SANJEEVANI PUBLIC SCHOOL, UTTAM NAGAR

CLASS- X (SCIENCE)

CHEMICAL REACTION AND EQUATION

(BY RUPESH GUPTA SIR)

NAME :- _____

Matter: - Anything which occupies space and has some mass is known as matter

Element: - The purest form of a matter is known as element

S. NO	NAME OF ELEMENT	SYMBOL	ATOMIC NO.	No of elect. = no of proton	No. of neutron	MASS NO.	ELECTRONIC CONFIGURATION	NO. OF VALENCE ELECTRON	VALENCY
1	Hydrogen	H	1	1	0	1	1	1	1+
2	Helium	He	2	2	2	4	2	2	Zero
3	Lithium	Li	3	3	4	7	2,1	1	1+
4	Beryllium	Be	4	4	5	9	2,2	2	2+
5	Boron	B	5	5	6	11	2,3	3	3+
6	Carbon	C	6	6	6	12	2,4	4	4+
7	Nitrogen	N	7	7	7	14	2,5	5	3-
8	Oxygen	O	8	8	8	16	2,6	6	2-
9	Fluorine	F	9	9	10	19	2,7	7	1-
10	Neon	Ne	10	10	10	20	2,8	8	Zero
11	Sodium	Na	11	11	12	23	2,8,1	1	1+
12	Magnesium	Mg	12	12	12	24	2,8,2	2	2+
13	Aluminium	Al	13	13	14	27	2,8,3	3	3+
14	Silcon	Si	14	14	14	28	2,8,4	4	4+
15	Phosphorus	P	15	15	16	31	2,8,5	5	3-
16	Sulphur	S	16	16	16	32	2,8,6	6	2-
17	Chlorine	Cl	17	17	18	35	2,8,7	7	1-
18	Argon	Ar	18	18	22	40	2,8,8	8	Zero
19	Potassium	K	19	19	20	39	2,8,8,1	1	1+
20	Calcium	Ca	20	20	20	40	2,8,8,2	2	2+

Ions: - Ions are electrically charged atoms or groups of atoms.
Ions are of two type (a) Cations (b) Anions

Cations: - cations are positively charged ions

Anions: - anions are negatively charged ions.
Cations and anions combine in the proper proportions to form neutral (uncharged) ionic compounds.

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Example of cations and anions

CATIONS		ANIONS	
ION	NAME	ION	NAME
Na^+	sodium	OH^-	Hydroxide
K^+	potassium	Cl^-	chloride
Fe^{2+}	iron (II) or ferrous	Br^-	bromide
Fe^{3+}	iron (III) or ferric	I^-	iodide
Cu^+	copper (I) or cuprous	CN^-	cyanide
Cu^{2+}	copper (II) or cupric	S^{2-}	sulphide
NH_4^+	ammonium	NH_2^-	amide
H_3O^+	hydronium	NO_3^-	nitrate
Zn^{2+}	Zinc	NO_2^-	nitrite
Pb^{2+}	Lead	SO_4^{2-}	sulphate
Mg^{2+}	Magnesium	SO_3^{2-}	sulphite
Sn^{2+}	Tin	PO_4^{3-}	phosphate
Mn^{2+}	Magnese	HPO_4^{2-}	hydrogen phosphate
Al^{3+}	Aluminium	$H_2PO_4^-$	dihydrogen phosphate
Ba^{2+}	Barium	ClO_4^-	perchlorate
Ag^+	Argentous (Silver)	ClO_3^-	chlorate
Au^+	Aurous [Gold(I)]	ClO_2^-	chlorite
Ni^{2+}	Nickel	ClO^-	hypochlorite
Hg^{2+}	Mercuric [Mercury(I)]	MnO_4^{2-}	magnate
Pt^{2+}	Platinous [platium(I)]	SiO_4^{4-}	silicate
		O_2^{2-}	Peroxide
		O^{2-}	oxide

Physical change: - such processes in which no new chemical substances are formed are called physical change. Ex: - melting of ice, evaporation of water, dissolution of sugar in water

Chemical change: - such processes in which the original substances lose their nature and identity and form new chemical substances with different properties is called a chemical change. The process involving a chemical change is called a chemical reaction. Ex: - souring of milk, respiration, burning of coke in air, digestion of food.

Chemical Reaction: - "Chemical reactions are the processes in which new substances with new properties are formed."

Chemical reaction involve the breaking of bonds b/w the atoms of the reacting substances and making of new bonds b/w atoms of products. During chemical reactions, a large variety of rearrangement of atoms can take place to produce new substances having entirely different properties.

