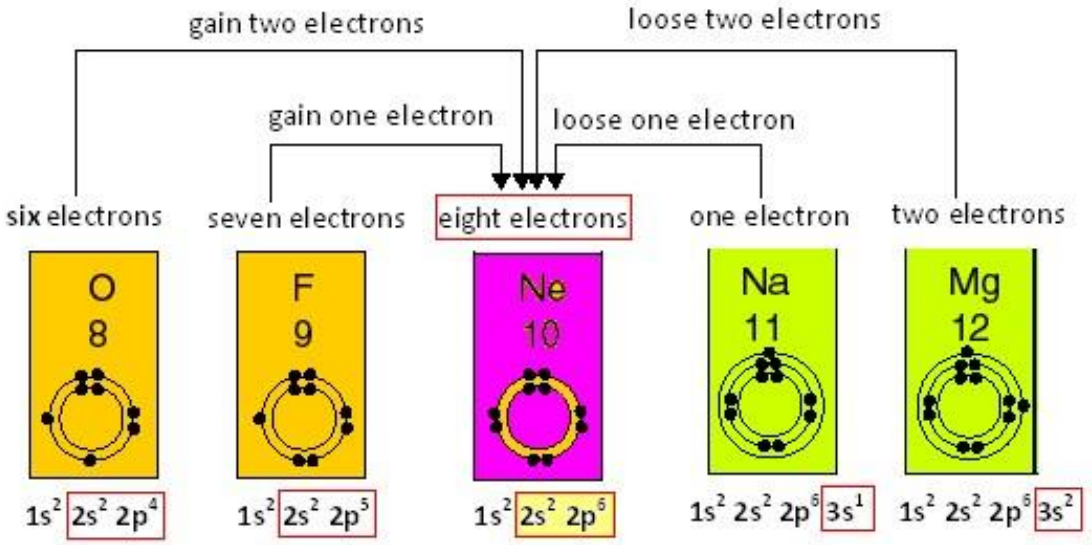
1. HOW ATOMS BOND: OCTET RULE.

Noble gases are the only elements that occur naturally as single atoms. In the rest of the elements, the atoms bond and form molecules or crystals. This fact can be explained by their electronic structure. The atoms of all noble gases have their **outer energy levels** (**valence shell**) **complete with 8 electrons** (except helium with 2). This electronic configuration is the most stable an atom can have, and because of this, noble gas atoms don't make bonds with any other element. The rest of the elements that do not have this electronic structure, tend to achieve this configuration and have 8 electrons in its valence shell. This is known as the **octet rule**.

To get the electronic configuration of the noble gases, atoms may:

Lose electrons.
Gain electrons.
Share electrons.



- Elements with 1, 2, or 3 electrons in their valence shell tend to **lose** electrons to fill their outer shell and become **cations**. These elements are the **metals** which always tend to lose electrons.
- Elements with 5 to 7 electrons in their valence shell tend to **gain** electrons to fill their outer shell and become anions. These elements are the **non metals** which always tend to gain electrons.

1.1 Lewis electron dot structures.

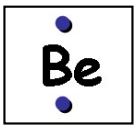
Lewis dot structures show the valence electrons distribution around at atom. It is very useful to represent the octet rule:

A neutral atom of Lithium has three protons and three electrons, giving an electron configuration of:

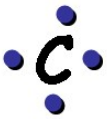
$1s^2$ $2s^1$, meaning it has ONE electron in its valence shell.

A neutral atom of Beryllium has four electrons, giving an electron configuration of:

$1s^2$ $\boxed{2s^2}$, meaning it has TWO electron in its outermost shell.



In a similar way:

$_5$**B**: $1s^2$ $\boxed{2s^2\ 2p^1}$	$_6$**C**: $1s^2$ $\boxed{2s^2\ 2p^2}$	$_7$**N**: $1s^2$ $\boxed{2s^2\ 2p^3}$	$_8$**O**: $1s^2$ $\boxed{2s^2\ 2p^4}$	$_9$**F**: $1s^2$ $\boxed{2s^2\ 2p^5}$	$_{10}$**Ne**: $1s^2$ $\boxed{2s^2\ 2p^6}$
3 electrons	4 electrons	5 electrons	6 electrons	7 electrons	8 electrons
					

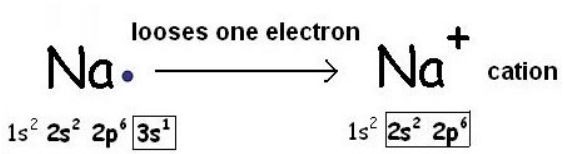
2. CHEMICAL BONDINGS.

