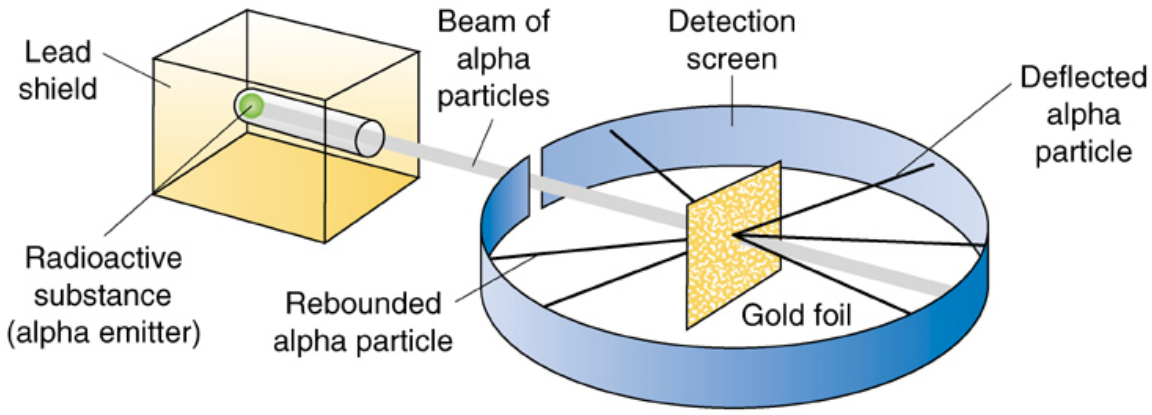
Recall that an atom is the smallest unit of an element. Atoms can chemically join together to make molecules.

But, what are atoms made of? Atoms are composed of particles called protons, electrons and neutrons. Protons carry a positive electrical charge, electrons carry a negative electrical charge and neutrons carry no electrical charge at all. The protons and neutrons cluster together in the central part of the atom, called the nucleus, and the electrons 'orbit' the nucleus. A particular atom will have the same number of protons and electrons and most atoms have at least as many neutrons as protons.

Section A. The Nucleus.

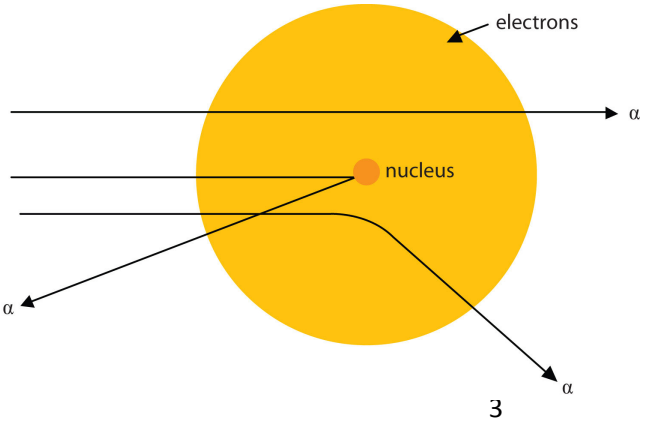
How was it discovered? Rutherford Gold Foil Experiment. Using an apparatus similar to that shown below, Ernest Rutherford discovered the atomic nucleus. The gold foil experiment was strong and convincing evidence that led to the theory of the nuclear atom.

Rutherford Gold Foil Experiment



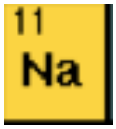
The atoms in the gold foil were bombarded with alpha particles. Over 99% of the alpha particles went through the gold atoms. Less than 1% of the alpha particles were deflected. These were deflected because they hit the nucleus where nearly all of the mass of the atom is concentrated. "It was almost as incredible as if you fired a 15-inch shell at a piece of tissue and it came back and hit you."

-Ernest Rutherford



The Atomic Nucleus: What particles are in the nucleus?
The nucleus contains protons (+1 charge) and neutrons (neutral). These particles have about the same mass, hence, nearly all the mass of the atom are concentrated in the nucleus. Electrons are outside the nucleus, have a -1 charge, and only a fraction of the mass of the proton and neutron.

Atomic Number: number of protons in a nucleus. An element has a fixed number of protons. It determines the identity of the atom, like our SSN. This number is found with the element symbol in the periodic table. See examples. The Na (sodium) atom has 11 protons, while the Cl (chlorine) atom protons. In the periodic table, the elements are arranged in increasing atomic number. This number is always a whole number.



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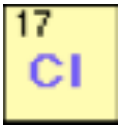

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Number of Electrons: The number of electrons orbiting the nucleus in an atom is the same as the number of protons. Atoms are neutral, so if an atom has 11 protons, then it should have 11 electrons.

Periodic Table: You should familiarize yourself with the periodic table. Find the periodic table link in modules and get to know how to find the element and its atomic number. Then do this learning check. Find the atomic symbol and atomic number for each of the following elements.

(a) nitrogen
(b) potassium
(c) gold
(d) oxygen

Answers:

Element	*Symbol*	*Atomic Number*
Nitrogen	*N*	*7*
Potassium	*K*	*19*
Gold	*Au*	*79*
Oxygen	*O*	*8*

Learning check: How many protons and electrons are there in each atom of

(a) nitrogen
(b) potassium
(c) gold
(d) oxygen

Answers:

Element	*Symbol*	*Number of protons*	*Number of Electrons*
Nitrogen	*N*	*7*	*7*
Potassium	*K*	*19*	*19*
Gold	*Au*	*79*	*79*
Oxygen	*O*	*8*	*8*

Isotopes have the same number of protons but different number of neutrons. Isotopes are atoms of the same element having different numbers of neutrons, and thus varying in mass.

Mass (Nucleon) Number: sum of protons and neutrons in a nucleus

Isotopes have the same atomic number but different mass number. For example:
Hydrogen exists as **Hydrogen-1** (1 proton and zero neutron), **Hydrogen-2** (1 proton and one neutron) and **Hydrogen-3** (1 proton and 2 neutrons). The three forms are drawn below and are called isotopes of hydrogen. Isotopes of an element have the same chemical properties but different weights. Some elements have many isomers. Tin (Sn) has about 38 known isotopes.

