9th CLASS

CHEMISTRY

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CHAPTER NO. 1

FUNDAMENTAL OF CHEMISTRY

Q.1: Describe the importance of chemistry in our daily life?

Ans: Importance of Chemistry:

Chemistry plays a vital role in our daily life. Some of its importance in different aspects (شعبے) of daily life is given below.

1. Medicinal importance:

i. The treatment (تشخیص) of strange diseases such as cancer has been made possible by radio isotopes (i.e Co-60)

ii. Antiseptics (جراثیم کش) and disinfectants (جراثیم سے پاک کرنے والا) have been prepared by knowledge of Chemistry.

iii. All the medicines that we use in our daily life are prepared by the knowledge of Chemistry.

2. Industrial importance:

i. Industries are considered (تصور ہوتے ہیں) as back bone of economy of a country.

ii. Metallurgy is a chemical process by which we can extract (حاصل کرنا) metals from their ores.

iii. Building materials like cement, paints, varnishes and glass are made in industries by using chemical process.

iv. Daily used substances like plastics, soaps, medicines, cane sugar and syrups are prepared in industries by chemical processes.

3. Agricultural importance:

i. Barren (بنجر) soils have been made productive (زرخیز) by using fertilizers.

ii. Vast (وسیع) areas of land have been made productive by as a result of the study of plant chemistry and soil chemistry.

iii. The production of crops has been increased by using fertilizers.

iv. Insecticides and herbicides which protect the plants from harmful insects and weeds are prepared by the knowledge of chemistry.

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4. Defensive importance:

i. High explosives, poisonous and tear gases (آنسو گیس) fire producers and fire extinguishers (آگ بجھانے والے آلے) and gas masks have been prepared by chemists.

ii. Heavy guns, airplanes and warships are mostly made up of metals which are obtained by chemical processes.

iii. Atomic bombs and hydrogen bombs are also the gifts of chemistry. Due to the fear of its use the nations feel secure (محفوظ) and enjoy peace.

5. Environmental importance:

Chemistry helps us to protect our environment from toxic and poisonous substances.

Thus it is clear from the above description that chemistry is responsible for modern civilization and it plays a very important role in almost all aspects of man's life.

Q.2 Discuss the Muslim period in history of chemistry.

Ans: Muslim period (600-1600):

"The period from 600 to 1600 AD in the history of chemistry is known as the period of **Al-chemists**." In this period the talented (قابل) and genius (ذہین) Muslim scientists observed the matter and conducted experiments for the truthfulness of their observations and thoughts.

Major aims:

Their major aims were 1) to change base metals into gold 2) to find methods to prolong human life and 3) To find physical evidence to support religious and philosophical belief. Although they failed to do so but they succeeded in introducing laboratory methods which are still used in chemical processes in modern chemistry.

Achievements:

Some of the inventions and discoveries of Muslim scientists are as follows:

i. The Muslim scientists discovered arsenic, antimony and bismuth.

ii. They made and used instruments for laboratory work like furnace (بھٹی), beakers, funnels, crucibles (وہ برتن جسمیں دھات پگھلایا جاتا ہے), and scale for weighing and retorts for distillation.

iii. Distillation, sublimation, calcinations and fermentation were introduced by Muslim scientists.

iv. They prepared various kinds of acids, alcohols and medicines.

Q.3. Discuss the contributions of Muslim scientists in the field of chemistry?

Ans: The Muslim Scientists:

The contributions of Muslim Scientists in the field of chemistry are given below:

1.Jabirlbn-e-Hayyan (721-803 AD):

He was born in Tus, Iran. His contributions in the field of chemistry are given below:

i. He is known as the father of the science of chemistry.
ii. He wrote about more than 70 books on chemistry.
iii. He was the first chemist having an equipped chemical laboratory.
iv. He prepared Aqua Regia. (Mixture of nitric acid and hydrochloric acid)
v. He described the method of production of white lead ($PbCO_3.Pb(OH)_2$).
vi. He prepared various acids like HCl, HNO_3 and H_2SO_4.
vii. He developed the methods of fractional distillation and extraction of metals.
viii. He also knew about methods of dying of cloth.

2. Muhammad Ibn-e-Zikriya Al-Razi (864-930)

He was born in Tehran, Iran. His contributions in the field of chemistry are given below:

i. Al-Razi was not only an Al-Chemist but also a successful physician, philosopher and skillful surgeon.
ii. He classified elements into metal and non-metals.
iii. He wrote about 20 books on chemistry in which the most common were Al-Israr (The Secret) and Sirr Al-Israr (The secrets of secrets).
iv. He was the pioneer of using opium as anesthetic.
v. He was the originator of dividing substances into living and non-living organisms.
vi. He also prepared alcohol by means of fermentation.
vii. His books were taught in Europe for centuries.

3.Al-Beruni (973-1048)

He was born in Kath, present Uzbekistan. His contributions in chemistry are given below:

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i. He had a sound knowledge of chemistry particularly chemical procedures and chemical combinations.
ii. One of his famous books *Kitab Al-Saidana*, contains more than 700 descriptions of drugs and their effects on human body.
iii. He also explained large varieties of precious stones and gems.
iv. He determined the densities of various substances.
v. Al-Beruni also made rich contribution in the fields of physics, mathematics, metaphysics, history and geography.

4. Ibne Seena (980-1037)

He was born in Bukhara present Uzbekistan. His contributions in the field of chemistry are given below:

i. Ibne Seena is known as the Aristotle of the Muslim world.
ii. He is famous for his contribution in the fields of medicines, mathematics, astronomy and philosophy.
iii. He was the first scientist who rejected the idea that metals could be changed into gold.
iv. He prepared essential oils by distillation.
v. He wrote four books on chemistry.
vi. His books were taught for centuries in the educational institutions of Europe.

Q.4 Define chemistry? Explain with an example.

Ans: Chemistry:

"It is a branch of science which deals with the study of:

i. Composition of matter
ii. Properties of matter
iii. Structure of matter
iv. Changes in matter
v. Different laws and principles which govern these changes".

Explanation with example:

Consider hydrogen gas:

1. It is a gas and consists of hydrogen molecules. A molecule of hydrogen is made up from the union of two hydrogen atoms (composition).
2. Hydrogen reacts with oxygen and chlorine to form water and hydrogen chloride gas respectively (properties).
3. When pressure is applied on hydrogen gas its volumes decrease (Boyle's law).

All the above description (وضاحت) about hydrogen is the chemistry of hydrogen in which composition, properties, change in volume and the law related to change in volume was discussed.

Q.5 State and explain the various branches of chemistry.

Ans: Branches of chemistry:

The different areas of chemistry for specialization are called branches of chemistry. Following are the main branches of chemistry.

I. Physical chemistry:

"It is the branch of chemistry which deals with the relations between physical properties of substances and their chemical composition and transformation (تبدیلی)". **OR**

"It is the branch of chemistry which deals with the study of laws and principles that describe changes in matter and energy ".

Example:

For example in this branch we study about structure of matter, chemical bonding, laws like Boyle's law, Charles's law etc.

ii. Inorganic chemistry:

"It is the branch of chemistry which deals with the study of elements and compounds of elements other than hydrocarbons and their derivatives.

Example:

For example in this branch we study about occurrence, structure, preparation, properties and uses of various elements and compounds like hydrogen, oxygen, sodium, sulphuric acid, nitric acid etc.

iii. Organic chemistry:

"It is the branch of chemistry which deals with the study of hydrocarbons and their derivatives."

Example:

For example in this branch we study about hydrocarbons like methane (CH_4), ethane (C_2H_6) and their derivatives like alkyl halides etc.

Analytical chemistry:

"This branch of chemistry deals with the qualitative (معیاری) and quantitative (مقداری) analysis (تجزیہ) of matter. Qualitative means what kind of atoms, molecules are present and quantitative means of how much mass and number of these atoms or molecules are present.

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Example:

Analysis of every matter is studied in this branch like analytical chemistry of water is given below:

Name of Compound	Kind	Quantity
Water	Made from H and O	2 atoms of H and 1 atom of O, 11.19% of H and 88.81% of O by mass.

iv. Biochemistry:

"It is the branch of chemistry which deals with synthesis(بنانا) of and decomposition (تحلیل،توڑپھوڑ) of the compounds and their reactions which occur in living organisms such as animals and plants".

Example:

For example in this branch we study about carbohydrates, protein, vitamins, respiration, etc.

v. Nuclear chemistry:

"It deals with the study of nucleus, changes occurring in it, properties of particles inside nucleus and the emission(اخراج) or absorption(جذب کرنا) of radiations from nucleus.

Example:

For example in this branch we study about various forces of nucleus, protons, neutrons, gamma rays, alpha rays, beta rays, fusion and fission reactions etc.

vi. Industrial chemistry:

"It deals with the study of techniques and chemical processes of manufacturing (بنانا،تیارکرنا) various industrial products."

Example:

For example in this branch we study about how to prepare industrial products like cement, fertilizer, glass, plastics etc in industries.

vii. Environmental chemistry:

"It deals with the study of interactions (ملاپ) of chemical substances/processes with the environment and their effects on it.

Example:

Air pollution and water pollution are the two main areas studied in this branch of chemistry.

Q.6: Define and classify matter? Give examples.

Ans: Matter:

"A thing that has mass and volume is called matter."

Classification of matter:

Matter is classified into the following types:

i) Pure substance

a. Elements b. compound

ii) Mixture

a. Homogeneous mixture

b. Heterogeneous mixture

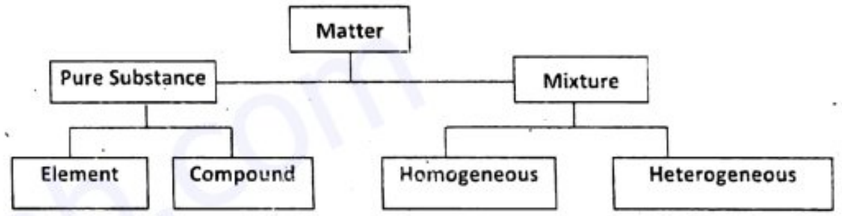

Figure: Chart of matter Classification

Example:

All the things around us are the examples of matter. For example chalk, chair, book, water, table salt etc.

Q.7: Define pure substance. Give its types.

Ans: Pure substance:

"A type of matter having a definite (کچھ) chemical composition and same properties everywhere is called a pure substance or simply substance."

Classification of substance:

Substance is further divided into the following two types:

i) Element
ii) Compound

Q.8: Define and explain the term element. Give suitable examples.

Ans: Element:

"An element is a type of pure simple substance that cannot be broken down into simpler substances by chemical or physical methods." **(OR)**

"A pure substance consisting of only one kind of atoms is called element."

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Explanation:

The fundamental unit of an element is called atom. An atom is the smallest particle of an element that can take part in a chemical reaction. Thus it can be said that atoms are the building blocks of an element. The atomic number of all the atoms of an element is exactly same. For example helium is an element consisting of helium atoms in which the atomic number of all the helium atoms is 2.

Total number of elements:

About 118 elements have been discovered uptill now. Elements are classified into natural and artificial. Elements are present in solid, liquid and gaseous states.

Naturally occurring elements:

The number of natural elements is 92.

Artificial or man-made elements:

The elements after uranium atomic number 92; have been prepared synthetically (مصنوعی طور پر) in the laboratory. They are called trans- uranium series elements.

Representation of an element:

An element is represented by a symbol which is the short abbreviated name of that element. It may consist of one, two or three letters.

Examples:

Some names of elements along with their symbols are given below:

S.No	Name of element	Symbol	S.No	Name of element	Symbol
1	Hydrogen	H	6	Iron(Ferrum)	Fe
2	Nitrogen	N	7	Sodium(Natrium)	Na
3	Oxygen	O	8	Potassium(Kalium)	K
4	Carbon	C	9	Copper(Cuprum)	Cu
5	Boron	B	10	Lead(Plumbum)	Pb

Q.9: What is meant by symbol? *How it is written. Give examples.

Ans: Symbol:

History:

In 1814, Berzelius formed the system of symbols.

Definition:

"The short abbreviated (مختصر) name of an element is called symbol."

Writing the symbol of an element:

The symbol of element consists of one, two or three letters. The first letter is written in capital while the second or the third are written in small letter s e.g. H for hydrogen He for helium, Na for sodium etc.

Examples:

Some names of elements along with their symbols are given below:

Name of element	Symbol	Name of element	Symbol
Hydrogen	H	Iron(Ferrum)	Fe
Nitrogen	N	Sodium(Natrium)	Na
Oxygen	O	Potassium(Kalium)	K
Carbon	C	Copper(Cuprum)	Cu
Boron	B	Lead(Plumbum)	Pb

Scientific Information:

Gallium is an element with symbol Ga. Its atomic number is 31 and atomic mass is 69.723. It is silvery white and very soft metal. Its melting point is 29.76°C therefore; it melts when kept in hand. It is never found in Free State.

Q.10: What is a compound? Explain with examples.

Ans: Compound:

"The pure substance which consists of two or more elements in a definite proportion (تناسب) by mass is called compound."

Characteristics of a compound:

A compound has the following properties:

i. A compound has different properties from the parent elements (elements which are making that compound). It is clear from the example given below:

For example water is a compound made up from hydrogen and oxygen. Water has quite different properties from hydrogen and oxygen such as: Water extinguishes fire, hydrogen burns by itself while oxygen helps in burning.

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ii. The parent elements of a compound lose (کھو دیتا) their properties when they chemically combine to form that compound as clear from the above example.

iii. Similarly a compound can be broken down into simple substances by various chemical methods. This fact is clear from the example given below:

Example:

For example sodium chloride (NaCl) is a compound made up of 39.3%sodium and 60.7% chlorine. It can be broken down into sodium and chlorine by a chemical process called electrolysis.

$$2NaCl_{(molten)} \xrightarrow{electrolysis} 2Na + Cl_2$$

iv. The composition of a compound is represented by a chemical formula which is the collection (مجموعہ) of symbols of which it is made.

Examples of compounds:

Some examples of compounds are given in the table below:

S.No.	Common Name	Chemical Name	Formula
1	Bleaching powder	Calcium oxy chloride or Calcium hypochlorite	$CaOCl_2$
2	Caustic Soda	Sodium Hydroxide	$NaOH$
3	Lime/Quick lime	Calcium oxide	CaO
4	Chile salt petre	Sodium Nitrate	$NaNO_3$
5	Lime stone	Calcium Carbonate	$CaCO_3$
6	Lime water/slaked lim/milk of lime	Calcium hydroxide	$Ca(OH)_2$
7	Baking Soda	Sodium bicarbonate	$NaHCO_3$
8	Magnesia	Magnesium oxide	MgO
9	Table Salt	Sodium Chloride	$NaCl$
10	Marsh Gas	Methane	CH_4

Q.11: What is a mixture? Explain with suitable examples.

Mixtures:

"The impure substances produced by the physical combination of two or more substances (elements or compounds) are called mixtures."

Characteristics of a mixture:

A mixture has the following properties:

i. The constituents (اجزا) of mixture do not have chemical bonds therefore; they can be separated by ordinary physical methods. This fact is clear from the following example:

Example:

If we dissolve sugar in water then it forms a mixture which can be separated into sugar and water by distillation.

ii. The constituents (اجزا) of mixture retain (برقرار رکھنا) their properties as in case of sugar in water taste of sugar doesn't change.

iii. A mixture has no definite composition i.e. its composition can be changed.

Example:

We can prepare sugar solution of different compositions by dissolving various amounts of sugar in water.

Examples of mixtures:

Following are the examples of mixtures:

- Table salt dissolved in water.
- Sugar dissolved in water
- Air
- Milk
- Ice cream
- Soda water
- Sea water
- Brass
- Bronze

Q.12: Give the types of mixture in detail.

Ans. Types of mixture:

Mixture is classified into two main groups as given below:

a. Homogeneous mixture

b. Heterogeneous mixture

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Their detail is given below:

a. Homogeneous mixture or solution:

"A type of mixture having uniform (یکساں) composition throughout is called Homogeneous mixture or solution."

Example: Some examples of homogeneous mixtures are given below:

i. Table salt dissolved in water
ii. Sodium carbonate dissolved in water
iii. Ethyl alcohol mixed with water
iv. Sodium hydroxide dissolved in water
v. Sugar dissolved in water
vi. Nitric acid dissolved in water

b. Heterogeneous mixture:

"The type of mixture having no uniform composition is called heterogeneous mixture"

In heterogeneous mixture one part of the sample has different composition from the other.

Example:

Some examples of heterogeneous mixtures are given below:

i. Concrete
ii. Petrol in water
iii. Muddy water
iv. Ice cream
v. Rock

Q.13: What is meant by atom? Explain it with examples.

Ans: Atom:

"The smallest particles of an element which may or may not exist freely are called atoms." OR

"The smallest particles of an element that take part in a chemical reaction are called atoms."

Explanation:

i. Atoms are the fundamental units (بنیادی اکائیاں) of elements.
ii. An element is made of the same kind of atoms.
iii. In noble gases the atoms have independent existence however in other elements the atoms cannot exist freely because of incomplete valance shells.

iv. The atoms are recognized (پہچانا) from one another by their atomic numbers.

Examples:

Some atoms of different elements along with their atomic numbers are given in the table below:

Name of atom	Atomic no.	Name	Atomic no.
Hydrogen atom	1	Boron atom	5
Helium atom	2	Carbon atom	6
Lithium atom	3	Nitrogen atom	7
Beryllium atom	4	Oxygen atom	8

Q.14. Differentiate between compound and mixture

Ans. Difference between compound and mixture:

	Compound	Mixture
1	"Compound is a pure substance consisting of two or more elements in a fixed ratio by mass."	"Mixture is a type of impure substance produced by physical combination of two or more substances(elements or compounds)."
2	A compound has a definite composition.	A mixture has no definite composition.
3	The constituents of a compound lose their properties	The constituents of a mixture retain their properties.
4	It can be separated to its constituents (elements) only by chemical methods.	It can be separated into its constituents by ordinary physical methods.
5	It has fixed melting points and boiling points.	It has no fixed melting points and boiling points.
6	It has homogeneous composition.	It may be homogeneous or heterogeneous in composition.
7	Examples: Water(H_2O),carbon dioxide(CO_2), table salt(NaCl), baking soda($NaHCO_3$) etc.	Examples: Air, milk, muddy water, rock, soda water etc.

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Q.15. What is meant by atomic number? Give examples.

Ans. Atomic Number:

"The number of protons or electrons present in an atom is called its atomic number."

Explanation:

Atomic number is denoted by "Z". It is the characteristic of an element i.e. the elements are differentiated (فرق کرنا، امتیاز) from each other by their atomic numbers. Atomic number is written below the symbol of an element .e.g. $_{8}O$, $_{10}Ne$ etc.

Examples:

A few elements along with their atomic numbers are given below:

Name of element	Atomic number
Hydrogen	1
Helium	2
Lithium	3
Beryllium	4

Q.16. What is meant by mass number? Give examples.

Ans. Mass Number:

"The total number of neutrons and protons present in the nucleus of an atom is called its **mass number**."

Explanation:

It is denoted by "A". Mass number is written above the symbol of an element e.g. ^{1}H, ^{16}O, ^{20}Ne etc.

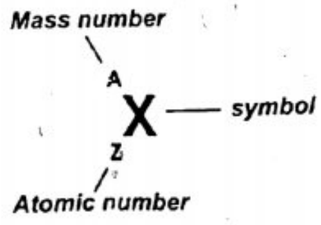
Mathematically:

Mass number (A) = number of protons (Z) + number of neutrons

Hence the number of neutrons = A – Z

Where A is the mass number while Z is the atomic number

The above information about an atom is usually shown as follows:



Examples:

i. Mass number of Carbon

Atomic number of Carbon (Z) = 6

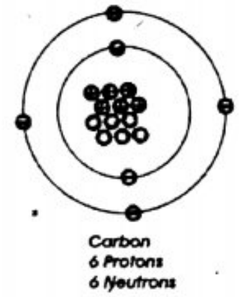
Number of protons =6

Number of neutrons = 6

Mass number = P+N

= 6+6

=12



ii. Mass number of Oxygen

Atomic number of Oxygen = 8

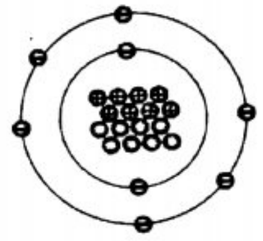
Number of protons =8

Number of neutrons = 8

Mass number = P+N

= 8+8

=16



Some other examples are given below:

Name of element	Mass number
Hydrogen	1
Helium	4
Lithium	7
Beryllium	9

Q.17. Define and explain the relative atomic mass of elements.

Ans. Relative atomic mass:

Introduction:

The mass of an atom is very small ranging(سے لیکر) from 1.67×10^{-24} g to 4.88×10^{-22} g. These extremely small masses are very difficult to measure. Therefore, a standard is necessary for measuring the atomic masses. The standard chosen now a days is the lightest isotope of carbon i.e. C-12 the mass of which is exactly 12.00 a.m.u. The atomic masses of other elements are determined by comparing them with $1/12^{th}$ mass of C-12 isotope.

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Carbon-12 is taken as standard because.

i. It is relatively stable.
ii. It can enter into many chemical reactions.
iii. The relative atomic masses of other elements can be measured easily.

Definition

"Relative atomic mass is defined as the mass of an atom of an element relative (نسبتاً) to 1/12th mass of C-12 isotope."

Atomic mass unit:

"The 1/12th mass of C-12 isotope is called atomic mass unit (a.m.u)."

Relation of a.m.u and gram:

As we know that:

$$1amu = \frac{1}{12} \times \text{mass of one atom of C-12 (eq.1)}$$

$$\text{As the mass of one atom of C-12} = \frac{12g\,mol^{-1}}{6.023\times10^{23}\,mol^{-1}}$$

Putting the values in eq.1 we get:

$$1amu = \frac{1}{12} \times \frac{12g\,mol^{-1}}{6.023\times10^{23}\,mol^{-1}}$$

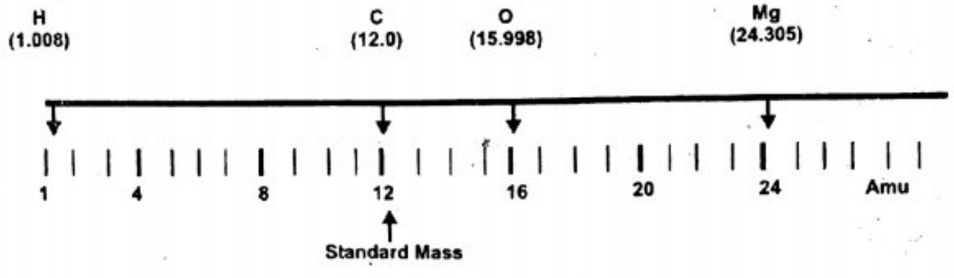
$$1amu = \frac{1}{12} \times \frac{12}{6.023} \times 10^{-23}\,g$$

$$= 0.166\times 10^{-23}\,g$$

$$\Rightarrow 1amu = 1.66\times10^{-24}\,g$$

$$= 1.66\times10^{-27}\,Kg$$

The atomic masses of other atoms are compared with this value to see how heavy or light it is.



Atomic scale showing relative atomic masses of some elements and that of the standard element C-12.

Examples:

Name of element	Relative Atomic mass in a.m.u
Hydrogen(H)	1.0079 a.m.u
Neon(Ne)	20.179 a.m.u
Magnesium(Mg)	24.305 a.m.u
Sodium (Na)	22.989a.m.u
Silver(Ag)	107.868 a.m.u
Gold(Au)	196.966 a.m.u
Mercury(Hg)	200.590 a.m.u
Oxygen(O)	15.999 a.m.u

Q.18.What is average atomic mass? How it is determined? Give example.

Ans. Average atomic mass:

"The average atomic mass of an element is the average of atomic masses all the existing isotopes of that element. Most of the atomic masses come in fractions because of the average atomic masses in which natural abundance of isotopes is also used.

For example, chlorine exists in two isotopic forms Cl-35 and Cl-37. The natural abundance of Cl-35 is 75% and Cl-37 is 25% its average atomic mass is calculated as follows:

$$\text{Average atomic mass} = \left(\frac{\text{atomic mass of isotope I} \times \text{its \% abundance}}{100}\right) + \left(\frac{\text{atomic mass of isotope II} \times \text{its \% abundance}}{100}\right)$$

Putting the values we get:

$$\text{Average atomic mass of chlorine} = \left(\frac{35\times75}{100}\right) + \left(\frac{37\times25}{100}\right)$$

$$= (0.75\times35\text{a.m.u}) + (0.25\times37\text{a.m.u})$$

$$= 26.25+9.25amu$$

$$= 35.50amu$$

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Q.19. Define and explain chemical formula with examples.

Ans: Chemical formula:

"The symbolical (علامتی طور پے) representation (اظہار) of a compound is called chemical formula." OR"A formula is the collection of symbols of different elements present in a compound."

Explanation:

A chemical formula gives information about:

i. Different elements making the compound
ii. The number of atoms of different elements
iii. The composition of a compound

For example the chemical formula of water is H_2O which shows us that it is made up from hydrogen and oxygen. The subscripts (نیچےلکھے ہوئے اعداد) show the number of atoms.

Example:

Some examples of chemical formula along with the names of compounds are given in the table below:

Compound name	Formula	Compound name	Formula
Ethyl alcohol	C_2H_5OH	Sucrose(Sugar)	$C_{12}H_{22}O_{11}$
Glucose	$C_6H_{12}O_6$	Sodium Bicarbonate	$NaHCO_3$
Lime	CaO	Acetylene(Ethyne)	C_2H_2
Hydrogen peroxide	H_2O_2	Ammonia	NH_3

Q.20: Define and explain empirical formula with examples.

Ans: Empirical formula:

"The formula which shows the simplest whole number ratio between atoms orions present in a compound is called empirical formula".

Explanation:

Empirical formula does not show the actual number of atoms present in a compound rather it represents the minimum ratio between atoms. For example the actual formula of benzene is C_6H_6 while the simplest ratio between C and H is 1:1. Hence the empirical formula of benzene is CH.

Formula unit:

"It is the smallest repeating unit of an ionic compound showing simplest ratio between ions". All the ionic compounds are represented by their

formula units (empirical formulas). For example, the simplest ratio between Na^+ and Cl^- ions, in the whole crystal lattice of sodium chloride is 1:1so its formula unit is NaCl.

Examples:

See the table in molecular formula on next page.

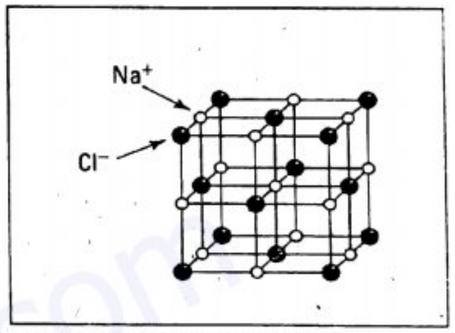

Figure: Crystal structure of NaCl Showing its ions Packed Together

Q.21. Define and explain molecular formula with examples.

Ans: Molecular formula:

"The formula which shows the actual number of atoms present in one molecule of a compound is called molecular formula".

Explanation:

Molecular formula shows the actual number of atoms in a molecule of a compound. All the covalent compounds are represented by their molecular formulas.

Molecular formula can be calculated from empirical formula by the following equation:

Molecular formula = n (empirical formula)

Where $n = \frac{molecular\ mass}{emprical\ formula\ mass}$

The value of n may be 1,2,3....and so on.

For example the empirical formula of hydrogen peroxide is HO and the value of n=2. Therefore its molecular formula is calculated as follows:

Molecular formula of hydrogen peroxide = 2(HO)

$= H_2O_2$

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Examples:

	Compound name	Molecular formula	Empirical formula
1	Benzene	C_6H_6	CH
2	Hydrogen peroxide	H_2O_2	HO
3	Glucose	$C_6H_{12}O_6$	CH_2O
4	Ethane	C_2H_6	CH_3
5	Acetylene(ethyne)	C_2H_2	CH
6	Acetic acid	$CH_3COOH(C_2H_4O_2)$	CH_2O
7	Methane	CH_4	CH_4
8	Ammonia	NH_3	NH_3
9	Sodium bromide	Nil	NaBr
10	Calcium chloride	Nil	$CaCl_2$
11	Suphuric Acid	H_2SO_4	H_2SO_4
12	Iron Oxide	Fe_2O_3	Fe_2O_3
13	Water	H_2O	H_2O

It is clear from the above table that some compounds have similar molecular and empirical formulas while some compounds do not have molecular formula because they do not have molecules and they are in ionic state.

Q.22. Define and explain molecular mass with examples.

Ans. Molecular mass:

"The sum of the atomic masses of atoms present in a molecule of a substance is called molecular mass".

Explanation:

The term molecular mass is used for those compounds which exist in the form of molecules. All covalent compounds except for a few exist in the form of molecules. Therefore, the term molecular mass is used for covalent compounds.

Mathematically:

Molecular mass = (atomic mass of 1st atom × its no. of atoms)
+
(atomic mass of 2nd atom × its no. of atoms)...and so on)

Examples:

Molecular mass is calculated as follows:

Name of compound	Molecular formula	Molecular mass
1 Ethane	C_2H_6	2(12) + 6(1) =30a.m.u
2 Sulphur dioxide	SO_2	1(32)+2(16)= 64a.m.u
3 Hydrogen sulphide	H_2S	2(1)+1(32) = 34 a.m.u
4 Water	H_2O	2(1)+1(16)= 18 a.m.u

Q.23. Define and explain formula mass with examples.

Ans: Formula mass:

"The sum of the atomic masses of atoms of all elements present in one formula unit of a compound is called formula mass".

Explanation:

The term formula mass is used for those compounds which do not exist in the form of molecules. Thus the term formula mass is used for all ionic compounds.

Examples:

Name of compound	Formula unit	Formula mass
1 Sodium chloride	NaCl	1(23)+1(35.5)=58.5 a.m.u
2 Calcium chloride	$CaCl_2$	1(40)+2(35.5)= 111 a.m.u
3 Magnesium chloride	$MgCl_2$	(24.3×1)+2(35.5)=95.3 a.m.u
4 Lithium chloride	LiCl	1(7)+1(35.5) = 42.5 a.m.u

Q.24. Define chemical species, Name its types.

Ans. Chemical species:

"An atom or group of atoms (neutral or charged), which take part in a chemical reaction, is called a chemical species."

Chemical species have many types like ion, molecular ion, free radical etc.

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Q.25. What is meant by ion? How it is formed. Discus its various types.

Ans: Ion:

"The charged particle which is formed by loss or gain of electrons is called ion" **OR**

"An atom or group of atoms having a net positive or negative charge is called ion."

Formation of ion:

An atom is electrically neutral (عنصر) which means that the total number protons are equal to the total number of electrons. Therefore an ion is formed when an atom lose or gain electrons. The magnitude of charge depends (انحصار کرنا) upon the number of electrons lost or gained by an atom.

Types of ions on the basis of charges:

On the basis of charges ions are of two types i.e. cations and anions they are discussed below

i.Cation:

"The positive ions are called cations."

Mechanism of positive ion formation:

A positive ion is formed when an atom loses one or more electrons. It has always less number of electrons than the number of protons.

Examples:

Some examples of cations along with chemical equations are given below

a. $Li \longrightarrow Li^{+1} + 1e$

b. $Na \longrightarrow Na^{+1} + 1e$

c. $Ca \longrightarrow Ca^{+2} + 2e$

ii. Anion

"The negative ions are called anions."

Mechanism of anion or negative ion formation:

A negative ion is formed when an atom gains one or more electrons. It has always more number of electrons than the number of protons.

Examples:

Some examples of anions along with chemical equations are given below

a. $Cl + 1e^- \longrightarrow Cl^-$

b. $Br + 1e^- \longrightarrow Br^-$

c. $O + 2e^- \longrightarrow O^{-2}$

Q.26. Differentiate between atom and ion?

Ans. Differences between atom and ion:

The differences between atom and ion are given in the tab le below:

S.No	Atom	Ion
1	The smallest particles of an element which may or may not exist freely are called atoms	"An atom or group of atoms having a net positive or negative charge is called ion."
2	It is neutral	It has positive or negative charge.
3	It has same number of electrons and protons	It has different number of electrons and protons.
4	It is not attracted by electric field	It is attracted by electric field.
5	Examples Hydrogen atom = H Oxygen atom = O Chlorine atom = Cl	Examples Hydrogen ion = H^+ or H^- Oxygen ion(oxide) = O^{-2} Chlorine ion(Chloride) = Cl^-

Q.27. Define and explain molecular ions with examples.

Ans: Molecular ions:

"The molecules having positive or negative charges are called molecular ions."

Explanation:

Just like ions they are also formed by loss or gain of electrons. The molecules which lose electrons, acquire (حاصل کرنا) a positive charge and is called cationic molecular ion while the molecules which gains electrons, acquire a negative charge and is called anionic molecular ion.

Cationic molecular ions are more common than anionic molecular ions.

Examples:

1. Cationic molecular ions:

Some examples of cationic molecular ions are CH_4^{+1}, O_2^{+1}, CO^{+1}, N_2^{+1}, SO_2^{+1} etc

2. Anionic molecular ions:

A few examples of this type are $(HOCH_2\text{-}CH_2OH)^{-1}$, $(C_2H_5OH)^{-1}$ etc.

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Q.28:What is free radical? Explain with an example.

Ans: Free radical:

"The chemical species with an unpaired of electron formed by the hemolytic breaking (بانڈ کا ایسا ٹوٹنا کہ دونوں ایٹم برابر الیکٹران لےلیں) of a bond is called free radical."

Explanation:

A free radical is a highly reactive species which do not exists independently. They are formed in some particular reactions.

Free radical atom of an element is also called nascent element.

Representation:

Free radical is represented by placing a dot on the right or left upper side of a species e.g. $Cl^{\bullet}$

Example:

Reaction of chlorine with methane:

When chlorine reacts with methane in the presence of diffused sunlight, it forms various chlorinated compounds. The reaction mechanism is given as under:

First chlorine atoms form free radicals as:

$$Cl_2 \xrightarrow{diffused\ sunlight} 2Cl^{\bullet}\ \text{(Chlorine free radicals)}$$

Chlorine free radical is very reactive and it readily reacts with methane to form methyl free radical as:

$$Cl^{\circ} + CH_4 \rightarrow {}^{\circ}CH_3 + HCl$$

The methyl free radical(${}^{\circ}CH_3$)is also highly reactive and it reacts with chlorine molecule to form chloromethane and Cl°again as given below:

$$CH_3 + Cl_2 \rightarrow {}^{\circ}CH_3 - Cl + Cl^{\circ}$$

And in this way a chain reaction continues until the final product is formed.

Q.29: What is molecule? Explain its types with examples.

Ans. Molecule:

"The smallest particles of matter which can exist independently as a separate unit are called molecules."

Except noble gases molecules are formed by combination of atoms. They show all the properties of that particular substance.

a. Types of molecules on the basis of number of atoms:

On the basis of the number of atoms, molecules are of four types i.e. mono-atomic, di-atomic, tri-atomic and polyatomic. They are described below:

i. Monoatomic molecules:

"Those molecules which consist of only one atom are called monoatomic molecules."

Example:

Examples of monoatomic molecules are the molecules of noble gases like helium(He), neon(Ne), argon(Ar), krypton(Kr), xenon(Xe) and radon (Rn)

ii. Di atomic molecules:

"Those molecules which consist of two atoms are called diatomic molecules."

Examples:

i. Carbon monoxide (CO)
ii. Oxygen (O_2) etc.

iii. Tri atomic molecules:

"Those molecules which consist of three atoms are called tri atomic molecules."

Examples:

i. Carbon dioxide (CO_2)
ii. Water (H_2O) etc.

iv. Poly-atomic molecules (Poly=many)

"Those molecules which consist of many atoms are called poly-atomic molecules".

Examples:

i. Sulphuric acid (H_2SO_4)
ii. Sulphur molecule (S_8) etc.

b. Types of molecules on the basis of nature of atoms:

On this basis there are two types which are given below:

Homoatomic molecules (Homo = same):

"A molecule consisting of atoms of the same element is called Homoatomic molecule or Homonulcear molecule."

Examples:

i. Oxygen molecule (O_2)
ii. Nitrogen molecule (N_2) etc.

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Heteroatomic molecules (Hetero = Different):

"A molecule consisting of atoms of the different elements is called Heteroatomic molecule or Heteronulcear molecule."

Examples:

i. Carbon monoxide molecule (CO)
ii. Water molecule (H_2O) etc.

c. Types of molecules on the basis of size

Macro molecules (Macro = big):

"Very big molecules consisting of a large number of atoms are called Macro molecules."

Examples:

i. Hemoglobin, a macromolecule found in blood consists of nearly10, 000 atoms per molecule and it is 68,000 times heavier (بھاری) than a hydrogen atom.
ii. Polyvinyl chloride (plastic) etc.

Q.30: What do you understand by the terms mole and Avogadro's number? Give examples.

Ans. Mole:

"Gram atomic mass, gram molecular mass or gram formula mass is known as mole". **OR**

"The quantity (مقدار) of a substance which contains Avogadro's number (6.023×10^{23}) is called mole.

Explanation:

In **SI,** mole is the basic unit of the quantity of a substance. A dozen contains 12 similar things, gross contains 144 similar things, in the same way one mole of any substance contains Avogadro's number (6.023×10^{23}) of particles. Number of moles can be calculated by the following equations:

Number of moles = mass in grams/molar mass (OR)
Number of moles = No. of particles/Avogadro's number

Representation:

As a unit it is represented by mol. It is also represented by n when used for number of moles.

Examples:

i. 1 mole of hydrogen atom = 1gram
ii. 1 mole of water (H_2O) = 18 grams
iii. 1 mole of NaCl = 58.5 grams
iv. 1 mole of hydrogen molecule (H_2) = 2 grams etc.

Avogadro's number

"The number of particles (atoms, ions or molecules) present in one mole of a substance is called Avogadro's number".

Discovery:

This number was determined by an Italian scientist, Amedeo Avogadro.

Denotation:

It is denoted by N_A.

Value:

Its value is 6.023×10^{23}. If we take one mole of any substance it will contain 6.023×10^{23} particles.

Examples:

1 mole (1.008gram) of hydrogen atom = 6.023×10^{23} atoms
1 mole (18.016 grams) of water = 6.023×10^{23} molecules
1 mole (2.016grams) of hydrogen molecule=6.023×10^{23} molecules
1 mole (32 grams) of oxygen molecule=6.023×10^{23} molecules

Q.31. Define gram atomic mass. Give examples.

Ans: Gram atomic mass:

"The atomic masses of elements when taken in grams are called gram atomic masses."It is also called mole.

Examples:

1. Gram atomic mass of hydrogen = 1g
2. Gram atomic mass of oxygen = 16g
3. Gram atomic mass of Neon = 20g
4. Gram atomic mass of sulphur = 32g etc.

Q.32. What is meant by gram molecular mass? Give examples.

Ans.Gram molecular mass:

"The molecular mass of a compound when taken in grams is called gram molecular mass or simply gram molecule." It is also called mole.

Examples:

i. Gram molecular mass of water = 18.015g
ii. Gram molecular mass of sulphuric acid = 98g

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iii. Gram molecular mass of acetylene = 26.016g
iv. Gram molecular mass of sulphur dioxide = 63.998g

Q.33: What is meant by gram formula mass? Give examples.

Ans: Gram formula mass:

"The formula mass of a compound when taken in grams is called gram formula mass." It is also called mole.

Examples:

i. Gram formula mass of NaCl = 58.5g
ii. Gram formula mass of $CaCl_2$ = 111g
iii. Gram formula mass of $MgCl_2$ = 95.3g
iv. Gram formula mass of LiCl = 42.5g

Mole mass calculation/mole mass relationship:

The following equation explains the relationship between mole and mass with the help of which we can convert mass into mole and mole into mass.

Number of moles(n) = mass in grams/molar mass **(eq.1)**

$\Rightarrow Mass\ in\ grams = number\ of\ moles \times molar\ mass$ **(eq.2)**

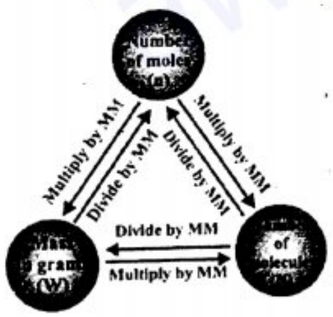
Mole particle calculations/mole particles relation:

We know that:

Number of moles(n) = $\frac{Number\ of\ particles}{Avogadro's\ number(N_A)}$ **(eq.1)**

$\Rightarrow Number\ of\ particles = No.of\ moles \times N_A$ **(eq.2)**

Using these formulas we can change the number of particles (atoms, ions or molecules) into mole or the number of moles into particles (atoms, ions or molecules).



Mole mass conversion

EXERCISE

Multiple Choice Questions

1. Choose the correct answer for each of the followings:

i. The Al-chemists tried to convert(تبدیل کرنا) base metals into _____:
A) Mercury B) Iron **C) Gold** D) Copper

ii. The branch of chemistry which deals with the study of laws and principles concerning the changes in matter and energy is called _____ chemistry:
A) Organic **B) Physical** C) Bio D) Analytical

iii. A pure substance that cannot be broken down into simpler substances by any physical or chemical mean is called _____
A) Element B) Compound
C) Homogeneous mixture D) Heterogeneous mixture

iv. Which of the following compound has both empirical and molecular formula identical?
A) Benzene (C_6H_6) B) Hydrogen peroxide (H_2O_2)
C) Water (H_2O) D) Glucose ($C_6H_{12}O_6$)

v. Which of the following elements is taken as standard for the determination of atomic masses?
A) $^{235}_{92}U$ B) $^{20}_{10}Ne$ C) $^{16}_{8}O$ **D) $^{12}_{6}C$**

vi. The gram molecular mass of HNO_3 is _____:
A) 60 B) 100 **C) 63** D) 98

vii. Which one of the following is a homogeneous mixture?
A) Smoke **B) Air** C) Fog D) Smog

viii. Which of the following is a chemical property of a substance?
A) Solubility B) Density C) Melting point **D) Corrosion**

ix. Which one of the following group is comprised of the elements?
A) Mercury, silica, brass **B) Iodine, tin, iron**
C) Copper, aluminium, bronze D) Coal, smoke, fog

x. Which of the following can be broken down into simpler substances?
A) Ammonia B) Oxygen C)Sulphur D) Iron fillings

xi. Which of the following molecules is not a compound?
A) N_2O **B) N_2** C)NO D) NO_2

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xii. Which of the following is equal to two moles of water?

A) 1.084×10^{25}molecules B) 6.022×10^{23}molecules

C) 1.204×10^{24}molecules D) 1.806×10^{24}molecules

xiii. Which one of the following is an example of tri-atomic molecule?

A) CO_2 B) O_2 C) CH_4 D) NH_3

xiv. Hydrogen gas is:

A) A mono-atomic gas

B) A mixture of hydrogen atoms

C) A di-atomic gas with each molecule made up of two atoms

D) A di-atomic gas made up of two molecules

Short Questions

2. Answer briefly the following questions:

i. How many elements are present in each of the followings?

(a) HF and Hf (b) Co and CO (c) Si and SiO_2

(d) $PoCl_2$ and $POCl_3$

Ans: Determination of elements from a formula:

As element symbol always starts from capital letter therefore, when we count the number of capital letters in a formula it will give us the number of elements in that formula.

Q.No.	Formula/ symbol	No. of elements	Names of elements
a	HF	2	Hydrogen, fluorine
a	Hf	1	Hafnium(Hf)
b	Co	1	Cobalt(Co)
b	CO	2	Carbon(C) and oxygen(O)
c	Si	1	Silicon(Si)
c	SiO_2	2	Silicon(Si) and oxygen(O)
d	$PoCl_2$	2	Polonium(Po) and chlorine(Cl)
d	$POCl_3$	3	Phosphorus(P), oxygen(O) and chlorine(Cl)

ii. Cm is the chemical symbol of curium, named after the famous scientist Madam Curie. Why wasn't the symbol C, Cu or Cr used instead?

Ans: Reason for Cm being used as a symbol for curium:

The symbol Cm was assigned to element Curium, atomic number 96instead of C, Cu or Cr because they were discovered before Curium and C symbol was already assigned to carbon, Cu was already assigned to copper and Cr was already assigned to chromium. That is why the symbol Cm was assigned to Curium.

iii. What is atomic number of an element? How does it differ from mass number of an element?

Ans: First define atomic number along with two examples then write the differences as given below:

Difference between atomic number and mass number

Atomic number	Mass number
1) "The number of protons or electrons present in an atom is called atomic number."	1) "The sum of the number of protons and neutrons present in the nucleus of an atom is called mass number."
2) Atomic number is denoted by "Z".	2) Mass number is denoted by "A".
3) It is written below the symbol of an element e.g. $_1H$,$_8O$, $_7N$ etc.	3) It is written above the symbol of an element e.g. ^1H, ^{16}O, ^{14}N etc.
4) Examples: Atomic number of hydrogen = 1 Atomic number of oxygen = 8 Atomic number of nitrogen = 7	4) Examples: Mass number of hydrogen = 1 Mass number of oxygen = 16 Mass number of nitrogen = 14

iv. Give names to each of the following:

a) Mg and Mn b) K and P c) Na and S d) Cu and Co

Ans:

Q.No.	Symbol	Element Name
a	Mg	Magnesium
a	Mn	Manganese
b	K	Potassium
b	P	Phosphorus

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c	Na	Sodium(Natrium)
c	S	Sulphur or Sulfur
d	Cu	Copper(Cuprum)
d	Co	Cobalt

v. a) Classify the following as mono-atomic, di-atomic, tri-atomic and poly-atomic?

H_2O, N_2, S_8, He, HCl, CO_2, Ar, H_2SO_4, $C_6H_{12}O_6$

Ans: Classification of the given molecules:

It is given below:

Mono-atomic molecules:

They consist of one atom.

He and Ar are mono-atomic molecules.

Di-atomic molecules:

They consist of two atoms.

N_2 and HCl are di-atomic molecules.

Tri-atomic molecules:

They consist of three atoms.

H_2O and CO_2 are tri-atomic molecules.

Poly-atomic molecules:

They consist of many atoms.

S_8, H_2SO_4 and $C_6H_{12}O_6$ are poly-atomic molecules.

a) Classify the following as cation, anion, molecular ion, free radical and molecule.

CH_4^+, $CH_3^{\bullet}$, CO^+, CO_2, Cl^-, Mg^{+2}, CO_3^{-2}, O_2, Na^+, $C_2H_5O^-$, H_2O, Cl_2.

Ans: Classification of the given species:

It is given below:

Cation:

The positive ions are called cations.

Mg^{+2} and Na^+ are cations.

Anions:

The negative ions are called anions.

CO_3^{-2}, $C_2H_5O^-$ and Cl^- are anions.

Molecular ions:

The molecules having positive or negative charges are called molecular ions.

CH_4^+, CO^+ are molecular ions.

Free Radical:

It is the chemical species with unpaired electrons.

$CH_3^{\bullet}$ is a free radical.

Molecules:

The smallest particle of matter which can exist independently as a separate unit is called molecule.

CO_2, H_2O, O_2 and Cl_2 are molecules.

Long Questions

i. State and explain with examples:

a) The empirical formula of a compound.

Ans: For the statement/definition and explanation see Q#20

b) The molecular formula of a compound.

Ans: For the statement/definition, explanations see Q# 21

ii. What do you understand by the term mole and Avogadro's number? Give examples.

Ans: For the answer see mole and Avogadro's number definitions, explanations and examples in Q#30

iii. a) Compare and contrast a mixture and a compound? Give examples of each of them.

Ans: For answer see Q#11

b) How will you classify a molecule? Support your answer with at least two examples of each.

Ans: For answer see Q#29

iv. a) What is molecular mass of a compound? How will differentiate it from the formula mass of?

