APPENDIX-A

A Table of Greek letters

Upper case	Lower case	In English
Α	α	alpha
Β	β	beta
Γ	γ	gamma
Δ	δ	delta
Ε	ε	epsilon
Ζ	ζ	zeta
Η	η	eta
Θ	θ	theta
Ι	ι	iota
Κ	κ	kappa
Λ	λ	lambda
Μ	μ	mu
Ν	υ	nu
Ξ	ξ	csi
Ο	ο	omicron
Π	π	pi
Ρ	ρ	rho
Σ	σ	sigma
Τ	τ	tau
Υ	υ	upsilon
Φ	ϕ	phi
Ψ	ψ	psi
Χ	χ	chi
Ω	ω	omega

APPENDIX-B

Useful Physical Constant in Chemistry

Constant	Symbol	Value
Acceleration due to gravity	g	$9.8\ m\ s^{-2}$
Atomic mass unit	amu, m_u or u	1.66×10^{-27} kg
Avogadro's Number	N, N_A	$6.022 \times 10^{23} mol^{-1}$
Bohr radius	r_o	0.529×10^{-10}m
Boltzmann constant	k	$1.38 \times 10^{-23}\ J\ K^{-1}$
Electron charge to mass ratio	$\frac{-e}{m_e}$	$-1.7588 \times 10^{11}\ C\ kg^{-1}$
Electron classical radius	r_e	2.818×10^{-15} m
Electron mass energy(J)	m_ec^2	8.187×10^{-14} J
Electron mass energy (MeV)	m_ec^2	0.511 MeV
Electron rest mass	m_e	9.109×10^{-31} kg
Faraday constant	F	$9.649 \times 10^4\ Cmol^{-1}$
Fine-structure constant	α	7.297×10^{-3}
Gas constant	R	$8.314\ J\ mol^{-1}\ K^{-1}$
Gravitational constant	G	$6.67 \times 10^{-11}\ Nm^2\ Kg^{-2}$
Neutron mass energy	m_nc^2	1.505×10^{-10} J or 939.565 MeV
Neutron rest mass	m_n	1.675×10^{-27} kg
Neutron-electron mass ratio	$\frac{m_n}{m_e}$	1838.68
Neutron-proton mass ratio	$\frac{m_n}{m_p}$	1.0014
Permeability of a vacuum	μ_0	$4\pi \times 10^{-7} NA^{-2}$
Permittivity of a vacuum	ε_0	$8.854 \times 10^{-12}\ F\ m^{-1}$
Planck constant	h	6.626×10^{-34} J s
Proton mass energy	m_pc^2	1.503×10^{-10} J or 938.272 MeV
Proton rest mass	m_p	1.6726×10^{-27} kg
Proton-electron mass ratio	$\frac{m_p}{m_e}$	1836.15
Rydberg constant	R_e	$1.0974 \times 10^7\ m^{-1}$
Speed of light in vacuum	c	2.9979×10^8 m/s

APPENDIX-C

Most Popular Chemists and their Contributions

AMEDEO AVOGADRO 1776 – 1856

The first scientist to realize that elements could exist in the form of molecules rather than as individual atoms; originator of Avogadro's law.

JACOB BERZELIUS 1779 – 1848

A founder of modern chemistry : the first person to measure accurate atomic weights for the chemical elements; discovered three elements: cerium, thorium and selenium; devised the modern symbols for elements; described how chemical bonds form by electrostatic attraction.

NIELS BOHR 1885 – 1962

Founded quantum mechanics when he remodeled the atom that electrons occupied 'allowed' orbits around the nucleus while all other orbits were forbidden; architect of the Copenhagen interpretation of quantum mechanics.

ROBERT BOYLE 1627 – 1691

Transformed chemistry from a field bogged down in alchemy and mysticism into one based on measurement. He defined elements, compounds, and mixtures; and he discovered the first gas law – Boyle's Law.

LAWRENCE BRAGG 1890 – 1971

Discovered how to locate the positions of atoms in solids using X-ray diffraction, enabling scientists to build 3D models of the atomic arrangements in solids. The discovery was arguably the most significant experimental breakthrough of twentieth century science.

HENNIG BRAND 1630 – 1710

Discovered phosphorus, becoming the first named person in history to discover a chemical element.

GEORG BRANDT 1694 – 1768

The first named person in history to discover a new metal – cobalt; was one of the first scientists to condemn alchemy, publicly demonstrating tricks used by alchemists to make people think they could make gold.

ROBERT BUNSEN 1811 – 1899

Discovered cesium and rubidium; discovered the antidote to arsenic poisoning; invented the zinc-carbon battery and flash photography; discovered how geysers operate.

ERWIN CHARGAFF 1905 – 2002
Chargaff's rules paved the way to the discovery of DNA's structure.

MARIE CURIE 1867 – 1934
Co-discovered the chemical elements radium and polonium; made numerous pioneering contributions to the study of radioactive elements; carried out the first research into the treatment of tumors with radiation.

JOHN DALTON 1766 – 1844
Dalton's Atomic Theory is the basis of chemistry; discovered Gay-Lussac's Law relating gases' temperature, volume, and pressure; discovered the law of partial gas pressures.

DEMOCRITUS (C. 460 — C. 370 BC)
Devised an atomic theory featuring tiny particles always in motion interacting through collisions; advocated a universe containing an infinity of diverse inhabited worlds governed by natural, mechanistic laws rather than gods; deduced that the light of stars explains the Milky Way's appearance; discovered that a cone's volume is one-third that of the cylinder with the same base and height.

