CHEMICAL BONDING

Chemical Bond: It is a force of attraction that binds different atoms is a molecule. A chemical bond balances the force of attraction and force of repulsion at a particuler distance (that distance is known as chemical bond)

Why do atoms combine

 \Box to attain the octet state.

- □ minimize energy
- gains tability

□ decrease reactivity

Type of Bonds :

(1) Ionic Bond \rightarrow Transfer of e^-

(2) Covalent bond \rightarrow sharing of e^-

(3) Coordinate bond \rightarrow unequal sharing

(4) Metallic bond \rightarrow Interaction

(5) Hydrogen bond \rightarrow Inter / Intra molecules interaction

(6) Van der Waal's force of attraction.

Bond strength decreases

Ionid Bond / Kernel Bond / Electrovalent Bond :

Kossel

When an electropositive atom comes in contact with electronegative atom, formation of cation and anion takes place.

Due to the formation of opposite charges an electrostatic force of attraction developes between them, because of which both ions are bonded with each other e.g. NaCl

 $Na + Cl \longrightarrow Na^+ Cl^-$

(2,8,1) (2,8,7) (2,8) (2,8)

 \Box Number of electron transferred is equal to electrovalency

 \Box As the electronegativity difference between 2 atoms increases, bond strength also increases

Properties of Ionic Compounds

(1) Solid & hard

(2) High M. P., B. P & Density

(3) conductors in fused, molten or aqueous state e.g. NaCl, MgCl₂, AlN etc.

Covalent Bonds

When 2 electronegative elements comes in contact with each other, equal sharing of electrons takes place between them and results in the formation of covalent bond

e.g. H₂O molecule Cl₂ molecule



Polar and Non-polar covalent bond

If atoms are same or their electronegativity is same the covalent bond between them is non-polar and vice-versa

Non-Polar \longrightarrow X - X, O = O, N = N

Polar
$$\longrightarrow H^{+\delta} \stackrel{-\delta}{O} \stackrel{+\delta}{H} , H^{-\delta} X$$

Types

(1) Single bond	$-\overset{l}{\overset{l}{\overset{}}}$	(2e- shared)
(2) Double bond	>C=C<	(4e- shared)
(3) Triple bond	$-C \equiv C -$	(6e- shared)

 $\hfill\square$ Number of electrons shared represents the covalency.

- Sigma (σ) and Pi (π) bonds
- 1. σ Bond : Formed by head to head or linear overlapping between two s s or s p or p p orbitals.



more stable & stronger

2. π -bond : Formed by cateral or sidewise overlapping between two p-orbital.



less stable & weaker.

Properties of covalent bond

(1) Mostly liquids and gases

(2) Low b. p. & m. p.

(3) Non-conductors

Coordinate or Dative Bonds

The bond formed between two atoms (or ions) in which the contribution of an electron pair is made by one of them while sharing is done by both.

Denoted by (\longrightarrow)

```
A: + B \longrightarrow A \longrightarrow B
Donor Receiver
e.g.
H F
H F
H F
H F
0_{3} \rightarrow
0 = 0 \rightarrow 0
```

Coordinate bond is intermediate between ionic and covalent bonds, but more closely resembles a covalent bond. The properties of coordinate compounds are more close to covalent compounds.

Hydrogen bond

It is a weak interaction denoted by dotted (\dots) lines between hydrogen and a highly electronegative and small sized atom like F, O and N.

Types of Hydrogen Bonds

1. Intermolecular H-bonding

It takes place between two or more different molecule of the same or different types For example, HF, H_2O , NH_3 etc.

Effects

(1) Because of intermolecular - H - Bonding B. P of water is high

(2) H - F is a liquid, while H-Br, H-I are gases

(3) Alcohol is highly soluble in water

2. Intramolecular H-bonding or chelation

This H-bonding takes place within a molecule



Effect

(1) Does not effect B.P.

(2) Volatility increases

Exceptions to the octet rule

(1) $H_2 \rightarrow$ Duplet is complected

(2) Contraction \rightarrow Be₄Cl₂, B₆F₃, Al₆Cl₃, etc.

(3) Expansion $\rightarrow PCl_5$, SF₆, IF₇

10e- 12e- 14e-

Compounds with both ionic & covalent bonds

(1) NaOH \longrightarrow Na⁺ - OH⁻, Na - O - H (Ionic) (Covalent)

(2) $HC \equiv N$

5. Metallic bond:

This bond is formed among metals like Na, K, Li etc.

6. Vander Waal's force of attraction :

This interaction is present between molecules (or ions) It can be of following kinds :

(1) Dipole – Dipole Interaction

$\overset{ \scriptscriptstyle \delta + \quad \scriptscriptstyle \delta - \\ A - B \quad A - B \quad$

(2) Dipole – Induced dipole interaction



(3) Dipole - Ion Interaction

 $\overset{\delta_{+}}{A-B} \overset{b_{-}}{B} \overset{t}{C}$

(4) Dispersion forces : Among molecules.

CHEMICAL BONDING

1.	The number of sigma and	pi bonds present in terracy	vanoethylene $\{(CN)_2 C = C(C)\}$	$(CN)_2$ molecules are respectively.						
	(A) 5 σ and 9 π	(B) 5 σ and 8 π	(C) 9 σ and 9 π	(D) 9 σ and 7 π						
2.	Unusually high boiling p	oint of water is the result	of							
	(A) Intermolecular hydrog	gen bonding	(B) Both intra and inter molecular hydrogen bonding							
	(C) High specific heat		(D) Intramolecular hydrogen bonding							
3.	Dissolution of ionic solid	in water is accompanied b	by release of energy represented by $\Delta H_{\text{solution}}$. This implies							
	that									
	(A) $\Delta H_{lattice} > \Delta H_{hydration}$		(B) $\Delta H_{\text{lattice}} = \Delta H_{\text{hydration}}$							
	(C) $\Delta H_{\text{hydration}} > \Delta H_{\text{lattice}}$		(D) $\Delta H_{\text{lattice}}$: $\Delta H_{\text{hydration}}$ =	1 : 2						
4.	In which of the following	g molecules, the central a	tom does not follow the o	octet rule?						
	(A) H_2O	(B) H_2S	(C) BF ₃	(D) CO ₂						
5.	Bond angle in water is									
	(A) 120°	(B) 107°	(C) 104.5°	(D) 109.5°						
6.	Which of the following i	s the electron deficient m	olecule?							
	(A) $C_2 H_6$	(B) $B_2 H_6$	(C) SiH ₄	(D) PH ₃						
7.	Which type of bond is n	ot present in HNO ₂ mole	ecule?							
	(A) covalent	(B) coordinate	(C) Ionic	(D) Ionic as well as coordinate						
8.	The angular shape of oz	zone molecule (O_3) consist								
	(A) 1 sigma and 1 pi bo	onds	(B) 2 sigma and 1 pi bonds							
	(C) 1 sigma and 2 pi bo	onds	(D) 2 sigma and 2 pi bo	onds						
9.	The correct sequence of	increasing covalent char	acter is represented by							
	(A) LiCl < NaCl < BeCl	2	(B) BeCl_2 < LiCl < NaC	21						
	(C) NaCl < LiCl < BeCl	2	(D) $BeCl_2 < NaCl < LiCl$							
10.	What is the correct orde	er of the strength of hydro	rogen bonds?							
	(A) NHN < OHO <	FHF	(B) ClHCl > NHN >	OHO						
	(C) CHCl < NHN <	OHO	(D) NHN > OHO > FHF							
11.	Which of the following;	molecules has almost neg	ligible tendency to form h	ydrogen bonds?						
	(A) NH ₃	(B) H ₂ O	(C) HF	(D) HI						
12.	The two atoms X and Y	lie on the top of group 2	2 and group 16 respective	ly. On combination, they form						
	form compound of the ty	pe (D) VV								
10	(A) $X_2 Y_2$	(B) XY	(C) $X_2 Y$	(D) XY_2						
13.	Inter-molecular hydroger	(D) 11 1 1								
14	(A) o-nitrophenol	(B) o-chlorophenol	(C) Ammonium chloride	(D) Water						
14.	Which one of the follow	ing compounds has the si	mallest bond angle in its r	nolecule?						
15	(A) SO_2	(B) OH ₂	(C) SH_2	(D) NH ₃						
15.	Which of the following f	has the highest bond orde	r?							
16	(A) N_2	(b) U ₂	(С) Пе ₂	(D) H ₂						
16.	Ine number of σ bond	In pent-4-en-1 yne is	(D) 2 - 4 -	(D) = 7						
	(Α) 10σ, 3π	(Β) 9σ, 9π	(Β) 3σ, 4π	(D) 5σ, /π						
28										

17.	Bond order of O_2 is						
	(A) 1 (B) 2.5	(C) 2	(D) 1.5				
18.	How many sigma and pi bonds are present	in toluene?					
	(A) $3\sigma + 6\sigma$ (B) $3\sigma + 8\sigma$	(C) 6σ + 6σ	(D) 3π + 15σ				
19.	Which one of the following is the weakest $? % \left({{{\left({{{{{\bf{n}}_{{\rm{c}}}}} \right)}}} \right)$						
	(A) Ionic bond (B) Covalent	(C) Metallic bond	(D) Vander Waal's forces				
20.	NH_{3} and BF_{3} form aduct readily because the	ey form					
	(A) Ionic bond (B) Covalent bond	(C) Datme bond	(D) Hydrogen bond				
21.	The molecular with maximum percentage ion	nic character is					
	(A) HI (B) HBr	(C) HCl	(D) HF				
22.	A metallic bond is						
	(A) Ionic (B) Polar covalent	(C) Non-polar covalent	(D) Electrostatic				
23.	The most suitable method to separate a mix	ture of orthonitrophenol and	para nitrophenol is ?				
	(A) Steam distilation (B) Crystallisation	(C) Vaporisation	(D) Spectroscopy				
24.	When 2 ice cubic are pressed over each other is responsible to hold then together ?	er they unit to form one cube	. Which of the following forces				
	(A) Ionic Interaction	(B) Vander Waal's force	S				
	(C) Covalent bond formation	(D) Hydrogen bond form	nation				
25.	If a neutron is added to the nucleus of an at	tom, then					
	(A) its atomic mass will increase	(B) its nuclear charge w	vill decrease				
	(C) its atomic mass will remain the same	(D) it will become negat	tive in polarity				
26.	The bond angle of H – C – H in a molecule	e of methane is					
	(A) 100° (B) 109°	(C) 103°	(D) 102°				
27.	The electronic configuration of an ion of Mg	++ is					
	(A) 2, 8, 1 (B) 2, 8	(C) 2, 8, 2	(D) 2, 8, 3				
28.	In a covalent bond the electrons are	between the two participating	atoms				
	(A) Transferred completely		(B) Shared				
	(C) neither transferred nor shared	(D) insufficient informati	on to predict				
29.	Why the H – Cl bond is polar ionic?						
	(A) The nucleus of hydrogen is stronger	(B) The nucleus of chlor	rine is stronger				
	(C) Both the nucleii are equally stronger	(C) None of the above					
30.	Which one of the following is not an electrow	valent compound?					
	(A) Common salt (B) Caustic soda	(C) Aluminium chloride	(D) Carbon tetrachloride				
31.	Which one of the following groups has the s	trongest tendency to lose an e	electron ?				
	(A) F, CI, Br (B) Li, Na, K	(C) Si, Pb	(D) Cu, Ag, Au				
32.	Electrovalent linkage is formed by						
	(A) transfer of electrons						
	(B) mutual sharing of electrons						
	(C) transfer as well as mutual sharing of elec	etrons					
	(D) None of the above						
			29				