Ans: First write definition and examples of molecular mass and then write the following table:

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Difference between molecular mass and formula mass:

Molecular mass	Formula mass
1) "The sum of the atomic masses of all the atoms present in one molecule of a compound or element is called molecular mass."	1) "The sum of the atomic masses of all the atoms present in a formula unit of a compound is called formula mass."
2) The term molecular mass is used for those compounds which can exist in molecular form.	2) The term formula mass is used for those compounds which cannot exist in the form of molecules.
3) It is taken for the covalent compounds.	3) It is taken for all ionic compounds.
4) Examples: Molecular mass of H_2O = 18 a.m.u Molecular mass of CO_2 = 44 a.m.u etc.	4) Examples: Formula mass of NaCl = 58.5 a.m.u Formula mass of $MgCl_2$ = 95.3 a.m.u etc.

a) Find out the number of protons, electrons and neutrons in the following elements:

$^{107}_{47}Ag, ^{23}_{11}Na, ^{56}_{26}Fe, ^{40}_{18}Ar, ^{16}_{8}O, ^{24}_{12}Mg, ^{31}_{15}P, ^{207}_{82}Pb, ^{238}_{92}U$

Ans: The number of protons, electrons and neutrons in the given elements are given below:

Element symbol	No. of protons (Z)	No. of electrons (Z)	Mass number (A)	No. of neutrons = A – Z
$^{107}_{47}Ag$	47	47	107	107 – 47 = 60
$^{23}_{11}Na$	11	11	23	23 – 11 = 12
$^{56}_{26}Fe$	26	26	56	56 – 26 = 30
$^{40}_{18}Ar$	18	18	40	40 – 18 = 22
$^{16}_{8}O$	8	8	16	16 – 8 = 8
$^{24}_{12}Mg$	12	12	24	24 – 12 = 12
$^{31}_{15}P$	15	15	31	31 – 15 = 16
$^{207}_{82}Pb$	82	82	207	207 -- 82 =125
$^{238}_{92}U$	92	92	238	238 – 92 =146

b) Complete the following table

	Symbol	Atomic No.	No. of protons	No. of electrons
a	K			
b		8		
c			15	15
d		10		
e	Cl			

Ans:

	Symbol	Atomic No.	No. of protons	No. of electrons
a	K	19	19	19
b	O	8	8	8
c	P	15	15	15
d	Ne	10	10	10
e	Cl	17	17	17

Test Yourself

b. A chemist mostly uses which branch of chemistry to determine the amount of impurity in drinking water?

Ans: A chemist will use environmental chemistry to determine the amount of impurity in drinking water because this branch is concerned with water pollution and air pollution.

c. In which branch of chemistry, a chemist determines the composition of substances and their masses?

Ans: In analytical chemistry, a chemist determines the composition of substances and their masses because this branch determines the kind and quantity of components in matter.

d. A chemist develops a medicine to help patient with thyroid problems. In which branch of chemistry is this chemist working.

Ans: He is working on biochemistry because biochemistry studies all the compounds and reactions in living organisms including humans.

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e. A lithium atom has three protons and four neutrons in its nucleus. How many electrons does it have? What is its atomic number and atomic mass?

Ans: Number of electrons in lithium:

Lithium has three electrons because the number of protons is equal to the number of electrons.

Atomic number of lithium:

The atomic number of lithium is 3 because atomic number is equal to the number of protons.

Atomic mass of lithium:

The atomic mass of lithium is 7 because it has 3protons and 4neutrons and 3+4 =7.

f. The atomic number of iron is 26 and atomic mass is 56. How many electron and protons does an iron atom have? How many neutrons does an iron atom have?

Ans: Number of electrons and protons in iron atom:

As atomic number of iron is 26 therefore, it has 26 electrons and 26 protons because atomic number shows both the number of electrons and protons.

Number of neutrons in iron atom:

As we know that:

Number of neutrons = mass no.(A) – atomic no.(Z)

Putting the values we get:

Number of neutrons = 56 – 26

= 30

g. Do you know any element with no neutrons in its atom?

Ans: Element with no neutrons in its atom:

Hydrogen is the element which has atom called protium, having no neutrons in it.

h. How many atoms of each element are present in one formula unit of each of the following compounds?

Hg_2Cl_2, $NH_4H_2PO_4$, $MgCl_2$, NH_4OH

Ans: No. of atoms of each element in Hg_2Cl_2:

One formula unit of Hg_2Cl_2 contains:

2 atoms of Hg (mercury) and 2 atoms of Cl (chlorine)

No. of atoms of each element in $NH_4H_2PO_4$:

One formula unit of $NH_4H_2PO_4$contains:

1 atom of N (Nitrogen)

6 atoms of H (Hydrogen)

1 atom of P (Phosphorus) and

4 atoms of O (oxygen)

No. of atoms of each element in $MgCl_2$:

One formula unit of $MgCl_2$ contains:

1 atom of Mg (Magnesium) and

2 atoms of Cl (Chlorine)

No. of atoms of each element in NH_4OH:

One formula unit of NH_4OH contains:

1 atom of N(Nitrogen),

5 atoms of H(Hydrogen) and

1 atom of O(Oxygen)

Numerical Problems

1. Naturally occurring gallium consists of 60.108% Ga-69, with a mass of 68.9256 a.m.u, and 39.892% Ga-71, with a mass of 70.9247 a.m.u. calculate the average atomic mass of gallium.

Ans: Given:

Isotopes of gallium i.e.

Ga-69 percentage =60.108% and mass = 68.9256a.m.u

Ga-71 percentage = 39.892% and mass = 70.9247

Required:

To calculate Average atomic mass of gallium

Solution:

As we know that:

$$\text{Average atomic mass} = \left(\frac{\textit{atomic mass of isotope I} \times \textit{its \% abundance}}{100}\right) + \left(\frac{\textit{atomic mass of isotope II} \times \textit{its \% abundance}}{100}\right)$$

As we are given that:

Atomic mass of *isotope I* = 68.9256a.m.u and its % abundance = 60.108%

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Atomic mass of *isotope II* = 70.9247 and its % abundance = 39.892%

Putting the values in the above equation we get:

$$\text{Average atomic mass of Ga} = \left(\frac{68.9256\times 60.108}{100}\right)+\left(\frac{70.9247\times 39.892}{100}\right)$$

$$= (41.4298) + (28.2933)$$

$$= \mathbf{69.7231 a.m.u}$$

Result:

Average atomic mass of Ag = **69.7231a.m.u**

2. Determine the average atomic masses of neon from the following data:

$^{20}_{10}Ne = 90.51\%,\ ^{21}_{10}Ne = 0.27\%,\ ^{22}_{10}Ne = 9.22\%$

Ans: Given:

$^{20}_{10}Ne = 90.51\%,\ ^{21}_{10}Ne = 0.27\%,\ ^{22}_{10}Ne = 9.22\%$

Required:

To calculate the average atomic masses of H and Ne

Solution:

As we know that:

$$\text{Average atomic mass} = \left(\frac{\text{atomic mass of isotope I} \times \text{its \% abundance}}{100}\right)+\left(\frac{\text{atomic mass of isotope II} \times \text{its \% abundance}}{100}\right)+\left(\frac{\text{atomic mass of isotopeIII} \times \text{its\% abundance}}{100}\right)$$

As we are given that:

Atomic mass of isotope-I = 20amu, its % abundance = 90.51%

Atomic mass of isotope-II = 21amu, its %abundance = 0.27%

Atomic mass of isotope-III = 22amu, its %abundance = 9.22%

By putting the values we get:

$$\text{Average atomic mass of neon} = \left(\frac{20\times 90.51}{100}\right)+\left(\frac{21\times 0.27}{100}\right)+\left(\frac{22\times 9.22}{100}\right)$$

Average atomic mass of neon = 18.102 + 0.0567+2.0284

= **20.187**

Result:

Average atomic mass of neon = **20.187**

3. *Calculate the average atomic mass of silver, which exists naturally as mixture of two isotopes $^{107}_{47}$Ag (57%) and $^{109}_{47}$Ag (43%)*

Ans: Given:

Isotopes of silver i.e. $^{107}_{47}$Ag = 57% and $^{109}_{47}$Ag = 43%

Required:

Average atomic mass of Ag

Solution:

As we know that:

$$\text{Average atomic mass} = \left(\frac{\text{atomic mass of isotope I} \times \text{its \% abundance}}{100}\right)+\left(\frac{\text{atomic mass of isotope II} \times \text{its \% abundance}}{100}\right)$$

As we are given that:

Atomic mass of isotope I = 107 and its % abundance = 57%

Atomic mass of isotope II = 109 and its % abundance = 43%

Putting the values in the above equation we get:

$$\text{Average atomic mass of Ag} = \left(\frac{107\times 57}{100}\right)+\left(\frac{109\times 43}{100}\right)$$

$$= (60.99) + (46.87)$$

$$= \mathbf{107.86\ a.m.u}$$

Result:

Average atomic mass of Ag = ***107.86 a.m.u***

4. Calculate the average atomic mass of lithium from the following data?

Isotope	Natural abundance(%)	Relative atomic mass(a.m.u)
^{6}Li	7.5	6.0151
^{7}Li	92.5	7.0160

Given:

Isotopes of lithium i.e. ^{6}Li = 7.5% and atomic mass = 6.0151

^{7}Li = 92.5% and atomic mass = 7.0160

Required:

To calculate the average atomic mass of Li

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Solution:

As we know that:

$$\text{Average atomic mass} = \left(\frac{\text{atomic mass of isotope } I \times \text{its \% abundance}}{100}\right) + \left(\frac{\text{atomic mass of isotope } II \times \text{its \% abundance}}{100}\right)$$

As we are given that:

Atomic mass of *isotope I* = 6.0151 and its % abundance = 7.5%

Atomic mass of *isotope II* = 7.0160 and its % abundance = 92.5%

Putting the values in the above equation we get:

$$\text{Average atomic mass of Li} = \left(\frac{6.0151 \times 7.5}{100}\right) + \left(\frac{7.0160 \times 92.5}{100}\right)$$

$$= (0.4511) + (6.4898)$$

$$= \boxed{6.9409 \text{a.m.u}}$$

Result:

Average atomic mass of Li = **6.9409 a.m.u**

5. Calculate the formula mass of $(NH_4)_2SO_3$ and $Fe(NO_3)_2$?

Ans. Given:

$(NH_4)_2SO_3$ and $Fe(NO_3)_2$

Required:

To find the formula masses

Solution:

i. $(NH_4)_2SO_3$:

As we know that:

Atomic mass of N = 14 a.m.u

Atomic mass of H= 1 a.m.u

Atomic mass of S = 32 a.m.u

Atomic mass of O = 16 a.m.u

Therefore formula mass of $(NH_4)_2SO_3$= 2(atomic mass of N)+8(atomic mass of H)+1(atomic mass of S)+3(atomic mass of O)

= 2(14) + 8(1)+ 1(32)+3(16)

= 28+8+32+48

= 116 a.m.u

ii. $Fe(NO_3)_2$:

As we know that:

Atomic mass of Fe = 56 a.m.u

Atomic mass of N = 14 a.m.u

Atomic mass of O = 16 a.m.u

Therefore formula mass of $Fe(NO_3)_2$=1(atomic mass of Fe)+2(atomic mass of N)+6(atomic mass of O)

= 1(56)+2(14)+6(16)

= 56+28+96

= 180 a.m.u

Result:

Formula mass of $NH_4)_2SO_3$= 116a.m.u

Formula mass of $Fe(NO_3)$ = 180 a.m.u

6. Calculate the molecular mass or formula mass, as the case may be, of the following compounds in a.m.u:

i. Benzene, C_6H_6 ii. Ethane gas, C_2H_6

iii. Aluminium chloride, $AlCl_3$ iv. Iron oxide, Fe_2O_3

Ans: Given:

C_6H_6, C_2H_6, $AlCl_3$ and Fe_2O_3

Required:

To find the formula mass or molecular mass

Solution:

i. Benzene (C_6H_6):

Atomic mass of carbon = 12 a.m.u

Atomic mass of hydrogen = 1 a.m.u

Therefore:

Molecular mass of benzene(C_6H_6)=6(atomic mass of C)+6(atomic mass of H)

= 6(12) + 6(1)

= 72 + 6

= 78amu

ii. Ethane gas (C_2H_6):

Atomic mass of carbon = 12 a.m.u

Atomic mass of hydrogen = 1 a.m.u

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Therefore:

Molecular mass of ethane (C_2H_6)=2(atomic mass of C)+6(atomic mass of H)

=2(12) + 6(1)
= 24 + 6
= 30 a.m.u

iii. Aluminium chloride ($AlCl_3$):

Atomic mass of Aluminium = 27 a.m.u
Atomic mass of chlorine = 35.5 a.m.u

Therefore,

Formula mass of Aluminium chloride ($AlCl_3$)=1(atomic mass of Al)+3(atomic mass of Cl)

= 1(27) + 3(35.5)
= 27 + 106.5
= 133.5 a.m.u

iv. Iron oxide (Fe_2O_3):

Atomic mass of iron = 56 a.m.u
Atomic mass of oxygen = 16 a.m.u

Formula mass of iron oxide = 2(atomic mass of Fe)+3(atomic mass of O)

= 2(56) + 3(16)
= 112 + 48
= 160 a.m.u

Result:

Molecular mass of C_6H_6 = 78 a.m.u
Molecular mass of C_2H_6 = 30 a.m.u
Formula mass of $AlCl_3$ =133.5 a.m.u
Formula mass of Fe_2O_3 = 160 a.m.u

7. Calculate the formula mass of KCl and Na_2CO_3

Ans: Given:

KCl and Na_2CO_3

Required:

To find the formula masses

Solution:

i. KCl:

Atomic mass of K = 39 a.m.u
Atomic mass of Cl = 35.5 a.m.u

Therefore formula mass of KCl =1(atomic mass of K)+1(atomic mass of Cl)
=1(39)+1(35.5)
= 39 + 35.5
= **74.5a.m.u**

ii. Na_2CO_3:

Atomic mass of Na =23 a.m.u
Atomic mass of C =12 a.m.u
Atomic mass of O = 16 a.m.u
Therefore formula mass of Na_2CO_3=
2(atomic mass of Na)+1(atomic mass of C)+3(atomic mass of O)
= 2(23)+1(12)+3(16)
= 46+12+48
= 106 a.m.u

Result:

Formula mass of KCl = 74.5 a.m.u
Formula mass of Na_2CO_3 = 106 a.m.u

8. Calculate the number of moles in 60g of CO_2?

Given:

Mass in grams of CO_2 = 60g

Required:

To calculate the number of moles of CO_2

Solution:

As we know that:

Number of moles = $\frac{Mass\ in\ grams}{Molar\ mass}$ **(eq.i)**

So first we find the molar mass of CO_2

Molar mass of CO_2 = 1(12) + 2(16)
= 44g $mole^{-1}$

Now putting the values in eq.1 we get:

No. of moles of CO_2 = $\frac{60g}{44g\ mole^{-1}}$
= 1.364mol

Result:

Number of moles of CO_2 in 60g = 1.364mol

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9. How many moles are there in 90g of water(H_2O)?

Given:

Mass in grams of H_2O = 90g

Required:

To calculate the number of moles of H_2O

Solution:

As we know that

Number of moles = $\frac{Mass\ in\ grams}{Molar\ mass}$ **(eq.i)**

So first we find the molar mass of H_2O

Molar mass of H_2O = 2(1) + 1(16)

= 2 + 16

= 18g $mole^{-1}$

Now putting the values in eq.1 we get:

No. of moles of H_2O = $\frac{90g}{18g\ mole^{-1}}$

= 5mol

Result:

Number of moles of H_2O in 90g = 5mol

10. Calculate the number of moles of butane, C_4H_{10} in151g of butane.(atomic mass of C=12a.m.u , H=1 a.m.u)

Given:

Mass in g of C_4H_{10} = 151g

Atomic mass of C = 12 a.m.u

Atomic mass of H = 1 a.m.u

Required:

To calculate the number of moles of C_4H_{10}

Solution:

As we know that:

Number of moles = $\frac{Mass\ in\ grams}{Molar\ mass}$ **(eq.i)**

So first we find the molar mass of CO_2

Molar mass of C_4H_{10} = 4(12) + 1(10)

= 48+10

= 58g $mole^{-1}$

Now putting the values in eq.1 we get:

No. of moles of C_4H_{10} = $\frac{151g}{58g\ mole^{-1}}$

= 2.603mol

Result:

Number of moles of C_4H_{10} in 151g = 2.603mol

11. *Calculate the number of moles in 550g of NaI . (atomic mass of Na = 23 a.m.u and I = 127 a.m.u)*

Ans: Given:

Mass in grams of sodium iodide NaI = 550g

Atomic mass of Na = 23 a.m.u

Atomic mass of I = 127amu

Required:

To calculate the number of moles of NaI

Solution:

As we know that:

Number of moles = $\frac{Mass\ in\ grams}{Molar\ mass}$ ..... **(eq.i)**

Molar mass of NaI = 1(23)+1(127)

= 150gmol^{-1}

Putting the values in the above equation we get:

Number of moles = $\frac{550g}{150g\ mol^{-1}}$

$\Rightarrow$ *Number of moles = 3.67mol*

Result:

Number of moles of NaI in 550g = 3.67moles

12. What is the mass of 5 moles of ice? (Atomic masses: H=1a.m.u , O=16a.m.u)

Given:

Number of moles of ice(H_2O) = 5moles

Atomic mass of H = 1a.m.u

Atomic mass of O = 16 a.m.u

Required:

To calculate the mass in grams of ice in 5mole

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Solution:

As we know that:

Mass in grams = number of moles × molar mass

So first we find the molar mass of water

Molar mass of ice(H_2O) = 2(1) + 1(16)

= 2+16

= 18g/mol

Putting the values in the above equation we get:

Mass in grams of ice = 5mol × 18g/mol = **90g**

Result:

Mass in grams of Ice in 5moles = **90g**

13. *How many grams are there in 3.5 mole of water?

Given:

Number of moles of water = 3.5mol

Required:

To calculate the mass in grams of water

Solution:

As we know that

*Mass in gram = number of moles × molar mass **(eq.i)***

So first we find the molar mass of water

Molar mass of water (H_2O) = 2(1) + 1(16)

= 18g/mole

Now putting the values in equation.1 we get

Mass in grams of water = 3.5mole×18g/mole = 63g

Result:

Mass in grams of water in 3.5 moles = 63g

14. How many moles of hydrogen are there in 8.9×10^{23} hydrogen atoms?

Given:

Number of atoms of hydrogen = 8.9×10^{23} atoms

Required:

To calculate the number of moles of hydrogen

Solution:

As we know that:

$$\text{Number of moles(n)} = \frac{Number\ of\ particles}{Avogadro's\ number(N_A)}$$

As number of particles = 8.9×10^{23} atoms and $N_A = 6.023\times10^{23}$

Putting the values we get:

$$\text{Number of moles(n)} = \frac{8.9\times10^{23}}{6.023\times10^{23}}$$

$$\Rightarrow Number\ of\ moles = 1.48mol$$

Result:

Number of moles of hydrogen in 8.9×10^{23}atoms = 1.48mol

15. How many moles of CO_2 are there in 3.01×10^{23}molecules of CO_2?

Given:

Number of molecules of CO_2 = 3.01×10^{23} molecules

Required:

To calculate the number of moles of CO_2

Solution:

As we know that:

$$\text{Number of moles(n)} = \frac{Number\ of\ particles}{Avogadro's\ number(N_A)}$$

As number of particles = 3.01×10^{23} molecules

and $N_A = 6.023\times10^{23}$

By putting the values we get:

$$\text{Number of moles(n)} = \frac{3.01\times10^{23}}{6.023\times10^{23}}$$

$$\Rightarrow Number\ of\ moles = 0.499mol\ or\ 0.5mol$$

Result:

Number of moles of CO_2 in 3.01×10^{23} molecules = 0.5 mol

16. *How many moles of CO_2 are there in 7.5×10^{24} molecules of the gas?*

Given:

Number of molecules of CO_2 = 7.5×10^{24} molecules

Required:

To calculate the number of moles of CO_2

Solution:

As we know that:

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$$\text{Number of moles} = \frac{\text{Number of particles}}{\text{Avogadro's number}(N_A)}$$

As number of particles = 7.5×10^{24} molecules

$N_A = 6.023 \times 10^{23}$

By putting the values we get:

$$\text{Number of moles of } CO_2 = \frac{7.5 \times 10^{24}}{6.023 \times 10^{23}}$$

$= 1.245 \times 10^{24} \times 10^{-23}$

$\Rightarrow$ Number of moles of $CO_2 = 1.245 \times 10$

= 12.45mol

Result:

Number of moles of CO_2 = **12.45mol**

17. Calculate the number of molecules in 5 moles of glucose ($C_6H_{12}O_6$)

Given:

Number of moles of glucose = 5mol

Required:

To calculate the number of molecules

Solution:

As we know that:

Number of molecules = Number of moles× Avogadro's number

As number of moles = 5mol

and $N_A = 6.023 \times 10^{23}$

By putting the values we get:

Number of molecules= 5 mole × 6.023 × 10^{23} molecules

$= 30.115 \times 10^{23}$

$\Rightarrow$ Number of molecules $= 3.0115 \times 10^{24}$ Molecules

Result:

The number of molecules in 5 moles of glucose = 3.0115×10^{24}

18. Calculate the number of molecules in 6.50 molofCH₄?

Given:

Number of moles of CH_4 = 6.50mol

Required:

To calculate the number of molecules

Solution:

As we know that:

Number of molecules = Number of moles× Avogadro's number

As number of moles = 6.50mol

and $N_A = 6.023 \times 10^{23}$

By putting the values we get:

Number of molecules= 6.50 mole × 6.023 × 10^{23} molecules

$= 39.14 \times 10^{23}$ molecules

$\Rightarrow$ Number of molecules $= 3.914 \times 10^{24}$ Molecules

Result:

The number of molecules in 5 moles of glucose = 3.914×10^{24}

19. *Determine the number of molecules in 40.5g of HBr.(atomic masses H=1&Br=80)

Given:

Mass in grams of HBr = 40.5g

Atomic mass of H = 1a.m.u

Atomic mass of Br =80 a.m.u

Required:

To calculate the number of molecules of HBr

Solution:

As we know that

No. of molecules = Number of moles × N_A _____(eq.i)

So first we find the number of moles

$$\text{Number of moles} = \frac{\text{Mass in g}}{\text{Molar mass}} \text{ _____(eq.ii)}$$

Molar mass of HBr = 1(1)+1(80)

$= 81 gmol^{-1}$

Putting the values in eq.2 we get:

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$$\text{Number of moles} = \frac{40.5g}{81g\,mol^{-}}$$

$$= 0.5mol$$

Now putting the values in eq-1 we get

$$\text{Number of molecules} = 0.5\times 6.023\times 10^{23}$$

$$= 3.0115\times 10^{23}\ molecules$$

Result;

Number of molecules in 40.5g of HBr = 3.0115×10^{23}molecules

Q 20: Calculate the mass in 6.68 × 10^{23} molecules of PCl_3?

Ans: Given: Number of particles (molecules) = **6.68 × 10^{23}**

Required:

To calculate the mass?

Solution:

As we know that:

Mass (in g) = No. of moles × molar mass _____ (i)

So. first we will find the number of moles,

$$\text{No. of moles} = \frac{\text{No. of particles}}{N_A}$$

Putting the values we get:

$$\text{No. of moles} = \frac{6.68\times 10^{23}}{6.023\times 10^{23}} \quad \therefore N_A = 6.023 .\times 10^{23}$$

No. of moles = 1.109 mol

Now;

Molar mass of PCl_3 = 1(31) + 3(35.5)

= 31 + 106.5

= 137.5 $gmol^{-1}$

Now putting the value in equation (1) we get:

Mass (in g) = 1.109 mol × 137.5 $gmol^{-1}$

= 152.48 g

Result:

Mass of PCl_3 in 6.68×10^{23} molecules = 152.8 g.

21. Calculate the molar mass of a compound if 10moles of that weigh 260g.

Ans. Given: Number of moles = 10moles

Mass in grams = 260g

Required:

Molar mass of the compound

Solution:

As we know that:

$$Number\ of\ moles(n) = \frac{Mass\ in\ g}{Molar\ mass}$$

multiplying both sides by molar mass

$$n\times molar\ mass = \frac{Mass\ in\ g}{Molar\ mass}\times molar\ mass$$

$$\Rightarrow n\times molar\ mass = mass\ in\ g$$

Now dividing both sides by n

$$\frac{n\times molar\ mass}{n} = \frac{Mass\ in\ grams}{n}$$

$$\Rightarrow molar\ mass = \frac{Mass\ in\ grams}{n}$$

Putting the values we get:

$$\text{Molar mass of the compound} = \frac{260g}{10mole} = \textbf{26g/mole}$$

Result:

Molar mass of the compound = **26g/mole**

***Extra Numerical of Mardan board paper 2015.**

22. Calculate the number of molecules in 31.96g of oxygen atoms.

Given:

Mass in grams of oxygen atoms = 31.96g

Required:

No. of molecules of oxygen

Solution:

As we know that

No. of molecules = no. of moles × Avogadro's number---------- (1)

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So first we will find the number of moles of oxygen molecules

No. of moles = mass in g/molar mass ---------- (2)

We are given mass in g of atoms but as we have to find no. of molecules so we will use molar mass of oxygen molecules in eq.(2)

Molar mass of oxygen molecule (O_2) = 2(15.99)

= $31.98 gmol^{-1}$

Now putting values in eq(1) we get:

No. of moles = $31.96g/31.98gmol^{-1}$

= 0.999moles or 1mole (by rounding)

Now putting the values in eq(1) we get:

No. of molecules = $1\times6.023\times10^{23}$

= 6.023×10^{23}molecules

Result:

No. of molecules in 31.96g of oxygen atoms = 6.023×10^{23}

Some extra Questions with answers

23.Given the atomic masses of C, H and O to be 12, 1 and 16 respectively. Calculate the molecular mass of glucose ($C_6H_{12}O_6$)

Ans: Given:

Atomic mass of carbon (C) = 12 amu

Atomic mass of hydrogen (H) = 1 amu

Atomic mass of Oxygen (O) = 16 amu

Required: Molecular mass of glucose ($C_6H_{12}O_6$)

Solution:

Molecular mass of glucose ($C_6H_{12}O_6$) =

6(atomic mass of C) + 12(atomic mass of H) + 6(atomic mass of O)

= 6(12) + 12(1) + 6(16)

= 72 + 12 + 96

= **180 a.m.u**

Result:

Molecular mass of glucose ($C_6H_{12}O_6$) = 180 a.m.u

Q. Define atomic mass unit (a.m.u)

Ans: Atomic mass unit:

"The $1/12^{th}$ mass of C-12 isotope are called atomic mass unit."

Denotation:

It is denoted by a.m.u.

a.m.u vs g and Kg:

1amu = 1.66×10^{-24} g = 1.66×10^{-27}Kg

Importance of a.m.u:

The masses of other atoms are compared with it to determine their atomic masses.

Q.How does molecule differs from an atom?

Ans: Differences between atom and molecule

	Atom	Molecule
1)	"The smallest particles of an element which may or may not have independent existence is called atom."	"The smallest particles of an element or compound which can exist as separate unit is called molecule."
2)	Atoms may or may not exist freely.	Molecules always exist freely.
3)	Atom represents just one particle e.g. hydrogen atom = H, helium atom = He and oxygen atom = O etc	Molecule may represent one or more atoms e.g. helium molecule = He, hydrogen molecule = H_2 and water molecule = H_2O etc
4)	Examples: Helium atom = He Hydrogen atom = H Oxygen atom = O Chlorine atom = Cl etc	Examples: Helium molecule = He Hydrogen molecule = H_2 Oxygen molecule = O_2 Chlorine molecule = Cl_2 Water molecule = H_2O

Q. What do you know by molar mass of an element or compound? Give examples.

Ans. Molar mass:

"The mass in grams of one mole of a substance (element or compound) is called molar mass."

Examples:

i. Molar mass of helium = 4g

ii. Molar mass of neon = 20g etc.

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Q. What is the molar mass of each of the following?

i. HF ii. KNO_3 iii. C_2H_2

(Atomic masses H = 1 amu, C = 12 amu, F = 19 amu, K = 39.1amu and N = 14 amu and O = 16 amu)

Ans:Given:

i. HF ii. KNO_3 iii. C_2H_2

Atomic masses of H = 1 amu, C = 12 amu, F = 19 amu, K = 39.1 amu, N = 14amu and O = 16 amu

Required:

Molar masses

Solution:

i. Hydrogen fluoride (HF):

Atomic mass of H = 1amu

Atomic mass of F = 19 amu

Therefore,

Molar mass of HF

= 1(1) + 1(19)

= 1+19

= 20g/mol

ii. Potassium nitrate (KNO_3):

Atomic mass of K = 39.1 amu

Atomic mass of N = 14 amu

Atomic mass of O = 16 amu,

Therefore, **Molar mass of KNO_3**

= 1(39.1) + 1(14) + 3(16)

= 39.1+14+48

= 101.1g/mol

iii. Ethyne (C_2H_2):

Atomic mass of C = 12 amu

Atomic mass of H = 1 amu

Therefore, **Molar mass of C_2H_2**

= 2(12) + 2(1)

= 24 + 2

= 26g/mol

Result:

Molar mass of HF = **20g/mol**, KNO_3 = **101.1g/mol** and C_2H_2 = **26g/mol**

Chapter No.02
Structure of Atom

Q.1: Describe the Greek concept about atom.

Ans: Greek concept about atom:

According to Greek philosopher Democritus (460-370BC), matter is composed (سے بنا ہوا) of small particles. These particles were named as atoms, which are taken from the Greek word "Atomos" meaning indivisible (ناقابل تقسیم).

Q.2: Describe the Dalton atomic theory. What are its drawbacks?

Ans. Dalton's atomic theory:-

In 1808 John Dalton, an English teacher, presented his atomic theory in his book naming "A new system of chemical philosophy". The main points of his atomic theory are following:

i. Matter is composed of extremely (انتہائی) small particles called atoms.
ii. Atom is an indivisible (ناقابل تقسیم) particle.
iii. All the atoms of the same elements are identical ((ایک جیسا in all respects i.e.in size, shape and in mass etc.
iv. Atoms of different elements are different in their properties.
v. Atoms combine with each other in small whole numbers ratio to form compound particles.
vi. The compound particles of a compound are exactly alike(ایک جیسا).
vii. Atom can neither be created nor destroyed.
viii. All chemical reactions occur due to combination or separation of atoms.)

***The drawbacks of Dalton's atomic theory:**

According to modern research, following are the drawbacks of Dalton's atomic theory:

i. Atom is no longer considered (تصور کرنا) as indivisible particle but it is composed of electrons, protons and neutrons.
ii. Atoms of the same elements may not be alike (ایک جیسا) e.g. **isotopes** like Na-23, Na-24 and atoms of different elements could have the same atomic masses e.g. **isobars** like Na-24, Mg-24.
iii. Atoms may not combine in simple whole number ratio e.g. **Tripalmitin $C_{51}H_{98}O_6$** and **Tristearin $C_{57}H_{110}O_6$** etc.
iv. Atoms can be created artificially (مصنوعی طور سے) and can be converted into the other atom (transmutation).

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Q.3: Summarize Rutherford model of atom and explain how he developed this model on the result of his famous gold foil experiment?

Ans: Rutherford's atomic model:

In 1911 Lord Rutherford, a New Zealand scientist, performed an experiment and presented a model of atom. The detail is given below:

1. Rutherford experiment:

Rutherford bombarded (برسانا) a thin (باریک) sheet of gold foil (ورق) about 0.0004cm thick with alpha particles (20,000) from a polonium source. Alpha rays are doubly positively charged rays. A photographic plate coated with Zinc Sulphide was used as detector. Lead plate with a hole was placed to bombard the alpha rays straight on the gold foil. Rutherford observed

a. Observation of the experiment:

i. Most of the alpha rays (19990) passed straight through the foil.
ii. Some of the rays (8) were deflected (جھکنا) at various angles.
iii. Only a few rays (2) were bounced back.

b. Conclusion of the experiment:

From his experiment he concluded that:

i. The central positive part called nucleus repelled the alpha particles. As similar charges repel each other therefore, alpha particles passing near the nucleus were repelled.

ii. The alpha particles passing very close to nucleus were deflected at large angles and those passing away were either not deflected or deflected at very mall angles.

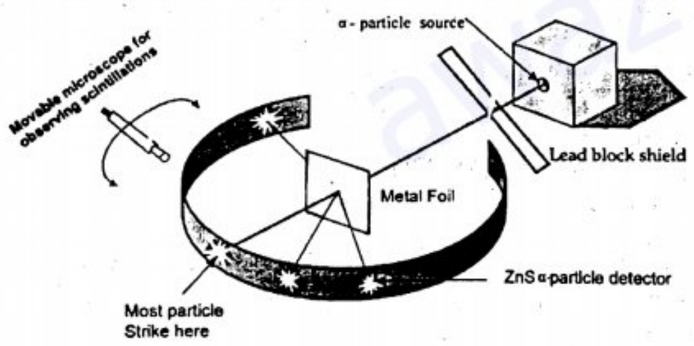

Fig. 2.1 Rutherford experiment

On the basis of his experiment, Rutherford presented a model for the structure of atom which is described below:

2. Main points of the Rutherford's atomic model:

The main points of Rutherford's atomic model are following:

i. The positively charged protons are present in the centre of the atom. This central part of atom is called nucleus.
ii. The size of the nucleus is very small as compared to the size of the atom.
iii. The whole mass of atom is present in the nucleus.
iv. The negatively charged electrons revolve around the nucleus at high speed just like the planets revolve around the sun
v. While revolving, electron needs centripetal force which is provided by the attractive force of the nucleus on electron.
vi. Most of the space in an atom is empty.
vii. An atom is a neutral particle.

Q.4.What are the draw backs/shortcomings of Rutherford atomic model?

Ans: Draw backs/shortcomings of the Rutherford's atomic model:

The followings are the drawbacks/shortcomings of the Rutherford's atomic model:

i. According Maxwell theory, due to continuous motion of electron, it will lose energy continuously (مسلسل) and ultimately (آخر کار) fall into the nucleus. Thus the structure of atom would collapse (تباہ ہونا). But it does not happen.

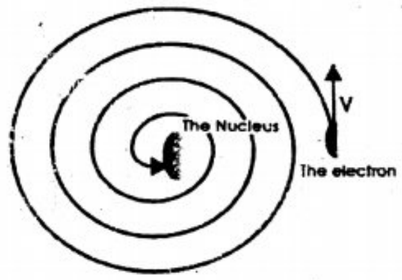

Fig: 2.2 Electron revolving around the nucleus

ii. As the electrons emit energy continuously in Rutherford's atomic model, the atom should give continuous spectrum but actually it gives line spectrum.

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iii. It did not provide any explanation about the chemical properties of the elements.
iv. It did not provide the detail of the arrangement of electrons around the nucleus as all the electrons could not remain in one orbit.
v. Rutherford's model of atom is based on laws of motion and gravitation, which are only applicable on neutral bodies but in the atom are charged bodies like electron protons.

Q.5 State the postulates which Bohr suggested to overcome the shortcomings of Rutherford atomic model. Or Describe Bohr atomic model.

Ans. Bohr atomic model:

Neil Bohr, in 1913, presented a new model for the structure of atom. The main points/postulates of his model are given below:

Main points:

i. Electrons revolve around the nucleus in fixed circular paths called shells, orbits or energy levels.
ii. Electrons do not radiate (خارج کرنا) energy while moving in an orbit i.e. energy of an orbit is fixed.
iii. The energy of electron in an orbit is directly proportional to its distance from the nucleus.
iv. Electron radiates energy when it jumps from higher to lower orbit or it absorbs energy when it jumps from lower orbit to higher orbit. The energy difference of two orbits is given by the following equation:

$\Delta E = E_2 - E_1 = h\upsilon$ This is also called quanta or bundle. Where:

ΔE = energy change
E_2 = energy of higher shell
E_1 = energy of lower shell
h = Plank's constant (6.6262×10^{-34} Js) and
υ = frequency of the radiation

v. Electron can only stay in an orbit and cannot stay in between two orbits.
vi. The electron can only reside in an orbit whose angular momentum (mvr) is an integral multiple of $\frac{h}{2\pi}$ i.e.

$$mvr = n\left(\frac{h}{2\pi}\right)$$

Where:
m = mass of electron
v = velocity of electron
r = radius of the orbit
n = number of shells i.e. 1, 2, 3.....
h = Plank's constant

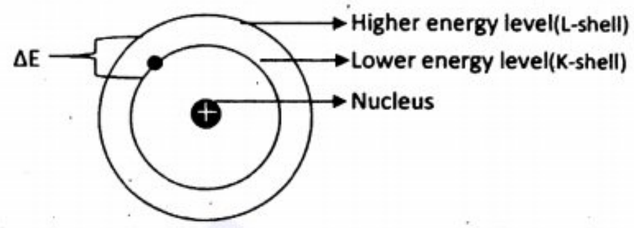

Figure:2.3 Bohr model of hydrogen atom

Q.6: What are fundamental particles?

Ans: The fundamental particles.

"Electrons protons and neutrons are called the fundamental particles of atom."

Their detail is given below:

i. Electron:

Location:
Electrons revolve around the nucleus in various orbits.

Charge:
The charge of an electron is -1.602×10^{-19}coulumbs

Mass:
Its mass is 0.000548597 a.m.u. or 9.11×10^{-31}Kg.

Comparison with other particles:
It is the lightest of all fundamental particles.

ii. Proton:

Location:
Protons are present in the nucleus of an atom.

Charge:
The charge of a proton is $+1.602\times10^{-19}$coulumbs.

Mass:
Its mass is 1.0072766 a.m.u or 1.6726×10^{-27}Kg.

Comparison with electrons:
A proton is 1837 times heavier than an electron.

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iii. Neutrons:

Location:

Neutrons are present in the nucleus of an atom except protium. Neutron is also called composite particle.

Charge:

Neutrons have no charge i.e. they are neutral.

Mass:

The mass of neutron is 1.0086654 a.m.u or 1.6749×10^{-27}Kg.

Comparison with electrons:

A neutron is 1842 times heavier than an electron.

Q.7 : What do you mean by the term electronic configuration?

Ans: Electronic configuration:

"The arrangement of electrons around the nucleus in various shells and sub-shells is called electronic configuration."

Explanation:

According to Bohr atomic model electrons revolve around the nucleus in different shells or orbits. These shells are named as K, L, M ....etc. They are also numbered as 1, 2, 3... where K=1, L=2 and so on.

Maximum number of electrons in a shell is determined by $2n^2$ rule where n is the number of shell. For example for K-shell n=1 therefore, the number of electrons in K-shell= $2(1)^2 = 2$

L-shell = $2(2)^2 = 8$ etc.

Modern research have shown that the shells are further divided into sub-shells which are s,p,d and f. The number of sub-shells in each shell and the number of electrons in each sub-shell are given in the table below:

No	Energy level or shell	Energy sub-level or sub-shell	Number of electrons in sub-shell	Total number of electrons in the shell
1	K	1s	2	2
2	L	2s, 2p	2+6	8
3	M	3s, 3p, 3d	2+6+10	18
4	N	4s,4 p, 4d,4 f	2+6+10+14	32

Auf Bau Principle:

Electrons are accommodated in different sub-shells by Auf Bau principle which states that electrons first go to lowest energy sub-shell and then to higher energy sub-shell. According to this principle the order of filling sub-shells is:

1s <2s <2p <3s <3p <4s <3d <4p.....and so on.

Examples:

Electronic configurations of hydrogen and chlorine are given below

i. Name of element = hydrogen

Atomic number = 1

Number of electrons = 1

Electronic configuration:

Main shell	sub-shell
K=1	$1s^1$

ii. Name of element = chlorine

Atomic number =17

Number of electrons = 17

Electronic configuration:

Main shells	Sub-shells
K =2	$1s^2$
L = 8	$2s^2$ $2p^6$
M =7	$3s^2$ $3p^5$

Q.8. Define and explain energy level and energy sub-levels.

Ans: Energy level:

"The circular paths around the nucleus in which electrons revolve are called energy level or shell or orbit."

Explanation:

The energy levels are named as K, L, M etc. They are also numbered as 1, 2, 3 etc where K =1, L=2 and so on. Maximum number of electrons in a shell is determined by $2n^2$ rule where n is the number of shell. For example for K-shell n=1 therefore, the number of electrons in K-shell = $2(1)^2 = 2$. Similarly:

L-shell = $2(2)^2 = 8$

M-shell = $2(3)^2 = 18$

N-shell = $2(4)^2 = 32$ etc

Energy sub-levels:

"The various regions in the main shells are called energy sub-levels or sub-shells." OR

"One or more orbitals of same energy is/are called sub-shell/sub-shells.

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Types of sub-shells:

There are four types of sub-shells naming s, p, d and f. where s stands for sharp, p for principal, d for diffused and f for fundamental. The s orbital is spherical; p is dumbbell shape while d and f are more complex in shape.

Orbitals:

"The orbitals are three dimensional regions around the nucleus of an atom where the probability of finding electrons is maximum."

An orbital can accommodate only two electrons.

Orbitals are present within a sub-shell.

s sub-shell has 1 orbital

p sub-shell has 3 orbitals i.e. p_x, p_y and p_z

d sub-shell has 5 orbitals i.e. d_{z^2}, $d_{x^2-y^2}$, d_{xy}, d_{xz} and d_{zy} while

f sub-shell has 7 orbitals which are complicated in shape.

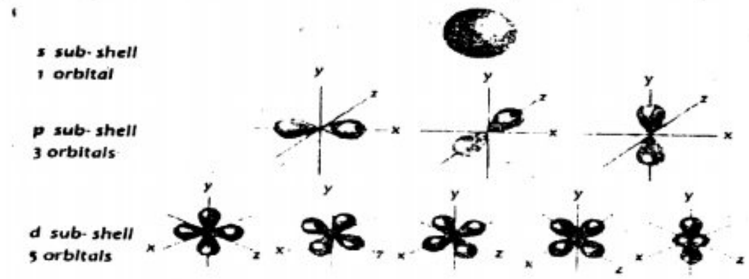

Fig:2.4 Shapes of Orbital

Number of electrons and orbitals in sub-shells:

s sub-shell = 1 orbital = 2electrons

p sub-shell = 3orbitals = 6electrons

d sub-shell = 5 orbitals = 10electrons

f sub-shell = 7orbitals = 14electrons.

Number of sub-shell in main shell:

The number of sub-shells in a shell is related to the value of n which is given below:

K (n = 1) = 1 sub-shell which is s

L (n = 2) = 2 sub-shell which are s and p

M (n = 3) = 3 sub-shell which are s, p and d

N (n = 4) = 4 sub-shell which are s, p, d, and f

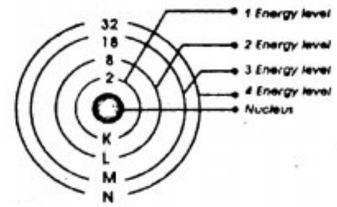

Fig. 2.5 Orbits and Maximum Number of Electrons in an Orbit

Electronic configuration of first 18 elements:

1. Hydrogen:

Atomic number = 1 Number of electrons = 1

Electronic configuration:

Energy level/shell	Energy sub-level/sub-shell
K =1	$1s^1$

2. Helium:

Atomic number = 2 Number of electrons = 2

Electronic configuration:

Energy level/shell	Energy sub-level/sub-shell
K = 2	$1s^2$

3. Lithium:

Atomic number = 3 Number of electrons = 3

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 1	$2s^1$

4. Beryllium:

Atomic number = 4 Number of electrons = 4

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 2	$2s^2$

5. Boron:

Atomic number = 5 Number of electrons = 5

Electronic configuration:

Energy level/shell	Energy sub-level/sub-shell
K = 2	$1s^2$
L = 3	$2s^2$ $2p^1$

6. Carbon:

Atomic number = 6 Number of electrons = 6

Electronic configuration:

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Energy level/shell	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 4	$2s^2$ $2p^2$

7. Nitrogen:

Atomic number = 7 Number of electrons = 7

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 5	$2s^2$ $2p^3$

8. Oxygen:

Atomic number = 8 Number of electrons = 8

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 6	$2s^2$ $2p^4$

9. Fluorine:

Atomic number = 9 Number of electrons = 9

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 7	$2s^2$ $2p^5$

10. Neon:

Atomic number = 10 Number of electrons = 10

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 8	$2s^2$ $2p^6$

11. Sodium:

Atomic number = 11 Number of electrons = 11

Electronic configuration:

Energy level/shell	Energy sub-level/sub-shell
K = 2	$1s^2$
L = 8	$2s^2$ $2p^6$
M = 1	$3s^1$

12. Magnesium:

Atomic number = 12 Number of electrons = 12

Electronic configuration:

Energy level/shell	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 8	$2s^2$ $2p^6$
M = 2	$3s^2$

13. Aluminium:

Atomic number = 13 Number of electrons = 13

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 8	$2s^2$ $2p^6$
M = 3	$3s^2$ $3p^1$

14. Silicon:

Atomic number = 14 Number of electrons = 14

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 8	$2s^2$ $2p^6$
M = 4	$3s^2$ $3p^2$

15. Phosphorus:

Atomic number = 15 Number of electrons = 15

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 8	$2s^2$ $2p^6$
M = 5	$3s^2$ $3p^3$

16. Sulphur:

Atomic number = 16 Number of electrons = 16

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 8	$2s^2$ $2p^6$
M = 6	$3s^2$ $3p^4$

17. Chlorine:

Atomic number = 17 Number of electrons = 17

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 8	$2s^2$ $2p^6$
M = 7	$3s^2$ $3p^5$

18. Argon:

Atomic number = 18 Number of electrons = 18

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 8	$2s^2$ $2p^6$
M = 8	$3s^2$ $3p^6$

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Example1.1

What is the number of protons, electrons and neutrons in each of the following elements?

i. $^{20}_{10}Ne$ ii. $^{235}_{92}U$

Ans:

Element	No. of electrons (Z)	No. of protons (Z)	Mass number (A)	Number of neutrons = A –Z
$^{20}_{10}Ne$	10	10	20	20 – 10 = **10**
$^{235}_{92}U$	92	92	235	235 – 92 = **143**

Q.9: What are isotopes? Or write a short note on isotopes?

Ans: Isotopes:

"The atoms of the same element having different atomic masses are called **Isotopes**." OR

"The atoms of the same element having different mass numbers are called **isotopes**."

Explanation:

As isotopes are the atoms of the same element so they contain the same number of electrons and protons therefore, the difference in mass is due to the different number of neutrons they have.

Isotopes have same chemical properties because of same number of electrons especially in the valance shell. However, they have different physical properties because of different mass numbers/atomic mass.

Isotopes can be separated by physical methods which depend on mass number/atomic mass.

Examples:

i. Isotopes of hydrogen are $^{1}_{1}H$, $^{2}_{1}H$ and $^{3}_{1}H$

ii. Isotopes of chlorine are $^{35}_{17}Cl$ *and* $^{37}_{17}Cl$

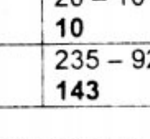
Q.10 Write a short note on isotopes of hydrogen.

Ans: Isotopes of hydrogen:

Hydrogen has three isotopes naming Protium (P), deuterium (D) and tritium(T). Their detail is given below:

i. Protium (P):

Atomic number =1
Number of electrons = 1
Number of protons = 1
Number of neutrons = 0

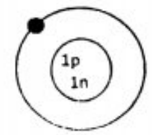


structure

Mass number = 1
Percentage abundance = 99.985%

ii. Deuterium (D):

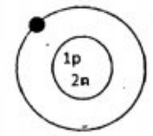
Atomic number =1
Number of electrons = 1
Number of protons = 1
Number of neutrons = 1
Mass number = 2
Percentage abundance = 0.015%



structure

iii. Tritium(T):

Atomic number =1
Number of electrons = 1
Number of protons = 1
Number of neutrons = 2
Mass number = 3
Percentage abundance = negligible



structure

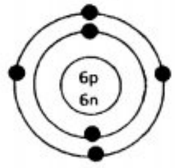
Q.11. Explain the isotopes of carbon.

Ans: Isotopes of carbon:

There are three isotopes of carbon i.e. C-12, C-13 and C-14 they are described below:

i. C-12

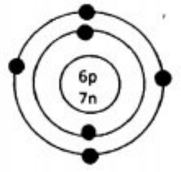
Atomic number =6
Number of electrons = 6
Number of protons = 6
Number of neutrons = 6
Mass number = 12
Percentage abundance = 98.98%



Structure

ii. C-13:

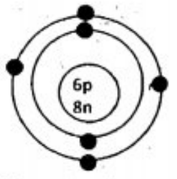
Atomic number =6
Number of electrons = 6
Number of protons = 6
Number of neutrons = 7
Mass number = 13
Percentage abundance = 1.109%



Structure

C-14:

Atomic number =6
Number of electrons = 6
Number of protons = 6
Number of neutrons = 8
Mass number = 14
Percentage = 1ppt



Structure

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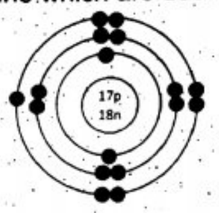
Q. 11 Write short note on the isotopes of chlorine.