EMPEDOCLES (C. 490 – C. 430 BC)
An ancient theory of natural selection; mass conservation; and the four elements which are now often misattributed to Aristotle.

MICHAEL FARADAY 1791 – 1867
Discovered electromagnetic induction; devised Faraday's laws of electrolysis; discovered the first experimental link between light and magnetism; carried out the first room-temperature liquefaction of a gas; discovered benzene.

ROSALIND FRANKLIN 1920 – 1958
Provided much of the experimental data used to establish the structure of DNA; discovered that DNA can exist in two forms; established that coal acts as a molecular sieve.

WILLARD GIBBS 1839 – 1903
Gibbs invented vector analysis and founded the sciences of modern statistical mechanics and chemical thermodynamics.

GEORGE DE HEVESY 1885 – 1966
Discovered element 72, hafnium. Pioneered isotopes as tracers to study chemical and biological processes; discovered how plants and animals utilize particular chemical elements after they are taken in as nutrients.

FRED HOYLE 1915 – 2001
Established that most of the naturally occurring elements in the periodic table were made inside stars and distributed through space by supernova explosions.

IRENE JOLIOT-CURIE 1897 – 1956
Co-discovered how to convert stable chemical elements into 'designer' radioactive elements; these have saved millions of lives and are used in tens of millions of medical procedures every year.

MARTIN KLAPROTH 1743 – 1817
Discovered the chemical elements uranium, zirconium, and cerium – naming the first two of these elements; verified the discoveries of titanium, tellurium and strontium, again naming the first two.

STEPHANIE KWOLEK 1923 – 2014
Invented kevlar, the incredibly strong plastic used in applications ranging from body armor to tennis racquet strings.

ANTOINE LAVOISIER 1743 – 1794
A founder of modern chemistry; discovered oxygen's role in combustion and respiration; discovered that water is a compound of hydrogen and oxygen; proved that diamond and charcoal are different forms of the same element, which he named carbon.

ERNEST LAWRENCE 1901 – 1958
Invented the cyclotron, used by scientific teams in his laboratories to discover large numbers of new chemical elements and isotopes. Founded big science.

JANE MARCET 1769 – 1858.
Author of *Conversations on Chemistry*, a unique textbook for its time written for people with little formal education, such as girls and the poor. The book inspired Michael Faraday to overcome his poor origins to become a great scientist.

DMITRI MENDELEEV 1834 – 1907
Discovered the periodic table in a dream. Utilized the organizing principles of the periodic table to correctly predict the existence and properties of six new chemical elements.

HENRY MOSELEY 1887 – 1915
Proved that every element's identity is uniquely determined by its number of protons, establishing this is the true organizing principle of the periodic table; correctly predicted the existence of four new chemical elements; invented the atomic battery.

GIULIO NATTA 1903 – 1979
Discovered how to produce polymer chains with orderly spatial arrangements – i.e. stereoregular polymers.

ALFRED NOBEL 1833 – 1896
Invented dynamite, the blasting cap, gelignite, and ballistite; grew enormously wealthy manufacturing explosives; used his wealth to bequeath annual prizes in science, literature, and peace.

HANS CHRISTIAN OERSTED 1777 – 1851
Discovered electromagnetism when he found that electric current caused a nearby magnetic needle to move; discovered piperine and achieved the first isolation of the element aluminum.

LOUIS PASTEUR 1822 – 1895
The father of modern microbiology; transformed chemistry and biology with his discovery of mirror-image molecules; discovered anaerobic bacteria; established the germ theory of disease; invented food preservation by pasteurization.

LINUS PAULING 1901 – 1994
Maverick giant of chemistry; formulated valence bond theory and electronegativity; founded the fields of quantum chemistry, molecular biology, and molecular genetics. Discovered the alpha-helix structure of proteins; proved that sickle-cell anemia is a molecular disease.

MARGUERITE PEREY 1909 – 1975
Discovered francium, the last of the naturally occurring chemical elements to be discovered – all elements since have been produced artificially.

WILLIAM PERKIN 1838 – 1907
At age 18 started the synthetic dye revolution when his discovery of mauveine brought the once formidably expensive color purple to everyone. Perkins' revolution took the world by storm, transforming textiles, foods and medicine.

C. V. RAMAN 1888 – 1970
Discovered that light can donate a small amount of energy to a molecule, changing the light's color and causing the molecule to vibrate. The color change acts as a 'fingerprint' for the molecule that can be used to identify molecules and detect diseases such as cancer.

WILLIAM RAMSAY 1852 – 1916
Predicted the existence of the noble gases and discovered or was first to isolate every member of the group; created the world's first neon light.

ERNEST RUTHERFORD 1871 – 1937
The father of nuclear chemistry and nuclear physics; discovered and named the atomic nucleus, the proton, the alpha particle, and the beta particle; discovered the concept of nuclear half-lives; achieved the first laboratory transformation of one element into another.

GLENN SEABORG 1912 TO 1999
Took part in the discovery of ten of the periodic table's chemical elements. His work on the electronic structure of elements led to the periodic table being rewritten.

HERMANN STAUDINGER 1881 – 1965

Founded macromolecular chemistry when he established that molecules made of hundreds of thousands of atoms exist; demonstrated that synthetic polymers can make fibers similar to natural fibers; discovered polyoxymethylene; discovered pyrethroid natural insecticides.

J.J. THOMSON 1856 – 1940

Discovered the electron; invented one of the most powerful tools in analytical chemistry – the mass spectrometer; obtained the first evidence for isotopes of stable elements.

