Al-Karrar H.S for Distinguished

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CHEMISTRY

2' nd Grade

Kasim alnasiry

07801575954

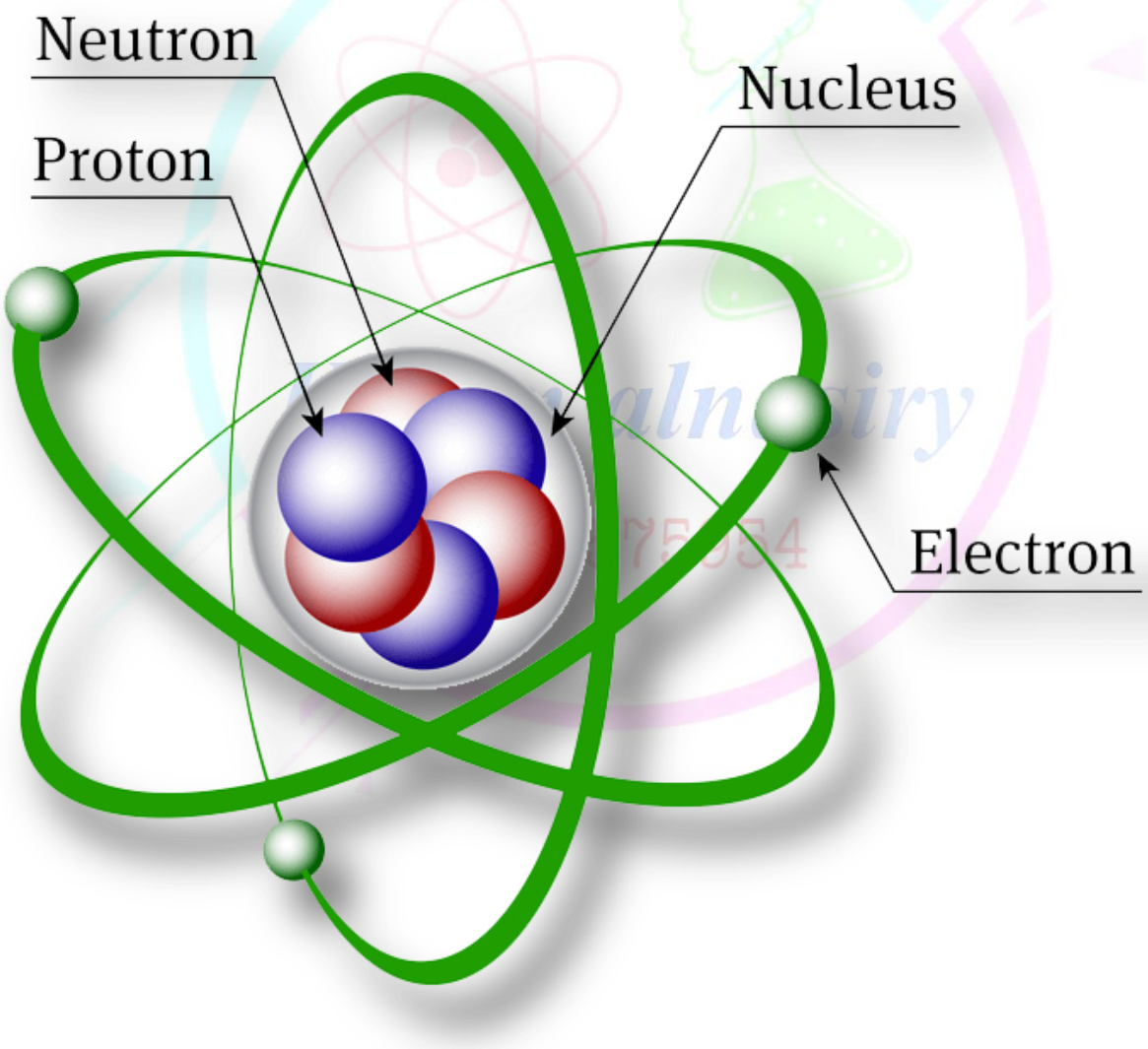
Definitions, explanations,
important notes
Solving chapters exercises

and questions

Kasim alnasiry
07801575954

CHAPTER 1

BUILDING BLOCKS OF MATTER



INTRODUCTION :

The air, water and clouds, mountains, plants and animals and the human body and the chair you sit on the book which is in your hands and everything you see and touch and feel it is matter.

Matter :

is everything occupies space and has mass . its composed of atoms, such as the foundation stone to build.

What is Dalton's conception of the building material ?

At the beginning of the nineteenth century were (Dalton) put his idea of building material, saying that atom: is the smallest particles of material involved in a chemical reaction.

Can we see the atom ?

The atoms are very fine particles is impossible for a person to see even with the most powerful microscopes and diameter of atom a millionth part of a millimeter.

What is Avogadro's conception of the building material ?

the Italian scientist (Avogadro), saying that smaller part in the article can be found in private may consist of more than one atom called (molecule).

Molecule :

Molecule : as a smaller part of the article holds the properties of that substance..

What is the difference between an element and a compound ?

Molecules of an element contain similar atoms , While the compound molecules contain different atoms.

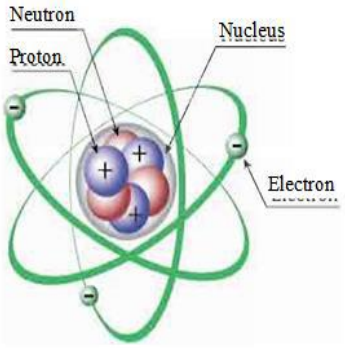
The Names and Symbols of Some Elements (to save)

0	Oxygen	K	Potassium	P	Phosphorus	H	Hydrogen	C	Carbon
Al	Aluminum	Si	Silicon	F	Fluorine	Ne	Neon	Cl	Chlorine
Ar	Argon	Na	Sodium	He	Helium	Mg	Magnesium	S	Sulfur
Be	Beryllium	B	Boron	N	Nitrogen	Ca	Calcium	Li	Lithium

STRUCTURE OF ATOMS :

Nucleus

The nucleus it is a small particle located in the center of the atom and its charge is positive. Around the nucleus is a sphere or cloud of negative charges and contains most of the mass of the atom .



To form the nucleus of the atom mass approximately 99.9 % of the mass of the atom, and this means that most of the mass of atom almost concentrated in the nucleus.
The nucleus contains two types of subatomic particles:
(Proton + Neutrons)

Proton (P^+)

It is a subatomic particle that is inside the nucleus with a positive charge and its mass is approximately equivalent to the mass of a neutron, which is more than 1840 times the mass of an electron.

atomic number Z : The number of protons ,which is equal to the number of electrons in the neutral atom. $Z = P^+ = e^-$

Neutrons (nº)

A subatomic particle in the nucleus. it has the same mass as a proton. The neutron is neutral and carries no electrical charge.

mass number A : It is the number of protons and neutrons N inside the nucleus, and it is symbolized by A. $A = Z + N \Rightarrow N = A - Z$

Example(1-1)

If you know that the atomic number of carbon, C is 6 and its mass number is 12. Find the number of neutrons in carbon atom.
Solution:

Exercise (1-1)

If you know that the atomic number of chlorine, Cl is equal to 17 and mass number is 35, find the number of neutrons in the nucleus of an atom of this element.
Solution:

Note :

The mass number A is written in the upper left of the element symbol, while the atomic number Z is written in the lower left of the element symbol,

$${}^{A}_{Z}X$$

Symbol	Atomic Number (Z)	Mass number (A)	Number of Neutrons (n)
${}^{23}_{11}Na$	11	23	12
${}^{31}_{15}P$	15	31	16
${}^{39}_{19}K$	19	39	20

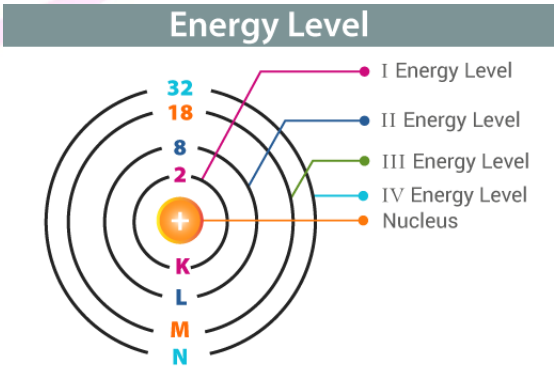
Electrone :

It has negative charge. Its mass is almost zero. The negatively charged electrons are located outside the tiny nucleus . Electrons move around the nucleus at very high speed.

Most of the space in an atom is filled by the negatively charged electrons. Imagine an atom to be the size of a large football stadium. The nucleus would be the size of a pea in the size of the field. Almost all the mass of the atom is concentrated in the nucleus.

How are the electrons arranged in an atom?

Electrons in an atom are arranged in different orbits called energy levels or shells. Number of shells in an atom are shown by n



How does the Volumes of energy level of the orbit change?

Volumes of energy levels change according to their distances to the nucleus, and shells are symbolized by capital letters such as :

K (n = 1) , L (n = 2) , M (n = 3) , N (n = 4) ,...etc. beginning from the closest orbit to the nucleus.

Why is the overall charge of an ordinary atom equal to zero?

there are always exactly the same number of protons and electrons. The negative and positive charges are balanced.

BOHR THEORY :

Description of Bohr's conception of the atom ?

The Bohr model, depicts the atom as small, with a positively charged nucleus surrounded by electrons that travel in circular orbits around the nucleus - similar in structure to the solar system.

Why Bohr worked on hydrogen atom?

Because it is the simplest atom and left a lot of conclusions that formed the basis of his theory of the hydrogen atom.

What are assumptions of Bohr's theory?

A- Electrons in atoms orbit around the nucleus.

B- The energy of the orbital is related to its size.

The lowest energy is found in the smallest orbit which means the closest energy level (n = 1) to the nucleus has the lowest energy .

ARRANGEMENT OF ELECTRONS ON THE SHELLS :

How are the electrons arranged in an atom ?

Electrons in an atom are arranged in different orbits called **energy levels** or shells.

The first energy level can have no more than **2** electrons.

The second energy level can hold up to **8** electrons.

The third energy level can contain a maximum number of **18** electrons.

Higher energy levels sometimes hold as many as **32** electrons

The energy levels for atoms and the number of electrons they can hold are found by using the following rules;

1) Total number of energy levels in the atom is the n .

2) Total number electrons found in the atom is calculated by The formula $2n^2$

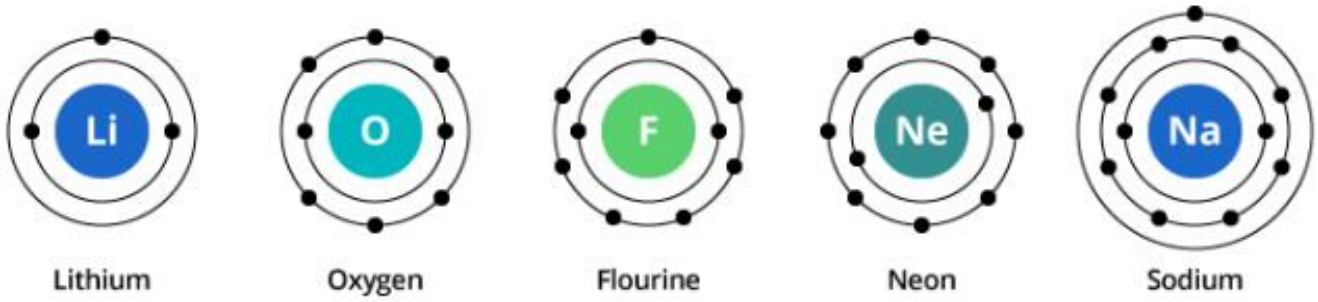
energy levels n	$2n^2$	Total number electrons
1	2×1^2	2
2	2×2^2	8
3	2×3^2	18
4	2×4^2	32

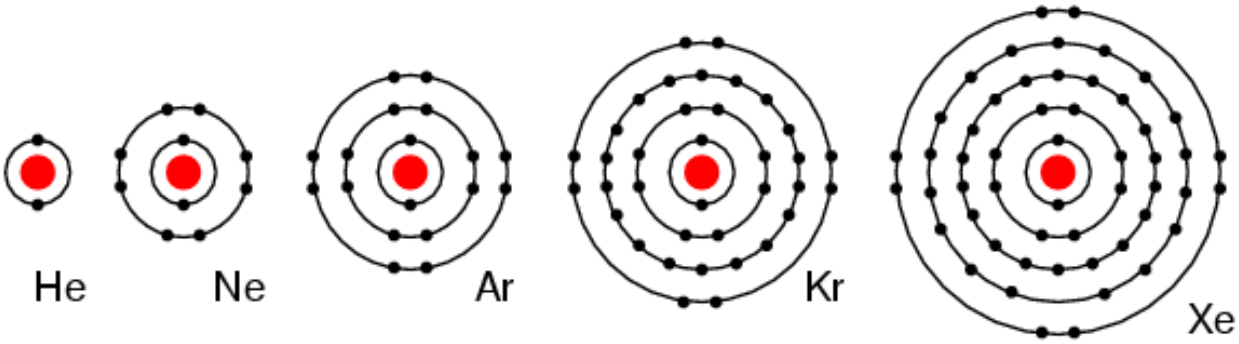
Note :

1) If any element has full of energy levels with electrons, this means that element is stable and called as noble gas.

2) All of the elements want to have the same electron arrangement with noble gases. They do this by losing or gaining electrons.

Electron arrangements of some noble gases and elements:





IONS :

are atoms or molecules that have gained or lost one or more of their valence electrons and have a positive or negative charge. so consists of two types, cations with a positive charge and an anion with a negative charge.

Cation :

It is the ion which the number of protons is greater than the number of electrons in an atom, it has positively charged such as : Na^{+} , Ca^{+2} , Al^{+3} and NH^{+}

Anion :

It is the ion which the number of protons is less than the number of electrons in an atom, it has negatively charged , such as : Cl^{-} , O^{-2} , N^{-3} and SO_2^{-2}

.

The Comparison of atom and ion :

1) An atom is the defining structure of an element ,
2) Elemental atoms differ from each other by the number of protons
3) Atoms have the same number of electrons as the number of protons.
4) The electrons form orbitals around the nucleus and cause much of the chemical properties of the element.
5) When an atoms outermost orbital gains or loses electrons the atom forms an ion wich are more stable than atoms .

How do we distinguish between oxygen and nitrogen atoms ?

it would be to count the number of protons each atom has. Oxygen will have eight where nitrogen will have seven.

Define the valence electrons ?

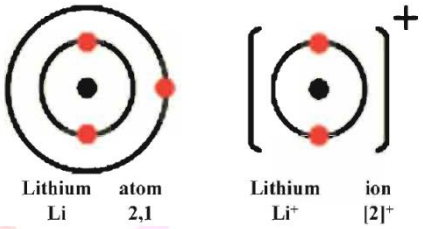
The number of electrons in the outer shell of the atom of the element, which the atom can lose, gain, or share in the chemical reaction.

Example (1- 2) :

Draw the electron arrangement of an atom of Lithium element and its ion . Atomic number 3 and mass number 7 ?

Solution:

Lithium atom, Li	Lithium ion, Li^+
e^- = 3	e^- = 2
p^+ = 3	p^+ = 3
n^o = 4	n^o = 4



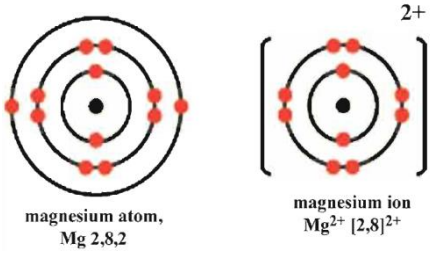
Lithium ion, Li^+. It looks like electron arrangement of Helium atom.

Example 1- 3 :

Draw the electron arrangement of an atom of Magnesium element and its ion. Atomic number = 12 and mass number = 24

Solution:

Magnesium atom. Mg	Magnesium ion, Mg^{+2}
e^- = 12	e^- = 10
p^+ = 12	p^+ = 12
n^o = 12	n^o = 12



It looks like electron arrangement of Neon atom.

Exercise 1-3 :

Draw the electron arrangement of an atom of potassium (K) element and its ion.
Atomic number = 19 and mass number = 39.

Example 1-5 :

Draw the electron arrangement of an atom of fluorine (F) element and its ion,
Atomic number = 9 and mass number = 19

Exercise 1- 4 :

Draw the electron arrangement of an atom of chlorine (Cl) element and its ion.
Atomic number = 17 and mass number = 35.