Ans: Isotopes of chlorine:

There are two isotopes of chlorine which are described below:

i. Cl-35:

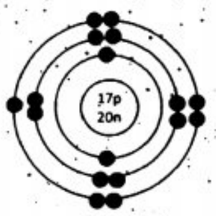
Atomic number = 17
Number of electrons = 17
Number of protons = 17
Number of neutrons = 18
Mass number = 35
Percentage abundance = 75.53%



Structure

ii. Cl-37:

Atomic number = 17
Number of electrons = 17
Number of protons = 17
Number of neutrons = 20
Mass number = 37
Percentage abundance = 24.47%



Structure

Q. 13 Write short note on the isotopes of uranium.

Ans: Isotopes of uranium:

There are three isotopes of uranium which are described below:

i. U-234:

Atomic number =92
Number of electrons = 92
Number of protons = 92
Number of neutrons = 142
Mass number = 234
Percentage abundance = 0.005%

ii. U-235:

Atomic number =92
Number of electrons = 92TR
Number of protons = 92
Number of neutrons = 143
Mass number = 235
Percentage abundance = 0.75%

iii. U-238:

Atomic number =92
Number of electrons = 92
Number of protons = 92



Number of neutrons = 146
Mass number = 238
Percentage abundance = 99.245%

Q.14: Write the uses of isotopes:

Ans: Uses of Isotopes

Isotopes are mainly used in agricultural, biochemical and physiochemical researches. Some important uses are of them are given below:

1. Isotope Tracing:

Iodine–131 $\left({}_{53}I^{131}\right)$ is used to trace the path of the element to the defective or obstructed part of the body. Similarly deuterium, heavy carbon(C–13) heavy nitrogen (N–15) and heavy oxygen (O–18) are used as tracer elements in biochemical and physiochemical researches.

2. Radium-223 and Co-60:

Radium-223 irradiation and cobalt–60 are used in the treatment of cancer and for diagnosis of tumors.

3. Americium-241

i. It is used in many smoke detectors.
ii. It is also used to determine where oil wells should be drilled.

4. Californium-252

i. It is used to inspect airlines luggage for hidden explosives.
ii. It is also used to gauge the moisture content of soil.

5. Krypton-85:

i. It is used in indicator lights in appliances like clothes washers, dryers and stereos.
ii. It is also used to measure dust and pollutants level in air.

6. Iodine-131 and Iodine-123:

i. Iodine-131 is used for the cure of goiter.
ii. Iodine-123 is used for brain imaging.

7. Sodium-24:

It used for identification of blood circulatory problems.

Some points for MCQ's:

- Electrons were discovered by J.J Thomson in 1897.
- Protons were discovered by Goldstein in 1885.
- Neutrons were discovered by James Chadwick in 1932.
- The mass of an electron is 9.11×10^{-31}Kg or 0.00055amu.
- The mass of a proton is 1.67×10^{-27}Kg or 1.0073amu.
- The mass of a neutron is 1.675×10^{-27}Kg or 1.0078amu.
- A proton is 1837 times heavier than an electron.
- A neutron is 1842 times heavier than an electron.
- The radioactive isotope of hydrogen is tritium.
- The radioactive isotope of carbon is C-14.

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EXERCISE

Multiple Choice Questions

i. The K-shell can accommodate maximum of electrons:
A) 2 B) 6 C) 8 D) 18

ii. The number of electrons in third energy level is:
A) 10 **B) 18** C) 32 D) 64

iii. Which one is the lightest:
A) An alpha particle B) A hydrogen atom
C) An electron D) A proton

iv. Electron in its ground state does not:
A) Spin B) Revolve
C) Radiate energy D) Reside in orbit

v. Rutherford bombarded gold foil by
A) Alpha particles B) Beta particles
C) Gamma rays D) Helium atoms

vi. Alpha particles are:
A) Neutral B) Negatively charged
C) Protons **D) Double positively charged**

vii. Electron does not radiate energy when it:
A) Resides in an orbit
B) Jumps from lower to higher orbit
C) Falls in nucleus
D) Jumps from higher to lower orbit

viii. Isotopes of an element have:
A) Different number of electrons
B) same number of protons
C) same number of neutrons
D) same mass numbers

ix. $^{12}_{6}C$, $^{13}_{6}C$ *and* $^{14}_{6}C$ *are* :
A) Isomers B) Isobars C) Allotropes **D) Isotopes**

x. Mass of an atom is mostly due to:
A) Nucleus B) Neutrons C) Electrons D) Protons

xi. If Rutherford had used neutrons instead of alpha particles in his scattering experiment, the neutron would:
A) have not deflect because they have no charge
B) have deflected more often
C) have been attracted to the nucleus easily
D) have given the same results

xii. Which statement about $^{12}_{6}X$, $^{14}_{6}Y$ is false?
A) They are isotopes
B) They are the same elements
C) They have same number of electrons
D) They have the same number of neutrons

xiii. The neutron particle has:
A) a mass equal to that of electron
B) a mass approximately equal to that of proton
C) a charge equal to but opposite to that of electron
D) a positive charge

xiv. The nucleus of an atom has all the following characteristics except that it:
A) is positively charged
B) is very dense
C) contains nearly all the atom's mass
D) contains nearly all the atom's volume

xv. L-shell has sub-shell/sub-shells:
A) s **B) s and p** C) s,p and d D) s,p,d and f

Short Questions

Q.2: Answer the following questions:

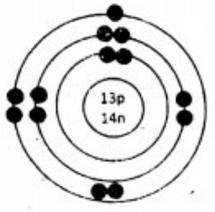
i. Aluminum is represented by $^{27}_{13}Al$ .Draw the structure of aluminum. Write its electronic configuration.

Ans: Name of element = aluminum
Atomic number = 13
Number of electrons = 13

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 8	$2s^2$ $2p^6$
M = 3	$3s^2$ $3p^1$

Structure:



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ii. The energy of an electron in K-Shell and L-Shell is same or different. Explain?

Ans: Energy of electron in K and L shells:

It is explained below:

Bohr's Postulate:

According to Bohr's postulate the energy of an electron in an orbit is directly proportional to its distance from the nucleus.

Explanation of the given case:

As K-shell is nearer to nucleus than L-shell, therefore K-shell has lower energy than L-shell.

Hence, the energy of an electron in K-shell is different from the energy of electron in L-shell.

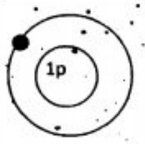
iii. Draw the structures of hydrogen isotopes.

Ans: Structures of hydrogen isotopes:

Hydrogen has three isotopes naming Protium($_1^1H$), deuterium($_1^2H$ or $_1^2D$) and tritium $_1^3H$ or $_1^3T$. Their structures are given below:

Structure of Protium:

Atomic number =1
Number of electrons = 1
Number of protons =1
Number of neutrons = 0
Mass number. = 1



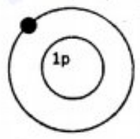
Structure of deuterium:

Atomic number =1
Number of electrons = 1.
Number of protons =1
Number of neutrons = 1
Mass number. = 2



Structure of tritium:

Atomic number = 1
Number of electrons = 1
Number of protons = 1
Number of neutrons = 2
Mass number = 3



iv.How many electrons are present in each of the following? Assuming that each is neutral. Identify the element.

a. $1s^2\ 2s^2\ 2p^6\ 3s^1$ **b.** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

c. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

Ans: a. $1s^2\ 2s^2\ 2p^6\ 3s^1$

Number of electrons = 2+2+6+1 = 11
Name of element = Sodium (Na)
Group = IA (Alkali metals)

b. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

Number of electrons = 2+2+6+2+5 = 17
Name of element = Chlorine (Cl)
Group = VIIA (Halogens)

c. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

Number of electrons = 2+2+6+2+6+2 = 20
Name of element = Calcium (Ca)
Group = IIA (Alkaline earth metals)

v. Why an atom is considered as neutral particle?

Ans: The answer of the given question is explained under the following heading:

Reason for an atom being a neutral particle:

An atom contains three fundamental particles i.e. protons (having positive charge), electrons (having negative charge) and neutrons (having no charge). Now, the number of protons (positively charged particles) in an atom is equal to the number of electrons (negatively charged particles). Their charges cancel each other that is why an atom is a neutral particle.

For example:

Hydrogen (H) contains 1proton and 1 electron therefore, its net charge is +1 – 1 = 0. Hence, it is neutral.

vi. The mass an atom is present in its nucleus. Can you explain?

Ans: The answer of the given question is explained under the following heading:

Reason for the most of mass of an atom being present in its nucleus:

According to modern research, an atom contains three fundamental particles: 1) Electrons 2) Protons and 3) Neutrons. The electrons have very small mass (negligible) and they are present outside the nucleus. While the protons and neutrons are the heaviest particles which are present in the nucleus of an atom. Therefore, most of the mass of an atom is present in its nucleus.

vii. What is the reason that Physical properties of isotopes are different but their chemical properties are same?

Ans: The answer of the given question is explained under the following headings:

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Reason for isotopes having different physical properties:

The physical properties of atoms depend on the atomic mass/mass number. As the isotopes have different atomic masses therefore, they have different physical properties.

Reason for isotopes having same chemical properties:

The chemical properties of atoms depend on the number of electrons especially the number of electrons in the valance shell. As isotopes have same number of electrons therefore, they have same chemical properties.

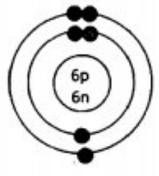
viii. Draw the structures of carbon isotopes. Then write down the number of electrons, protons and neutrons.

Ans: Isotopes of carbon:

There are three isotopes of carbon i.e. C-12, C-13 and C-14. Their structures and number of electrons, protons and neutrons are given below:

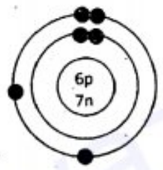
i. C-12

Atomic number =6
Number of electrons = 6
Number of protons = 6
Number of neutrons = 6
Mass number = 12



ii. C-13:

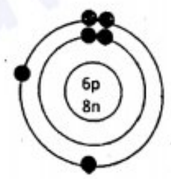
Atomic number =6
Number of electrons = 6
Number of protons = 6
Number of neutrons = 7
Mass number = 13



Structure

C-14:

Atomic number =6
Number of electrons = 6
Number of protons = 6
Number of neutrons = 8
Mass number = 14



Structure

ix. How many electron could be contained in the K, L and M energy levels?

Ans: Number of electrons in K, L and M shells:

The number of electrons in a shell is find by $2n^2$ formula where n is the number of shell. Therefore number of electrons in these shells is given below:

(1) K-shell (n=1)
By putting n=1 in $2n^2$ formula we get: $2(1)^2 = 2$
(2) L-shell (n=2)
By putting n=2 in $2n^2$ formula we get: $2(2)^2 = 8$
(3) M-shell (n=3)
By putting n=3 in $2n^2$ formula we get: $2(3)^2 = 18$

Conclusion:

Number of electrons in K-shell =2, L-shell = 8 and M-shell = 18.

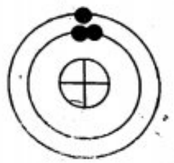
x. Write detail electronic configuration of $^{7}_{3}Li$, $^{12}_{6}C$ and $^{24}_{12}Mg$.

Ans:1. Lithium ($^{7}_{3}Li$):

Atomic number = 3 Number of electrons = 3

Electronic configuration:

Energy levels/shells	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 1	$2s^1$

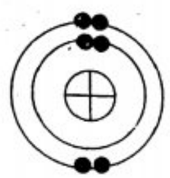


Carbon:

Atomic number = 6 Number of electrons = 6

Electronic configuration:

Energy level/shell	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 4	$2s^2$ $2p^2$



Magnesium:

Atomic number = 12 Number of electrons = 12

Electronic configuration:

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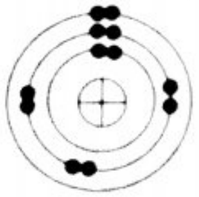
Energy level/shell	Energy sub-levels/sub-shells
K = 2	$1s^2$
L = 8	$2s^2$ $2p^6$
M = 2	$3s^2$



xi. Write the symbol for an isotope:

a. Containing one proton and two neutrons

b. For which atomic number is one and there is one neutron

c. For which the atomic number and mass number is one

Ans: a. Element name = Hydrogen

Isotope name = Tritium

As number of proton is one and neutron is 2 therefore

Atomic number = 1

Mass number = 2+1 = 3

Symbol = ${}_1^3H$ *or* ${}_1^3T$

b. Element name = Hydrogen

Isotope name = Deuterium

As atomic number is one and number of neutron is also one therefore

Atomic number = 1

Mass number = 1+1 = 2

Symbol = ${}_1^2H$ *or* ${}_1^2D$

c. Element name = Hydrogen

Isotope name = Protium

Atomic number = 1

Mass number = 1

Symbol = ${}_1^1H$

Long Questions

i. Why Dalton's atomic theory is considered as a base for modern atomic concepts?

Ans: Dalton's atomic theory, as a base for modern atomic concepts:

It is explained under the following headings:

i. A comprehensive detail about atom:

Although the word atom was discussed by Greeks before Dalton's atomic theory but they have not given any detail and no experimental proof However a comprehensive detail about atom was given by this theory and Dalton gave experimental proofs to support his theory which was never done by anyone

ii. Explained the nature of atom:

Before this theory, no one has explained the nature of atom. This theory explained the atoms of a particular element are same in size, shape and mass This explanation helped many scientists to explore the atom

iii. Explained the nature of chemical reactions:

This theory explained the nature of chemical reactions like it say all chemical reactions are due to the combination of atoms.

iv Explained the law of definite proportion and law of conservation of mass:

Dalton's atomic theory successfully explained the law of definite proportion and law of conservation of mass.

v. Explained the composition of matter:

This theory explained the composition of matter that it is composed of atoms

As Dalton's atomic theory gave a detail about atom, its nature therefore it helped the scientists to explore the atom and they found further particles of atom They explained the structure of atom which would be impossible without this theory That is why Dalton's atomic theory is considered as a base for modern atomic concepts.

I. Summarize Rutherford model of an atom and explain how he developed this model on the basis of his famous gold-foil experiment?

Ans: See Question no. 3

ii. State the postulates which Bohr suggested to overcome the shortcomings of Rutherford's atomic model?

Ans: See Question no. 5

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iii. Complete the following table for neutral atoms of specific isotopes:

	Isotopic symbol	Atomic No.	Mass No.	No. of Protons	No. of Electrons	No. of neutron
A	$^{131}_{54}Xe$					
b		27	59			
c			144			84
d		22				26
e						
f			128	52		
g				18		22

Ans:

	Isotopic symbol	Atomic No.	Mass No.	No. of Protons	No. of Electrons	No. of neutrons
a	$^{131}_{54}Xe$	54	131	54	54	77
b	$^{59}_{27}Co$	27	59	27	27	32
c	$^{144}_{60}Nd$	60	144	60	60	84
d	$^{48}_{22}Ti$	22	48	22	22	26
e	$^{178}_{72}Hf$	72	178	72	72	106
f	$^{128}_{52}Te$	52	128	52	52	76
g	$^{40}_{18}Ar$	18	40	18	18	22

iv. a. Define energy level and sub-energy levels.

b. Explain the contribution of electrons in various energy level and energy sub-levels for 1st four elements of the periodic table.

Ans(a):Energy level:

"The circular paths around the nucleus in which electrons revolve are called energy levels or shells or orbits."

Energy levels are seven in number. They are named as K, L, M...etc. They are also numbered as 1, 2, 3 .... etc where K=1, L=2 and so on.

The maximum number of electrons an energy levels is K=2, L=8, M=18, N =32 this is find by $2n^2$ rule where n is the number of shell.

Energy sub-levels:

"The various regions in the main shells are called energy sub-levels or sub-shells."**OR**

Sub-shells are four in number. Their names are s, p, d and f. The maximum number of electron they can accommodate is given below:

s = 2, p = 6, d = 10 and f = 14.

Ans(b): See page#63 from Hydrogen to Beryllium.

Test Yourself

1. Sodium has 11 protons and 12 neutrons. Write its electronic configuration.

Ans: See Page # 64

2. Potassium has the electronic configuration 2,8,8,1

a. What is its proton number?

b. Draw its electronic structure.

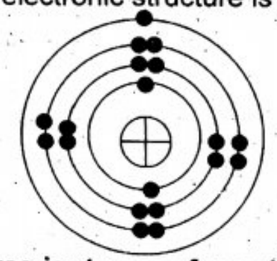
3. Write the electronic configuration of N, P and Ar.

Ans: For answer of questions 1 and 3 see page no. 63+64

Ans.2(a): The number of proton = 2+8+8+1 = 19

(b) Electronic Structure:

Its electronic structure is drawn below:



4. There are three isotopes of uranium having atomic number 92 and mass number 234, 235 and 238 respectively. Calculate the number of neutrons in their nuclei.

Ans:

Uranium isotopes	Atomic no. (Z)	Mass no. (A)	Number of neutrons = A – Z
U-234	92	234	234 – 92 = **142**
U-235	92	235	235 – 92=**143**
U-238	92	238	238 – 92 = **146**

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Chapter No.03
Periodic Table and Periodicity of Properties

Q.1: What is meant by classification of elements? Give the need & importance of classification of elements.

Classification of Elements:

"The arrangement of elements into horizontal and vertical rows on the basis of similarities (مشابہت) in properties is called classification of elements."

Need for classification of elements:

With the discovery of new elements, a need was felt for its classification. By classifying the elements, maximum information can be obtained with less effort (کوشش). About 118 elements have been discovered and they have been classified in the form of periodic table.

Importance of classification of elements:

The classification of elements is very important for chemists.

For example:

i. It helps the chemists to understand the properties of elements in an easier way.
ii. Maximum information about elements can be obtained by applying less effort.
iii. It helps in the discoveries of new elements.

Q.2: Describe the history or development of modern periodic table.

Ans. Development/history of periodic table:

In the development of periodic table the following scientists played their role:

1. Al-Razi classification:

Al-Razi classified the elements into two groups i.e. metals and non-metals but it failed after the discovery of metalloids.

Lavoisier in 1787 also followed this classification.

2. Dobereiner's Triad:

In 1817, a German chemist, J.W Dobereiner classified the elements into groups of three elements called triad. The properties of elements in

each triad were similar. In each triad the atomic weights of middle element was approximately the mean of the atomic weights of other two elements e.g. ^{7}Li, ^{23}Na, ^{39}K. But it had very limited applications (استعمال/اطلاق).

3. Newland's octaves:

In 1864, an English chemist, J. Newland classified the elements in order of increasing atomic weights. He classified the elements into 7 groups and presented his law of octave which states that" **every eighth element has the same properties like the first one when arranged in the ascending order of their atomic weights".** But this classification failed after the discovery of noble gases.

Table: Newland's Octave

H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe

4. Lother Meyer's classification:

Lother Meyer, a German chemist, in 1869 arranged the elements in order of increasing atomic weights and plotted a graph between atomic volume and atomic masses of elements. He observed that elements with similar properties occupy (جگہ،گھیرنا) same position in the curve (گراف سے حاصل ہونے خمدار لکیر).

5. Mendeleev's classification:

In 1869, a Russian chemist, Mendeleev classified the then known elements in order of increasing atomic weights. As a result of this, the properties of elements were repeated (دہراو) at regular intervals (وقفے). He called this relationship as periodic law, which states that "**The properties of elements are the periodic function of their atomic weights.**

On the basis of Mendeleev's periodic law a table of elements was obtained, called Mendeleev's periodic table. In this table elements were placed in horizontal and vertical rows. Mendeleev's periodic table was very precise and formed the basis of modern periodic table. In this table he left vacant spaces for undiscovered elements and also predicted their properties.

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Q.3: Write a short note on modern periodic table.

Modern periodic table:

"A table of elements in which the elements are arranged in the increasing order of their atomic numbers in various periods and groups is called modern periodic table."

i. History:

In 1913, Mosely classified the elements in order of increasing atomic number. As a result, elements with similar chemical properties recour at regular intervals. From this he presented modern periodic law which is given below:

Modern periodic law:

"The physical and chemical properties of elements are the periodic function of their atomic number".

ii. Recommendation:

Modern periodic table was recommended (منظور کرنا) by IUPAC in 1957.

iii. Features of modern periodic table:

Modern periodic table has the following essential features:

a. Groups: "The vertical columns of elements in the periodic table are called groups." There are 8 groups in modern periodic table. Which are further sub-divided into two sub-groups i.e. sub-group A called normal elements and sub-group B called transition elements.

b.Periods:"The horizontal rows of elements in periodic table are called periods."

There are 7 periods in modern periodic table.

c.Blocks: On the basis of position of electron in the last orbital modern periodic table has 4 blocks which are s-block, p-block, d-block and f-block elements.

Q.4: Discuss the periods of modern periodic table.

Ans: Periods:

"In the periodic table the horizontal rows of elements are called **periods**." Elements of each period have same number of shells.

There are seven periods in modern periodic table. Their details are given below:

1st period:

First period is called shortest period because it contains only two elements naming hydrogen and helium both of which are normal elements.

2nd and 3rd periods:

These periods are called the short periods. These contain 8 elements each which are normal elements. The second period starts from lithium and ends at neon. The third period starts from sodium and ends at argon.

4th and 5th periods:

These periods are called long periods and contain 18 elements each i.e. 8 normal elements and 10 transition elements. The fourth period starts from potassium and ends at krypton, while the fifth period starts from rubidium and ends at xenon.

6th period:

The sixth period is a longest period of 32 elements i.e. 8 normal, 10 transition and 14 lanthanide series elements which are placed at the bottom of the periodic table above the actinide series. This series ranges from cerium, Ce (atomic number 58) to lutetium, Lu (atomic number 71).

7th period:

According to the textbook, the seventh period is incomplete but now-a-days it is complete and contains 32 elements. A fourteen-member series of elements is also taken out from this period and placed at bottom of the periodic table beneath the lanthanide series. This series starting from Thorium, Th (atomic number 90) to Lawrencium, Lr (atomic number 103) is called actinide series.

Q.5: What are groups of modern periodic table?

Ans:Groups:

"The vertical rows of elements in the periodic table are called **groups or families"**.

Elements in each group have the same number of electrons in their valance shell and therefore show similar chemical properties.

There are 8 groups in modern periodic table which are further subdivided into two subgroups i.e. subgroup **A** and subgroup **B**. The subgroup **A** elements are called normal or representative elements while the subgroup **B** elements are called outer transition elements.

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Names of groups:

IA group elements are called alkali metals, IIA group elements are called alkaline earth metals, IIIA group elements are called boron family, IVA group elements are called carbon family (OR) VA group elements are called nitrogen family, VIA group elements are called chalcogens(copper ore formers) or oxygen family, VIIA group elements are called halogens (salt formers) while VIIIA group elements are called noble gases, inert gases or rear gases.

Q.6. Write short note on all groups of periodic table.

Ans: Group VIIIA (the noble gases):

Group members:

The members of this group are helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe) and radon (Rn).

General characteristics:

The general properties of these elements are following:

i. These elements are called noble gases or inert gases because their valance shells are completed with electrons and they are chemically unreactive therefore, they have little tendency to form compounds.
ii. These elements are also called rare gases because these exist only in minute (کم) quantities in the atmosphere.
iii. All of these elements are non-metals.
iv. They exist in mono atomic state due to their complete valance shells with electrons.
v. These elements have low melting points and boiling points.
vi. These elements contain eight electrons in their valance shells except helium which contains two electrons in its valance shell.
vii. Except radon these gases are obtained from the liquefaction (مائع میں تبدیلی) of air.

Group IA (Alkali metals):

Group members:

Alkali metals consist of lithium (Li), sodium (Na), potassium (K), rubidium (Rb), cesium (Cs) and francium (Fr).

General characteristics:

The general characteristics of these elements are following:

i. They are called alkali metals because they form alkalies (alkalies are those hydroxide containing bases which are water soluble).
ii. These elements are very soft.
iii. They are the most electropositive elements of the periodic table.
iv. These elements are very reactive as they can lose electron easily.
v. These elements have one electron in their valance shell.
vi. They lose their one valance electron to form ionic bonds with other elements.

Group IIA (Alkaline earth metals):

Group members:

The members of this group are beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba) and radium (Ra).

General characteristics:

The general characteristics of this group are:

i. Since the elements of this group are mostly obtained from rocks of the earth and they form alkalies, therefore these elements are called alkaline earth metals.
ii. Under normal conditions all of these elements are solids.
iii. These elements are harder, less reactive and less electropositive as compared to alkali metals.
iv. These elements have high melting and boiling points as compared to alkali metals.
v. These elements contain two electrons in their valance shell, and form ionic bond by losing these two electrons.

Group IIIA (The Boron family):

Group members:

This group consists of boron (B), aluminium (Al), gallium (Ga), indium (In) and thallium (Tl).

General characteristics:

The general properties of this group are as follows:

i. Under normal conditions all the members of this group are solids
ii. Due to small size and high charge Boron is metalloid while other elements of this group are metals.
iii. These elements have three electrons in their valance shell.
iv. These elements usually form covalent bond.

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Group IVA (The Carbon family)

Group members:

The members of this group are carbon (C), silicon (Si), germanium (Ge), tin (Sn) and lead (Pb).

General characteristics:

The general characteristics of this group are:

i. This group forms a link between the more electropositive and more electronegative elements of the periodic table.
ii. Under normal conditions all of these elements are solids.
iii. Carbon electronegative and non metals, Silicon and germanium is metalloid while tin and lead are electropositive and metals.
iv. These elements have four electrons in their valance shell and they require four more electrons for the completion of their octet.
v. In most of the compounds, these elements are linked through four covalent bonds.

Group VA (The Nitrogen family):

Group members:

Nitrogen family consists of nitrogen (N), phosphorus (P), arsenic (As), antimony (Sb) and bismuth (Bi).

General characteristics:

The general characteristics of this group are following:

i. Nitrogen is a gas while other elements of this group are solids.
ii. Nitrogen and phosphorus are non metals; arsenic and antimony are metalloids while bismuth is a metal.
iii. These elements have five electrons in their valance shell and they require three more electrons for the completions of their octet. So, usually these elements are linked through three covalent bonds in their compounds.
iv. The tendency of covalent bond formation decreases down the group.

Group VIA (The Oxygen family):

Group members:

This group consists of oxygen (O), sulphur (S), selenium (Se), tellurium (Te) and polonium (Po).

General characteristics:

These elements have the following characteristics:

i. Under normal condition oxygen is a gas while others are solids.

ii. Oxygen, sulphur and selenium are non metals while tellurium and polonium are metalloids.
iii. All of these elements have six electrons in their valance shell.
iv. They require two electrons for the completion of their octet.
v. They attain noble gas configuration either by gaining two electrons (forming ionic bonds) or by sharing two electrons (forming covalent bonds).

Group VIIA (The Halogens):

Group members:

The group members of this group are fluorine (F), chlorine (Cl), bromine (Br), iodine (I) and astatine (At).

General characteristics:

The general characteristics of this group are following:

i. These elements are called halogens because they form salts i.e. halogens mean salt forming.
ii. Under normal condition fluorine and chlorine are gases, bromine is a liquid while iodine and astatine are solids.
iii. All of these elements are non-metals.
iv. These elements are the most electronegative elements of the periodic table.
v. They contain seven electrons in their valance shell.
vi. They form ionic bond (by gaining one electron) or covalent bond(by sharing one electron) to complete their octet.
vii. Due to their high reactivity they are not found in free state.

Q 7: Write a note on transition elements?

Ans: Transition elements:

In periodic table the elements from group IB to VIIIB are called transition elements. These elements have incomplete inner shells and show variable valences, therefore, they are called transition elements.

General characteristics:

The general characteristics of these elements are following:

i. These elements form coloured compounds.
ii. These elements act as catalyst.
iii. All of these elements are metals.
iv. They have a strong bond between their atoms call metallic bond.
v. All of these elements are solids except mercury which is a liquid.
vi. They have high melting and boiling points.

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Q.8: Discuss the blocks of periodic table.

Division of periodic table into blocks:

On the basis of position of last electron in a sub-shell the periodic table has been divided into 4 blocks which are s, p, d, and f-blocks their detail is given below:

S-block elements:

"Those elements in which the last electron enters to s orbital are called s-block elements."

The IA and IIA group elements are s-block elements.

P-block elements:

"Those elements in which the last electron enters to P orbital are called p-block elements."

P-block contains the elements from group IIIA to VIIIA except He.

d-block elements:

"Those elements in which the last electron enters to d orbital are called d-block elements."

d-block contain the elements from group IB to VIIIB. d-block elements are also called outer transition elements.

f-block elements:

Those elements in which the last electron enters to f orbital are called f-block elements. "The f-block elements contain actinide and lanthanide series elements. They are also called rare earth or inner transitions elements.

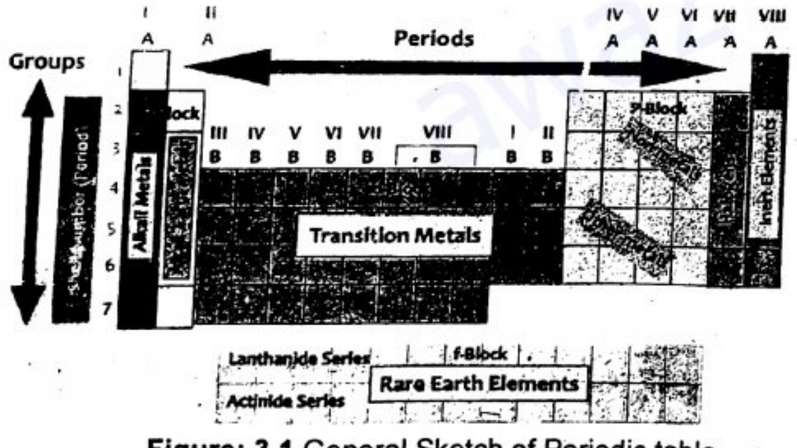

Figure: 3.1 General Sketch of Periodic table

Q.9: What do you understand by periodicity of properties?

Ans: Periodicity of property:

When elements are arranged in the increasing order of their atomic numbers their properties are repeated (دہراو) after a certain interval (وقفے). Thus,

"In the periodic table the repetition of properties after a certain interval (2, 8,18etc) is called periodicity of properties.

Periodic properties include atomic size, ionization energy, electron affinity, shielding effect and electronegativity.

Q.10: Discuss the periodicity of atomic sizes (radii) of elements in the periodic table.

Ans: Atomic size

Introduction:

The size of an atom is not rigidly fixed (محدود). Its size is affected by a number of factors. The same atom may have different sizes in different combinations. It is difficult to measure the exact size of an atom. However, atomic size is usually expressed in terms of atomic radius or covalent radius. Both of which are directly proportional to atomic size. Their detail is given below:

1. Atomic Radius:

"The distance from the centre of the nucleus to the valance shell of an atom is called **atomic radius."**

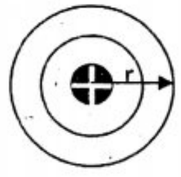

Figure: An atom showing atomic radius

Representation:

It is represented by r.

Units:

The SI unit of atomic radius and covalent radius is either picometre or nanometer. However, the commonly used unit is angstrom (A^0).

$1A^0 = 10^{-10}m = 10^{-8}cm$

$1pm = 10^{-12}m$

$1nm = 10^{-9}m$

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Factors affecting atomic radius:

Following factors affects the atomic radius of an atom:

i. Number of shells:

Atomic radius is directly proportional to the number of shells.

ii. Nuclear charge:

Greater the nuclear charge lesser will be the atomic radius and vice versa. (if the number of shells remain constant)

iii. Shielding effect of low lying electrons:

Greater the shielding effect of low lying electrons greater will be the atomic radius and vice versa.

Variation/Trends of atomic radius in periodic table:

i. Variation/Trends in period:

The atomic radius decreases in going from left to right in a period because the number of shells in a period remains the same and one proton is added to the nucleus successively along a period. Therefore, the attraction of the nucleus for the valance electrons increases and they are pulled (کھینچنا) nearer to the nucleus. Hence, the atomic radius decreases.

ii. Variation/Trends in group:

The atomic radius increases from top to the bottom in a group because shells after shells are added in going from top to the bottom in a group thus the shielding effect increases hence, the atomic radius increases.

2. Covalent radius:

"Half of the distance between the nuclei/centers of two similar bonded atoms is called covalent radius".

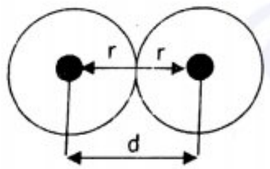

Figure: Two similar bonded atoms, Showing Covalent radius which is r = d/2

The bond distance of two atoms A and B is the average of the distances between A-A and B-B.

Q.11. Define and explain the ionization energy of an element. Discuss the periodic variation of in ionization energies of the elements in the periodic table.

Ans. Ionization Energy or Ionization Potential:

Definition:

"The minimum amount of energy required (درکار) to remove an electron from the valance shell of a gaseous atom to form a cation is called ionization energy or ionization potential."

Explanation:

Ionization potential is denoted by I.E or I.P. Electrons can be removed from an atom by supplying energy in the form of heat, light or electrical discharge.

Units:

Ionization energy is usually measured in J/mol or KJ/mol. However, electron volt (ev) and Kcal/mol are also used.

We can remove more than one electron from the valance shell of an atom. Thus we can have different types of I.P which are given below:

1st I.P:

The energy requires to remove 1st electron from the valance shell of an atom is called 1st I.P

Examples:

$Na + Energy \longrightarrow Na^{+1} + 1\bar{e}$ $\quad 1^{st}$ I.P = +496KJ/mol

$Mg + Energy \longrightarrow Mg^{+1} + 1\bar{e}$ $\quad 1^{st}$ I.P=+738KJ/mol

2nd I.P:

The energy requires to remove 2nd electron from the valance shell of an atom is called 2nd I.P

Example:

$Mg^{+1} \xrightarrow{Energy} Mg^{+2} + 1\bar{e}$ 2^{nd}I.P=+1450KJ/mol

It may be noted that 2nd I.P is always greater than the 1st.

The value of I.P gives an idea about the metallic character of elements. Greater the I.P value lesser will be the metallic character and vice versa.

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Factors affecting Ionization energy:

Following factors affects the ionization energy:

i. Atomic size:

Greater the atomic size lesser will be the ionization energy and vice versa.

ii. Nuclear charge:

Greater the nuclear charge greater will be the ionization energy and vice versa. (if the number of shells remains the same)

iii. Shielding effect of low lying electrons:

Greater the shielding effect lesser will be the ionization energy and vice versa.

iv. Electronic configuration:

Those elements which have half-filled orbitals or completely filled orbitals are more stable (قیام پذیر) and they have high values of ionization energies.

Trends/Variation of Ionization energy in the periodic table:

i. Trends/Variation in periods:

The ionization energy increases in going from left to the right in a period because the number of shells in a period remains the same and one proton is added to the nucleus successively along a period. Therefore, the attraction of the nucleus for the valance electrons increases because of which the atomic size decreases and thus the valance electrons need more energy to remove.

ii. Trends/Variation in groups:

The ionization potential decreases down the group because in going from top to bottom in a group the number of shells increases due to which the valance electrons become farther(دور) from the nucleus and thus the nucleus attractive force on the valance electrons decreases. Hence the ionization energy decreases.

Q.12. What do you mean by electron affinity? Discuss its periodic variation in the periodic table.

Ans: Electron affinity:

Introduction:

Electron affinity means love for electron acceptance. Different elements have different tendencies for electron acceptance. When a new electron is entered to an atom its nucleus attracts it and thus energy is

given out. Therefore, electron affinity is measured in terms of energy evolved (خارج کرنا). Thus it is defined as given below:

Definition:

"The amount of energy released (خارج کرنا) when an electron enters to the valance shell of a gaseous atom to form an anion is called electron affinity."

Explanation:

It is given negative sign when 1st electron is added to an atom because the energy is released. However, when a second electron is added to a uni-negative ion, energy is absorbed and it is given positive sign.

Examples:

$Cl + 1\bar{e} \longrightarrow Cl^-$ E.A = - 348.8KJ/mol
(2,8,7) (2,8,8)

$O + 1\bar{e} \longrightarrow O^{-1}$ E.A = - 141 KJ/mol
(2,6) (2,7)

$O^{-1} + 1\bar{e} \longrightarrow O^{-2}$ E.A = +844 KJ/mol
(2,7) (2,8)

Units:

Electron affinity is usually measured in J/mol or KJ/mol. However, electron volt (ev) and Kcal/mol are also used.

Factors affecting electron affinity:

Following factors affects the electron affinity:

i. Atomic size:

Greater the atomic size lesser will be the electron affinity and vice versa.

ii. Nuclear charge:

Greater the nuclear charge greater will be the electron affinity and vice versa. (if the number of shells remains the same)

iii. Shielding effect:

Greater the shielding effect, lesser will be the electron affinity and vice versa.

iv. Electronic configuration:

Those elements which have half-filled orbitals have low values of electron affinities e.g. group VA while elements with completely filled orbitals and shells have generally positive values of electron affinities e.g. group IIA and VIIIA

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Variation of electron affinity in the periodic table:

The variation of E.A in periodic table is given below:

i. Variation in periods:

The electron affinity increases in going from left to the right in a period due to the increasing nuclear charge on the same number of shells and decreasing atomic size. Thus IA group elements have lowest and VIIA group elements have the highest electron affinity values in their respective periods.

ii. Variation in groups:

The electron affinity decreases down the group because in going from top to bottom in a group not only the atomic size increases but the shielding effect also increases thus, the nucleus attractive force on the valance electrons decreases. Hence the electron affinity decreases down the group.

Q.13. What do you understand by the term shielding effect? How it affects the ionization energies and electron affinities of elements in the periodic table.

Ans: Shielding effect:

Definition:

The effect in which the inner shell electrons shield(ڈھانپنا) the valance electron from the nucleus attractive force and thus reduces the nuclear attractive force on the valance electrons is called shielding effect or screening effect,"

Explanation:

We know that the electron revolve around the nucleus in various shells. During the revolution the inner shell electron shield the outer electron from the nuclear charge as shown in the figure below:

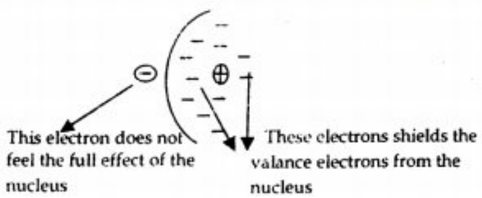

Figure: Shielding effect

Factors affecting shielding effect:

Shielding is effected by number of inner shells and the number of electrons in the inner shells. Greater the number of inner shells and the number of inner electrons greater will be the shielding effect and vice versa

Effects on ionization energy/electron affinity/electronegativity:

As shielding effect decrease the nuclear attractive force on the valance electrons therefore, greater the shielding effect lesser will be the electron affinity/ionization energy/electronegativity.

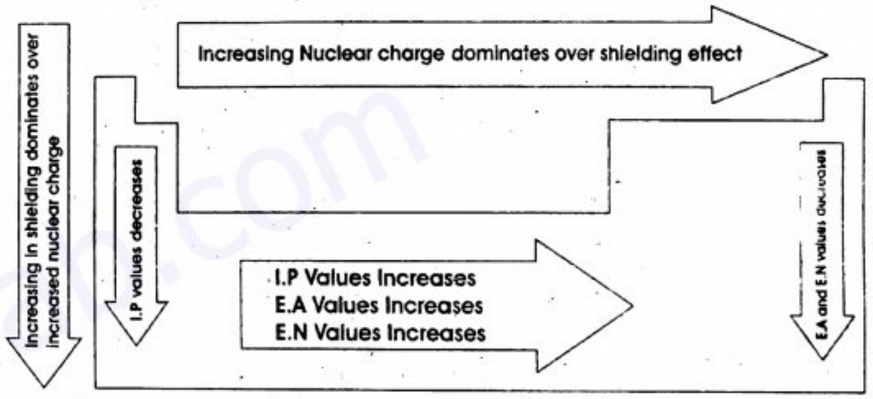

Figure: Periodicity of shielding effect, I.P, E A and E.N

The variation of shielding effect in periodic table and its effects on ionization energy/electron affinity/electronegativity are given below:

i. Trends/Variation in periods and effects on I.P, E.A and E.N:

Generally, in going from left to right in a period the shielding effect remains constant because the number of inners shells remains constant and the increasing nuclear charge wins over the shielding. Thus the values of I.P, E.A and E.N increase.

ii. Variation in groups and effects on I.P, E.A and E.N:

In going from top to the bottom in a group the number of inner shells increases which shields the nucleus more effectively (موثر طریقے سے) thus, the size of atom increases and the values of ionization energy, electron affinity and electronegativity decrease.

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Q.14. Define and explain the electronegativity of an element. Discuss its periodic variation in periods and groups of the periodic table.

Ans. Electronegativity:

"The force with which an atom attracts a shared pair of electrons towards itself in a covalent bond is called **electronegativity**." **OR**

"The power of attracting shared pair of electrons is called **electronegativity**."

Explanation:

Electronegativity is a property related (تعلق رکھنا) to the atoms when they are covalently bonded. In a covalent bond the shared pair of electron is attracted by both the bonded atoms. If they have same force of attraction, then they have same value of electronegativity and the bond is said to be non-polar. However, if they have different values of electro negativities then the bond will be polar.

H —H	$H^{+\delta}—Cl^{-\delta}$
Non-polar	Polar

Factors affecting electronegativity:

i. Atomic size:
Greater the atomic size lesser will be electronegativity and vice versa.

ii. Nuclear charge:
Greater the nuclear charge greater will be the electronegativity and vice versa. (if the number of shells remains the same)

iii. Shielding effect of low lying electrons:
Greater the shielding effect lesser will be the electronegativity and vice versa.

iv. Electronic configuration:
Those elements which have nearly filled shells are more electronegative for example halogens.

Determination of electronegativity:

Pauling, an American chemist determined the electronegativity values of elements. He developed a scale from the bond energies of di-atomic molecules. On this scale fluorine has a value of 4, which is the most electronegative element of the periodic table.

Mulliken, Sanderson and Allen was some other scientists to determine the values of electronegativity of elements.

Variation of electronegativity in the periodic table:

The variation of E.N in periodic table is given below:

i. Variation in periods:

The electronegativity increases in going from left to the right in a period because the number of shells in a period remains the same and one proton is added to the nucleus successively along a period. Therefore, the attraction of the nucleus for the valance electrons increases because of which the atomic size decreases and thus the values of electronegativity increase.

ii. Variation in groups:

The electronegativity decreases down the group because in going from top to bottom in a group the number of shells increases due to which the valance electrons become farther(دور) from the nucleus and thus the nucleus attractive force on the valance electrons decreases. Hence, the electronegativity decreases.

It is concluded (نتیجہ اخزکرنا) from the above two points that elements on the right upper side are the most electronegative elements.

Extra Q:15 Write a note on lanthanides and actinides series?

Ans: Lanthanides and actinide series:

In periodic table the elements from cerium(Ce) atomic number 58 to lutetium(Lu) atomic number 71 are called lanthanide series, while the elements from thorium (Th) atomic number 90 to lawrencium(Lr) atomic number 103) are called actinide series. These two series are also called inner transition elements.

The properties of the elements of each series are alike but their properties do not fit with the properties of elements of any group in the periodic table, therefore, they are placed separately at the bottom of the periodic table.

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EXERCISE

Multiple Choice Questions

Q.1 Choose the correct answer:

i. The law of triad was presented by:
A) Newland **B) Dobereiner** C) Lother Meyer D) Mosely

ii. Number of periods in modern periodic table are:
A) 7 B) 8 C) 10 D)18

iii. Which of the following is a transition element:
A) Cl B) B C) S **D) Cu**

iv. The modern periodic table is based on:
A) Law of triad B) Law of octave
C) Mendeleev's periodic law **D) Modern periodic law**

v. Another name for group VII is:
A) Alkali metals B) Alkaline earth metals
C) Halogens D) Noble gases

vi. Which of the following group does not belong to p-block elements:
A) Group I B) Group III C) Group V D) Group VII

vii. Ionization energies of elements in a period of the periodic table(from left to right) generally:
A) Decrease B) Sometime increase and sometime decrease
C) Increase D) Remain constant

viii. The number of valance electrons of group II elements are:
A) 2 B) 4 C) 6 D) 8

ix. s-block elements are:
A) Non-metals **B) Metals**
C) Metalloid D) Transition

x. An element has eight electrons in its valance shell. It is a member of:
A) Alkali family B) Halogen family
C) Noble family D) Carbon family

xi. Which the following element is the same family as fluorine?
A) Silicon B) antimony **C) iodine** D) arsenic

xii. Which of the following has the smallest ionization energy?
A) K B) P C) S D) Ca

xiii. An element has electronic configuration 2,8,1 it belongs to:
A) group I and III period B) group III and I period
C) group I and VII period D) group VII and III period

xiv. Which of the following elements would be similar to carbon?
A) nitrogen B) boron C) oxygen **D) silicon**

xv. Which of the following has largest ionization energy?
A) Na B) Al C) H **D) He**

xvi. Elements in a _____ have similar chemical properties.
A) period **B) group** C) both D) none

xvii. Shielding effect is due to _____
A) neutron B) proton
C) proton and neutron **D) electron**

Short Questions

Q.2: Answer briefly the following questions:

i. Which element of group IA is not an alkali metal and why?

Ans: Element of group IA which is not alkali metal:

Hydrogen is the element of group IA which is not an alkali metal.

Reason:

It is because all the other elements of group IA are metals and they form alkalies while hydrogen is neither metal nor it forms alkali.

ii. Place the following elements in increasing ionization energies.
Na, S, Mg and Ar

Ans: Increasing order of I.E for given elements:

Ionization energy is inversely ↔proportional to atomic size and atomic size decrease along a period due to which ionization energy increase. These elements are the members of same period i.e. period 3 therefore, the increasing order of ionization energy for these elements is:

Na < Mg < S < Ar
496<738<1000<1521 KJ/mol

iii. Name the group and state the group number of each of the following elements?
a) K b) Ne c) Be d) Cl e) C

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Ans:

S.No.	Element symbol with name	Group Name	Group Number
a	Potassium (K)	Alkali metals	IA
b	Neon (Ne)	Noble gases	VIIIA
c	Beryllium (Be)	Alkaline earth metals	IIA
d	Chlorine (Cl)	Halogens	VIIA
e	Carbon (C)	Carbon family	IVA

iv. Which element is the most electronegative among C, N, O, Br and S which group does it belongs to?

Ans: Most electronegative element among the given elements:

Oxygen is the most electronegative element among C, N, O, Br and S. Its electronegativity value is 3.5 while the electronegativity of C is 2.1, N is 3, Br is 2.8 and S is 2.5.

Group name and number:

Oxygen belongs to group VIA called oxygen family or chalcogens.

v. How do the first ionization energies of representative elements vary across a period and down a group?

Ans: First ionization energy:

"The amount of energy required to remove first valance electron from a gaseous atom is called first ionization energy."

Variation in periods for representative elements:

For representative elements, the first ionization energy increases in going from left to the right in a period because the number of shells in a period remains the same and one proton is added to the nucleus successively along a period. Therefore, the attraction of the nucleus for the valance electrons increases because of which the atomic size decreases. Hence the first I.E increases.

Variation in groups for representative elements:

The first ionization potential ↔decreases down the group because in going from topto bottom in a group the number of shells increases due to which the valance electrons become farther (دور) from the nucleus and thus the nucleus attractive force on the valance electrons decreases. Hence the first ionization energy decreases.

vi. Which element is found in

a) Period 2 group VIIb) Period 4, group III

c) Period 5, group VId) Period 1, group VIII

Ans: a. Element found in Period 2, group VII:

Fluorine (F) is found in period 2, group VII.

b. **Element found in Period 4, group III:**

Gallium (Ga) is found in period 4, group III.

c. **Element found in Period 5, group VI:**

Tellurium (Te) is found in period 5, group VI.

d. **Element found in Period 1, group VIII:**

Helium (He) is found in period 1, group VIII.

vii. How will you differentiate between representative elements and transition elements?

Ans:Differences between representative and transition elements:

S.No	Representative elements	Transition elements
1	The s-block and p-block elements are together called representative elements.	The d-block and f-block elements are together called transition elements.
2	They range from group IA to group VIIIA.	They range from group IB to VIIIB.
3	In these elements the last electron enters to valance shell.	In these elements the last electron usually enters to innermost shell.
4	These elements contain metals, non-metals and metalloids.	All of these elements are metals.

viii. Make a general sketch of modern periodic table(without mentioning the symbols, to show the s, p, d and f-block elements)

Ans: For general sketch of periodic table see Q#8

ix. Why s-block elements have two groups only?

Ans: The answer of the given question is explained under the following heading:

Reason for s-block having only two groups:

As s-orbital can accommodate only two electrons therefore, s-block contains only two groups i.e. group IA and IIA because the number of

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groups in a block depends on the maximum number of electrons accommodated by that orbital.

x. What type of element is sulphur, a representative element, a transition element or lanthanide element?

Ans: Position of sulphur in periodic table:

The atomic number of sulphur is 16 and its electronic configuration is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$. As the last electron enters to p-orbitals therefore, it is a representative element because representative element contains elements of s-block and p-block.

Long Questions

i. How modern periodic table is different from Mendeleev's periodic table.