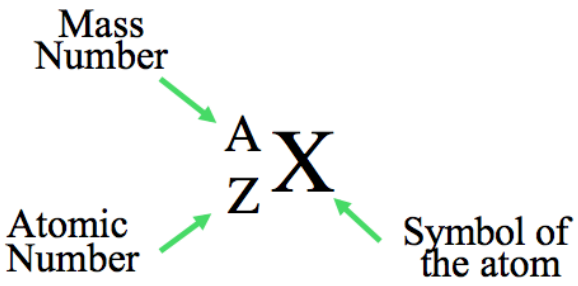
Hydrogen-1 Hydrogen-2 Hydrogen-3

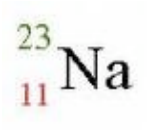
Learning Check. If unsure your answers are correct, please post in Laulima Discussion.

1. The three basic components of an atom are: _____, _____ and _____.
2. An element is identified by the number of _____.
3. The nucleus of an atom consists of _____ and _____.
4. A single proton has what electrical charge?_____.
5. Which particles have approximately the same size and mass as each other? _____ & _____
6. The atomic number of an atom is the same as the number of _____.
7. Changing the number of neutrons of an atom changes its _____.
8. Rutherford's gold foil experiment demonstrated the existence of a _____ in an atom.
9. Look at the periodic table and tell the number of protons of gold (Au): _____.
10. The mass (or nucleon) number of Hydrogen-3 is _____.

Ans: pen, p, pn, +1, pn, p, mass, nucleus, 79, 3

Section B. Nuclear Symbol: can distinguish isotopes. Watch the video. The periodic table contains the symbol and atomic number of the elements but does NOT contain any information about the isotopes. Hence, nuclear symbols of the following format is used:



Example: 

What information can you get from this **nuclear/isotope symbol**?
Translation: mass (nucleon) number = 23
atomic number = 11
In the isotope symbol, the atomic number is written as a subscript (bottom left).
Please note that in the periodic table, the atomic number is most often written above the symbol. In order to avoid making a mistake, please use the whole number (not the number with decimal point).
Answer:

1. The name of this isotope is **Sodium-23.**
2. From its atomic number (11), you can tell that sodium has **11 protons**.
3. Sodium atom has 11 electrons because the number of protons =number of electrons.
4. Number of neutrons: Subtract 23-11 = **12 neutrons**

In other words, given this symbol one should be able to determine the number of protons, electrons and neutrons. Please be aware that sometimes the number 11 is omitted because this is available in the periodic table.

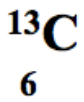
More Examples:

a. How many protons, electrons and neutrons are in **Lithium-7**?

# of protons	# of electrons	# of neutrons
3	3	7-3 = 4

b. How many protons, electrons and neutrons are in **Carbon-13**? Write its isotope symbol. Ans. Here you are not given the symbol, only the name. You should know that the number 13 is the mass (nucleon) number. You should look at the periodic table to know its atomic number. On your own, you should be able to figure out that

# of protons	# of electrons	# of neutrons
6	6	13-6 = 7

The isotope symbol is 

Conceptual Example. Write the nuclear symbol for tritium (hydrogen-3) atom?
Solution:
From the periodic table, we find the atomic number of hydrogen is 1. The mass (or nucleon) number is given as 3. The symbol is 

Conceptual Example. How many protons, electrons and neutrons are there in the atom? $^{235}_{92}U$

Solution: 92 protons, 92 electrons, 143 neutrons

Z (subscript) is 92, which means 92 protons. An atom means it is neutral, hence the no.of protons (+) is equal to no. of electrons (-). Therefore no. of electrons is also 92.
To determine no. of neutrons, simply subtract the atomic number *Z* (number of protons) from the nucleon number *A* (number of protons plus neutrons).
***A* – *Z* = number of neutrons**
235 – 92 = 143
There are **143 neutrons** in the nucleus.

Conceptual Example. How many neutrons are there in the strontium-90 nucleus?
Solution:

From the periodic table, we find the atomic number of strontium (Sr) is 38. The nucleon number is given as 90. The number of neutrons is therefore
90 – 38 = 52

Conceptual Example. Refer to the following isotope symbols, in which we use the letter X as the symbol for all elements so that the symbol will not identify the elements. Which are isotopes of the same element?

$^{16}_{8}X$ $^{16}_{7}X$ $^{14}_{7}X$ $^{14}_{6}X$ $^{12}_{6}X$

Solution
Isotopes of the same element will have the same atomic number (subscript).
Therefore, the isotopes of nitrogen (N) are $^{14}_{7}X$ and $^{16}_{7}X$

The isotopes of carbon (C) are $^{12}_{6}X$ and $^{14}_{6}X$

Learning Check

1. An atom of zinc (Zn) has a mass number of 65. What is its number of
A. protons
B. electrons
C. neutrons

2. Write its nuclear/ isotope symbol.

Ans: 30, 30, 35

Section C. Electron Arrangement or electron configuration.

The electron configuration is the arrangement of the electrons in space around a nucleus. The electrons are found in different **orbitals** (paths around the nucleus). The names of the orbitals are **1s, 2s, 2p, 3s, 3p, 3d**, etc. The ***number*** in the name of the orbital refers to the **main energy level**, which is determined by the electron's distance from the nucleus. The closer it is to the nucleus, the lower is its energy. The lowest energy orbitals are filled up first. The letter, ***s, p, d,*** and ***f*** refers to the **orbital sublevel**.

Each main energy level has a number of sublevels equal to its value. Main energy level "1" has only 1 sublevel, called the "1s" orbital. Main energy level "2" has two sublevels, namely: 2s and 2p. Main energy level "3" has three sublevels, namely: 3s, 3p and 3d. Main energy level "4" has four sublevels, namely: 4s, 4p, 4d and 4f.
Only the 4 main energy levels are shown in the table below.

Main Energy Level	Has this number of orbital sublevels	Name of **orbital sublevels**
1	1	**1s**
2	2	**2s** and **2p**
3	3	**3s, 3p** and **3d**
4	4	**4s, 4p, 4d** and **4f**

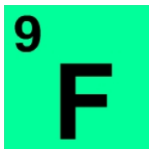
To **write the electron configuration**, you simply need to know two things: (1) how many electrons the particular atom has, and (2) the standard **electron configuration pattern**. The number of electrons in a **neutral atom** is the same as the atomic number of the element (look at the periodic table). The **standard electron configuration pattern** is as follows:

$$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^6 7s^2 5f^{14} 6d^{10}$$

The small raised numbers, called ***superscripts,*** represent the maximum number of electrons each orbital sublevel can hold. An orbital sublevel may hold LESS electrons than its maximum, but it can *never* hold MORE. Note that each "s" gets 2 electrons. Each "p" gets 6 electrons. Each "d" gets 10 electrons. Each "f" gets 14 electrons.