Exercise 1-5 :

Draw the electron arrangement of an atom of sulfur (S) element and its ion.
Atomic number = 16 and mass number = 32 .

Example 1- 6 :

Draw the electron arrangement of an atom of oxygen (O) and and its ion.
Atomic number = 8 and Mass number = 16

Example 1-7 :

Draw the electron arrangement of nitrogen (N) element and its ion.
Atomic number = 7 and Mass number = 14

Exercise 1- 6 :

Draw the electron arrangement of an atom of phosphorus (P) Atomic number = 15 and mass number = 31

Explain why when atoms ionize, they lose their characteristic properties?
Because the last energy levels of these ions become are full of electrons.

Why the atoms of Noble gases, do not need to lose or gain electrons and thus not be ions under normal conditions .
Because the last energy level of Noble gases are full of electrons (stable atoms) .

Generally :

atoms of metallic elements tend to lose electrons and change into cations.
While nonmetallic atoms tend to gain electrons and change into anions .

CHEMICAL BONDING :

Why Almost all atoms tend to join together with other atoms. Except for the noble gases ?

elements tend to gain, lose, or share electrons to have full shells of electrons to have special stability like a Noble gas , As a result chemical bonding occurs.

Chemical bonds:

are strong forces of attraction between atoms , There are two types of chemical bonds : Ionic bonding and Covalent bonding .

IONIC DONDING

is a type of chemical bond formed through an electrostatic attraction between two oppositely charged ions. Ionic bonds are formed between a cation (metal) and an anion (non-metal).

A- ionic bonding between lithium and fluorine atoms :

When lithium and fluorine react together, the lithium atom loses one electron and the fluorine atom gains one electron.

An atom that loses one or more electrons gains a positive charge.

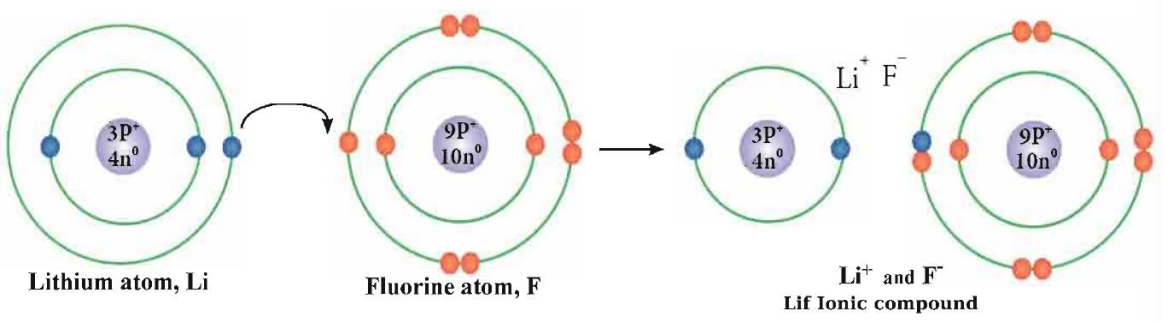
In this case, lithium atom has 3 protons and 2 electrons. The overall charge is (+1).

Then, a positively charged ion, called cation, is formed.

If an atom gains electron(-1), negatively charged ion, called anion, is formed.

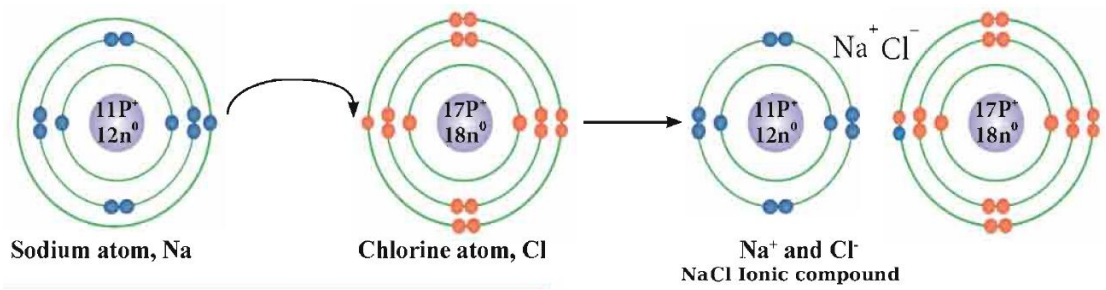
The net charge is written to the upper right of the symbol for the element.

The newly formed lithium (Li_+) and fluoride (F_-) ions attract each other. This is known as electrostatic attraction.



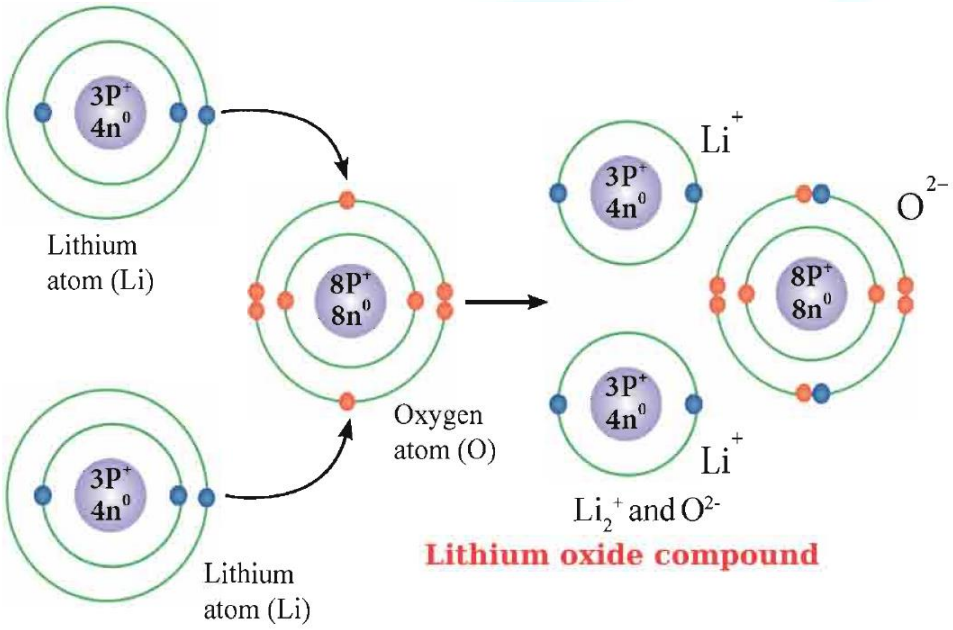
B - Ionic bonding between sodium and chlorine atoms ;

When sodium atom, Na (Z = 11) and chlorine atom, Cl (Z=17) are bonded to form an ionic compound that is sodium chloride, NaCl, this bonding can be illustrated by the time following figure



C - Ionic bonding between lithium and oxygen atoms :

When lithium atom, Li (Z = 3) and oxygen atom, O (Z = 8) are bonded to form an ionic compound that is lithium oxide, Li_2O



This shows that oxygen atom has six electrons in its last shell and needs only two electrons to fill it . therefore oxygen atom is bonded to two lithium atoms. Because both of lithium atoms consist of 2 single electrons in their last energy levels that can be transferred easily.

Exercise 1 – 7

Draw the figure which shows the ionic bonding between $_{19}K$ and $_{17}Cl$ atoms to form potassium chloride, KCl that is an ionic compound.

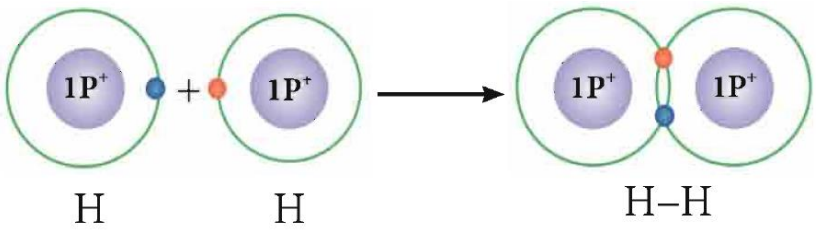
Exercise 1 – 8

Draw the figure which shows the ionic bonding between $_{11}Na$ and $_{8}O$ atoms to form sodium oxide. Na_2O that is an ionic compound.

COVALENT BONDING :

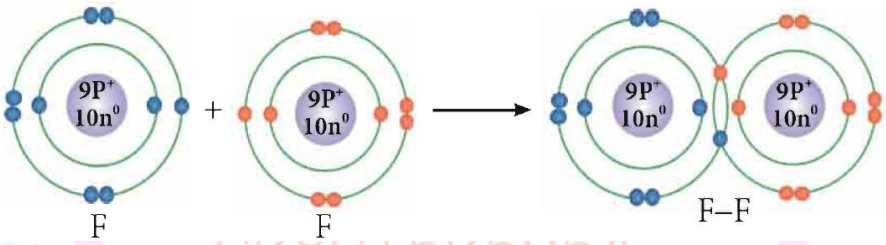
It is the chemical bond that involves the sharing of pairs of electrons between atoms .

For example, hydrogen has one electron in its outer shell. so, it needs only one electron to fill the outer shell. One way it can be filled is by joining with another hydrogen atom, and sharing electrons .

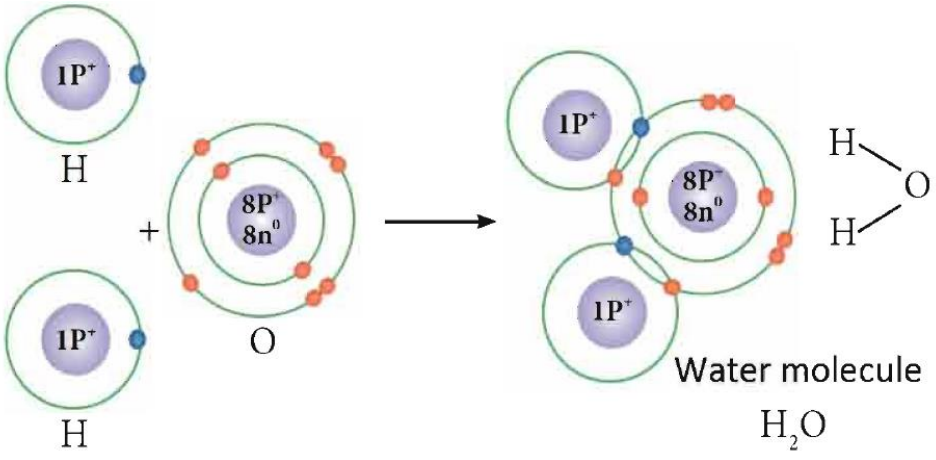


Element hydrogen exists as diatomic molecules like H_2 . Some common gases, such as oxygen O_2 , fluorine F_2 , and nitrogen N_2 have diatomic molecules. The bonds that hold together the atoms in these molecules are covalent bonds .

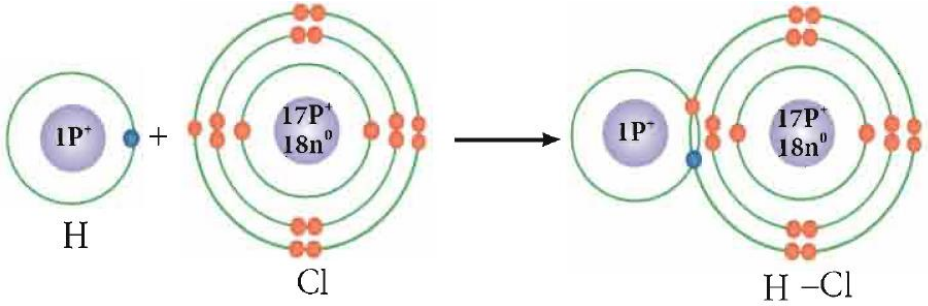
Another example is covalent bonding between two fluorine atoms (Z = 9). Fluorine has seven electrons in its outer shell. So it is one electron short of a full outer shell . there is only one way for filling its outermost shell is by joining with another fluorine atom, and sharing electrons



One more example for covalent bonding is the bonding between two hydrogen atoms (Z = 1) and one oxygen (Z = 8) to form water, H_2O compounds.
To fill the last energy level of oxygen atom, we need two electrons and these two electrons can be obtained by sharing from each of two hydrogen atoms.



Example for covalent bonding is the bonding between one hydrogen atom (Z = 1) and one chlorine atom (Z =17) to form hydrogen chloride, HCl compound. Chlorine has seven electrons in its outer shell. So it is one clectron short of a full outer shell. Hydrogen has one electron in its outer shell. So it is one electron short of a full outer shell. Both of them need one electron to fill last energy level. There is only one way for filling their outermost shells is by sharing one electron.



Exercise 1 – 9

Show the covalent bonding in chlorine molecule ($C1_2$) which is formed from combination of 2 chlorine atoms. Atomic number = 17 ?

Exercise 1 – 10

Show the covalent bonding in ammonia molecule, NH_3 by drawing. Hydrogen has one electron in its outer energy level. Nitrogen has two electrons in its first energy level and five electrons in its second energy level ?

VALENCY :

Valence electrons : *as the number of lost, gained or shared electrons of atoms obtained during the chemical reactions* . it determines the chemical behaviour of element .

To find the valency of an atom, the following rules must be applied :

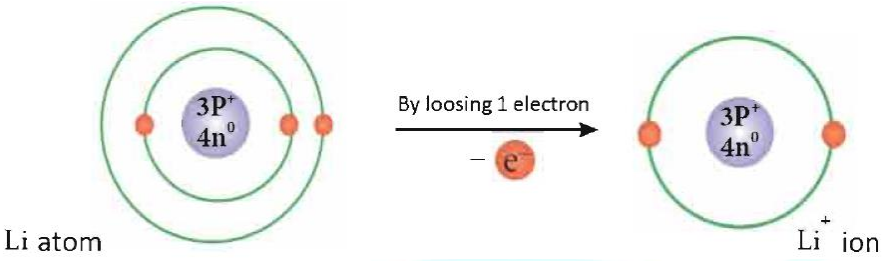
1- must be known The number of electrons in the outer shell and whether the shell is full or not.

2- The number of electrons which would be lost, gained or shared by the atoms to fill their last shells must be known. During the formation of a chemical bond betwecen atoms.

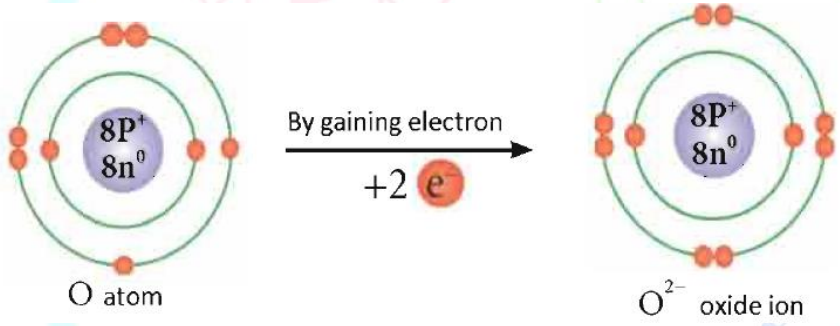
Explain why The last outer shell in atom plays a great role for valency ?

Ans : Because electrons used to form the bond are transferred or shared from the last shell of the atoms.

For example; lithium atom (atomic number is 3) contains one valence electron. After loosing that one electron from its outermost shell, it changes into lithium ion, Li lithium is considered as a .



An oxygen atom (Z=8) contains six valence electrons. Therefore, oxygen atom tends either to gain or to share two electrons with another atom to form two bonds. At the end of this, oxygen atom completes its last energy level with eight electrons.



All the atoms tend to saturate its valence shell to have the full shell as in the noble gases.

A polyatomic ion :

is known as a molecular ion, is a charged species composed of two or more atoms covalently bonded to each other , such as :

monovalent : hydroxide ion OH^- , ammonium ion NH_4^+

divalent : carbonate ion CO_3^{-2} , sulfate ion SO_4^{-2}

trivalent : phosphate ion PO_4^{-3}.

OXIDATION NUMBER AND CHEMICAL FORMULA :

Chemical Formula :

is a shorthand way of writing the name for a compound. The chemical symbols that are assigned to the elements are used to write formulas.

A chemical formula is a symbolic representation of :

1) The elements present in a compound.
2) The relative numbers of atoms of each element.

Examples :

C_8H_{18}

Subscript indicates that there are 8 carbon atoms in a molecule of octane.

Subscript indicates that there are 18 hydrogen atom: in a molecule of octane

$Al_2(SO_4)_3$

Subscript 2 refers to 2 aluminum atoms .
Subscript 4 refers to 4 oxygen atoms in sulfate ion.
Subscript 3 refers to everything inside parentheses, giving 3 sulfate ions, with a total of 3 sulfur atoms and 12 oxygen atoms

The number in front of a symbol or formula is called a coefficient .