33.	Why is carbon the hard	est substance in the world	l when it is found as a dia	amond?								
	(A) C – C bonds are str	rongest due to heat and p	pressure during the format	tion								
	(B) The C – H bonds a	re strongest in diamond										
	(C) The structure is a te	etrahedron which has a sta	able configuration									
	(D) Carbon is pure and	hence, the hardest										
34.	What the valency of alk	ali metals?										
	(A) +1	(B) –2	(C) –1	(D) +2								
35.	The atomic number of a	an element is 11. What is	s the number of electrons	in the M shell of the atom?								
	(A) 2	(B) 1	(C) 0	(D) 3								
36.	The valency of elements	s in the periodic table tov	vard, hydrogen									
	(A) decreases regularly from 1 to 8											
	(B) first increases from	Group I to Group IV and	then, decreases									
	(C) first decreases from	Group I to Group IV and	l then, increases									
	(C) first decreases from Group I to Group IV and then, increases(D) None of the above											
37.	(D) None of the above The bond formed between the atoms of the same element is a $/$ an											
	(A) covalent											
	(B) ionic bond											
	(C) metallic bond											
	(D) depends upon the c	conditions of temperature	and pressure									
38.	Which one has more ab	pility to gain an electron?										
	(A) F	(B) Na	(C) C	(D) Mg								
39.	The atomic number of (Cl is 17. After it gains an	n electron, the electronic o	configuration of Cl ⁻ becomes								
	(A) 2, 8, 7	(B) 2, 8, 9	(C) 2, 8, 8	(D) 2, 8, 7, 1								
40.	If coal is burned in limit	ed supply of oxygen, CO	is formed. Why?									
	(A) All the carbon atom	s are unable to get attact	ned to oxygen atoms to p	roduce molecules of CO2								
	(B) O is less electrovaler	nt than C										
	(C) Oxygen is sufficient	to produce bonds with C	such that $\mathrm{CO}_{\!_2}$ may be fo	rmed								
	(D) C and O do never p	procuce CO ₂										
41.	The existence of a num	ber of free and mobile el	lectrons in some elements	make them good								
	(A) conductors	(B) insulators	(C) partial conductors	(D) All of the above								

	ANSWER KEY														
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	С	А	С	С	С	В	D	В	С	А	D	В	D	С	А
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	А	С	D	D	С	А	D	С	D	А	В	В	В	В	D
Que.	31	32	33	34	35	36	37	38	39	40	41				
Ans.	В	А	А	А	В	В	А	А	С	А	А				
30															

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MOLE CONCEPT

MOLE

Mole is a unit which represents $6.023 \text{ H} 10^{23}$ particles, atoms, molecules or ions etc., irrespective of their nature.

Mole is related to the mass of substance, the volume of gaseous substance and the number of particles

Mole = $\frac{W}{M}$ = $\frac{Wt. \text{ of substance in gm.}}{Molar \text{ mass of substance (G. m. m,)}}$

Here G. m. m. = Gram molecular mass

Mole =
$$\frac{\text{Volume of substance in litre}}{22.4 \text{ litre}}$$

Volume of one mole of any gas is equal to 22.4 litres of dm³ at STP. It is known as molar volume.

$$Mole = \frac{Number of identities}{Avogardo's number}$$

Mole = $\frac{PV}{RT}$

Here P = Pressure in atmosphere

- V = Volume in litre
- T = Temperature in Kelvin
- R = Universal gas constant

Relationship of Mole :

A mole of any substance (like N_2) stands for :

- \square 6.023 \dashv 10²³ molecules of N₂
- \square 2 4 6.023 4 10²³ atoms of nitrogen
- □ 28 gm of nitrogen
- \Box 22.4 litre of N₂ at STP.

To Find Total Number of Identities

- \Box Total number of Molecule = mole(n) N_A
- \Box Total number of Atoms = mole (n) Ψ N_A Ψ Number of atoms present in one molecule
- \Box Total number of Electrons = mole (n) Y N_A Y Number of electron present in one atom
- $\Box\,$ Total charge on any ion = mole (n) Y N_A Y charge on one ion Y 1.6 Y $10^{-19}C$

MASS

Mass can be expressed in terms of atoms or molecules as follows :

Atomic Mass

It is the relative mass of an atom which show how many time an atom is heavier than $\frac{1}{12}$ mass of C - 12.

 \Box The atomic mass of any element expressed in grams is called G. A. M. (gram atomic mass). Atomic mass = E 4 V

Here E = Equivalent weight

V = Valency

 \Box Atomic mass = Specific Heat in cal.

It is known as Dulong Petit's law.

REMEMBER

Gram atomic weight is atomic weight expressed in grams but it has a special significance with reference to a mole.

Molecular Mass

Molecular mass represents the total mass of a molecule, that is, number of time a molecule is heavier

than that of $\frac{1}{12}$ weight of C – 12.

- □ It is non-variable.
- $\hfill\square$ It is now called relative molecular mass.

Chemical Formula

A chemical formula represents the combination of atoms of all the elements which makes up a compound. It represents the relative ratio of atoms of its constituent elements. In case of a compound, it represents one molecule, one mole, one gram molecular weight one molecule of phosphorous and one mole of phosphorous.

Example, $CuSO_4.5H_2O$ represents one molecule, one mole and one gram molecular weight of hydrated copper sulphate.

Empirical and Molecular Formulas

Empirical Formula

It gives the simplest ratio of the number of atoms of different elements present in one molecule of a compound. It does not represent the actual number of atoms of different elements present in one molecule of the compound.

Calculation of the Empirical Formula : It involves the following steps, one by one.

- (i) First determine the percentage composition by weight of each element present in the compound.
- (ii) Now the percentage of each element is divided by its atomic weight to get the relative number of atoms of each element.

(iii) These relative numbers obtained are divided by smallest number to get the simplest ratio numbers.

(iv) If the simplest ratio number is not a whole number it should be multiplied by a suitable integer to get a whole number.

(v) The ratio of these simple whole numbers gives the empirical formula of the compound.

Molecular Formula

It shows the actual number of atoms of different elements present in one molecule of the compound.

Molecular weight

 \Box n = $\overline{\text{Empirical formula weight}}$

 \Box Molecular formula = empirical formula n.

 $\hfill\square$ Molecular weight of a substance can be determined by difference methods.

 \Box Molecular weight = empiricial formula wt. Y 'n'.

 $\hfill\square$ For some compounds the molecular formula and empirical formula may be same also.

Expression of Concentration of Solution

The solutions whose concentration is exactly known is referred as standard solution and such solutions are prepared in volumetric or standard flask.

Concentration

It is the amount of solute present in one litre of solution. It is denoted by C or S.

$$C \text{ or } S = \frac{\text{Weight of solute in gram}}{\text{Volume in litre}}$$
$$C = N \ \text{H } E$$
$$\text{Here } N = \text{normality}$$
$$E = Eq. \ \text{wt.}$$

Molarity

It is the number of moles or gram moles of solute dissolved per litre of the solution. Molarity is denoted by 'M'.

 $M = \frac{\text{Weight of solute in gram}}{\text{Molar mass Wolume in litre}}$

 \Box When molarity of a solution is one, it is called a molar solution and when it is 0.1 solution is called decimolar solution.

Molality

It is the number of moles or gram moles of solute dissolved per kilogram of the solvent. It is denoted by 'm'.

m = Weight of solute in gram Molar mass YWeight of solvent in Kg

- \Box If molality is one solution, it is called molal solution.
- $\hfill\square$ One molal solution is less than one molar solution.
- □ Molality is preferred over molarity during experiments as molality is temperature independent while molarity is temperature dependent.

Normality

It is the number of gram equivalents of solute present in one litre of the solution and it is denoted by 'N'.

 $N = \frac{\text{Weight of solute in gram}}{\text{Equivalent mass 4Volume in litre}}$

 \Box When normality of a solution is one, the solution is called normal solution and when it is 0.1, the solution is called deci-normal solution.

Normality Equation

 $N_1V_1 = N_2V_2$

Relation between Normality and Molarity

N Y Equivalent weight = molarity Y molar mass

 $N = molarity \ Y \ valency$

N = molarity Y number of H^+ or OH^- ion.

Mole fraction

It is the ratio of moles of one component to the total number of moles present in the solution. It is expressed by X for example, for a binary solution two component A and B.

$$X_A = \frac{n_A}{n_A + n_B}$$
$$X_B = \frac{n_B}{n_A + n_B}$$
$$X_A + X_B = 1$$

MOLE CONCEPT

1.	The number of molecu	lles in 16 g of oxygen (C	D ₂) is :						
	(A) 6.022 Y 10 ²³	(B) 3.011 Y 10 ²³	(C) 3.011 Y 10 ²²	(D) 1.5 Y 10 ²³					
2.	Which has the maximu	im number of molecules	?						
	(A) 1 g of CO_2	(B) 1 g of N_2	(C) 1 g of H_2	(D) 1 g of CH_4					
3.	Which weighs the max	imum ?							
	(A) 2.24 litres of CO_2	at N. T. P.	(B) 6.022 Y 10 ²³ mole	cule of CO ₂					
	(C) 6.022 Y 10 ²³ atom	ns of carbon	(D) 10 g of CO_2						
4.	The number of atoms	in 4.25 g of NH_3 is app	proximately						
	(A) 1 Y 10 ²³	(B) 2 Y 10 ²³	(C) 4 Y 10 ²³	(D) 6 Y 10 ²³					
5.	The number of molecu	lles in 16g of methane is	5 :						
	(A) 3.0 Y 10 ²³	(B) 6.022 Y 10 ²³	(C) 16/6.022 4 10 ²³	(D) 16/3.0 Y 10 ²³					
6.	The number of gram-n	nolecules of oxygen in 6.	022 Y 10^{24} molecule of	CO is :					
	(A) 10 gm moles	(B) 5 gm moles	(C) 1 gm moles	(D) 0.5 gm moles					
7.	Largest number of mo	lecules are present in :							
	(A)36 g of water	(B) 28 g of CO_2	(C) 46 g of C_2H_5OH	(D) 54g of N_2O_5					
8.	Element X (Atomic ma having 75.8% X. The	ss = 75) and element Y formula of the compound	(Atomic mass = 16) cor d is :	nbine to give a compound					
	(A) XY	(B) X ₂ Y	(C) X ₂ Y ₂	(D) X ₂ Y ₃					
9.	4.4 g of an unknown g	gas occupies 2.24 L of v	volume under N. T. P. c	onditions. The gas may be :					
	(A) CO ₂	(B) CO	(C) O ₂	(D) SO ₂					
10.	The number of moles standard conditions is :	of oxygen in 1L of air w	hich contains 21% oxyg	en by volume under					
	(A) 0.186 mol	(B) 0.21 mol	(C) 2.10 mol	(D) 0.0093 mol					
11.	One amu stands for								
	(A) An atom of carbon	(C ¹²)	(B) $\frac{1}{12}$ th of carbon atom (C ¹²)						
	(C) $\frac{1}{12}$ th hydrogen ato	m	(D) One atom of all ato	oms					