HAROLD UREY 1893 – 1981

Discovered deuterium; showed how isotope ratios in rocks reveal past Earth climates; founded modern planetary science; the Miller-Urey experiment demonstrated that electrically sparking simple gases produces amino acids – the building blocks of life.

ALESSANDRO VOLTA 1745 – 1827

Pioneer of electrical science; invented the electric battery; wrote the first electromotive series; isolated methane for the first time; discovered a methane-air mixture could be exploded using an electric spark – the basis of the internal combustion engine.

SERGEI WINOGRADSKY 1856 – 1953

Founded microbial ecology; discovered chemosynthetic life forms which obtain energy from chemical reactions rather than from sunlight; discovered nitrogen-fixing bacteria in soil that make nitrates available to green plants.

APPENDIX-D

Periodic Table of the Elements

1 1IA 1A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13	14	15	16	17	18
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.99	12 Mg Magnesium 24.305											13 Al Aluminium 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulphur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 45.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.5	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.789
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.9	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.3
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 197.0	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium 208.982	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (286)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

Lanthanide Series	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.9	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
Actinide Series	89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.004	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium (254)	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawerencium (262)

Alkali Metal | Alkaline Earth | Transition Metal | Basic Metal | Semi-metal | Non-metal | Halogen | Noble Gas | Lantha-nide | Actinide

APPENDIX-E

Important Organic Chemical Reactions

Sandmeyer Reaction

The Sandmeyer reaction is a chemical reaction which is used to synthesize aryl halides from aryl diazonium salts. This reaction is a method for substitution of an aromatic amino group by preparing diazonium salt that is followed by its displacement and copper salts often catalyze it.

$$ArN_2^+X^- \xrightarrow{CuCl/HCl} ArCl + N_2$$
$$ArN_2^+X^- \xrightarrow{CuBr/HBr} ArBr + N_2$$
$$ArN_2^+X^- \xrightarrow{CuCN/KCN} ArCN + N_2$$

Gattermann Reaction

Bromine and Chlorine can be present in the benzene ring by preparing the benzene diazonium salt solution with similar halogen acid present with copper powder. This is the Gattermann Reaction.

$$ArN_2^+X^- \xrightarrow{Cu/HCl} ArCl + N_2 + CuX$$
$$ArN_2^+X^- \xrightarrow{Cu/HBr} ArBr + N_2 + CuX$$

Balz-Schiemann Reaction

When arene-diazonium chloride is prepared with fluoroboric acid, arene diazonium fluoroborate is precipitated and decomposes to yield aryl fluoride which on heating.

$$Ar\overset{+}{N}_2Cl^- + \underset{\text{Fluoroboric acid}}{HBF_4} \longrightarrow Ar-\overset{+}{N}_2BrF_4^- \xrightarrow{Heat} Ar-F + BF_3 + N_2$$

Finkelstein Reaction

In the Finkelstein Reaction Alkyl iodides are prepared easily by the reaction of alkyl chlorides with NaI in dry acetone.

$$R-X + NaI \rightarrow R-I + \underset{(X = Cl, Br)}{NaX}$$

Swarts Reaction

When alkyl chloride is heated in the presence of a metallic fluoride like AgF, Hg_2F_2, SbF_3 or CoF_2, we get alkyl fluoride The reaction is specifically used to prepare alkyl fluorides.

$$H_3C-X + AgF \rightarrow H_3C-F + \underset{(X = Cl, Br)}{AgX}$$

Wurtz Reaction

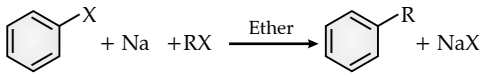
When Alkyl halides get reacted with sodium with dry ether, we get hydrocarbons that include the double number of carbon atoms present in the halide. This is known as the Wurtz Reaction.

$$\underset{\text{Bromomethane}}{CH_3Br} + 2Na + BrCH_3 \xrightarrow{\text{dry ether}} \underset{\text{Ethane}}{CH_3-CH_3} + 2NaBr$$

$$\underset{\text{Bromoethane}}{CH_3Br} + 2Na + BrC_2H_5 \xrightarrow{\text{dry ether}} \underset{\text{n-Butane}}{C_2H_5-C_2H_5}$$

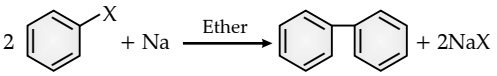
Wurtz-Fittig Reaction

When a mixture of alkyl halide and aryl halide gets treated with sodium in dry ether, we get an alkyl arene.



Fittig Reaction

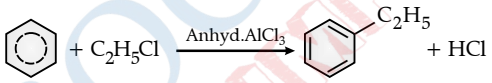
Aryl halides prepared with sodium in dry ether to give analogous compounds where two aryl groups joined.



Friedel-Crafts Alkylation Reaction

Benzene is prepared with an alkyl halide in the presence of anhydrous aluminum chloride to give alkylbenzene.

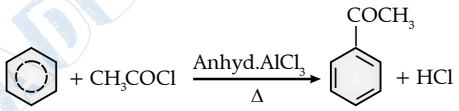
Toluene (13.75)



Ethylbenzene

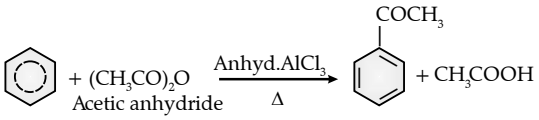
Friedel-Crafts Acylation Reaction

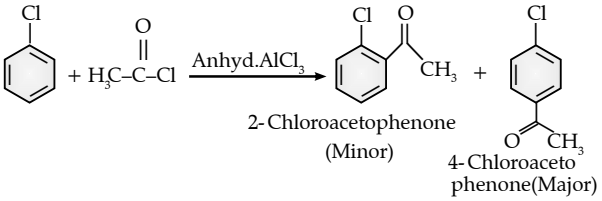
We get acyl benzene when an acyl halide is reacted with benzene in the presence of Lewis acids.