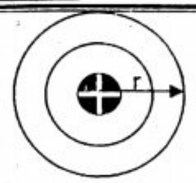
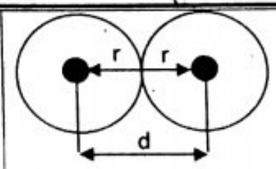
Ans: Differences between modern periodic table and Mendeleev's periodic table:

S.No.	Modern periodic table	Mendeleev's periodic table
1	This table is based on increasing order of atomic number.	This table is based on increasing order of atomic weights.
2	This table has 7 periods and 8 groups having two sub-groups.	This table has 12 periods and 8 groups having no sub-group.
3	This table is called long form periodic table containing 118 elements now.	This table is called short form of the periodic table which contained about 65 elements.
4	This table is accurate (صحیح).	This table has many discrepancies.(خامیاں)

ii. Differentiate between atomic radii and covalent radii. Explain the trends of atomic radius in the periodic table?

Ans: Differences between atomic radii and covalent radii:

S.No.	Atomic radius	Covalent radius
1	"The distance from the centre of the nucleus to the valance shell of an atom is called atomic radius."	"Half of the distance between the nuclei/centers of two similar bonded atoms is called covalent radius".
2.	Atomic radius is used for isolated atoms.	Covalent radius is used for covalently boded atoms.

3.	 Atomic radius=r	 Covalent radius(r) = d/2

Trends of atomic radius in periodic table:

i. Trends in periods:

The atomic radius decreases in going from left to right in a period because the number of shells in a period remains the same and one proton is added to the nucleus successively along a period. Therefore, the attraction of the nucleus for the valance electrons increases and they are pulled (کھینچنا) nearer to the nucleus. Hence, the atomic radius decreases.

ii. Trends in groups:

The atomic radius increases from top to the bottom in a group because shells after shells are added in going from top to the bottom in a group thus the shielding effect increases hence, the atomic radius decreases.

iii. What is electronegativity? Identify the most and least electronegative groups of elements in the periodic table? Why is fluorine special in terms of electronegativity?

Ans: Electronegativity:

"The force with which an atom attracts a shared pair of electrons towards itself in a covalent bond is called **electronegativity**." **OR**

"The power of attracting shared pair of electrons is called electronegativity."

Explanation:

Electronegativity is a property related (تعلق رکھنا) to the atoms when they are covalently bonded. In a covalent bond the shared pair of electron is attracted by both the bonded atoms. If they have same force of attraction, then they have same value of electronegativity and the bond is said to be non-polar. However, if they have different values of electro negativities then the bond will be polar.

H —H
Non-polar

$H^{+\delta}—Cl^{-\delta}$
Polar

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The most and least electronegative groups:

The most electronegative group is group VIIA called halogens because of their lowest atomic sizes and high nuclear charges.

The least electronegative group is group IA called alkali metals because of their highest atomic sizes.

Specialty of fluorine in terms of E.N:

Fluorine has highest electronegativity (4) in the periodic table because of its lowest atomic size.

Fluorine has a special position in periodic table because of which it has maximum value of E.N. In a period from left to right the E.N increase and down the group it decreases. Since fluorine is present on right top position therefore, it has highest E.N value.

iv. Define shielding effect and draw it affects the ionization energy, electron affinity and electronegativity?

Ans: See Q#13

v. Explain the following terms

a. Periodicity of property

b. Electron affinity

c. Modern periodic law

Ans (a) See Q#9

Ans (b) See Q#12

Ans (c) Modern periodic law:

History:

This law was presented by Henry GwynJeffreys Mosley in 1913.

Statement:

This law states that the properties of elements are the periodic function of their increasing atomic number.

On the basis of this law modern periodic table was formed having seven periods and eight groups.

Examples

EXAMPLE 3.1

Use the periodic table to identify each of the following:

i. The fifth element of first transition series

ii. The element of the fourth period that is also in group VB.

iii. The last lanthanide.

iv. The seventh transition element.

v. The second actinide metal

vi. The first element of group VIIIB

vii. The third halogen.

viii. The first alkaline earth metal.

ix. The first coinage metal

x. The second noble gas

Ans:

Q.No	Position of element	Name
i.	The fifth element of first transition series	Manganese(Mn)
ii.	The element of the fourth period that is also in group VB.	Vanadium(V)
iii.	The last lanthanide.	Lutetium(Lu)
iv.	The seventh transition element.	Cobalt(Co)
v.	The second actinide metal	Protactinium(Pa)
vi.	The first element of group VIIIB	Iron(Fe)
vii.	The third halogen.	Bromine(Br)
viii.	The first alkaline earth metal.	Beryllium(Be)
ix.	The first coinage metal	Copper(Cu)
x.	The second noble gas	Neon(Ne)

EXAMPLE 3.2

Which element in each of the following sets has largest ionization energy?

a) K, Ga, Se b) O, S, Se c) In As Cl

d) Be, C, N e) Mg, Ca, Sr f) Sn Se F

Ans: Highest I.E of elements in the given sets:

Ionization energy increases from left to right in period and decreases down the group. Thus, elements on the right side of a period and top of the group have highest ionization energies. The detail of answer on this basis is given below:

a) Potassium (K), Gallium (Ga) and Selenium (Se) lie in the same period in which selenium is on the right side, therefore it has the highest ionization energy in this set of elements.

b) Oxygen, sulphur(S) and selenium (Se) lie in the same group in which oxygen is at the top, therefore, oxygen has highest ionization energy in this set of elements.

c) Indium (In), arsenic (As) and chlorine (Cl) lie in different gro periods. However, the right and top element in these is chlo Therefore, chlorine has highest ionization energy in this set of ele

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d) Beryllium (Be), carbon(C) and nitrogen (N) lie in same period in which nitrogen is on the right side, therefore, nitrogen has highest I.E in this set of elements.

e) Magnesium (Mg), calcium (Ca) and strontium (Sr) lie in same group in which magnesium is at the top, therefore, magnesium has highest ionization energy in this set of elements.

f) Tin (Sn), selenium (Se) and fluorine (F) lie in different groups and periods. However, the right and top element in these is fluorine (F). Therefore, fluorine has highest ionization energy in this set of elements.

EXAMPLE 3.3:

Can you explain the abnormalities in I.P values from Be to B and N to O on the basis of their electronic configuration andshielding effect?

Ans. Abnormalities in I.P from Be to B and N to O:

If we go from left to right in a period the I.P values generally increases but from Be to B and N to O the order is reversed because of the following reason:

It is a rule that elements with completely filled orbitals and half-filled orbitals are stable and they have high ionization energies.

The electronic configuration of beryllium (Be) is $1s^2,2s^2$ while that of boron(B) is $1s^2,2s^2$, $2p^1$. It is clear from the electronic configuration of beryllium (Be) that it has a completely filled orbital so its ionization energy is higher than the expected. Similarly the electronic configuration of Nitrogen (N) is $1s^2$, 2s2, 2p3 while that of Oxygen (O) is $1s^2$, 2s2, 2p4 from which it is clear that Nitrogen (N) has a half filled orbital and the electrons of half-filled orbital are more stable therefore, the ionization energy of N is higher than the expected (متوقع).

I.P values in KJ/mol

Li	Be	B	C	N	O
520	**899**	801	1086	**1402**	1314

(abnormal increase in I.P due to half and completely filled orbital)

If we compare the I.P values of Li with B and that of C with O we find that from left to right increase in the I.P values has been occurred but the I.P values of Be and N has been increased unexpectedly(غیرمتوقع) due do the completely filled orbital of Be and half-filled orbital of N.

EXAMPLE 3.3:

Which set has more similar chemical properties?

a) N, P, As b) Li, C, F

Ans: Most similar chemical properties set:

In the given sets set (a) containing nitrogen, phosphorus and arsenic have most similar chemical properties because they lie in the

same group and we know that element in the same group same number of valance electrons, therefore they have similar chemical properties.

In set (b) elements lie in the same period and in period the properties gradually changes from one element to the other. Therefore, they have different chemical properties.

EXAMPLE 3.4:

Is sulphur more likely to be similar to selenium (Se) or chlorine (Cl) in its chemical properties?

Ans: Similarity of sulphur with selenium:

The chemical properties of sulphur are similar to selenium because both of these lie in the same group i.e. group VIA. Both have six electrons in their valance shell. Hence, they are similar in chemical properties.

Test Yourself

1. **The least electronegative element is Cs, can you guess where it is located in the table?**
2. **Can you tell, elements of which group have highest electronegativity values in their respective period?**

Ans:1. Location of Cs in periodic table:

The element cesium is located on the left bottom side of the periodic table.

2. Highest electronegative group:

Halogen is the group of elements which have the highest values of electronegativity in their respective periods because of their smallest atomic sizes and highest nuclear charges in their respective periods.

***Define shielding effect. Does it vary in a period?**

Ans: Shielding effect:

Definition:

"The effect in which the inner shell electrons shield(ڈھانپنا) the valance electron from the nucleus attractive force is called shielding effect or screening effect,"

Variation in period:

In normal elements the shielding effect does not vary(remains constant) in a period because the number of inner electrons in the inner shells remains constant while in transition elements the shielding effect varies(gradually increases) in a period because the number of electrons in inner d or f-orbitals increases.

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Chapter No.04
Structure of Molecules

Q.1: Define chemical bond? Why a chemical bond is formed/why most atoms are chemically bonded to other atoms in nature?

Ans: Chemical Bond:

"The attractive force which holds (پکڑنا) the atoms or ions together is known as **chemical bond.**"

Reason Of Chemical Bond Formation:

Every system in this universe tends (ارادہ) to lower its energy to attain stability. For example

i. Water flows from higher level to lower level.
ii. The electric current flows from a higher potential to lower potential.
iii. Heat flows from hot to cold body.

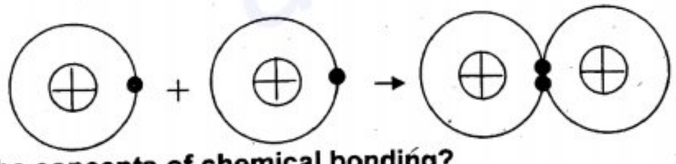
Similarly, the energies of unbounded atoms are greater and they are unstable because of their incomplete valence shells. Therefore, they become stable by forming a chemical bond. As during bonding, atoms not only complete their valence shells but also their energies become lower. Therefore, atoms combine to form chemical bonds.

Example:

Consider hydrogen atoms. The energy of isolated (الگ،علیحدہ) H-atoms is higher due incomplete valance shell therefore, they are unstable. To gain stability they combine to form H_2 molecule.

$$H^{\bullet} + H^{\bullet} \longrightarrow H_2 \qquad \Delta H = -436 KJ/mol$$

Unstable stable



Q.2: Explain the concepts of chemical bonding?

Ans: Concepts Of Chemical Bonding:

There are two concepts of chemical bonding which are given below:

1. The valance concept
2. The orbital concept

The detail is given below:

1. The Valance Concept:

History:

This theory was introduced by G.N Lewis and W. Kossel in 1916.

Main Points/Statements:

The main points of this theory are:

i. In a chemical bond formation, atoms take part by sharing, losing or gaining electrons.
ii. After making a chemical bond, the atoms attain the noble gas electronic configuration.

This concepts has further two parts which are:

a) Octet theory of valance or Rule of eight
b) Duplet theory of valance or Rule of two

Their detail is given below:

a) Octet Theory Of Valance Or Rule Of Eight:

History:

This theory/rule was introduced by G.N Lewis in 1916.

Statement:

The tendency of atoms to have eight electrons in the valance shells to attain stability, is called octet theory of valance or octet rule.

Explanation:

All the atoms of noble gases except helium have eight electrons in their outermost shells and they are stable, other atoms tend to attain the noble gas electronic configuration and become stable. This tendency of acquiring eight electrons in the valance shell like noble gases (except helium) is called octet rule.

Example:

In the formation of NaCl, both Na and Clcomplete their valance shells with eight electrons obeying octet rule.

$$Na + energy \longrightarrow Na^{+} + 1e^{-}$$
(2, 8, 1) ⟶ (2, 8) Electronic configuration of neon

$$Cl + 1e^{-} \longrightarrow Cl^{-}$$
(2, 8, 7) ⟶ (2, 8,8) Electronic configuration of argon

b) Duplet Rule Of Valance Or Rule Of Two:

History:

This theory was also presented by G.N Lewis in 1916.

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Statement:

The tendency of atoms to have two electrons in the valance shells to attain stability is called duplet theory of valance rule of two.

Explanation:

Helium has two electrons in its outermost shells and it is stable. Hydrogen, lithium and beryllium atoms tend to attain two electrons in valance shell and become stable. Thus they obey duplet rule.

Example:

When two hydrogen atoms share their valance electrons with each other, they obey duplet rule.

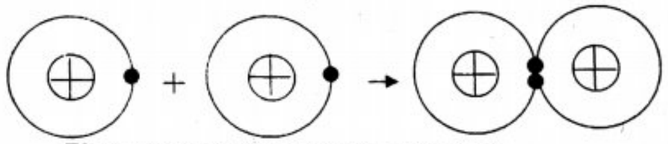


Figure: Formation of H_2 molecule

2. The Orbital Concept:

History:

This concept was introduced by Friedrich Hund and Robert Mulliken in 1927.

Statement/Main Points:

According to this concept:

i. During bonding, atomic orbitals combines to form molecular orbitals.
ii. Atomic orbitals having one electron can combine with other atomic orbital having one electron.
iii. These orbitals when come closer to each other they overlap each other.
iv. The atomic orbital overlaps either end wise or side wise.
v. Endwise overlap or linear overlap produce sigma bond while sidewise overlap produce pi-bond.

Example:

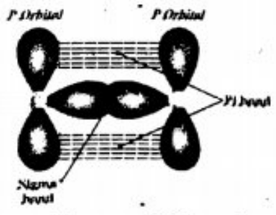
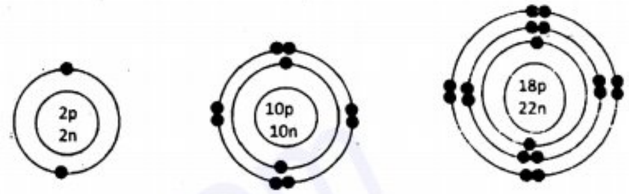


Figure: Sigma and Pi-bonds

Q.3:Why noble gases do not form chemical bond or why noblegasesare stable?

Ans: The stability of atoms depends on the completion of outer most shell with electrons and lower energy states of atoms. Noble gases have complete valance shells i.e. two electrons in case of helium and eight electrons in other noble gases. That is why they are stable and do not form bonds with other atoms.



$^{4}_{2}He$ $^{20}_{10}Ne$ $^{40}_{18}Ar$

Figure:Some noble gases

Q.4. In how many ways a chemical bond can be formed? OR describe the main types of chemical bond?

Ans: **Types Of Chemical Bond:**

There are four main types of chemical bonds which or given below:

1. Ionic bond or electrovalent bond
2. Covalent bond or molecular bond
3. Co-ordinate covalent bond or dative bond
4. Metallic bond

Q.5: Define ionic bond? Explain the formation of ionic bond with example.

Ans: **Ionic Bond:**

History:

W. Kossel, a German chemist in 1916, introduced theconceptof ionic bond.

Definition

"A type of chemical bond, which is formed by the complete transfer of electron/electrons from one atom to the other atom, is known as ionic bond." **(OR)**

"The electrostatic force of attraction between two oppositely charged ions produced as a result of transfer of electron/electrons from one atom to the other is called ionic bond"

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Formation Of Ionic Bond:

Ionic bond is formed between a metal atom and non-metal atom having electronegativity difference greater than 1.7. The detail is given below:

i. Formation Of Positive Ion:

In the formation of ionic bond the metal atom, having low electronegativity lose one or more electrons forming positive ion.

ii. Formation Of Negative Ion:

The non-metal atom, having high electronegativity, accepts these electrons forming negative ion.

Both ions attain (حاصل کرنا) the inert gas electronic configuration. They either complete their octet or duplet.

iii. Establishment Of Electrostatic Force:

Then the two oppositely charged ions attract each other due to electrostatic force of attraction and form ionic bond. Ionic bond is also called electrovalent bond.

Example Of Ionic Bond Formation:

Formation Of Ionic Bond In Sodium Chloride (NaCl):

It is explained below:

i. Formation Of Na^+ Ion:

The electronic configuration of sodium is:

Atomic number of sodium = 11

Electronic configuration of **sodium**= K=2, L=8, M=1

Sodium atom has one electron in its valance shell, it has larger atomic size and low I.P. Therefore, it gives one electron to Cl atom to form Na+ ion and thus it attains the electronic configuration of the nearest noble gas neon (K=2, L=8).

$$Na + energy \longrightarrow Na^+ + 1\bar{e}$$

(2, 8, 1) ⟶ (2, 8) Electronic configuration of neon

ii. Formation Of Cl^- ion:

Atomic number of chlorine = 17

Electronic configuration of **chlorine**= K=2, L=8, M=7

Chlorine atom has seven electrons in its valance shell, as it has smaller atomic size and greater electronegativity value. Therefore, it gains one electron of Na to form chloride ion (Cl), and thus attains the electronic configuration of the nearest noble gas argon (K=2, L=8, M=8).

$$Cl + 1\bar{e} \longrightarrow Cl^-$$

(2, 8, 7) ⟶ (2, 8, 8) Electronic configuration of argon

iii. Establishment Of Electrostatic Force:

Now both these ions (Na^+ and Cl^-) attract each other due to electrostatic force of attraction forming ionic bond. Thus sodium chloride is formed.

$$Na^+ + Cl^- \longrightarrow NaCl$$

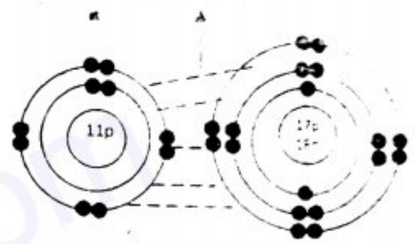

Figure: NaCl

Q.6 Explain the formation of ionic bond in calcium chloride.

Ans: Formation Of Ionic Bond In Calcium Chloride:

The formation of calcium chloride is explained below:

i. Formation Of Ca^{+2} Ion:

Calcium has 2 electrons in valance shell. It loses these electrons to form Ca^{+2} ion:

$$Ca + energy \longrightarrow Ca^{+2} + 2e$$

(2, 8, 8, 2) (2,8,8) Electronic configuration of argon

ii. Formation Of Cl^- Ions:

The two chlorine atoms gain one electron each from calcium forming two chloride ions (Cl^-) and thus attain the electronic configuration of the nearest noble gas argon (2, 8, 8).

$$2Cl + 2e \longrightarrow 2Cl^-$$

(2, 8, 7) (2, 8, 8)Electronic configuration of argon

iii. Establishment Of Electrostatic Force:

Now the two chloride ions and one calcium ion attract each other due to electrostatic force forming ionic bond and thus calcium chloride is formed.

$$Ca^{+2} + 2Cl^- \longrightarrow CaCl_2$$

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Q.7: Which atoms form ionic bond? Or what is the condition of ionic bond formation.

Ans:Condition For Ionic Bond Formation:

Ionic bond is formed between a metal atom and non-metal atom having electro negativity difference greater than 1.7.

Elements Of Periodic Table Which Form Ionic Bond:

Generally, the elements of group IA and IIA form ionic bond with the elements of group VIA and VIIA because IA and IIA elements have larger atomic sizes and low I.P therefore, they lose electrons easily while the elements of group VIA and VIIA have smaller atomic sizes and high values of electronegativity therefore, they gain electron easily.

Q.8: What is covalent bond? Describe its various types in detail.

Ans:Covalent Bond:

History:

G N. Lewis, an American chemist in 1916, introduced the concept of covalent bond.

Definition:

"A type of chemical bond which is formed by the mutual sharing of electrons between two atoms is called **covalent bond**."

The shared pair of electron is usually represented by a dash(-) between the bonded atoms.

Examples:

This type of bonding exists in many molecules like H_2, O_2, H_2O, CO, HCl, SO_2 etc.

In the formation of H_2 molecule, the two H atoms complete their valance shell with two electrons by sharing their one electron with each other, forming a covalent bond.

$$\dot{H} + \dot{H} \longrightarrow H{\cdot\cdot}H \text{ OR } H{-}H$$

Types Of Covalent Bond:

On the basis of shared pair of electrons between the two atoms the covalent bond is classified into the following types:

i. Single Covalent Bond:

"The type of covalent bond which is formed by the mutual sharing of two electrons (one pair) between the two atoms is called **single covalent bond**."

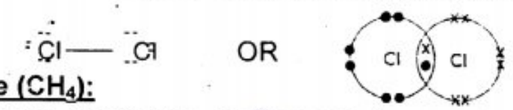
Representation:

Single covalent bond is represented by two dots or a single dash.

Examples:

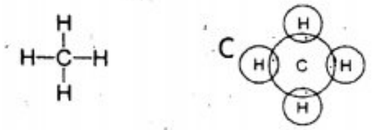
a. Chlorine (Cl_2):

Chlorine molecule has single covalent bond formed by two chlorine atoms. Both atoms have seven electrons in their valance shells (2,8,7). Therefore, they share their electrons with each other to complete their octet. Both atoms attain the electronic configuration of argon (2,8,8).



b. Methane (CH_4):

Methane molecule is formed from one carbon atom and four hydrogen atoms. Carbon has four valance electrons (2,4). Therefore, it shares its four electrons with four hydrogen atoms to complete its octet. Carbon attain the electronic configuration of neon (2,8) while hydrogen attains the electronic configuration of helium(2).



ii. Double Covalent Bond:

"The type of covalent bond that is formed by the mutual sharing of four electrons (two pairs of electrons) between the two atoms is known as double covalent bond."

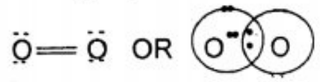
Representation:

Double covalent bond is represented by four dots or double dashes (=).

Examples:

a. Oxygen(O_2):

Oxygen molecule is formed by two oxygen atoms. Oxygen atom has six electrons in valance shell(2,6). Therefore, it shares two electrons with other oxygen atom to complete its octet. They attain the electronic configuration of neon(2,8).



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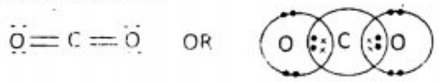
b. Carbon dioxide

Carbon dioxide molecule is formed from one carbon and two oxygen atoms. In this molecule the carbon atoms share all its four electrons with two oxygen atoms forming two double covalent bonds. Thus, it completes its octet.



Triple Covalent Bond:

"That type of covalent bond which is formed by the mutual sharing of six electrons (three pairs of electrons) between the two atoms is called **triple covalent bond**."

Representation:

Triple covalent bond is represented by six dots or three dashes (≡)

Examples:

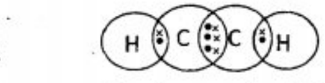
a. Nitrogen(N_2):

Nitrogen molecule is formed from two nitrogen atoms. They have five electrons in their valance shells(2,5). Therefore, they share three electrons with each other to form a triple covalent bond. Thus they attain the electronic configuration of neon (2,8).



b. Acetylene (C_2H_2):

Acetylene molecule is formed from two carbon and two hydrogen atoms. In this molecule the two carbon atoms form a triple covalent bond with each other and a single covalent bond with hydrogen atoms. The carbon atoms attain the electronic configuration of neon (2,8) while hydrogen atoms attain the electronic configuration of helium(2).



Q.9 Define and explain co-ordinate covalent bond?

Ans: Co-ordinate Covalent Bond Or Dative Bond:

"The covalent bond in which only one atom donates the shared pair of electrons is known as coordinate covalent bond or dative bond."

Explanation:

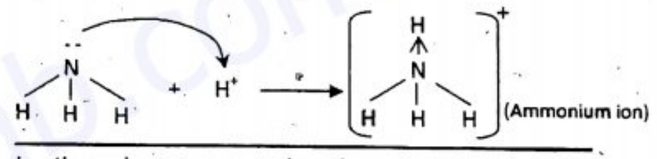
In the formation of co-ordinate covalent bond the atom which donates electron pair is known as donor atom while the atom which accepts it, is known as acceptor atom.Generally those atoms which have lone pairs of electron acts as donor atoms while electron deficient (کمی) species acts as acceptor atom. Co-ordinate covalent bond is just different from covalent bond in mode of formation and after formation it adopts the covalent character.

Representation:

Co-ordinate covalent bond is represented by an arrow, the head of which is towards the acceptor atom.

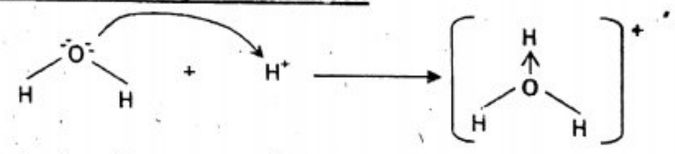
Examples:

1. Formation Of Ammonium Ion:



In the above example nitrogen of ammonia give a lone pair of electrons to H^+ ion forming a co-ordinate covalent bond. Thus, ammonium ion $(NH_4)^+$ is formed. In the ammonium ion nitrogen forms three covalent bonds while one co-ordinate covalent bond.

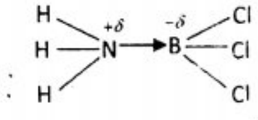
2. *Formation Of Hydronium Ion:



In the above example the oxygen of water give a lone pair of electrons to H^+ forming a co-ordinate covalent bond. As a result the positively charged hydronium ion is formed.

In the above example oxygen of water gives a lone pair of electrons to H^+ ion, forming a co-ordinate covalent bond.

3. Addition Compound Of NH_3 And BCl_3:



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In the above example nitrogen of ammonia has lone pair of electrons while boron of BCl_3 is short of two electrons to complete its octet. Therefore, nitrogen of ammonia gives a lone pair to boron of BCl_3, forming a co-ordinate covalent bond.

Q.10. What is meant by Lewis structure?

Ans: Lewis structure:

"The structure which represents the valance electrons of atoms or molecules by dots and crosses is called Lewis structure or dot and cross structure."

This structure was suggested by G.N. Lewis for covalent compounds. In this structure the valance electrons of atoms are written around the symbols of elements in dots or crosses. For shared pair of electrons, a dash or bar is used.

Examples:

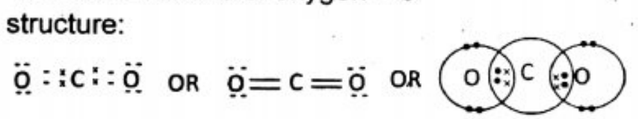
The Lewis structures of some molecules are given below:

a. Carbon Dioxide(CO_2):

valance electrons of carbon =4

valance electrons of oxygen = 6

Lewis structure:

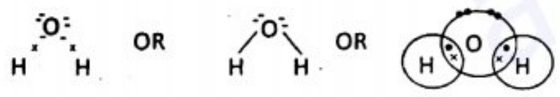


b. Water(H_2O):

valance electrons of carbon =4

valance electrons of oxygen = 6

Lewis structure:



Q.11 What is polar and non-polar covalent bond? Explain.

Ans: Polar covalent bond:

"A type of covalent bond which is formed between atoms of different elements is called **polar covalent bond**." **OR** "The type of covalent bond which is formed between atoms having different electronegativities is called polar covalent bond."

Explanation:

As two different bonded atoms have different values of electronegativity, so the shared pair of electron will be attracted more towards the more electronegative atom. This will produce a partial negative charge on the more electronegative atom and a partial positive charge on the other atom. A polar covalent bond is also called a dipole(meaning two poles i.e. positive and negative).

Examples:

The bond formed between hydrogen and chlorine atoms is polar because the shared pair of electron will be attracted more towards the more electronegative chlorine atom. This will produce a partial negative charge on the chlorine atom and a partial positive charge on hydrogen atom. Similarly, the bond between H and O in H_2O is also polar.



Polar covalent bonds in HCl and H_2O

Some other compounds which contain polar covalent bonds are H_2O, SO_2, and HF, HI etc.

Non-polar Covalent Bond:

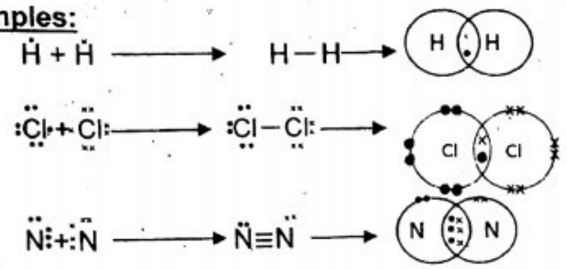
"A type of covalent bond which is formed between atoms of same element is called **non-polar covalent bond**."

OR "The type of covalent bond which is formed between atoms having same electronegativities is called non-polar covalent bond."

Explanation:

As two same bonded atoms have the same values of electro negativities, therefore, the shared pair of electron will be equally attracted by both the atoms. Therefore, no partial positive or negative charge will be produced on either end of the bond.

Examples:



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Q.10. Write a short note on metallic bond.

Ans. Metallic Bond:

"The force of attraction between sea of free valance electrons and positive ions of metals is called metallic bond".

Explanation:

Metals like iron, nickel, zinc show different properties from that of covalent or ionic compounds. They are lustrous, sonorous, malleable, ductile and good conductors of heat and electricity. This is due to the presence of metallic bonds in them.

Various theories have been put forward to explain metallic bond one of them is described below:

Electron Sea Model Or Electron Sea Theory:

Drude and Loven presented a theory of metallic bonding in 1923 called electron sea theory or electron sea model. According to this theory/model:

i. The valence electrons of a metal atom are not firmly held by the nucleus attractive force due to large size and low ionization potential values of metal atoms.
ii. The valence electrons are free from their respective atoms forming positive ions. These valance electrons do not belong to any individual ion but they belong to all the ions present in the metal.
iii. These electrons form a sea of electrons, which can move easily from one atom to the other.
iv. These free electrons bind the metal ions together which is called metallic bond.
v. Thus, the structure of metals consists of positive ions packed in sea of electrons.
vi. When an electric current is applied, the free electrons flow from one atom to the other. In this way, metals conduct electricity.

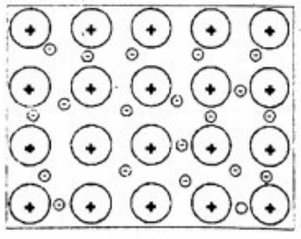


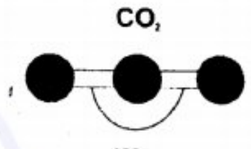
Figure: Metallic bond in sodium metal

Q.11 Write a note on shape of molecules.

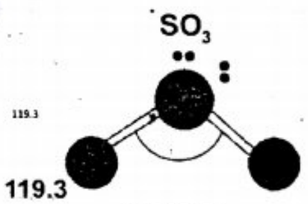
Ans: Shapes Of Molecules:

Molecules are very small which cannot be seen with naked eye however their shapes are determined by various experiments. The experiments have shown that the molecules may be linear, bent, tetrahedral, pyramidal and bipyramidal etc. For example CO_2 molecule has linear shape, water has a bent or angular shape, BCl_3 has triangular shape, CH_4 has tetrahedral shape, NH_3 has pyramidal shape and PCl_5 has bipyramidalshape.The shapes of some molecules are given below:

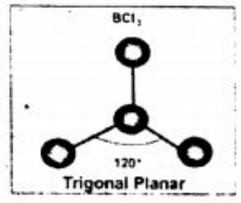
I. Carbon dioxide (CO_2):
It is linear in shape.



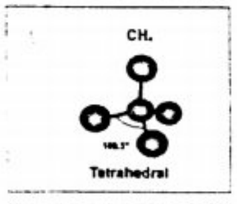
II. Sulphur dioxide (SO_2):
It has a bent shape.



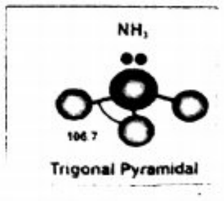
III. Boron trichloride (BCl_3):
It has trigonal planar shape.



IV. Methane (CH_4):
It has tetrahedral shape.



V. Ammonia (NH_3):
It has trigonal pyramidal shape.



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Q.12. Write a note on intermolecular forces?

Ans: Intermolecular Forces:

"The forces of attraction between the molecules of a substance are called intermolecular forces."

Explanation:

These forces are weaker forces of attraction. They are about 25 times weaker than a covalent bond. For example bond breaking energy of H-O bond is 464 $Kjmol^{-1}$ while the energy required to break intermolecular forces of water is 19Kjmol.

Intermolecular Forces In States Of Matter:

Solids have strongest intermolecular forces, gases have weakest intermolecular forces while in liquids they are stronger than gases but weaker than solids. The melting points and boiling points of a substance depends on these forces.

Types:

They are mainly of three types which are collectively called Vander Waal's force. i.e. dipole-dipole interactions, hydrogen bonding and London dispersion forces.

Q.13. Describe dipole-dipole interactions in detail.

Ans: Dipole-dipole Interactions/Forces:

Definition:

"The type of intermolecular forces in which the partial positive or negative end of one polar molecule attracts the partial negative or positive end of the other are called dipole- dipole interactions/forces."

Explanation:

A polar molecule is formed between different atoms which has two ends i.e. partial negative and partial positive ends. Therefore, they are also called dipoles. When these molecules are brought closer to each other the partial positive end of one molecule is attracted to the partial negative of the other. This force of attraction between polar molecules is called dipole-dipole attractions or dipole-dipole forces.

Example:

The molecule of hydrogen chloride(HCl) is polar. In this molecule hydrogen has partial positive charge while chlorine has partial negative charge. These molecules have forces of attraction among them which are dipole-dipole interactions/forces. In HCl, these forces of attraction are

relatively weak because they require only 3.3Kj/mol energy to break them. Due to weak forces HCl boils at -85.0 ^0C.

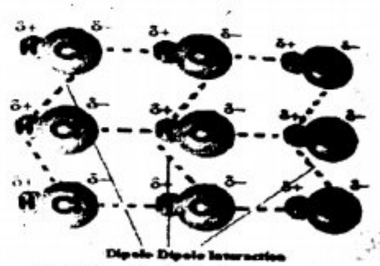

Fig. 4.19 Dipole-Dipole Interaction

Factors affecting dipole-dipole forces:

i. Intermolecular distances
ii. Electronegativity difference

Q.14 Write a note on hydrogen bonding.

Ans: Hydrogen Bonding:

Definition:

"When hydrogen is covalently bonded to F, O or N when they have lone pair of electrons, then a strong intermolecular force exist called hydrogen bonding."

Properties Of Hydrogen Bonding:

i. Strength comparison:

Hydrogen bonding is stronger than dipole-dipole forces but weaker than a covalent bond. It is about twenty times weaker than covalent bond and ten times stronger than dipole-dipole forces.

ii. Directional Bond:

Hydrogen bond is directional.

iii. Chain Formation:

This bond forms long chains and helps in the formation of network of molecules.

Examples:

Consider water(H_2O) in which the partial positively charged hydrogen atom attracts the partial negatively charged oxygen atom of another water molecule and forms hydrogen bond. Some other molecules having hydrogen bonding are HF, NH_3, CH_3OH etc.

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Q.15 Describe the applications of hydrogen bonding?

Ans: Applications Of Hydrogen Bonding:

Some of the applications of hydrogen bonding are given below.

i. Adhesive action of paints and dyes:

The adhesive action of substances like paint and dyes is due to hydrogen bonding.

ii. Existence Of Water In Liquid State:

The existence of water in liquid state is due to its strong hydrogen bonding otherwise it would be a gas.

iii. Structure Of Proteins And DNA:

The specific structures of DNA and proteins are due to hydrogen bonding.

iv. Sticking Action Of Synthetic Resins:

The synthetic resins bind two surfaces together by hydrogen bonding and dipole-dipole interactions.

Q.16. Describe the properties of ionic compounds.

Ans: Properties Of Ionic Compounds:

Ionic compounds are formed by strong electrostatic force of attraction between the ions. They have the following general properties:

i. **Physical State:**
All ionic compounds are solids at room temperature.

ii. **Crystalline state:**
Ionic compounds exist in crystalline states.

iii. **Ionization:**
Ionic compounds forms ions in aqueous solutions or in molten states. (یگھلیوئےحالت).

iv. **Non-directional Bond:**
Ionic compounds have non-directional bonds.

v. **Solubility:**
Ionic compounds are generally soluble in polar solvents like water, in which they dissociate into positive and negative ions.

vi. **Electrical Conductivity:**
In solid state ionic compounds are non-conductors of electricity while they conduct electricity in molten forms or in aqueous solutions.

vii. **Melting Points And Boiling Points:**
Ionic compounds have sharp and high melting points and boiling points.

viii. **Rate Of Reaction:**
The reactions of ionic compounds are very fast in solutions.

Q.17 Describe the properties of covalent compounds in detail.

Ans: Properties of covalent compounds:

Covalent compounds are also called molecular compounds.The properties of covalent compounds depend on:

i. intermolecular forces
ii. Shape of molecules
iii. Type of bond whether single, double or triple

Some general properties of covalent compounds are given below:

i. **Physical states:**

Covalent compounds exist in all the three states of matter i.e. solid, liquid and gas. For example, sugar and glucose are solids, water and alcohol are liquids while carbon dioxide and methane are gases.

ii. **Solubility:**

Non polar covalent compounds are generally more soluble in non-polar solvents like benzene, acetone etc. and less soluble in polar solvents like water, while polar covalent compounds are soluble in polar solvents like water.

iii. **Ionization:**

Certain covalent compounds dissociate into ions in water. For example, acids like HCl dissociates into H^+ and Cl^- ions. Similarly CH_3COOH, H_2SO_4, HF etc also dissociate into ions in water. However, there are many covalent compounds which do not form ions in water such as glucose ($C_5H_{12}O_6$), sugar ($C_{12}H_{22}O_{11}$), ethyl alcohol (C_2H_5OH) etc.

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Iv. Electrical conductivity:

Covalent compounds are non-conductors of electricity in their normal states.

However those covalent compounds which dissociates into ions in water are conductors of electricity. For example HCl, H_2SO_4, HBr etc.

v. Melting points and boiling points:

Most of the covalent compounds have low melting points and boiling points as compared to ionic compounds.

vi. Crystalline state:

Only solid covalent compounds can exist in crystalline state.

vii. Rate of reaction:

The reactions of covalent compounds are slower than ionic compounds.

Q.18 Describe the properties of metals in detail.

Ans: Properties of metals:

Metals contain a special type of bond called metallic bond. Due to metallic bond metals have the following properties:

i. **Physical state:**
At room temperature all the metals are solids except mercury which is liquid.

ii. **Electrical and thermal conductivity:**
All metals are good conductors of heat and electricity due to the presence of free valance electrons.

iii. **Metallic luster:**
Metals have shiny appearance called metallic luster.

iv. **Malleability:**
Metals are malleable (ورقپزیر) i.e. they can be drawn into sheets.

v. **Ductility:**
Metals are ductile (تارپزیر) i.e. they can be drawn into wires.

vi. **Sonorous:**
Metals are sonorous i.e. they produce a ringing sound when hammered.

EXERCISE

Multiple Choice Questions

Q.1. Choose the correct answer:

i. The bond which never result in compound formation is:
A) Ionic bond B) Covalent bond
C) Metallic bond D) Dative bond

ii. Identify that compound which is formed by three types of bonds:
A) Water B) Carbon dioxide
C) Sodium chloride **D) Ammonium chloride**

iii. Cation formation by the atoms results in:
A) Increase in size
B) Decrease in size
C) Decrease in number of protons
D) Increase in number of electrons

iv. Which pair of compounds ionizes completely in water?
A) NaCl and HCl B) NaBr and CO_2
C) NH_3 and HCl D) CH_3COOH and K_2CO_3

v. Which type of bond exists in HCl?
A) Purely ionic **B) Polar Covalent**
C) Covalent D) Co-ordinate covalent

vi. What geometrical shape NH_3 has?
A) Linear B) Triangular
C) Tetrahedral **D) Trigonal pyramidal**

vii. What happen to valance electron in metals?
A) Shared between atoms
B) Transferred between atoms
C) Pooled between atoms
D) None of the above

viii. Which one of the following is liquid:
A) Pt B) Au C)Ag **D)Hg**

ix. An atom with a charge is called _____:
A) An electron B) A molecule C) A metal **D) An ion**

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x. An element X belongs to group VI of the periodic table. Its ion will be represented by:
A) X^{+} B) X^{-} **C) X^{-2}** D) X^{+2}

xi. Which pair of elements join to form a compound with one to one ratio(1:1)?
A) Magnesium and chlorine B) Sodium and oxygen
C) Potassium and fluorine D) Lithium and sulphur

xii. When calcium atom becomes a calcium ion(Ca^{+2}) then:
A) It loses an electron **B) It loses two electrons**
C) It gains electron D) It gains two electrons

xiii. Which two elements will form covalent compound?
A) Sodium and oxygen B) Copper and oxygen
C) Carbon and oxygen D) Magnesium and oxygen

xiv. In the formation of an ionic bond, the atoms taking part:
A) Only gain electrons B) Only share electrons
C) Lose and gain electrons D) Only lose electrons

xv. Fluorine has an electronic configuration 2,7 and oxygen 2,6. The formula of fluorine oxide will be:
A) FO **B) F_2O** C) FO_2 D) F_2O_2

xvi. Which of the following statement about covalent bonds is incorrect?
A) HCl contains one pair of shared electrons
B) CCl_4 contains four pairs of shared electrons
C) H_2O contains three pairs of shared electrons
D) NH_3 contains three pairs of shared electrons

xvii. Which of the following ions do not have the electronic configuration of argon atom?
A) Ca^{+2} B) S^{-2} C) K^{+1} **D) O^{-2}**

xviii. Which one of the following group contains only ionic compounds?
A) Calcium oxide, hydrogen chloride, magnesium oxide
B) Calcium oxide, magnesium oxide, sodium chloride
C) Carbon dioxide, copper sulphate, hydrogen chloride
D) Copper sulphate, methane, sodium chloride

Short Questions

Q.2: Answer briefly the following questions:

i. What is electron sea model of metallic bonding?

Ans: See question no.10 along with diagram

ii. Why most atoms are chemically bonded to other atoms in nature?

Ans: See Question no. 1 (from second heading)

iii. Identify and define the four major types of chemical bonding?

Ans: Four Major Types Of Chemical Bonding:

The four major types of chemical bonding along with their definitions are given below:

1. Ionic bond or electrovalent bond:

"A type of chemical bond, which is formed by the complete transfer of electron/electrons from one atom to the other atom, is known as ionic bond. e.g. NaCl. Contains ionic bond

2. Covalent bond or molecular bond:

"A type of chemical bond which is formed by the mutual sharing of electrons between two atoms is called **covalent bond**." e.g. HCl Contains covalent bond

3. Co-oridnate covalent bond or dative bond:

"The covalent bond in which only one atom donates the shared pair of electrons is known as coordinate covalent bond or dative bond." e.g. NH_4^+ Contains dative bond

4. Metallic bond:

"The force of attraction between sea of free valance electrons and positive ions of metals is called metallic bond".
e.g. Fe contains metallic bond

iv. Arrange the following from strongest to weakest attraction?
a. covalent bond **b. dipole-dipole interactions**
c. hydrogen bond **d. ionic bond**

Ans: Strongest to weakest attraction order:
Ionic bond > Covalent bond > hydrogen bond>dipole-dipole interactions.

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v. Why ionic compounds are good electrolytes in molten or solution form not in solid state?

Ans: Reason for ionic compounds being good electrolytes in molten or solution forms:

Electrolytes are those substances which form free ions in solution or molten forms and conduct electric current. Since ionic compounds form free ions in aqueous solutions or in molten forms that is why they are good electrolytes in solution or molten forms. On the other hand they do not have free ions in solid states therefore; they are not electrolytes in solid states.

vi. What types of elements/atoms tend to form the following types of bonding:

a. Ionic b. covalent c. metallic

Ans: a. Element/atoms which form ionic bond:

Ionic bond is formed between a metal atom and non-metal atom.

Examples:

i. Na and Cl atoms form ionic bond (NaCl)
ii. Ca and F atoms form ionic bond (CaF_2) etc.

b. Elements/atoms which form covalent bond:

A covalent bond is formed between two non-metals.

Examples:

i. H and O(H_2O, H_2O_2)
ii. N and H(NH_3) etc.

c. Metallic bond:

Only metals can form metallic bond.

Examples:

Cu, Na, Fe etc. have metallic bond.

vii. Give example of a non-polar molecule with polar bonds. Give reasons.

Ans: A non-polar molecule with polar bonds:

CCl_4 is a non-polar molecule with polar bonds.

Reasons:

The individual bonds of CCl_4 are polar because of the difference in electronegativity of carbon and chlorine. Chlorine has partial negative and carbon has partial positive charge. But the overall molecule is non-polar because of the tetra-hedral geometry. All the individual dipoles are equal

and in opposite directions therefore, they cancel the effect of each other due to which the whole molecule is non-polar.

viii. Predict the bond type(ionic, polar covalent, non-polar covalent) in each of the following:

a. $CaCl_2$ b. H_2O c. CO_2 d. C_2H_4

Ans: Bond Type In Given Compounds:

a. $CaCl_2$:

In $CaCl_2$, the bond is ionic because Ca is metal and Cl is non-metal.

b. H_2O:

In H_2O, the bonds are polar covalent because it is formed between two non-metal atoms which have different electronegativities.

c. CO_2:

In CO_2, the individual bonds are polar covalent because it is formed between two non-metal atoms which have different electronegativities. However, the overall molecule is non-polar because the individual dipoles are same and they cancel the effect of each other due to its linear structure.

d. C_2H_4:

In C_2H_4, the bond is polar covalent because it is formed between two non-metal atoms which have different electronegativities. However, the overall molecule is non-polar because the individual dipoles are same and they cancel the effect of each other due to its trigonal planar structure.

ix. Ionic compounds are good conductors as compared to covalent compounds.

Ans: The answer of the given question is explained under the following headings:

Reason for ionic compound being good conductors as Compared to covalent compound:

Generally ionic compounds completely ionize in aqueous solutions or in molten state therefore, in aqueous solutions or in molten state they are good conductors of electricity due to the free movements of their ions.

Covalent compounds generally do not ionize in aqueous solutions or partially ionize in aqueous solutions. That is why ionic compounds are good conductors of electricity as compared to covalent compounds.

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For example:

Ionic compounds like NaCl, KCl, $MgCl_2$ etc are good conductors of electricity in aqueous solution or in molten form due the free movement of their ions while aqueous solutions of covalent compounds like sugar, kerosene oil, glucose etc. are non-conductors due to lack of ions.

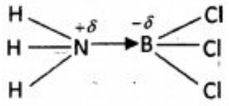
x. Dative/co-ordinate covalent bond is always polar.

Ans: The answer of the given question is explained under the following headings:

Reason for dative bond being always polar:

In co-ordinate covalent the shared pair of electrons is donated by only one atom which is called donor atom. The other atom which accepts it for sharing is called acceptor atom. The donor atom after giving electron develops a partial positive charge due shortage of electrons while a partial negative charge develops on the acceptor atom. That is why dative/co-ordinate covalent bond is always polar.

For example:



Long Questions

i. Describe octet rule in terms of noble gas electronic configurations and stability.

Ans: For answer see Question No. 2

ii. a. What is the main distinction between ionic and covalent bonds? Explain your answer with suitable examples.

Ans: Distinction between ionic and covalent bonds:

The main distinctions between ionic and covalent bonds are given below:

S.No	Ionic Bond	Covalent Bond
1	"It is the type of chemical bond which is formed by the complete transfer of electron/electrons from one atom to the other."	"It is a type of chemical bond which is formed by the mutual sharing of electrons between two atoms."

2.	During this bond formation, positive and negative ions are produced.	During this bond formation, no ions are produced.
3.	This bond is non-directional.	This bond is directional.
4.	Examples: i. The bond formed between Na and Cl in NaCl is ionic. ii. The bond formed between K and F in KF is also ionic etc.	Examples: i. The bond formed between H and O in H_2O is covalent. ii. The bond formed between C and O in CO is also covalent etc.

b. How is electronegativity used in determining the ionic or covalent character of the bonding between elements?

Ans: Use Of Electronegativity For Determination of Bond Type:

Generally if the electronegativitydifference of two atoms is more than 1.7, the bond is ionic but one atom must be metal.

Example:

E.N of Na = 0.9
E.N of Cl = 3
Difference = 3-0.9 = 2.1

Therefore Na and Cl form ionic bond.

However if the electronegativity difference of bonded atoms is less than 1.7, the bond will be covalent.

Example:

E.N of H = 2.1
E.N of O =3.5
Difference = 3.5-2.1= 1.4

Therefore, H and O form covalent bond.

If the difference is 1.7, then the bond will be 50% ionic and 50% covalent.

Example:

E.N of Si = 1.8

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E.N of O = 3.5

Difference = 3.5-1.8=1.7, Therefore, Si and O will form a bond having 50% ionic and 50% covalent character.

iii. Draw the Lewis structures for each of the following compounds.