12. Which of the following is not an element ? (C) Tungsten (A) Diamond (B) Silica (D) Graphite 13. How many times an atom of sulphur is heavier than an atom of carbon ? (A) 32 times (B) 12 times (C) 8/3 times (D) 12/32 times The number of moles in 0.64 g of SO_2 is : 14. (A) 100 (B) 10 (C) 0.1 (D) 0.01 **15.** The volume occupied by 1.0 g of hydrogen in litres under N. T. P. conditions is : (A) 2.24 (B) 22.4 (C) 1.12 (D) 11.2 16. One molal solution contains 1 mole of a solute in : (A) 1000 g of the solvent (B) one litre of the solvent (C) One litre of the solution (D) 22.4 litres of the solution 17. Which of the following is the standard for atomic mass ? (B) ${}^{12}_{6}C$ (C) ${}^{14}_{6}$ C (D) ¹⁶₈O $(A) {}^{1}_{1}H$ 18. If 10^{21} molecules are removed from 200 mg of CO₂, then the number of moles of CO₂ left will be: (A) 2.88 Y 10⁻³ (B) 1.66 Y 10⁻³ (C) 4.54 Y 10⁻³ (D) 1.66 Y 10⁻² **19.** The number of atoms of oxygen present in 11.2 L of ozone at N. T. P. are : (A) 3.01 Y 10²² (B) 6.02 Y 10²³ (C) 9.03 Y 10²³ (D) 1.2 Y 10²⁴ **20.** 2.76 g of silver carbonate (Ag_2CO_3) on strong heating yeilds a residue weighing (A) 2.16 g (B) 2.48 g (D) 2.64 g (C) 2.32 g 21. The number of oxygen atoms in 4.4 g of CO_2 is approx (A) 6 Y 1022 (B) 6 Y 10²³ (C) 12 Y 1022 (D) 1.2 Y 10²³

CHEMISTRY

	ANSWER KEY														
Que. 1 2 3 4 5 6 7 8 9 10 11 12 13 14													14	15	
Ans.	В	С	В	С	В	В	А	D	А	D	В	В	С	D	D
Que.	16	17	18	19	20	21									
Ans.	А	В	Α	С	С	D									
															25

ELECTROLYSIS

Electrochemistry is defined as that branch of chemistry which deals with the relationship between electrical energy and chemical changes taking place in redox reactions, ie., how chemical energy produced in a redox reaction can be converted into electrical energy or how electrical energy can be used to bring about a redox reaction which is otherwise non-spontaneous.

Chemical changes involving production or consumption of electricity are called *electrochemical changes*. Thus, the three main aspects of study in the branch of electrochemistry are:

(1) Electrolysis (2) Electrolytic conduction (3) Electrochemical cells/Galvanic cellsroltaic cells.

Importance of Electrochemistry. The subject of electrochemistry has great theoretical as well as practical importance. For example,

- (i) A number of metals such as Na Mg, Ca and Al and a number of chemicals such as NaOH, Cl₂, F₂, *etc.* are commercially produced by electrochemical methods.
- (ii) Batteries and cells used in various instruments and other devices convert chemical energy into electrical energy.
- (iii) The sensory signals sent to the brain through the cells and vice versa and also the communication among different cells are based on electrochemical phenomena.

Moreover, the reactions carried out electrochemically are generally energy efficient and less polluting, i.e., they are eco friendly. Hence, their study is gaining importance to develop new technologies. Now, in this unit, we shall take up the study of different aspects one by one.

Importance of Electrolysis. Electrolysis has wide applications in industries. Some of the important applications are :

- (i) Production of hydrogen by electrolysis of water.
- (ii) Electrolysis extraction of metals like Na, K, Mg, Ca, Al, etc. Sodium and potassium are produced by the electrolysis of their fused chlorides whereas aluminium is produced by electrolysis of molten aluminium oxide mixed with cryolite.
- (iii) Production of chlorine by electrolysis of aqueous NaCl solution.
- (iv) Manufacture of heavy water (D_2O).
- (v) Eectroplating and electrolytic refining of metals.

Quantitative Aspects Electrolysis and Faraday's Laws

The relationship between the amounts of substances liberated at the electrodes during electrolysis and the amount of current passed was studied by *Michael Faraday* (1833). He put forward the following two laws which are called *Faraday's Laws of Electrolysis*.

(1) Faraday' First Law of Electrolysis : It states that

The amount of chemical reaction and hence the mass of any substance deposited or liberated at any electrode is directly proportional to the quantity of electricity passed through the electrolyte (solution or melt).

Thus, if W gram of the substance is deposited on passing Q coulombs of electricity, then

$$W \propto Q$$
 or $W=ZQ$

where Z is a constant of proportionality and is called **electrochemical equivalent** of the substance deposited.

During Faraday's time, there were no devices available which could supply constant current. Hence, the quantity of electricity passed was measured by putting an apparatus called **coulometer** (coulomb measurer) in the circuit which is simply a standard electrolytic cell. Generally, copper or silver coulometers were used and the quantity of electricity passed was calculated from the mass of copper or silver deposited or consumed in the coulometer. However, coulometers are no longer used because now we have devices which supply constant current (I) and quantity of electricity can be calculated using the formula $Q = I \ U \ t$, where Q is in coulombs when I is in ampere and t in seconds.

If a current of I amperes is passed for t seconds, then Q = I Y t so that W = Z Y Q = Z Y I Y t

Thus, if Q = 1 coulomb or I = 1 ampere and t = 1 second, W = Z. Hence,

Electrochemical equivalent of a substance may be defined as the mass of the substance deposited when a current of one ampere is passed for one second, i.e., a quantity of electricity equal to one coulomb is passed.

(2) Faraday's Second Law of Electrolysis : It states that

When the same quantity of electricity is passed through solutions of different electrolytes connected in series, the weights of the substances produced at the electrodes are directly proportional to their equivalent weights.

For example, for $AgNO_3$ solution and $CUSO_4$ solution connected in series, if the same quantity of electricity is passed,

 $\frac{\text{Weight of Ag deposited}}{\text{Weight of Cu deposited}} = \frac{\text{Eq. wt. of Ag}}{\text{Eq. wt. of Cu}}$

Quantitative Aspects of Electrolysis.

Consider the electrolysis of molten NaCl, i.e.,

$$Na^+ Cl^- \longrightarrow Na + \frac{1}{2}Cl_2$$

Thus, we have

 $Na^+ + e^- \longrightarrow Na$

This means that one electron produces one sodium atom. Therefore, passage of one mole of electrons will produce one mole of sodium.

Again from the above reaction,

 $Cl^{-} \longrightarrow Cl + e^{-}or 2Cl^{-} \longrightarrow Cl_{2} + 2 e^{-}$

i.e., 2 moles of electrons produce one mole of Cl₂.

Similarly, looking at the reactions, $Cu^{2+} + 2e^- \longrightarrow Cu$ and $Al^{3+} + 3e^- \longrightarrow Al$, we find that two moles of electrons produce one mole of Cu whereas three moles of electrons will produce one mole of Al. The charge carried by one mole of electrons can be obtained by multiplying the charge present on one electron with Avogadro's number, i.e., it is equal to $(1.6021 \text{ H } 10^{-19} \text{ coulombs}) \text{ H} (6.022 \text{ H } 10^{23}) = 96487 \text{ coulombs}$. This quantity of electricity is called **one faraday**. As it is a constant quantity, it is known as Faraday's constant and is represented by F. For approximate calculations, the value used is 96500 C mol⁻¹.

Hence, Faraday's constant, F = 96487 C mol⁻¹ = 96500 C mol⁻¹

Thus, it may be concluded that



Electrolytic cells (voltameters) connected in series

If n electrons are involved in the electrode reaction, the passage of n faradays (i.e., n 4 96500 C) of electricity will liberate one mole of the substance.

In terms of gram equivalents (old concept), it maybe remembered that

One faraday (i.e., 96500 coulombs) of electricity deposits one gram equivalent of the substance. This is because

equivalent weight of any element = $\frac{\text{Atomic weight of the element}}{\text{No. of electrons gained or lost by one atom ion of the element}}$

Two Important Results/Conclusions. (i) As one faraday (96500 coulombs) deposits one gram equivalent of the substance, hence electrochemical equivalent can be calculated from the equivalent weight,

i.e., $Z = \frac{Eq. wt. of the substance}{96500}$

(ii) Knowing the weight of the substance deposited (W gram) on passing a definite quantity of electricity coulombs),

the equivalent weight of the substance can be calculated, i.e., Eq. wt. = $\frac{W}{Q} \times 96500$

The quantity of electricity actually passed is calculated from the current and time as follows :

Quantity of electricity in coluombs = Current in amperes x Time in seconds

Thus, knowing the quantity of electricity passed, the amount of substance deposited can be calculated.

EXERCISE ELECTROLYSIS

- 1. The effect of temperature increase on conduction is as follows :-
 - (A) Metallic conduction increases, electrolytic conduction decreases.
 - (B) Electrolytic conduction increases, metallic conduction decreases.
 - (C) Both metallic and electrolytic conduction decrease.
 - (D) Both metallic and electrolytic conduction decrease.
- 2. Effect of dilution on conduction is as follows
 - (A) Specific conductance increases, molar conductance decreases
 - (B) Specific conductance decreases, molar conductance increases.
 - (C) Both increase with dilution.
 - (D) Both decrease with dilution.
- 3. The products of electrolysis of aqueous NaCl solution are
 - (A) Na at cathode and Cl_2 at anode (B) H_2 at cathode and Cl_2 at anode
 - (C) H_2 at cathode and O_2 at anode (D) Na at cathode and O_2 at anode.
- 4. An electrochemical cell stops working after some time because :
 - (A) One of the electrodes is eaten away
 - (B) electrode potentials of both the electrodes become equal in magnitude
 - (C) Electrode potentials of both electrodes go on decreasing.
 - (D) Electrode potentials of both the electrodes go on increasing.