$2H_2O$

Coefficient (number of molecules)
In the above example, it is the formula of water which contains four hydrogen atoms and two oxygen atoms.

Notes :

1) Atoms are the building blocks of elements. Molecules are the building blocks of compounds.
2) The only difference between atoms and molecules is that chemically bonded different atoms form the molecules . But molecules of divalent compounds are formed by bonding the same atoms.

Example 1 – 10

How many atoms are found in the following formulas ?

a) 2HCl b) $(NH_4)_2SO_4$ c) K_2SO_4 d) $5H_3PO_4$

Solution:

a) 2HCl = 2 × 1(H)+ 2 × 1(Cl) = 4 atoms

b) $(NH_4)_2SO_4$ = 2 × 1(N) + 4 × 2(H) + 1(S) + 4(O) = 15atoms

c) K_2SO_4 = 2(K) + 1(S) + 4(O) = 7 atoms

d) $5H_3PO_4$ = 5 × 3(H) + 5 × 1(P)+ 5 × 4(O) = 40 atoms

Exercise 1 – 11

How many atoms does each of the following compounds consist of?

a) $Ba(OH)_2$

b) $3Fe_2O_3$

c) $5Li_2CO_3$

d) $10H_2S$

e) $(NH_4)_2CO_3$

g) $5MgBr_2$

Notes :

1) By gaining or losing electrons, many elements form ions with noble gas configurations. For example,

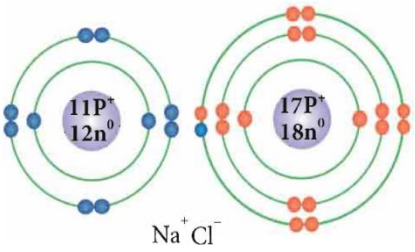
Na atom lose one electron to give cations Na^+ , It looks like Neon atom

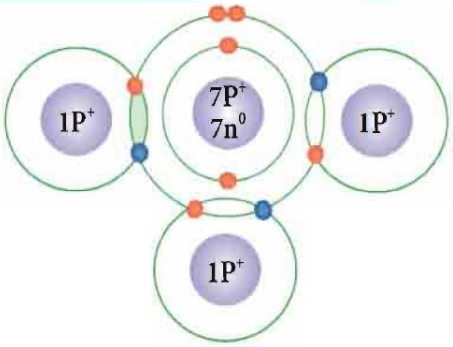
Cl_2 atom gain one electrons to give anions Cl^-

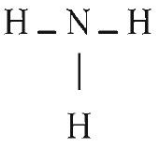
Mg atom lose two electrons to give cations Mg^{+2}

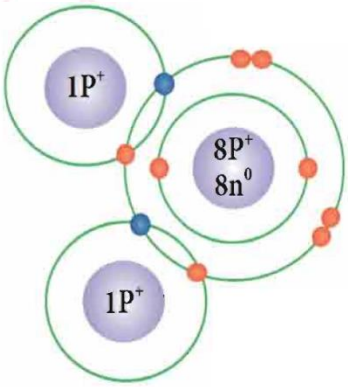
N_2 atom gain three electrons to give anions N^{-3}

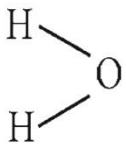
O_2 atom gain tow electrons to give anions O^{-2}











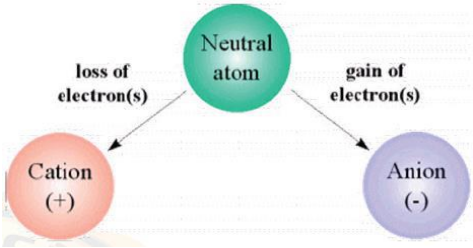
Oxidation number :

is the number of electrons gained or lost by any atom during the formation of a chemical bond. It can be either a positive integer number or a negative integer number .

Notes :

If any atom loses electron, atom will be positively charged

If any atom gains electron, atom will negatively charged .



+1	Ammonium (NH_4^+)	+2	Barium (Ba^{2+})
-1	Chloride (Cl^-)	+2	Iron (II) (Fe^{2+})
-1	Bromine (Br^-)	+2	Copper (II) (Cu^{2+})
-1	Hydroxide (OH^-)	+2	Lead (II) (Pb^{2+})
-1	Nitrate (NO_3^-)	-2	Carbonate (CO_3^{2-})
-1	Nitride (NO_2^-)	-2	Sulfate (SO_4^{2-})
-1	Chlorate (ClO_3^-)	-2	Sulfide (S^{2-})
-1	Iodide (I^-)	-2	Oxide (O^{2-})
-1	Fluoride (F^-)		
Oxidation Number	**Species**	**Oxidation Number**	**Species**
+3	Aluminum (Al^{3+})	+4	Lead (IV) (Pb^{4+})
+3	Iron (III) (Fe^{3+})	+4	Tin (IV) (Sn^{4+})
-3	Phosphate (PO_4^{3-})	+4	Manganese (IV) (Mn^{4+})

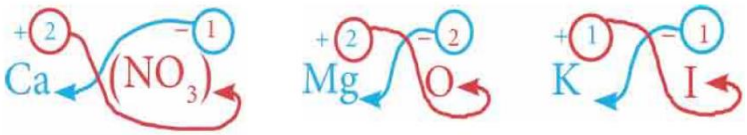
Writing the chemical formulas rules :

1. Cations are written first.
2. Anions are written last
3. The net charge on the resulting compound must be zero.

Notes :

the charges indicated by the valence numbers must be balanced.

To do this, subscripts are written to the upper right of the element or polyatomic ion.



4. The valence of polyatomic ion must equal the algebraic sum of the charges to the individual atoms making up the polyatomic ion.

$NH_4^+ \Rightarrow (N^{-3}H_4^+)^+$, $CO_3^{-2} \Rightarrow (C^{+4}O_3^{-2})^{-2}$

5. If a polyatomic ion appears (more than once in the formula), it is enclosed in parentheses, and the subscript is placed just outside to the lower right .

$Ca_3(PO_4)_3$, $Al_2(SO_4)_3$, $Ba(OH)_2$

Notes :

The formula for the compound formed between the ion X^n and Y^m my be written as : X_mY_n , if $m = n$ the formula is written XY

Name and chemical formula for some compounds :

Name of the Compound	Chemical Formula	Name of the Compound	Chemical Formula
Sodium chloride	NaCl	Calcium oxide	CaO
Magnesium bromide	$MgBr_2$	Aluminum oxide	Al_2O_3
Barium hydroxide	$Ba(OH)_2$	Lithium carbonate	Li_2CO_3
Barium carbonate	$BaCO_3$	Ammonium sulfate	$(NH_4)_2SO_4$
Hydrogen sulfide	H_2S	Aluminum sulfate	$Al_2(SO_4)_3$
Calcium phosphate	$Ca_3(PO_4)_2$	Dihydrogen monoxide (water)	H_2O

Exercise 1 - 12

Write the correct formula and name of compounds formed between the following ions :

a) Na^+ and Cl^-

b) Mg^{+2} and Cl^-

c) Al^{+3} and O^{-2}

d) Mg^{+2} and N^{-3}

e) Pb^{+4} and O^{-2}

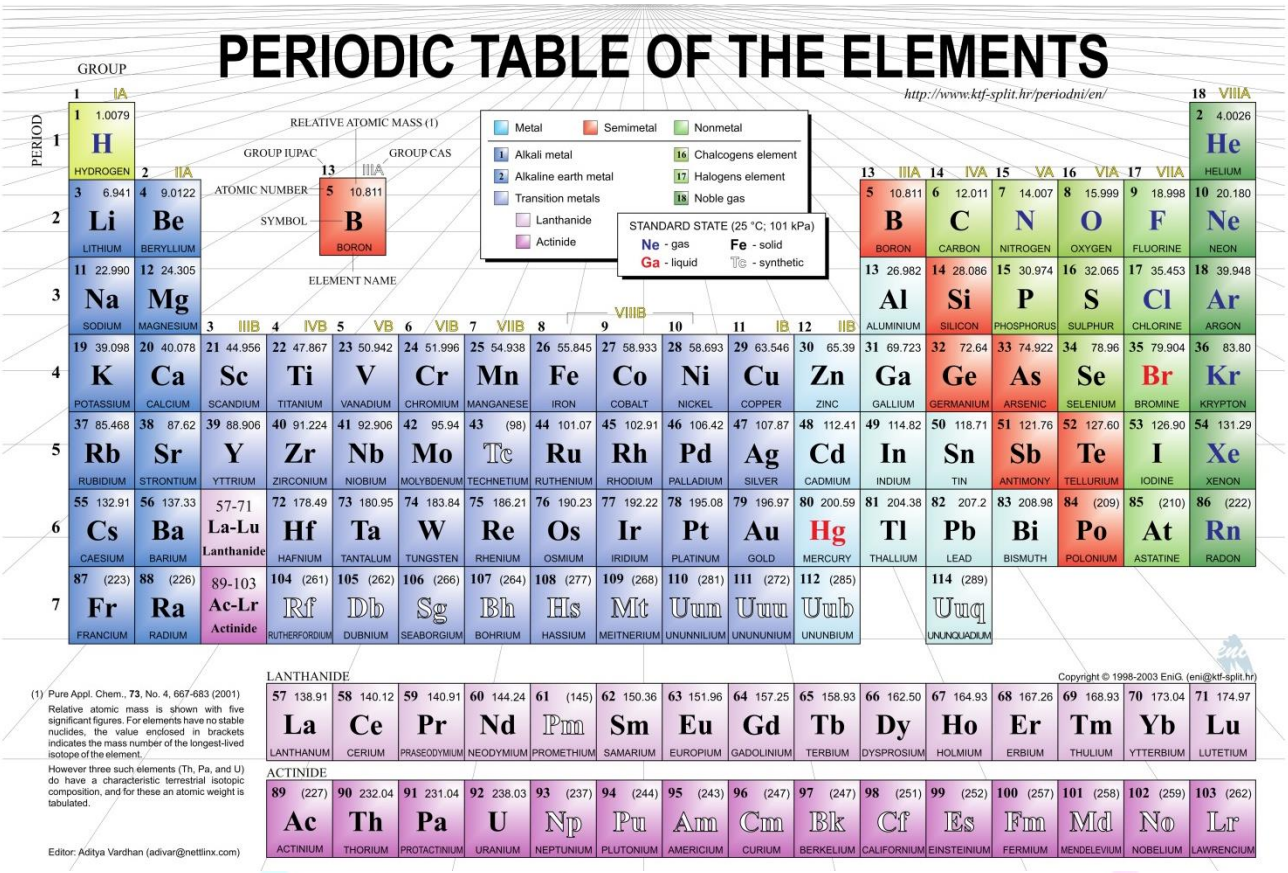
f) NH_4^+ and Br^-

g) NH_4^+ and SO_4^{-2}

i) Fe^{+3} and OH^-

PERIODIC TABLE :

is a tabular display of the chemical elements, organized on the basis of their atomic numbers, electron configurations, and recurring chemical properties.



Elements are presented in order of increasing atomic number(number of protons).

Elements with the same number of electrons in outer shell are put in the same Columns .

Elements with similar chemical properties fall into the same group in the periodic Table

The table can also be deconstructed into four rectangular blocks:

1) The s- block to the left.
2) The p- block to the right.
3) The d- block in the middle.
4) The f- block below that (to the down) .

Dmitri Mendeleev is generally credited with the publication, in 1869, of the first widely recognized periodic table.

The atom of a single element with different mass numbers are called **isotopes** of the element.

GROUPS :

is a vertical column in the periodic table , Elements within the same group generally have the same electron configuration in their valence shell so they are similar in chemical properties.

groups usually have more significant periodic trends than periods.

The groups are numbered numerically from 1 to 18 from the leftmost column (the alkali metals) to the rightmost column (the noble gases)

PERIODS :

A period is a horizontal row in periodic table , the elements are put in order of increasing atomic number in the same period .

Elements within the same period generally have the differ electron configuration in their valence shell so they are diffrent in chemical properties.

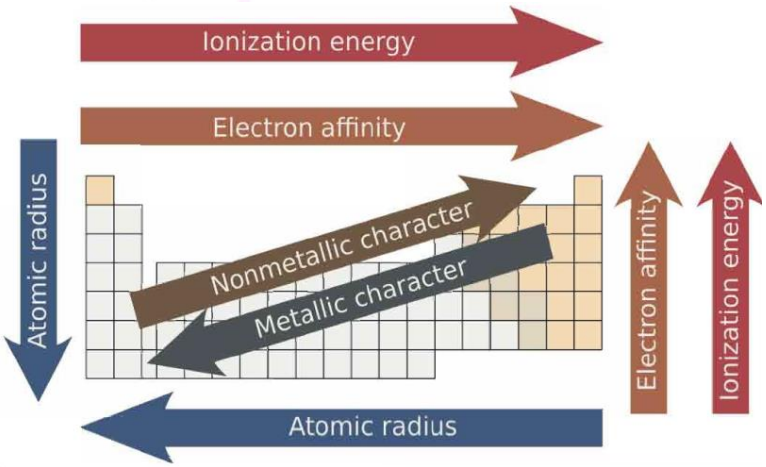
Although groups generally have more significant periodic trends, there are regions where horizontal trends are more significant than vertical group trends

Period trends :

element in the same peroid show trend in : atomic radius , ionization energy , electron affinity , and electronegativity

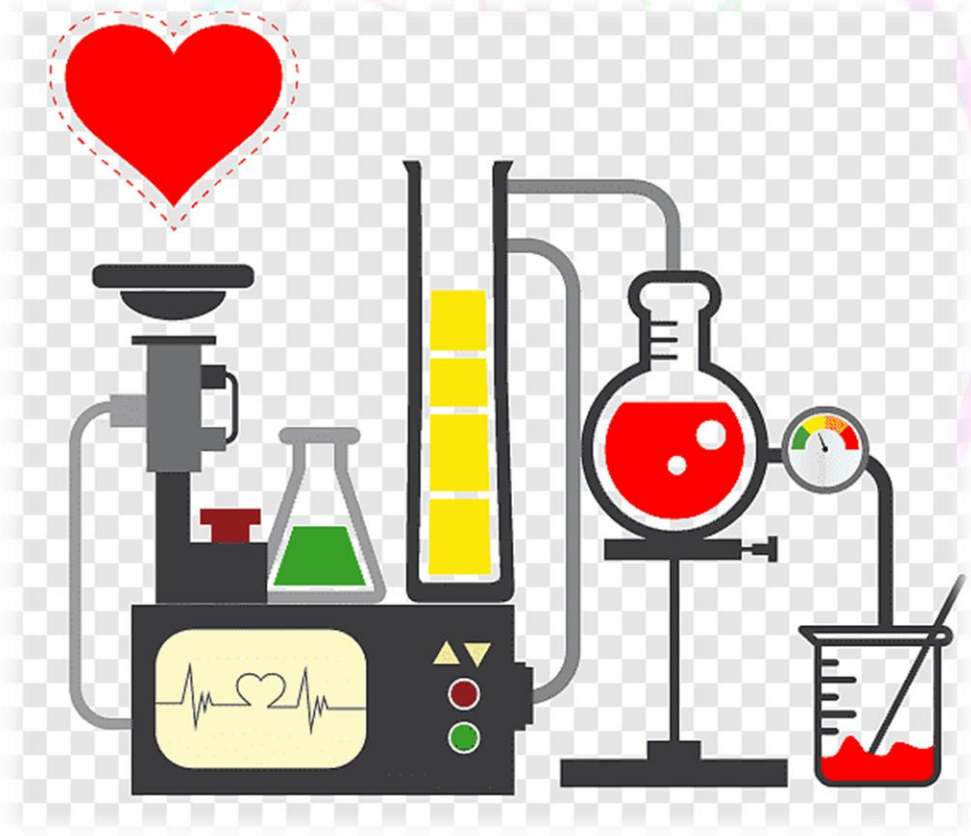
moving left to right across aperiod :

1) atomic radius decreases , because added protons & electrons causes electrons drawn closer the nucleus
2) ionization energy increase,because more energy is required to remove electron
3) electronegativity increase,because the pull exerted on by the neucleus
4) electron affinity also shows a slight trend across a period ,metal (left) have lower Than non-metal , exept the noble gas .



CHAPTER 2

CHEMICAL REACTIONS AND EQUATIONS



Kasim alnasiry
07801575954

CHEMICAL REACTIONS :

There are a few key points you should know about chemical reactions :

1) A chemical change must occur. When You start with one compound and turn it into another such as iron rust because iron combine with oxygen .
While the change in state of matter (or temperature) is a physical change.
2) A reaction could include ions, compounds, or molecules of a single element.
And might the reaction happened by a catalyst for speeding of chemical reaction .
3) Single reactions often happen as part of a larger series of reactions.