Atoms are joined together by chemical bonds. We can say that a chemical bond is the strength that holds atoms together. There are three types of chemical bonds: ionic, covalent and metallic

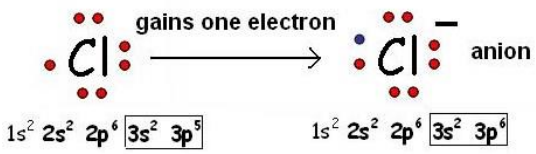
2.1. IONIC BOND.

It occurs when **metal atoms** bond with **non-metal atoms**, that is, when the atoms are far from each other in the periodic table. The metal atoms tend to lose electrons of the last energy level and form **cations** while the non metal atoms prefer to incorporate electrons in its outer energy level and form **anions**. The electrostatic **force of attraction** between a **cation** (positive charged) and an **anion** (negative charged) that hold the ions together is defined as the **ionic bond**.

Let's look at an example. Sodium (Na) has 11 electrons: its electron configuration is $1s^2$ $2s^2$ $2p^6$ **$3s^1$.** If sodium looses 1 electron in its 3rd shell, it will achieve the gas noble configuration.

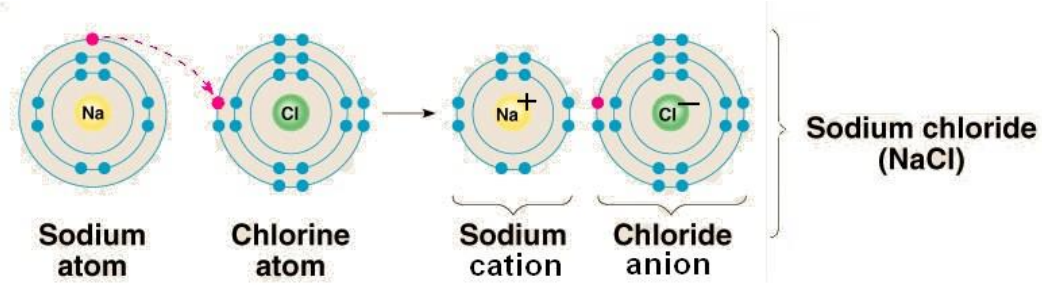


In its turn, chlorine (Cl) has 17 electrons: its electron configuration is $1s^2$ $2s^2$ $2p^6$ **$3s^2 \cdot 3p^5$**, so chlorine will try to pick up another electron to fill its outermost shell.



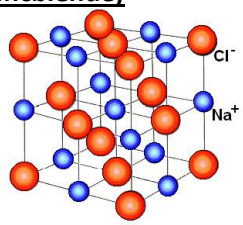
Thus chlorine and sodium are a perfect match for each other. One needs an electron and the other wants to lose an electron. When this transfer takes place, sodium loses an

electron and becomes a positive ion, and since chlorine gains an electron it becomes a negative ion. The opposite charges on the Na^+ and Cl^- ions will cause them to attract each other and form an **ionic bond**.

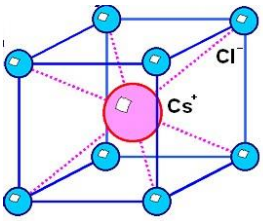


As a result of these electrostatic forces of attraction, each ion is surrounded by opposite charge ions which give rise to the formation of a three-dimensional **solid ionic crystal lattice**, so ionic compounds are solid at room temperature. An example of such substances is sodium chloride or table salt (NaCl).

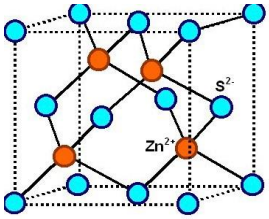
Sodium chloride crystal lattice (zincblende)



Caesium chloride crystal lattice



Zinc sulphide crystal lattice



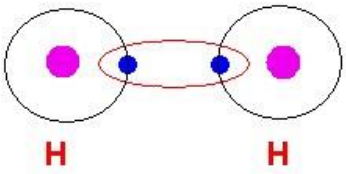
A crystal is a solid whose constituent particles are arranged in space following a pattern to form geometric figures.

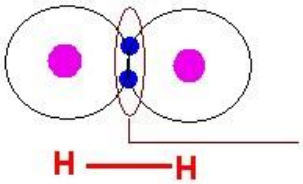
Physical characteristics of ionic solids.

- Ionic solids are hard and brittle.
- Ionic solids have high melting and boiling points.
- Ionic solids do not conduct electricity in a solid state but do so in the molten state or in solution.
- Ionic solids dissolve in water.