Acetophenone

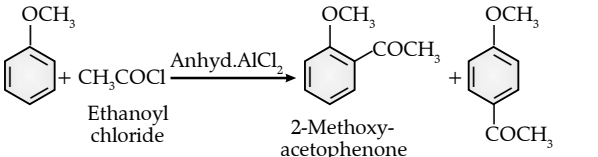
(13.77)





2-Chloroacetophenone (Minor)

4-Chloroaceto phenone(Major)



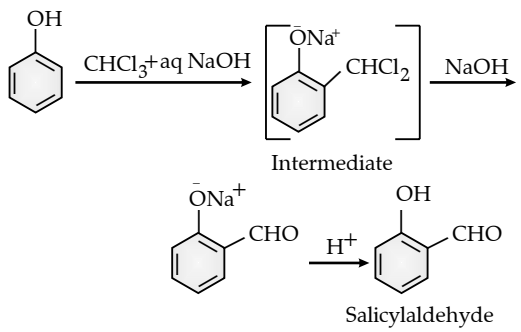
Ethanoyl chloride

2-Methoxy-acetophenone (Minor)

4-Methoxy-acetophenone (Major)

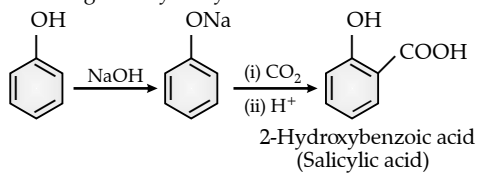
Reimer-Tiemann Reaction

When preparing phenol with chloroform in the presence of sodium hydroxide, –CHO group is present at the ortho position of the benzene ring which results into salicylaldehyde.



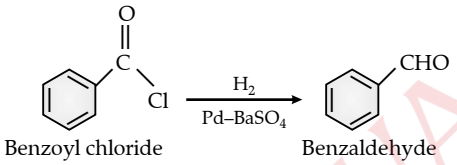
Kolbe's Reaction

Phenol reacts with sodium hydroxide to give sodium phenoxide which then reacts with carbon dioxide in acidic medium to give 2-hydroxybenzoic acid.



Rosenmund Reduction

When Acyl chloride is hydrogenated to an aldehyde over a catalyst, known as Rosenmund catalyst which is either palladium or barium sulfate. The catalyst is poisoned with either sulphur or quinoline in order to prevent further reduction of aldehyde to alcohol.



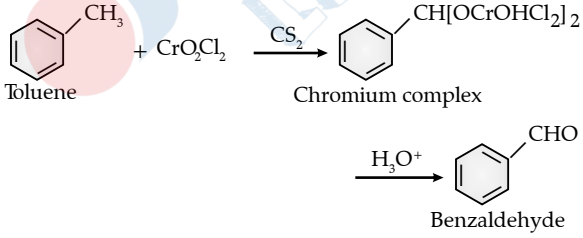
Stephen Reaction

Nitriles with stannous chloride in the presence of hydrochloric acid reduced to the corresponding imine and give the corresponding aldehyde after hydrolysis.

$$RCN + SnCl_2 + HCl \longrightarrow RCH = NH \xrightarrow{H_3O^+} RCHO$$

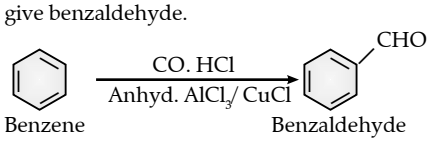
Etard Reaction

Chromyl chloride oxidizes methyl group to get chromium complex which on hydrolysis provides corresponding benzaldehyde.



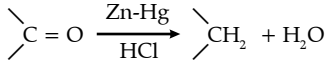
Gatterman – Koch Reaction

Benzene is prepared with carbon monoxide and hydrogen chloride in the presence of anhydrous aluminium chloride to give benzaldehyde.



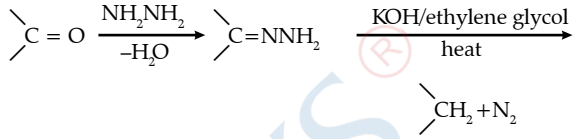
Clemmensen Reduction

In Clemmensen reduction, Carbonyl group of aldehydes and ketones on treatment with zinc amalgam and concentrated hydrochloric acid reduced to CH_2 group.



Wolff Kishner Reduction

Carbonyl group of aldehydes and ketones on treatment with hydrazine produces hydrazone which on heating with potassium hydroxide in a high boiling solvent (ethylene glycol) and reduce to $-CH_2-$ group.