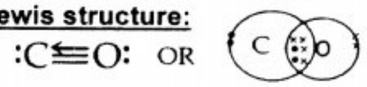
CO, HCl, SO_2, CCl_4, BF_3 and NH_3

Ans: **CO:**

Valance electrons of C = 4

Valance electrons of O = 6

Lewis structure:

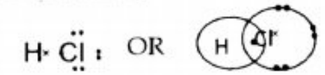


HCl:

Valance electrons of H = 1

Valance electrons of Cl = 7

Lewis structure:

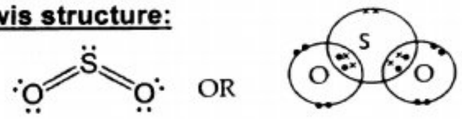


SO_2:

Valance electrons of S = 6

Valance electrons of O = 6

Lewis structure:

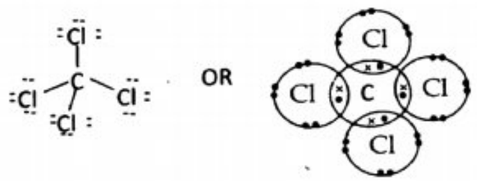


CCl_4:

Valance electrons of C = 4

Valance electrons of Cl = 7

Lewis structure:

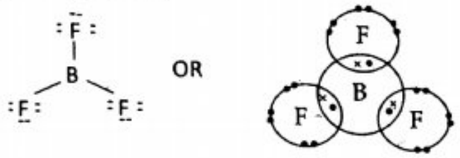


BF_3:

Valance electrons of B = 3

Valance electrons of F = 7

Lewis Structure:



NH_3:

Valance electrons of N = 5

Valance electrons of H = 1

Lewis structure:



iv. Explain why most metals are malleable and ductile but ionic crystals are not?

Ans: **Reason For Metals Being Malleable And Ductile:**

Metals have a special type of bond called metallic bond in which the electrons are delocalized. Since the atoms(positive ions) held by metallic bonding can roll over one another without breaking of bond. That is why metals are malleable and ductile.

Reason For Ionic Crystals Being Non-malleable And Non-ductile:

In ionic crystals there is a strong ionic bond which holds the ions tightly packed together. They cannot change their place that is why ionic crystals arenon-malleable and non-ductile.

v. a) What is the meaning of the term polar, as applied tochemical bonding?

Ans: **Meaning of term polar:**

This term is applied to that covalent bond which is formed between atoms having different electronegativities. Which is explained below?

Polar Covalent Bond:

"The type of covalent bond which is formed between atoms having different electronegativities is called polar covalent bond."

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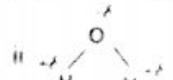
Explanation:

In this bond the more electronegative atom has a partial negative charge and the other atom has partial positive charge. A polar covalent bond is also called a dipole (meaning two poles i.e. positive and negative)

Examples:

i. $H^{+\delta}—Cl^{-\delta}$

ii. 

Some other compounds which contain polar covalent bonds are H_2O, SO_2 and HF, HI etc

b. Distinguish between polar covalent and non-polar covalent bonds?

Ans: Differences between polar and non-polar covalent bond:

The differences between polar and non-polar covalent bond are given in the table below

	Polar covalent bond	Non-polar covalent bond
(1)	The type of covalent bond which is fromed between atoms of different elements is called polar covalent bond	The type of covalent bond which is fromed by atoms of same element is called non-polar covalent bond
(2)	It has partial positive and partial negative ends	It has no partial positive or partial negative end
(3)	In this bond the shared pair of electron is not equally attracted by both atoms	In this bond the shared pair of electron is equally attracted by both atoms
(4)	Examples HCl, H_2O, HBr, CO etc have polar covalent bonds	Examples Cl_2, H_2, O_2, N_2 etc have non-polar covalent bonds

What is polarity?

Ans: Polarity:

"The property of a molecule having partial positive and partial negative charges is called polartiy"

Factors Affecting Polarity:

i) Electronegativity difference

ii) Molecular geometry

Examples:

Polarity is shown by many molecules like HCl, HF, HBr, H_2O, H_2S etc.

Some Important terms

Valance Electrons:

The electron/electrons present in the outermost shell is/are called valance electrons

Examples:

Carbon has 4 valance electrons

Oxygen has 6 valance electrons

Bonding Electrons:

The electrons which take part in chemical bond are called bonding electrons

Examples:

i. HCl has 1pair of bonding electrons.

ii. H_2O has 2 pairs of bonding electrons.

Lone pair of electrons or non-bonding electrons:

The pair of electrons which do not take part in chemical bond, is called lone pair of electrons or non-bonding electrons.

Example:

i. In HCl, chlorine has 3 lone pairs of electrons.

ii. In H_2O, oxygen has 2 lone pairs of electrons.

Valance shell:

The outermost shell of an atom is called valance shell.

Example:

Sodium has electronic configuration of

K=2, L=8, M=1

Therefore, its valance shell is M which contains one electron

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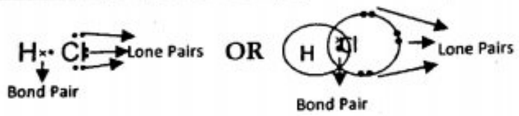
Examples

Example 4.1

Draw an electron dot and cross diagram for HCl. Label the single bond and lone pairs.

Ans: Dot and cross diagram of HCl:



Example 4.2:

Which of the following is (1) uncombined atoms (2) molecules (3) ions? O_2, Ne, NO_2, KCl, Na_2O, H_2, He, HCl, HgO

Ans: Prediction of species to be atoms, ions or molecules:

Two non-metal atoms form molecules, atoms with complete valance shells exist in uncombined atomic states while metal and non-metal atoms form ions.O_2 ,N_2O, H_2 and HCl are molecules because they are formed by non-metal atoms.Ne and He exist in uncombined atomic state because of complete valance shell.KCl, Na_2O and HgO exist in ionic state because they are formed by metal atoms with non-metal atoms.

Example 4.3

Identify common substances in and around your home and indicate whether you would expect these substances to contain ionic, covalent or metallic bonds.

Ans:Some Commons Substances with Bond Type:

i. Soap and detergents contain ionic as well as covalent bond
ii. Electric wires, nuts, metal utensils, keys, fans etc contain metallic bonds.
iii. Plastic made substances like cup, table, boards etc contain covalent bonds.
iv. Sugar, glucose etc contain covalent bonds.
v. Table salt contains ionic bond.

Example 4.4

Which of the following will form hydrogen bond?

HF, C_2H_2, HBr, NH_4^+ , H_2O, CH_3OH,NH_3

Ans. Hydrogen Bond:

"When hydrogen is covalently bonded with high electronegative atoms like N, F or O when they have lone pair of electrons, then a strong intermolecular force exist called hydrogen bonding."

Explanation Of The Given Species:

HF,H_2O, CH_3OH and NH_3will form hydrogen bonds because hydrogen is bonded with high electronegative atoms which have lone pairs of electrons.

C_2H_4 will not form hydrogen bonds because in this molecule hydrogen in not bonded with high electronegative atom.

HBr will not form hydrogen bond bonds because in this molecule hydrogen in not bonded with high electronegative atom.

NH_4^+ will not form hydrogen bond although hydrogen is bonded with high electronegative atom but it has no lone pairs of electrons.

Activity 4.1:

Classify the following as covalent or ionic:

CO_2, NaCl, H_2O, C_6H_6, $MgCl_2$ and HCl

Ans: Classification Of Given Compounds:

Ionic bond is formed between metal and non-metal atoms while covalent bond is formed between two non metal atoms. CO_2, H_2O, HCl and C_6H_6 are covalent compounds because they are formed by non-metal atoms.NaCl and $MgCl_2$ are ionic compounds because they are formed by metal atoms with non-metal atoms.

Activity:4.2

The first column in the table below lists some general properties of metals. Complete the second and third columns of the table?

General Property Of Metal	Correct Name For The Property	One use that depends on this property
Can be drawn into wires	Ductility	Metals are used in electric wires
Can be bent into shape	Malleability	Metals are used in making utensils.
Reflect light	Metallic Luster	Silver is used in mirrors.
Make a ringing sound when struck	Sonorous	Metals are used in bells.
Allow electricity to pass through	Electrical Conductivity	Metals are used in electric wires.
Heavy for their volume	High Density	Metals used in heavy machines.
Transfer heat well	Thermal Conductivity	Metals are used in cooking utensils.

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Test Yourself

i. a. In what ways atoms form ion?
b. Why do atoms form ions?
ii. Ionic bonds are formed between which types of elements?
iii. State formula for the ions formed by following atoms:
a. Calcium (2,8,8,8) **b. Fuorine (2,7)**
c. Lithium (2,1) **d. Oxygen(2,6)**
iv. Draw a diagram to show ionic bonds in magnesium oxide(MgO) and magnesium chloride ($MgCl_2$)?

Ansi(a):Ways in which atoms form ions:

There are two ways in which atoms form ions:

a. By loss of electrons, the atoms form cations.
b. By gain of electrons, the atoms form anions.

Examples:

a. Na +energy $\longrightarrow$ $Na^+ + 1e^-$ (Cation)

b. $Cl + 1e^- \longrightarrow Cl^-$ (Anion)

Ans i(b): Reason For Ion Formation By Atoms:

The atoms form ions in order to complete their valance shell and become stable like noble gases.

Examples:

Na +energy $\longrightarrow$ $Na^+ + 1e^-$
(2, 8, 1) $\longrightarrow$ (2, 8) Electronic configuration of neon
$Cl + 1e \longrightarrow Cl^-$
(2, 8, 7) $\longrightarrow$ (2, 8, 8) Electronic configuration of argon

Ans ii: Types Of Elements Which Form Ionic Bond:

Ionic bond is formed between a metal and non-metal atoms.

Example:

Sodium is metal and chlorine is non-metal therefore they form ionic bond.

$Na^+ + Cl^- \longrightarrow NaCl$

Ans iii. Formula For Ions of Given Atoms:

a. Ca(2,8,8,2):

Calcium has 2 electrons in its valance shell therefore, it loses these two electrons to complete its octet. Hence, formula for its ion is Ca^{+2}.

b. Fluorine (2,7):

Fluorine has seven electrons in its valance shell therefore, it gains one electron to complete its octet. Hence the formula for its ion is F^-.

c. Lithium (2,1):

Lithium has one electron in its valance shell therefore, it loses this electron to complete its duplet. Hence, the formula for its ion is Li^+.

d. Oxygen (2,6):

Oxygen has six electrons in its valance shell. Therefore, it gains two electrons to complete its octet. Hence the formula for its ion is O^{-2}.

Ans iv.

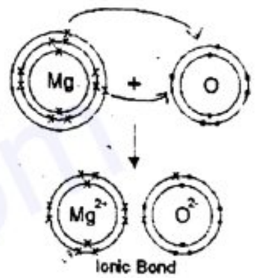

Figure:MgO

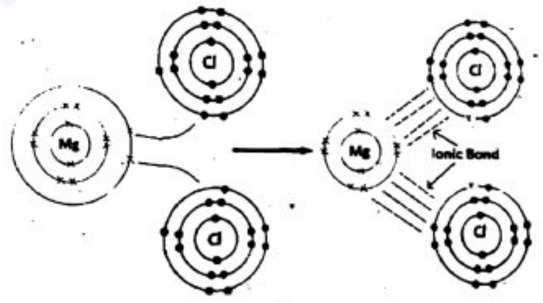

Figure:$MgCl_2$

v. a.Which group of the elements form covalent bond?
b.How is covalent bond formed between two atoms?
vi. How many electrons are shared in a
a. Single bond **b. Double bond**

Ans v (a)Group Of The Elements Which FormCovalent Bond:

Non-metal group i.e. group VIIA form covalent bond. However, they also form ionic bonds.

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Similarly covalent bond is formed between all non-metals when they react with each other.

Ansv(b)Formation Of Covalent Bond:

A covalent bond is formed between two atoms when they share their electrons with each other. This sharing may be:

i. A pair of electron between two atoms(Single covalent bond)
ii. Two pairs of electrons between two atoms(Double covalent bond)
iii. Three pairs of electrons between two atoms(Triple covalent bond)

Examples:

i. :Cl — Cl:

ii. O = O

iii. N ≡ N etc.

Ansvi(a) Electrons Shared In Single Bond:

In single covalent bond two electrons or one pair is mutually shared between two atoms.

Example:

:Cl — Cl:

Ansvi(b)Electrons Shared In Double Bond:

In single covalent bond four electrons or two pairs is mutually shared between two atoms.

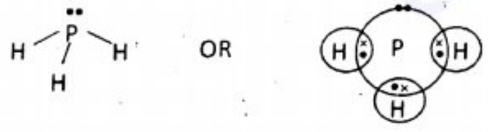
Example:

O = O

Phosphine(PH_3)

Valance electrons of P = 5
Valance electrons of H = 1

Lewis structure:



Chapter No.05
Physical State Of Matter

Q.1. Define gaseous state of matter. What are the typical properties of gases?

Ans. Gaseous state Of Matter:

"The state of matter in which the molecules are far away from each other having weakest intermolecular forces is called gaseous state of matter." **OR** "The state of matter having no definite shape and no definite volume is called gaseous state of matter."

Typical Properties Of Gases:

Gases have the following typical properties

i.Indefinite Volume:

Gases have no definite volume and they occupy(گھیرنا) all the available(مہیا)space.

ii. Indefinite Shape:

Gases have no definite shape and they take(لینا) the shape of the container.

iii.Pressure:

"The force exerted by gas molecules per unit area is called pressure."

Mathematically:

$P = F/A$

Its SI unit is N/m^2 which is also called Pascal

The molecules of gases are in constant motion therefore, they collide (ٹکرانا) with each other and with the wall of the container. The colliding of molecules with the walls of the container produces pressure. Thus, gases exert (ڈالنا) pressure at the container which increases with the temperature.

Example:

. Air is a gas and it exerts a pressure called atmospheric pressure. Normal atmospheric pressure is 760mm of Hg or 760 torr at sea level and 0^0C.

1 atm = 760 mm of Hg = 760torr
1atm = 101.325KPa = 1.01325×10^5 Pa

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iv. Compressibility And Expansion:

Gases can easily be compressed (دبانا) because their molecules are far apart from each other. Similarly, they expand (پھیلنا) if the pressure is decreased.

v. Mobility:

Molecules of gases are in constant motion and they move freely due to weakest intermolecular attractive forces.

vi. Diffusion:

"The spontaneous mixing of the molecules of one gas with another at a given temperature and pressure is called diffusion." OR

"The spreading of molecules of a substance from higher concentration to lower concentration is called diffusion."

As the molecules of gases are in constant motion therefore, when gases are released their molecules mix with each other until homogeneous mixture is formed thus, the process of diffusion occurs. Once the molecules are uniformly distributed then the diffusion stops.

Graham's Law:

Thomas Graham in 1833, stated that the rate of diffusion is inversely proportional to the mass of molecules. Greater the mass of molecules lesser will be the rate of diffusion and vice versa.

vii. Effusion:

The evolution (اخراج) of gas molecules one by one without collision, from a container, through a small pore of molecular size is called effusion.

Example:

For examples a balloon full of hydrogen gas, becomes empty due to effusion.

viii. Density:

Mass per unit volume of a substance is called density i.e. d =m/v. As there is a large distance among gas molecules therefore, their volume is greater and hence they have low densities as compared to the same amount of liquids or solids.

Example:

Density of oxygen in various states is:

Gaseous oxygen = 0.00142g/cm^3 at 0 ^{0}C and 1 atm.

Liquid oxygen = 1.149 g/cm^3 at -103 ^{0}C

Solid oxygen = 1.42 g/cm^3 at -252 ^{0}C.

ix. *Intermolecular Forces:

The intermolecular attractive forces of gases are negligible.

Q.2 State and explain Boyle's law OR Describe Boyle's law of gases.

Ans: Boyle's Law:

History:

This law was presented by an English scientist Robert Boyle in 1662. In this law he related volume to pressure at constant temperature.

Statement:

"This law states that the volume of a given mass of a gas is inversely proportional to its pressure at constant temperature."

Mathematical Form:

$$V \propto \frac{1}{P} \text{ (at constant temperature)}$$

$$\Rightarrow V = K_b \frac{1}{P} \text{ (Where } K_b \text{ is constant for Boyle's law)}$$

$$\Rightarrow PV = K_b$$

Boyle's law can also be stated as "For a given mass of a gas the product of pressure and volume remains constant at constant temperature."

This law can also be written as $P_1V_1 = P_2V_2$ = constant

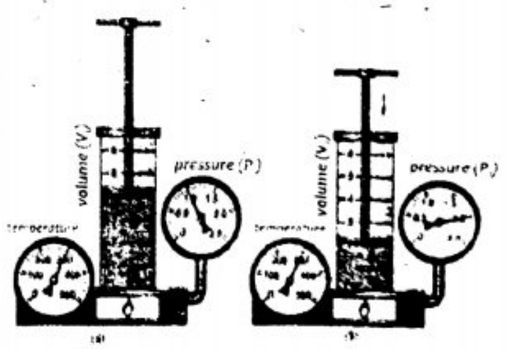
Where:

P_1 = initial pressure, P_2 = final pressure

V_1 = initial volume and V_2 = final volume

Experimental Verification:

A gas is taken in a cylinder having a movable frictionless piston. When the pressure is increased, the volume is decreased. The values of pressure and volume are noted. In each case the product of pressure and volume remain constant. i.e. $P_1V_1 = P_2V_2 = P_3V_3$ = constant



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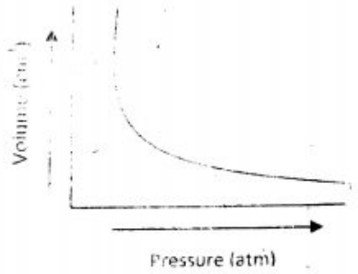
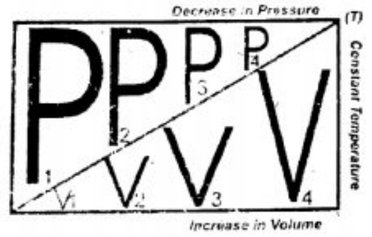
Graphic Representation:

If the values of pressure are plotted against volume on a graph, a curve line is obtained which shows that the volume is inversely proportional to pressure.



Diagrammatic Representation:



Q.3. Explain Charles's law of gases.

Ans: Charles's Law:

History:

This law was presented by a French chemist Jacques Charles in 1787. In this law he related temperature to volume at constant pressure.

Statement:

"This law states that the volume of a given mass of a gas is directly proportional to its absolute temperature at constant pressure."

Mathematical Form:

$V \propto T$ (at constant pressure)

$\Rightarrow V = K\,T$ (Where K is constant for Charles's law)

$$\Rightarrow \frac{V}{T} = K$$

It means that at constant pressure the ratio of volume to temperature remains constant.

Thus, this law can be written mathematically as:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} = \text{constant}$$

Where:

T_1 = initial temperature, T_2 = final temperature

V_1 = initial volume and V_2 = final volume

Experimental Verification:

The apparatus used for experimental verification of Charles's law consist of a cylinder with a movable piston. The sides of cylinder are heat insulators while the base is conductor. If the temperature is increased, then due to the increase in kinetic energies of molecules the piston will move upward and the volume increase. The values of T and V are noted. The ratio of volume to temperature remains constant this can be written mathematically as:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} = \text{constant}$$

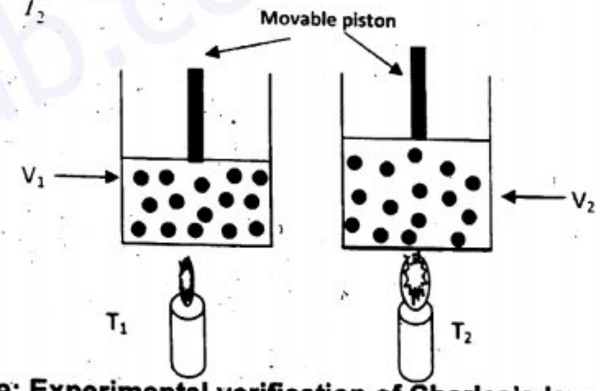
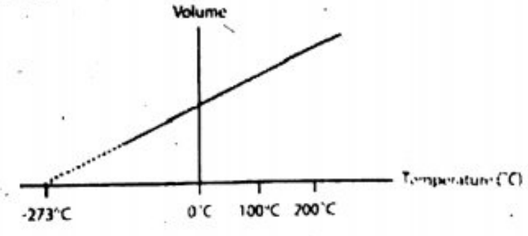


Figure: Experimental verification of Charles's law

Graphic Representation:

If the values of V are plotted against T on a graph, a straight line is obtained which shows that the volume is directly proportional to temperature.



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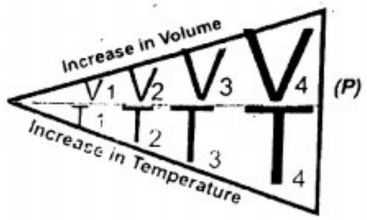
Diagrammatic Representation:



Q.4. Define liquid sate. What are the typical properties of liquids?

Ans: Liquid State:

"A state of matter having a definite volume but no definite shape is called liquid."

In liquids the intermolecular forces are strong enough to hold (پکڑنا) the molecules but not so strong to stop the motion of molecules. Therefore, liquids flow and take the shape of the container.

Typical properties Of Liquids:

Some typical properties of liquids are given below:

i. Volume And Shape:

Liquids have a definite volume but no definite shape and take the shape of the container.

ii. Mobility:

The molecules of liquids can flow due to weak intermolecular forces.

***iii.*Diffusion:**

Like gases liquids can also diffuse into each other. For example if we put a drop of ink in water it slowly diffuses into water until the whole water becomes coloured.

***iv.*Evaporation:**

"The spontaneous (خودبخود) change of liquid into gaseous state is called evaporation."

Explanation:

Evaporation in liquids occurs at all temperatures.

In a liquid the molecule with higher kinetic energy overcome intermolecular forces and they move upward. The temperature of remaining liquid falls. Therefore, evaporation causes cooling.

Factors Affecting Evaporation:

a) Intermolecular Forces:

Stronger the *intermolecular* forces of a liquid lower will be the rate of evaporation and vice versa.

Example:

Water has stronger intermolecular forces than petrol therefore it evaporates quickly than petrol

b) Surface Area:

Larger the surface area higher will be the rate of evaporation and vice versa.

c) Temperature:

Higher the temperature higher will be the rate of evaporation and vice versa.

v. Vapour pressure:

"The pressure exerted by the vapours above the liquid at a given temperature when the rate of evaporation becomes equal to the rate of condensation is called vapour pressure."

Explanation:

When a liquid is kept in a closed container, the molecules with higher kinetic energy go upward and start gathering(جمعہونا) above the surface this is called evaporation. Some of the vapours lose energy and come back into the liquid. This process is called condensation. The two processes continue until the rate of evaporation becomes equal to the rate of condensation and equilibrium is established.(قائمہونا). At this stage the pressure of the vapours is called vapour pressure.

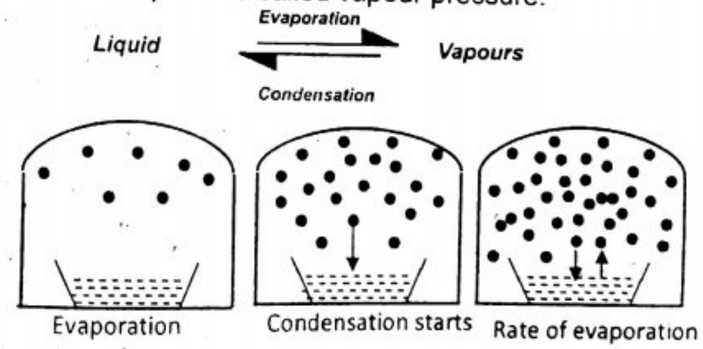


Figure: Vapour pressure

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Factors Affecting Vapour Pressure:

a) Temperature:

Vapour pressure increases with the increase of temperature because increasing the temperature of a liquid increases the kinetic energies of molecules which causes increase in vapour pressure.

b) Intermolecular Forces:

The strength of intermolecular forces is inversely proportional to vapour pressure.

Example:

Petrol has high vapour pressure than water because it has weaker intermolecular forces than water.

c) Size Of Molecules:

Small size molecules evaporate quickly than large size molecules. Therefore, small size molecules have high vapour pressure than large size molecules.

Example:

Pentane (C_5H_{12}) has small size molecule than decane ($C_{10}H_{22}$). Therefore pentane has high vapour pressure than decane.

d) Nature Of Liquids:

Vapour pressure also depends on nature of liquids. Polar liquids have high boiling points. Therefore, they have low vapour pressures. Similarly non-polar liquids have low boiling points, therefore, they have high vapour pressures.

Example:

Water is polar which has low vapour pressure than acetone which is non-polar.

Table: Vapour Pressure Of Some Compounds

Name of compound	Formula	Vapour pressure at 25°C or 298K in mm of Hg
Chloroform	$CHCl_3$	170
Carbon tetrachloride	CCl_4	87
Water	H_2O	18
Glycerol	$C_3H_8O_3$	0.00016

vi. Boiling Point:

"The temperature at which the vapour pressure of a liquid becomes equal to the external atmospheric pressure is called boiling point."

When a liquid is heated its vapour pressure increases gradually until it becomes equal to the atmospheric pressure, at this stage the liquid starts boiling and the temperature at this stage is called boiling point.

At the boiling the temperature of a liquid becomes constant because at this stage the heat supplied is used to overcome the intermolecular forces.

Factors Affecting Boiling Point:

a).Nature of the liquid(Intermolecular forces):

Boiling point depends on the nature of a liquid because different liquids have different strength of the intermolecular forces. If the intermolecular forces are strong then more energy will be required to break them to change the liquid into its vapours therefore, stronger the intermolecular forces of a liquid higher will be the boiling point and vice versa.

b). External Atmospheric Pressure:

Boiling point is directly proportional to atmospheric pressure. Pressure cookers work on this principle.

Example:

Boiling point of water at 760mm of Hg pressure is 100°C while its boiling point at 600mm of Hg pressure is about 94 °C.

vii. Freezing point:

"The temperature at which a liquid freezes is called its freezing point."

The freezing point and melting point of a liquid are the same.

Example:

For example water has a freezing point and melting point of 0°C.

Table:M.P and B.P Of Some Compounds:

	Solvent	Formula	Freezing Point(°C)	Boiling Point(°C)
1	Water	H_2O	0	100
2	Acetic acid	CH_3COOH	17	118.1
3	Benzene	C_6H_6	5.5	80.2
4	Phenol	C_6H_5OH	43	181
5	Chloroform	CH_3Cl	63.5	61.2
6	Ethanol	C_2H_5OH	-114.7	78.4

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Density:

Mass per unit volume of a substance is called density. Since liquid molecules are closer than gases therefore, they have high density than gases.

Q.5: Define solid state of matter. Describe the typical properties of solids.

Ans. Solid:

"A state of matter having a definite shape and volume is called solid "

In solids the particles are closely packed in a fixed pattern (طرز). The intermolecular forces are the strongest in solids due to which the molecules cannot move.

Typical Properties Of Solids:

The typical properties of solids are given below:

i. Volume And Shape:

Solids have a definite shape and a definite volume due to strongest intermolecular forces

ii. Rigidity:

The solids have the property of rigidity (سختپن) i.e. they resist the deforming force (تبدیلیلانےوالیقوت) due to strong intermolecular forces.

iii. Density:

Density is defined as "mass per unit volume of a substance is called its density." Mathematically d = m/V. As the molecules of solids are tightly packed therefore, they have less volume. Therefore, solids have greater density than gases or liquids.

***iv.* Melting Point:**

"The temperature at which a solid starts changing into liquid state is called melting point."

During melting of a solid the temperature remains constant until the whole solid is converted into liquid. Pure solids have fixed melting points and it can be used to check their purity.(خالصپن)

v. Molecular Motions:

The molecules of solids cannot move due to strongest intermolecular forces.

Q.6Describe the types of solids. Give examples.

Ans:Types Of Solids:

Depending upon the arrangement of particles, solids are of two types:

i. Crystalline solids ii. Amorphous solids

Their detail is given on next page:

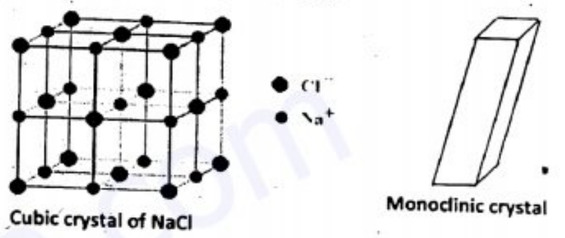
i. Crystalline Solids:

"The solids in which the atoms, ions or molecules are arranged in a definite pattern (خاصطرز،ترتیب) to form a three dimension geometrical shape is called crystalline solid."

They have definite faces. Each face has a definite angle with other faces. Pure crystalline solids have sharp melting points.

Examples:

Some examples of crystalline solids are sodium chloride, diamond, silver nitrate, sugar, copper sulphate etc.



Cubic crystal of NaCl Monoclinic crystal

Figure: Different patterns of crystals

ii. Amorphous Solids:

"The solids in which the particles are not arranged properly in three dimensions are called amorphous solids."

They do not have sharp melting points rather they melt over a range of temperature.

Examples:

Waxes, plastics, glass, rubber, butter, cotton, candy etc.

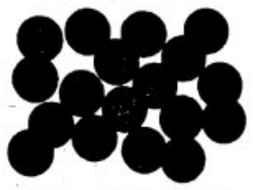


Figure: Particles of amorphous solids

Q.7 What is allotropy? Explain.

Ans: Allotropy:

"The existence of an element in more than one crystalline forms or physical forms, is called allotropy and the different forms are called allotropes."

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Reasons For Existence Of Allotropic Forms:

i. The allotropic forms exist due to existence of an element in more than one physical forms such as carbon exists in Kajal, soot, coal, charcoal etc.

ii. Allotropes also exist due to existence of an element in more than one molecular forms such as oxygen has two molecular forms oxygen(O_2) and ozone(O_3)

iii. Allotropes also exist due to arrangement of particles of an element in different crystalline forms. For example sulphur has two allotropes i.e. monoclinic sulphur and orthorhombic sulphur, due to different arrangement of molecules S_8 in crystal.

Explanation:

Allotropes of an element have same chemical properties but different physical properties.

The change in temperature of an allotrope, changes its particles arrangement and new allotrope is formed.

Transition Temperature:

The temperature at which two allotropic forms are in equilibrium with each other is called transition temperature.

Examples:

S_8 (orthorhombic) $\underset{}{\overset{95.5^\circ C}{\rightleftharpoons}}$ S_8 (monoclinic)

Grey tin (cubic) $\underset{}{\overset{13.2^\circ C}{\rightleftharpoons}}$ white tin (tetragonal)

Q.8 Write a note on the allotropes of carbon.

Ans: Allotropes Of Carbon:

Carbon exists in amorphous and crystalline allotropic forms they are discussed below:

i. Amorphous Allotropic Forms:

The amorphous allotropic forms of carbon are coal, coke, charcoal, lampblack, Kajal, soot etc.

ii. Crystalline Allotropic Forms:

Carbon exists in three crystalline allotropic forms which are diamond, graphite and bucky ball. Their detail is given below:

1. Diamond:

It is the hardest substance known. It is present in large amounts in Brazil and South Africa.

Structure Of Diamond:

In diamond each carbon atom is covalently bonded to four carbon atoms making a tetrahedral geometry. In turn, each carbon atom is covalently bonded to 4 other carbon atoms, thus the structure

extends(آگے جانا) in three dimensions making a interlocked(مضبوط) structure. As the covalent bonding in diamond is strong and the atoms occupy fixed positions. Therefore, diamond is hard. It is also non-conductor of electricity due to absence of free electrons.

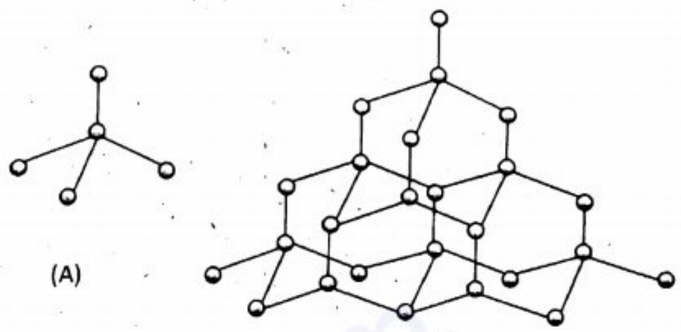

Figure: Structure of Diamond

Uses:

a. It is used as gem.(قیمتیپتھر)
b. It is used for cutting and boring purposes.
c. It is used in jewelleries.

2. Graphite:

It is a black and soft allotropic form of carbon. It is naturally found in mines in India, Brazil, and Mexico etc. It can also be prepared artificially.

Structure Of Graphite:

In graphite each carbon atom is covalently bonded to three other carbon atoms making a hexagonal structure. In turn, each carbon atom is attached to three other carbon atom making sheets. These sheets are bonded to each other through weak attractive forces. Therefore, they can slide over one another that is why graphite is soft. Furthermore, in graphite each carbon atom has one free electron due to which it is good conductor of electricity.

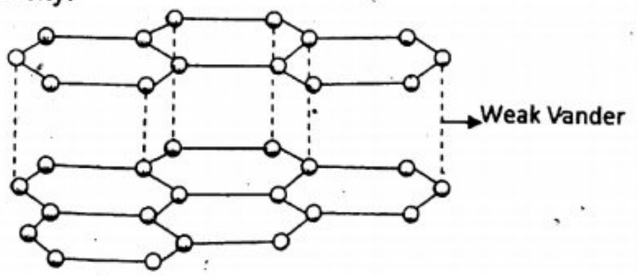

Figure: Structure of graphite

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Uses:

a. It is used as lubricant.
b. It is used as electrode.
c. It is used in lead pencils.

Bucky Ball:

It is a new allotropic form of carbon discovered in 1985 by a group of scientists. Its full name is Buckminster fullerene which is reduced to bucky ball.

Structure:

Bucky ball molecules contain 20 to 100 carbon atoms in which the most common is C_{60}. These atoms are arranged in hollow cage like structure called bucky balls. They assume the shape of a football in which the carbon atoms are linked to form hexagons and pentagons.

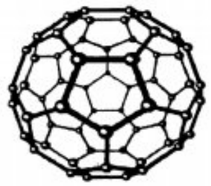

Figure: Bucky ball

Uses:

a. It is used as lubricant.
b. It is used as semiconductor.
c. It is used as superconductor.

Comparison Of Properties Of Solids, Liquids And Gases

S#	Properties	Solid	Liquids	Gases
1	Mass	Definite	Definite	Definite
2	Shape	Definite	Indefinite	Indefinite
3	Volume	Definite	Definite	Indefinite
4	Compressibility	Not possible	Almost negligible	Highly compressible
5	Fluidity	Not possible	Can flow	Can flow
6	Rigidity	Highly rigid	Less rigid	Not rigid
7	Diffusion	Almost impossible	Fast	Very fast
8	Space between particles	No space	A little space	Far away
9	Intermolecular forces	Strongest	Weaker than solids	Negligible

EXERCISE

Multiple Choice Questions

Q.1.Choose the correct answer:

i. The increase in the temperature of the gas decrease the:
A) Pressure B) Volume
C) Forces of attractions D) Kinetic energy

ii. Which is the pressure of the gas, if the volume of the gas at 2atm is increased from $1.5dm^3$ to $3dm^3$:
A) 1atm B) 1.5atm C) 2at D) 2.5atm

iii. Ink spreads in water because of:
A) Vapour pressure B) compressibility
C) Diffusion D) Dipole moment

iv. The vapour pressure of a liquid in a closed container depends upon:
A) Amount of the liquid B) surface area of the liquid
C) Temperature D) Both B and C

v. At higher altitude water boils:
A) At any temperature B) At 100 ^{0}C
C) Higher than 100 ^{0}C **D) lower than 100 ^{0}C**

vi. Evaporation takes place:
A) At all temperatures
B) Only at low temperature
C) When quantity of the liquid is more
D) When quantity of the liquid is less

vii. Water always boils when:
A)Its temperature is 150 ^{0}C
B)Atmospheric pressure is increased
C) Its vapour pressure becomes equal to atmospheric pressure
D) Its vapour pressure reaches zero

viii. The boiling point of a liquid increases if.
A) The amount of liquid decreases
B) The dimension of the container increases
C) The forces of attraction increase
D) More heat is provided

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ix. Glass is a solid which is:
A) Crystalline **B) Amorphous** C) Allotrope D) None

x. The crystalline forms of carbon exist in:
A) Rhombic, monoclinic B) Cubic, tetragonal
C) Cubic, hexagonal D) Rhombic, cubic

xi. The spontaneous mixing of particles is called ___
A) Evaporation B) Sublimation
C) Diffusion D) boiling

xii. Which statement for the particles of solids is not correct?
A) They move at great speed
B) They are arranged in definite pattern
C) There is very little space between the particles
D) The force of attraction between the particles is strong

xiii. A liquid boils when its vapour pressure becomes equal to:
A) 760cm of Hg B) 1Pascal
C) 101.325kilo Pascal D) 0.1 atom

xiv. The vapour pressure of a liquid increase with the increase of:
A) Pressure **B) Temperature**
C) Intermolecular forces D) Polarity of molecules

xv. Water normally boils at 100 ^{0}C but it is possible to boil at 50 ^{0}C, which variable would you have to change to do this:
A) Increase external pressure
B) Decrease external pressure
C) Increase surface area
D) Decrease surface area

xvi. Which one of the following is not an example of amorphous solid?
A) Rubber B) Glass **C) Glucose** D) Plastic

xvii. At freezing point which one of the following co-exist in dynamic equilibrium?
A) Gas and solid B) Liquid and gas
C) Liquid and solid D) All of these

Numerical Questions

Example 1.1:

A 530dm^3 sample of hydrogen gas was collected in a container of 800mm of Hg pressure. What volume the gas will occupy at 400mm of Hg pressure?

Given:

Initial volume = V_1= 530dm^3
Initial pressure = P_1 = 800mm of Hg
Final pressure = P_2 = 400mm of Hg

Required:

Final volume of hydrogen gas = V_2 =?

Solution:

According to Boyle's law:

$P_1V_1 = P_2V_2$

Therefore:

$$V_2 = \frac{P_1V_1}{P_2}$$

Putting the values:

$$V_2 = \frac{800mm \times 530dm^3}{400mm}$$

$\Rightarrow V_2$ = 1060dm^3

Result:

Final volume of hydrogen gas = V_2 = **1060dm^3**

Example 5.2:

3dm^3 of air is heated from 300K to 400K at constant pressure what is the volume of the gas at higher temperature?

Given:

Initial volume = V_1 = 3dm^3
Initial temperature = T_1 = 300K
Final temperature = T_2 = 400K

Required:

Final volume = V_2= ?

Solution:

According to Charles's law:

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$$\frac{V_1}{T_1}=\frac{V_2}{T_2}$$

Therefore:

$$V_2=\frac{V_1\times T_2}{T_1}$$

Putting the values:

$$V_2=\frac{3dm^3\times 400K}{300K}\Rightarrow V_2 = \mathbf{4dm^3}$$

Result:

Final volume = V_2 = **$4dm^3$**

i. Calculate the final pressure of a sample of gas that is changed at constant temperature from $7.55dm^3$ to $14.3dm^3$ at 828 torr.

Given:

Initial volume = V_1 = 7.55 dm^3

Final volume = V_2 = 14.3 dm^3

Initial pressure = P_1 = 828 torr

Required:

Final pressure = P_2= ?

Solution:

According to Boyle's law:

$P_1V_1 = P_2V_2$

Therefore:

$$P_2=\frac{P_1V_1}{V_2}$$

Putting the values:

$$P_2=\frac{828torr\times 7.55dm^3}{14.3dm^3}$$

$\Rightarrow P_2$ = **437.160 torr**

Result:

Final pressure (Pz) = **437.160 torr**

ii. Calculate the final volume at 302K, of a $5.41dm^3$ sample of a gas originally at 353K, if the pressure does not change?

Given:

Initial temperature = T_1 = 353K

Final temperature = T_2 = 302K

Initial volume = V_1 = 5.41 dm^3

Required:

Final volume = V_2= ?

Solution:

According to Charles's law:

$$\frac{V_1}{T_1}=\frac{V_2}{T_2}$$

Therefore:

$$V_2=\frac{V_1\times T_2}{T_1}$$

Putting the values:

$$V_2=\frac{5.41dm^3\times 302K}{353K}$$

$\Rightarrow V_2 = \mathbf{4.628dm^3}$

Result:

Final volume = V_2 = **$4.628dm^3$**

iii. Calculate the initial volume at 0^0C of a sample of a gas that is changed to $731cm^3$ by cooling to -14^0C at constant pressure?

Given:

Initial temperature = T_1 = $0\ ^0$C
= 0 + 273
= 273K

Final temperature = T_2 = -14^0C
= -14 + 273
= 259K

Final volume = V_2 = 731 cm^3

Required:

Initial volume = V_1 = ?

Solution:

According to Charles's law:

$$\frac{V_1}{T_1}=\frac{V_2}{T_2}$$

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Therefore:

$$V_1 = \frac{V_2 \times T_1}{T_2}$$

Putting the values:

$$V_1 = \frac{731 cm^3 \times 273 K}{259 K}$$

$\Rightarrow V_1 = \mathbf{770.513\ cm^3}$

Result:

Initial volume = V_1 = **770.513 cm^3**

iv. A sample of a gas at room temperature occupies 0.80dm^3 at 1.5atm. What will be the volume of the gas if the pressure of the gas is increased to 2.1atm?

Given:

Initial volume = V_1 = 0.80 dm^3

Initial pressure = P_1 = 1.5 atm

Final pressure = P_2 = 2.1atm

Required:

Final volume of hydrogen gas = V_2 =?

Solution:

According to Boyle's law:

$P_1V_1 = P_2V_2$

Therefore:

$$V_2 = \frac{P_1V_1}{P_2}$$

Putting the values:

$$V_2 = \frac{1.5 atm \times 0.80 dm^3}{2.1 atm}$$

$\Rightarrow V_2 = \mathbf{0.571 dm^3}$

Result:

Final volume (V_2) = **0.571dm^3**

v. Calculate the final volume of 319 ^{0}C of a sample of a gas originally 5.13dm^3 at 171^{0}C, if the pressure does not change?

Given:

Initial temperature = T_1 = 171 ^{0}C

= 171 + 273

= 444 K

Final temperature = T_2 = 319 ^{0}C

= 319 + 273

= 592K

Initial volume = V_1 = 5.13 dm^3

Required:

Final volume = V_2=?

Solution:

According to Charles's law:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Therefore:

$$V_2 = \frac{V_1 \times T_2}{T_1}$$

Putting the values:

$$V_2 = \frac{5.13 dm^3 \times 592 K}{444 K}$$

$\Rightarrow V_2 = \mathbf{6.84\ dm^3}$

Result:

Final volume = V_2 =**6.84dm^3**

vi. A 1.54dm^3 cylinder in a chemistry laboratory contains oxygen gas at 21 ^{0}C. The air conditioning in the laboratory breaks down and the temperature rises to 31 ^{0}C.What will be the volume of oxygen in the cylinder now?

Given:

Initial volume = V_1 = 1.54dm^3

Initial temperature = T_1 = 21 ^{0}C = 21 ^{0}C + 273 = 294 K

Final temperature = T_2 = 31 ^{0}C = 31 + 273 = 304 K

Required:

Final volume = V_2=?

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Solution:

According to Charles's law:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad \Rightarrow V_2 = \frac{V_1 \times T_2}{T_1}$$

Putting the values:

$$V_2 = \frac{1.54 dm^3 \times 304 K}{294 K}$$

$\Rightarrow V_2 = \mathbf{1.59 dm^3}$

Result:

Final volume = V_2 = **1.59dm^3**

Practice Problem 5.1:

Calculate the initial volume of a sample of gas at 1.20atm. If its volume is changed to 70.4cm^3 as it pressure is changed to 3 atm at constant temperature?

Given:

Initial pressure = P_1 = 1.2 atm

Final pressure = P_2 = 3 atm

Final volume = V_2 = 70.4 cm^3

Required:

Initial volume = V_1 = ?

Solution:

According to Boyle's law:

$P_1V_1 = P_2V_2$

Therefore:

$$V_1 = \frac{P_2V_2}{P_1}$$

Putting the values:

$$V_1 = \frac{3 atm \times 70.4 dm^3}{1.2 atm}$$

$\Rightarrow V_1 = \mathbf{176\ cm^3}$

Result:

Initial volume (V_1) = 176cm^3

Short Questions

i. Can you give reason why it takes longer to cook at high altitude?

Ans: The answer of this question is explained under the following heading:

Reason For Cooking, To Take Long Time At High Altitudes:

Cooking is usually done in water which has a boiling point of 100 °C. The boiling point is directly proportional to external atmospheric pressure. At high altitudes the external atmospheric pressure becomes lower therefore, at high altitudes the water boils below 100 °C due to which the heat is lost in the form of vapours because at boiling the heat supplied is used to convert the molecules of liquid to gaseous state. That is why it takes long time to cook at high altitudes.

ii. Glass softens over a wide range of temperature. Ice melts at a specific temperature. Explain the reason for this difference?

Ans: The answer of this question is explained under the following two headings:

i. Reason For Glass To Soften Over A Range Of Temperature:

Amorphous solids melt over a range of temperature due to no proper arrangement of particles. Since, glass is an amorphous solid therefore, it melts or softens over a range temperature.

ii. Reason For Ice To Melt At A Specific Temperature:

Crystalline solids melt at a specific temperature due to proper arrangement of particles. Since, ice is a crystalline solid therefore it melts at a specific temperature.

iii. Explain why it happens that on a hot summer day, when there is sweat on the body of a person, one feel cool under a fast moving fan.

Ans: The answer of the given question is explained under the following heading:

Reason For Feeling Cool Under a fan, When There is Sweating:

In hot summer when sweat comes on the body then it starts changing into vapours, during this process it takes the heat of the body. The fast moving fan increases the rate of evaporation which takes the heat of the body more quickly and thus the body becomes cool that is why in a hot

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summer days, when there is sweat on the body of a person, he feels cool under fast moving fan.

iv. Why are the densities of gases lower than that of liquids?

Ans: The answer of the given question is explained under the following heading:

Reason For Gases Having Low Densities Than Liquids:

Mass per unit volume of a substance is called density. Mathematically:

Density = m/v

It is clear from the above equation that density is inversely proportional to volume. Same amount of gases occupy large volume than liquids, because the gas molecules are far away from each other. That is why gases have low densities than liquids.

Example:

Density of oxygen gas = 0.00142 g/cm^3

Density of liquid oxygen = 1.149g/cm^3

v. What is the relationship between atmospheric pressure and boiling point of a liquid?

Ans: Relationship Between Atmospheric Pressure And Boiling Point:

Atmospheric pressure is directly proportional to boiling point of a liquid i.e. greater the atmospheric pressure greater will be the boiling point and vice versa.

Example:

Boiling point of water at 760mm of Hg pressure is 100^{0}C. While its boiling point at 600mm of Hg pressure is about 94 ^{0}C.

vi. Why a gas can be compressed but a solid cannot?

Ans: The answer of the given question is explained under the following headings:

Reason For A Gas Being Compressible:

In gases the molecules are far apart from each other having large empty spaces therefore, a gas can easily be compressed.

Reason For A Solid Not Being Compressible:

In solids the molecules are tightly packed together having no space between them therefore, a solid cannot be compressed.

Long Questions

i. Define Boyle's law and verify it experimentally?

Ans: See Question no.2

ii. Differentiate between

a. Evaporation and boiling

b. Effusion and diffusion of gases

c. condensation and evaporation

Ans(a) Difference between evaporation and boiling:

	Evaporation	Boiling
1	"The spontaneous change of liquid into gaseous state at any temperature is called evaporation."	"The conversion(تبدیلی) of liquid state into gaseous state at the boiling point is called boiling."
2	Evaporation occurs at all temperatures.	Boiling occur only at that temperature when vapour pressure of the liquid becomes equals to the atmospheric pressure.(Boiling point)
3	For evaporation there is no specific value of temperature.	At boiling there is a definite value of temperature which is called boiling point.
4	Evaporation can occur without external heating.	Boiling occurs with external heating.

Ans(b) Differences Between Diffusion And Effusion:

	Diffusion	Effusion
1	"The spontaneous mixing of the molecules of one gas with another at a given temperature and pressure is called diffusion."	The evolution(اخراج) of a gas molecules one by one from a container, through a small pore of molecular size is called effusion
2	Diffusion occurs in different gases.	Effusion occurs in a single gas.
3	It occurs with the collision of molecules.	It occurs without the collision of molecules.
4	For example if a perfume is sprayed at one corner of the room very soon it will be smelled at the other corner due to the process of diffusion.	For examples a balloon full of hydrogen gas, becomes empty due to effusion.

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Ans(c) Differences Between Evaporation And Condensation:

	Evaporation	Condensation
1	"The spontaneous change of a liquid into gas is called evaporation."	"The change of gas into liquid is called condensation."
2	During evaporation the molecules absorb energy	During condensation the molecules lose energy
3	During evaporation the intermolecular forces are broken.	During condensation the intermolecular forces are formed.
4	For example wet clothes become dry due to evaporation.	For example fog is formed due to condensation.

iii. Define the term allotropy with examples. Explain the three allotropes of carbon.