Chemical reactions :

is the process reaction between substances reactant for production of new substances differ in their properties from the properties of the materials they are made of .

1. Some chemical reactions release energy to the surroundings.
2. Other chemical reactions absorb energy from the surroundings .

The provariables that can effect chemical reaction rates, include :
1. temperature 2. pressure 3. catalysts.

Catalysts :

is the substances which accelerate the chemical reaction rate without themselves being consumed.

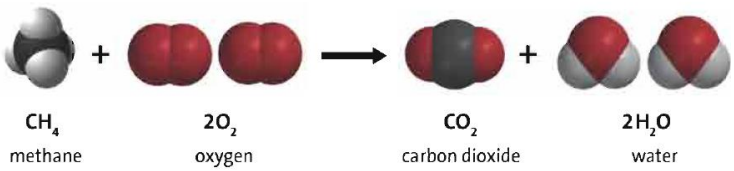
Chemical equation :

is a written representation of the process that occurs in a chemical reaction. the reactants on the left side of an arrow , and the products on the right side of the equation .

(reactants) → (products)

An example of a chemical equation may be seen in the combustion of methane :

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$



Participants in the Chemical Reaction: element Symbols ,
In this reaction, C is carbon, H_2 is hydrogen and O_2 is oxygen.
Left Side of Reaction : Reactants are methane CH_4 and oxygen $2O_2$
Right Side of Reaction: Products are carbon dioxide CO_2 and water H_2O.
Direction of Reaction Arrow: The reactants on the lefthand side of the chemical equation and the products on the righthand side of the chemical equation.
The arrow between the reactants and products should point from left to right.

Example 2 – 1 :
Magnesium and sulfur elements are chemically combined to form compound magnesium sulfide . Write the word equation and the formula equation for this reaction .
Answer : magnesium + sulfur → magnesium sulfide (word equation)
Mg + S → MgS (formula equation)

Example 2 – 2 :
Magnesium and oxygen elements are chemically combined to form magnesium oxide. Write the the word equation and the formula equation for this reaction.
Answer :
Magnesium + Oxygen → Magnesium oxide (word equation)
Mg + O_2 → MgO (formula equation)

Exercise 2 – 1 :
Express the following chemical reactions both in word and formula equations :
1- Methane gas burns with oxygen gas to produce carbon dioxide and water.

2- After dissociation of calcium carbonate, calcium oxide and carbon dioxide compounds are produced.

3- The reaction between nitrogen gas and hydrogen produce ammonia.

Balancing chemical equations

It refers to establishing the mathematical relationship between same elements of reactants and products , coefficient are used to balance an equation.

In a balanced equation,the number of each kind of atom is the same both sides of the arrow.
You can change the coefficient to balance an equation.
You should never change the subscripts in the formula of a compound in order to balance the equation .

What coefficients must be written and where should they be placed , in order to balance the following equation :

$$Fe + O_2 \rightarrow Fe_2O_3$$

There is only 1 iron atom on the left and 2 iron atoms on the right. Then you write 2 as the coefficient of Fe.
There are 2 oxygen atoms on the left and 3 oxygen atoms on the right. You may write 3/2 in front of O_2

$$2Fe + \frac{3}{2} O_2 \rightarrow Fe_2O_3$$

You can multiply both sides of the equation by 2 , if you want to see the whole number coeflicients .

$$4Fe + 3\,O_2 \rightarrow 2\,Fe_2O_3$$

This equation shows that four atoms of (4Fe) iron combine with three molecules of oxygen ($3O_2$) to form two molecules of rust ($2Fe_2O_3$) .

Exercise 2 – 2 :

1 – Write a balanced chemical equation for each reaction :

a) water → hydrogen + oxygen

b) calcium hydroxide + hydrochloric acid → calcium chloride + water

c) magnesium + sulfuric acid → magnesium sulfate + hydrogen

d) calcium carbonate → calcium oxide + carbon dioxide

2 – Balance the following equations :

a) $KClO_3 \rightarrow KCl + O_2$

b) $Fe + H_2O \rightarrow Fe_3O_4 + H_2$

.

TYPES OF CHEMICAL REACTIONS

There are several different types of chemical reactions and more than one way of classifying them. Here are some common reaction types .

1- Combination reactions 2- Decompostion reactions

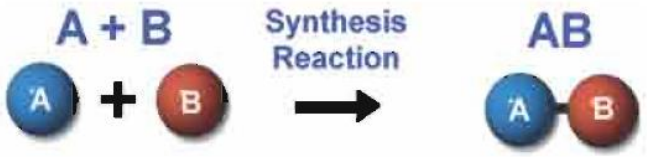
3- Single displacement reactions 4- Double displacement reactions

5- Compostion reactions

Combination Reactions (Synthesis Reactions)

This means that two or more simple substances combine to form a more complex substance , or Two or more reactants yielding one product

These reactions are in the general form : $A + B \rightarrow AB$



One example of a synthesis reaction is the combination of iron and sulfur to form iron(II)sulfide :

$$Fe + S \rightarrow FeS$$

Another example is simple hydrogen gas combined with simple oxygen gas to produce a more complex substance, such as water :

$$H_2 + O_2 \rightarrow H_2O$$

Decomposition Reactions

is a reaction its compound is broken into smaller chemical species.and its a decomposition reaction is the opposite of a synthesis reaction

$$AB \rightarrow A + B$$

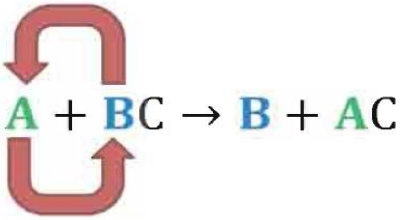
The electrolysis of water into oxygen and hydrogen gas is an example of a decomposition reaction :

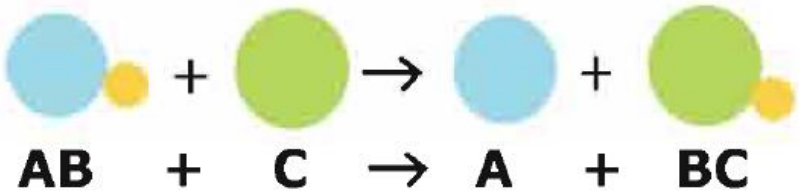
$$2H_2O \rightarrow 2H_2 + O_2$$

Single Displacement Reactions

is a single displacement reaction of one element being displaced from a compound by another element

These reactions come in the general form of





One example of a single displacement reaction is when soduim replaces hydrogen in water to make soduim hydroxide and hydrogen gas :

$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$

Another example of a single displacement reaction occurs when zinc combines with hydrochloric acid . The zinc replaces the hydrogen :

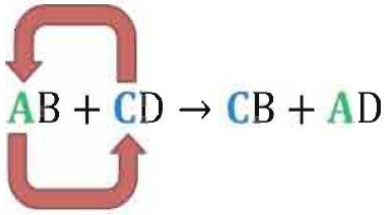
$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

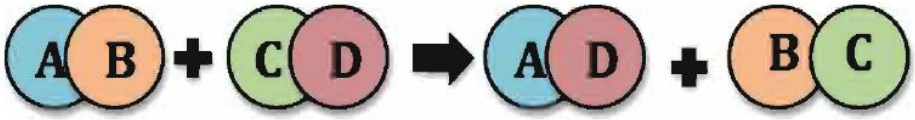
Double Displacement Reactions

Is a double replacement reaction, the anions and cations of two compounds switch places and form two entirely different compounds .

These reactions are in the general form :

$$AB + CD \rightarrow AD + CB$$





For example, when barium chloride, $BaCl_2$, and magnesium sulfate, $MgSO_4$ react, the sulfate, SO_4^{-2} anion switches places with the chloride, Cl^- anion, giving the compounds barium sulfate, $BaSO_4$ and magnesium chloride, $MgCl_2$.

$$BaCl_2 + MgSO_4 \rightarrow BaSO_4 + MgCl_2$$

Another example of a double displacement reaction is the reaction of lead(II)nitrate, $Pb(NO_3)_2$ with potassium iodide, KI to form lead(I)iodide, PbI_2 and potassium nitrate, KNO_3

$$Pb(NO_3)_2 + 2KI \rightarrow PbI_2 + 2KNO_3$$

One more example of a double displacement reaction occurs between sodium chloride, $NaCl$ and silver nitrate, $AgNO_3$ to form sodium nitrate, $NaNO_3$ and silver chloride, $AgCl$.

$$NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$$

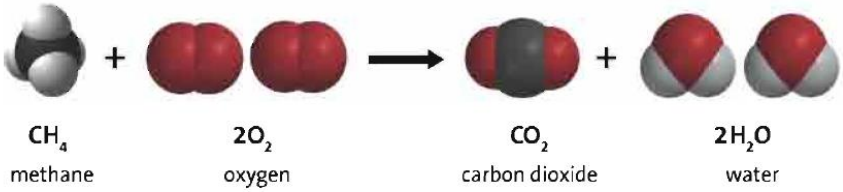
Combustion Reactions

is a major class of chemical reactions. combustion involves a reaction between any combustible material and an oxidizer to form an oxidized product .

Combustion is an exothermic reaction, so it releases heat, but sometimes the reaction proceeds so slowly that a temperature change is not noticeable
General Form of a combustion reaction **:**

$$\text{Hydrocarbon} + \text{Oxygen} \rightarrow \text{Carbon dioxide} + \text{Water}$$

Examples of combustion reactions combustion of methane



Burning of naphthalene : $C_{10}H_8 + 12O_2 \rightarrow 10CO_2 + 4H_2O$

Combustion of ethane : $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

Exercise 2 – 3 :

Determine the type of each of the following reactions :

1) $H_2 + I_2 \rightarrow 2HI$

2) $2HBr \rightarrow H_2 + Br_2$

3) $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$

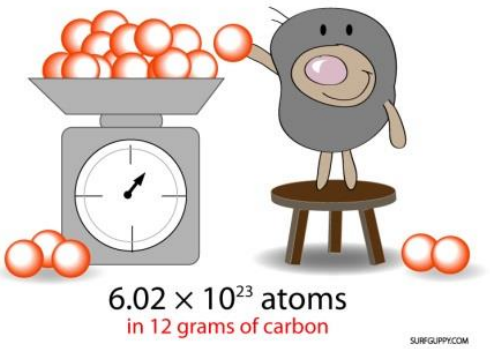
4) $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

AVOGADRO'S NUMBER AND MOLE CONCEPT

Avogadro's number : *is the number of particles that existing a mole of a substance*

Avogadro's number = 6.02×10^{23}

Mole : *is the amount of matter that contains Avocadro's number of matter (atoms, molecules, or ions)*



kilo Avogadro number for the count of particles in a kilomole is 6.02×10^{26}

milli Avogadro number for the count of particles in a millimole is 6.02×10^{20}

1 mole of element contains 6.02×10^{23} atoms.

1 mole of compound contains 6.02×10^{23} molecules.

1 mole of hydrogen ion contains 6.02×10^{23} ions

1 mole of electron is equal to 6.02×10^{23} electrons.

CHAPTER 2 QUESTIONS ANSWERS :

Q1) Define the following terms :

Chemical equation , chemical reaction , mole , reactant , product

Chemical equation : is a written representation of the process that occurs in a chemical reaction.

Chemical reactions :- is the process reaction between substances reactant for production of new substances differ in their properties from the properties of the materials they are made of .

Mole : is the amount of matter that contains Avocadro's number of matter (atoms, molecules, or ions)

Reactant : are the substances that are written on the left side of the chemical equation.

Products: The materials that are written on the right side of the chemical equation.

Q2) What are the benefits of a chemical equation ?

1. Express the chemical reaction in a simple way.
2. Show the nature of the substances involved in the reaction.
3. It shows the relative number of particles involved in the reaction.

Q3) Show the following reactions with a balanced formula equation

1. Silver + Chlorine gas → Silver chloride
   $2Ag + Cl_2 \rightarrow 2AgCl$
2. Copper + Oxygen gas → Copper (II) oxide
   $2Cu + O_2 \rightarrow 2CuO$
3. Zinc + Chlorine gas → Zinc chloride
   $Zn + Cl_2 \rightarrow ZnCl2$
4. Iron + Oxygen → Iron (II) oxide
   $2Fe + O_2 \rightarrow 2FeO$
5. Sodium + Chlorine gas → Sodium chloride
   $2Na + Cl_2 \rightarrow 2NaCl$

Q4) Balance the following reactions :

1. $Mg + O_2 \rightarrow MgO$ — $2Mg + O_2 \rightarrow 2MgO$
2. $Mg + N_2 \rightarrow Mg_3N_2$ — $3Mg + N_2 \rightarrow Mg_3N_2$
3. $N_2 + O_2 \rightarrow NO$ — $N_2 + O_2 \rightarrow 2NO$

4. $CO + O_2 \rightarrow CO_2$ $2CO + O_2 \rightarrow 2CO_2$
5. $Hg + O_2 \rightarrow HgO$ $2Hg + O_2 \rightarrow 2HgO$

Q5) Correct if there is something wrong in balancing of the following equations

1. $Al + O_2 \rightarrow Al_2O_3$ Not correct
   $4Al + 3O_2 \rightarrow 2Al_2O_3$
2. $CH_4 + O_2 \rightarrow CO_2 + H_2O$ Not correct
   $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
3. $2K + Br_2 \rightarrow 2KBr$ Correct

Q6) Write the names of types of the chemical reactions and give an example for each of them :

1. Combination Reactions (Synthesis Reactions)
   $Fe + S \rightarrow FeS$
2. Decomposition Reactions
   $2H_2O \rightarrow 2H_2 + O_2$
3. Single Displacement Reactions
   $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
4. Double Displacement Reactions
   $BaCl_2 + MgSO_4 \rightarrow BaSO_4 + MgCl_2$
5. Combustion Reactions
   $C_{10}H_8 + 12O_2 \rightarrow 10CO_2 + 4H_2O$

Q7) At the high temperature, potassium chlorate compound, $KClO_3$ decomposes into potassium chloride, KCl and oxygen gas, O_2 as shown in the following reaction : $2KClO_3 \rightarrow 2KCl + 3O_2$, Write what you deduce from this reaction.

Two molecules of potassium chlorate are broken down under the effect of heat into two molecules of potassium chloride and three molecules of oxygen.

Q8) Complete the following reactions and then determine the type of each reaction.

1. $Br_2 + 2KI \rightarrow 2KBr + I_2$ (Single Displacement Reaction)
2. $Zn + 2HCl \rightarrow ZnCl_2 + H_2$ (Single Displacement Reaction)
3. $Ca + Cl_2 \rightarrow CaCl_2$ (Combination Reaction)
4. $2NaClO_3 \rightarrow 2NaCl + 3O_2$ (Decomposition Reaction)
5. $2C_7H_{14} + 21O_2 \rightarrow 14CO_2 + 14H_2O$ (Combustion Reaction)
6. $CuCl_2 + Na_2S \rightarrow CuS + 2NaCl$ (Double Displacement Reaction)

Q9) Write the balanced chemical reaction between the givens below :

1. Metal and oxygen

$2Cu + O_2 \rightarrow 2CuO$

2. Nonmetal and oxygen

$2H_2 + O_2 \rightarrow 2H_2O$

3. Metal and nonmetal

$Ca + Cl_2 \rightarrow CaCl_2$

Q10) Complete the following reactions and then balance each of them :

1. $Hg + 2HCl \rightarrow HgCl_2 + H_2$
2. $2Na + 2H_2O \rightarrow 2NaOH + H_2$
3. $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

Q11) Complete the following chemical reactions and then balance them :

1. $2Li + O_2 \rightarrow Li_2O$ (Combination Reaction)
2. $2Na + 2H_2O \rightarrow 2NaOH + H_2$ (Single Replacement Reaction)
3. $2HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + 2H_2O$ (Double Displacement Reaction)

Q12) Classify the following reactions :

1. $N_2 + 3H_2 \rightarrow 2NH_3$ (Combination Reaction)
2. $2Li + 2H_2O \rightarrow 2LiOH + H_2$ (Single Replacement Reaction)
3. $2NaNO_3 \rightarrow 2NaNO_2 + O_2$ (Decomposition Reaction)
4. $2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$ (Combustion Reaction)
5. $NH_4Cl \rightarrow NH_3 + HCl$ (Decomposition Reaction)
6. $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$ (Double Displacement Reaction)

Q13) Balance the following reactions and then write the type of each reaction

1. $H_2 + Cl_2 \rightarrow 2HCl$ (Combination Reaction)
2. $2Mg + O_2 \rightarrow 2MgO$ (Combination Reaction)
3. $BaO + H_2O \rightarrow Ba(OH)_2$ (Combination Reaction)
4. $H_2CO_3 \rightarrow CO_2 + H_2O$ (Decomposition Reaction)
5. $2H_2O \rightarrow 2H_2 + O_2$ (Decomposition Reaction)
6. $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ (Single Replacement Reaction)
7. $2KI + Br_2 \rightarrow 2KBr + I_2$ (Single Replacement Reaction)

CHAPTER 3

HYDROGEN

THE FUTURE OF CLEAN ENERGY

INTRODUCTION :

Q1: What are the properties of hydrogen?