Once you can write the standard electron configuration pattern, you can then write the electron configuration for any atom or ion. To write the electron configuration, you just count the number of electrons you have and use as many orbital sublevels as you need to hold all your electrons. Be sure to always fill the lowest energy levels first.

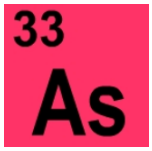
Example 1: What is the electron configuration of fluorine (F)?



A neutral atom of fluorine has **9 electrons**. We need to distribute the 9 electrons in the **electron configuration pattern**. The **1s orbital can hold 2 electrons** and the **2s orbital can hold 2 more electrons**. The **five remaining electrons** must go into the next orbital, the **2p orbital**. The 2p orbital can hold up to 6, but we only have 5. So the correct electron configuration for a neutral atom of fluorine is: 2 + 2 + 5 = 9.

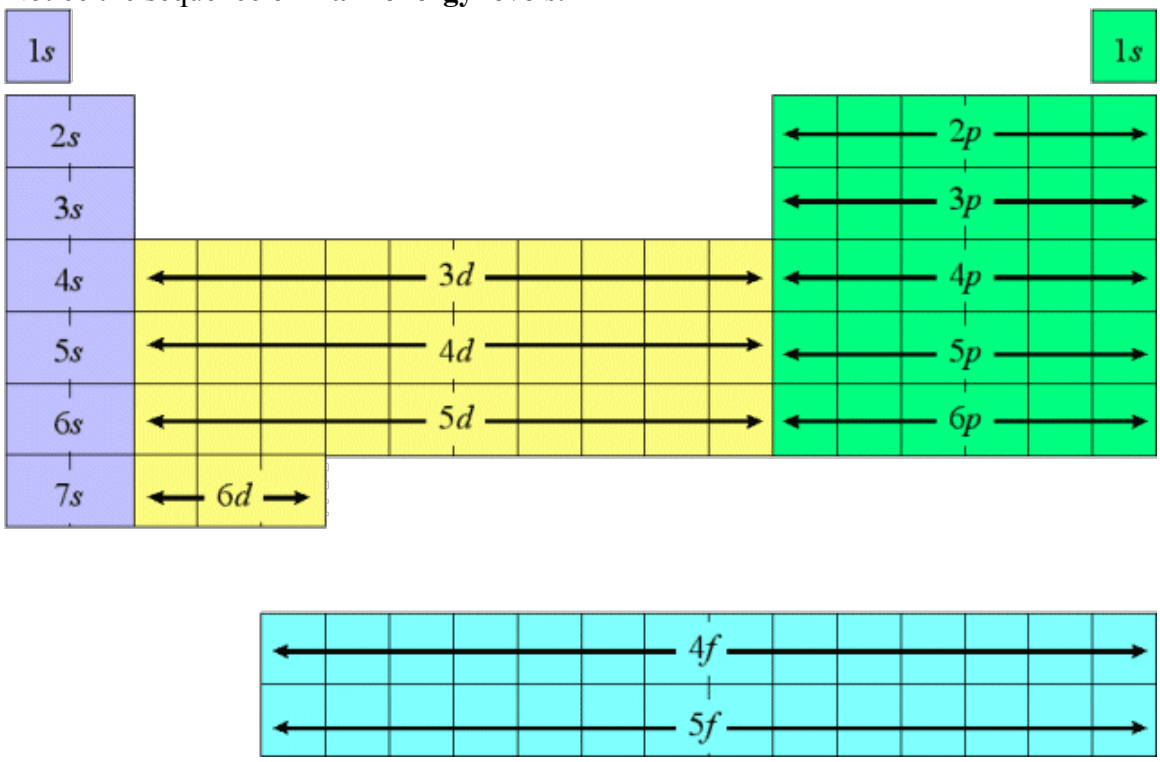
The electronic configuration of a neutral F atom is: $\mathbf{1s^2 2s^2 2p^5}$

Example 2: What is the electron configuration of arsenic (As)?



Arsenic has atomic number 33. Fill up all the orbital sublevels in the **electron configuration pattern** until you get to the 3d orbital sublevel. Then you would have only 3 electrons left. 2 + 2 + 6 + 2 + 6 + 2 + 10 + 3 = 33. The electron configuration for arsenic is as follows: $\mathbf{1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^3}$

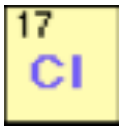
How do you remember the electronic configuration pattern? By using the periodic table below. The electronic configuration pattern is in the periodic table. Notice the **s, p, d and f blocks**. Notice the sequence of **main energy levels**.



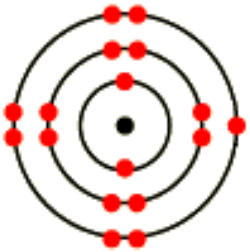
Find the location of fluorine (F) and arsenic (As) in the table above. Please use this link to learn more examples. https://www.youtube.com/watch?v=8TZ97JLWqMA

Atomic Models. The electron configuration can tell you how many energy levels an atom has and how many electrons are in each level. From this, you can draw the atomic model.

Example: What is the electronic configuration of chlorine (Cl) and draw the atomic model. First, write the electron configuration of chlorine:



$1s^2 2s^2 2p^6 3s^2 3p^5$



The "1s" is on main level 1, "2s" and "2p" are in main level 2, while "3s" and "3p" are in main level 3. It has two electrons in the first main level, eight electrons (2 + 6 = 8) in the second main level and seven electrons (2 + 5 = 7) in the third main level (outermost).

The atomic model shows the nucleus at the center and surrounding it, are the three main energy levels. Each electron is drawn as a small red sphere.

main level 1	**$1s^2$**	**2 electrons**
main level 2	**$2s^2\ 2p^6$**	**2+6 = 8 electrons**
main level 3	**$3s^2\ 3p^5$**	**2+5 = 7 electrons**

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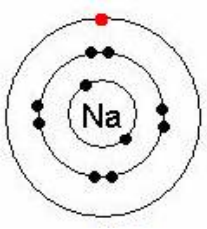
Learning Check: What is the electron arrangement in the sodium (Na) atom? Draw the model of Na atom.