Example: - rusting of iron, the changing of milk into curd and digestion of food in our body.

Characteristics of a chemical reaction: - a chemical equation is characterized by

1. Change in state
2. Change in colour
3. Change in temperature
4. Evaluation of gas (es)
5. Formation of new product

Chemical Equation: - chemical equation is the short representation of chemical reactions in symbolic form.

Example: - The word equation

Magnesium + Oxygen → Magnesium oxide

Reactants Product

Can be written as

$2Mg + O_2 \rightarrow 2MgO$

"The method of representing a chemical reaction with the help of symbols and formulae of the substances involved in it is known as a chemical equation"

Example: - zinc metal reacts with dil sulphuric acid to form Zinc Sulphate and hydrogen gas. This reaction can be written in word as

Zinc + sulphuric acid → Zinc sulphate + Hydrogen

In symbolic form it can be written as

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Reactants: - The substances which take part in chemical reactions are known as reactants.

Products: - The new substances produced in a reaction are known as products.

Example: - $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Zn and H_2SO_4 are the reactants and $ZnSO_4$ & H_2 are the products.

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Balanced Chemical Equations: - A balanced chemical equation has an equal number of atoms of different elements in the reactants and products.

Or

A balanced chemical equation has an equal number of atoms of different elements on both the sides.

Example: - $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Unbalanced Chemical Equations: - An unbalanced chemical equation has an unequal number of atoms of one or more elements in the reactants and products.

Or

An unbalanced chemical equation has an unequal number of atoms of one or more elements on its two sides.

Example: - $H_2 + O_2 \rightarrow H_2O$

In this reaction Hydrogen atoms are equal in reactant & product side but Oxygen atom are unequal.

Balancing of Chemical Equations: - The process of making the number of different types of atoms equal on both sides of an equation is called balancing of equations.

- We should remember the following four steps for writing equations for the chemical reactions.

FIRST STEP: - write down the chemical reaction in the form of word equation, keeping the reactants on the left side and products on the right side.

SECOND STEP: - put the symbols and formulae of all the reactants and products in the word equation.

THIRD STEP: - Balanced the equation by multiplying the symbols and formulae by the smallest possible figures (Do not change the formulae to balance the equation)

FOURTH STEP: - If possible, make the equation more informative

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TO MAKE EQUATIONS MORE INFORMATIVE: - The chemical equations can be made more informative in three ways

1. By indicating the "physical states" of the reactant and products
2. By indicating the "heat changes" taking place in the reaction
3. By indicating the "condition" under which reaction takes place.

1. **To indicate the physical states of reactants and products in an equation**
   Solid state is indicated by the symbol (s)
   Liquid state is indicated by the symbol (l)
   Aqueous solution (solution made in water) is indicated by the symbol (aq)
   Gaseous state is indicated by the symbol (g)

Example: - $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$

- An arrow pointing upwards (↑) is used to indicate a gaseous product in an equation. (i.e. Evolution of gas)
  $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2\uparrow$
- An arrow pointing downward (↓) is used to indicate an insoluble product or precipitate in an equation

Example: - $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3\downarrow + H_2O(l)$
Calcium hydroxide — Carbon dioxide — Calcium Carbonate (White ppt) — Water

2. **To indicate the heat changes in an equation**
   There are two types of reaction on the basis of heat changes involved
   Exothermic reaction and Endothermic reactions

Exothermic Reactions: - Those chemical reactions in which heat is released are called exothermic reactions. It is indicated by writing '+ Heat on product side'

Example: **(1)** All combustion reactions are exothermic reactions.

Example: - when methane burns in air (i.e. combustion) a lot of heat energy is released.

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + Heat$
Methane — Oxygen (From air) — Carbon dioxide — Water (as steam)

(2) Thermite Reaction: - Thermite reactions are those reaction in which extremely large amount of energy is released.

Example: - Aluminium powder reduces iron (III) oxide to form iron metal and aluminium oxide, and an extremely large amount of heat is produced during this reaction

Fe_2O_3 (s) + 2Al (s) → 2 Fe (l) + Al_2O_3 (s) + Heat

Iron (III) oxide Aluminium Iron metal (molten state) Aluminium oxide

The heat gives out in this reaction is so great that iron metal formed by this reaction is in molten state. This molten iron can be poured b/w broken rail pieces (or other broken iron objects) to weld them together.

(3) When nitrogen combine with hydrogen in the presence of iron catalyst to form ammonia, a lot of heat is produced.