There are a few key points you should know about Hydrogen :

1. Hydrogen is a colorless, odorless and tasteless gas.
2. Hydrogen gas is lighter than other gas molecules .
3. Hydrogen is insoluble or only slightly soluble in water and other solvents.
4. Hydrogen forms ionic hydrides with active metals, such as KH .
5. Hydrogen forms covalent compounds with nonmetals, such as HF, HCl , H2O .
6. Electronegativity of hydrogen is higher than metals, but less than nonmetals.

Isotopes

Q2: define Isotopes.

Isotopes is different versions of the same element that all have the same atomic number, but different number of neutrons.

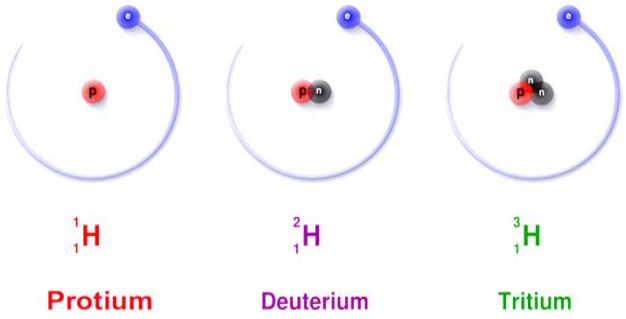
Q3: How many isotopes of hydrogen are there and what are the percentages of each?

Hydrogen (H) has three isotopes :

$^{1}_{1}H$ (99,985 %) naturally occurring

$^{2}_{1}H$ (0.015 %) stable constitutes

$^{3}_{1}H$ (trace amount) radioactive



Q4: What is the difference between the three isotopes of hydrogen?

The atomic number, or number of protons,of the isotopes of hydrogen are the same, but their neutrons and atomic masses are different

PLACEMENT IN THE PERIODIC TABLE

Q5: Why is there hydrogen in the first group?

Because it contains only one electron.

Q6: What are hydrogen like properties with halogens?

1. it forms covalent bonds.
2. It is found in the form of diatomic molecule (H_2), in the gaseous state
3. It has a high electron affinity.

OCCURRENCE

Q7: How hydrogen exists in nature?

Hydrogen makes up about 0.15% by mass and 15.5% by the number of atoms, of the earth's crust and atmosphere . Hydrogen found in the form of free diatomic molecules and its compounds :

1) Free hydrogen occurs in nature only in negligible amounts, for example, in volcanic gases.
2) its also found as a component of organic substances such as hydrocarbons, oil coal, and natural gas .
3) Clays and certain hydrates are common inorganic compounds
4) The most important compound of hydrogen is water (H_2O)

PREPARATION

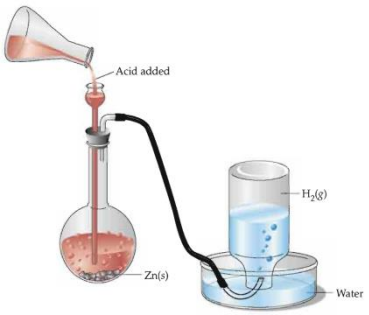
① In the Laboratory

Q8: What are the methods of preparing hydrogen in the laboratory ?

A : Hydrogen gas can be prepared in the laboratory from the following:

a) The reaction of zinc with hydrochloric acid

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$



b) Active metals with water

$$2Na_{(S)} + H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)}$$

c) Amphoteric metals with bases.

$$2Al_{(s)} + 6NaOH_{(aq)} \rightarrow 2Na_3AlO_{3(aq)} + 3H_{2(g)}$$

B : The reactions of alkali metal hydrides with water

$$CaH_{2(g)} + 2H_2O_{(l)} \rightarrow Ca(OH)_{2(aq)} + 2H_{2(g)}$$

$$KH_{(s)} + H_2O_{(l)} \rightarrow KOH_{(aq)} + H_{2(g)}$$

C. Electrolysis of water and solutions of some acids, bases and salts

$$2HCl + H_2O \xrightarrow{\text{electrolysis}} H_2 + Cl_2 + H_2O$$

$$2NaOH + 2H_2O \xrightarrow{\text{electrolysis}} 2H_2 + O_2 + 2NaOH$$

$$2NaCl + 2H_2O \xrightarrow{\text{electrolysis}} H_2 + Cl_2 + 2NaOH$$

Q9: Explain Why Although hydrogen produced by the electrolysis of water is rather pure,it is expensive ?

since electrolysis requires extreme amount of electricity . This method is not used in industry. $2H_2O_{(l)} + 112806\ kJ \xrightarrow{\text{electrolysis}} 2H_{2(g)} + O_{2(g)}$

② In Industry

Q10: How to Get Industrial Hydrogen Gas ?

A. water steam is passed over red hot charcoal :

$$C_{(s)} + 2H_2O_{(g)} \rightarrow CO_{2(g)} + 2H_{2(g)}$$

B. expos C_3H_8 to water steam at 850 ℃ with alkali catalyst :

$$C_3H_8 + H_2O \rightarrow 3CO_2 + 10H_2$$

C. decomposing from hydrocarbons with the help of heat without of oxygen :

$$CH_4 \rightarrow C + 2H_2$$

CHEMICAL PROPERTIES

Q11: What are the chemical properties of hydrogen ?

1- Hydrogen and Nitrogen is reacted under high pressure and temperature to produce ammonia industry

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

2 -Hydrogen used to saturate oils, by saturating these double bonds with hydrogen, fats, such as margarines.

3- H_2 gas is a good reducing agent. Because of this property it is , widely used in the production of metals firom their oxides

$$CuO + H_2 \rightarrow Cu + H_2O$$

4- Methanol, CH_3OH is produce industry as result of the reaction between hydrogen and carbon monoxide.

$$CO + 2H_2 \rightarrow CH_3OH$$

5- Hydrogen is a inflammable and combustible gas. So hydrogen may be an alternative energy source in the future

$$2H_2 + O_2 \rightarrow 2H_2O + 485\ kJ$$

6- Hydrogen does not react with halogens at ordinary temperature. but at high temperature in the presence of catalyst , hydrogen react to give their respective halides.

$$H_2 + Cl_2 \xrightarrow{Heat} 2HCl$$

7- When hydrogen is burnt in sulfur H_2S is formed.

$$H_2 + S \rightarrow H_2S$$

8- Hydrogen reacts with active metals to form hydrides.

$$2Na + H_2 \rightarrow 2NaH$$

Q11: What are the uses of hydrogen ?

1. Hydrogen used for synthesis of ammonia in Haber's process.
2. Hydrogen used for the manufacture of ethanol, HCl etc.
3. It is use in hydrogenation of oil to produce artificial ghee.
4. It is use as a reductant in metallurgical process.
5. Liquid hydrogen is use as a fuel in rockets and missiles.
6. It is use for filling balloons, study of atmosphere etc.

Hydrogen as a fuel

Hydrogen is one of the most advantageous alternative energy sources, a very efficient and clean fuel, Energy from hydrugen can be cvonverted to electicity by special devices called fuel cells.

Q12: What are the problems that prevent the use of hydrogen as a fuel ?

- Storage: Since hydrogen is so light, it is difficult to store a lot of it in a small tank.
- Distribution: There is not a widespread distribution channel for getting hydrogen to the masses.
- Cost: Hydrogen is much more expensive than gasoline , Hopefully

CHAPTER 3 QUESTIONS ANSWERS :

Q3) Discuss the position of hydrogen in the periodic table .

Although hydrogen is placed in the periodic table at the head of group 1A, in fact it does not show alkali metal properties because of its one valence electron .

Q8) Label the following statements as true (T) or false (F) :

a. Hydrogen is a mono-atomic colorless gas at room temperature.

F (diatomic molecule H_2)

b. Hydrogen resembles alkali metals . T

c. Hydrogen is a good oxidizing agent.

F (H_2 gas is a good reducing agent)

d. Hydrogenation is a process of hydrogen removal.

F (Hydrogenation is the process of adding hydrogen)

Q9) Complete and balance the following equations :

a. $CO + 2H_2 \rightarrow CH_3OH$

b. $C_{(s)} + 2H_2O_{(g)} \rightarrow CO_{2(g)} + 2H_{2(g)}$

c. $Ca + H_2 \rightarrow CaH_2$

d. $C_2H_6 + 4H_2O \rightarrow 2CO_2 + 7H_2$

Q11) Write 5 reactions between the following substances :

1. HCl 2. H_2 3. CuO 4. Zn 5. O_2

$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$

$CuO + H_2 \rightarrow Cu + H_2O$

$2H_2 + O_2 \rightarrow 2H_2O + 485\ kJ$

$2Zn + O_2 \rightarrow 2ZnO$

$2HCl + CuO \rightarrow CuCl_2 + H_2O$

Q13) Hydrogen can act both as an oxidizing agent and a reducing agent in chemical reactions. Give one example of each and determine the oxidation number of hydrogen.

1. (Reducing agent) : $CuO + H_2 \rightarrow Cu + H_2O$

The oxidation number of hydrogen = +1

2. (Oxidizing agent) : $Ca + H_2 \rightarrow CaH_2$

The oxidation number of hydrogen = –1

Q17) Choose the correct answer for the following questions :

1. Which one is not correct for hydrogen ?

A) Its symbol is H.

B) Its atomic number is 1.

C) has no neutron.

D) Its physical state is solid.

2. Which of the following is not true for hydrogen ?

A) It occurs in the form of free diatomic molecules.

B) It occurs in the form of compounds.

C) It is the most abundant element in the universe.

D) It is found as a component of hydrocarbons.

E) It is the most abundant element in the earth's crust.3. Which substance does not contain hydrogen ?

3. Which substance does not contain hydrogen ?

A) Water B) Ammonia C) Alcohols D) Acids E) Table salt

4. Which of the following is used in the industry preparation of hydrogen ?

A) Metal- acid reactions

B) Metal- water reactions

C) Electrolysis of water

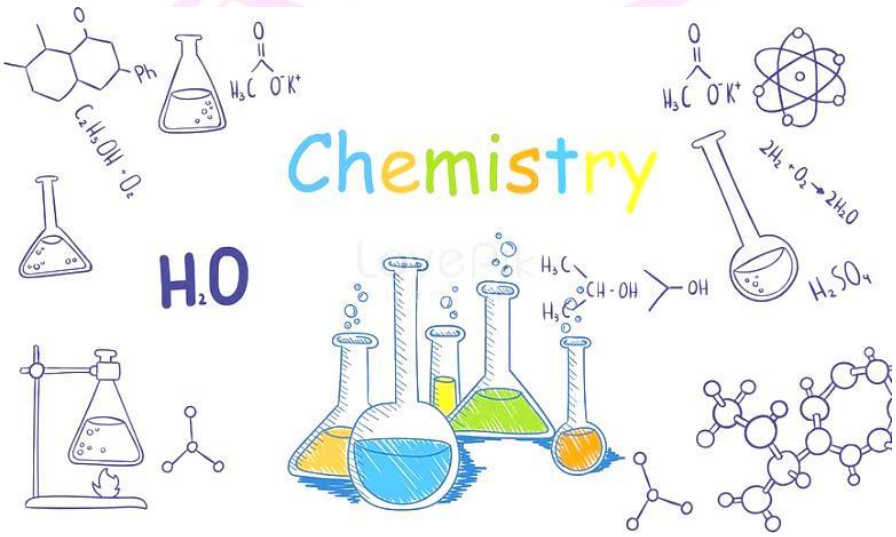
D) Decomposition of hydrocarbons

5. Which of the following reactions does not produce hydrogen gas?
A) Zn + HCl
B) Zn + NaOH
C) $2Na + 2H_2O$
D) CH_4
E) H_2O electrolysis

6. In which of the given compounds does hydrogen have a different oxidation state?
A) HCl
B) HNO_3
C) CH_3COOH
D) NaOH
E) KH

7. Which one of the following is not a use of hydrogen ?
A) In the synthesis of methanol
B) In the reduction of metals
C) In the synthesis of NH_3
D) In preparing margarines
E) In preparing pesticides

8. Which of the following is/are exactly correct about all neutral hydrogen atoms ?
I. All possess 1 proton. II. All possess 1 electron. III. All have a mass of 1 amu.
A) I only
B) I and II
C) I and III
D) II and III
E) I , II and III



CHAPTER 4

OXYGEN

OXYGEN IS NATURE'S BREATHER

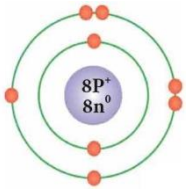
INTRODUCTION :

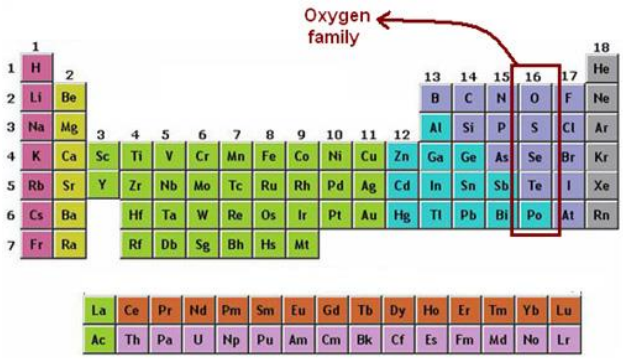
Symbol : O

Molecular formula : O_2

Atomic number : 8

Mass number : 16





1. The members of group 6A (oxygen group, oxygen family, or chalcogens) are :
Oxygen (O) , Sulfur (S) , Selenium (Se) , Tellurium (Te) and Polonium (Po)
2. Oxygen is the second most electronegative non-metal after fluorine.
3. Oxidation number for oxygen is -2

Q1: What are the general characteristics of group 6?

1. Most of the elements found in natural ores as oxides or sulfides.
2. generally show nonmetallic properties
3. they are less reactive than the halogens in the same periods
4. they have six electrons in their valence shell.

Q2 : What is the difference between oxygen and the rest of the 6A group elements?

1. Oxygen is a gas, but the others are solids.
2. The bonding capacity of Oxygen is limited to two, whereas the others have bonding capacity of four or six.
3. Oxygen forms ionic compounds with all metals

OXYGEN

(Q3 : Fill in the following blanks)

Oxygen was discovered by Priestley in I774. The name oxygen, which means acid-producer, comes from Greek.

Oxygen is the first member of 6A group with electron arrangement 2,6 .
It is a nonmetal and the most active element of the group.

There are three stable isotopes oxygen : ^{16}O , ^{17}O and $^{18}0$.

It has two allotropes : oxygen gas O_2 , and ozone O_3.

Oxygen gas

Q3 : What are the Physical Properties of Oxygen?

1. Oxygen is a colorless, tasteless, odorless gas, and it exists in a diatomic structure.
2. Oxygen gas is more stable than ozone.
3. The density of oxygen is greater than air.
4. The boiling point of oxygen is –l53°C , and its melting point is -2l8.3°C
5. It dissolves slightly in water

Ozone gas

Q4: What are the Properties of Ozone ?

1.It is a light blue colored gas with a sharp pleasant odor.
2.It may be liquefied at -112 C , It may be solidified at -193 C
3.It is slightly soluble in water

Q5: How to prepared ozone ?

It can be prepared by passing pure oxygen gas through an electrical discharge; the electrical energy breaks the bonds in some O_2 molecules to give oxygen atoms, which react with other O_2 mole cules to form O_3

$$O_2 \rightarrow 2O \quad \Rightarrow \quad O_2 + O \rightarrow O_3 \quad \Rightarrow \quad 3O_{2(g)} \rightarrow 2O_{3(g)}$$

Q6 : Why the ozone layer is especially important

A: because it absorbs ultraviolet light, acting as a screen to block this radiation, which can cause skin cancer.
When an ozone molecule absorbs this energy, it splits in to an oxygen molecule and an oxygen atom. $O_3 \xrightarrow{energy} O_2 + O$

Q7: facts about ozone (fill blanks)

- Ozone exists naturally in the upper atmosphere of the earth.
- Free oxygen constitutes about 21% By volume of atmospheric air, and about 33% by volume of dissolved air.
- In compounds, oxygen accounts for about 50% of the mass of the earth crust, oceans and air.
- Oxygen is present as oxides of both metals and non-metals,which make up the rocks and clays.
- Water, one of the most abundant compounds on the earth, contains 88.9% oxygen by mass.