Solution: Na has atomic number 11.
Its electronic configuration is as follows: $1s^2 2s^2 2p^6 3s^1$
This drawing is the atomic model:



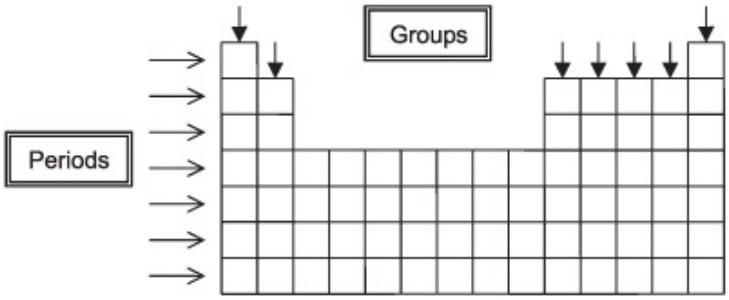
Valence Electrons. There is an important significance in the **outermost level**, called the valence shell. **Valence electrons** determine the properties and chemical reactivity of the element.

Example: How many valence electrons does chlorine (Cl) have? Look at the atomic model of chlorine Count the number of electrons in the outermost level. You should count 7 electrons. **Cl has 7 valence electrons.**

Example: How many valence electrons does sodium (Na) have? Look at the atomic model of Na. How many valence electrons? **Na has 1 valence electron.**

Section D. The Periodic Table.

Elements in the periodic table are arranged in **periods** (rows) and **groups** (columns).

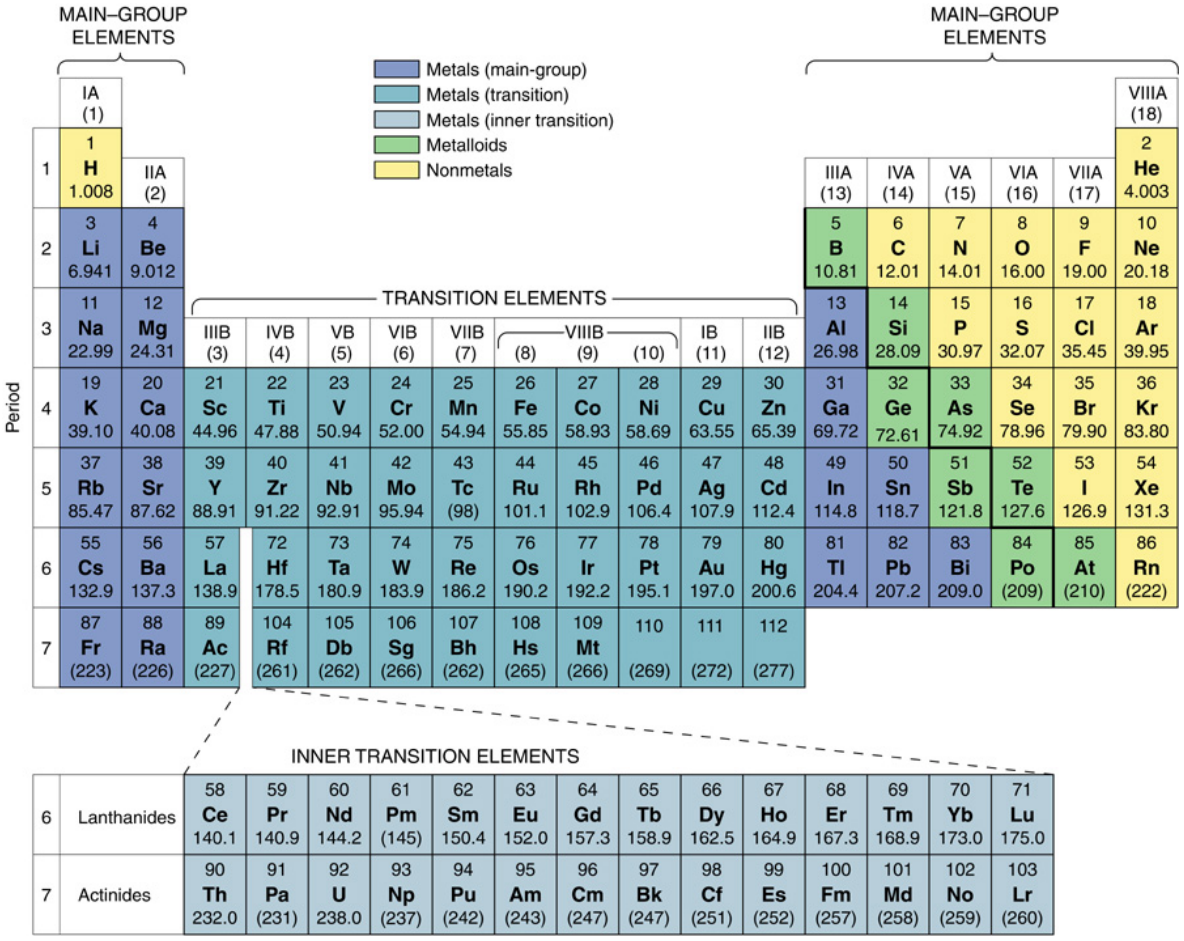


Periods. The ***first period*** contains only hydrogen (H) and helium (He). The ***second period*** has 8 elements: lithium (Li) through neon (Ne). The ***third period*** also contains 8 elements: sodium (Na) through argon (Ar). The ***fourth period*** has 18 elements: potassium (K) through krypton (Kr). The ***fifth period*** also has 18 elements: rubidium (Rb) through xenon (Xe). The ***sixth period*** has 32 elements; cesium (Cs) through radon (Rn). To make the table less bulky, the sixth and seventh period rows have been divided. These rows are shown fully expanded at the bottom of the chart. The elements in the *last two rows* are called **inner transition elements**.

Groups. The groups of the Periodic Table are numbered most frequently with Roman numerals (**A and B**). In some cases, the A/B designation is dropped, and the numbers 1 through 18 is

used. The **A groups** are called the main groups or ***representative*** **elements** and the **B groups** called the ***transition*** **elements**.