- 5. Calculate the standard free energy change for the reaction, $2 \text{ Ag} + 2\text{H}^{\scriptscriptstyle +} \longrightarrow \text{H}_2 + 2\text{Ag}^{\scriptscriptstyle +},$ E° for $Ag^{+} + e^{-} \longrightarrow Ag$ is 0.80 V. (A) 54.4 kJ (B) +308.8 kJ (C) – 154.4 kJ (D) -308.8 kJ 6. A current of 2.0 A passed for 5 hours through a molten metal salt deposits 22.2 g of metal (At. wt. = 177). The oxidation state of the metal in the metal salt is (C) +3 (A) +1 (B) +2 (D) +4. 7. A dilute aqueous solution of Na_2SO_4 is electrolysed using platinum electrodes. The products at the anode and cathode are (B) SO₂, Na (D) $S_2O_8^{2-}$, H_2 (A) O_2, H_2 $(C) O_{o}$, Na For the cell reaction, 8. Cu^{2+} (C_1 aq) + Zn (s) \rightarrow Zn²⁺ (C_2 aq) + Cu (s) of an electrochemical cell, the change in free energy, AG, at a given temperature is a function of (D) $\ln (C_1 + C_2)$ (B) $\ln (C_2/C_1)$ (C) $\ln C_2$ (A) $\ln C_1$ 9. A gas X at 1 atm is bubbled through a solution containing a mixture of 1 M Y⁻ and 1 M Z⁻ at 25°C. If the reduction potantial of Z > Y > X, then (A) Y will be oxidise X and not Z (B) Y will oxidise Z and not X (C) Y will oxidise both X and Z (D) Y will reduce both X and Z. 10. For the electrochemical cell, $M \mid M^+ \mid \mid X^{-1} \mid X, E^\circ$ (M⁺/M) = 0.44 V and E° (X/X-) 0.33 V. From this data, one can deduce that (A) M + X \longrightarrow M⁺ + X⁻ is the spontaneous reaction (B) $M^+ + X^- \longrightarrow M + X$ is the spontaneous reaction (C) $E_{cell} = 0.77 V$
 - (D) $E_{cell} = 0.77 V$

	ANSWER KEY													
1. (B)	2. (B)	3. (B)	4. (B)											
5. (A)	6. (C)	7. (A)	8. (B)											
9. (A)	10. (B)													

STUDY OF SOME COMPOUNDS

Ammonia

Ammonia is present in small quantities in air and soil where it is formed by the decay of nitrogenous organic matter, e.g., urea

Urea

 $\mathrm{NH}_{2}\mathrm{CONH}_{2} + 2\mathrm{H}_{2}\mathrm{O} \longrightarrow (\mathrm{NH}_{4})_{2}\mathrm{CO}_{3} \longrightarrow 2\mathrm{NH}_{3} + \mathrm{H}_{2}\mathrm{O} + \mathrm{CO}_{2}$ Amm. carbonate Ammonia

Preparation of Ammonia

(1) By heating ammonium salts with a strong base. On a small scale, ammonia is prepared by heating ammonium salts with a strong base.

 $(NH_4)_2SO_4 + 2NaOH \xrightarrow{Heat} 2NH_3 + 2H_2O + Na_2SO_4$ Amm. sulphate

Ammonia

$$NH_4Cl + KOH \longrightarrow NH_3 + H_2O + KC$$

In the **laboratory**, ammonia is prepared by heating a mixture of slaked lime and ammonium chloride.

$$2NH_4Cl + Ca(OH)_2 \xrightarrow{Heat} 2NH_3 + 2H_2O + CaCl_2$$

Slaked lime

(2) By the action of water on metal nitrides

 $Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3$ Mag. nitride AlN + $3H_2O O Al(OH)_3 + NH_3$

Aluminium nitride

Drying of ammonia gas. The moisture present in ammonia may be removed by passing it through a glass tower packed with quick lime, CaO. It cannot be dried by :

(i) Conc. H₂SO₄ since it reacts with it forming ammonium sulphate.

 $2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$

(ii) Anhydrous calcium chloride since it forms a complex having the composition, CaCl₂.8NH₃.

(iii) Phosphorus pentoxide since it reacts to form ammonium phosphate.

$$P_2O_5 + 3H_2O \longrightarrow 2H_3PO_4$$
; $3NH_3 + H_3PO_4 \longrightarrow (NH_4)_3PO_4$

Manufacture of Ammonia

On a commercial scale, ammonia is manufactured by Haber's process.

 N_2 (g) + $3H_2$ (g) $\square \square \square \square$ $2NH_3$ (g) ; $\Delta_r H^\circ = -92.4 \ U \ mol^{-1}$

This reaction is reversible, exothermic and occurs with decrease in volume. Therefore, according to Le Chatelier's principle, the favourable conditions for the manufacture of ammonia are :

- (i) Low temperature. Since the forward reaction is exothermic, low temperature will favour the formation of ammonia. However, at low temperatures, the rate of the reaction will be slow. The optimum temperature for the reaction has been found to be around 700 K.
- (ii) High pressure. Since the forward reaction occurs with decrease in volume, high pressure will favour the formation of ammonia. The reaction is usually



carried out at a pressure of about 200 Y 10⁵ Pa or 200 atmospheres.

- (iii) Catalyst. The rate of reaction is fairly low around 700 K. It is increased by using iron oxide as catalyst with small amounts of K₂O and Al₂O₃. Sometimes, molybdenum is used as a promoter (which increases the efficiency of the catalyst). The flow chart for production of ammonia is shown in Figure. Physical Properties of Ammonia
- 1. Ammonia is a colourless gas with a characteristic pungent smell called the ammoniacal smell. It causes tears in the eyes.
- **2.** It is lighter than air (density = 0.68 g/cm^3)
- **3.** It is extremely soluble in water ; one volume of water can dissolve about 1000 volumes of the gas at 273 K.
- **4.** Ammonia can be easily liquefied by cooling under pressure. Liquid ammonia boils at 239.6 K and freezes at 198.4 K. Like water, ammonia is also associated in solid and liquid states through hydrogen bonding. This accounts for its higher melting and boiling points than expected on the basis of its molecular mass.
- 5. When vapourized, liquid ammonia causes intense cooling.

Structure of Ammonia

The nitrogen atom in NH_3 is sp³-hybridised, The three of the four sp³-orbitals form three N—H σ -bonds while the fourth contains a lone pair of electrons. Since the lone pair-bond pair repulsions are stronger than bond pair-bond pair repulsions, therefore, the H–N–H bond angle decreases from 109° 28' to 107.8°. As a result, NH_3 molecule has **pyramidal geometry** with N – H bond length of 101.7 pm and bond angle of 107.8°.

Uses of Ammonia

Some important uses of ammonia are

- (i) In the formation of various nitrogenous fertilizers such as urea, ammonium nitrate, ammonium sulphate, ammonium phosphate, calcium ammonium nitrate (CAN), etc.
- (ii) In the manufacture of nitric acid by the *Ostwald's process* and in the manufacture of sodium carbonate by the *Solvay's process*.
- (iii) Liquid ammonia is used as a refrigerant in ice-factories and cold storages.
- (iv) As a cleansing agent for removing grease, etc.
- (v) As a laboratory reagent.

Tests of Ammonia

(i) It turns moist red litmus paper blue and moist turmeric paper brown.

(ii) It gives brown precipitate with Nessler's reagent

(iii) With a drop of HCI, it produces dense white fumes of ammonium chloride.

(iv) With copper sulphate solution, it gives a deep blue solution.

(v) It gives a yellow precipitate with chloroplatinic acid.

H ₂ PtCl ₆	+	$2NH_3$	\longrightarrow	$(NH_4)_2 PtCl_6$
Chloroplatinic	acid		Amm	. chloroplatinate (yellow ppt.)

Nitric Acid, HNO₃

Nitrogen forms three oxoacids such as $H_2N_2O_2$ (hyponitrous acid), HNO_2 (nitrous acid) and HNO_3 (nitric acid). Their structures are :

$$HO$$
 $H-O-N=O$ $H-O-N$ O O $H-O-N$ O $H-O-N$ O $H-O-N$ O $H-O-N$ O $H-O-N$ O $H-O-N$ O $Nitric acid O $Nitric acid O $Nitric acid O $Nitric acid O O $Nitric acid O O $Nitric acid O O $Nitric acid O $Nitric acid O$ $N$$$

CBSE <u>: CLASS-X</u>

Preparation of Nitric Acid

In the laboratory, nitric acid is prepared by heating KNO3 or NaNO3 and concentrated sulphuric acid in a glass retort.

$$NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$$

On commercial scale, it is mainly prepared by Ostwald's process. This method is based upon the catalytic oxidation of ammonia by atmospheric oxygen.

 $4 \text{ NH}_{3}(g) + 5O_{2}(g) \xrightarrow{\text{Pu/Rh gauge catalyst}}{500 \text{ K}, 9\text{bar}} 4\text{NO}(g) + 6H_{2}O(g)$

Nitric oxide thus formed readily combines with oxygen to give NO₂.

 $2NO(g) + O_2(g) \longrightarrow 2 NO_2(g)$

Nitrogen dioxide thus formed dissolves in water to form HNO₃.

 $3 \text{ NO}_2(g) + H_2O(\ell) \longrightarrow 2HNO_3(aq) + NO(g)$

The nitric oxide thus formed is recycled and the aqueous HNO_3 is concentrated by distillation to give 68% HNO_3 by mass. Further concentration to 98% can be achieved by dehydration with concentrated H_2SO_4 .

Structure of Nitric acid

Spectroscopic studies have shown that in the gaseous state, HNO_3 exists as a planar molecule with the bond angle and bond length as shown.



Gaseous nitric acid

Actually nitric acid is a resonance hybrid of the following two structures :



Resonance structure of HNO₃

Like nitric acid, nitrate (NO) ion is a resonance hybrid of the following three resonance structures



Resonating structure of NO₃ ion

As a result of resonance, all the three N – O bond lengths in NO_3 ion are equal and are 218 pm long.

Physical Properties of Nitric Acid

- 1. Pure nitric acid is a colourless *fuming liquid* with pungent odour. However, impure nitric acid is yellow due to the presence of dissolved oxides of nitrogen.
- 2. Pure nitric acid freezes at 231.4 K and boils at 355.6 K.
- 3. Laboratory grade nitric acid is a constant boiling (394 K) mixture, (i.e., azeotrope) containing 68% HNO3 and 32% H₂O by mass. It has a specific gravity of 1.504.
- 4. Furning nitric acid is pure nitric acid containing oxides of nitrogen dissolved in it.