Preparation

① In the Laboratory

a) Heating of metal oxides with low activity such as Ag_2O and HgO.

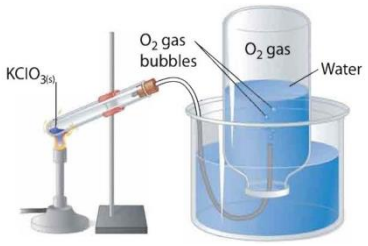
$$2HgO_{(s)} \xrightarrow{energy} 2Hg_{(l)} + O_{2(g)}$$
$$Ag_2O_{(s)} \xrightarrow{energy} 2Ag + O_2(g)$$

b) Heating of peroxides, such as Na_2O_2 and H_2O_2 :

$$2H_2O_{2(l)} \xrightarrow{energy} 2H_2O_{(l)} + O_{2(g)}$$

c) Heating of chlorate ClO_3^- compounds :

$$2KClO_{3(s)} \xrightarrow{heat} 2KCl_{(s)} + 3O_{2(g)}$$



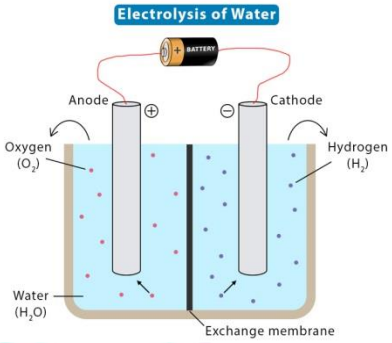
d) Heating of permanganate (MnO_4) compounds :

$$2KMnO_{4(s)} \xrightarrow{heat} K_2MnO_{4(s)} + MnO_{2(s)} + O_{2(g)}$$

e) Electrolysis of water :

$$2H_2O_{(L)} \xrightarrow{Electrolysis} O_{2(g)} + 2H_{2(g)}$$

This method is more expensive than the others.



Q8 : How can oxygen be prepared in the laboratory from : metal oxides , peroxides Chlorate , permanganate , water ? answers above .

② in industry.

the preparation of oxygen industry involves two main steps:

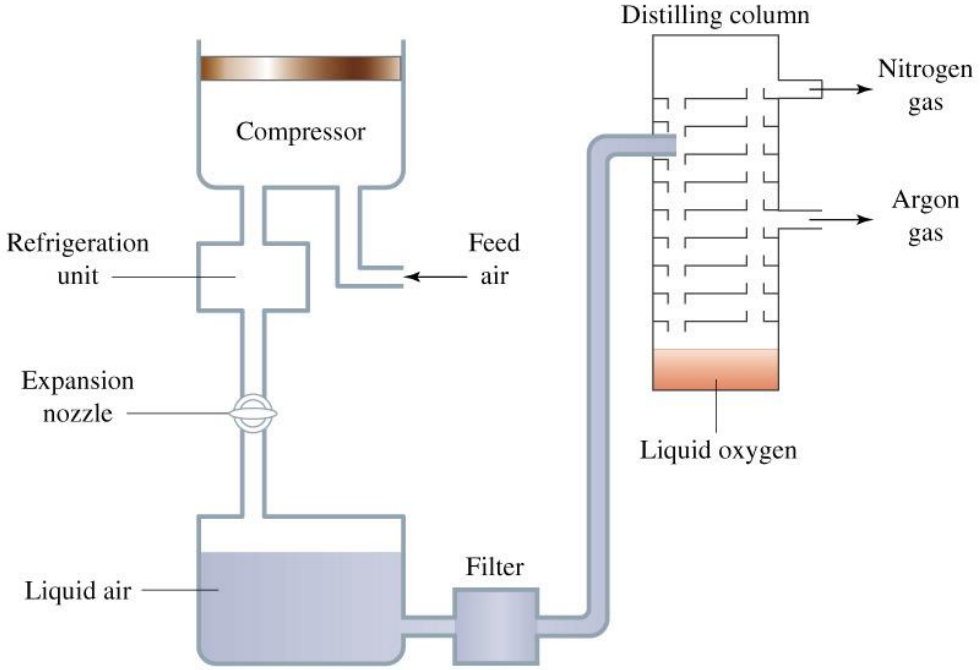
a) the liquefaction of air

1.Air in the gaseous form, is first passed through caustic soda to remove CO_2

2.It compressed to a pressure of about 200 atm., cooled, and allowed to escape rapidly through a very small hole.

3. The sudden expansion of the air in to a region of lower pressure causes it to cool.

4. It cooled until it becomes a liquid at -200°C.



b) the fractional distillation of the liquid air.

1. The liquid air led to a fractionating (distilling) column
2. During distillation, nitrogen gas, with the lower boiling point of -196 ℃ , is evolved first, leaving behind a liquid very rich in oxygen.
3. Further heating turns the liquid oxygen into a gas at -183C.
4. The oxygen is dried, compressed and stored in steel cylinders under a pressure of 100 atm.

CHEMICAL PROPERTIES

Q9 : What are the chemical properties of oxygen ?

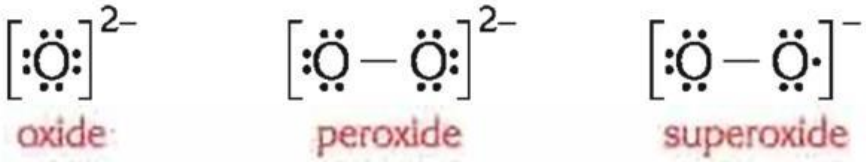
1. Oxygen is the second most active nonmetal
2. The reactions of oxygen are slow.
3. Oxygen takes (-2) charge in its compounds, except OF_2.
4. Oxygen combines most elements to form oxides.

Q10 : why Even though oxygen is the second most active nonmetal, the reactions of oxygen are slow.

Because of the strong double bond between oxygen atoms .

① Reactions with metals :

a) Oxygen reacts with alkali metals to form oxides , peroxides (O_2^{-2}) or superoxides (O_2^{-1}) .



$2Na_{(s)} + O_{2(g)} \rightarrow Na_2O_{2(s)}$ sodium peroxide

b) Oxygen gas gives thermal reactions with other metals to form basic oxides

$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)} + heat$

$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)} + heat$

② In general all nonmetals react with oxygen gas

a) Depending on the kind of nonmetal and amount of oxygen,different types of oxides may be formed. (Acidic oxides)

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$

$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$

$2S_{(s)} + 3O_{2(g)} \rightarrow 2SO_{3(g)}$

b) Reaction with nitrogen is possible at high temperature 1000 ° C

$$N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)}$$

③reacts with some compounds, the oxides of each element form

$$2H_2S_{(g)} + 3O_{2(g)} \rightarrow 2H_2O_{(g)} + 2SO_{2(g)}$$

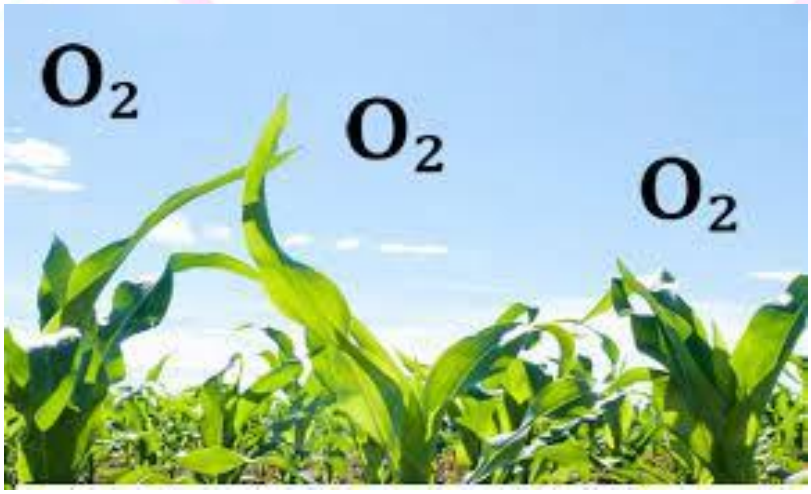
④ Oxygen gives combustion reactions with organic compounds

$$CH_{4\,(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$$

$$C_2H_{2\,(g)} + 5O_{2(g)} \rightarrow 4CO_{2(g)} + 2H_2O_{(g)}$$

USES OF OXYGEN

1. Oxygen is required for respiration by divers, patients and astro nauts.
2. Oxygen is stored in special tubes and tanks.
3. Oxygen is used in the burning of acetylene gas to produce a(oxy-acetylene)
4. It is used to cut through metals oxygen mixed with liquid hydrogen is used as a powerful rocket fuel.
5. Oxygen used in the steel industry to remove carbon.
6. It is used in the production of compounds, such as H_2SO_4 and HNO_3



CHAPTER 4 QUESTIONS ANSWERS :

4 – 2 Write the physical properties of oxygen.

1. Oxygen is a colorless, tasteless, odorless gas, and it exists in a diatomic structure.
2. Oxygen gas O_2 is more stahle than ozone O_3
3. The density of oxygen is greater than air.
4. It dissolves slightly in water.

4 – 4 What does oxygen mean in Greek language ?

Means acid-producer, comes from Greek

4 – 5 Write the abundance of oxygen in the earth's crust and in the atmosphere (by mass and by volume).

Oxygen is the most abundant element on the earth. It occurs in nature in both the free and combined state. Free oxygen constitutes about 21% by volume of atmospheric air, and about 33% by volume of dissolved air. In compounds, Oxygen accounts for about 50% of the mass of the earth's crust, oceans and air. Oxygen is present as oxides of both metals and non-metals, which make up the rocks and clays. Water, one of the most abundant compounds on the earth, contains 88.9% oxygen by mass.

4 – 11 Air is a mixture of some gases. How would you separate oxygen from this mixture?

1. Liquefaction of air
2. Fractional distillation of liquid air

4 – 13 Complete and balance the following reactions :

a. $2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$

b. $2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)} + heat$

c. $2Na_{(s)} + O_{2(g)} \rightarrow Na_2O_{2(s)}$

d. $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$

e. $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$

4 – 16 Choose the correct answer for the following questions :

1. I. Ozone is an allotrope of oxygen.
II. Oxygen is lighter than air.
III. Oxygen was discovered in 1774.

1. Which one(s) of the above statements is/are correct for oxygen?

A) I only B) I and III C) III D) I , II E) I , II , II

2. Which one of the following statements is not correct for oxygen?
A) Oxygen forms ozone.
B) Oxygen is used in metallurgy.
C) Oxygen is used in diving.
D) Oxygen is needed for combustion.
E) Oxygen is a flammable gas. .

3. Which one is wrong for combustion reactions?
A) Oxygen is needed
B) Heat is needed.
C) Light is given off.
D) They are exothermic.
E) Water is used. .

4. Which one of the following is not a method of preparation for oxygen ?

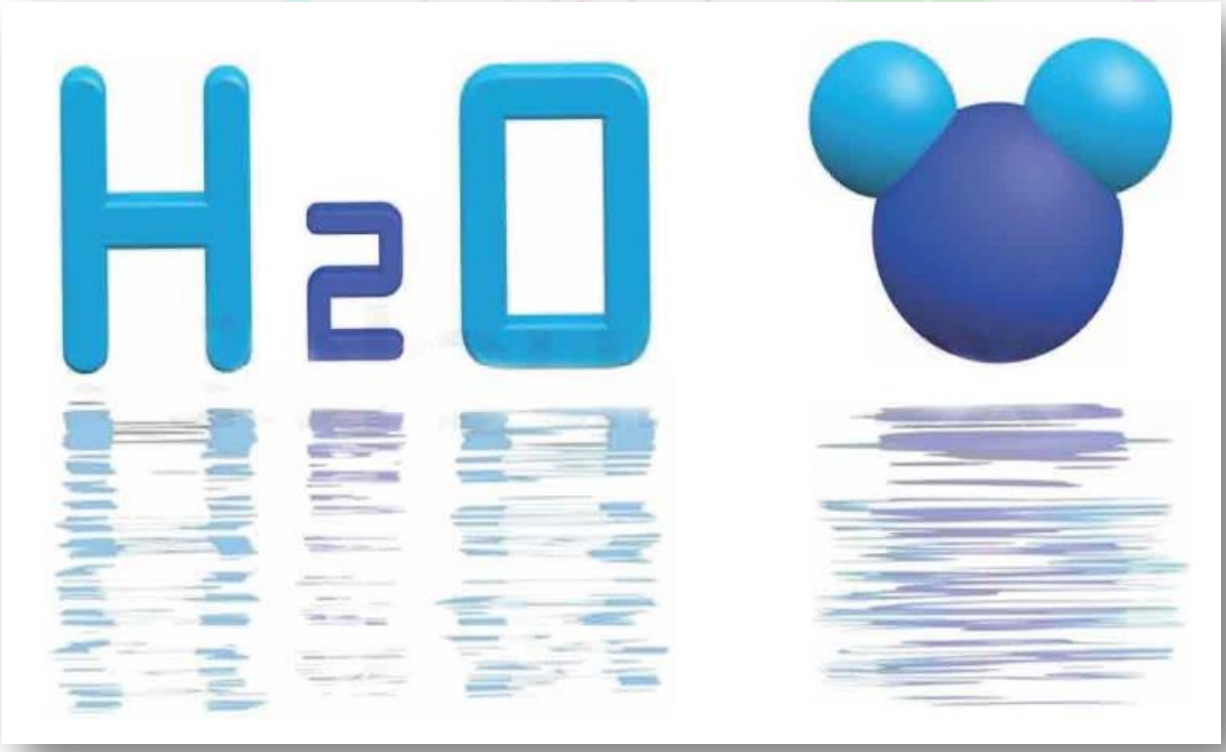
A) $2HgO_{(s)} \xrightarrow{heat} 2Hg_{(s)} + O_{2(g)}$
B) $2H_2O_{2(L)} \xrightarrow{MnO2} 2H_2O + O_2$
C) $2H_2O_{(L)} \xrightarrow{Electrolysis} 2H_{2(g)} + O_{2(g)}$
D) $2KClO_{3(s)} \xrightarrow{heat} 2KCl + 3O_{2(g)}$
E) $2Ag_2O_{(s)} \xrightarrow{light} 4Ag_{(s)} + O_2$

5. Which one of the following reactions of oxygen does not occur ?
A) $S + O_2 \rightarrow SO_2$
B) $Ag_2O_{(s)} \xrightarrow{heat} 2Ag + O_{2(g)}$
C) $2KClO_{3(s)} \xrightarrow{heat} 2KCl + 3O_{2(g)}$
D) $4Al + 3O_2 \rightarrow 2Al_2O_3$
E) $Au + 3O_2 \rightarrow 2Au_2O_3$

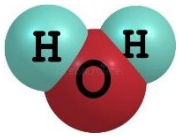
CHAPTER 5

WATER H_2O

" WE CREATED FROM WATER EVERY LIVING THING "



INTRODUCTION :



- Water is the most common and essential oxide found in nature.
- Water is the only substance naturally present on the earth in all three states: solid , liquid and gas
- The water is solid in near the north and south poles and in glaciers.
- The water is gas state in (water vapor) in the atmosphere.

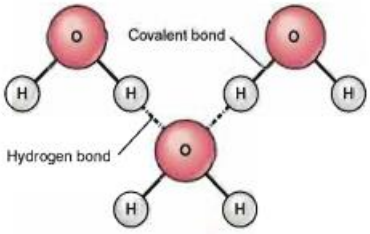
OCCURRENCE

- About 75% of the earth's surface is covered with water in which many other compounds (such as salt) are dissolved.
- Oceans, more than 97% of the water, help in the heat balance of the world
- Water is essential for all living organisms.
- The water we lose when we breathe out, sweat and urinate must be replaced.
- Water is needed to dissolve chemicals in our cells and to carry it around our body.
- Water takes part in some metabolic reactions, and our blood is about 90% water .

HYDROGEN BONDING IN WATER

Q1: Define Hydrogen Bonding :

attraction force occurs between water molecules Because of two elements H_2 (anode) and O (cathode) forming water,



the water molecules attract each other and form a molecule sequencing , Because water possesses molecules which form poles like magnets.