2.2 COVALENT BOND.

Covalent bonding occurs between two or more non-metal atoms. The atoms of non metals elements have similar or identical properties. Because both of the non-metals tend to gain electrons, the elements involved have to share electrons to fill their valence shells and achieve the configuration of noble gas. The shared electrons "belong" to both atoms in the bond. Thus, a **covalent bond** is formed by the sharing of one or more pairs of electrons between atoms





Covalent bond:
atoms share a pair of electrons to form a molecule

Covalent substances can be:

a) Molecules of elements
b) Molecules of compounds
c) Covalent solids.

a) Molecule of elements:

It is the covalent bonding of two or more atoms of the same element. Ex: H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2:

For example: In the molecule of fluorine (F_2), the fluorine atoms share one pair of electrons. Each fluorine atom contributes one electron, so that now each one is surrounded by 8, and gets the electronic configuration of neon.

F_2 { **F** (Z=9)= $\mathbf{1s^2\ 2s^2\ 2p^5}$; **F** (Z=9)= $\mathbf{1s^2\ 2s^2\ 2p^5}$

b) Molecule of compounds:

It is the covalent bonding of two or more atoms of different elements, Ex: H_2O, NH_3, CH_4, HF, HCl...

For example: In the molecule of water (H_2O), oxygen needs 2 electrons and hydrogen needs 1 to complete its valence shell, so an oxygen atom shares one electron with each of the two hydrogen atoms.

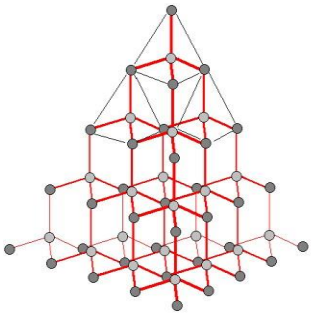
H_2O { **O** (Z=8)= $\mathbf{1s^2\ 2s^2\ 2p^4}$; **H** (Z=1)= $\mathbf{1s^1}$

Properties of molecules:

- They are gases or liquids at room temperature.
- They have low melting and boiling points.
- They are poor conductors of electricity.
- They are insoluble in water but they dissolve in organic solvents.

c) Covalent solids.

Covalent solids are substances in which every atom is bonded to its neighbours by a *covalent* bond. This gives rise to a three-dimensional network of atoms. An excellent example is **diamond**, which is pure carbon. In diamond, each carbon atom is covalently linked to four other carbon atoms, to form a huge network containing many millions of millions of atoms. This is the reason why diamond is the hardest substance known, with high density and melting point.



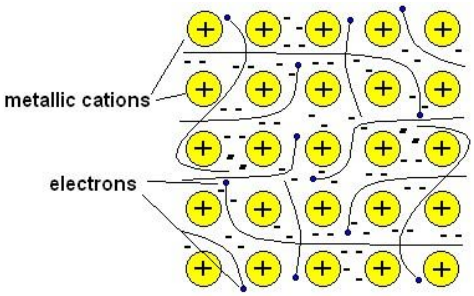
Diamond crystal lattice

Properties of covalent solids:

- They are very hard solids.
- They have very high melting and boiling points.
- They are poor conductors of electricity.
- They are insoluble in any solvent.

2.3 METALLIC BOND.

Metallic bonding is the bonding between atoms within metals. The metal atoms tend to lose electrons and form cation. These cations are placed in space forming a lattice. The electrons lost now belong to all the atoms of the network and form an electron cloud that surrounds the cations. These electrons move easily and are responsible for electrical and thermal conductivity of metals.



Properties of metals:

As we have already mentioned at the beginning of the unit, metals:

- Have a special shine (metallic lustre) and they are opaque.
- Are solid at room temperature (with the exception of a few).
- Have very high melting and boiling points.
- Are good conductors of heat and electricity.
- Are ductile and malleable.

ACTIVITIES

1.- How many groups are there in the periodic table? And how many periods?

2.- Using the periodic table locate the arsenic.

Its atomic number is ___. It has ___ protons and __ electrons.

It belongs to the group ____ and the period _____

Write an element that has three electrons less than arsenic _____ Write an element that has five electrons that arsenic _____

3.- Check the periodic table and find five metallic and five non metallic elements. Write their names, symbols, and which group and period they belong to.

Metals

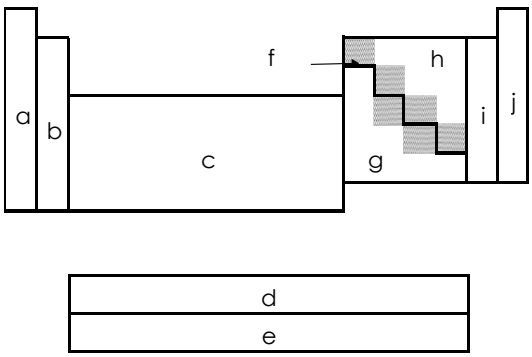
Name	Symbol	group	period

Non metals

Name	Symbol	group	period

4.- What are the main properties of metals?