Tollens' test

Heating an aldehyde with fresh prepared ammoniacal silver nitrate solution produces a bright silver mirror due to the formation of silver metal.

$$RCHO + 2[Ag(NH_3)]_2 + 3OH^- \longrightarrow RCOO^- + 2Ag + 2H_2O + 4NH_3$$

Silver mirror

Fehling's test

Fehling's solution A (aqueous copper sulfate) and Fehling solution B (alkaline sodium potassium tartrate) are mixed in equal amounts before the test. A reddish brown precipitate is obtained when an aldehyde is heated with Fehling's reagent.

$$R\text{-}CHO + 2Cu^{2+} + 5OH^- \longrightarrow RCOO^- + Cu_2O + 3H_2O$$

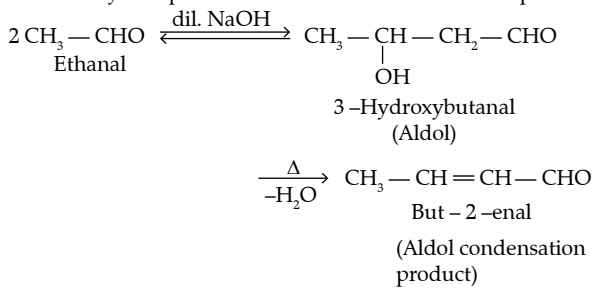
Reddish-brown ppt

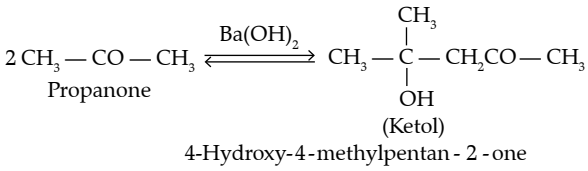
Aldol reaction

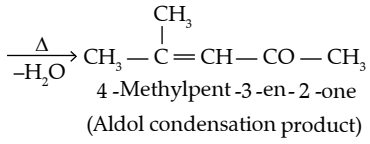
Aldehydes and ketones having one α-hydrogen undergo a reaction in the presence of dilute alkali as the catalyst to produce α-hydroxy aldehydes or β-hydroxy ketones.

(i) Aldol condensation

Aldol and Ketol lose water to provide α,β-unsaturated carbonyl compounds which are aldol condensation products.







(ii) Cross aldol condensation

Aldol condensation is carried out between two different aldehydes and ketones. It gives a mixture of four prod-

ucts if both of them includes α-hydrogen atoms.

$$CH_3-\underset{\underset{CH_3}{|}}{CH}=CH-CHO + CH_3CH_2-CH=CHCHO$$

2-Methylbut-2-enal Pent-2-enal

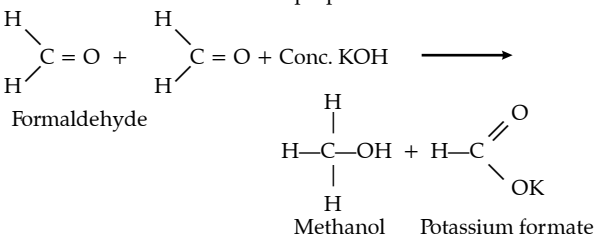
$$\begin{matrix} CH_3CHO \\ + \\ CH_3CH_2CHO \end{matrix} \xrightarrow[2.\ \Delta]{1.\ NaOH} CH_3-CH=CH-CHO$$

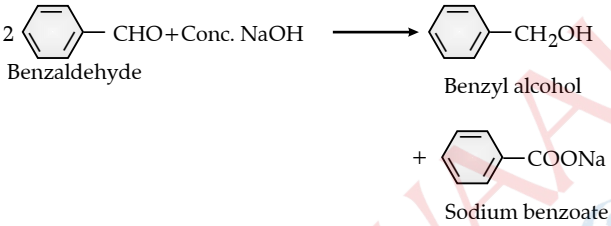
But-2-enal

$$+ CH_3-CH_2-CH=\underset{\underset{CH_3}{|}}{C}-CHO$$

Cannizzaro Reaction

Aldehydes without α-hydrogen atom undergo self-oxidation and reduction reaction when prepared with concentrated alkali. The reaction is known as disproportionation reaction.





Kolbe electrolysis

In Kolbe electrolysis, An aqueous solution of sodium or potassium salt of a carboxylic acid gives alkane containing an even number of carbon atoms on electrolysis.

$$\underset{\text{Sodium acetate}}{2CH_3COONa} + 2H_2O \xrightarrow{\text{Electrolysis}} CH_3-CH_3 + 2CO_2 + H_2 + 2NaOH$$

Hell-Volhard-Zelinsky (HVZ) Reaction

Carboxylic acids having a α-hydrogen are halogenated at the α-position give α-halo carboxylic acids on treatment with chlorine or bromine in the presence of small amount of red phosphorus.

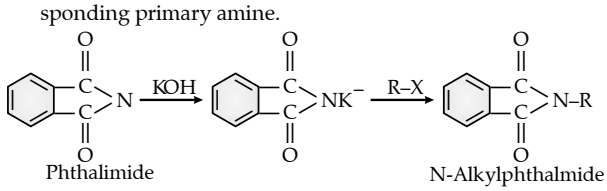
$$R-CH_2-COOH \xrightarrow[\text{(ii) } H_2O]{\text{(i) } X_2/\text{Red phosphorus}} R-\underset{\underset{X}{|}}{CH}-COOH$$

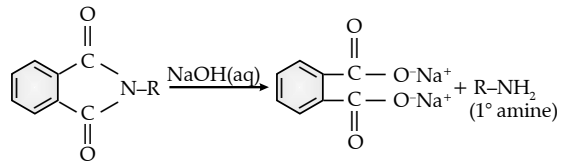
X=Cl, Br

α – Halocarboxylic acid

Gabriel Phthalimide Synthesis

Phthalimide prepared with ethanolic potassium hydroxide produces potassium salt of phthalimide when heated with alkyl halide followed by alkaline hydrolysis forms the corresponding primary amine.