N_2 (g) + $3H_2$ (g) → $2NH_3$ (l) + Heat

Nitrogen Hydrogen Ammonia

Endothermic reactions: - Those chemical reactions in which heat is absorbed are called endothermic reactions. It is indicated by writing '+ Heat on Reactant side'

Example: - (1) When nitrogen and oxygen are heated to a very high temperature, they combine to form nitrogen monoxide, and a lot of heat is absorbed in this reaction.

N_2(g) + O_2(g) + Heat → 2NO(g)

Nitrogen Oxygen Nitrogen monoxide

(2) Carbon mono oxide gas react with ferric oxide to form iron and carbon dioxide gas with the absorption of heat

Fe_2O_3(s) + 3CO (g) +Heat → 2Fe(s) + $3CO_2$(g)

Ferric oxide carbon mono oxide Iron Carbon dioxide

Photo Chemical Reaction: - those chemical reactions which take place in the presence of light are called photo chemical reactions

Example: (1) Methane and chlorine react in the presence of sunlight to form chloromethane and hydrogen chloride

$CH_4(g)$ + $Cl_2(g)$ $\xrightarrow{\text{sunlight}}$ $CH_3Cl(g)$ + HCl

Methane Chlorine Methyl Chloride Hydrogen chloride

(2) Photosynthesis by plants

$6CO_2(g)$ + $6H_2O(l)$ $\xrightarrow{\text{sunlight}}$ $C_6H_{12}O_6(aq)$ + $6O_2(g)$

Carbondioxide water Glucose Oxygen

3. **To indicate the condition under which the reaction takes place**

If heat is required for a reaction to take place, then the heat sign delta (Δ) is placed over the arrow of the equation.

If the reaction takes place in the presence of catalyst, then the symbol or formula of the catalyst is also written above or below the arrow sign in the equation.

Example: - when potassium chlorate is heated in the presence of manganese dioxide catalyst, it decomposes to form potassium chloride and oxygen gas.

$2KClO_3(s)$ $\xrightarrow{\Delta,\ MnO_2}$ $2KCl(s)$ + $3O_2(g)$

Poatssium chlorate potassium chloride Oxygen

Information conveyed by a chemical equation

1. Names of various reactants and products
2. Formulae of reactant and products
3. Relative amount (in mol) of the reactants and products
4. Relative masses of reactants and products.
5. Relative volumes of gaseous reactants and products

Limitations of chemical equation

1. A chemical equation does not tell us about physical states of various species.
2. It does not tell us about reaction conditions
3. It does not tell us about rate of the reaction- whether it is slow or fast.
4. It does not tell us about the heat changes taking place during the reaction.

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TYPES OF CHEMICAL REACTIONS

Some of the important types of chemical reactions are –

1. Combination reactions	**5. Ionic Equation**
2. Decomposition reactions	**6. Polymerization**
3. Displacement Reaction	**7. Isomerization**
4. Double Displacement Reaction	**8. Oxidation and Reduction**

1. **Combination Reactions:** - those chemical reactions in which two or more substances (element, compound) combine to form a single substance are called combination reactions.

   Example: - (1) magnesium wire is heated in presence of oxygen; it combines to form magnesium oxide

   $2Mg + O_2 \xrightarrow{\text{combination}} 2MgO$

   Magnesium Oxygen Magnesium oxide

   (2) Carbon (charcoal) burns in air to form carbon dioxide

   $C + O_2 \xrightarrow{\text{Combination}} CO_2$

   Carbon Oxygen Carbon dioxide

   (3) Calcium oxide react with water to form calcium hydroxide

   $CaO + H_2O \xrightarrow{\text{Combination}} Ca(OH)_2$

   Calsium oxide water calcium hydroxide

2. **Decomposition Reactions**: - those reactions in which a compound split up into two or more simple substances are known as decomposition reactions.

   The decomposition reactions are carried out by applying **Heat, catalyst, electricity and light**.

   Decomposition reactions are just opposite of combination reactions

   Example: - Decomposition by heat

   When calcium carbonate is heated, it decomposes to give calcium oxide and carbon dioxide.

   $CaCO_3 \xrightarrow{\text{Heat, Decomposes}} CaO + CO_2$

   Calsium carbonate calcium oxide carbon dioxide

   Example: - Decomposition by catalyst

   When potassium chlorate is heated in the presence of manganese dioxide catalyst, it decomposes to form potassium chloride and oxygen gas.