5.- Match each of the following families with its position on the periodic table above



Noble Gases ___

Non-Metals ___

Alkali Metals ___

Halogens ___

Metalloids ___

Alkaline Earth Metals ___

Lanthanides ___

Actinides ___

Transition Metals___

Metals ___

6.- Fill in the blank

Elements that have the most stable electron configurations _____

Element that forms a 2+ ion to have the same electron configuration as Ar _____

Give the element in group 2, period 3 _____

Give the halogen in period 5 _____

The gas in the s block _____

Elements that share properties of non-metals and metals and are often used as semiconductors _____

7.- Classify each of the following elements as an alkali metal, an alkaline-earth metal, a transition metal, a metalloid, a halogen, or a noble gas:

boron _____ copper _____

gold_____ nitrogen_____

krypton _____ radium _____

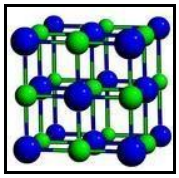
calcium _____ rhodium_____

8.- Complete the following sentences using the words: electrons, metal, non metal, eight, share.

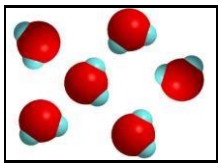
In an ionic bond _____ atoms will transfer one or more _____ to a _____ atom to form the bond. Each atom will have ____ _____ in its outer shell.

In a covalent bond _____ atoms _____ one or more electrons with each other to form the bond.

9.- Classify the following substances as molecules of elements, molecules of compounds, crystals or isolated atoms. What type of bond is there in these substances?



A



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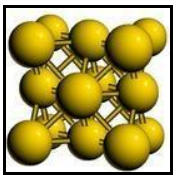

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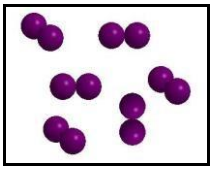

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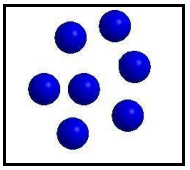

E

_____ _____ _____ _____ _____

_____ _____ _____ _____ _____

10.- a) Write the electronic configuration and draw the Lewis dot structures for the elements hydrogen and fluorine.

b) What type of bond will they form? Draw the Lewis dot structures for the compound.

11.- a) Write the electronic configuration and draw the Lewis dot structures for bromine and calcium.

b) According to its configuration, say if these elements have a strong tendency to gain electrons or lose electrons?

c) What type of bond will form these elements between them?

d) Which properties will show this compound?

12.- Indicate whether the following statements are true or false:

a) The ionic compounds have high melting points.
b) Noble gases are elements that never form compounds.
c) The common salt (NaCl) is a molecule.
d) Covalent compounds are formed through the union of metallic elements with non metallic elements.

13.- This table gives you information about certain substances. Indicate the bond type present in each of them.

Substance	Water solubility	Melting point	Conductivity		Type of bond
			Solid		
A	Low	112 ^{O}C	no	A	
B	High	612 ^{O}C	no	B	
C	Insoluble	2000 ^{O}C	yes	C	
D	Insoluble	4000 ^{O}C	no	D	

14. Choose the correct answer:

14.1. Non-metals and non-metals tend to form ……. bond.

a) Covalent.
b) Ionic
c) Metallic

14.2. Metals and non-metals tend to form ……. bond.

a) Covalent.
b) Ionic
c) Metallic

14.3. Non-metals and hydrogen tend to form ……. bond.

a) Covalent.
b) Ionic
c) Metallic

14.4. Non-metals tend to _____ electrons to become _____ ions. a) gain, negative.
b) lose, positive.
c) gain, positive

d) lose, negative

14.5. Metals tend to _____ electrons to become _____ ions.

a) gain, negative.

b) lose, positive.

c) gain, positive

d) lose, negative

15. Match one formula of left column with their corresponding bond in right column.

O_2	
NaCl	Covalent
HCl	
H_2O	Ionic
Al	
SO_2	Metallic
CaS	
HCl	

16. Complete the following table:

	IONIC	COVALENT	METALLIC
Types of Atoms Involved			
Method of Bond Formation			
Type of Structure			
Physical State			
Melting Point (high/low)			
Soluble in Water? (yes/no)			
Conducts Electricity? (yes/no)			

Other Properties			