Ans: Allotropy:

"The existence of an element in more than one crystalline or physical forms is called allotropy and the different forms are called allotropes."

Examples:

In periodic table carbon, sulphur, oxygen, phosphorus, tin etc show the phenomenon of allotropy.

i. Allotropes of sulphur are monoclinic sulphur and orthorhombic sulphur.
ii. Allotropes of tin are grey tin and white tin etc.

Three Allotropes Of Carbon:

See Question no.8 from crystalline allotropes.

iv. What are solids? Differentiate between amorphous and crystalline solids?

Ans: Solids:

"A state of matter having a definite shape and volume is called solid."

In solids the particles are closely packed in a fixed pattern (طرز). The intermolecular forces are the strongest in solids due to which the molecules cannot move.

Examples:

Carbon, silver, gold, NaCl, sugar etc are the examples of solids.

Differences between amorphous and crystalline solids:

Write Question no.6 in tabular form

v. Define Charles's law and verify it graphically and diagrammatically.

Ans: For answer see Question no.3

Chapter No.06
Solution

Q.1.What is meant by solution? Explain it?

Ans. Solution:

"A homogeneous mixture of two or more than two substances is called **solution**."

Explanation:

i. A homogeneous mixture means that its composition is uniform(یکساں) throughout.(ہر جگہ)
ii. A solution is made of two components(اجزاء) i.e. solvent and solute which are defined below:

Solvent

"The substance which dissolves (حل کرنا) other substances in it or the substance which is present in larger amount in solution is called solvent."

Solute:

"The substance which dissolves or the substance which is present in smaller amount in a solution is known as solute."

iii. The solute particles of a solution cannot be seen with or without the help of microscope.
iv. The solute particles do not settle down at the bottom if it is left undisturbed.
v. The solute particles of a solution pass through filter paper during filtration.

Example:

i. Sugar in water(solute= sugar, solvent = water)
ii. NaCl in water (solute = NaCl, solvent = water)
iii. Naphthalene in benzene (solute = naphthalene, solvent = benzene) etc.

Q.2 Explain the following terms with examples:

i. **Aqueous solutions**
ii. **Non aqueous solutions**

Ans: i. Aqueous Solutions:

"The solution in which water is used as a solvent is called aqueous solutions."

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Examples:

i. Sugar in water
ii. Glucose in water etc.

ii. Non-aqueous Solutions:

"The solution which contains a solvent other than water is called non-aqueous solution".

Examples:

i. Naphthalene(کافور) in benzene.(بنزین ایک مائع ہے)
ii. Wax in benzene etc.

Q.3. Define and explain the following terms:

i. **Unsaturated solution**
ii. **Saturated solution**
iii. **Supersaturated solution.**

Ans:i. Unsaturated Solution:

Definition:

"The type of solution which can dissolve more solute at a given temperature is called unsaturated solution."

Explanation:

When a small amount of a solute is added to a solvent, at constant temperature, it begins to dissolve. We can dissolve more solute in it with constant stirring which will raise the concentration of solute in the solution. Such a solution which has the capacity to dissolve more solute is called unsaturated solution.

ii. Saturated Solution:

Definition:

"The type of solution which cannot dissolve more solute at a given temperature is known as saturated solution."

Explanation:

If a solute is added to an unsaturated solution at constant temperature, it begins to dissolve. If we keep on adding more and more solute by constant stirring, a stage will reach when no more solute will be dissolved and the excess (زیادہ مقدار) solute will settle down at the bottom of the container. At this stage if more solute is added, it will not be dissolved; such a solution is called saturated solution.

iii. Supersaturated Solution:

Definition:

"That type of solution which has more amount of solute than a saturated solution at a given temperature is called supersaturated solution."

Explanation:

Supersaturated solutions are formed by heating saturated solutions, dissolving more solutes and then cooling them to room temperature. Such a solution is unstable and the excess solute will settle down at the bottom of the container if a small solute particle (seed) is added to it. This process is called seeding.

Very soluble salts like sodium thiosulphate ($Na_2S_2O_3$), sodium acetate (CH_3COONa) and sodium sulphate (Na_2SO_4) etc easily form supersaturated solutions.

Q.4: How will you experimentally determine that the given solution is unsaturated, saturated or supersaturated?

Ans: To determine whether the given solution is unsaturated, saturated or supersaturated, add a few crystals of the solute to the solution:

i. If the solute dissolves then the solution is unsaturated.
ii. If the solute does not dissolve then the solution is saturated.
iii. If the addition of solute causes crystallization then the solution is supersaturated.

Q.5: What are dilute and concentrated solutions?

Ans: Dilute Solution:

"The solution containing less amount of solute as compared to other solution is called dilute solution."

Example:

For example a solution of sugar containing 20g of sugar in 100ml of water is dilute as compared to the solution containing 30g of sugar in 100ml of water.

Concentrated Solution:

"The solution containing more amount of solute as compared to other solution is called concentrated solution."

Example:

For example a solution of sugar containing 30g of sugar in 100ml of water is concentrated as compared to the solution containing 20g of sugar in 100ml of water.

Q.6: What are binary solutions?

Ans: Binary Solutions:

"The solutions consisting of two components are called binary solutions."

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Examples:

Sugar dissolved in water, NaCl dissolved in water, wax dissolved in benzene etc.

Q.7: Explain the different types of solutions on the basis of state of solvent.

Ans: Different Types Of Solutions:

On the basis of states of matter, solutions are of nine types which are given in the table below:

Solution Type	Solution	Example	Solute	Solvent
Gas Solutions	i. Gas in gas	Air(gas)	Oxygen(gas)	Nitrogen(gas)
	ii. Gas in liquid	Carbonated drinks	CO_2(gas)	Water(liquid)
	iii. Gas in solid	Hydrogen adsorbed in palladium	hydrogen(gas)	Palladium(solid)
Liquid Solutions	i. Liquid in gas	Fog	Water vapours (liquid)	Air(gas)
	ii. Liquid in liquid	Alcohol in water	Alcohol(liquid)	Water(liquid)
	iii. Liquid in solid	Dental amalgam	Mercury(liquid)	Silver(solid)
Solid Solutions	i. Solid in gas	Smoke	Carbon particles(solid)	Air (gas)
	ii. Solid in liquid	Sea water	NaCl (solid)	Water(liquid)
	iii. Solid in solid	Brass	Zinc(solid)	Copper(Solid)

- Sterling silver is solid in solid solution having 92.5% silver and 7.5% copper.
- Bronze is also solid in solid solution made from copper (92%) and tin (8%)

Q.8: What is meant by concentration? Explain it.

Ans: Concentration:

"The amount of solute dissolved in a specified (خاص) amount of solution / solvent is known as concentration or strength of the solution."

Explanation:

For example if we dissolve some salt in water, then the amount of salt that we have dissolved in water is the concentration of the solution.

Mathematically:

$$\text{Concentration} = \frac{Amount\ of\ solute}{Amount\ of\ solution\ or\ solvent}$$

Different names of solutions on the basis of concentration:

A solution having high concentration of solute is called concentrated solution while a solution containing low concentration of solute is called dilute solution.

A solution of known concentration is called standard solution.

Units of Concentration:

In chemistry there are various units of concentration for example percentage composition (W/W%, V/W%, W/V%, V/V %), molarity etc.

Q.9: How the percentage composition of a solution is expressed?

Ans: Percentage composition of a solution:

"A method of expressing concentration which shows the relative amount of solute in 100g or 100mLof a solution is called percentage composition." The percentage composition of a solution is expressed in 4 different ways which are given below:

1. Mass-mass Percentage (m/m %):

"The mass in grams of solute present in 100 grams of the solution is called mass-mass percentage (m/m %)."

Mathematically:

$$m/m\% = \frac{mass\ of\ solute\ in\ grams}{mass\ of\ solution\ in\ grams} \times 100$$

Example:

A 7% m/m solution means that 7g of solute are dissolved in 93g of solvent to make 100g of the solution.

2. Mass-volume Percentage (m/V %):

"The mass in grams of the solute present in 100 mL of the solution is known as mass-volume percentage (m/V %)."

Mathematically:

$$m/V\% = \frac{mass\ of\ solute\ in\ grams}{Volume\ of\ solution\ in\ mL} \times 100$$

Example:

A 7% m/V solution means that 7g of the solute are dissolved in enough solvent to make 100 mL of the solution.

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3. Volume-mass Percentage (V/m %):

"The volume in mL of the solute present in 100g of the solution is known as volume-mass percentage (V/m %)."

Mathematically:

$$V/m\% = \frac{Volume\ of\ solute\ in\ mL}{mass\ of\ solution\ in\ grams} \times 100$$

Example:

A 7% V/m solution mean that 7 mL of the solute are dissolved in enough (کافی) solvent to make 100g of the solution.

4. Volume-volume percentage (V/V %):

"The volume in mL ofthe solute present in 100 mL of the solution is known as volume-volume percentage (V/V %)."

Mathematically:

$$V/V\% = \frac{Volume\ of\ Solute\ in\ mL}{Volume\ of\ Solution\ in\ mL} \times 100$$

Example:

A 5% V/V solution means 5mL of solute are dissolved in 95 mL of solvent to make 100 mL of the solution.

Q.10: Define and explain molarity with example.

Ans: Molarity:

"The number of moles of the solute present in one dm^3 or one litre of the solution is known as **Molarity**."

Denotation:

Molarity is denoted by M.

Unit:

Its unit is mol/dm^3 or mol/L.

Mathematically:

$$Molarity = \frac{No.\ of\ moles\ of\ solute}{Volume\ of\ solution\ in\ litre}$$

As we know that:

$$Number\ of\ moles = \frac{Mass\ in\ g}{Molar\ mass}$$

Therefore, molarity can also be written as:

$$Molarity = \frac{Mass\ in\ grams\ of\ solute}{Molar\ mass \times volume\ of\ solution\ in\ dm^3\ or\ litre}$$

Example:

1molar NaOH solution contains 1mole (40g) of NaOH in one litre or dm^3 of the solution.

Q.11: What is meant by solubility? What are the different factors that affect the solubility?

Ans: Solubility:

"The maximum amount of solute (in grams) required to saturate 100 grams of the solvent at a given temperature is called **solubility**".

Generally when saturated solution is formed then the amount of solute dissolved in it is called solubility.

Mathematically:

$$Solubility = \frac{mass\ of\ solute\ in\ grams}{mass\ of\ solvent\ in\ grams} \times 100$$

Factors affecting solubility:

Following are the main factors which affect the solubility of substances:

1. **Nature of solvent**
2. **Nature of solute**
3. **Temperature**
4. **Pressure**

Their detail is given below:

1. Nature Of Solvent:

If the structure and properties of solute is similar to the solvent then the solubility will be more because "like dissolve like" It means that polar solutes dissolve in polar solvents and non-polar solutes dissolve in non-polar solvents.

Examples:

Sugar (a polar solute) has greater solubility in polar solvent like water and low solubility in non-polar solvent like benzene. Similarly, naphthalene (a non-polar solute) has greater solubility in benzene and low solubility in water.

2. Nature Of Solute:

The nature of solute also affects the solubility. Different solutes have different solubility in the same solvent i.e. if the solute is changed and solvent is kept constant then the solubility is changed. "Like dissolve like" rule can also be applied to nature of solute affecting solubility.

Example:

Sodium chloride is more soluble in water as compared to sugar.

3. Temperature:

Temperature also affects the solubility of substances.

It is explained under the following headings:

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i. Effect Of T On Solubility Of Solids In Liquids:

Temperature affects the solubility of solids in liquids in the following four ways:

a. Generally the solubility of solids in liquids increases with the increase of temperature.

Examples:

The solubility of sugar, KNO_3, $CaCl_2$, $NaNO_3$ etc increase with the increase of temperature.

b. The solubility of some solutes decrease with the increase of temperature.

Examples:

The solubility of $Ce_2(SO_4)_3$, CaO, Li_2CO_3, $Yb_2(SO_4)_3$etc decrease with the increase of temperature.

c. The solubility of a few solutes is not affected by temperature.

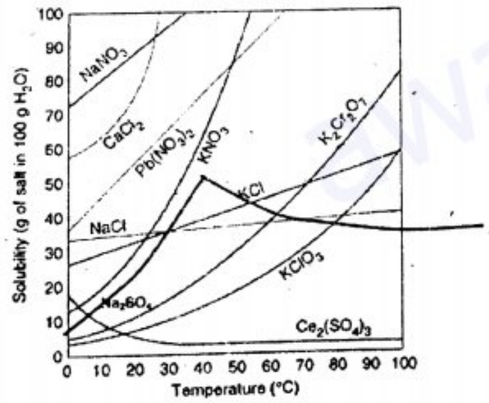
Examples:

The solubility of NaCl, KBr etc is not affected by temperature.

d. There are very small number of solutes whose solubility first increase up to a certain temperature, then decrease and at last remains almost constant.

Example:

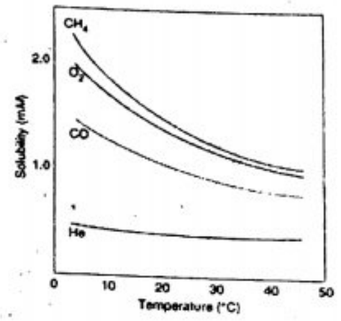
The solubility of sodium sulphate increases up to 32.4^0C and then decrease above this temperature. It forms $Na_2SO_4 .10H_2O$ at 32.4^0C and above this temperature it forms anhydrous Na_2SO_4.



ii. Effect Of T On Solubility Of Gas In Liquid:

The solubility of gases in liquids decreases with the increase of the temperature because raising the temperature of solution increases the

average speed of its molecule and the molecules of dissolved gas leave the liquid at faster rate.



4. Pressure:

Since solids and liquids are incompressible, therefore, the solubility of solids and liquids are not affected by pressure. However, the solubility of gases is greatly affected by pressure. The solubility of gases increases with the increase of pressure.

For example

In soda water bottles the carbon dioxide gas is dissolved under high pressure. When the cap is removed then the pressure is reduced and much of the carbon dioxide comes out as gas bubbles which is called effervescence. Because at lower pressure its solubility becomes low in water.

Q.12 Explain with examples the solute- solvent interactions.

Ans: Solute-solvent Interactions:

"The forces of interactions between the molecules of solvent and ions or molecules of solutes are called solute-solvent interactions."

Explanation:

The solute and solvent interactions of different types of solutes and solvent are discussed below:

i. Dissolving Ionic Solutes In Polar Solvents:

Ionic solutes are soluble in polar solvents like water. The polarity of water plays an important role in dissolving ionic solutes. It dissolves ionic solutes by hydration.

Hydration:

"It is a process in which water molecules surround the ions of ionic solutes in such a way that the positive end of water is directed toward the

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negative ions and the negative end of water is directed towards the positive ion."

The water molecules pull the closely packed ions and thus separate them from each other thus they are dissolved in water. These ions are called hydrated ions.

Example:

If we add some sodium chloride in water. The water splits it crystals to Na^+ and Cl^- ions. The positive end of water molecules is directed towards Cl^- ions and negative end of water is directed towards Na^+ ions. Thus they get separated from crystals and are dissolved. They disappear in water and new ions of crystals are exposed to be dissolved by water.

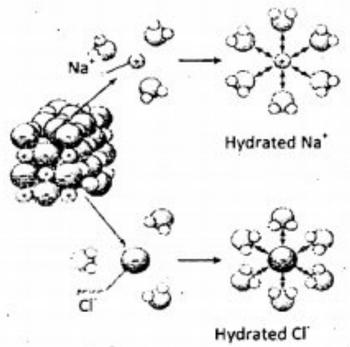

Figure: Hydration Of NaCl

ii. Dissolving Ionic Solutes In Non-polar Solvents:

The non-polar solvents do not attract the ions of ionic solutes. Therefore, they are not dissolved.

Example:

Ionic solutes like NaCl, LiCl, CaO etc do not dissolve in non-polar solvents like carbon tetrachloride(CCl_4), benzene(C_6H_6) etc.

iii. Liquid Solutes And Solvents:

They have three types

a. Completely Miscible:

Liquids which completely dissolve into each other are called completely miscible.

Example:

Benzene and carbon tetra chloride etc.

b. Completely Immiscible:

Liquids which do not dissolve into each other are called completely immiscible.

Example:

Benzene and water etc.

c. Partially Miscible:

Liquids which partially dissolve into each other are called partially miscible.

Example:

Phenol and water etc.

Hydrogen Bonding And Dissolution:

Polar solutes are dissolved in water by hydrogen bonding. For example ethanol is dissolved in water by hydrogen bonding. They both exist in a single phase.

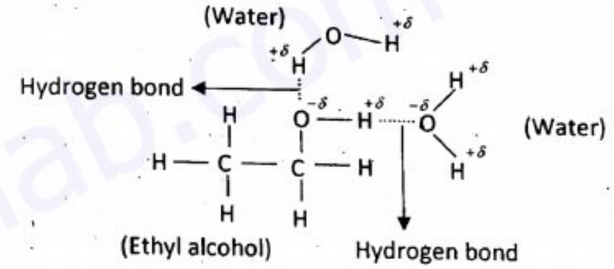

Figure: Hydrogen bonding between ethanol and water

Q.13 Define and explain with examples
i) Suspension ii) Colloidal solution

Ans: i. Suspension:

Definition:

"A heterogeneous mixture of two or more substances is called suspension."

Explanation:

i. Heterogeneous mixture means that its composition is not uniform(یکساں) throughout.(ہر جگہ)
ii. The solute particles of a suspension can be seen with the help of naked eye.(کھلی آنکھ)
iii. All the particles of suspension cannot pass through filter paper.
iv. The particles of suspension settle down, if it is left undisturbed, leaving clear liquid at the top. (This process of settling down of small particles is called sedimentation.

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Examples:

Some of the examples of suspension are given below:

1. Muddy water
2. Chalk in water
3. Medicines like antacids.

ii. Colloidal Solution:

Definition:

"A solution in which the solute particles are bigger in size than the solute particles of a true solution but smaller than the solute particles of a suspension is called colloid or colloidal solution."

Explanation:

i. The solute particles of a colloid are not homogenized with the solvent.
ii. The solute particles are a little bit bigger than the solute particles of a true solution but not so bigger that can be seen with naked eye.
iii. The solute particles of a colloidal solution pass through the filter paper during filtration.
iv. The particles of a colloidal solution do not settle down, if it is left undisturbed.

Examples:

Some examples of colloidal solutions are given below:

1. Starch in water
2. Indian ink
2. Paints
4. Milk etc.

Q.14 Discuss the various classes of colloids.

Ans: Classes Of Colloids:

They are given in the table below:

Class Of colloid	Phases	Example
Sol	Solid dispersed in liquid	Paints, mud
Gel	Solid network extending throughout liquid	Gelatin
Liquid Emulsion	Liquid dispersed in a liquid	Milk, mayonnaise
Foam	Gas dispersed in liquid	Shaving cream, whipped cream
Solid Aerosol	Solid dispersed in gas	Smoke, airborne particulate matter, auto exhaust
Liquid Aerosol	Liquid dispersed in gas	Fog, mist, clouds, aerosol spray
Solid Emulsion	Liquid dispersed in solid	Cheese, butter

Properties Of Solutions, Colloids And Suspension:

	Solutions	Colloids	Suspesions
1	Homogeneous	Heterogeneous	Heterogeneous
2	Particles size: 0.01-1nm; can be atom, ions or molecules	Particles size:1-1000nm can be aggregate or large molecules	Particles size: over 1000nm, can be large particles or aggregate
3	Particles remain dissolve on standing.	Particles remain dissolve on standing.	Particles settled down on standing.
4	Cannot be separated by filtration.	Cannot be separated by filtration.	Can be separated by filtration.
5	Do not scatter light.	Scatter light	May scatter light but are not transparent.
6	Particles are invisible.	Particles are invisible.	Particles are visible.

Q.15: What is meant by colligative properties?

Ans:Colligative Properties:

"The physical properties of a solution which depends on the number and not on the nature of solute particles are called colligative properties."

Examples:

Colligative properties of a solution are given below:

i. Decrease in melting point
ii. Increase in boiling point
iii. Lowering of vapour pressure
iv. Increase in osmotic pressure

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EXERCISE

Multiple Choice Questions

Q.1 Choose the correct answer:

i. Solution whose concentration is known is called:
A) Aqueous solution B) Saturated solution
C) Standard solution D) Non-aqueous solution

ii. Keep in mind that all the given substances are organic, which one is soluble in water:
A) Kerosene oil B) Carbon tetrachloride
C) Methyl alcohol D) Benzene

iii. Water droplets in air is an example of solution of:
A) Gas in gas B) Gas in liquid
C) Liquid in gas D) Liquid in liquid

iv. Weight of solute present in 100g of solution is called:
A) Percentage V/W **B) Percentage W/W**
C) Percentage V/V D) Percentage W/V

v. A mixture in which the solute particles are dissolved is called:
A) Heterogeneous mixture **B) Solution**
C) Colloidal solution D) Suspension

vi. Milk is an example of:
A) Solution **B) Colloidal solution**
C) Suspension D) Heterogeneous mixture

vii. The boiling point of a solution as compared to the solvent is:
A) Higher B) Lower
C) Remains same D) Variable

viii. The particles of solute in colloids are:
A) Visible **B) Invisible**
C) In size like suspension solute D) In size like solution solute

ix. 2moles of Na_2SO_4 has been dissolved in one dm^3 of solution. Molarity of the solution is:
A) 1 **B) 2** C) 3 D) 4

x. The molecules of ice have:
A) An ionic bond between them
B) A covalent bond between them
C) A co-ordinate covalent bond between them
D) Hydrogen bond between them

xi. Which of the following is more dilute?
A) 1M B) 0.55M C) 0.05M **D) 0.005M**

xii. When there is low concentration of solute in a solution, it is known as:
A) Dilute solution B) Saturated solution
C) Concentrated solution D)Super-saturated solution

xiii. What is the molarity of a $NaNO_3$ solution made by diluting $250cm^3$ of à 1.6M solution to a final volume of $400cm^3$?
A) 1.2M **B) 1M** C) 0.2M D) 0.16M

Solution:
M_1=1.6M V_1=$250cm^3/1000 = 0.250dm^3$
$V_2 = 400cm^3/1000=0.400dm^3$ M_2= ?
$M_1V_1=M_2V_2$ => $M_2 = M_1V_1/V_2$
=> $M_2 = 1.6M \times 0.250dm^3/0.400dm^3 = 1M$

xiv. What is the concentration in %, by volume(m/V) of a solution containing 15g of KCl in $600cm^3$ solution?
A) 5% B) 2% C) 0.200% **D) 2.5%**

Solution:
m/V% = mass of solute×100/volume of solution
⇨ m/V%= 15×100/600 = 2.5%

xv. When KCl dissolves in water, the following will be produced:
A) K &C **IB) K^+&Cl^-** C) K & Cl_2 D) K^+& Cl_2

xvi. Molarity is the number of moles dissolved in:
A) 1kg of solvent B) 1kg of solution
C) $1dm^3$ of solvent **D) $1dm^3$ of solution**

xvii. The molarity of NaOH solution by dissolving 4g of it in 250ml water is:
A) 0.4M B) 0.8M C) 0.2M D) 0.1M

Solution:
Molarity= mass in g/molar mass×volume of solution
⇨ Molarity = $4g/40gmol^{-1} \times 0.250dm^3$
⇨ Molarity = $0.4mol/dm^3$ or 0.4M

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Short Questions

Answer briefly the following Questions:

i. Is sea water a solution? How would you prove with a simple experiment whether it is pure water or solution?

Ans: **Sea Water Being Solution:**

Yes, sea water is a solution because it contains dissolved minerals and salts. These form a homogeneous mixture with water. Hence, sea water is a solution.

Simple Way To Find That Sea Water Is Solution:

a. Pure water is tasteless, so if we taste sea water it will have a salty taste which proves that it is a solution.

b. Pure water does not conduct electric current. If we pass electric current from sea water, it will conduct electric current due to dissolved ions of various salts thus it proves that it is a solution.

ii. A bottle in a drug store contains a label "3 percent hydrogen peroxide" what does it mean?

Ans: **Meaning Of "3% H_2O_2:**

3% hydrogen peroxide shows us its percentage composition (V/V%). It means that 3ml of hydrogen peroxide is dissolved in water to make 100ml solution i.e every 100ml solution contains 3ml of hydrogen peroxide.

iii. Classify the following as a solution, colloid or suspension and explain why?

i. Milk ii. Hot cup of tea iii. Orange juice with pulp
iv. Mayonnaise v. Listerine mouthwash vi. Cheese
vii. Milk of magnesia viii. Mist ix. Bottled water

Ans: **Colloids:**

Mist Milk, Mayonnaise, cheese and hot cup of tea are colloids because they scatter light i.e. show tyndall effect.

Solutions:

Listerine mouth wash and bottled water are solutions because they are homogeneous mixtures and their particles are invisible and do not show tyndall effect.

Suspensions:

Orange juices with pulp, Milk of magnesia are suspensions because they are heterogeneous mixtures and their particles are visible.

iv. Why we stir paints thoroughly before using it?

Ans: **Reason For Stirring Of Paints:**

Paints are suspension. Therefore, their particles settle down when left undisturbed. Hence, it is necessary to stir well, in order to uniformly mix the particles in the whole mixture. Otherwise, it won't be useful.

v. Why suspensions and solutions do not show tyndall effect, while colloids do?

Ans: The answer of this question is explained under the following headings:

Reason For Suspension, Not Showing Tyndall Effect:

The solute particles of suspension are too large therefore, they block the light and it is not scattered. That is why suspensions do not show tyndall effect.

Reason For Solution, Not Showing Tyndall Effect:

The solute particles of solution are extremely small therefore, the light passes from them and is not scattered. That is why solutions do not show tyndall effect.

Reason For Colloid, Showing Tyndall Effect:

The solute particles of colloids are intermediate in size therefore, they scatter light. That is why they show tyndall effect.

Long Questions

i. Define solution? Explain its types on the basis of states of matter.

Ans: **Solution:**

"A homogeneous mixture of two or more substances is called solution."

A solution has two main components:

Solute:

The dissolved substance of a solution is called solute or the substance present in small amount in solution is called solute.

Solvent:

The dissolving medium of a solution is called solvent or the substance present in large amount in solution is called solvent.

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Examples:

i. Sugar in water(solute= sugar, solvent = water)
ii. NaCl in water(solute = NaCl, solvent = water)

Different Types Of Solutions:

See Question No.7

ii. a) Discuss the solubility of a substance.
b) Explain the factors that are responsible for the solubility of a substance?

Ans: **a)** For answer see Question No.11 first heading
b) For answer see Question No.11

iii. a) What is the difference between concentrated and dilute solutions? Give examples of each.

Ans: For answer see Question No.5

b) Differentiate between unsaturated, saturated and super-saturated solutions?

Ans: For answer see Question No.3

iv. Describe one way to prove that a mixture of sugar and water is a solution and that a mixture of sand and water is not a solution.

Ans: **Way To Find That Sugar In Water Is A Solution:**

When we dissolved sugar in water it disappears and forms a homogeneous mixture called solution.

It can be proved that it is solution by invisibility of its particles which cannot be seen with naked eye and when we filter this solution. All the particles pass through filter paper during filtration showing that it is a solution.

Way To Find That Sand In Water Is Not A Solution:

When we add sand in water it does not dissolve and forms a heterogeneous mixture called suspension.

It can be proved that it is not a solution by visibility of its particles which can be seen with naked eye and its particles do not pass through filter paper during filtration.

v. Explain the following concentration units
a. Percentage composition
b. Molarity

Ans: **a)** For answer see Question no. 9
b) For answer see Question no. 10

Numerical Questions

i. 5.85g of NaCl is dissolved in water so as to make 500cm^{3}solution. Determine the molarity of solution. (Atomic mass of Na=23g and Cl=35.5g)

Given:

Mass in grams of solute (NaCl) = 5.85g

Volume of solution=500cm^3= $\frac{500}{1000}$ =0.5dm^3 Q $1dm^3 = 1000cm^3$

Atomic mass of Na =23g and Atomic mass of Cl = 35.5g

Required:

Molarity of the solution (M) =?

Solution:

As we know that:

$$\text{Molarity} = \frac{\text{mass in grams of solute}}{\text{Molar mass of solute} \times \text{volume of solution in } dm^3 \text{ or litre}}$$

So first we find the molar mass of NaCl

Molar mass of NaCl = 1(23) + 1(35.5)
= 23 + 35.5
= 58.5g/mol

Now putting the values in the above equation we get:

$$\text{Molarity} = \frac{5.85g}{58.5g\,mol^{-1} \times 0.5dm^3}$$

$\Rightarrow$Molarity = **0.2mol/dm^3 or 0.2M**

Result:

Molarity of the solution (M) = **0.2mol/dm^3 or 0.2M**

ii. Calculate the molarity of 50 cm^3 of solution containing 7.5g of CH_3OH?

Given:

Mass in grams of solute (CH_3OH) = 7.5g

Volume of solution = 50cm^3

= $\frac{50}{1000}$ dm^3 Q $1dm^3 = 1000cm^3$

= 0.05dm^3

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Required:

Molarity of the solution(M) =?

Solution:

As we know that:

$$\text{Molarity} = \frac{\text{Mass in grams of solute}}{\text{Molar mass} \times \text{volume of solution in } dm^3}$$

So first we find molar mass of CH_3OH:

Molar mass of CH_3OH = 1(12) + 4(1) + 1(16)

= 12+4+16

= 32gmol^{-}

Putting the values we get:

$$\text{Molarity} = \frac{7.5\,g}{32\,g\,mol^{-1} \times 0.05\,dm^3}$$

⇒Molarity = **4.69mol/dm^3 or 4.69M**

Result:

Molarity of the solution = **4.69mol/dm^3 or 4.69M**

iii. Calculate the molarity of 11.6cm^3 solution containing 0.750g of $CaCl_2$?

Given:

Mass in g of solute ($CaCl_2$) = 0.750g

Volume of solution= 11.6cm^3

$$= \frac{11.6}{1000}\ dm^3 \quad Q\ 1dm^3 = 1000cm^3$$

= 0.0116dm^3

Required:

Molarity of the solution (M) =?

Solution:

As we know that:

$$\text{Molarity} = \frac{\text{Mass in grams of solute}}{\text{Molar mass} \times \text{volume of solution in } dm^3}$$

So first we find molar mass of $CaCl_2$:

Molar mass of $CaCl_2$ = 1(40) + 2(35.5)

= 40 + 71

= 111gmol^{-}

Putting the values we get:

$$\text{Molarity} = \frac{0.750g}{111\,g\,mol^{-1} \times 0.0116\,dm^3}$$

⇒Molarity = **0.58mol/dm^3 or 0.58M**

Result:

Molarity of the solution = **0.58mol/dm^3 or 0.58M**

iv. Calculate the molarity of a solution containing 7.5 mol of $CaCO_3$ to make 1.50 dm^3 of solution?

Given:

No. of moles of solute ($CaCO_3$) = 7.5 mol

Volume of solution= 1.5 dm^3

Required:

Molarity of the solution (M) =?

Solution:

As we know that:

$$\text{Molarity} = \frac{\text{No. of moles of solute}}{\text{Volume of solution in } dm^3}$$

By putting the values in the above equation we get:

$$\text{Molarity} = \frac{7.5\,mol}{1.5dm^3}$$

⇒Molarity = **5mol/dm^3 or 5M**

Result:

Molarity of the solution (M) = **5mol/dm^3 or 5M**

v. What is the molarity of of 5.85g of potassium iodide (KI) dissolved in enough water to make 0.125dm^3 of solution?

Given:

Mass in grams of solute (KI) = 5.85g

Volume of solution= 0.125dm^3

Required:

Molarity of the solution (M) =?

Solution:

As we know that:

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$$\text{Molarity} = \frac{\text{mass in grams of solute}}{\text{Molar mass of solute} \times \text{volume of solution in } dm^3 \text{ or litre}}$$

So first we find the molar mass of KI

Molar mass of KI = 1(39) + 1(127)

= 39 + 127

= 166gmol^{-}

Now putting the values in the above equation we get:

$$\text{Molarity} = \frac{5.85g}{166g\,mol^{-1} \times 0.125dm^3}$$

⇒Molarity = **0.281mol/dm^3 or 0.2M**

Result:

Molarity of the solution (M) = **0.281mol/dm^3 or 0.2M**

vi. How many moles of H_2SO_4 are present in 0.500 dm^3 of 0.150 M H_2SO_4 solution?

Given:

Molarity of solution = 0.150 M or mol/dm^3

Volume of solution= 0.500 dm^3

Required:

Number of moles of H_2SO_4 =?

Solution:

As we know that:

$$\text{Molarity} = \frac{\text{No. of moles of solute}}{\text{Volume of solution in } dm^3}$$

Multiplying both sides by volume of solution we get:

$$\text{No. of moles} = \text{Molarity} \times \text{Volume of solution in } dm^3$$

Putting the values in the above equation we get:

$$\text{No. of moles} = 0.150\frac{mol}{dm^3} \times 0.500dm^3$$

⇒No. of moles = 0.07**5 mol or 0.075mol**

Result:

Molarity of the solution (M) = 0.07**5mol or 0.07 5mol**

vii. Suppose you want to dissolve 40g of NaOH in enough water to make 6dm^3 of solution.

a. What is the molar mass of NaOH?

b. What is the molarity of solution?

Given:

Mass in grams of solute (NaOH) = 40g

Volume of solution= 6dm^3

Required:

a. Molar mass of NaOH = ?

b. Molarity of the solution (M) =?

Solution:

a. Molar Mass Of NaOH:

Atomic mass of Na = 23 a.m.u

Atomic mass of O = 16 a.m.u

Atomic mass of H = 1 a.m.u

Therefore:

Molar mass of NaOH = 1(23) + 1(16) + 1(1)

= 23+16+1

= 40g/mol

b. Molarity Of Solution:

As we know that:

$$\text{Molarity} = \frac{\text{mass in grams of solute}}{\text{Molar mass of solute} \times \text{volume of solution in } dm^3 \text{ or litre}}$$

Now putting the values in the above equation we get:

$$\text{Molar mass} = \frac{40g}{40g\,mol^{-1} \times 6dm^3}$$

⇒Molarity = **0.166mol/dm^3 or 0.166M**

Result:

a. Molar mass of NaOH = 40g/mol

b. Molarity of solution = 0.166M

viii. What is the molarity of a solution 14g NH_4Br in enough H_2O to make 150cm^3 of solution?

Given:

Mass in grams of solute (NH_4Br) = 14g

Volume of solution = 150cm^3

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$= \frac{150}{1000}$ dm^3 $\quad Q\ 1dm^3 = 1000cm^3$

$= 0.150$dm^3

Required:

Molarity of the solution (M) =?

Solution:

As we know that:

$$\text{Molarity} = \frac{mass\ in\ grams\ of\ solute}{Molar\ mass\ of\ solute \times volume\ of\ solution\ in\ dm^3\ or\ litre}$$

So first we find the molar mass of NH_4Br

Molar mass of $NH_4Br = 1(14) + 4(1) + 1(79.9)$

$= 14 + 4 + 79.9$

$= 97.9 gmol^{-}$

Now putting the values in the above equation we get:

$$\text{Molarity} = \frac{14g}{97.9g\ mol^{-1} \times 0.150dm^3}$$

$\Rightarrow$ Molarity = **0.9533mol/dm^3 or 0.9533M**

Result:

Molarity of the solution (M) =**0.9533mol/dm^3 or 0.9533M**

ix. Suppose you want to produce 1.00 dm^3 of 3.5M solution of H_2SO_4.

a. What is the solute?

b. What is the solvent?

c. How many grams of solute are needed to make the solution?

Ans (a): Solute:

The solute is H_2SO_4 because it is present in small amount.

Ans (b): Solvent:

The solvent is water because it is present in large amount.

Ans (c): Given:

Molarity of solution = 3.5M

Volume of solution = 1dm^3

Required:

Mass in g of solute =?

Solution:

As we know that:

$$\text{Molarity} = \frac{mass\ in\ grams\ of\ solute}{Molar\ mass\ of\ solute \times volume\ of\ solution\ in\ dm^3\ or\ litre}$$

Multiplying both sides by molar mass and volume:

Mass in g of solute = Molarity × Molar mass of solute × Volume of solution in dm^3 ..... (1)

So first we find the molar mass of H_2SO_4

Molar mass of $H_2SO_4 = 2(1) + 1(32) + 4(16)$

$= 2 + 32 + 64$

$= 98 gmol^{-}$

Now putting the values in equation-1 we get:

$$\text{mass in g of solute} = 3.5\frac{mol}{dm^3} \times 98gmol^{-1} \times 1dm^3$$

$\Rightarrow$mass in g of solute = **343g**

Result:

Mass in grams of solute = **343g**

Dilution Formula:

To dilute a concentrated solution the following formula is used:

$M_1V_1 = M_2V_2$

Where M_1 and V_1 are the molarity and volume of concentrated solution while M_2 and V_2 are the molarity and volume of dilute solution.

Example 6.4:

What will be the molarity of a 30cm^3, 2.5M solution if enough water is added to it and the volume of solution is made 280cm^3?

Given:

Molarity of concentrated solution (M_1) = 2.5M

Volume of concentrated solution (V_1) = 30 cm^3

Volume of dilute solution (V_2) = 280cm^3

Required:

Molarity of dilute solution (M_2) = ?

Solution:

As we know that:

$M_1V_1 = M_2V_2$

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Therefore,

$$M_2 = \frac{M_1V_1}{V_2}$$

Putting the values we get:

$$M_2 = \frac{2.5M \times 30cm^3}{280cm^3}$$

⇨ $M_2 = 0.267M$

Result:

Molarity of dilute solution (M_2) = 0.267M

Example 6.5:

What volume of water must be added to 85cm^3 of 3.5M Na_2CO_3 solution to dilute it to 0.4M?

Given:

Molarity of concentrated solution (M_1) = 3.5M

Volume of concentrated solution (V_1) = 85 cm^3

Molarity of dilute solution (M_2) = 0.4M

Required:

Volume of water required = ?

Solution:

First we will find total volume of dilute solution (V_2) and then subtract 85cm^3 from it to find the volume of water.

As we know that:

$M_1V_1 = M_2V_2$

Therefore:

$$V_2 = \frac{M_1V_1}{M_2}$$

Putting the values we get:

$$V_2 = \frac{3.5M \times 85cm^3}{0.41M}$$

⇨ $V_2 = 725.60cm^3$

Therefore, volume of water required = 725.60cm^3-85cm^3

= 640.60cm^3

Result:

Volume of water required = 640.60cm^3

Test Yourself

1.Suggest a method for differentiation between pure liquid and solution?

Ans: Method For Differentiation Between Pure Liquid And Solution:

A pure liquid can be differentiated from a solution on basis of boiling point. The boiling point of a solution is always high than a pure liquid. Thus by finding the boiling point of solution or liquid, can reveal that whether it is solution or pure liquid.

2. Which solvent-liquid ammonia (NH_3) OR benzene(C_6H_6) is more likely to dissolve each the following solutes?

a. H_2O b. C_6H_{12} c. AgCl

Ans: For solubility, there is general rule that "like dissolve like". Which means that polar and ionic solutes dissolve in polar solvents and non-polar solutes dissolve in non-polar solvents.

a. H_2O is polar, therefore it is more likely to dissolve in liquid ammonia which is also polar.

b. C_6H_{12} is non-polar, therefore it is more likely to dissolve in benzene which is also non-polar.

c. AgCl is ionic, therefore it is more likely to dissolve in liquid ammonia which is a polar solvent.

Example 6.2:

Which type solvent, polar or non-polar, is most likely to dissolve methyl alcohol (CH_3OH)?

Ans: Solvent, Most likely To Dissolve CH_3OH:

Methyl alcohol(CH_3OH) is polar therefore, a polar solvent like water is most likely to dissolve it.

Project work: 6.1

Which of the following are pure substances and which are mixtures? Sea water, orange squash, cooking oil, salt, coal, milk, steel, oxygen gas, chilli sauce, air, bronze, orange juice, sand, coke, gold, soil.

Ans: Pure substances:

Salt, oxygen gas and gold are pure substances.

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Mixtures:

Sea water, orange squash, cooking oil, coal, milk, steel, chilli sauce, air, bronze, orange juice, sand, coke and soil are mixtures.

Some Extra Numericals From Previous Course

Q. 100g of sodium hydroxide are dissolved in water and the volume of solution is made one dm^3. Determine the molarity of this solution?

Ans: **Given:**

Mass in grams of solute (sodium hydroxide) = 100g

Volume of solution = $1dm^3$

Required:

Molarity of the solution =?

Solution:

Molar mass of sodium hydroxide (NaOH) = 1(23) + 1(16) + 1(1)

= 40 g mol^{-1}

As we know that:

$$\text{Molarity} = \frac{\textit{Mass in grams of solute}}{\textit{Molar mass} \times \textit{volume of solution in } dm^3 \textit{ or litre}}$$

Putting the values we get:

$$\text{Molarity} = \frac{100g}{40\ g\ mol^{-1} \times 1dm^3}$$

$\Rightarrow$ Molarity = **2.5mol/dm^3 or 2.5M**

Result:

Molarity of the solution = **2.5mol/dm^3 or 2.5M**

Q. Calculate the molarity of a solution which has 0.530g of Na_2CO_3 in $250cm^3$ of solution.

Ans: **Given:**

Mass in grams of solute (Na_2CO_3) = 0.530g

Volume of solution=$250cm^3 = \frac{250}{1000}$

$= 0.250dm^3$ Q 1 dm^3 = 1000 cm^3

Required:

Molarity of the solution =?

Solution:

Molar mass of sodium carbonate (Na_2CO_3) = 2(23) + 1(12) + 3(16)

= 106 g mol^{-1}

As we know that:

$$\text{Molarity} = \frac{\textit{Mass in grams of solute}}{\textit{Molar mass} \times \textit{volume of solution in } dm^3 \textit{ or litre}}$$

Putting the values we get:

$$\text{Molarity} = \frac{0.530g}{106g\ mol^{-1} \times 0.250dm^3}$$

$\Rightarrow$ Molarity = **0.02mol/dm^3 or 0.02M**

Result:

Molarity of the solution = **0.02mol/dm^3 or 0.02M**

Q. Calculate the molarity of 5% by mass of NaOH solution.

Ans: **Given:**

Percentage composition of solution by mass = 5%

Required:

Molarity of the solution =?

Solution:

As the percentage composition of solution is 5%, therefore it will contain:

i. Mass of solute (NaOH) = 5g

ii. Volume of solution = $100cm^3 = \frac{100}{1000}$

$=0.1dm^3$ Q 1 dm^3 = 1000 cm^3

Molar mass of sodium hydroxide (NaOH) = 1(23) + 1(16) + 1(1)

= 40 g mol^{-1}

Now according to the formula:

$$\text{Molarity} = \frac{\textit{Mass in grams of solute}}{\textit{Molar mass} \times \textit{volume of solution in } dm^3 \textit{ or litre}}$$

Putting the values we get:

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$$\text{Molarity} = \frac{5g}{40g\ mol^{-1} \times 0.1dm^3}$$

$\Rightarrow$ Molarity = **1.25mol/dm^3 or 1.25M**

Result:

Molarity of the solution = **1.25mol/dm^3 or 1.25M**

Q. 40g of sodium chloride solution contains 5g of sodium chloride. Determine its percentage by weight.

Ans: Given:

Weight of solution = 40g

Weight of solute (sodium chloride) = 5g

Required:

Weight-weight percentage (W/W %) =?

Solution:

As we know that:

$$W/W\% = \frac{Weight\ of\ solute\ in\ grams}{Weight\ of\ solution\ in\ grams} \times 100$$

Putting the values we get:

$$W/W\% = \frac{5g}{40g} \times 100$$

$\Rightarrow$ W/W% = **12.5%**

Result:

Weight-weight percentage (W/W %) = **12.5%**

Chapter No.07
Electrochemistry

Q.1. Define electrochemistry. What are its applications?

Ans: Electrochemistry:

"The branch of chemistry which deals with the study of chemical changes bring about by electricity and production of electricity through chemical reactions is called electrochemistry." OR

"The branch of chemistry which deals with the interconversion (باہم تبدیلی) of chemical and electrical energy is called electrochemistry."

***Applications of electrochemistry:**

i. Various batteries and cells like mobile batteries, car batteries are the results of electrochemistry.

ii. Decoration (سجاوٹ) and prevention (حفاظت) of various metal has been made possible due to electrochemistry.

iii. Electrochemistry also plays a vital (اہم) role(کردار) in various industries.

Q.2 Define and explain oxidation and reduction.

Ans: Oxidation:

Definitions:

Oxidation is defined by two concepts given below:

1. Classical concept:

According to classical concept oxidation is defined as:

i. The reaction in which addition of oxygen occurs is called oxidation.

Examples:

a. $C + O_2 \longrightarrow CO_2$

b. $S + O_2 \longrightarrow SO_2$

ii. The reaction in which removal of hydrogen occurs is called oxidation.

Examples:

a. $2NH_3 + 3Cl_2 \longrightarrow N_2 + 6HCl$

b. $CH_4 \xrightarrow{Heat} C + 2H_2$

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2. Modern electronic concept:

The reaction in which loss of electrons occurs is called oxidation.

Examples:

a. $Fe^{+2} \longrightarrow Fe^{+3} + 1e^-$

b. $Sn^{+2} \longrightarrow Sn^{+4} + 2e^-$

Reduction:

Definitions:

Reduction is defined by two concepts which are given below:

1. Classical concept:

According to this concept reduction is defined in two ways:

i. The reaction in which removal of oxygen occurs is called reduction.

Examples:

a. $2HgO \xrightarrow{Heat} 2Hg + O_2$

b. $ZnO + H_2 \longrightarrow Zn + H_2O$

ii. The reaction in which addition of hydrogen occurs is called reduction.

Examples:

a. $N_2 + 3H_2 \longrightarrow 2NH_3$

b. $C_2H_4 + H_2 \xrightarrow{Catalyst} C_2H_6$

2. Modern electronic concept:

The reaction in which gain of electrons occurs is called reduction.

Examples:

a. $Fe^{+3} + 1e^- \longrightarrow Fe^{+2}$

b. $Sn^{+4} + 2e^- \longrightarrow Sn^{+2}$

Q.3. Define oxidation number? What are the rules for assigning oxidation numbers?

Ans: Oxidation state/number:

Definition:

"The apparent (واضح) charge, positive or negative, on an atom of an element in a molecule or an ion is called oxidation sate."The oxidation state of an element is described (بیان کرنا) by its oxidation number, which is assigned according to the following rules:

Rules for assigning oxidation numbers:

i. The oxidation number of all free elements is zero. For example the oxidation number of H_2, Cl_2, Na etc is zero.

ii. The oxidation number of a simple ion is the same as the charge on it. For example the oxidation number of Na^{+1} = +1, Ca^{+2} = +2, Al^{+3} = +3, Br^{-1} = –1 etc.

iii. The oxidation number of hydrogen in its compounds is +1 except in the case of metal hydrides, where it is -1 e.g. Na^+H^-.

iv. The oxidation number of oxygen in its compounds is -2 except in peroxides, where it is -1, super oxide where it is -1/2 and in the case of OF_2 where it is +2.

v. The oxidation number of elements of group IA is +1, group IIA is +2 while that of group IIIA is +3.

vi. The oxidation number of elements of group VIIA in their binary compounds is -1.

vii. In neutral molecules or formula units, the sum of the oxidation numbers of all elements is zero.
e.g. $H_2O = (+1\times2) + (-2\times1) = +2 - 2 = 0$

viii. In ions, the sum of the oxidation numbers of elements is equal to the net charge on the ion e.g. $CO_3^{-2} = (+4\times1)+(-2\times3) = +4 - 6 = -2$

ix. In any substance the more electronegative atom has the negative oxidation number.

x. The same element may show different oxidation numbers in different compounds e.g. CO(C=+2,O=-2), CO_2(C=+4, O=-2).

Q.4.What is the difference between oxidizing and reducing agents? Explain your answer with examples.

Ans: Difference between oxidizing and reducing agents:

The differences between oxidizing and reducing agents are given in the table below:

	Oxidizing agents	Reducing agents
1	**Definitions:** Oxidizing agents are defined as: "The substances which oxidize other substances but itself get reduced are called oxidizing agents."	**Definitions:** Reducing agents are defined as: "The substances which reduce other substances but itself get oxidized are called reducing agents."