Ring Test for Nitrate ion

In qualitative analysis, the presence of nitrate ion is detected by *ring test. In* this test, a freshly prepared solution of ferrous sulphate is added to the aqueous solution of a nitrate. Pure conc. H_2SO_4 is then added carefully dropwise along the walls of the test tube. *The appearance of a dark brown ring at the junction of the two layers indicates the presence of a nitrate ion.*

The brown ring test for nitrates depends upon the ability of Fe^{2+} ions to reduce nitrate ions to nitric oxide which then reacts with Fe2+ ions to form brown coloured complex

 $NO_{3}^{-}(aq) + 3Fe^{2+}(aq) + 4H^{+}(aq) \longrightarrow NO(g) + 3Fe^{3+}(aq) + 2H_{2}O(\ell)$

Nitric oxide

 $[Fe(H_2O)_6]^{2+} + NO(g) \longrightarrow [Fe(H_2O)_5NO^+]^{2+}(aq) + H_2O(\ell)$

Pentaaquanitrosoniumiron (I)

(Brown complex)

The colour of the complex is actually due to charge transfer, i.e., an electron is transferred from NO to Fe^{2+} ion. As a result, this complex formally contains iron in the +1 state and NO⁺ (nitrosonium ion). Consequently, the correct name of this complex is pentaaquanitrosoniumiron (I) and not pentaaquanitrosyliron (II), $[Fe(H_2O)_5NO]^{2+}$.

Uses of Nitric Acid

Some important uses of nitric acid are given below

(i) In the manufacture of ammonium nitrate and basic calcium nitrate $[CaO.Ca(NO_3)_2]$ which are used as fertilizers. NH_4NO_3 is also used as an explosive, since on strong heating (above 573 K), or with a detonator, it decomposes rapidly. The solid has almost zero volume but on heating, it produces seven volumes of gas which causes the explosion.

$$2NH_4NO_3(s) \xrightarrow{>573K} 2N_2(g) + O_2(g) + 4H_2O(g)$$

- (ii) In the manufacture of explosives and pyrotechnics such as gun cotton, nitroglycerine, trinitrotoluene (T.N.T.), picric acid, etc.
- (iii) In the preparation of nitro compounds which are used as perfumes, dyes and medicines.
- (iv) In the manufacture of artificial silk.
- (v) For purification of gold and silver.
- (vi) For pickling (cleaning) of stainless steel and etching of metals.
- (vii) As an oxidiser in rocket fuels.
- (viii) As a reagent in the laboratory.

Manufacture of Sulphuric acid (H_2SO_4) by Contact Process

These days sulphuric aicd is mostly prepared by the Contact process. The acid produced by this method is free from arsenic impurities and hence can be safely used for the preparation of edible products.

Theory. The manufacture of H_2SO_4 by the Contact process involves the following steps

1. Production of SO_2 by burning sulphur or roasting iron pyrites.

$$S_8 + 8O_2 \longrightarrow 8SO_2$$
; $4FeS_2 + 11O_2 \longrightarrow 2Fe_2O_3 + 8SO_2$
Invites

2. Catalytic oxidation of sulphur dioxide by air to give sulphur trioxide.

 $2SO_{2}(g) + O_{2}(g) = 2SO_{3}(g) ; \Delta_{f}H^{\circ} = -196.6 \text{ kJ mol}^{-1}$

This step is the key step in the manufacture of H_2SO_4 . In accordance with *Le Chatelier's principle*, the **favourable** conditions for the maximum yield of SO_3 are :

- (i) High pressure. Since the forward reaction proceeds with decrease in number of moles, therefore, high pressure will favour the reaction. In actual practice, a pressure of about 2 bars is used. This is because gases are acidic and corrosion of the plant occurs at high pressures.
- (ii) Low temperature. Since the forward reaction is exothermic, therefore, low temperature will favour the reaction. However, rate of the reaction decreases with decrease in temperature. Therefore, the reaction is carried out at an optimum temperature of 720 K.
- (iii) Use of a catalyst. To increase the rate of reaction at low temperature, a catalyst is to be used. The commonly used catalyst is platinum, or divanadium pentoxide (V_20_5). Since platinum is quite costly and is easily poisoned by arsenic impurities usually present in SO₂, therefore, these days, divanadium pentoxide is employed because it is not only cheaper but is also not easily poisoned.
- (iv) Purity of gases. To prevent poisoning of catalyst, the gases must be free from the impurities of As_2O_3 , dust particles and moisture.
- (v) Excess of oxygen. To have maximum yield of SO₃, H₂SO₄ is used in excess.
- (vi) Absorption of sulphur trioxide in 98% sulphuric acid to form oleum.

$$SO_3 + H_2SO_4 \longrightarrow H_2S_2O_7$$
 (oleum

(vii)Dilution of oleum to get sulphuric acid of desired concentration.

 $H_2S_2O_7 + H_2O \longrightarrow 2H_2SO_4$

In industry, the two steps, i.e., absorption of SO_3 in H_2SO_4 to form oleum and its subsequent dilution with water are carried out simultaneously to make the process a continuous one and also to reduce the cost. The sulphuric acid obtained by the Contact process is generally of 96-98% purity.

Plant and its working. The plant used in the Contact process is shown in Figure.

The plant consists of the following parts



- 1. Pyrite or sulphur burners. Here, sulphur dioxide is produced by roasting of pyrites or by burning sulphur.
- 2. Purifying unit. It consists of the following parts
- (i) Dust remover Dust is removed either by blowing steam or by using Cottrell electrical precipitator.
- (ii) Scrubber or washer Soluble impurities are removed by washing gases with water.
- (iii) Drier A spray of conc. H_2SO_4 is used for drying of gases.
- (iv) Arsenic purifier Gelatinous Fe(OH)₃ is used to absorb impurities.

- 3. Catalytic converter. The pure gases coming from the testing box are preheated to 720 K in a preheater. The gases are then passed over a catalyst consisting either of platinized asbestos or V₂O₅. Under these conditions, SO₂ gets oxidised to SO₃ and the heat produced in the reaction is used for heating the gases in the preheater.
- **4.** Absorption tower. SO_3 from the catalytic converter is introduced at the base of the absorption tower from the top of which H_2SO_4 (98%) is showered. As SO_3 moves above, it is absorbed by H_2SO_4 forming oleum.

$$SO_3 + H_2SO_4 \longrightarrow H_2S_2O_7$$
 (oleum)

Oleum is then diluted with water to get H_2SO_4 of desired concentration.

$$H_2S_2O_7 + H_2O \longrightarrow 2H_2SO_4$$

It may be noted that sulphur trioxide is not directly absorbed in water to form sulphuric acid because it forms a dense fog of sulphuric acid which does not condense easily.

A flow-sheet diagram of Contact process is given in Figure.



- (i) Pure concentrated sulphuric acid is a colourless syrupy liquid. It is also known as oil of vitriol.
- (ii) Concentrated sulphuric acid (98.3%) has a specific gravity of 1.84 at 298 K. It boils at 590 K and freezes at 283 K.
- (iii) It is highly corrosive and produces bums on the skin.
- (iv) Sulphuric acid has a high boiling point (590 K) and a high viscosity because its molecules are associated due to intermolecular hydrogen bonding as shown in Figure.



H-Bonding in H₂SO₄

(v) It has a strong affinity for water. Thus, when sulphuric acid dissolves in water, a large amount of heat is produced which may spurt the acid out of the container. Hence, care must be taken while preparing dilute sulphuric acid from concentrated sulphuric acid (which is 98.3% and is 18M or 36N). Therefore, concentrated H₂SO₄ is always diluted by adding the acid slowly into water with constant stirring and not by adding water to the acid.

Uses of Sulphuric Acid

Sulphuric acid has a vast variety of applications both in industry as well as in laboratory The industrial strength of a nation largely depends on the amount of sulphuric acid it produces and consumes. Therefore, it is rightly called **King of Chemicals.** Some important commercial uses of sulphuric acid are :

- (i) In chemical industry. Sulphuric acid is employed in the manufacture of hundreds of other chemicals such as hydrochloric acid, nitric acid, phosphoric acid, sulphates and bisulphates, diethyl ether, etc.
- (ii) In fertilizer industry. Sulphuric acid is used to manufacture fertilizers like ammonium sulphate and super phosphate of lime.
- (iii) In dyes, drugs, paints, pigments and detergents. It is used directly or indirectly in the manufacture of number of chemicals such as dyes, drugs, paints, pigments and detergents.
- (iv) In petroleum refining. Crude petroleum is treated with sulphuric acid to remove unwanted sulphur and other tarry compounds.
- (v) In the manufacture of explosives. A mixture of sulphuric acid and nitric acid called *nitrating mixture* is used for nitration of organic compounds. This nitration process is used for the manufacture of a large number of explosives like dynamite (a mixture of glyceryl trinitrate and glyceryl dinitrate absorbed over Kieselguhr a porous earth), gun cotton, (nitrocellulose) T.N.T. (2, 4, 6-trinitrotoluene), picric acid (2,4,6-trinitrophenol), etc.
- (vi) In metallurgy. A number of metals like copper and silver are extracted from their ores using sulphuric acid.
- (vii) In pickling. Sulphuric acid is used for cleaning *(pickling)* the surface of metals before enamelling, electroplating and galvanising.
- (viii) In lead storage batteries as electrolyte.
- (ix) As laboratory reagent It is widely used in laboratory as a drying and dehydrating agent.