PREPARATION

1. Direct union of hydrogen and oxygen:

when hydrogen burns in air. This reaction is highly exothermic .

$$2H_2 + O_2 \rightarrow 2H_2O + heat$$

2. Decomposition of certain substances:

Some oxygen-containing organic compound such as simple sugar, $C_6H_{12}O_6$ give water when they are thermally decomposed.

$$C_6H_{12}O_6 \rightarrow 6C + 6H_2O$$

3. Neutralization reactions:

When acids and bases react, they give salt and water as products.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

The exceptional base that doesn't release water from its neutralization reaction is ammonia, NH_3

$$NH_3 + HCl \rightarrow NH_4Cl$$

4. Reduction:

When hydrogen is used as a reducing agent for metal oxides, the products are elemental metal and water

$$CuO + H_2 \rightarrow Cu + H_2O$$

PHYSICAL PROPERTIES OF WATER

1. Pure water is colorless and tasteless.
2. It boils at 100°C and freezes at 0°C under 1 atmosphere pressure (at sea level) .
3. Its density is highest at 4°C equal $1g/cm^3$.
4. Its density decreases and volume increases when it freezes.
5. It is often called the universal solvent.

Q2: When the water freezes stay life possible in seas and lakes .in winter

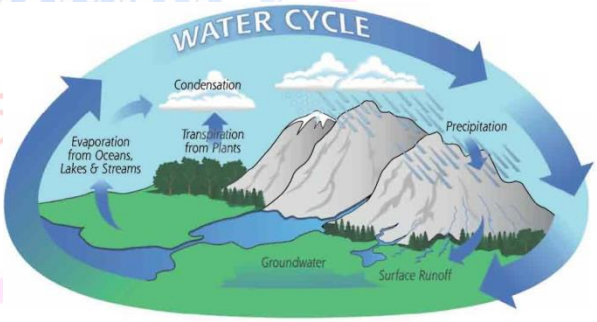
Because water is the only substance whose density is lower when it freezes, thus the ice floats on the water.

Q3: Water can dissolve polar substances.

Because two pairs of non-bonding electrons in oxygen a charge imbalance in water molecules and makes them polar

WATER CYCLE

1. Water evaporates from oceans, lakes and streams
2. The water vapor formed condenses in the upper regions of the atmosphere
3. Vapor further condense s into larger drops which fall as rain
4. This rain water slowly passes through the soil back to streams, lakes and oceans



CHEMICAL PROPERTIES

1) Water reacts with active metals (Li, K, Ba, Ca and Na) to give bases of these metals and hydrogen gas :

$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$
$$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$$

2) Less active metals such as iron and zinc react with water only at high temperature. The products of these reactions are metal oxide instead of hydroxide :

$$Zn + H_2O \xrightarrow{heat} ZnO + H_2$$

3) Water reacts with basic oxides to produce bases :

$$Na_2O + H_2O \rightarrow 2NaOH$$

4) Water reacts with acidic oxides to produce acids :

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Uses

1. In industry water is mainly used for cooling and as a solvent.
2. Water is also used in the production of steel and paper.
3. Water is used in the home for cooking, drinking and washing.
4. Water in the form of steam is used to generate electricity.
5. It is used to extract oil, sulfur and sodium chloride from the earth
6. In the manufacture of several chemicals such as nitric and sulfuric acid

CHAPTER 5 QUESTIONS ANSWERS :

5 – 1 What is the chemical formula of water ?

Chemical formula of water is H_2O

5 – 2 Why water is important in our life ?

- Without water, there would not be life.
- Water is used as temperature control both for our bodies as well as our planet
- Water gets rid of body waste and can help with a number of health concerns.
- Water is the only substance that can get the dirt and bacteria off our bodies

5 – 3 Explain the electrolysis of water .

Water is placed in the electrolysis device, and when the electric current passes, the water separates into hydrogen and oxygen gases, where the volume of hydrogen is twice the volume of oxygen.

5 – 4 Explain the water cycle

1. Water evaporates from oceans, lakes and streams
2. The water vapor formed condenses in the upper regions of the atmosphere
3. Vapor further condense s into larger drops which fall as rain
4. This rain water slowly passes through the soil back to streams, lakes and oceans

5 – 5 Write the uses of water .

1. In industry water is mainly used for cooling and as a solvent.
2. Water is also used in the production of steel and paper.
3. Water is used in the home for cooking, drinking and washing.
4. Water in the form of steam is used to generate electricity.
5. It is used to extract oil, sulfur and sodium chloride from the earth.
6. In the manufacture of several chemicals such as nitric and sulfuric acid.

5 – 6 Complete the following reactions :

1) $Zn + H_2O \xrightarrow{heat} ZnO + H_2$

2) $Na_2O + H_2O \rightarrow 2NaOH$

3) $SO_3 + H_2O \rightarrow H_2SO_4$

4) $2H_2O \rightarrow 2H_2 + O_2$

5) $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

5 – 7 What percentage of our body and world is water ?
About 70% of our body is made up of water, about 75% of the earth's surface is covered with water , more than 97% of the water, help in the heat balance of the world.

5 – 8 What are the constituents of water ?
A water molecule consists of two hydrogen atoms and one oxygen atom that are bonded together by a covalent bond.

5 – 9 Explain the preparation methods of water by giving examples.
The answer is page 4

5 – 10 How much of Earth's surface is covered with water ?
A) 2%
B) 3%
C) 75%
D) 97%

5 – 11 What are the three states of water on Earth ?
A) Groundwater, lakes, and clouds
B) Liquid water, ice, and water vapor
C) Gas, steam, and vapor
D) Groundwater, oceans, and ice

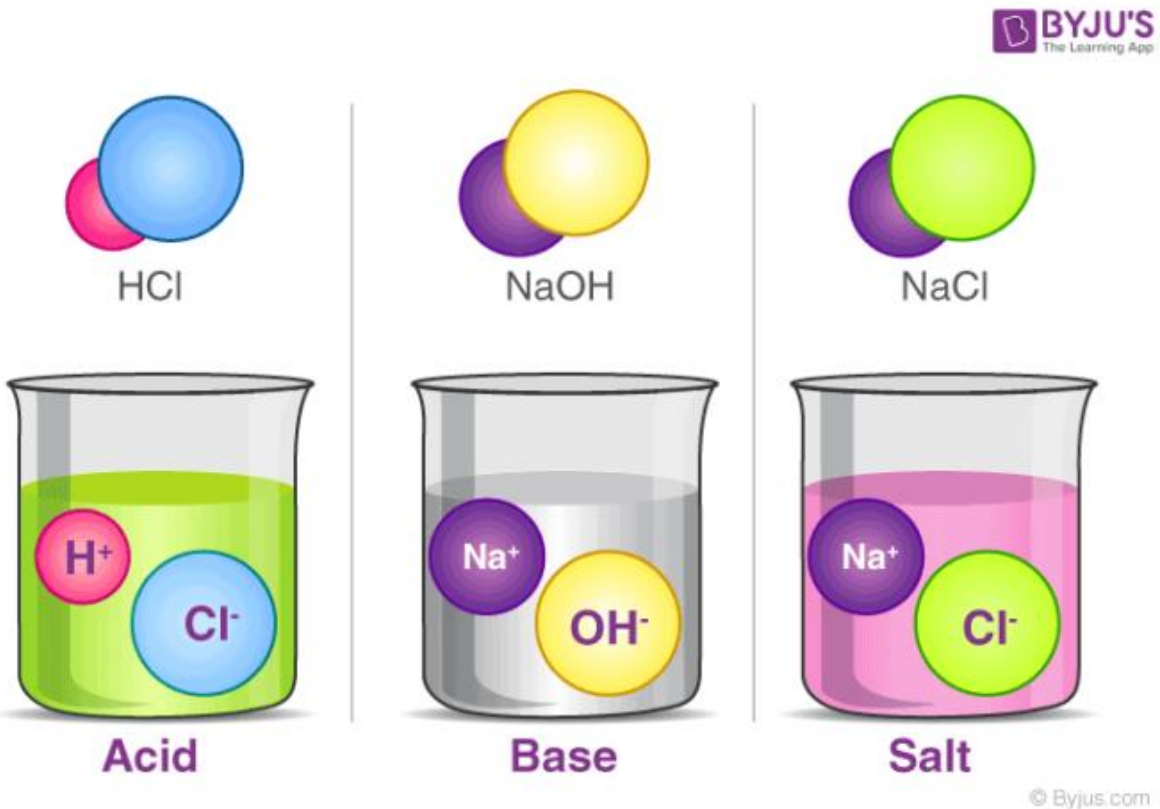
5 – 12 "Condensation is an important process in the water cycle."
What forms because of condensation?
A) Water vapor
B) Clouds
C) Rain
D) Snow

Kasim alnasiry
07801575954

CHAPTER 6

ACIDS , BASES , AND SALTS

THE TASTE OF LIFE



Kasim alnasiry
07801575954

INTRODUCTION :

There are many different chemical compounds. These compounds can be classified according to their properties. Such as acids, bases and salts

ACIDS

Acids are one of the most important classes of compounds in inorganic chemistry. The sourness of lemonade, the fizz of fizzy drinks and the distinctive taste of vinegar all come from acids.

- Car batteries use sulfuric acid
- Many cleaning materials contain hydrochloric acid.
- The tomatoes containing ascorbic acid

characteristics of acids :

1. Acids have a sour taste and are very corrosive and irritant.
2. Most acids are soluble in water.
3. Aqueous solutions of acids conduct electricity.
4. In normal conditions may acids are liquids (HNO_3 , H_2SO_4).
   while some of them are solid ($HSiO_3$, H_3PO_4).
   some volatile acids (HCl , HNO_3) have a characteristic odor.

A Swedish chemist, Arrhenius, defined :

Acids : are substances that dissolve in water by producing a hydrogen ion H^+

$$HCl_{(g)} \xrightarrow{H_2O} H_{(+aq)} + Cl_{(aq)-}$$

Acids are often shown as HA, where H is hydrogen and A is the acidic negative ion
But not all compounds containing hydrogen are acids. For example,
methane (CH_4) glucose ($C_6H_{12}O_6$) and ammonia (NH_3) are not acids.

The Naming of Acids

Acids containing only two types of atoms are called binary acids. These acids do not have oxygen in their structures. Their names follow the form :

hydro + (nonmetal) + ic + acid

HCl	Hydrochloric acid	HF	Hydrofluoric acid
HI	Hydroiodic acid	H_2S	Hydrosulfuric acid

Acids are that contain oxygen in addition to hydrogen and a nonmetal are called oxyacids :

① If there is only one possible oxyacid, the suffix - ic is used to name the acid.

H_3BO_3	boric acid	H_3PO_4	phosphoric acid.

② If a non-metal can form more than one oxyacid,
the acid containing more oxygen atoms will be named using the suffix - ic,
and the acid containing less oxygen atoms is named using the suffix - ous.

H_2SO_4	Sulfuric acid	H_2SO_3	Sulfurous acid
HNO_3	Nitric acid	HNO_2	Nitrous acid

The Classification of Acids :

① According to Strength

Strong acid : is the acid which ionizes completely in water , for instance HCl .
when HCl pass through water, almost all the molecules ionize to give ions H^+ & Cl^-

Weak acid : is the acid which ionizes partially in water such as HF
If you pass HF gas through water, some of it will ionize to give H^+ and F^-
However, most of the dissolved hydrogen fluoride will remain as HF molecules in water.
Some examples of strong and weak acids :

Strong Acids	HCl	HBr	HI	H_2SO_4	HNO_3	$HClO_3$
Weak Acids	HF	HCN	H_2CO_3	H_2SO_3	H_3PO_4	CH_3COOH

② According to the Number of Hydrogen Atoms

different acids going to produce one, two or three H^+ ions per molecule in their aqueous solutions.
According to the number of H^+ ions are produced, acids are classified as :
Monoprotic , Diprotic , Triprotic.
For example, hydrochloric acid is monoprotic because each HCl molecule ionizes to give one H^+ ion : $HCl_{(g)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$
Similarly, sulfuric acid is diprotic $H_2SO_{4(L)} \rightarrow 2H^+_{(aq)} + SO_4^{-2}{}_{(aq)}$
and phosphoric acid is triprotic : $H_3PO_{4(s)} \rightarrow 3H^+_{(aq)}\ PO_4^{-3}{}_{(aq)}$

Chemical Properties of Acids

Acids are chemically active substances. Several acids ionize when added to water. These ions make aqueous solutions of acids which conduct electricity.

$$HCl_{(g)} \xrightarrow{-H_2O} H^+_{(aq)} + Cl^-_{(aq)}$$

The ionization of acids in water produce heat.so we should be careful while adding concentrated acid to water
Because certain amount of energy is released when a concentrated acid is added to water.

Acids can also act on indicators

Indicators : *are substances that change their color depending on the acidic or basic character of the media*

Colors of some indicators in acidic solutions

Litmus paper	Red	Phenolphthalein	Colorless
Methyl orange	Red	Bromothymol blue	Yellow

Bases react with acids to give salt and water. Such reactions are called neutralization reactions. Both alkalis and insoluble bases are capable of reacting with acids.

Acid + Base → Salt + Water

$HCl + NaOH \rightarrow NaCl + H_2O$

Q1: Acids are described as corosive (eat away) other meteial ?

Because acids react and give displacement reactions with the metals that are more active than hydrogen.

$2Al_{(s)} + 6HCl_{(aq)} \rightarrow 2AlCl_{3(aq)} + 3H_{2(g)}$

$Zn_{(s)} + H_2SO_{4(aq)} \rightarrow ZnSO_{4(aq)} + H_{2(g)}$

Exercise (6-1)

Write the equations for the reactions of magnesium and aluminum with hydrofluoric acid and sulfuric acid (four equations in total)

1) $Mg + 2HF \rightarrow MgF_2 + H_2$
2) $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$
3) $2Al + 6HF \rightarrow 2AlF_3 + 3H_2$
4) $2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$

BASES :

Bases are substances known as the "opposite" of acids, and it is the compounds of metals with hydroxide (OH^-) , All bases taste biter. & a slippery feeling.

Q2 : why bases must be handled carefully

Because bases, especially the strong ones, are capable of destroying the texture of anything or eating away its substance by chemical action.

Usage of Bases :

- Cleaning materials often contain bases.
- Ammonia solutions are widely used as household cleaners and detergents.
- Sodium and potassium hydroxide are used in the production of soap.
- In medicine, some bases are used to prepare antacid tablets
- Water soluble bases are called alkalis and they can easily give OH^- ions
- Most alkalis are solid.

Bases can be shown as Me(OH)x, where "Me" refers to a metal and "x" shows the number of hydroxides

Q3: Why ammonia considered a base although it does not contain metal or hydroxide

Ammonia, NH_3 is an exceptional base. It does not contain metal or hydroxide. However, when it is passed through water, the solution produced contains OH^- and acts as an alkali.

$$NH_{3(aq)} + H_2O_{(L)} \rightarrow NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

Q4: How to prepare Bases with examples mentioned ?

Bases are often prepared from the reactions of active metals (Li, K,Ba,Ca,Na) or hydrides of these metals with water. Such reactions give bases and hydrogen gas :

$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$
$$CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + 2H_2$$

The Naming of Bases :

In the naming of bases, the word hydroxide is added after the name of the metal. Do not forget to write the valency of the metal if it can take more than one valencies .

NaOH	Sodium hydroxide	$Ca(OH)_2$	Calcium hydroxide
LiOH	Lithium hydroxide	$Ba(OH)_2$	Barium hydroxide
$Mg(OH)_2$	Magnesium hydroxide	$Fe(OH)_2$	Iron(II) hydroxide

The Classification of Bases

① According to Strength

1. Strong bases : are bases that completely ionize in water, their aqueous solutions conduct electricity well , such as NaOH , KOH , $Ba(OH)_2$
2. Weak bases : are bases that dissociate in water slightly, their aqueous solutions poor conductors of electricity. Such as NH_3 , $Mg(OH)_2$

Chemical Properties of Bases

- Alkalis are soluble in water change the color of indicators
  Litmus paper ⇒ Blue , Methyl orange ⇒ Yellow , Phenolphthalein ⇒ Pink

- Bases are reacting with acids (Neutralization reactions) to give salt and water.
  $NaOH + HCl \rightarrow NaCl + H_2O$
  $3Ba(OH)_2 + 2H_3PO_4 \rightarrow Ba_3(PO_4)_2 + 6H_2O$

- Ammonia can react with acids to give only salt, not water :
  $NH_3 + HNO_3 \rightarrow NH_4NO_3$
  $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

- Water insoluble bases decompose on heating to give metal oxides
  $Mg(OH)_2 \xrightarrow{-heat} MgO + H_2O$

- Alkalis can react with amphoteric metals such as zn and Al to give salt and H_2
  $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

- However, most alkalis do not decompose
  $KOH \xrightarrow{-heat} \text{No reaction}$

Exercise (6-2)

Write the equations for the reactions of nitric acid with the following compounds
a. Sodium hydroxide , b. Copper (II) hydroxide , c. Iron (III) hydroxide

a. $HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$
b. $2HNO_3 + Cu(OH)_2 \rightarrow Cu(NO_3)_2 + 2H_2O$
c. $3HNO_3 + Fe(OH)_3 \rightarrow Fe(NO_3)_3 + 3H_2O$

Q3 : Compare of properties acids with bases ?