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2	"According to classical concept it is: a. The donor of oxygen to a substance. b. The acceptor of hydrogen from a substance	"According to classical concept it is: a. The acceptor of oxygen from a substance. b. The donor of hydrogen to a substance
3	According to electronic concept it is: a. The acceptor of electron/s from a substance. b. Its oxidation number decreases during a chemical reaction.	According to electronic concept it is: a. The donor of electron/s to a substance. b.Its oxidation number increases during a chemical reaction.
4	**Reactions:** i.$2HNO_2+2HI \longrightarrow 2NO+I_2+2H_2O$ N = +3 N = +2 In HNO_2 the oxidation state of N decreases from +3 to +2 therefore, HNO_2 acts as an oxidizing agent. ii. $Sn^{+2} + Cl_2 \longrightarrow Sn^{+4} + 2Cl^-$ Cl = 0 Cl = –1 The oxidation number of Cl_2 is decreased from 0 to –1 therefore it acts as an oxidizing agent.	**Reactions:** $Br_2 + H_2S \longrightarrow 2HBr + S$ S= –2 S = 0 In H_2S the oxidation state of S increases from –2 to 0 therefore, H_2S acts as a reducing agent. ii.$2Na+Cl_2 \longrightarrow 2NaCl$ Na=0 Na = +1 The oxidation state of Na increases from 0 to +1 therefore, it acts as reducing agent.
5	**Examples:** Carbon dioxide(CO_2), oxygen(O_2) Ozone(O_3), nitric acid(HNO_3),nitrous acid(HNO_2), potassium permanganate($KMnO_4$), potassium dichromate($K_2Cr_2O_7$), chlorine(Cl_2) etc are the examples of oxidizing agents.	**Examples:** Carbon(C), carbon monoxide (CO), hydrogen(H_2), hydrogen Sulphide(H_2S), Sodium(Na), Aluminium(Al), magnesium (Mg), lithium AluminiumHydride($LiAlH_4$) etc are the examples of reducing agents.

Q.5. What are the oxidation reduction reactions?

Ans: Oxidation reduction reactions:

Definition:

"The chemical reactions in which gain and loss of electrons occur simultaneously (بیک وقت) are called oxidation reduction reactions or Redox reactions." **OR**

The chemical reactions in which one atom is reduced while other is oxidized at the same time are called oxidation-reduction reactions.

Explanation with examples:

Oxidation reduction reactions consist of two half reactions. In the first half reaction loss of electrons takes place. This is called oxidation half reaction. In the second half reaction gain of electrons takes place it is called reduction half reaction.

Following are the examples of Redox reactions:

i. $2Na + I_2 \longrightarrow 2Na^+ + 2I^-$

The two half reactions are:

$2Na \longrightarrow 2Na^+ + 2e^-$ (Oxidation)

$2I + 2e^- \longrightarrow 2I^-$ (Reduction)

ii. $K + Ag^+ \longrightarrow K^+ + Ag$

The two half reactions are:

$K \longrightarrow K^+ + 1e^-$ (Oxidation)

$Ag^+ + 1e^- \longrightarrow Ag$ (Reduction)

iii. $Sn^{+2} + I_2 \longrightarrow Sn^{+4} + 2I^-$

The two half reactions are:

$Sn^{+2} \longrightarrow Sn^{+4} + 2e^-$ (Oxidation)

$2I + 2e^- \longrightarrow 2I^-$ (Reduction)

iv. $2Fe^{+3} + Mg \longrightarrow 2Fe^{+2} + Mg^{+2}$

The two half reactions are:

$Mg \longrightarrow Mg^{+2} + 2e^-$ (Oxidation)

$2Fe^{+3} + 2e^- \longrightarrow 2Fe^{+2}$ (Reduction)

v. $CuSO_4 + Zn \longrightarrow ZnSO_4 + Cu$

The two half reactions are:

$Zn \longrightarrow Zn^{+2} + 2e^-$ (Oxidation)

$Cu^{+2} + 2e^- \longrightarrow Cu$ (Reduction)

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Q.6. Define electrochemical cell and describe its types in detail.

Ans: Electrochemical cell:

"A device in which inter-conversion (بابم تبدیلی) of electrical and chemical energy takes place is called electrochemical cell."

Types of electrochemical cells:

There are two types of electrochemical cells which are:

i. Electrolytic cell
ii. Galvanic or voltaic cell

Their detail is given below:

i. Electrolytic cell:

"A device in which non-spontaneous reactions (وہ تعامل جو خوبخود واقع نہ ہو) are carried out by passing the electric current is called electrolytic cell."

Construction of electrolytic cell:

An electrolytic cell consists of a container, electrolyte and two electrodes. The electrodes are connected to the two terminals of a battery. The electrode connected to the positive terminal of the battery is called the anode while the other connected to the negative terminal is called the cathode. Nelson's cell and Down's cell are the examples of electrolytic cell.

Working:

The process occurring in the electrolytic cell is called electrolysis. When electric current is passed, the ions move towards their respective electrodes. The anions move towards anode and usually lose their electrons which passed through the external circuit and are taken by the cations surrounding the cathode. Thus, the number of electrons lost is equal to the number of electrons gained. Thus oxidation occurs at anode and reduction occurs at cathode.

Example:

For example the following reactions occur when electric current is passed from fused NaCl.

$2Cl^- \longrightarrow Cl_2 + 2e^-$ (oxidation)

$2Na^+ + 2e^- \longrightarrow 2Na$ (reduction)

Net reaction:

$$2Na^+ + 2Cl^- \longrightarrow 2Na + Cl_2$$

A general sketch of an electrolytic cell is given in the figure below:

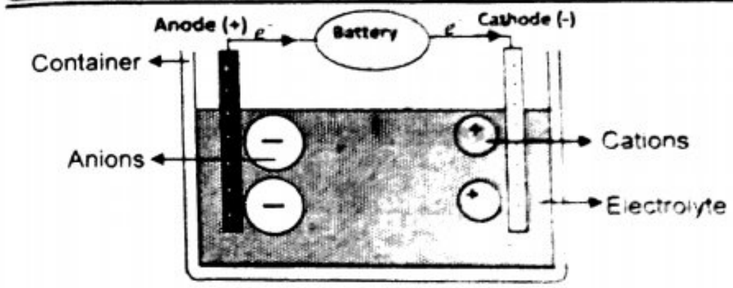

Figure: Electrolytic cell

ii. Galvanic Or Voltaic Cell:

"The cell which produces electric current by undergoing an oxidation reduction reaction is called a galvanic or voltaic cell."

This cell is the reverse of electrolytic cell because in this cell spontaneous reactions occur while in electrolytic cell non-spontaneous reactions occur.

Construction Of Galvanic Or Voltaic Cell:

Galvanic cell is made up of two half cells, one for oxidation and the other for reduction. The two half cells are connected internally by a salt bridge (a u shaped tube filled with an electrolyte like KCl) and externally by a wire.

A salt bridge performs three major functions.

i. It allows electrical contacts between the two half cells
ii. It prevents the mixing of two solutions.
iii. It keeps electric neutrality in each half cell.

A galvanometer or voltmeter is connected with the external wire which records the current. Daniel cell is the best example of galvanic cell

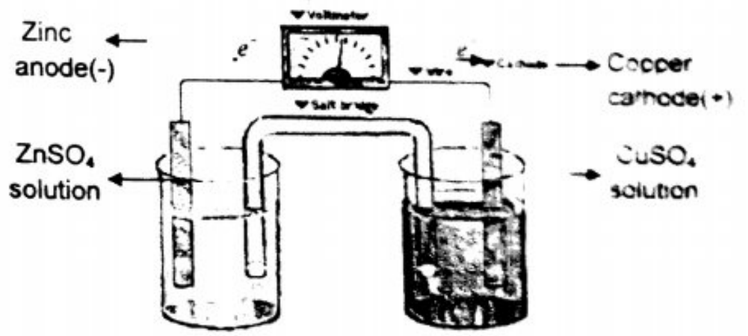

Figure: Galvanic cell

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Q.7. Define electrolytes and non-electrolyte? Give examples?

Ans: Electrolytes:

"The substances which in aqueous solutions or in molten state dissociate into positive and negative ions and conduct the electric current are called electrolytes."

Acids, bases and salts are the examples of electrolytes.

Types of electrolytes:

On the basis of the degree of ionization electrolytes are of two types which are:

i. Strong electrolytes ii. Weak electrolytes

Strong electrolytes:

"Those substances which ionize in water up to a maximum extent (زیادہ سے زیادہ حد تک) and can easily pass electric current are called strong electrolytes".

Examples:

Some examples of strong electrolytes are given below:

i. Hydrochloric acid (HCl)
ii. Nitric acid (HNO_3)
iii. Sodium hydroxide (NaOH)
iv. Sodium chloride (NaCl)

$HCl\ (aq) \longrightarrow H^+(aq) + Cl^-(aq)$

$NaOH\ (aq) \longrightarrow Na^+(aq) + OH^-(aq)$

Weak Electrolytes:

"Those substances which partially (نامکمل، جزوی طور سے) ionize in water and can partially pass electric current are called weak electrolytes."

Examples:

Some examples of weak electrolytes are given below:

i. Acetic acid(CH_3COOH)
ii. Ammonium hydroxide(NH_4OH)
iii. Carbonic acid(H_2CO_3)
iv. Hydrofluoric acid(HF)

$CH_3COOH\ (aq) \rightleftharpoons H^+(aq) + CH_3COO^-(aq)$

$NH_4OH\ (aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

Non electrolytes:

"The substances which in aqueous solutions do not ionize and thus do not conduct the electric current are called **non electrolytes**."

Examples:

Some of the examples of non-electrolytes are given below:

i. Sugar ($C_{12}H_{22}O_{11}$)
ii. Glucose ($C_6H_{12}O_6$)
iii. Pure water (H_2O)
iv. Ethyl alcohol (C_2H_5OH)
v. Urea (H_2NCONH_2).

Q.8. What is meant by electrodes?

Ans: Electrodes:

"The metallic plates or rods through which the electric current enters or leave the electrolyte in a cell are called electrodes."

Types of electrodes:

There are two types of electrodes which are defined below:

Anode:

The electrode where oxidation takes place is called anode. It is positive in electrolytic cell and negative in Galvanic cell.

Cathode:

The electrode where reduction takes place is called cathode. It is negative in electrolytic cell and positive in Galvanic cell.

Q.9. What is meant by electrolysis?

Ans: Electrolysis:

Definition:

"The chemical change brought by passing electric current through an electrolyte in aqueous solution or in molten state is called electrolysis."

Explanation:

Electrolysis process is done in an apparatus called electrolytic cell. In electrolysis process, when an electric current is passed through an electrolyte in molten form or in aqueous solution the following reactions occur:

1. Anode half reaction:

The negative ions (anions) of electrolyte move towards the anode where they give electrons which pass through the external circuit and are consumed at the cathode.

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2. **Cathode half reaction**:

The positive ions (cations) of electrolyte move towards cathode and they receive the electrons lost at the anode. Thus the number of electrons lost is equal to the number of electrons gained. By adding the above two reactions, net reaction of the electrolysis is obtained.

Net Reaction = Anode half reaction + cathode half reaction

Q.10: How metals are purified electrolytically or Describe the electrolytic refining of copper.

Ans. Electrolytic Refining Of Copper:

Introduction:

Copper is one the most important metal used in electrical wires, utensils and different alloys like brass and bronze. The blister copper obtained from the metallurgy of copper is only 99%pure. Therefore, it must be made pure by the electrolysis process.

Construction Of The Cell:

It consists of a block of anode made of blistered copper. Cathode consists of a thin sheet of copper. These two electrodes are suspended in a solution of copper sulphate and sulphuric acid.

Conditions:

This process is carried out at 50^0C, voltage of 0.3 volts and a current density of 160-400 A/m^2.

Working:

When electric current is passed through the cell, the impure copper from the anode dissolves to give Cu^{+2} ions and $2e^-$ which move towards cathode. At cathode each Cu^{+2} picks up two electrons and reduced to pure metallic copper. Thus pure copper is deposited over the cathode. The reactions occurring at electrodes are given below:

At anode: $Cu(s) \longrightarrow Cu^{+2}(aq) + 2e^-$

At cathode: $Cu^{+2}(aq) + 2e^- \longrightarrow Cu(s)$

The impurities like Au, Ag, and Pt present in the blister copper remain undissolved due their less reactivity. They settle at the bottom of the tank called anode mud or sludge, where they are removed. By electrolytic refining of copper 99.99%pure copper is obtained.

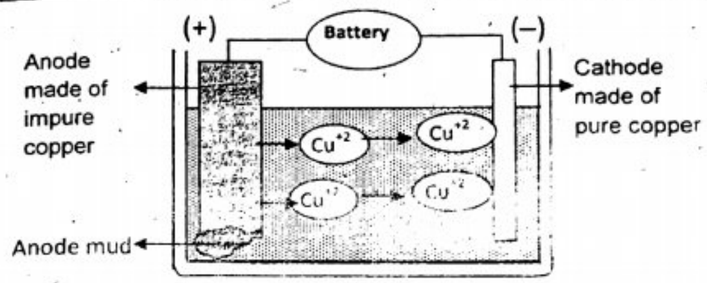

Figure: Electrolytic refining of Cu

Q.11: Describe Daniel cell OR write a note on Daniel cell.

Ans: Daniel cell:

Definition:

"Daniel cell is a galvanic cell which converts chemical energy into electric current."

Construction:

The Daniel cell consists of two half cells. In one half cell zinc rod is dipped in the solution of zinc sulphate acting as anode while the second half cell consists of copper rod dipped in a solution of copper sulphate acting as cathode. The two half cells are connected by a salt bridge. A salt bridge is a U-shaped tube containing an electrolyte such as potassium chloride (KCl). The electrodes are connected by wire and a voltmeter or Galvanometer is connected to it to record the electric current.

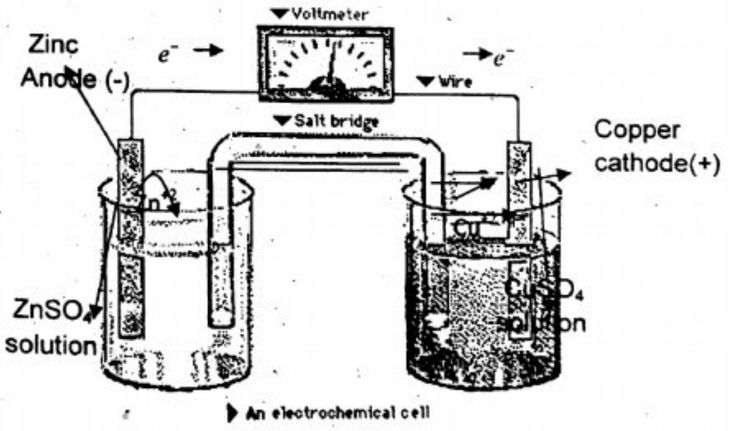

Figure: Daniel cell

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Working:

When the circuit is completed, zinc is oxidized to Zn^{+2} to and gives electrons to the electrode. These electrons are received by Cu electrode through the external circuit. Cu^{+2} ion present in solution take electrons from the cathode and are deposited over it as Cu metal. The two half reactions are given below:

Anode Half Reaction:

$$Zn(s) \longrightarrow Zn^{+2}(aq) + 2e^-$$

Cathode Half Reaction:

$$Cu^{+2}(aq) + 2e^- \longrightarrow Cu(s)$$

Net Reaction:

$$Zn(s) + Cu^{+2}(aq) \longrightarrow Zn^{+2}(aq) + Cu(s)$$

Both the half-cell reactions take place simultaneously, electrons travel in external circuit while ions move through the salt bridge and in this way electricity is generated.

Q.12: What are the differences between Galvanic cell and electrolytic cell?

Ans: Differences Between Galvanic Cell And Electrolytic Cell:

	Galvanic Cell	Electrolytic Cell
1.	It converts chemical energy into electrical energy.	It converts electrical energy into chemical energy.
2.	Its redox reaction is spontanseous.	Its redox reaction is non-spontaneous.
3.	The two electrodes are setup in separate containers.	The two electrodes are setup in the same container.
4.	The anode is negative and cathode is positive electrode.	The anode is positive and cathode is negative electrode.
5.	The electrons are supplied by the species getting oxidized.	The electrons are supplied by the external battery.

Q.13. Write a short note on battery.

Ans: Battery:

"A group of electrochemical cells connected in series to produce electric current is called battery.

Explanation:

Batteries contain chemicals and electrodes that can produce electric current for a specific period of time. There are two types of batteries.

i. Primary Batteries:

These are the batteries which cannot be recharged.

Example: Dry cells

ii. Secondary Batteries:

These are the batteries which can be recharged.

Examples:

Lead storage batteries, Li-ion batteries etc.

Q.14: Write a note on Dry cell?

Ans. The Dry Cell:

History:

The dry cell was prepared by French scientist Leclanche in 1887

Construction:

The dry cell consists of a zinc metal can which acts as anode. Inside this can is a moist porous paper which prevents zinc from coming in contact with other reactants but allows the diffusion of ions. In the centre of the can is a carbon rod (graphite), which acts as the cathode. Surrounding this rod is a watery paste of NH_4Cl and MnO_2, with some carbon added to improve the conductivity. The cell is water proofed with wax.

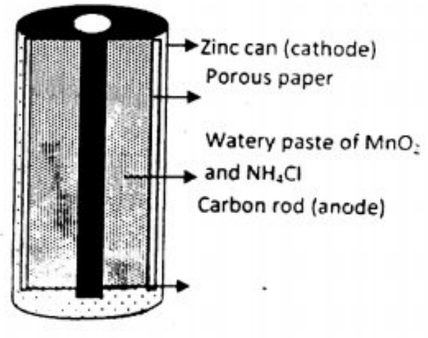

Figure: The dry cell

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Reactions:

The electric current is produced by oxidation-reduction reactions which are given below:

Reaction At Anode:

Zinc acts as anode in the cell. Each zinc atom loses two electrons to form Zn^{+2} ions.

$$Zn \longrightarrow Zn^{+2} + 2e^-$$

Reaction At Cathode:

The graphite acts as cathode in the cell. At cathode NH_4Cl and MnO_2 are reduced to Mn_2O_3 and NH_3.

$$2MnO_2 + 2NH_4Cl + 2e^- \longrightarrow Mn_2O_3 + 2NH_3 + H_2O + 2Cl^-$$

Net Reaction:

$$Zn + 2MnO_2 + 2NH_4Cl \longrightarrow Zn^{+2} + Mn_2O_3 + 2NH_3 + H_2O + 2Cl^-$$

The Zn^{+2} and Cl^- ions react to form $ZnCl_2$.

$$Zn^{+2} + 2Cl^- \longrightarrow ZnCl_2$$

Uses:

The dry cells are commonly used in many electrical appliances like calculators, clocks, electrical toys, radios, etc.

Q.15: What are electrochemical industries write their significance?

Ans: Electrochemical industries:

Electrochemical industries are the industries in which various processes like construction of batteries, cells, electroplating of metals, electrolytic conduction of metals are carried out.

Significance of electrochemical industries:

Some of the significances of electrochemical industries are given below:

i. These industries produce electrochemical batteries and cells which are used in toys, flash lights, mobiles, calculators, automobiles, radios, tape recorders etc,
ii. Electroplating (an electrochemical industry) is done for beauty, prevention from corrosion or repairing.
iii. Pure metals can be obtained by the electrolysis process.
iv. Many important chemicals are produced by electrochemical industries e.g. NaOH.

Q.16 Write in detail about the changes taking place when molten sodium chloride is electrolyzed OR Describe the electrolysis of molten (fused) sodium chloride.

Ans: Electrolysis of molten (fused) sodium chloride:

Pure sodium metal is commercially obtained by the electrolysis of fused NaCl. This process is done in an apparatus known as Down's cell. The detail is given below:

Construction Of Down's Cell:

The Down's cell consists of a steel container lined inside with fire bricks. The anode is made from graphite which is present at the centre of the lower bottom. The cathode is circular made from iron or copper. Both electrodes are separated by an iron screen for separation of the products. Above anode is a dome for collection of chlorine gas. The molten sodium above the cathode compartment.

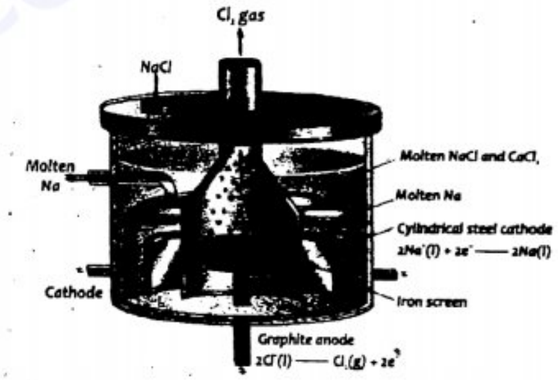

Figure:Down's Cell

Working:

Sodium chloride has a high melting point of 801^0C. So it is mixed with calcium chloride in ratio of 1:3, to lower its melting point up to 600^0C.

The molten NaCl is added to Down's cell containing Na^+ and Cl^- ions. When an electric current is passed then the Na^+ ions move towards the cathode(-ive electrode) while the Cl^- ions move towards the anode(+ive electrode). The detail of their reactions at the electrode is given below:

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Anode Half Reaction:

At anode each Cl^- ion give one electron and is changed to Cl-atom as Cl atoms cannot exist independently due to incomplete valance shell therefore, the two Cl atoms combine to form Cl_2 molecule. The reaction is given below:

$$2Cl^- \longrightarrow Cl_2 + 2e^- \quad \text{(oxidation)}$$

Cathode Half Reaction:

At cathode each Na^+ ion picks up one electron and is changed to Na-atom. The half reactions taking place is given below:

$$2Na^+ + 2e^- \longrightarrow 2Na \quad \text{(reduction)}$$

Net Reaction:

$$2Na^+ + 2Cl^- \longrightarrow 2Na + Cl_2$$

Thus, Cl_2 gas is obtained as by-product at the anode while pure Na metal is obtained at the cathode.

(Sodium was discovered by Humphrey Davey in 1807.)

Q.17: Describe the electrolysis of aqueous solution of NaCl OR how NaOH is obtained from Brine?

Ans: Electrolysis Of Aqueous Solution Of NaCl (Manufacture Of NaOH From Brine):

Sodium Hydroxide (NaOH) is commercially (صنعتی پیمانے پر) obtained from the electrolysis of concentrated solution of NaCl called brine. This process is done in an apparatus called Nelson's cell. The detail is given below:

Construction of Nelson's cell:

Nelson's cell consists of an outer steel cover. In the middle of the cell is a perforated U-shaped steel cathode. The anode is made from graphite which is suspended in the middle of U-shaped cathode. At the bottom is a catch basin for collecting NaOH.

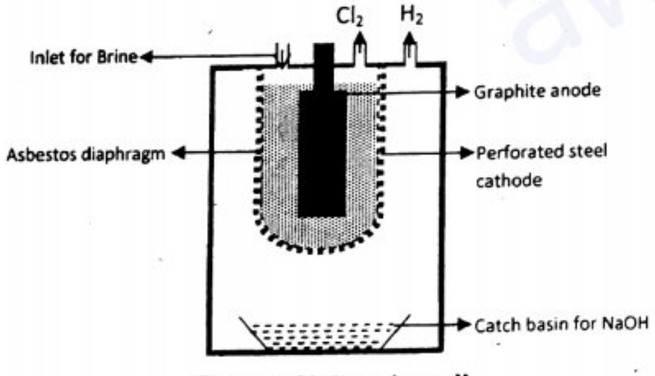

Figure: Nelson's cell

Working:

The saturated brine solution and water molecules ionize as follows:

$$2NaCl(aq) \longrightarrow 2Na^+(aq) + 2Cl^-(aq)$$
$$2H_2O(l) \longrightarrow 2H^+(aq) + 2OH^-(aq)$$

The brine is introduced to the cell through the upper inlet. When the electrode are connected to a battery, the positive ions Na^+ and H^+ move towards the cathode. Since H^+ ions have greater tendency to pick up electrons as compared to Na^+ ions therefore, the H^+ ions pick up electrons to form hydrogen gas. (The Na^+ ions remain in the solution)

At cathode:

$$2H^+(aq) + 2e^- \longrightarrow H_2(g) \text{ (reduction)}$$

The Cl^- and OH^- ions move towards the anode. As the Cl^- ions have greater tendency to give electrons therefore, the Cl^- ions give electrons and form chlorine gas.

At anode:

$$2Cl^-(aq) \longrightarrow Cl_2(g) + 2e^-$$

The Na^+ ions are not reduced instead they combine with the OH^- ions present in the solution to form NaOH(caustic soda).

$$2Na^+(aq) + 2OH^-(aq) \longrightarrow 2NaOH(aq)$$

Net Reaction:

$$2NaCl_{(aq)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)} + Cl_{2(g)}$$

The NaOH is collected at the bottom of the cell while Cl_2 gas is released at the anode and H_2 gas at the cathode.

Q.18: What is corrosion? How it can be prevented or describe the various method to prevent corrosion.

Ans: Corrosion:

"The slow and continuous eating away of a metal surface is called corrosion."

Explanation:

Corrosion usually starts at the exposed (کھلی ہوئی) surface of a metal and then become deeper and deeper and thus destroys the whole metal. Corrosion involves oxidation-reduction reactions and it is due to the conversion of metal into oxide by the environmental effect.

Examples:

Rusting of iron, zinc, etc are the examples of corrosion.

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Methods to prevent corrosion:

Corrosion can be prevented by the following methods:

i. Metallic coating:

Metallic coating is used to prevent (بچانا) the metal from the atmospheric effects. A thin coating of one superior metal is deposited over the other by spraying, galvanizing or by electroplating. For example iron articles are protected (حفاظت کرنا) from corrosion by nickel (Ni), chromium (Cr) or tin(Sn) plating

ii. Paints coating:

Paints form a protective layer (تہہ) over metals thus prevent them from corrosion. Modern paints contain chemicals called stabilizers which protect metals from corrosion as well as from weathering and other atmospheric effects.

iii. Alloying:

Alloying of the metals also eliminates (ختم کرنا) corrosion. For example stainless steel is corrosion resistant which is an alloy of iron with Ni, Cr and Si.

iv. Corrosion Inhibitors:

These are chemicals which stops the reaction of corrosion e.g. glycine, polyethylene etc.

v. Cathodic Protection:

This method is used to protect iron in buried fuel tanks and pipelines. In this method, an active metal like zinc or magnesium is connected with iron through a wire. They are good reducing agents than iron, therefore they supplies electrons and are oxidized instead of iron. During this process the Mg or Zn dissolves so they are replaced periodically.

Ships hulls are protected in the same way by attaching bars of titanium metal to the steel hull.

vi. Removal Of Stains:

By removing stains corrosion can be eliminated to some extent.

Q.19: Write a short note on rusting of iron.

Ans: Rusting of iron:

Pure iron is a silvery white but when it is exposed to moist air it is corroded and converted into a reddish brown mass called rust.

Composition of rust:

Chemically rust is hydrated iron(III) oxide ($Fe_2O_3\ xH_2O$).

Conditions necessary for rusting:

i. Water or moisture
ii. Air in the environment

Process/Chemistry Of Rust Formation:

Rusting occurs at that part which contains dents and stains. This is called anodic site and the following reactions occur at this site.

At Anode:

Iron is oxidized at the anode forming Fe^{+2} ions and electrons. The electrons move on the surface of the metal to cathode where they react with water and oxygen of air to form hydroxide ions.

Anode reaction:

$$2Fe \longrightarrow 2Fe^{+2} + 4e^-$$

Cathode reaction:

$$2H_2O + O_2 + 4e^- \longrightarrow 4OH^-$$

The Fe^{+2} ion is further oxidized by atmospheric oxygen to Fe^{+3} ion which react with OH^- ions to form $Fe(OH)_3$ which is then changed to hydrated iron(III) oxide (rust)

$$Fe^{+2} \longrightarrow Fe^{+3} + 1e^-$$

$$Fe^{+3} + 3\ OH^- \longrightarrow Fe(OH)_3$$

The rust mass is soft and porous(سوراخدار) therefore, it cannot stop further atmospheric action and the rust goes on deeper and deeper and destroys the whole iron articles.

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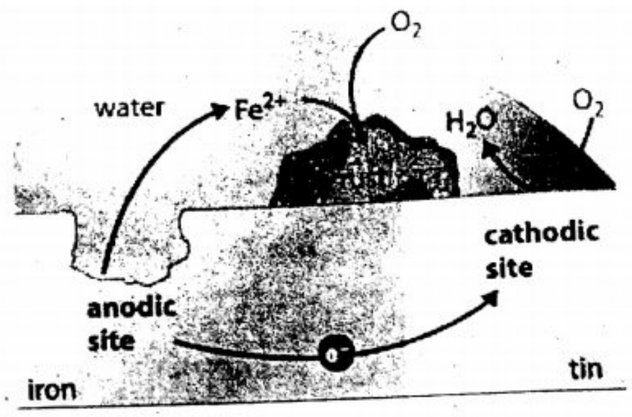

Figure: Rusting of iron

Q.20: What is electroplating and what are its significance/purposes?

Ans: Electroplating:

"A process in which a layer of some superior (جس کو رنگ نہ لگے) metal is deposited (چڑھانا) over some other elements like iron, copper etc. with the help of electricity is called **electroplating**."

Procedure Of Electroplating:

It is explained under the following headings:

i. Cathode:

During this process the substance to be electroplated is cleaned with caustic soda and water and then it is made the cathode.

ii. Anode:

A pure sheet or rod of the metal to be deposited is made the anode.

iii. Electrolyte:

Soluble salt of the metal to be deposited is used as electrolyte. The container is made of glass, cement or wood.

iv. Passage Of Electric Current:

The electrodes are connected to the two terminals of a battery. When electric current is passed, the metal atoms from the anode are deposited over the cathode.

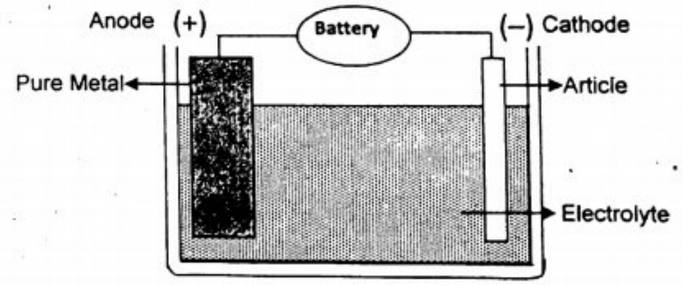

Figure: Electroplating

Significance/Purposes Of Electroplating:

Electroplating is done for the following purposes:

1. For Decoration:

It is done for decoration. For example silver (Ag) and gold (Au) are deposited over the cheap metals like copper (Cu) to give it pleasing look (اچھا نظر آنا).

2. For Protection:

It is done for protection from corrosion. For example nickel (Ni) and chromium (Cr) are deposited over other metals like iron (Fe) or copper (Cu) to prevent them from corrosion (زنگار پذیری).

3. For Repairing:

Electroplating is also done for welding the broken parts of machinery.

Q.21: Write a short note on zinc plating?

Ans: Zinc Plating:

"The deposition of zinc metal over other metals with the help of electricity is called zinc electroplating or zinc plating."

Procedure Of Zinc Plating:

In this process the cleaned article to be zinc plated is made the cathode. A pure sheet of zinc is made the anode. The solution of zinc sulphate ($ZnSO_4$) and sulphuric acid (H_2SO_4) is used as electrolyte. The two electrodes are connected to a battery.

When electric current is passed the atoms of zinc from the anode give electrons forming Zn^{+2} ions. The electrons reach the cathode through the external circuit where they are consumed by Zn^{+2} ions of the solution.

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Thus, Zn metal is deposited over the cathode. The anode is used up gradually and is replaced after sometime.

Reactions:

The reactions occurring at the cathode and anode are given below:

At Anode:

$$Zn(s) \longrightarrow Zn^{+2}(aq) + 2e^-$$

At Cathode:

$$Zn^{+2}(aq) + 2e^- \longrightarrow Zn(s)$$

Q.22: Write a short note on chrome plating?

Ans: Chrome Plating:

"The deposition of chromium metal over other metals with the help of electricity is called chrome electroplating or chrome plating."

Procedure Of Chrome Plating:

In this process the cleaned article to be chromium plated is made the cathode. A pure sheet of chromium is made the anode. The solution of chromic acid (H_2CrO_4) and sulphuric acid (H_2SO_4) is used as electrolyte. The two electrodes are connected to a battery.

When electric current is passed the atoms of chromium from the anode give electrons forming Cr^{+3} ions. The electrons reach the cathode through the external circuit where they are consumed by Cr^{+3} ions of the solution. Thus, Cr metal is deposited over the cathode. The anode is used up gradually and is replaced after sometime.

Reactions:

The reactions occurring at the cathode and anode are given below:

At Anode:

$$Cr(s) \longrightarrow Cr^{+3}(aq) + 3e^-$$

At Cathode:

$$Cr^{+3}(aq) + 3e^- \longrightarrow Cr(s)$$

Q.23 *Write a short note on silver plating?

Ans: Silver Plating:

"The deposition of silver metal over other metals with the help of electricity is called silver electroplating or silver plating."

Procedure Of Silver Plating:

In this process the cleaned article to be silver plated is made the cathode. A pure sheet of silver is made the anode. The solution of silver cyanide (AgCN) is used as electrolyte. The two electrodes are connected to a battery.

When electric current is passed the atoms of silver from the anode give electrons forming Ag^{+1} ions. The electrons reach the cathode through the external circuit where they are consumed by Ag^{+1} ions of the solution. Thus, Ag metal is deposited over the cathode. The anode is used up gradually and is replaced after sometime.

Reactions:

The reactions occurring at the cathode and anode are given below:

At Anode:

$$Ag(s) \longrightarrow Ag^{+1}(aq) + 1e^-$$

At Cathode:

$$Ag^{+1}(aq) + 1e^- \longrightarrow Ag(s)$$

Q.24: Write a short note on tin plating?

Ans:Tin Plating:

"The deposition of tin metal over other metals with the help of electricity is called tin electroplating or tin plating."

Procedure Of Tin Plating:

In this process the cleaned article to be tin plated is made the cathode. A pure sheet of tin is made the anode. The solution of sodium stennate [$Na_2SnO_3.3H_2O$] is used as electrolyte. The two electrodes are connected to a battery.

When electric current is passed the atoms of tin from the anode give electrons forming Sn^{+2} ions. The electrons reach the cathode through the external circuit where they are consumed by Sn^{+2} ions of the solution. Thus, Sn metal is deposited over the cathode. The anode is used up gradually and is replaced after sometime.

Reactions:

The reactions occurring at the cathode and anode are given below:

At Anode:

$$Sn(s) \longrightarrow Sn^{+2}(aq) + 2e^-$$

At Cathode:

$$Sn^{+2}(aq) + 2e^- \longrightarrow Sn(s)$$

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EXERCISE

Multiple Choice Questions

Q.1. Choose the correct answers:

i. Which one of the following is an electrolyte?
A) Sugar solution **B) Table salt solution**
C) Plastic D) Wood

ii. Which of the following is not an electrolyte?
A) Acid solution B) Bases solution
C) Salt solution **D) Glucose solution**

iii. Which one of the following is a strong electrolyte in solution?
A) H_2CO_3 B) NH_4OH **C) HCl** D) CH_3COOH

iv. Ionic compounds conduct electricity when they are in:
A) Solid state B) Crystalline state
C) Anhydrous state **D) Molten state**

v. Cathode is the electrode where the reaction taking place is:
A) Oxidation reaction **B) Reduction reaction**
C) Salt is formed D) No reaction occurs

vi. An element is reduced if its:
A) Oxidation number is decreased
B) Oxidation number is increased
C) There is no change in the oxidation number
D) Both A and C

vii. Which of the following is a reduction reaction?
A) $Br_2(s) + 2e^- \longrightarrow 2Br^-(aq)$
B) $Na^+(aq) \longrightarrow Na(s) + e^-$
C) $Zn(s) \longrightarrow Zn^{+2}(aq) + 2e^-$
D) $K(s) \longrightarrow K^+(aq) + e^-$

viii. The lead storage battery is a/an:
A) Daniel cell **B) Reversible voltaic cell**
C) Dry cell D) Electrolytic cell

ix. In a Galvanic cell the energy converted to electrical energy is:
A) Kinetic energy B) Potential energy
C) Heat energy **D) Chemical energy**

x. A cation is a/an:
A) Neutral B) Negatively charged
C) Positively charged D) Coloured

xi. The oxidation number of nitrogen(N_2) is:
A) +1 B) +3 **C) 0** D) -3

xii. What is the oxidation number of C in CH_3OH?
A) -2 B) -1 C) 0 D) +1

xiii. Electrons are lost by:
A) Reducing agent as it undergoes oxidation
B) Reducing agent as it undergoes reduction
C) Oxidizing agent as it undergoes oxidation
D) Oxidizing agent as it undergoes reduction

xiv. What is the oxidation number of manganese in $KMnO_4$:
A) +7 B) +3 C) +2 D) +4

xv. In a particular reaction, the oxidation number of phosphorus changed from -3 to 0. From this information it may be concluded that phosphorus:
A) Lost 3 electrons and was reduced
B) Lost 3 electrons and was oxidized
C) Gained 3 electrons and was reduced
D) Gained 3 electrons and was oxidized

xvi. Which statement in true for an electrochemical cell?
A) Oxidation occurs at anode only
B) Reduction occurs at anode only
C) Oxidation occurs at both the anode and cathode
D) Reduction occurs at both the anode and cathode

xvii. In which of the following sulphur has an oxidation state of +7?
A) HSO_3 B) SO_3 C) H_2SO_4 **D) $H_2S_2O_8$**

xviii. What happens to reducing agent in oxidation-reduction reaction?
A) It is oxidized as it gains electrons
B) It is oxidized as it loses electrons
C) It is reduced as it gains electrons
D) It is reduced as it loses electrons

xix. In an electrochemical cell electrons travel in which direction?
A) From anode to cathode through the external circuit
B) From anode to cathode through the salt bridge
C) From cathode to anode through the external circuit
D) From cathode to anode through the salt bridge

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Short Questions

Answer briefly the following questions:

i. Indicate which element is reduced in the following reactions?

a. $Ca_{(s)} + Br_{2(g)} \longrightarrow CaBr_{2(s)}$

b. $8H^+ + MnO_4^- + 5\bar{e} \longrightarrow Mn^{+2} + 4H_2O$

Ans: The element whose oxidation number decreases during a chemical reaction is said to be reduced. Therefore:

(a) $Ca_{(s)} + Br_{2(g)} \longrightarrow CaBr_{2(s)}$

Ca = 0, Br = 0 Ca = +2, Br = -1

In the above reaction the oxidation state of Br is decreased from 0 to -1. Therefore, Bromine (Br) is reduced in this reaction.

(b) $8H^+ + MnO_4^- + 5\bar{e} \longrightarrow Mn^{+2} + 4H_2O$

H = +1 H = +1

Mn = +7 Mn = +2

O = -2 O = -2

In the above reaction the oxidation state of Mn is decreased from +7 to +2. Therefore, manganese (Mn) is reduced in this reaction.

ii. What is the oxidation state of silver on each side of the following equation?

$4Ag_{(s)} + O_{2(g)} \longrightarrow 2Ag_2O_{(s)}$

Ans: Oxidation State Of Ag In The Given Equation:

$4Ag_{(s)} + O_{2(g)} \longrightarrow 2Ag_2O_{(s)}$

Reactant Side:

On reactant side the oxidation state of Ag is zero because it is in free state.

Products Side:

According to rules:

Oxidation state of O = -2

Let oxidation state of Ag=x

Therefore in Ag_2O:

2(oxidation state of Ag) + (oxidation state of O) = 0

Putting the values we get:

2(x)+(-2) = 0

⇨ 2x – 2 = 0

⇨ 2x -2+2 = 0+2

⇨ 2x = +2

⇨ 2x/2 =+ 2/2

⇨ x = +1

Thus oxidation state of Ag on product side is +1.

iii. Why NaOH is a strong but NH_4OH is a weak electrolyte?

Ans: The answer of the given question is explained under the following headings:

Reason For NaOH Being Strong Electrolyte:

Strong electrolytes are those which ionize in water up to a maximum extent and easily pass electric current. NaOH is a strong electrolyte because it ionizes in water up to a maximum extent(84%) and it easily pass the electric current.

Reason For NH_4OH Being Weak Electrolyte:

Weak electrolyte are those which partially ionize in aqueous solution and partially pass the electric current.NH_4OH is a weak electrolyte because it partially ionizes (1.3%) in water and hardly passes electric current.

iv. How to prevent corrosion? Enlist few of the methods.

Ans: For answer see Question no.18

v. Write chemical reactions that occur in Nelson's cell?

Ans: Chemical Reactions Of Nelson's Cell:

In Nelson's cell the following two reactions occur:

At Cathode:

The positive ions Na^+ and H^+ move towards the cathode. Since H^+ ions have greater tendency to pick up electrons as compared to Na^+ ions therefore, the H^+ ions pick up electrons to form hydrogen gas. (The Na^+ ions remain in the solution)

$2H^+(aq) + 2e^- \longrightarrow H_2(g)$ (reduction)

At anode:

The Cl^- and OH^- ions move towards the anode. As the Cl^- ions have greater tendency to give electrons therefore, the Cl^- ions give electrons and form chlorine gas.

$2Cl^-(aq) \longrightarrow Cl_2(g) + 2e^-$ (oxidation)

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The Na^+ ions are not reduced instead they combine with the OH^- ions present in the solution to form NaOH(caustic soda).

$$2Na^+(aq) + 2OH^-(aq) \longrightarrow 2NaOH(aq)$$

Net Reaction:

$$2NaCl_{(aq)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)} + Cl_{2(g)}$$

vi. Write one example from daily life which involves oxidation-reduction reaction?

Ans: One Example From Daily Life involving Redox Reaction:

It is given below:

Burning Of Coal:

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

C=0, O=0 C=+4, O=-2

In the above example, carbon is oxidized while oxygen is reduced, therefore it is oxidation-reduction reaction.

vii. Assign oxidation numbers to each element in the following compounds?

a. HI b. PBr_3 c. $CaCO_3$ d. H_3PO_4
e. As_2O_5 f. H_2SO_4

Ans:

S.No	Compound	Oxidation state of each element
a.	HI	H=+1, I= -1
b.	PBr_3	P=+3, Br = -1(3Br = -3)
c.	$CaCO_3$	Ca=+2, C=+4, O= -2(3O = -6)
d.	H_3PO_4	H=+1(3H=+3), P=+5, O=-2(4O=-8)
e.	As_2O_5	As=+5(2As=+10), O= -2(5O= -10)
f.	H_2SO_4	H=+1(2H=+2), S=+6, O= -2(4O= -8)

viii. Why O_2 is necessary for rusting?

Reason For O_2 Being Necessary For Rusting:

Chemically rusting is the change of iron surface into oxide (Fe_2O_3). The composition of rust contains oxygen atoms. Therefore rust cannot be formed without oxygen as it is the basic constituent of rust.

Ix. Sketch Daniel cell, labeling the cathode, anode and the direction of the flow of current.

Ans: For answer see the diagram in Question no.11

x. Write down some possible uses of electrolytic cell?

Ans: Some Uses Of Electrolytic Cell:

Some uses of electrolytic cell are given below:

i. For Preparation Of Various Chemicals:

Electrolysis is used for the preparation of important chemicals e.g. NaOH

ii. For Preparation Of Pure Metals:

Pure metals are obtained by this process e.g. Pure Na

iii. For Refining Of Metals:

Electrolytic cell is also used for the refining of metals e.g. electrolytic refining of copper

iv. For Electroplating:

Electrolytic cell is also used in electroplating process e.g. copper plating

Long Questions

i. a. What is electroplating?

b. Distinguish the nature of anode and cathode in such process.

Ans (a) For answer see Question no.16

Ans (b) Nature Of Anode And Cathode During Electroplating:

The nature of anode and cathode during electroplating is given below:

	Anode	Cathode
1	During electroplating anode is made from the metal to be electroplated on other articles.	During electroplating the cathode is made from cleaned article, on which electroplating is to be done.
2	It is positive.	It is negative.
3	On this oxidation occurs.	On this reduction occurs.
4	It dissolves during electroplating.	It does not dissolves rather plate is formed on it.

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ii. Differentiate between oxidation and reduction? Write an equation to illustrate each.

Ans: **Differences Between Oxidation And Reduction:**

	Oxidation	Reduction
1	The reaction is which addition of oxygen occurs is called oxidation.	The reaction in which removal of oxygen occurs is called reduction.
2	The reaction in which loss of electrons occur is called oxidation.	The reaction in which gain of electrons occur is called reduction.
3	The reaction in which removal of hydrogen occurs is called oxidation	The reaction is which addition of hydrogen occurs is called reduction.
4	**One Equation:** $C+O_2 \longrightarrow CO_2$	**One Equation:** $2HgO \longrightarrow 2Hg+O_2$

iii. a. What is corrosion? Explain rusting of iron as example?

Ans: For answer see Question no.18 + 19

b. Differentiate between electrolytic cell and voltaic cell?

Ans: For answer see question no.12

c. Discuss the method of recovering metal from its ore.

Ans: **Method Of Recovering Metal From Its Ore:**

The method of recovering metal form its ore is called metallurgy.

Steps:

It involves the following steps

i. Mining
ii. Grinding and crushing
iii Concentration
iv. Roasting and calcination
v Smelting and reduction
vi. Electro-refining

Their detail is given below:

i. Mining:

Extracting ores from the ground by digging the earth is called mining.

ii. Grinding and crushing:

The ore obtained by mining consists of large pieces. In this step the ore is converted to small pieces.

iii. Concentration:

The ore contain a large amount of gangue. In order to remove sufficient amount of gangue, concentration of ore is carried out.

iv. Roasting and calcination:

The heating of ore in the presence of air is called roasting e.g.

$Cu_2S.Fe_2S_3 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2$

The removal of water from hydroxide ore or removal of CO_2 from carbonate ore by heating the ore in absence of air is called calcination e.g.

$2Al(OH)_3 \xrightarrow{heat} Al_2O_3 + 3H_2O$

$CaCO_3 \xrightarrow{heat} CaO + CO_2$

v. Smelting and reduction:

In smelting and reduction, the ore is heated with a reducing agent and a flux ($CaCO_3$) to a high temperature.

vi. Electro-refining:

By electro-refining process, metal is purified. For example:

Electrolytic Refining Of Copper:

Introduction:

Copper is one the most important metal used in electrical wires, utensils and different alloys like brass and bronze. The blister copper obtained from the metallurgy of copper only 99%pure. Therefore, it must be made pure by the electrolysis process.

Construction Of The Cell:

It consists of a block of anode made of blistered copper. Cathode consists of a thin sheet of copper. These two electrodes are suspended in a solution of copper sulphate and sulphuric acid.

Conditions;

This process is carried out at 50^0C, voltage of 0.3 volts and a current density of 160-400 A/m^2.

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Working:

When current is passed through the cell, the impure copper from the anode dissolves to give Cu^{+2} ions which move towards cathode. At cathode each Cu^{+2} picks up two electrons and reduced to pure metallic copper. Thus pure copper is deposited over the cathode. The reactions occurring at electrodes are given below:

At anode: $Cu(s) \longrightarrow Cu^{+2}(aq) + 2e^-$

At cathode: $Cu^{+2}(aq) + 2e^- \longrightarrow Cu(s)$

The impurities like Au, Ag, and Pt present in the blister copper remain undissolved due their less reactivity. They settle at the bottom of the tank called anode mud or sludge, where they are removed. By electrolytic refining of copper 99.99%pure copper is obtained.

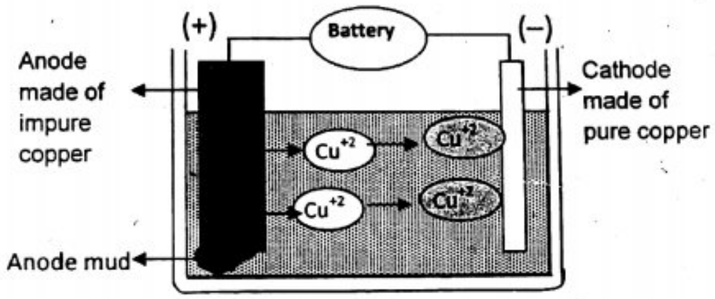

Figure: Electrolytic refining of Cu

iv. Discuss the preparation of sodium hydroxide from brine along with diagram and reactions at cathode and anode?

Ans: For answer see Question no.17

Some Extra Questions

i. Define oxidation state.

Ans: **Oxidation state:**

"The apparent charge, positive or negative, on an atom of an element in a molecule or an ion is called oxidation sate."

Examples:

For example oxidation state of:

i. Na in NaCl = +1

ii. Mg in $MgCl_2$ = +2,

iii. Al in $AlCl_3$ = +3 etc.

Numerical Questions

i. Determine the oxidation numbers of phosphorus and chlorine in phosphorus pentachloride(PCl_5)?

Given:

Substance = PCl_5

Required:

Oxidation states of P and Cl= ?

Solution:

According to rules oxidation number of Cl= -1

Let oxidation number of P = x

In PCl_5:

(oxidation no. of P)+5(oxidation no. of Cl) = 0

Putting the values we get:

$x + 5(-1) = 0$

$\Rightarrow x - 5 = 0$

$\Rightarrow x - 5 + 5 = 0 + 5$

$\Rightarrow x = +5$

Result:

Oxidation no. of P = +5, oxidation no. of Cl = -1

ii. What is the oxidation no. of nitrogen innitrite ion (NO_2^-)?