Basically, groups of elements are divided into four main classes.
(1) Representative or Main Group elements (groups IA-VIIA)
(2) Noble or inert gases (group VIIIA)
(3) Transition metals (group B elements)
(4) Inner transition metals



Learning Check

Look at the periodic table and identify the period and group to which each of the following elements belongs:

a) Si b) element number 21 c) zinc d) element number 35

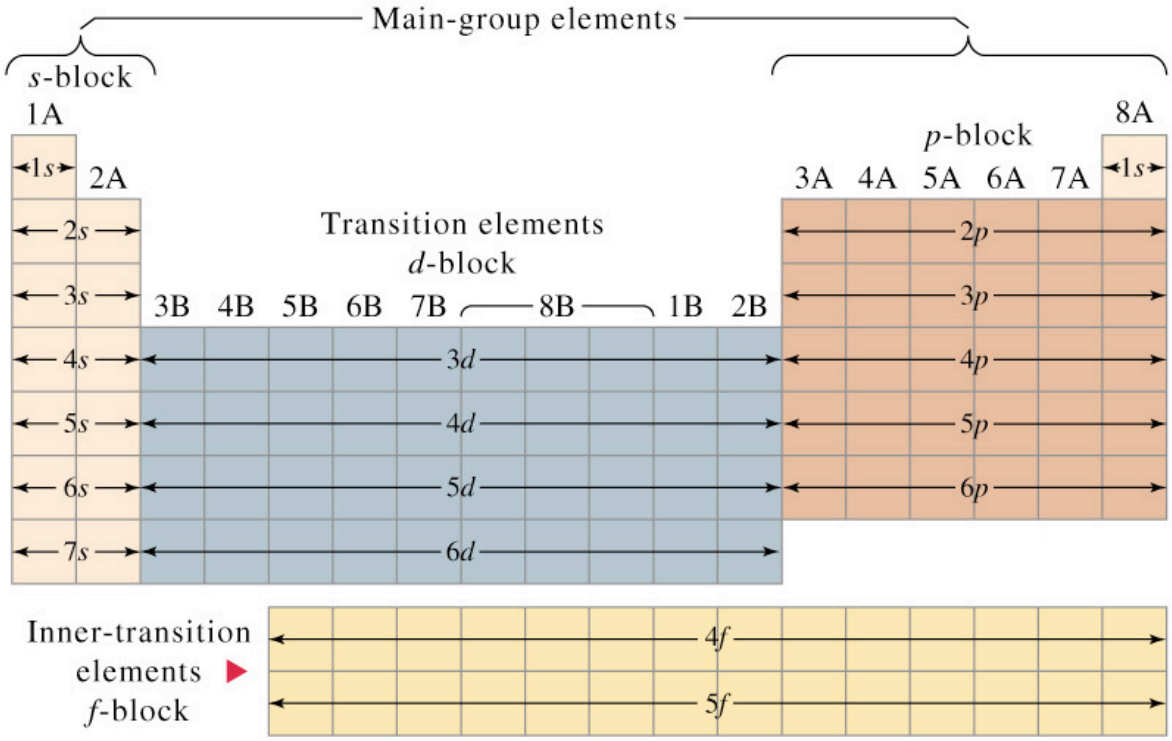
Ans. a) Period 3, group IVA b) Sc, Period 4, group IIIB c) Period 4, group IIB d) Br, Period 4, group VIIA. Si and Br are representative elements while Sc and Zn are transition elements.

The ***representative elements*** or main group of elements is further defined as follows. **Group IA**, the *alkali metals* (e.g., lithium, potassium), are all soft metals that react readily with water. **Hydrogen is a group by itself**. H is a gaseous nonmetal. It does NOT belong to alkali metals. **Group IIA**, known as the *alkaline earth metals* (e.g., beryllium, cadmium), are also reactive chemically. The *halogens*, group VIIA, are all non-metals. *Chalcogens*, group VIA (e.g., oxygen, sulfur), comes from the Greek word *chalkos* meaning ore. Many ores are made with varying amounts of oxygen and sulfur. The rest of the representative element groups (IIIA-VA) have not been given descriptive names. All representative elements fill either the **s** or **p** orbitals last.

The ***noble* or *inert gases*** (group VIII) are called ***inert*** since they seldom form chemical compounds. In fact, helium, neon, and argon don't form any compounds at all. All these gases exist naturally as individual atoms in the environment. All noble gas elements have **8 valence electrons.**

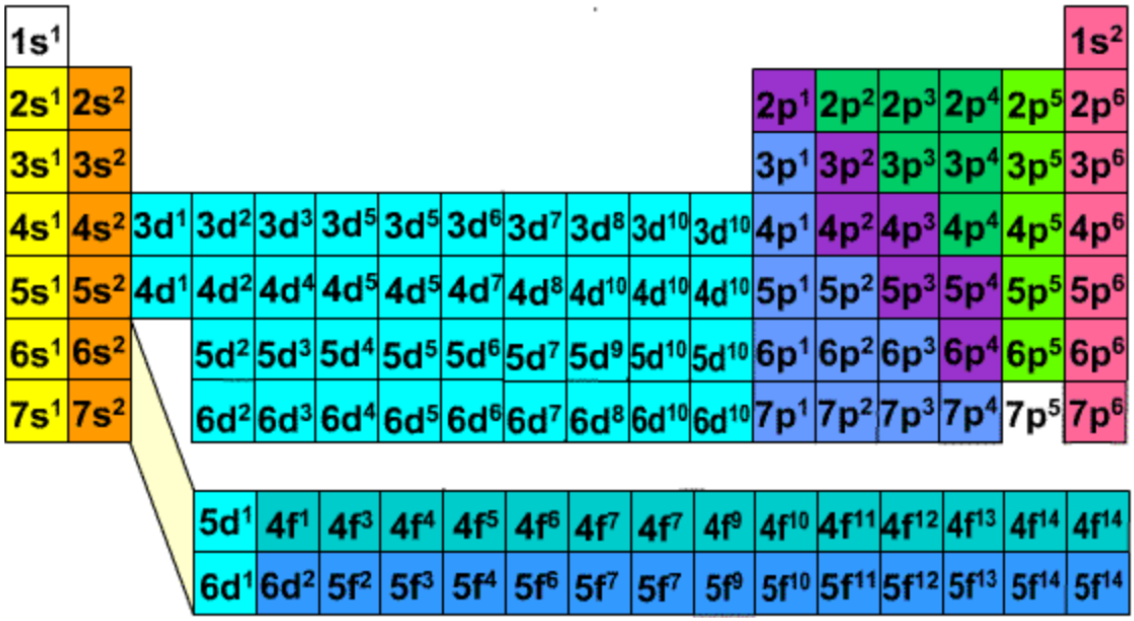
The ***transition metals*** (group B) contain the more recognizable metals. They are used in construction, coins, and jewelry. The transition metals group includes iron, nickel, and chromium as well as gold, silver, and copper. All transition elements fill the **d-orbital** last.