Hoffmann Bromamide Degradation Reaction

An amide upon heating with bromine in presence of sodium hydroxide produces primary amine. Migration of an alkyl or aryl group takes place from carbonyl carbon of the amide to the nitrogen atom. The amine so produced includes one carbon less than that present in the amide.

$$R-\overset{\overset{O}{||}}{C}-NH_2 + Br_2 + 4NaOH \longrightarrow R-NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$$

Carbylamine Reaction

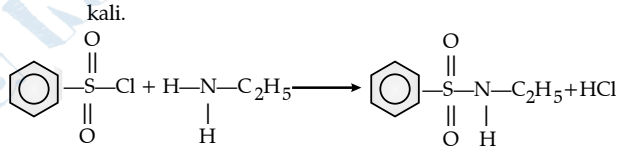
Aliphatic and aromatic primary amines when heated with chloroform and ethanolic potassium hydroxide produces isocyanides or carbyl amines which are foul smelling substances.

$$R-NH_2 + CHCl_3 + 3KOH \xrightarrow{\text{Heat}} R-NC + 3KCl + 3\,H_2O$$

Hinsberg's Test

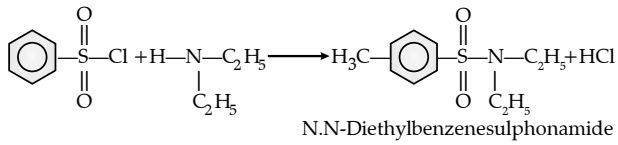
Benzenesulfonyl chloride ($C_6H_5SO_2Cl$) reacts with primary and secondary amines to produce sulphonamides.

(i) The reaction of benzene-sulfonyl chloride with primary amine yields N-ethyl benzene-sulfonyl amide. The hydrogen attached to the nitrogen in sulphonamide is strongly acidic due to the presence of strong electron withdrawing sulfonyl group. Hence, it is soluble in alkali.



N-Ethylbenzenesulphonamide
(Soluble in alkali)

(ii) In the reaction with a secondary amine, N, N-diethylbenzenesulfonamide is formed. Since N,N-diethyl benzene sulphonamide does not contain any hydrogen atom attached to a nitrogen atom, it is not acidic and hence insoluble in alkali.

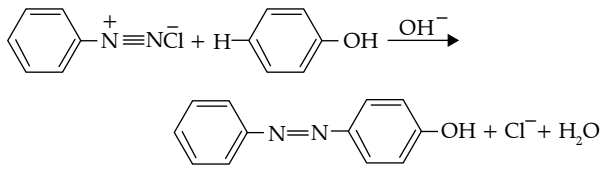


N.N-Diethylbenzenesulphonamide

(iii) Tertiary amines do not react with benzenesulphonyl chloride.

Coupling Reactions

Benzene diazonium chloride gets reacted with phenol in which the phenol molecule at its para position is mixed with the diazonium salt to give p-hydroxyazobenzene.



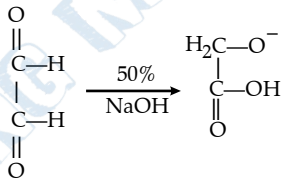
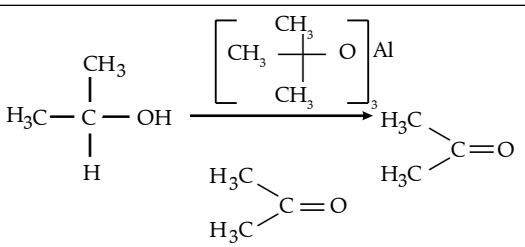
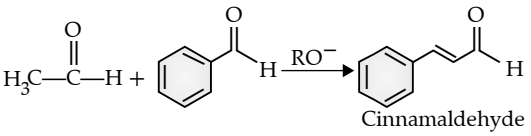
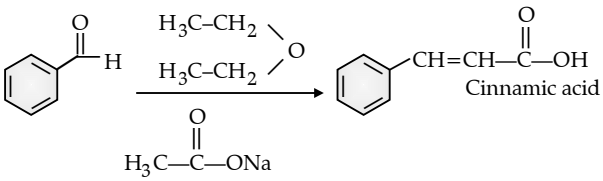
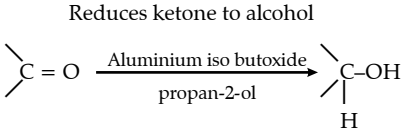
p – Hydroxyazobenzene (orange dye)

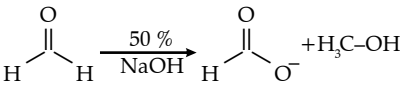
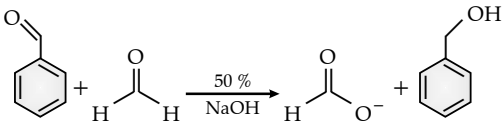
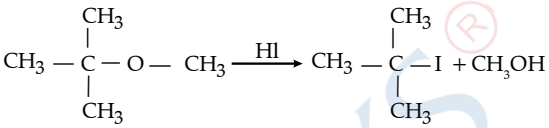
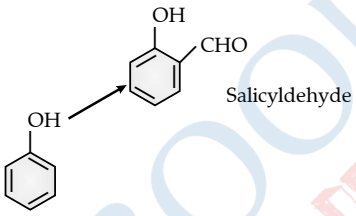
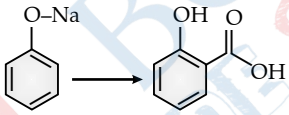
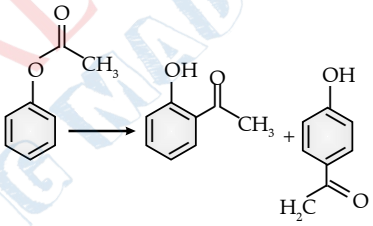
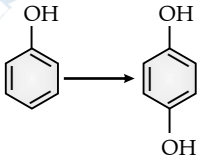
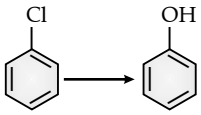
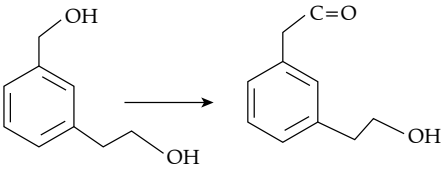
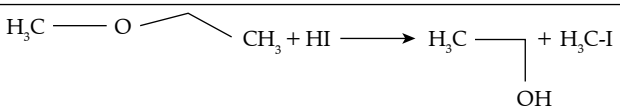
APPENDIX-F