   $2KClO_3(s) \xrightarrow{\Delta,\ MnO_2} 2KCl(s) + 3O_2(g)$

Poatssium chlorate potassium chloride Oxygen

Example: - Decomposition by electricity

When electric current is passed through acidified water, it decomposes to give hydrogen gas and oxygen gas.

$2H_2O$ $\xrightarrow{\text{Electricity}}$ $2H_2$ + O_2

Water Hydrogen Oxygen

This reaction is known as electrolysis of water.

Example: - Decomposition by light

Silver chloride decomposes in presence of sunlight to give silver and chloride.

Silver chloride turns grey in sunlight

$2AgCl\ (s)$ $\xrightarrow{\text{sunlight}}$ $2Ag\ (s)$ + $Cl_2(g)$

Silver chloride silver chlorine

(Grey in colour)

3. **Displacement Reactions:** - those reactions, in which one element takes the place of another element in a compound, are known as displacement reactions. A more reactive element displacement a less reactive element from its compound.

Reactivity Series of Metals: - the arrangement of metals in a vertical column in the order of decreasing reactivities is called reactivity series of metals (or activity series of metals)

These Metal Are more Reactive Than hydrogen	**Potassium**	**K**	**(Most reactive Metal)**
	Sodium	**Na**	
	Calcium	**Ca**	
	Magnesium	**Mg**	
	Aluminium	**Al**	
	Zinc	**Zn**	
	Iron	**Fe**	
	Nickel	**Ni**	
	Tin	**Sn**	
	Lead	**Pb**	
	Hydrogen	**H**	

These Metal Are less Reactive Than hydrogen	**Copper**	**Cu**	
	Mercury	**Hg**	
	Silver	**Ag**	
	Gold	**Au**	**(least reactive metal)**
	Platinum	**Pt**	**(least reactive metal)**

A LITTLE FUN TO LEARN THE REACTIVITY SERIES

Kedar (K) Nath (Na) ka (Ca) Mali (Mg) Aaloo (Al) Jara (Zn) feke (Fe) Se (Sn) pakata (Pb) Hain (H) Kuch (Cu) Hoga (Hg) Agar (Ag) Abhi (Au) pata (Pt) nahin.

Example of displacement Reactions: -

(1) When a strip of zinc metal is placed in copper sulphate solution, then zinc sulphate solution and copper are obtained.

$CuSO_4$ (aq) + Zn (s) → $ZnSO_4$(aq) + Cu (s)

Copper sulphate (Blue solution) | zinc | zinc sulphate | copper

(2) Chlorine gas reacts with potassium iodide solution to form potassium chloride and iodine

Cl_2(aq) + 2KI(aq) → 2KCl (aq) + I_2(s)

Chlorine | potassium iodide | potassium chloride | iodine

This reaction occurs because chlorine is more reactive than bromine.

4. **<u>Double Displacement Reaction</u>**: - Those reaction in which two compound react by an exchange of ions to form two new compounds are called double displacement reactions. These reactions also known as metathesis reactions.
A double displacement reaction usually occurs in solution and one of the products being insoluble (i.e. ppt)

Example: 1. When silver nitrate solution is added to sodium chloride solution, then a white ppt of silver chloride is formed along with sodium nitrate solution.

$AgNO_3$(aq) + NaCl (aq) → AgCl (s) + $NaNO_3$(aq)

Silver Nitrate | sodium chloride | silver chloride | sodium nitrate

2. When Ammonium hydroxide solution is added to aluminium chloride solution, then a

white precipitate of Aluminium hydroxide is formed along with ammonium chloride solution.

$3\ NH_4OH\ (aq) + AlCl_3(aq) \rightarrow Al(OH)_3(s) + 3NH_4Cl\ (aq)$

Ammonium hydroxide — aluminium chloride — aluminium hydroxide — ammonium chloride

Double displacement reactions are also known as double decomposition reactions. Double displacement reactions mainly classified into two categories

(a) Neutralization reactions
(b) Precipitation reactions

(a) Neutralization Reactions: - Neutralization reactions are those reactions in which acid and base react to form a salt and water.

Example: - Hydrochloric acid react with Sodium hydroxide to form Sodium chloride and water.