The ***inner transition metals*** consist of the 15 *rare earth* metals or lanthanides. They are all silvery white in color and used in such products as permanent magnets and headphones. The other inner transition metals, a set of elements named after the element actinium, include uranium, americium, and neptunium. They are primarily human-made elements. These metals are radioactive and used in advanced smoke detectors, neutron-detection devices and in nuclear reactions. The inner transition elements fill the **f orbital** last.



Section E. Valence Electrons & the Periodic Table.

By experiment, it is known that the properties of elements in the same column (**group**) behave similarly. And, when you look at their electronic configurations, they have the same number of electrons in their outermost shell. For example: the alkali metals in **Group 1A**, all have **one electron** in the outermost shell. This is reflected in the periodic table, hence it is used extensively to predict properties of elements.



Look at **Group IIA**, they all behave similarly and they all have 2 valence electrons. Look at **Group VIIA**, they are the halogens, all are similar in behavior and all have 7 electrons in the outermost shell. And, **Group 8A** all have eight electrons in the outermost shell. All the elements with eight valence electrons are ***inert*** (unreactive). And this group is called the '***Noble Gases***.'

The **Group number** of representative (main-group A) elements coincide with the **number of valence electrons**. And, they have similar chemical properties. The number of electrons in the valence shell is the same as the group number of the element in the periodic table.

Group	Special Name	Valence electrons
Group IA **(except H)**	**Alkali Metals**	*1*
Group II A	**Alkaline Earth Metals**	*2*
Group VII A	**Halogens**	*7*
Group VIII A	**Noble Gases**	*8*

One final note about electron configurations. You can use the periodic table to quickly determine the valence electrons of each element.

The **valence electrons** are the outermost electrons in an atom—the ones that are involved in bonding. Elements in a group or family have the same number of valence electrons. For example: Li (Period 2, Group IA): Na (Period 3, Group IA): Both have *one valence electron*.

The **number of valence electrons** coincides with the **group number**. The next element in Group IA is K, it is in period 4, will have four main levels, yet, the outermost will have only one electron as well. The period number tells us how many main levels/shells there are around the nucleus, and the **group number tells us the number of valence electrons.**

Learning Check

Look at the periodic table and predict the number of valence electrons of the following elements:

a) element number 51 b) the fifth element (reading left to right) in period 3
c) Al d) the third element (reading down) in group VIA(16)

Ans. a) Sb (Group VA) = 5 b) P (Group VA) = 5 c) Al (Group IIIA) = 3 d) Se = 6

Real life application. Radioactive isotopes of strontium (Sr) are released by the explosion of nuclear weapons and in nuclear fallout. These are considered serious health hazards because they are incorporated into the bones of animals that ingested them. Explain why Sr would be likely to be deposited in bones.

Solution
Animal bones contain large amounts of calcium. Since **calcium (Ca) and strontium (Sr)** are both in group IIA, strontium is similar to calcium and would be deposited into new bone growth with the calcium.

Which of these is used by Corning to replace Na in making unbreakable HercuGlass? Mg, K, Br or Ne?

Ans. K (because like Na, K is located in Group IA)

In order to have a healthy thyroid, which of these should be avoided? Kr, Cr, Na or Br?

Ans. Br and I appear similar to the thyroid gland. Bromine inhibits the activity of iodine.

Learning Check

1. The noble gases are sometimes referred to as inert gases. Why?
Hint: What is the meaning of inert.
Solution

For the most part, they are chemically unreactive (inert). This is because each has a completed octet (eight electrons in the outermost shell.

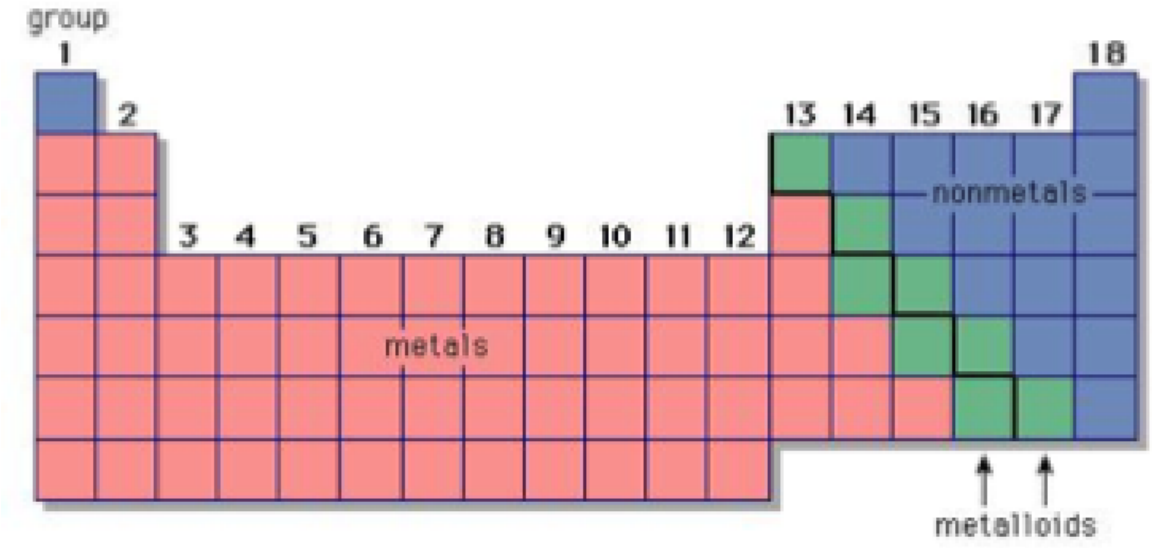
2. Classify the following elements as representative, transition, inner-transition, or noble gases. a) W b) Cm c) element number 10 d) helium e) barium

Ans. a) transition b) inner-transition c) noble gas d) noble gas e) representative

Tell what type of element is U? Ans. Inner-transition
How about Zn? Ans. Transition
How about K? Ans. Main-group/representative

Section F. Metals Vs. Non-metals

Observe that metals and non-metals are shown on the Periodic Table by a *heavy zigzag line* with **metals to the left side** and **non-metals to the right**. The **periodic table** below shows this dividing line. The elements along the zigzag line are metalloids, except Al which is a metal.