STUDY OF SOME USEFUL COMPOUNDS

1.	Solvay process is used for	the manufacture of :		
	(A) Na ₂ CO ₃	(B) K ₂ CO ₃	(C) (NH ₄) ₂ CO ₃	(D) CaOCl ₂
2.	Which one of the followin	ng formulae represents soda	a ash?	
	(A) Na ₂ CO ₃	(B) Na ₂ CO ₃ . H ₂ O	(C) Na ₂ CO ₃ . 5H ₂ O	(D) Na ₂ CO ₃ . 10H ₂ O
3.	Washing soda crystals ha	ve the molecular formula :		
	(A) Na_2CO_3 . H_2O	(B) Na ₂ CO ₃ . 5H ₂ O	(C) Na ₂ CO ₃ . 8H ₂ O	(D) Na ₂ CO ₃ . 10H ₂ O
4.	Which of the following is a soda process?	one of the starting materials	for the manufacture of soc	lium carbonate by Ammonia
	(A) CaO	(B) Ca(OH) ₂	(C) $CaCl_2 \cdot 6H_2O$	(D) NaCl
5.	Which of the following is	quicklime'?		
	(A) CaO	(B) Ca(OH) ₂	(C) CaCO ₃	(D) $CaCl_2 \cdot 6H_2O$
6.	Which of the following is	not a calcium compound?		
	(A) Baryta	(B) Bleaching powder	(C) Milk of lime	(D) Plaster of Paris
7.	Slaked lime is prepared b	by adding water to :		
	(A) Bleaching powder	(B) Lime water	(C) Milk of lime	(D) Quicklime
8.	Chemical formula of blea	ching powder is :		
	(A) CaOCl ₂	(B) Ca(OCl) ₂	(C) CaO ₂ Cl	(D) CaO_2Cl_2 . $2H_2O$
9.	Bleaching powder is not a	used :		
	(A) As a disinfectant		(B) As a germicide	
	(C) For manufacturing chl	oroform	(D) For washing clothes	
10.	Plaster of Paris has the fo	ormula :		
	(A) $CaSO_4 \cdot \frac{1}{2} H_2O$	(B) CaSO ₄ . H ₂ O	(C) CaSO ₄ . $1\frac{1}{2}$ H ₂ O	(D) CaSO ₄ . 2H ₂ O
11.	Which of the following co	mpounds is called blue vitri	ol?	
	(A) Anhvdrous CuSO	(B) CuSO₄ . H₀O	(C) CuSO ₄ . 3H ₂ O	(D) CuSO ₄ . 5H ₂ O
12.	Which of the following co	mpounds is basic in nature	?	() 4 Z
	(A) $Ca(OH)_{2}$	(B) CaCl ₂ . 6H ₂ O	(C) NaCl	(D) CuSO ₄ . 5H ₂ O
13.	Which of the following co	mpounds is acidic in nature	?	4 Z
	(A) $Ca(OH)_2$	(B) $CuSO_4 \cdot 5H_2O$	(C) Na ₂ CO ₃	(D) NaCl
14.	Which of the following co	mpounds is neutral to litmu	is?	
	(A) NaNO3	(B) $CuSO_4 \cdot 5H_2O$	(C) NaHCO3	(D) $Ca(OH)_2$
15.	Which of the following co	mpounds can act as an oxi	dizing agent?	L
	(A) $CaCO_3$	(B) Na2CO3 . 10H2O	(C) CaOCl ₂	(D) NaHCO3
16.	Which of the following co	mpounds is not white?	2	3
	(A) Anhydrous CuSO4	(B) $BaSO_4$	(C) $CaSO_4$. $2H_2O$	(D) $CuSO_4 \cdot 5H_2O$
17.	'Available chlorine' is the	chlorine available :	T L	T 2
	(A) In the atmosphere			
	(B) In gas cylinders			
	(C) From CaCl ₂ on strong	heating		
	(D) From CaOCl ₂ when e	xposed to air or by the acti	on of dilute acid on carbon	dioxide
	(D) From CaOCl ₂ when e	xposed to air or by the acti	on of dilute acid on carbon	dioxide

Question 18 to 20 are based on the following passage :

A coloured metal salt 'A' is used in electroplating. It is also used as a fungicide and germicide in agriculture. On heating it gives a white substance 'B'.

18.	Coloured salt 'A' is :			
	(A) Na ₂ CO ₂ . 10H ₂ O	(B) CaCl ₂ . 6H ₂ O	(C) CaSO ₄ . 2H ₂ O	(D) CuSO ₄ . 5H ₂ O
19.	White substance 'B' is :		4 2	4 <u>2</u>
	(A) Na_2CO_3	(B) CaCl ₂	(C) $CaSO_4$	(D) $CuSO_4$
20.	When 'B' is placed in mo	isture, the final product wil	l be :	т
	(A) Na ₂ CO ₃ . 10H ₂ O	(B) CaCl ₂ . 6H ₂ O	(C) $CaSO_4$. $2H_2O$	(D) CuSO ₄ . 5H ₂ O
21.	Which of the following is	slaked lime?	· - 2	1 2
	(A) CaO	(B) Ca(OH) ₂	(C) CaCl ₂ . 6H ₂ O	(D) NaCl
22.	The lime water is a :	_		
	(A) Solution of excess of	CaO in limited quantity of v	water	
	(B) Solution of Ca(OH) ₂ ir	n water		
	(C) Solution of $CaCl_2$ in w	vater		
	(D) Suspension of slaked	lime in water		
23.	The milk of lime is a :			
	(A) Solution of $Ca(OH)_2$ in	n excess of water	(B) Solution of CaCl ₂ in w	vater
	(C) Suspension of slaked	lime in water	(D) Salt CaSO ₄ . $\frac{1}{2}$ H ₂ O	
24.	The baking soda is :		-	
	(A) Na_2CO_3	(B) Na ₂ CO ₃ . 10H ₂ O	(C) NaHCO ₃	(D) NaCl
25.	The bleaching powder is	manufactured by passing of	hlorine gas into :	
	(A) Slaked lime	(B) Quick lime	(C) Washing soda	(D) Baking soda
26.	Plaster of Paris is obtaine	ed :		
	(A) By adding water to ca	lcium sulphate	(B) By adding sulphuric a	cid to calcium hydroxide
	(C) By heating gypsum to	a very high temperature	(D) By heating gypsum to	120°C
27.	Crude sodium chloride is	deliquescent in nature. Th	is is due to the presence of	:
	(A) Sodium sulphate		(B) Calcium sulphate	
	(C) Magnesium sulphate		(D) Chlorides of calcium a	and magnesium
28.	The caustic lime is :			
	(A) CaO	(B) CaOCl ₂	(C) Ca(OH) ₂	(D) $CaSO_4 \cdot \frac{1}{2} H_2O$
29.	The standard bleaching p	oowder contains about :		_
	(A) 30 percent of active of	chlorine	(B) 35 percent of active of	chlorine
	(C) 40 percent of active of	chlorine	(D) 50 percent of active of	chlorine

	ANSWER KEY																			
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	А	А	D	D	А	А	D	А	D	А	D	А	В	А	С	D	D	D	D	D
Que.	21	22	23	24	25	26	27	28	29											
Ans.	В	В	С	С	А	D	D	А	В											
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ORGANIC CHEMISTRY

GENERAL INTRODUCTION

Hydrocarbons are the parent compounds of all classses of organic compounds. Paraffins (alkanes) react with halogens to give compounds in which one or more hydrogen atoms have been replaced by halogens. Monohalogen derivatives of alkanes are called (**haloalkanes**) or alkyl halides. The general formula of alkane is C_nH_{2n+2} or RH (R = C_nH_{2n+1}). So, the general formula of haloalkanes is C_nH_{2n+1} X or RX.

 $RH \xrightarrow[+X]{-H} RX$

(Haloalkane) Alkyl halides

If hydrogen of alkyl group attached to benzene in arenes is replaced by halogen atom, we get **aralkylhalides**. For example,



Haloalkenes or alkenyl halides are obtained by the replacement of one hydrogen from alkynes by halogen.

$$C_nH_{2n} \xrightarrow{-H} C_nH_{2n-1}X$$

Alkene

(Haloalkyne) Alkynyl halide

Haloalkynes or alkynyl halide are obtained by the replacement of one hydrogen from alkynes by halogen.

$$C_nH_{2n-2} \xrightarrow{-H} C_nH_{2n-3}X$$

Alkyne

(Haloalkyne) Alkynyl halide

Many halogen compounds occur in nature and are clinically important. Antibiotic chloromycetin (chloramphenicol) produced by soil microorganisms is used for the treatment of typhoid fever. Our body produces hormone thyroxine which contains iodine. Its deficiency causes goitre. Synthetic halogen compounds are used in medicine and health care. Chloroquine is used for the treatment of malaria and halothane (CF₃CHClBr) is used as an anaesthetic during surgery. Certain fluoro compounds are being considered as potential blood substitutes in surgery.





Replace X by OH and get allylic alcohols, benzylic alcohols and vinyl alcohol.

NOMENCLATURE

The pefixes n, iso, sec, tert, neo, etc. are attached for the following alkyl and aralkyl groups.

Structural Formula	Name	Structural Formula	Name
$CH_3 - CH_2 - CH_2 -$	n–Propyl	C_5H_{11} -	Amyl
CH ₃ -CH-CH ₃	Isopropyl	$CH_{3}-CH_{2}-$	N-Pentyl
CH ₃ -CH ₂ -CH ₂ -CH ₂ -	n–Butyl	CH ₃ -CH-CH ₂ -CH ₂ CH ₃	Isopentyl or Isoamyl
CH ₃ -CH-CH ₂ -CH ₃	Sec-Butyl		
CH ₃ -CH-CH ₂ - CH ₃	Isobutyl	CH_{3} $CH_{3}-C-CH_{2}-$ CH_{3}	neo-Pentyl or neo-Amyl
$\begin{array}{c} CH_{3}\\ CH_{3}-C-\\ CH_{3}\end{array}$	Tert-Butyl	CH_3 CH_3-CH_2-C- CH_3	tert-Pentyl
$CH_2 = CH$	Vinyl Propargyl	$CH_2 = CH - CH_2 - C_cH_c - $	Allyl Phenyl
CH ₃ -CH=CH-CH ₂ -	Crotyl	C ₆ H ₅ CH=CHCH ₂ -	Cinnamyl
-CH2-	Benzyl	CH<	Benzylidene Or Benzal
C<	Benzo	R-	Alkyl

Some alkyl and aralkyl groups

While naming IUPAC, the halogen derivatives of alkanes the following rules are followed :

(a) Longest chain of C-atoms is selected. If more than one longest chain, then that chain is selected which has maximum substituents.

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(b) The numbering is done in such a way that the sum of locants is least (least sum rule).

- (c) However, if the sum of locants is same, then the substituent which comes **first alphabetically** should get **lesser number**, e.g.,
- (1) $CH_2CI-CH_2-CH_2Br$ is **1-bromo-3-chloropropane** and not 3-bromo-1-chloropropane.
- (2) CH_3 -CH-CH₂-CH-CH₃ is **2-chloro-4-methylpentane** and not 4-chloro-2-methylpentane. CH₃ CH₃ CH-CH₂-CH-CH₃ is **2-chloro-4-methylpentane** and not 4-chloro-2-methylpentane.

Aralkyl halides are named as pheylhaloalkanes. If the carbon chain contains a functional group (C=C, or C=C), then the longest chain containing the functional group is taken and numbering is done in such a way that the functiona group gets the least-numeral and the suffix 'ene' if it contains C=C and 'yne' if it contains C=C is added.