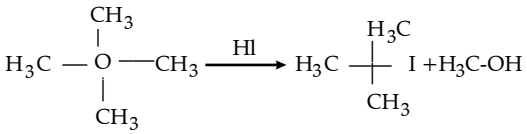
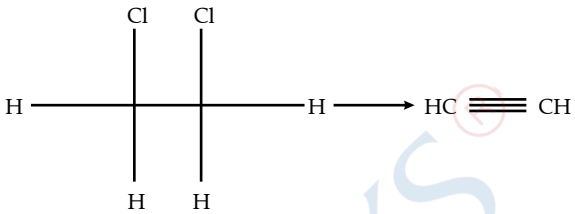
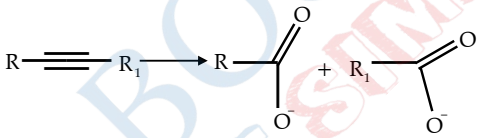
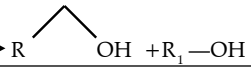
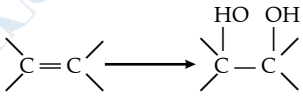
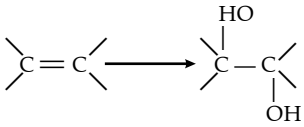
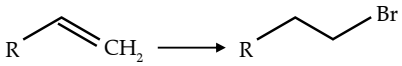
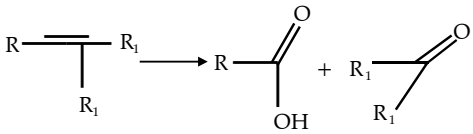
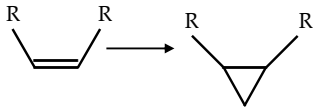
Important Reagents

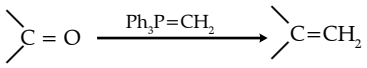
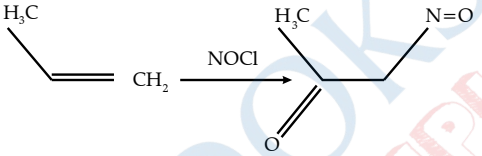
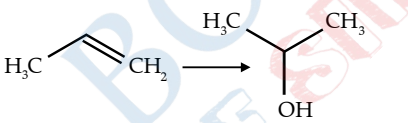
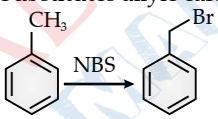
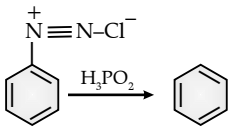
List of Organic Reagents

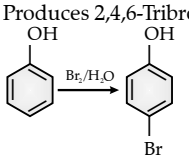
Aqueous NaOH	Reflux	Nucleophilic substitution, converts haloalkanes to alcohols.
Mg in dry ether	Reflux	Used to make Grignard reagents with haloalkanes.
PCl_5	Room temperature	Chlorinating agent, reacts with OH group in alcohols and carboxylic acids.
HNO_3 and H_2SO_4	55°C	Adds NO_2 group into benzene ring.
Cl_2 and $AlCl_3$	Warm gently	Adds Cl group into benzene ring.
CH_3CH_2Cl and $AlCl_3$	Warm gently	Adds CH_3CH_2 group into benzene ring.
HCl and $NaNO_2$	Below 5°C	Forms diazonium salts with phenylamine.

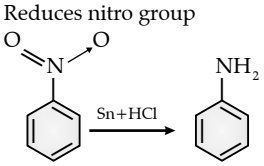
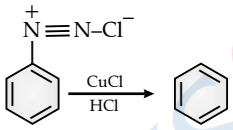
Name of Reagent	Conditions	Example of its Use
$K_2Cr_2O_7$ with conc. H_2SO_4	Warm gently	**Oxidising agent,** used commonly for oxidising secondary alcohols to ketones.
Excess conc. H_2SO_4	Heat to 170°C	Dehydrating agent, used to dehydrate alcohols to alkenes.
$Cl_2(g)$	Ultra violet light	Free radical reaction, used to convert alkanes to haloalkanes.
Br_2 in CCl_4	Room temperature, in the dark	Electrophilic addition, converts alkenes to dihaloalkanes.
$H_2(g)$	Nickel catalyst, 300°C and 30 atmospheric pressure	**Hydrogenating agent,** used to convert benzene to cyclohexane.
$H_2(g)$	Nickel catalyst, 150°C	**Reducing agent,** used to convert alkenes to alkanes
Tin in hydrochloric acid	Reflux	Reducing agent for converting nitrobenzene to phenylamine.
Acidified $KMnO_4$	Room temperature	**Oxidising agent,** converts alkenes to diols.
NaOH in ethanol	Reflux	Elimination reaction, converts haloalkanes to alkenes.
NaOH (Intramolecular Cannizaro) reaction		
(i) Aluminium isobutoxide **(ii)** Acetone (Oppenaur Oxidation)		
RO^-(Claisen Schmidt Reaction)		 Cinnamaldehyde
(i) Acetic anhydride **(ii)** Sodium acetate (Perkin's reaction)		 Cinnamic acid
(i) Aluminium isobutoxide **(ii)** Propan-2 ol (MPV Reduction)		Reduces ketone to alcohol 