Metals, about 80% of the elements, can be pulled into thin wires (ductile) or pounded into sheets (malleable). *Most* **metals** are shiny solids and good conductors of heat and electricity. Mercury is the only metallic element that is liquid at room temperature. **Metals** readily **lose** their valence electrons.

Non-metals. Most are gases such as helium and argon, or brittle solids such as phosphorus and selenium. Bromine is the only liquid, non-metallic element at room temperature. **Nonmetals readily gain valence electrons.**

Metalloids. The elements found along the zigzag borderline are known as *semi-metals* or *metalloids* since they have the characteristics of both metals and non-metals (example: shiny but brittle). For example, silicon is used to make lubricants, computer circuits, and medical implants and joints. The other semi-metals or metalloids are B, Si, Ge, As, Sb and Te..

Again, this is due to the number of valence electrons. If the number of valence electrons is 1 to 3, the atom is metallic, and if the number of valence electrons is 4 to 7, it is nonmetallic, and when the number of valence electrons is 8, then it is a noble gas.

Across a period, the metallic property decreases. This means Na is more metallic than Mg (both are in Period 3). **Down a group, metallic property increases**. This means Ca is more metallic than Mg (both are in Group 2).

Example 1. Predict the order of metallic property of Na, Mg and K?
Ans. K is most metallic, followed by Na and then Mg
Example 2. Predict whether Pb is more metallic than C? Yes!

Example 3: Predict whether Sulfur (S) is a metal, semimetal or nonmetal?
Ans. S is to the right of the zigzag line. It is nonmetal.

Learning Check
Classify the following as metals, nonmetals, or metalloids. a) rubidium b) arsenic c) element number 50 d) S e) Br

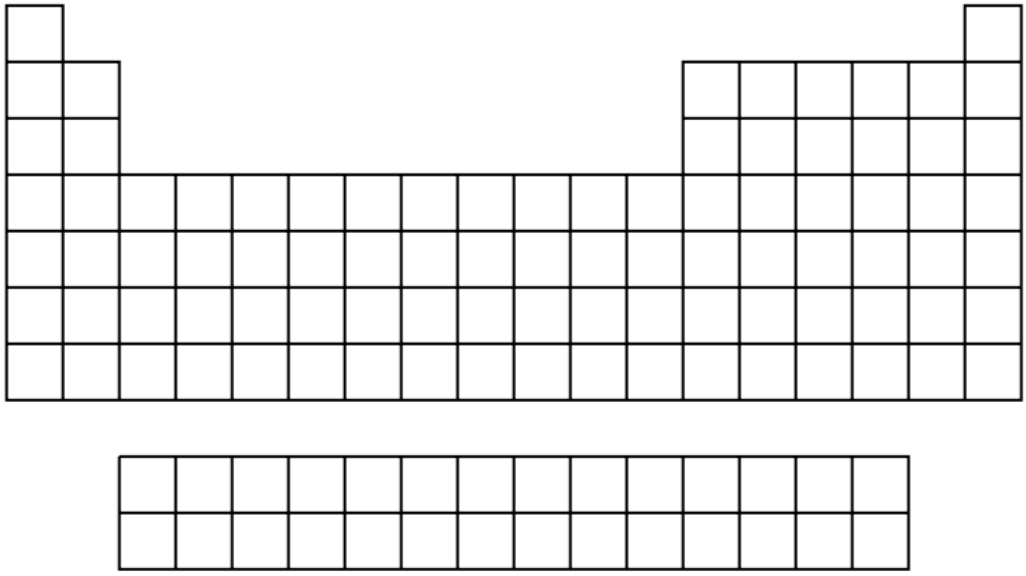
Ans. Locate the zigzag line. If the element is to the left, it is a metal.
a) metal b) metalloid c) metal d) nonmetal e) nonmetal

Learning Check
Use trends within the periodic table to predict which member of each of the following pairs is more metallic. a) C or Sn b) Sb or In c) Ca or As d) Al or Mg

Ans. Elements to the left in a row or down in a column are more metallic.
a) Sn b) In c) Ca d) Mg

Real world application. Which of these appear as metals and which are nonmetals?

Learning Check
Using colored pens, label the following sections on the blank periodic table below: metals, nonmetals, metalloids, representative, noble, transition and inner-transition elements.



Section G. Lewis (Electron Dot) Symbols. G. N. Lewis developed a method of visually representing the **valence electrons** as dots around the symbol of an atom. For example, **F atom has 7 dots** because it has **7 valence electrons** (Group 7A). Please follow the rule: distribute the electrons singly first, as in doing the "sign of the Cross." If there are more electrons, make another "sign of the Cross" distribution. Do not immediately pair the electrons. Distribute the dot singly to all four sides of the atomic symbol. Pair the dot only after all the four sides have one dot. You will use the dot symbols in the next chapter.

TABLE 5.1 Lewis Symbols for Selected Main Group Elements

Group 1A	Group 2A	Group 3A	Group 4A	Group 5A	Group 6A	Group 7A	Noble Gases
H·							He:
Li·	·Be·	·B·	·C·	:N·	:O·	:F·	:Ne:
Na·	·Mg·	·Al·	·Si·	:P·	:S·	:Cl·	:Ar:
K·	·Ca·				:Se·	:Br·	:Kr:
Rb·	·Sr·				:Te·	:I·	:Xe:
Cs·	·Ba·						

Learning Check

Refer to the group numbers of the periodic table and draw Lewis structures for the following:
a) lithium b) sodium c) chlorine d) boron

a) Li• Group IA(1) b) Na• Group IA(1)

c) :Cl:• Group VIIA(17) d) •B• Group IIIA(13)

Learning Check

What period 2 element has chemical properties similar to silicon? How many valence-shell electrons does this element have? How many valence-shell electrons does silicon have?

Solution

Carbon. C and Si are both located under Group IVA, and have 4 valence shell electrons.