Structural Formula	General or Common or	IUPAC Name; Haloalkanes
	Trivial Name	Haloalkenes, Haloalkynes
CH ₃ CH ₂ CH ₂ Cl	n-Propyl chloride	1-Chloropropane
CH ₂ -CH-CH ₃ Cl	Isopropyl Chloride	2–Chloropropane
CH3-CH2-CH2-CH2-I	n-Butyl iodide	1–Iodobutane
CH ₃ CH ₂ CHICH ₃	sec-Butyle iodide	2–Iodobutane
$\begin{array}{ccc} & 2 & 1 \\ CH_3-CH-CH_2Cl \\ & I \\ CH_3 \end{array}$	Iso-butyl chloride	1–Chloro–2–methylpropane
$^{1}CH_{3}$ CH ₃ - 2 -C-Cl $^{3}CH_{3}$	tert-Butyl chloride	2–Chloro–2–methylpropane
CH ₂ =CHCl	Vinyl chloride	Chloroethene
$^{1}CH_{2} = ^{2}CH - ^{3}CH_{2}I$	Allyl iodide	3-Iodopropene
$CH = C - CH_2CI$	Propargyl chloride	3-Chloropropyne
\frown		
$\langle \bigcirc \rangle$ -CH ₂ -Cl	Benzyl chloride	Chloromethylbenzene
		or 1-Chloro-1-phenylmethane
		or Phenylchloromethane
		(Not Chlorophenylmethane)
CH-Cl,	Benzylidene chloride or	Phenyldichloromethane or
	dichloride or Benzalchloride	1,1-Dichloro-1-phenylmethane
\frown	or dichloride	Or Dichloromethylbenzene
$\langle \bigcirc \rangle$ -CCl ₃	Benzotrichloride	Phenyldichloromethane or
	Or Benzylidyne chloride	1,1,1-Trichloro-1-phenylmethane
		or Trichloromethylbenzene
$\langle \bigcirc \rangle^2$ -CH ₂ -CH ₂ Cl	β -Phenyl-1-chloroethane	1–Chloro–2–phenylethane
	(Note : C of chloro comes before p	of phenyl)

TABLE : HALOALKANES, HALOALKENS AND HALOALKYNES

$C_6H_5-^1CH=^2CH-^3CH_2Br$	Cinnamyl bromide	3-Bromo-1-phenylpropene
CHCI-CH ₃	—	1–Chloro–1–phenylethane
CH ₂ Br–CH–CH ₂ Cl	(B of Br before C of Cl alphabetically)	1-Bromo-3-chloro-2-phenylpropane
³ CH ₃ ⁻² CH ⁻¹ CH ₂ -Br	_	1–Bromo–2–phenylpropane
CH_{3} ${}^{2}CH_{3} - {}^{2}C - {}^{1}CH_{2}Cl$ H_{3}	neo-Pentyl chloride or neo-Amyl chloride	1–Chloro–2,2,–dimethylpropane
$CH_3 CH_2 CH_2 CH_2 CI$	n-Amyl chloride or	
	n-Pentyl chloride	1-Chloropentane
${}^{4}\text{CH}_{3} - {}^{3}\text{CH} - {}^{2}\text{CH}_{2} - {}^{1}\text{CH}_{2}\text{Cl}$	Isopentyl chloride	1-Chloro-3-methylbutane
CH ₃	or Isoamyl chloride	
CH ₃ I BrCH ₂ -CH-CH ₂ Cl	Alphabetic order	1-Bromo-3-chloro-2-methyl propane
CH_{3} $^{1}CH_{3}$ ^{-2}C $^{-3}CH_{2}$ $^{-4}CH_{3}$	tert-Pentyl chloride or	
	tert-Amyl chloride	2-Chloro-2-methylbutane
CF ₃ CF ₂ CF ₃	Perfluoropropane (all F)	Octafluoropropane
CH ₃ CH ₂ Cl	Ethyl chloride	Chloroethane
CH ₂ Cl ₂	Methylene chloride	Dichloromethane
	(or dichloride)	

CHCl ₃	Chloroform	Trichloromethane
CCl ₄	Carbontetrachloride	Tetrachloromethane
(CH ₃) ₃ CX,		2-Halo-2-methylpropane
i.e., tert-Butyl halide		
(CH ₃) ₂ CHCH(CH ₃)	$CH_3 CH_3$ ⁵ CH - ⁴ CH - ³ CH - ² C - ¹ CH Br	1–Bromo–2,2,3,4–tetramethyl
C(CH ₃) ₂ CH ₂ Br, i.e.,	$CH_3 = CH_2 + CH_2$ $CH_3 = CH_3$	Pentane (least sum rule)
CH ₃ CH ₂ Cl	Ethyl chloride	Chloroethane
CH ₃ CHCl ₂	Ethylidene chloride or	1,1-Dichloroethane
	Ethylidene dichloride	
CH ₃ -Cl ₂ -CH ₃	Isopropylidene iodide or diiodide	2,2-Diiodopropane
CH_3 -CBr-CH ₂ Br	Isobutene bromide or	1,2–Dibromo–2–methylpropane
CH ₃	Isobutylene bromide	
CHCl2-CHCl2	Acetylene tetrachloride	1,1,2,2-Tetrachloroethane
CCl ₃ -CCl ₃	Perchloroethane (All Cl)	Hexachloroethane
BrCH ₂ CH ₂ Br	Ethylene bromide or	1,2-Dibromoethane
	Ethylene dibromide	
CH ₃ -CHCl-CH ₂ Cl	Propylene chloride	1,2–Dichloropropane
$CH = C - CH_2Br$	Propargyl bromide	3-Bromopropyne
BrCH ₂ -CH ₂ -CH ₂ Cl	Note : If Sum Rule same then	1-Bromo-3-chloropropane
	Alphabeic Order	

ORGANIC CHEMISTRY

1.	Which is a refrigerant ?			
	(A) CCl ₄	(B) CHCl ₃	(C) CH_2F_2	(D) CF_2Cl_2
2.	n-Propyl bromide on tre	atment with alc. KOH giv	ves	
	(A) n-propyl alcohol	(B) propene	(C) 2-propanol	(D) propyne
3.	Aryl halides are less rea	ctive than alkyl halides to	wards nucleophilic substitu	ution
	(A) longer C – X		(B) sp ² hybridisation of	C attached to halogen
	(C) Resonance stabilisation	on	(D) formation of less sta	ble carbonium ion
4.	1-chlorobutane with aq.	KOH gives		
	(A) 1-Butene	(B) 1-Butanol	(C) 2-Butanol	(D) 2-Butene
5.	$CH_2 - CH = CH_2 + HO$	$Cl \xrightarrow{peroxides} gives$		
	(A) 2-Chloropropane	(B) 1-Chloropropane	(C) Alkyl chloride	(D) no reaction
6.	Which obevs Markownik	off's rule with HBr ?		· · /
	(A) $CH_2 = CH_2$	(B) cis-2- Butene	(C) trans-2-Butene	(D) $Me_2C = CH_2$
7.	Carbylamine test is perf	ormed in alcoholic KOH	by heating a mixture of	5 2
	(A) $CH_2Cl_2 + Ag$ powde	r	(B) trihalogenated metha	ane and p-amine
	(C) alkyl halide and p-ar	nine	(D) alkyl cyanide and p-	amine
8.	Chloroform is kept in d	ark brown bottles because	2	
	(A) it vaporises easily		(B) it react with CO ₂ of	air
	(C) it absorbs moisture		(D) it produces poisonou	is substances
9.	Which will react with al	c. KCN ?	()]	
			a	СНО
	(A) C ₂ H ₅ Cl	(B) CH ₃ COCl	(C) O	(D) O
10.	C_6H_5COOAg reacts with	n Br ₂ to produce	•	·
	0 0 -	2 -	2000Ag	
	(A) $C_6 H_5$	$(B) C_6 H_5 COOC_6 H_5$	(C) m·C ₆ H ₄	(D) C ₆ H ₅ Br
11.	S _{N2} mechanism proceed	ls via	`Br	
	(A) carbonium ion forma	tion	(B) transition state	
	(C) free radical		(D) carbanion	
12.	Substitution at higher te	emperature takes place wi	ith	
	(A) $CH_2 = CH_2$	(B) $CH = CH$	(C) $CH_2 - CH = CH_2$	(D) None of these
13.	Geometrical isomerism i	s shown by	(, 5 2	· · /
	(A) $CH_{\alpha} = C(Br)I$	(B) $CH_{2}CH = C(Br)Cl$	$(C) (CH_2) C = C(CI)Br$	(D) $CH_{2}CH = CCl_{2}$
14.	Br_{o} does not react with	() - 3 () -	(-) (- 3/2 (-)	() = 3 = = - 2
	(A) propene	(B) aniline	(C) phenol	(D) chloroform
15.	Phosgene is the commo	n name of		. ,
	(A) phosphyoryl chloride		(B) carbondioxide and p	hsophine
	(C) carbonyl chloride		(D) CCL	- I
16.	CHCl _o is obtained from		(-) 4	
	(A) CH ₂ OH		(B) HCHO	
	() OLL OLL OLLO			
	$(C) CH_3 - CH_2 - CH_2O$	П		
17		(1) 11 1 1 1 • / 11	UH 1.) .	
1 /	I blowbottop of tobiopo	revertied by bydreivere fell		

Chlorination of toluene followed by hydrolysis (alkaline) gives 17.