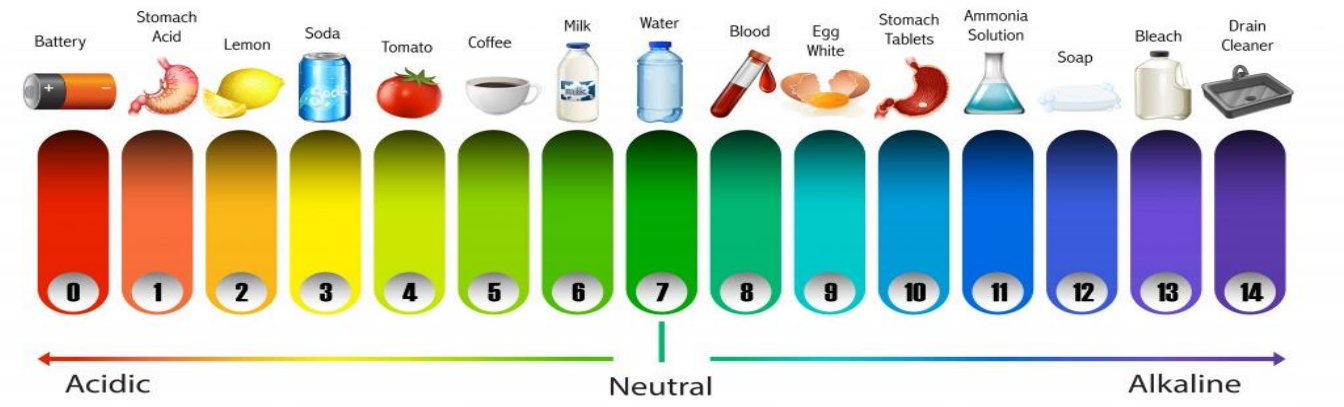
Properties of Acids	Properties of Bases
1. Have a sour taste.	1. Have a bitter taste.
2. Dissociate in water to give H^+ ions.	2. Dissociate in water to give OH^- ions.
3. Aqueous solutions conduct electricity.	3. Aqueous solutions conduct electricity.
4. Change the color of litmus paper to red.	4. Change the color of litmus paper to blue.
5. React with metals to give H_2 gas & salt.	5. React with amphoteric metals to give H_2 gas & salt & Water
6. React with bases to produce salt and water.	6. React with acids to produce salt and water

THE pH SCALE

pH : is a numeric scale used to specify the acidity or basicity (alkalinity) of an aqueous solution, the pH scale ranges from 0 to 14.

Note :

1. A pH of 7 is neutral , such as Pure water.
2. Solutions with a pH less than 7 are acidie .
3. Solutions with a pH greater than 7 are basic.



Indicator : *is a chemical compound, that changes color reversibly at different pH values , such as phenolphthalein or methyl orange .*

Indicator	Acidic	Basic
Phenolphthalein	Colorless	Red-ViOlet
Methyl orange	Red	Orange - Yellow
Litmus	Red	Blue

Salts :

are crystalline solids. They have ionic structure and therefore their boiling and melting points are high.

- Salts may have a variety of colors. For example :
Nickel (II) sulfate is green . Lead (II) iodide is yellow . Sodium chloride is white.
- Solubility is the most important characteristic property of salts.
- Aqueous solutions of salts conduct electricity
- A salt results when an acid reacts with a base

The Naming of Salts

The names of salts are composed of the name of the metal first and then the name of the radical

NaCl	Sodium chloride	$FeSO_4$	Iron (II) sulfate	NH_4Br	Ammonium bromide
$CaCO_3$	Calcium carbonate	$Fe_2(SO_4)_3$	Iron (III) sulfate	$(NH_4)_2SO_4$	Ammonium sulfate

Classification of Salts

When salts are dissolved in water, they may exhibit neutral, acidic or basic characteristics.

1) Neutral Salts : are salts that formed by the reactions of strong acids and strong bases. For example NaCl wich formed by the r eactions of NaOH with HCl
some other examples of neutral salts are KNO_3, Li_2SO_4 and $NaClO_4$

2) Acidic Salts : are salts that formed by the reaction of strong acids with weak bases. They have acidic properties , such as :
$FeCl_2$, $CuSO_4$, NH_4NO_3 , $NaHSO_4$

3) Basic Salts : are salts are produced from the reactions of weak acids with strong bases. They have basic properties , such as :
NaCN, NaF , Na_2CO_3 , CaOHCl

Chemical Properties of Salts

Salts are selective in their reactions. They react with other substances only under certain conditions. For example, they may react with metals but only if the free metal is more active than the metal of the salt. Consider the following reaction:

$$Cu_{(s)} + 2AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + 2Ag_{(s)}$$

This reaction takes place because copper is more active than silver.
However, if you put silver particles in a copper (II) nitrate solution, no reaction takes place as silver is less active than copper.

$$Ag + Cu(NO_3)_2 \rightarrow \text{No reaction}$$

Common and systematic names of some salts are given below.

Formula	Systematic Name	Common Name
$NaCl$	Sodium chloride	Table salt
$CaCO_3$	Calcium carbonate	Limestone
Na_2CO_3	Sodium carbonate	Washing soda
KNO_3	Potassium nitrate	Saltpeter
$CaSO_4.2H_2O$	Calcium sulfate dihydrate	Gypsum

Kasim alnasiry
07801575954

CHAPTER 7

CARBON

THE BLACK GOLD

INTRODUCTION :

- Carbon has an atomic number of 6
- Carbon has three natural isotopes $_{12}C$: 98.9%, $_{13}C$: 1.1 % , $_{14}C$ (trace amounts)
- $_{12}C$ and $_{13}C$ are stable isotopes of carbon whereas the $_{14}C$ isotope is radioactive .
- Carbon is the basic element , importante of living organisms in our daily life.
- Carbon has a crystalline lattice structure
- Carbon has two allotropes : graphite and diamond

Q1: Carbon has the highest melting And boiling points in the group 4 ?

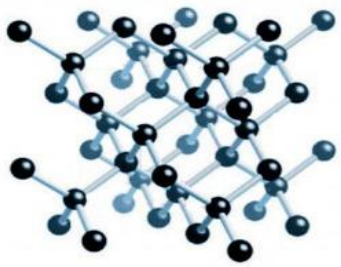
Because it has a crystalline lattice structure and there are strong covalent bonds between its atoms.

Q1: carbon chemistry has become a special branch of chemistry called organic Chemistry ?

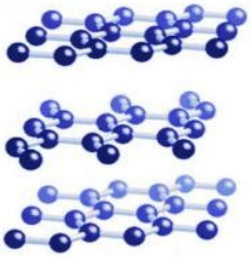
Because an enormous number of carbon compounds

Q3: Compare the diamonds with the graphite ?

DIAMOND	GRAPHITE
- the hardest substance in nature - nonconductor - used as an abrasive , cut hard Materials , as jewelry - transparent - high melting point	- soft - good conductor - used as a lubricant oil , electrodes in dry cells , manufacture of pencils - dark black - low melting point



Diamond
(sp^3 hybridized carbon
3D structure)



Graphite
(sp^2 hybridized carbon)

Q4: Why the graphite conducts heat and electricity ?

Graphite crystals have a layered structure formed by hexagonal carbon cycles. These layers slide over each other easily because they are bonded to each other with weak bonds.

Q5: How diamonds consists in nature ?

Diamond is formed naturally by the transformation of graphite exposed to high underground pressure over millions of years.

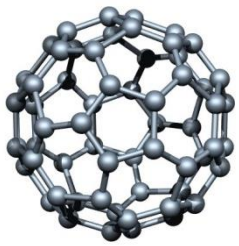
Q6: How to get artificial diamonds ?

Artificial diamond is obtained by changing the crystalline structure of graphite under high pressure and temperature. Such a .diamond does not have any value as jewelry

Note :

In addition to these allotropes, carbon is found naturally in the forms of coal, coke, charcoal and soot, but they are not in crystalline forms. They are amorphous solids with wide surfaces .

Fullerenes



In 1985, another allotropic form of carbon was discovered. There are two important forms of these new allotropic forms, C_{60} and C_{70} there are hexagonal and pentagonal structures.
Today we can produce C_{60} from graphite by laser technology
Fullerenes are used especially in preparation of super conductors.

Q7: Where is carbon in nature ?

1. Carbon makes up only 0.91% of the earth's crust.
2. Free carbon is found in nature as diamond and graphite.
3. It is found in natural gas and petroleum as its compounds.
4. It is exist in the atmosphere as carbon dioxide (CO_2),
5. It is exist in the earth's crust as its carbonates.
6. In the structure of proteins,saccharides and amino acids

Chemical properties

- Carbon is a nonmetal. It has an atomic number of 6 and It takes oxidation states between – 4 and + 4.
- carbon can form ionic compounds with active metals, such as Al_4C_3 and CaC_2 .
- it tends to make covalent bonds by sharing its valence electrons. This property allows it to form a vast number of compounds.

Reactions

1) Graphite burns easily, but diamond hardly burns.
The burning product at low temperature is carbon dioxide.

$$C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)} + 393.5\ kJ$$

The burning product at high temperature and in lmited oxygen is carbon monoxide

$$2C_{(s)} + O_{2(g)} \rightarrow 2CO_{(g)} + 220.7\ kJ$$

CO is not stable and combuses to form CO_2 and C.

$$2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)} + 566.0\ kJ$$

2) Carbon is not affected by acids and bases, but it is oxidized by hot concentrated HNO_3 and H_2SO_4

$$C_{(s)} + 4HNO_{3(conc.)} \rightarrow CO_{2(g)} + 4NO_{2(g)} + 2H_2O_{(L)}$$

$$C_{(s)} + 2H_2SO_{4(conc.)} \rightarrow CO_{2(g)} + 2SO_{2(g)} + 2H_2O_{(L)}$$

3) Carbon reacts with steam at very high temperature.

$$C_{(s)} + H_2O_{(g)} + heat \rightleftharpoons CO_{(g)} + H_{2(g}$$

The gas mixture formed in this reaction (CO-H_2) is called water gas, and is used as a fuel

4) Carbon forms carbides by reacting with metals at high temperatures

$$2C + Ca \xrightarrow{-heat} CaC_2$$ (Calcium carbide)

5) Carbon react with sulfur , flourine in high tempreture 700-800 °C

$$C + 2S \xrightarrow{-heat} CS_2$$

$$C + 2F_2 \xrightarrow{-heat} CF_4$$

6) Since carbon is a good reducing agent, it is used to produce metals from their oxides at obout 600 °C.

$$2CuO + C \rightarrow 2Cu + CO_2$$

7) Carbon forms organic compounds in reaction with H_2

$$C + 2H_2 \xrightarrow{-1500\ °C\ pressure\ ,\ Pt} CH_4$$

Compounds of Carbon

Carbon monoxide CO :

- Carbon monoxide is found in the atmosphere in trace amounts.
- It is a colorless, odorless and poisonous gas that is lighter than air.
- It is slightly soluble in water and its boiling point is – 191.5 °C
- The exhausts of motor cars and the combustion of fuels cause an increase in the concentration of carbon monoxide in air.

Preparation

Atmospheric CO forms in incomplete reactions of oxygen and carbon compounds.

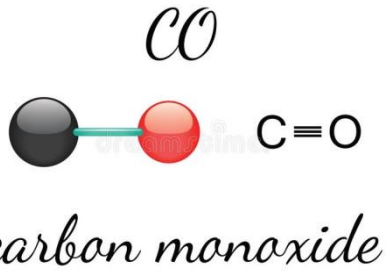
$$2C_8H_{18(L)} + 17O_{2(g)} \rightarrow 16CO_{(g)} + 18H_2O_{(L)}$$

In industry

1) Carbon heating in the presence of carbon dioxide.

$$CO_{2(g)} + C_{(s)} \xrightarrow{-Heat} 2CO_{(g)}$$

2) formic acid is dehydrated using concentrated sulfuric acid $HCOOH \xrightarrow{-H_2SO_4} CO + H_2O$



Chemical Properties

- Carbon monoxide is neither acidic nor basic. It is a neutral oxide.
- a strong reducing agent at high termperatures, (reduces metal oxides to metals

$$ZnO_{(s)} + CO_{(g)} \xrightarrow{-Heat} Zn_{(s)} + CO_{2(g)}$$

- CO also reduces steam to hydrogen at 230 °C

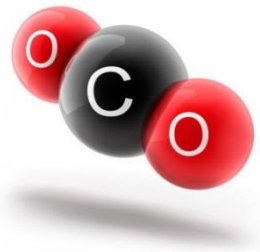
$$H_2O_{(g)} + CO_{(g)} \xleftarrow{} Fe_2O_3 \rightarrow H_{2(g)} + CO_{2(g)}$$

Uses

- as a reducing agent in the extraction of metals from their ores
- as a gaseous fuel
- as a primary substance in many organic synthesis reactions, such as methanol

Carbon dioxide CO_2

- Carbon dioxide is found in the atmosphere at around 0.03% by volume.
- It is a colorless, odorless and nonpoisonous gas
- It is approximately 1.5 times heavier than air.
- It is moderately soluble in water.
- It soldifies at -78 °C to form dry ice



Preparation

a. In industry

limestone is heated to make quicklime and by the ermentation of glucose.

$$CaCO_3 \xrightarrow{-1200°C} CaO + CO_2$$

b. In the Laboratory

1. By the action of dilute acids on metal carbonates and hydrogen carbonates

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

2. After combustion reactions of carbon containing substances.

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

Chemical Properties

◉ Carbon dioxide is an acidic oxide, When it is dissolved in water, it forms carbonic acid, which is unstable.

$$CO_{2(g)} + H_2O_{(L)} \rightarrow H_2CO_{3(aq)}$$

◉ It reacts with basic oxides and bases

$CO_{2(g)} + CaO_{(s)} \rightarrow CaCO_{3(s)}$ & $CO_{2(g)} + 2NaOH_{(aq)} \rightarrow Na_2CO_{3(aq)} + H_2O_{(L)}$

◉ At high temperatures CO_2 , behaves like an oxidizing agent.

$$CO_2 + 2Mg_{(s)} \xrightarrow{-1200°C} 2MgO_{(L)} + C_{(s)}$$

Detection of CO_2

◉ We can detect the existence of carbon diaxide with limewater $Ca(OH)_2$.
When carbon dioxide is introduced into a solution of limewater colorless limewater solution becomes turbid, and a millky white precipitate of calcium carbonate forms :

$$CO_{2(g)} + Ca(OH)_{2(aq)} \rightarrow CaCO_{3(s)} + H_2O_{(L)}$$

◉ If more CO_2 is added, excess carbon dioxide reacts with water to form Carbonic acid H_2CO_3 and the milky solution becomes colorless.
Carbon dioxide reacts with calcium carbonate to form a colorless solution of calcium hydrogen carbonate :

$$CO_{2(g)} + CaCO_{3(s)} + H_2O_{(L)} \rightarrow Ca(HCO_3)_{2(aq)}$$

◉ Calcium hydrogen carbonate decomposes when heated. In that case a colorless solution of hydrogen carbonate again changes into the white insoluble product as calcium carbonate, $CaCO_3$.

$$Ca(HCO_3)_{2(aq)} \xrightarrow{-heat} CaCO_{3(s)} + H_2O_{(L)} + CO_{2(g)}$$

Uses

◉ Carbon dioxide is used in fire extinguishers, carbonated drinks (soft drinks), medicine, manufacture of industrially important substances such as washing soda ($Na_2CO_3.10H_2O$), yeast, baking powder, dry ice, coolant and preservation of fruits.

Q8: Why Carbon dioxide is it used in fire extinguishers?

Because carbon dioxide heavier than air, and as a result it cuts the interaction of air with the burning substance . Without air (oxygen), burning is impossible.

dry ice: The solid form of carbon dioxide , It sublimes at -78 °C. It is used as a refrigerating agent