Given:

Species = NO_2^-

Required:

Oxidation states N = ?

Solution:

According to rules:

oxidation number of O = -2

Let oxidation number of N = x

Therefore in NO_2^-:

(oxidation no. of N) +2(oxidation no. of O) = 0

Putting the values we get:

$x + 2(-2) = -1$

$\Rightarrow x - 4 = -1$

$\Rightarrow x - 4 + 4 = -1 + 4$

$\Rightarrow x = +3$

Result:

Oxidation no. of N = +3

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iii. What is the oxidation number of carbon in CO_2?

Given:

Substance = Carbon dioxide (CO_2)

Required:

Oxidation number of C = ?

Solution:

According to the rules oxidation number of oxygen = **–2**

Let oxidation number of carbon = x

Therefore in CO_2:

(Oxidation number of C) + 2(oxidation number of O) = 0

Putting the values

$x + 2(-2) = 0$

$\Rightarrow x - 4 = 0$

$\Rightarrow x = +4$

Oxidation number of carbon = **+4**

Result:

Oxidation number of C = **+4**

iv. Determine the oxidation number of sulphur in sulphite ion(SO_3^{-2})?

Given:

Species = SO_3^{-2}

Required:

Oxidation states S = ?

Solution:

According to rules:

oxidation number of O = -2

Let oxidation number of S = x

Therefore in SO_3^{-2}:

(oxidation no. of S)+3(oxidation no. of O) = -2

Putting the values we get:

(x)+3(-2) = -2

⇨ x-6 = -2

⇨ x – 6+6 = -2+6

⇨ x = +4

Result:

Oxidation no. of S = +4

v. What are the three possible oxidation states of sulphur?

Ans: Three Possible Oxidation States Of S:

In free state = 0

In combined state its possible oxidation states are +6 and -2

(it can have oxidation states of +2 and +4)

Examples:

Oxidation state of S in S_8 = 0

Oxidation state of S in H_2SO_4 = +6

Oxidation state of S in H_2S = -2

(Oxidation state of S in SO_2 = +4

Oxidation state of S in $Na_2S_2O_3$ = +2)

vi. What are the possible oxidation states of copper?

Ans: Possible Oxidation States Of Cu:

In free state = 0

In combined state its possible oxidation states are +1 and +2.

Examples:

The oxidation state of free Cu = 0

In Cu_2O the oxidation state of Cu = +1

In CuO the oxidation state of Cu = +2

vii. What is minimum oxidation number of silver?

Ans: Minimum Oxidation Number Of Silver:

The minimum oxidation number of silver is +1.

Example:

Oxidation number of silver in AgCl = +1

Extra Numerical Questions

Q : Calculate the oxidation number of Sn in $SnCl_4$.

Given:

Substance = $SnCl_4$

Required:

Oxidation number of Sn (tin) in $SnCl_4$ (tin tetrachloride)

Solution:

According to the rules the oxidation number of Cl = –1

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Let oxidation number of Sn = x
Therefore in $SnCl_4$:
Oxidation number of Sn + 4(oxidation number of Cl) = 0
Putting the values
$x + 4(-1) = 0$
$\Rightarrow x - 4 = 0$
$\Rightarrow x = +4$
Oxidation number of Sn = **+4**

Result:
Oxidation number of Sn in $SnCl_4$ = **+4**

Q: Calculate the oxidation number of S in K_2SO_4.
Given:
Substance = K_2SO_4
Required:
Oxidation number of S (sulphur) in K_2SO_4
Solution:
According to the rules the oxidation number of K = +1
Similarly oxidation number of O = –2
Let oxidation number of S = x
Therefore in K_2SO_4:
2(Oxidation number of K) + oxidation number of S +4(oxidation number of O) = 0
Putting the values
$2(+1) + x + 4(-2) = 0$
$\Rightarrow +2 + x - 8 = 0$
$\Rightarrow x - 6 = 0$
$\Rightarrow x = +6$
Oxidation number of S = **+6**

Result:
Oxidation number of S in K_2SO_4 = **+6**

Q : What is the oxidation state of N in NO, NO_2 and HNO_3?
Ans: Given:
Substances = NO, NO_2 and HNO_3
Required:
Oxidation states of N in NO, NO_2 and HNO_3

Solution:
i. Oxidation state of N in NO:
According to the rules the oxidation state of O = –2
Let the oxidation state of N = x
Therefore in NO:
Oxidation state of N + oxidation state of O = 0
Putting the values
$x + (-2) = 0$
$\Rightarrow x - 2 = 0$
$\Rightarrow x = +2$
Oxidation state of nitrogen = **+2**

ii. Oxidation state of N in NO_2:
According to the rules the oxidation state of O = –2
Let the oxidation state of N = x
Therefore in NO_2:
Oxidation number of N + 2(oxidation number of O) = 0
Putting the values
$x + 2(-2) = 0$
$\Rightarrow x - 4 = 0$
$\Rightarrow x = +4$
Oxidation state of nitrogen = **+4**

iii. Oxidation state of N in HNO_3:
According to the rules the oxidation sate of O = –2 and H = +1
Let the oxidation number of N = x
Therefore in HNO_3:
Oxidation sate of H + oxidation sate of N + 3(oxidation sate of O) = 0
Putting the values
$1+x+ 3(-2) = 0$
$\Rightarrow 1+x - 6 = 0$
$\Rightarrow x - 5 = 0 \Rightarrow x = +5$
Oxidation sate of nitrogen = **+5**

Result:
Oxidation states of N in NO = **+2**, in NO_2= **+4** and in HNO_3= **+5**

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Chapter No.08
Chemical Reactivity

Q.1. Describe the occurrence of metals on the earth.

Ans. Occurrence of metal on the earth:

Metals made a large part of the earth. It is made up of about 8% aluminum, 5% iron, 4% calcium and less than 4% of potassium, sodium and magnesium. The core (زمین کا اندرونی حصہ) of the earth is made up mainly of nickel and iron. Mercury, gold and lead is also present in it away from the surface.

Q.2. In periodic table which groups contain metal elements?

Ans. Position of metals in periodic table:

It is explained below:

Group IA:

In periodic table the elements of group IA (except hydrogen) are metals.

Group IIA:

All the elements of group IIA are metals.

Group IIIA:

All the elements of group IIIA, except boron, are metals.

Group IVA:

In group IVA, tin and lead are metals.

Group VA:

In group VA, antimony and bismuth are metals.

d- block and f-block:

The d-block elements (IB to VIIIB) and f-block elements (actinide and lanthanide series) are all metals.

Q.3. How a metal can be recognized? OR
Describe a test for identifying metal?

Ans. Test for metals:

In order to decide whether the element is metallic or not, the electrolytic test is conducted(ٹیسٹ کرنا). The test is explained below:

In this test the element is dissolved in an acid solution. Then electric current is passed through the solution. If the element is metallic its atoms will become positively charged and will move towards the cathode (negative electrode).

Example:

The example is given below:

$Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$

$ZnCl_2(aq) \longrightarrow Zn^{+2}(aq) + Cl^-(aq)$

Zn^{+2} will move towards the cathode. Therefore, Zn is a metal.

Q.4. Define metals and non-metals and compare their properties both physical and chemical?

Ans: Metals and non-metals:

"A metal is that element which loses electron(s) and forms a cation while a non-metal is that element which gains electron(s) and form anion."

Examples Of Metals:

Sodium (Na), iron(Fe), gold(Au), silver(Ag) etc are the examples of metals.

Examples Of Non-metals:

Hydrogen (H), oxygen(O), nitrogen(N), Chlorine(Cl) etc are the examples of non-metals.

Comparison Between Physical Properties:

It is given below:

	Metals	Non-metals
1.	Metals are good conductors of heat and electricity.	Non-metals are insulators except graphite.
2.	Metals are malleable.	Non-metal are not malleable.
3.	Metals are ductile.	Non-metals are not ductile.
4.	Metals are lustrous.	Non-metals are usually non-lustrous.
5.	At room temperature metals are solids except mercury.	At room temperature non-metals exist in all the three states of matter.
6.	Metals are sonorous.	Non-metals are not sonorous.

Comparison Between Chemical Properties:

It is given below:

	Metals	Non-metals
1	**Electropositive Character:** Metals have the ability to lose electron(s) to form cation (s). This is called electropositive or metallic character. **Examples:** $Na \longrightarrow Na^+ + 1e^-$ $Ca \longrightarrow Ca^+ + 2e^-$	**Electronegative Character:** Non-metals have the ability to accept electron(s) to form anion(s). This is called electronegative character. **Examples:** $Cl + 1e^- \longrightarrow Cl^-$ $O + 2e^- \longrightarrow O^{-2}$
2	**Reaction With Dil. Acids:** Generally metals react with dilute acids to form salts and hydrogen gas.	**Reaction With Dil. Acids:** Non-metals do not react with dilute acids.

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	Examples: $Zn_{(s)}+2HCl_{(dil)} \longrightarrow ZnCl_{2(aq)}+H_{2(g)}$ $Mg_{(s)}+2HCl_{(dil)} \longrightarrow MgCl_{2(aq)}+H_{2(g)}$	
3	**Nature Of Oxides:** The oxides of metals are basic and form basic solution in water. **Examples:** $Na_2O+H_2O \longrightarrow 2NaOH(basic)$ $Li_2O+H_2O \longrightarrow 2LiOH(basic)$	**Nature Of Oxides:** The oxides of non-metals are acidic and form acidic solution in water. **Examples** $CO_2+H_2O \longrightarrow H_2CO_3(Acidic)$ $SO_3+H_2O \longrightarrow H_2SO_4(Acidic)$
4	**Reaction With Each Other:** Metals do not chemically react with each other	**Reaction With Each Other:** Non-metals can react with each other to form compounds. e.g, $C_{(s)}+O_{2(g)} \longrightarrow CO_{2(g)}$

Q.5. What is electropositive character/metallic character? OR Discuss its variation along a period and group.

Ans. Electropositive character:

All the metals have the ability to lose electrons to form cation (positive ion). This ability of metal atom to lose electron is called electropositive or metallic character.

For example:

$Na + energy \longrightarrow Na^+ + 1e^-$

$K + energy \longrightarrow K^+ + 1e^-$

Explanation:

The elements having low ionization energies have higher tendency to give electrons, thus they are electropositive or metallic in their behaviors. Alkali metals have lowest ionization energies therefore they are the most electropositive elements

On the other hand elements having high ionization energies are non-metals while the border line elements behave as metalloids.

Factors Affecting Electropositive/Metallic Character:

Electropositive or metallic character depends on the following factors;

i. Atomic size
ii. Nuclear Charge
iii. Ionization energy
iv Shielding effect

Variation in Periods:

The electropositive or metallic character decreases along a period because of decrease in atomic size and increase in I.E. In other words the non-metallic character increases.

For example let us consider elements of periods 2 and 3.

		Metals		Metalloid	Non-metals			
Period 2	Li	Be	B	C	N	O	F	Ne
Period 3	Na	Mg	Al	Si	P	S	Cl	Ar
		Metals		Metalloid	Non-metals			

Variation In Groups:

Down the group the electropositive or metallic character increases due to increase in atomic size and decrease in I.P. In other words the non-metallic character decreases.

For example let us consider the elements of group IVA and VA.

	Group IV	Group V	
Nonmetal	C	N	Non- metals
Metalloids	Si	P	
	Ge	As	Metalloids
Metals	Sn	Sb	
	Pb	Bi	Metal

Q.6. Write a note on alkali metals.

Ans. Alkali Metals:

Alkali is an Arabic word which means "ashes". These metals were first found in ashes of plants. Some chemists say that they are called alkali metals because they form alkalies.

Group Number:

In periodic table the elements of group IA except hydrogen are called alkali metals.

Group Members:

The group members of alkali metals along with their symbols are given below:

Elements	Symbols
Lithium	Li
Sodium	Na
Potassium	K
Rubidium	Rb
Cesium	Cs
Francium	Fr

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Occurrence Of Alkali Metals:

Alkali are very reactive metals due to their lowest I.P values that is why they are not found free in nature.

Lithium:

It is mostly found in the form of Spodumene, $LiAl(SiO_3)_2$.

Sodium And Potassium:

They are found in earth crust about 2.4%.

Rubidium And Cesium:

They are found in small amount In potassium salts deposits.

Francium:

It is not found in nature and is prepared in the lab.

General Properties:

i. These elements are very soft.
ii. They are the most electropositive elements of the periodic table.
iii. These elements are very reactive as they can lose electron easily.
iv. These elements have one electron in their valance shell.
v. They lose their one valance electron to form ionic bonds with other elements like group VIA and VIIA elements.

Q.7: Describe the reactivity of alkali metals?

Ans: Reactivity Of Alkali Metals:

Order of reactivity of alkali metals is:

Lithium < sodium < potassium < rubidium < cesium < francium

A comparison of the first three elements of alkali metals is given in the table below:

Reactions Of First Three Alkali Metals

Element	Reaction With Air	Reaction With Water	Reaction With Chlorine
Lithium	Burns with red flame to give a white solid, lithium oxide. $4Li_{(s)}+O_{2(g)} \rightarrow 2Li_2O_{(s)}$	Floats on water surface and reacts quickly to form lithium hydroxide and hydrogen gas. $2Li_{(s)}+2H_2O_{(l)} \rightarrow 2LiOH_{(aq)}+H_{2(g)}$	Burns with a bright flame to form white solid, lithium chloride. $2Li_{(s)}+Cl_{2(g)} \rightarrow 2LiCl_{(s)}$
Sodium	Burns with bright yellow flame to give a white solid, sodium oxide. $4Na_{(s)}+O_{2(g)} \rightarrow 2Na_2O_{(s)}$	Floats on water surface and reacts very quickly to form sodium hydroxide and hydrogen gas. $2Na_{(s)}+2H_2O_{(l)} \rightarrow 2NaOH_{(aq)}+H_{2(g)}$	Burns with a bright flame to form white solid, sodium chloride. $2Na_{(s)}+Cl_{2(g)} \rightarrow 2NaCl_{(s)}$

Potassium	Burns with light coloured flame to give a white solid, potassium oxide. $4K_{(s)}+O_{2(g)} \rightarrow 2K_2O_{(s)}$	Floats on water surface and reacts very violently to form potassium hydroxide and hydrogen gas. $2K_{(s)}+2H_2O_{(l)} \rightarrow 2KOH_{(aq)}+H_{2(g)}$	Burns vigorously with a bright flame to form white solid, potassium chloride. $2K_{(s)}+Cl_{2(g)} \rightarrow 2KCl_{(s)}$

Q.8. Write a note on alkaline earth metals.

Ans. Alkaline Earth Metals:

The elements of group IIA are called alkaline earth metals. Since the elements of this group are mostly present in rocks of the earth and they form Alkalies (those bases which ionize in water up to a maximum extent are called alkalies), therefore these elements are called alkaline earth metals.

Group Members:

The group members of alkaline earth metals and their symbols are given below:

Elements	Symbols
Beryllium	Be
Magnesium	Mg
Calcium	Ca
Strontium	Sr
Barium	Ba
Radium	Ra

Occurrence:

They are not found free in nature due to their high reactivity.

Beryllium:

It is found in beryl ($Be_3Al_2(SiO_3)_6$) a mineral present inside earth curst.

Magnesium:

It is very abundant in earth's crust. Magnesium halides are found in sea water. It is also an important constituent of chlorophyll.

Calcium:

It is also found in earth crust in the form of calcium phosphate ($Ca_3(PO_4)_2$) and calcium fluoride(CaF_2). It also occurs in bones, teeth, egg shells etc.

Strontium:

It is also found in earth's crust in the form of sulphates and carbonates.

Barium:

It is also found in earth's crust in the form of sulphates.

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Radium:

Radium is found in traces amount in uranium ores. It is a radio-active metal.

General properties:

i. These elements are harder, less reactive and less electropositive as compared to alkali metals.
ii. These elements have high melting and boiling points as compared to alkali metals.
iii. These elements contain two electrons in their valance shell, and form onic bond by losing these two electrons.

Q.9. How ionization potential values vary for group I and group II elements on descending the group?

Ans: Variation of ionization potential values for group IA and IIA down the group:

"Ionization energy is the amount of energy required to remove an electron from the valance shell of a gaseous isolated(علیحدہ) atom."

Ionization potential depends on nuclear charge, atomic size, shielding effect of low lying electrons. The variation of I.P in group IA and IIA is explained below:

Variation of I.P in group IA:

As we go down the group in group IA(alkali metals) the atomic size increases. As a result, the valance electrons become farther the nucleus and thus they can easily be removed. Therefore, the ionization potential values decrease down the group.

Variation of I.P in group IIA:

For group IIA (alkaline earth metals) the ionization energy decreases down the group in the same manner as for group IA. However, the ionization potential values of group IIA are higher as compared to group IA elements due to their smaller atomic sizes and high nuclear charges.

Table: I.P values of IA and IIA element

Group IA(Alkali metals)			Group IIA(Alkaline earth metals)		
Element	Atomic no.	I.P values in KJ/mol	Element	Atomic no.	I.P values in KJ/mol
Li	3	520	Be	4	898
Na	11	496	Mg	12	738
K	19	419	Ca	20	589
Rb	37	403	Sr	38	548
Cs	55	375	Ba	56	503

Q.10.Compare the properties of alkali and alkaline earth metals with reactions.

Ans. Comparison Of Properties Of Alkali And Alkaline Earth Metals:

It is given under the following headings:

1. Comparison Of Physical Properties:

	Alkali Metals	Alkaline Earth Metals
1.	These are soft solids.	These are hard solids.
2.	These have low melting points and boiling points.	These have high melting points and boiling points.
3.	They have large atomic sizes.	They have small atomic sizes.
4.	They have low densities.	They have high densities.

2. Comparison Of Chemical Properties:

	Alkali Metals	Alkaline Earth Metals
1.	These elements are highly reactive due to their lowest I.P values.	These elements are less reactive than alkali metals.
2.	These are highly electropositive and can easily give electron to form uni-positive ions. $Na \rightarrow Na^{+} + 1e^{-}$ $K \rightarrow K^{+} + 1e^{-}$	These are less electropositive than alkali metals and give electron to form di-positive ions. $Ca \rightarrow Ca^{+2} + 2e^{-}$ $Mg \rightarrow Mg^{+2} + 2e^{-}$
3.	They vigorously reacts with water forming hydrogen gas and heat. $2Na_{(s)}+H_2O_{(l)} \rightarrow 2NaOH_{(aq)}+ H_{2(g)}$	They do not react with water.
4.	They reacts very rapidly with halogens. $2Na_{(s)}+Cl_{2(g)} \rightarrow 2NaCl_{(s)}$	They comparatively react slowly with halogens. $Mg_{(s)}+Cl_{2(g)} \rightarrow MgCl_{2(s)}$
5.	They have low I.P values. $Li \rightarrow Li^{+} + 1e^{-}$ I.P = +520Kj/mol $Na \rightarrow Na^{+} + 1e^{-}$ I.P = +496Kj/mol	They have high I.P values. $Be \rightarrow Be^{+2} + 1e^{-}$ I.P = +899Kj/mol $Mg \rightarrow Mg^{+2} + 1e^{-}$ I.P = +737.7Kj/mol

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***Q.11: What is the difference in the reactivities of group I and group II elements?**

Ans: Difference In the Relativities Of Group IA And IIA:

The reactivity of element shows that how much the element is reactive when it is reacted with other substances especially air, acids and water. The difference in the reactivates of group IA and group IIA is described below:

As we go from group IA (alkali metals) to group IIA (alkaline earth metals), along a period, the atomic number increases but the number of shells remain the same. Thus, the nuclear charge increases and the atomic size decreases. Therefore, the valance electrons of group IIA are more tightly bound to the nucleus as compared to alkali metals. So, alkali metals have low I.P values as compared to alkaline earth metals and hence group IA elements are more reactive as compared to group IIA.

Q.12: Describe the occurrence position of sodium in periodic table.

Ans: Occurrence Of Sodium:

Sodium is a reactive metal which is found in sea as sodium chloride, sodium bromide and sodium iodide. It is also found in deposits as rock salt.

Position In Periodic Table:

Its position in periodic table is given below:

Position In Group:

It occupies third position in IA group because it has one electron in its valance shell.

Position In Period:

It occupies 1st position in 3rd period because it has three electronic shells.

Q.13: Describe the properties of sodium.

Ans: Properties Of Sodium:

The properties of sodium are given below:

1. Physical Properties:

i.Softness:

Sodium is very soft metal and can easily be cut with a knife.

ii. Density:

Its density is $0.971 g/cm^3$. Thus it is lighter than water and floats on its surface.

iii. Colour:

It is grayish white in colour.

iv. Melting And Boiling Points:

It melts at 97.6 ^0C and boils at 880 ^0C.

v.Electrical and thermal conductivity:

It is good conductor of heat and electricity due to the free motion of valance electrons.

vi. Malleability And Ductility:

It is malleable and ductile.

2. Chemical properties:

Sodium is a very reactive metal. It readily reacts with hydrogen, oxygen, water and halogens etc. It acts as reducing agent. Some of its reactions with various substances are given below:

i. Reaction with hydrogen:

Sodium forms sodium hydride on reaction with hydrogen gas.

$$2Na(s) + H_2(g) \longrightarrow 2NaH(s)$$

ii. Reaction with oxygen:

Sodium reacts with oxygen to form basic oxide which on reaction with water forms an alkali.

$$4Na(s) + O_2(g) \longrightarrow 2Na_2O(s)$$
$$Na_2O(s) + H_2O(l) \longrightarrow 2NaOH(aq) \quad [alkali]$$

iii. Reaction with water:

Sodium reacts vigorously with water. It is a highly exothermic reaction and due to the heat energy produced, the liberated hydrogen catches fire.

$$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g) + Heat$$

iv. Reaction with halogens:

Sodium reacts with halogens to form sodium halides e.g.

$$2Na(s) + Cl_2(g) \longrightarrow 2NaCl(s)$$
$$2Na(s) + Br_2(l) \longrightarrow 2NaBr(s)$$

v. Reaction with sulphur:

Sodium reacts with sulphur to form sodium sulphide.

$$2Na(s) + S(s) \longrightarrow Na_2S(s)$$

vi. Reaction as reducing agent:

Sodium is powerful reducing agent. It reduces most of the oxides and halide of metal to free metals e.g

$$2Na(s) + MgO(s) \longrightarrow Na_2O(s) + Mg(s)$$
$$4Na(s) + TiCl_4(s) \longrightarrow 4NaCl(s) + Ti(s)$$

Q.14: Describe the uses of sodium.

Ans: Uses of sodium:

Uses of sodium are given below:

i. In manufacture of synthetic rubber:

Sodium is used in the manufacture of synthetic rubber from an organic compound isoprene (C_5H_8).

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ii. For purification of petroleum:

It is used to remove sulphur from petroleum to purify it. This is called desulphurization.

iii. In manufacture of dyes and drugs:

It is used in the manufacture of certain dyes and drugs.

iv. In sodium vapour lamps:

The high way lamps have often sodium which produces a bright orange-yellow glow.

v. As a reducing agent:

It is used as reducing agent to prepare free metals such as titanium, magnesium form their chlorides and oxides e.g.

$$2Na(s) + MgO(s) \longrightarrow Na_2O(s) + Mg(s)$$
$$4Na(s) + TiCl_4(s) \longrightarrow 4NaCl(s) + Ti(s)$$

vi. In the formation of alloys:

It forms alloys with other metals the most useful alloy is with mercury called sodium amalgam and with silver metal. Both mercury and silver retard its reactivity and thus it can easily be handled and used.

vii. In Nuclear Reactors:

It is used as coolant in nuclear reactors.

Q.15. Describe the occurrence and positions of calcium and magnesium in periodic table.

Ans: Occurrence Of Magnesium:

It is a member of Alkaline earth metals. It occurs in nature only in combined state as:

i. Dolomite($CaCO_3.MgCO_3$)
ii. Kieserite ($MgSO_4$)
iii. Epsom Salt($MgSO_4.7H_2O$)
iv. It is also found in many silicates including talc and asbestos.
v. It is also found in sea water as chlorides and bromides.
vi. It is also essential constituent of chlorophyll.

Position In Periodic Table:

It is given below:

Position In Group:

Magnesium occupy second position in IIA group because it has two valance electrons.

Position In Period:

It occupies second position in third period because it has three electronic shells.

Occurrence Of Calcium:

It is also a member of alkaline earth metals. It occurs abundantly in combined state minerals such as:

i. As calcium carbonate($CaCO_3$) in lime stone, chalk and marble
ii. As calcium sulphate($CaSO_4$) in gypsum.

Positions Of Calcium In Periodic table:

It is given below:

Position In Group:

Calcium occupies third position in IIA group because it has two valance electrons.

Position In Period:

It occupies second position in 4th period because it has four electronic shells.

Q.16: Describe the properties of magnesium and calcium.

Ans: Properties of magnesium and calcium:

The properties of magnesium and calcium are give below:

1. Physical properties:

i.Colour:

Magnesium is grayish white while calcium is silvery white in colour.

ii. Density:

The density of magnesium is 1.74g/cm^3 while that of calcium is 1.55 g/cm^3 which show that both are heavier than water.

iii. Melting points and boiling points:

The melting and boiling points of Mg and Ca are given below:

Element	Melting point	Boiling point
Magnesium	651^{0}C	1106^{0}C
Calcium	851^{0}C	1487^{0}C

iv. Electrical and thermal conductivity:

Both magnesium and calcium are good conductors of heat and electricity.

2. Chemical properties:

The chemical properties of magnesium and calcium are given below:

i. Reaction with hydrogen:

Magnesium and calcium react with hydrogen forming hydrides.

$$Mg(s) + H_2(g) \longrightarrow MgH_2(s)$$
$$Ca(s) + H_2(g) \longrightarrow CaH_2(s)$$

ii. Reaction with air/oxygen:

Both burn in air/oxygen. Magnesium burns with a dazzling flame(چمکدار شعلہ) forming MgO, called magnesia while calcium burns with brick red colour flame producing CaO, called lime or quick lime.

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$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$
$2Ca(s) + O_2(g) \longrightarrow 2CaO(s)$

iii. Reaction with nitrogen:

They react with nitrogen to form their respective nitrides.

$3Mg(s) + N_2(g) \longrightarrow Mg_3N_2(s)$
$3Ca(s) + N_2(g) \longrightarrow Ca_3N_2(s)$

iv. Reaction with acids:

They react with acids liberating hydrogen gas.

$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)\uparrow$
$Ca(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2(g)\uparrow$
$Mg(s) + H_2SO_4(aq) \longrightarrow MgSO_4(aq) + H_2(g)\uparrow$
$Ca(s) + H_2SO_4(aq) \longrightarrow CaSO_4(aq) + H_2(g)\uparrow$

v. Reaction with halogens:

They react with halogens to form their respective halides.

$Mg(s) + Cl_2(g) \longrightarrow MgCl_2(s)$
$Ca(s) + Cl_2(g) \longrightarrow CaCl_2(s)$
$Mg(s) + Br_2(l) \longrightarrow MgBr_2(s)$
$Ca(s) + Br_2(l) \longrightarrow CaBr_2(s)$

Q.17: Describe the uses of Magnesium (Mg) and calcium (Ca).

Ans: Uses of Magnesium (Mg):

The uses of magnesium are given below:

i.In The Formation Of Alloys:

Magnesium is used in the formation of low density alloys e.g. magnalium (mixture of Mg and Al), duralumin (mixture of Mg, Al, Cu and Mn). These alloys are used for construction of aircrafts, cars etc.

ii.In The Formation Of Refractory Bricks:

Magnesia (MgO) is formed from magnesium which is mixed with clay to make refractory bricks(وہ اینٹیں جو بہت ذیادہ حرارت سہہ سکے) for furnace lining (بھٹی کا اندرونی حصہ).

iii. In Various Industries:

$MgSO_4$, a salt of magnesium, is used in textile, paper, soap and pharmaceutical industries.(دوائیاں بنانے والے کارخانے)

iv. In Flash lights And Fireworks:

Magnesium powder is used as essential constituent of flashlights and fireworks.

v.In Metallurgy:

It is also used as deoxidant in metallurgy and in the extraction of titanium and uranium.

Uses of Calcium(Ca):

The uses of calcium are given below:

i. In agriculture:

Lime (CaO) is made from calcium. It is added to soil in the form of fertilizer to decrease the acidity of soil.

ii. For water softening and in various industries:

Lime (CaO) is used for water softening, environmental control and in pulp (گودہ), paper, sugar and glass industries.

iii.In steel making:

It is used in steel making.

iv. As dehydrating agent:

Some of its compounds are used as dehydrating agent (خشک کرنے والا).

v. As Deoxidant:

It is also used as deoxidant in steel casting and paper making.

Q.18. Differentiate between soft and hard metals OR what are soft and hard metals?

Ans. Soft and hard metals:

About 93 elements out of 118 elements of periodic table are metals but some of them are soft while others are hard. Their detail is give below:

i. Soft metals:

Those elements which are very soft, very reactive, having low I.P values are called soft metals.

Examples:

IA group elements are soft metals. However, group IIA elements are also included in soft metals but they are hard than IA group elements.

ii. Hard Metals:

Those metals which are hard, having high I.P values, less reactive are called hard metals.

Examples:

Silver, copper, tin, zinc, iron etc are the examples of hard metals.

A comparison between hard and soft metal is given below:

-	Sodium(soft)	Iron(Hard)
1.	Sodium is an alkali metal having atomic number 11.	Iron is a transition metal having atomic number 26.
2.	It is very soft and can be cut with a knife.	It is very hard and cannot be cut with a knife.
3.	Its melting point 97.6 ^{0}C.	It melting point is 1538 ^{0}C.
4.	Its boiling point is 880 ^{0}C.	Its boiling point is 2862 ^{0}C.
5.	It density is 0.971 g/cm^3	Its density is 7.874 g/cm^3.
6.	It is lighter than water.	It is heavier than water.
7.	Very reactive and stored in kerosene oil.	Less reactive than sodium.
8.	Low tensile strength.	High tensile strength.

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Q.19. What are noble metals? Write down the uses of noble metals.

Ans. Noble metals:

"Those metals which are highly stable or less reactive and resist oxidation and corrosion in moist air, are called noble metals or inert metals.".They are found free in nature.

Examples:

Following elements are the examples of noble metals.

Ruthenium (Ru), rhodium (Rh), palladium (Pd), silver (Ag), osmium (Os), iridium (Ir), platinum (Pt) and gold (Au). Some scientists also include mercury (Hg), rhenium (Re) and copper (Cu) in noble metals.

Q.20 Describe the commercial importance/uses of silver, gold and platinum?

Ans: Commercial Importance Of Silver, Gold And Platinum:

These metals are very expensive due to which they have great commercial importance which is given below:

1. Silver

Occurrence:

It is a soft white metal which occur in nature in one of the following four forms:

a. As a native element
b. As a primary constituent in silver minerals
c. As natural alloy
d. As minor constituent in ore of other metals.

Uses/Importance:

It is a precious metal because it has high economic value.

i. Pure silver is very soft therefore, it is usually mixed with copper to form alloy from it. This alloy is used to make coins, jewellery, utensils (برتن) and table ware.
ii. Silver chloride combined with silver bromide is used in photography.
iii. It is also used in mirrors.
iv. It is also used in electric wires.

2. Gold:

Occurrence:

It is found in free state, in earth crust. It is also found in deposits of other metals like copper.

Uses/Importance:

It is also a precious metal having high economic value. It has very attractive colour.

i. Modern jewellery industry use a large amount of gold because of its inertness and attractive colour.

ii. It is also used for coating of watches and in artificial satellites.
iii. It is also used in standard laptops or desktop computers.
iv. It is also used in dentistry.

3. Platinum:

Occurrence:

Its name comes from the Spanish word platina meaning little silver. It is 72nd most common element found in earth crust in mines of other metals like copper.

Uses/Importance:

i. It is a precious metal like gold and is used in jewellery.
ii. It is also used for coating surgical instruments.
iii. It is used as catalyst in various reactions.
iv. It is also used in scientific laboratory apparatus.
v. It is also used in electrical industry, in laser and making photographic materials.

Q.21. Describe the electronegative character of non-metals.

Ans. Electronegative character of non-metals:

All the non-metals have small atomic sizes and high nuclear charges thus, they have the ability to gain electrons from the other elements and hence they are electronegative in nature. The most electronegative character is shown by halogens as they have the smallest atomic sizes of all non-metals. They can gain electron very easily to form halide ions:

$$X + 1e^- \longrightarrow X^-$$

Where X^- is halide ion for example chloride ion is formed as:

$$Cl + 1e^- \longrightarrow Cl^-$$

Q.22. Write a short note on halogens (group VIIA).

Ans: Halogens (group VIIA):

Group VIIA of the periodic table is called halogen which means salt former because these elements forms salts like NaCl, NaF, NaI etc.

Group member:

The group members of this group are fluorine(F), chlorine(Cl), bromine(Br), iodine(I) and astatine(At)

General properties:

The general properties of halogens are given below:

i. Under normal condition fluorine and chlorine are gases, bromine is a liquid while iodine and astatine are solids.
ii. All of these elements are non-metals.

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iii. These elements are the most electronegative elements of the periodic table.
iv. They contain seven electrons in their valance shell.
v. They form ionic bond (by gaining one electron) or covalent bond(by sharing one electron) to complete their octet.
vi. Due to their high reactivity they are not found in Free State.

Q. 23: Describe the physical properties of halogens.

Ans: Physical properties of halogens:

Fluorine and chlorine are gases, bromine is a liquid while iodine and astatine are solids under normal conditions. They are strongly electronegative. They have the tendency to form negative ions when react with strong electropositive elements. Their m.p and b.p increase down the group.

Table: Physical properties of halogens

Element	Fluorine (F)	Chlorine (Cl)	Bromine (Br)	Iodine (I)	Astatine(At)
Electronic configuration	$[He]2s^2, 2p^5$	$[Ne]\ 3s^2, 3p^5$	$[Ar]\ 3d^{10}, 4s^2, 4p^5$	$[Kr]\ 4d^{10}, 5s^2, 5p^5$	$[Xe]\ 4f^{14}, 5d^{10}, 6s^2, 6p^5$
Physical state	Gas	Gas	Liquid	Solid	Solid
M.P (^{0}C)	-220	-102	-7	14	302
B.P (^{0}C)	-188	-34	59	184	380
Atomic radius(pm)	72	99	114	133	227
Density(g/cm^3)	1.69	1.56	3.12	4.93	--
I.P(KJ/mol)	1681	1251	1140	1008	
E.A(KJ/mol)	-322	-349	-325	-295	
Electronegativity	4.0	3.0	2.80	2.50	2.2

Q.24: Describe the chemical properties of halogens.

Ans: Chemical properties of halogens:

All the halogens are very reactive elements existing in diatomic state. Their reactions with various substances are given below:

i. Reaction with H_2:

Halogens react with hydrogen to form halogen acids. For example:

$H_2(g) + F_2(g) \longrightarrow 2HF(l)$
$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$
$H_2(g) + Br_2(l) \longrightarrow 2HBr(g)$
$H_2(g) + I_2(g) \leftrightharpoons 2HI(g)$

Fluorine reacts violently, chlorine in the presence of sunlight, bromine on heating while iodine reacts reversibly.

ii. Reaction with O_2:

Only fluorine directly reacts with oxygen and forms monoxide and dioxide.

$O_2(g) + 2F_2(g) \longrightarrow 2OF_2(g)$
$O_2(g) + F_2(g) \longrightarrow O_2F_2(g)$

Indirectly other halogens also form oxides like dichlorineheptoxide (Cl_2O_7), tribrominetetraoxide (Br_3O_4) and iodine pentoxide (I_2O_5).

iii. Reaction with metals:

Halogens react with metal to form the corresponding ionic halides. For example:

$Cu(s) + Br_2(l) \longrightarrow CuBr_2(s)$
$2K(s) + I_2(s) \longrightarrow 2KI(s)$

iv. Reaction with non-metals:

They react with non-metals to form corresponding covalent halides. For example with phosphorus form tri-halides and penta-halides.

$2P(s) + 3Cl_2(s) \longrightarrow 2PCl_3(s)$
$2P(s) + 3Br_2(l) \longrightarrow 2PBr_3(s)$
$2P(s) + 5Cl_2(s) \longrightarrow 2PCl_5(s)$
$2P(s) + 5Br_2(l) \longrightarrow 2PBr_5(s)$

v. Reaction with other compounds:

Halogens react with certain compounds and they get reduced. For example

$H_2S(aq) + Cl_2(g) \longrightarrow 2HCl(aq) + S(s)$
$2NH_3(aq) + 3Cl_2(g) \longrightarrow 6HCl(aq) + N_2(g)$

Chlorine reacts with lime water [$Ca(OH)_2$] to form bleaching powder [$CaOCl_2$]:

$Ca(OH)_2(aq) + Cl_2(g) \longrightarrow CaOCl_2(s) + H_2O(l)$

vi. Displacement Reaction:

During this reaction a more reactive halogen displaces a less reactive halogen from its halide solution. Their reactivity decreases down the group.

Order of reactivity is F>Cl>Br>I>At

$2NaBr_{(aq)} + Cl_{2(g)} \longrightarrow 2NaCl_{(aq)} + Br_{2(l)}$

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EXERCISE

Multiple Choice Questions

Q.1: Choose the correct one:

i. At room temperature metals exist as:
A) Gas and liquid B) Gas and solid
C) Solid and liquid D) All the three

ii. All the gaseous elements present in the nature are:
A) Metals **B) Non-metals**
C) Actinides D) Lanthanides

iii. Metal atoms by loss of electron form:
A) Cations B) Anions
C) Atoms D) Molecules

iv. Potassium is an element of group:
A) I B) IV C) II D) VII

v. Alkaline earth metals exist in oxidation state:
A) +1 **B) +2** C) +3 D) –1

vi. $Ca(OH)_2$ is the formula of:
A) Lime stone B) Lime
C) Lime water D) Bleaching powder

vii. The halogen present in solid form is:
A) Chlorine B) Fluorine
C) Iodine D) Bromine

viii. Hard metals possess ionization potential:
A) Low **B) High** C) Zero D) Negative

ix. The noble metals are very:
A) Reactive **B) Passive**
C) Soft D) Electronegative

x. The halogens are:
A) Inert **B) Reactive**
) Electropositive D) Metallic

xi. Bromine is a non-metal in _____ state:
A) Solid **B) Liquid** C) Gas D) Plasma

xii. Halogens react with metals to form ____
A) Halides B) halogen sulphides
C) Oxides D) Hydrogenated compounds

xiii. Alkali metals are____
A) Oxidizing agents B) Dehydrating agents
C) Reducing agents D) All of these

xiv. Among the alkali metals the element with highest ionization potential is
A) Na **B) Li** C) Rb D) Cs

xv. The tendency of a metal to lose electron is ____
A) Electronegativity **B) Electropositivity**
C) Electroplating D) Electrolysis

xvi. The word alkali means _____
A) Base B) Basic salt C) Acid **D) Ashes**

xvii. The oxides of calcium, CaO is ____:
A) Acidic B) Amphoteric **C) Basic** D)Neutral

xviii. Which of the following in not an alkali metal?
A) Francium B) Cesium C) Rubidium **D) Radium**

xix. Group IIA elements are called alkaline earth metals because:
A) Their oxides are basic
B) Their oxides and hydroxide are water soluble
C) Both A and B
D) They are found in earth

Short Questions

Answer briefly the following questions:

i. Identify at least two groups which contain only metal elements?

Ans. **Two Groups Containing Metals Only:**

The two groups containing only metals are given below:
i. Alkali metals (IA) ii. Alkaline earth metals (IIA)

ii. Write down the reactions of group IA metals with oxygen with balanced chemical equations.

Ans. **Reactions Of Alkali Metals With Oxygen:**

They react with oxygen to form their respective oxides.

$4Li(s) + O_2(g) \longrightarrow 2Li_2O(s)$
$4Na(s) + O_2(g) \longrightarrow 2Na_2O(s)$
$4K(s) + O_2(g) \longrightarrow 2K_2O(s)$
$4Rb(s) + O_2(g) \longrightarrow 2Rb_2O(s)$
$4Cs(s) + O_2(g) \longrightarrow 2Cs_2O(s)$
$4Fr(s) + O_2(g) \longrightarrow 2Fr_2O(s)$

iii. State the physical properties of sodium?

Ans: For answer see Question no.13

iv. How does sodium acts as a reducing agent? Write its reactions also.

Ans: For answer see heading no.vi in Question no.13

v. Ionization energy of alkaline earth metals is higher than alkali metals why?

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Reason For Alkaline Earth Metals Having High I.E Than Alkali Metals:

Ionization energy depends on atomic size and nuclear charge. It is inversely proportional to atomic size and directly proportional to nuclear charge.

Since alkaline earth metals have smaller atomic size and high nuclear charges than alkali metals therefore, their valance electrons are tightly held and more energy is required to remove electron from their valance shells. That is why alkaline earth metals have high I.E than alkali metals

vi. Pure gold is not used for ornaments why?

Ans: **Reason For Pure Gold Not Being Used In Ornaments:**

Pure gold is soft. Therefore, it cannot be used to make ornaments. Therefore it is mixed with copper to make it hard. That is why pure gold is not used in ornaments.

vii. What are the uses of magnesium?

Ans: For answer see Question no.17

viii. Write down the reaction of chlorine with sodium hydroxide with balanced chemical equation.

Ans: **Reaction Of Chlorine With Sodium Hydroxide:**

Chlorine reacts with dilute sodium hydroxide to produce sodium chloride, sodium hypochlorite and water.

$2NaOH_{(aq)} + Cl_{2(g)} \longrightarrow NaCl_{(aq)} + NaClO_{(aq)} + H_2O_{(l)}$

ix. How does ionization energy value vary in group?

Ans: For answer see ionization energy in Ch#3

x. What happens during displacement reaction in halogens?

Ans: For answer see Question no.24.

Long Questions

i. Compare and contrast the properties of alkali and alkaline earth metals with reactions.

Ans: For answer see Question no.10

ii. a. Differentiate between soft and hard metals

Ans: For answer see Question no.18

b. Give the reactions of magnesium with

i. H_2 ii. HCl iii. O_2 iv. H_2O v. Cl_2

Ans: **Reactions Of Magnesium:**

These are given below:

i. Reaction with H_2:

Magnesium reacts with hydrogen forming magnesium hydride.

$Mg(s) + H_2(g) \longrightarrow MgH_2(s)$

ii. Reaction With HCl:

Magnesium reacts with HCl liberating hydrogen gas.

$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)\uparrow$

iii. Reaction With O_2:

It burns with oxygen. It burns with a dazzling flame (چمکدار شعلہ) forming MgO, called magnesia.

$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$

iv. Reaction With H_2O:

Magnesium does not react with water. However it reacts with steam to form magnesium oxide and hydrogen gas.

$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$

v. Reaction With Cl_2:

Magnesium reacts with chlorine to form magnesium chloride.

$Mg(s) + Cl_2(g) \longrightarrow MgCl_2(s)$

iii. Give reasons that some elements exist as free elements in nature while other occurs in combined state as compounds. Give two examples of each type.

Ans. **Reasons For Some Elements Existing In Free States:**

Some elements exist free states because they are highly stable and less reactive therefore, they are found free in nature.

Two Examples:

i. Gold ii. Silver

These elements are found in free states in earth's crust.

Reasons For Some Elements Existing In Combined States:

Some elements exist in combined states because these are highly reactive. These elements may be highly electropositive like alkali metals or highly electronegative like halogens. They readily reacts with the substances present around them. Therefore, they are found in combined states as compounds.

Two Examples:

i. Sodium does not found free in nature it is found in combined state as NaCl, NaBr and NaI etc.

ii. Magnesium is also found in combined state as $MgSO_4$, $MgCO_3$ etc.

iv. Define metal and non-metals and compare their properties both physical and chemical.

Ans. For answer see Question no.4

v. Halogens are very reactive elements write down the reactions with hydrogen, oxygen, metals, non-metals and other compounds.

Ans: For answer see Question no.24

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***What is aqua regia?**

Ans: Aqua Regia(Royal water):

"A mixture of concentrated solutions of hydrochloric acid and nitric acid in the ratio of 3:1 is called Aqua Regia or Royal water."

Discovery and use:

It was discovered by Muslim scientist Jabir Ibne Hayyan. It is to dissolve gold as clear from the following chemical equation:

$Au(s) + 3HCl(aq) + HNO_3(aq) \longrightarrow AuCl_3(aq) + NO(g) + 2H_2O(l)$

***Why Alkali metals are good reducing agents.**

Ans: The answer of the given question is explained under the following heading:

Reason for alkali metals being good reducing agents:

According to electronic concept reducing agents are those substances which can lose electrons.

Alkali metals have large atomic sizes due to which they are the most electropositive elements. Thus, they can lose their one valance electron very easily. That is why alkali metals are good reducing agents.

Test Yourself

A. Describe and explain what will happen if bromine water is added to potassium iodide solution?

Ans. Reaction Of Br With KI:

Bromine is more reactive than iodine. Therefore when bromine water is added to KI solution, it will displace iodine from its compound to form potassium bromide and iodine.

$$Br_2(l) + 2KI(aq) \longrightarrow 2KBr(aq) + I_2(s)$$

B. Infer the identify of an element

i. Element found in period 3

ii. will displace iodine from sodium iodide.

iii. Greenish gas, which is denser than air

iv. used in swimming pools to kill germs

Ans. This element is chlorine with symbol Cl which is present in period 3, displaces iodine from sodium iodide, greenish gas, denser than air and used in swimming pools to kill germs.

The End

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Model Paper
Chemistry
9th (Fresh, Reappear)

TIME: 20 Min MARKS: 12

Q 1: Write the correct option a, b, c and d in empty boxes provided opposite to each part.

i. Which one of the following is known as marsh gas?
a) CO_2 b) CH_4 c) H_2 d) Cl_2

ii. Mass number is also called.....
a) Atomic number b)Mole c)Nucleon number d) Avogadro's number

iii. electron in ground state does not.....
a) Spin b) Revolve c) Radiate energy d) Reside in Orbit

iv. Hydrogen has ..... Isotopes.
a) 2 b) 3 c) 4 d) 5

v. The ability of an atom to attract electron or shard pair of electrons towards itself is called
a)electron affinity b) Electro negativity
c) Shielding effect d)Electro positivity

vi. According to Octet rule atom has the tendency to have ..... electrons in its outer most shell.
a) 2 b) 4 c) 6 d) 8

vii. Calcium Chloride ($CaCl_2$) has ..... Bond.
a) Ionic b) covalent c) Coordinate d) metallic

viii. the SI unit of pressure is
a) Jouls b) Pascal c) Newton d) warts

ix. One of the following is not amorphous solid.
a) Wax b) Butter c) Diamond d) Plastics

x. Brass is an example of ..... solution.
a) Solid in solid b) solid in liquid c) solid in gas d) liquid in liquid

xi. the oxidation number of all electron in free state is.....
a) Zero b) two c) Three d) four

xii. Bromine is non metal in .....
a) Solid state b) liquid state
c) gaseous state d) Plasma state

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Model Paper

CHEMISTRY

9th (Fresh/Reappear)

Note: Time allowed for Section – B and Section – C is 2 Hours and 45 minutes. **Marks: 32**

Section – B

Q-II Answer any EIGHT parts. Each part carries FOUR marks.

1. Differentiate between organic and inorganic Chemistry.
2. How many moles are present in 60g of Co_2?
3. Draw structure of chlorine isotopes.
4. Define atomic radius. Discuss its periodic variation in the table.
5. Differentiate between polar and non-polar covalent bonds. Give two examples of each.
6. Write down four properties of Ionic compounds.
7. A 530 dm_3 sample of Hydrogen gas was collected in a container at 800 mm of Hg pressure, at room temperature. What volume will the gas occupy at 400 mm of Hg?
8. How would you determine that the given solution is unsaturated, saturated or super saturated?
9. Define reduction. Give two examples.
10. Write four uses of electrolytic cells.
11. Write any four uses of sodium metal.

Marks: 21

Section – C

Note : Attempt any THREE questions. All questions carry equal marks.

Q-III (a) Describe the deductions made by Rutherford in his atomic model. 4

(b) NaCl form ionic bond and HCl from covelant bond. Why? 3

Q-IV (a) Write down the typical properties of Gases. 4

(b) 5.85g of NaCl are dissolved in water so as to make 500 cm^3 solution. Determine the molarity of solution. (Atomic mass of Na = 23 gm and Cl = 35.59 gm) 3

Q-V (a) Explain the electrolytic refining of copper. 4

(b) Write balanced chemical reaction of magnesium with 3
(i) Hydrogen (ii) Oxygen (iii) Halogens.

Q-VI (a) Discuss electro negativity of an element. 4

(b) Explain noble metals.

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