$HCl + NaOH \rightarrow NaCl + H_2O$

Hydrochloric acid — Sodium Hyroxide — Sodium Chloride — water

(b) Precipitation Reaction: - precipitation reaction are those reaction in which precipitate(i.e. undissolve substance remain in the solution) is formed

Example: - Barium chloride solution reacts with aluminium sulphate to form aluminium chloride and a ppt of barium sulphate remains in the solution

$BaCl_2 + Al_2(SO_4)_3 \rightarrow AlCl_3 + BaSO_4 \downarrow$

Barium Chloride — Aluminium Sulphate — Aluminium Chloride — Barium Sulphate

5. **Ionic equation**: - ionic equations are those equation in which contain not only atoms but also contain ions actually taking part in the reaction.
   For balancing ionic equation we balance
   (1) Mass of atoms in reactant and product side (i.e. by balancing number of atoms)
   (2) Charge of atom in reactant and product side.

   Example: - $Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$
   In this reaction number of atom of each element is same i.e. mass balance and the charge on both reactant and product side is equal so that is charge balance.

6. **Polymerization:** - the combination of two or more similar small molecules to form a

single bigger molecule is known as polymerization. These reactions mainly occur in organic compounds and shown by carbon atom.

Example: - Three molecules of acetylene (ethyne) combine together to form benzene molecule.

$3C_2H_2 \xrightarrow{\text{Heat}} C_6H_6$

Ethyne Benzene

7. **Isomerization:** - The reaction in which rearrangement of atoms, within molecules of a substance takes place, resulting in the formation of new substances, is known as isomerization reaction or rearrangement reactions.

   Example: - when ammonium cyanate is heated, it undergoes rearrangement giving a new compound, Urea.

$H_4N\text{-}N{=}C{=}O(NH_4CNO) \xrightarrow{\text{Heat}} H_2N\text{-}\overset{\overset{O}{\|}}{C}\text{-}NH_2(H_2NCONH_2)$

Ammoniumcyanate Urea

8. **Oxidation and reduction**

Oxidation: - (1) The addition of oxygen to a substance is called oxidation
(2) The removal of hydrogen from a substance is also called oxidation
(3) Loss of electron is known as oxidation

Reduction: - (1) The addition of hydrogen to a substance is called reduction
(2) The removal of oxygen from a substance is also called reduction
(3) Gain of electron is known as reduction

Oxidizing agent: - (1) The substance which gives oxygen for oxidation is called an oxidizing agent.
(2) The substance which removes hydrogen is also known as oxidizing agent

Reducing agent: - (1) The substance which gives hydrogen for reduction is called a reducing agent.
(2) The substance which removes oxygen is also known as reducing agent

Example: - when copper oxide is heated with hydrogen, then copper metal and water are formed

Removal of oxygen: Reduction

$$\underset{\downarrow}{CuO} + \underset{\downarrow}{H_2} \rightarrow \underset{\downarrow}{Cu} + \underset{\downarrow}{H_2O}$$

Addition of oxygen: Oxidation

(1) In this reaction H_2 is changing into H_2O that is oxygen is being added to hydrogen. Now by definition oxidation occurs (i.e. hydrogen is being oxidized to water)

(2) CuO is changing into Cu that is oxygen is being removed from copper. Now by definition reduction occurs (i.e. copper oxide is being reduced to copper)

- Copper oxide is the oxidizing agent.
- Hydrogen is the reducing agent here.

Effect of Oxidation Reactions in Everyday life

Oxidation reactions carry out

(1) Corrosion (2) Rancidity

Corrosion: - "The eating up of metal by the action of air and moisture on their surface is called corrosion."

Most of the metal corrodes when they exposed to damp air (or moist air). For example- iron metal corrodes when kept in damp air for a considerable time, and then a red brown substance called rust ($Fe_2O_3.xH_2O$) is formed on its surface. Rust is soft and porous

- Corrosion of iron is called rusting

Reaction take place in rusting of iron is

$$\mathbf{4Fe + 3O_2 + 2xH_2O \rightarrow 2Fe_2O_3.xH_2O}$$

Condition necessary for the rusting of iron: Two conditions are necessary for the rusting of iron to take place

- Presence of air

- Presence of water

Prevention of rusting:

- Rusting of iron can be prevented by painting
- Rusting of iron can be prevented by applying grease and oil
- Rusting of iron can be prevented by galvanization
- Rusting of iron can be prevented by tin-plating and chromium-plating
- Rusting of iron can be prevented by converting them into alloys(i.e. stainless steel)

Rancidity: - the oxidation of oils or fats in a food resulting into a bad smell and bad taste is called rancidity

Or

The spoiling of food is called rancidity

Method to prevent rancidity: The different methods used to prevent or slow down to rancidity are

- By adding anti-oxidant
- Vacuum packing
- Replacing air by Nitrogen
- Refrigerator of the food stuff