(A) o-cresol (B) p-cresol (C) 2, 4-dihydroxytoluene (D) benzoic acid

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18.	$CH_3MgBr + CH_3CH_2OH \longrightarrow ?$		
	(A) CH_4	(B) $C_2 H_6$	
	(C) $CH_3 - CH_2 - CH_3$	(D) $CH_3 - CH_2 - CH_2$	– CH ₃
	C C		0
10	C C hand angle in 1 1 2 2 totrachlorothene	a and dichloromathana are	
19.	C = C bond angle in 1, 1, 2, 2-terrachioronnenk		
00	(A) 120°, 109.5° (B) 90°, 109.5°	$(C) 109.5^{\circ}, 90^{\circ}$	(D) 109.5° and 120°
20.	C - H bond length is longest in		
01	$(A) C_2 H_2$ $(B) C_2 H_4$	$(C) C_2 H_6$	(D) $C_6 H_6$
21.	The $CI = C = CI$ angle on I, I, Z, Z -tetrachloro	thene and tetrachlorometr	ane will be about
	(A) 120°, 109.5° (B) 90°, 109.5°	(C) 109.5°, 90°	(D) 109.5° and 120°
22.	Which of the following compounds is formed whe	$en C_6H_6 + Cl_2 \xrightarrow{sunlight} \rightarrow$	
	(A) Chlorobenzene (B) p-Dichlorobenzene	(C) Hexachlorobenzene	(D) Benzene hexachloride
23.	Chlorobenzene is		
	(A) less reactive than benzyl chloride	(B) more reactive they e	ethyl bromide
	(C) nearly as reactive as methyl chloride	(D) more reactive than i	sopropyl chloride
24.	Phenol is heated with CHCl_3 and alcoholic KOH	when salicyladehyde is pr	oduced. The reaction is
	(A) Rosenmund's reaction	(B) Reimer Tiemann rea	iction
	(C) Friedel Craft's reaction	(D) Wurtz reaction	
25.	In the addition of HBr to propene in the absence	e of peroxides, the first st	ep involves the addition of
	(A) H ⁺ (B) Br ⁻	(C) H [_]	(D) Br ⁺
26.	When hydrochloric acid gas is treated with prop	ene in the presence of be	nzoyl peroxide, it gives
	(A) 2-Chloropropane (B) Allyl chloride	(C) n-Propyl chloride	(D) no reaction
27.	The reagent used in the conversion of 1-butanol	to 1-bromobutane is	
	(A) CHBr ₃ (B) Br ₂	(C) CH ₃ Br	(D) P/Br ₂
28.	A mixture of two organic compounds was treated wi	th sodium metal in ether solu	ution. Isobutane was obtained
	as a product. The two chlorine compounds are		.1 1 11 .1
	(A) Methyl chloride and propyl chloride	(B) Methyl chloride and	etnyl chloride
00	(C) isopropyl chloride and methyl chloride	(D) None of these	
29.	what happens when CCl_4 is treated with AgiNO _{$\frac{1}{2}$}	$(\mathbf{D}) \wedge \dots h$ its mussimitate	
	(A) Chloropichin is formed	(D) Nothing will happen	or Ager will be tonned
30	Which of the following compounds does not read	(D) Notifing will happen	
50.	(A) Propene (B) Apiline	(C) Phenol	(D) Chloroform
31	Geometrical isometrism is shown by		
01.	(A) $CH_{-} = C(Br)I$ (B) $CH_{-}CH = C(Br)I$	$(C)(CH_{1})C = C(C)Br$	$(D) CH_{C}CH = CCL$
32	Which dichlorobenzene has maximum melting po	$\frac{1}{3}$	
02.	(A) Ortho (B) Meta	(C) Para	(D) All are equal
33.	Which has maximum dipole moment?	(0) 1 010	
	(A) CH ₂ I (B) CH ₂ F	(C) CH _a Cl	(D) CH _a Br
34.	Chlorination of toluene in presence of light and	heat + treatment with aq.	NaOH gives
	(A) o-Cresol (B) p-Cresol	(C) Benzoic acid	(D) 2, 4 Dihydroxy toluene
35.	For carbylamine reaction we need alcoholic KOF	I and	
	(A) Any amine and chloroform	(B) Chloroform and silve	er powder
	(C) A primary amine and an alkyl halide	(D) A monoalkyl amine	and trichloromethane
36.	Industrial preparation of chloroform employs ace	tone and	
	(A) Phosgene (B) Calcium hypochloric	le (C) Chlorine gas	(D) Sodium chloride

37.	Which of the following is formed when chloral is boiled with NaOH ?									
	(A) CH ₃ Cl	(B) CHCl ₃	(C) CCl ₄	(D) None of these						
38.	C_2H_5OH reacts with ble	eaching powder. The produ	ict is							
	(A) $C_2 H_4$	$(B) C_2 H_5 Cl$	(C) CHCl ₃	(D) CH ₃ COOH						
39.	Which carbon is chlorin	ated easiest in $\overset{1}{CH_3}\overset{2}{CH_2}\overset{3}{CH_2}$	$H - H_3$?							
		ď	-L S							
	(A) C ₁	(B) C ₂	(C) C ₃	(D) C ₄						
40.	The reactivity of ethyl c	hloride is								
	(A) More or less equal (A)	to that of benzyl chloride	(B) More than that of be	enzyl chloride						
41	(C) More that chloroben	zene	(D) Less than that of chl	orobenzene						
41.	The $C - H$ bond distant	(P) C LL								
	(A) $C_2 \Pi_2$	(B) C ₂ H ₄	$(C) C_2 \Pi_6$	(D) $C_2 \Pi_2 Br_2$						
42.	CH ₃ -CH-CH ₂ Cl — I CH ₃	$\stackrel{\Delta}{\longrightarrow}$ A is								
	(A) n-Butyl chloride	(B) Isobutylene	(C) sec-Butyl chloride	(D) tert-Butyl chloride						
43.	n-Propyl bromide on tre	eatment with ethanoic pota	assium hydroxide produces	6						
	(A) Propane	(B) Propene	(C) Propyne	(D) Propanol						
44.	Out of the following con	mpounds, which one will h	ave a zero dipole momer	nt ?						
	(A) 1, 1-Dichloroethylen	e	(B) cis-1, 2-Dichloroethyl	ene						
	(C) trans-1, 2-Dichloroet	thylene	(D) None of these							
45.	Which is used in dry cle	eaning ?								
	(A) CH ₃ Cl CH	(B) $\operatorname{CCl}_2\operatorname{CCl}_2$	(C) CCl_4	(D) CHCl ₃						
46.	$(1)^{-Cl_2/383}$ A, A	is								
	(A) m-Chlorotoluene		(B) o-Chlorotoluene							
47	(C) a and p-Chlorotolue	ne No ki ki o	(D) Benzylchloride							
47.	Which of the following	(B) Rect L CL R								
48.	(A) $CH_3 CHBr_2$ The reaction conditions	(B) $BrCH_2CH_2Br$ leading to the best yield o	$(C) CH_3 CHBrCH_2 Br$ of $C_2 H_5 Cl$ are	(D) $CH_3 CHBr CH_2 Br$						
	(A) C_2H_6 (excess) + Cl_2	UV light	(B) $C_2H_6 + Cl_2 - \frac{Da}{room ten}$	rk						
	(C) $C_{2}H_{2} + Cl_{2}$ (excess)	UV light	(D) $C_2H_c + Cl_2$ UV light							
49.	The compound with hig	hest boiling point is :-	2 0 2							
	(A) CH ₄	(B) CH ₃ OH	(C) CH ₃ Cl	(D) CH ₃ Br						
50.	Toluene reacts with chlo	orine in the presence of lig	ght to give	Ŭ						
	(A) Benzyl chloride	(B) Benzoyl chloride	(C) p-Chlorotoluene	(D) o-Chlorotoluene						
51.	The compound which re	eacts with HBr obeying Ma	arkownikoff's rule is :							
	(A) $CH_2 = CH_2$	(B) cis-2-Butene	(C) trans-2-Butene	(D) $(CH_3)_2C = CH_2$						
52.	Diethyl ether on heating	g with excess of HI yields	:							
	(A) C_2H_5OH	(B) C ₂ H ₅ I	(C) C ₂ H ₄	(D) C ₂ H ₆						
53.	Which of the following	is obtained when bleaching	g power is distilled with et	hanal?						
	(A) CCl ₄	(B) CHCl ₃	(C) CH_2Cl_2	(D) CH ₃ Cl						
54.	CH_3CH_2I reacts with dr	y Ag ₂ O to give :								
	(A) Diethyl ether	(B) Ethene	(C) Ethanal	(D) Ethanol						

55.	Acetylene reacts with H	Cl and HgCl ₂ to give?					
	(A) Vinyl chloride	(B) Dichloroethane	(C) Ethyl chloride	(D) Ethylidene chloride			
56.	Only two isomeric mono	ochloro derivatives are pos	sible for :				
	(A) n-Butane	(B) 2,4-Dimethylpentane	(C) Benzene	(D) 2-Methylpropane			
57.	When 1-chloropropane	s treated with alcoholic K	OH, it forms an alkene. 7	This reaction is :			
	(A) Substitution reaction		(B) β -Elimination reaction				
	(C)Addition reaction		(D) Dehydrogenation rea	ction			
58.	Which undergoes chlorin	ation easier?					
	$(A) CH_3 CH_3$		(B) $CH_2 = CH - CH_3$				
	$(C) CH_{3} - CH(CH_{3})_{2}$		(D) $C_6 C_6$				
59.	Which does not undergo	Markonikoff addition with	n HBr?				
	(A) Propyne	(B) Propene	(C) 1-Butene	(D) 2-Butene			
60.	CHCl ₃ reacts with conc.	HNO ₃ , which of the follo	wing is formed :				
	(A) CHCl ₃ NO ₂	(B) CCl ₃ NO ₂	(C) CHCl ₃ HNO ₃	(D) $CHCl_3NO_2$			
(A) $CHCl_3NO_2$ (B) CCl_3NO_2 (C) $CHCl_3HI$ 61. Which is Swartz reaction?				5 2			
	(A) CH ₃ Cl + Nal	(B) CH ₃ Br + KI	(C) CH ₃ Br + AgI	(D) None of these			
62.	Aryl halides are less read	tive towards nucleophilic s	substitution reactions as co	mpared to alkyl halides due			
02.	to:						
	(A) The formation of les	s stable carbonium ion	(B) Resonance stabilisation				
	(C) Longer carbon-haloge	en bond	(D) sp ² -Hybridised carbon attached to halogen				
63.	1-Chlorobutane on react	ion with alcoholic potash	gives :				
 62. 63. 64. 65. 	(A) 1-Butene	(B) 2-Butanol	(C) 2-Butene	(D) 2-Butanol			
64.	The products of reaction	n of alcoholic silver nitrite	with ethyl bromide are \colon				
	(A) Ethyne	(B) Ethene	(C) Nitroethane	(D) Ethyl nitrite			
65.	Which of the following i	s used as a refrigerant?					
	(A) Glycerol	(B) CH ₂ OHCHOH	(C) CCl ₄	(D) CCl_2F_2			
66.	Alkyl halides react with	aq. KOH to give :					
	(A) Alkene	(B) Alkene	(C) Alcohol	(D) Ester			
67.	The reaction $C_2H_5Cl + C_2H_5Cl$	aq. KOH $\longrightarrow C_2H_5OH$ +	- KCl is ?				
	(A) Electrophilic addition		(B) Nucleophilic addition				
	(C) Electrophilic substitut	ion	(D) Nucleophilic substitut	ion			
68.	Grignard reagent is prej	pared by the reaction bet	ween :				
 63. 64. 65. 66. 67. 68. 	(A) Li and Alkyl halide		(B) Magnesium and alkyl hadlide				
	(C) magnesium and alka	ne	(D) magnesium and aromatic hydrocarbon				
69.	In the preparation of CI	HCl ₃ from ethanol and ble	leaching powder, the latter provides :				
	(A) Cl ₂	(B) Ca(OH) ₂	(C) Both Cl_2 and alkali	(D) None of these			
70.	One mole of $C_2H_5OC_2H$	${ m I}_5$ on heating with conc. H	HI gives two moles of :				
	(A) C_2H_5OH	(B) CHI ₃	(C) CH ₃ I	(D) C ₂ H ₅ I			

	ANSWER KEY														
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	D	В	В	В	А	D	В	D	А	D	В	С	В	D	Α
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	D	D	Α	А	С	А	D	А	В	А	А	D	С	D	D
Que.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	В	С	Α	С	С	В	В	С	С	В	С	D	В	С	В
Que.	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	D	А	Α	В	А	D	В	В	А	А	А	В	В	D	В
Que.	61	62	63	64	65	66	67	68	69	70					
Ans.	D	D	A	C	D	A	D	В	С	D					