Learning Check. How many elements do you know? What element…

a.	…has the same name as a U.S. coin?	ALUMINUM
b.	…is a metal and is found in blood?	NICKEL
c.	…is an important mineral found in milk?	PLATINUM
d.	…is needed in order for something to burn?	IRON
e.	…is used in glowing signs?	FLUORINE
f.	…makes balloons float?	HELIUM
g.	…is found in toothpaste to help prevent cavities?	OXYGEN
h.	… is used to make airplanes?	CALCIUM
i.	…helps to purify water in swimming pools?	CHLORINE
j.	…is used to make jewelry?	NEON

Chapter 3 Self-Assessment: (answers are in the Appendix)

1. What is the number of protons, electrons and neutrons of $^{55}_{26}Fe$

A 26 p, 26 e, 55 n
B 55 p, 55 e, 26 n
C 26 p, 26 e, 29 n
D 26 p, 29 e, 29 n

2. **Write the atomic symbol for the atom with 17 p^+, 20 n, 17 e^-?**

A $^{37}_{20}Ca$

B $^{17}_{37}Cl$

C $^{37}_{17}Cl$

D $^{34}_{20}Ne$

3. A noble gas in Period 4
A. Silver B. arsenic C. krypton

4. Which of these is incorrectly paired?
A. Na, alkali metal B. Ba, alkaline-earth
C. O, halogen D. Ne, noble gas

5. Based on electron configuration, which of the elements below would exhibit a chemical behavior most like that of oxygen?

A. C
B. H
C. N
D. S
E. P

6. Oxygen (atomic number = 8) has how many electron(s) in its first main level and in its second main energy level, respectively?

A. One: seven
B. Two: six
C. Four: four
D. Six: two
E. Eight: none

7. How many electrons does nitrogen (N), have in its outermost (valence) energy level?
A. 4
B. 8
C. 7
D. 5
E. 2

8. What is the total no. of electrons and (valence electrons) of P?
A. 30 (5)
B. 15 (5)
C. 15 (3)

9. Which of these is a transition element?
A $_{38}Sr$
B $_{79}Au$
C $_{9}F$

10. Which pair of elements have similar chemical properties?
A $_{37}Rb$ and $_{38}Sr$
B $_{7}N$ and $_{82}$ Pb
C $_{9}F$ and $_{17}Cl$

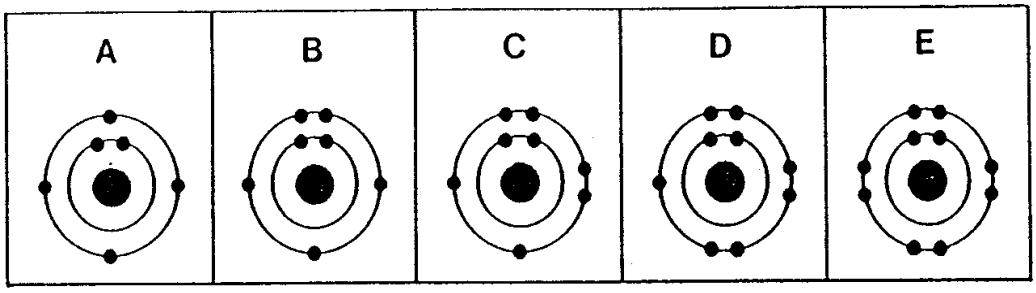
11. From its atomic number of 15, it is possible to predict that the phosphorus (P) atom has:
A. 15 neutrons
B. 15 protons and therefore 15 neutrons
C. a combined number of protons and electrons that total 15
D. 15 protons and therefore 15 electrons

12. Which elements have only one valence electron?
A. Alkali metals
B. Alkaline earth metals
C. Halogens

13. How many neutrons are there in Mg-25?
A. 12
B. 13
C. 25

14. ^{14}C is heavier than ^{12}C because ^{14}C has
A. two additional protons
B. two additions electrons
C. two additional neutrons
D. one additional proton and one additional neutron
E. one additional proton and one additional electron

15. Which of the below drawings depicts the electron configuration of neon (Ne)?



Chapter 3 Extra Credit.

Of all the elements, only about 20 are essential to health. The four major elements that make up 96% of our body mass are O, C, H and N. The macrominerals, present in lesser amounts, are Ca, P, K, Cl, S, Na and Mg. For each of the macrominerals, classify (whether metal or nonmetal?) and give one function in the human body.

Chapter 3 Worksheet Homework
(By Prof. B Reeves)

1. The nucleus was discovered by _____.

2. Fill in the chart

atomic particle	Charge	Mass	Location

3. Use the Periodic Table to find the symbol for
a. copper
b. hydrogen
c. oxygen
d. silver
e. magnesium
f. gold
g. lead
h. nitrogen
i. carbon
j. uranium

4. An isotope has the same number of _____ but a different number of neutrons.
An isotope has the same atomic number but a different _____ _____.

5. Tell the number of protons, neutrons, and electrons for each isotope

$^{190}_{50}Sn$ $^{238}_{92}U$

6. Fill in the table below:

Symbol	Atomic Number	Mass Number	Number of Neutrons
$^{1}_{1}H$			
	8	17	
	80		119
^{63}Cu			
	35		36

7. The **electronic configuration pattern** is the following:

8. On main level #1, there is the **1s** sublevel which can hold a maximum of _____ electrons. On main level #2, the **2s** sublevel holds ____ electrons and **2p** sublevel holds _____ electrons. The maximum total number of electrons in main energy level '2' is _____ electrons. This coincides with the number of elements in period 2 in the periodic table. On main level "3", there can be **3d** sublevel which can hold a maximum of _____ electrons. On main level "4", there can be the **4f** sublevel which can hold a maximum of _____ electrons.

An atom whose last electron fills an **s** or a **p** orbital is called a _____ element. An atom whose last electron fills a **d** orbital is a _____ element. An atom whose last electron fills an **f** orbital is called an _____ element.

9. What is the electron configuration for
a. Na

b. Ar

10. A _____ is a row on the periodic table and a _____ is a column on the periodic table.

11. a. Identify the element in the second period and Group VA.
b. Identify the element in the fifth period and Group IIA.
c. How would you describe Zn in terms of period and group?

12. How many valence electrons do the following elements have.
a. C b. N c. Ar d. K e. P f. Na

13. a. Find the element that is an alkali metal in period 6_____
b. Find the element that is an alkaline-earth metal in period 3_____
c. Find the element that is a halogen in period 5_____
d. Find the element that is a noble gas in period 4_____

14. Identify as a **representative** element, a **transition**, **metal**, a **noble gas**, or an **inner transition** metal.
a. helium b. uranium c. iron d. sulfur

15. _____ means does not react.

16. Across a period, the metallic property _____ and down a family, the metallic property _____

17. Write the **Lewis symbol** for K and Cl.