Cannizzaro Reaction		This is reaction of compounds which don't have alpha hydrogen. 
Cross Cannizaro reaction		
Anhydrous HI contains no water		
(i) $CHCl_3$ - Alc KOH **(ii)** H_3O^+ (Riemann Tiemann reaction)		 Salicyldehyde
(i) CO_2 **(ii)** H_3O^+ (Kolbe's reaction)	High Pressure	
$AlCl_3$ (Fries rearrangement)	Heat	
(i) $K_2S_2O_8$ **(ii)** H_3O^+ (Elb's persulphate oxidation)		
(i) Fused NaOH **(ii)** H_3O^+ (Dow's process)	High Pressure	
$KMnO_4$, H^+ (or) $K_2Cr_2O_7$, H^+ (or) H_2CrO_4		Oxidises alcohol to acid
PCC (Pyridinium chloro chromate)	Solvent CS_2	Restricted oxidation of alcohol. Forms aldehyde.
MnO_2 special oxidising agent for alcohol		 MnO_2 selectively oxidizes primary or secondary allylic or benzylic alcohols to carbonyl compounds.
HI		
For 1 degree carbon		

For 3 degree carbon		$CH_3\text{-}O\text{–}C(CH_3)_3 + HI = (CH_3)_3C\text{–}I + CH_3OH$
Conc HI contains very less water		
(i) Alc KOH **(ii)** $NaNH_2$		
X_2/CCl_4		Adds both X on compound having double or triple bond
Cold Dil $KMnO_4$		
Hot $KMnO_4/OH^-$		
$CF_3SO_3^-$		Super Leaving Group
$LiAlH_4$–ether		Reduces ester to alcohol
$NaBH_4$– ROH (protic solvent)		Reduces aldehydes and ketones to alcohol but cannot act on ester
$Cr_2O_3\text{-}Cu_2O$	Heat, High pressure	Causes cleavage and reduction of ester $RCOOR_1 = RCH_2OH + R_1\text{–}OH \longrightarrow$ 
$OsO_4 + H_2O\text{-}NaHSO_3$ or Cold Dilute $KMnO_4$ (Hydroxylation)		Gives syn vicinal diol from alkene 
Per-formic acid (Anti Hydroxylation)		Gives anti vicinal diol 
HBr in presence of H_2O_2 (Only for HBr)		Anti Markovnikov's 
Hot Alkaline $KMnO_4$		Replaces "=" with either C = O or COOH 
$CH_2\text{-}I_2$, ZnCu		Adds methyl group in cyclic manner 

Alcoholic KOH	Heat	Causes dehydrohalogenation of alkyl halides to form alkenes. HX from compound and adds double bond
Zn dust		Convert vicinal dihalides to alkenes.
H_2 Pd/$BaSO_4$ or S-Quinoline (Lindlar's catalyst) or BH_3-THF		Reduces alkyne to *cis*-alkene. It also reduces acid halides to aldehydes.
$Ph_3P = CH_2$		Converts aldehyde or ketones to alkene. The reaction is known as Wittig Reaction. 
NOX		 Check the reaction. The final product should be $CH_3CH(X)CH_2N{=}O$
OMDM (Oxymercuration demercuration) **(i)** Hg $(OAc)_2$ + THF-H_2O **(ii)** $NaBH_4$-OH^-		
NBS		Substitutes allyic carbon with aldehyde 
(i) NH_2-NH_2 **(ii)** RO^-	heat	Reduces carbonyl group to ketone or aldehyde
H_3PO_2	Heat	Removes diazo group 
$LiAH_4$ or $NaBH_4$ or Ph_3 SnH		Reduction
R_2CuLi (Lithium dialkylcuprate)		Removes halogen from RX and adds R. The reaction is known as Corey-House synthesis. The reaction is used to produce an alkane. The R- from R_2CuLi displaces -X from R-X to produce an alkane.
Mg-ether		Adds Mg between R & X
Red P + HI		Reduces alcohols, aldehydes, ketones and carboxylic acids to alkanes.

Name	Condition	Example
$Br_2 + CS_2$		Causes mono-bromination of phenol to produce p-bromophenol.
$Br_2 + H_2O$	Compound should be more activated than benzene	Produces 2,4,6-Tribromophenol from phenol. 

Sn + HCl or Fe + HCl		Reduces nitro group 
CuCl + HCl		Removes Diazo group 
NH_4SH or Na_2S		Special regents which reduce only $–NO_2$ group to $–NH_2$
$CrO_2Cl_2 + H_3O^+$		Converts toluene to benzaldehyde

APPENDIX-G

Important Minerals, Compositions & their Chemical Formula

Mineral	Composition		Remarks
Apatite	Calcium phosphate	$Ca_{10}(PO_4)_6X_2$ (X is F, Cl, or (OH).]	Main mineral in phosphate rock
Asbestos	Hydrated magnesium silicate	$Mg_6(Si_4O_{12})(OH)_3$	In form of long fibres
Baryte	Barium sulphate	$BaSO_4$	Filler for pigments
Betonies	A clay mineral	$(Al.Mg)_8(Si_4O_{10})_3(OH)_{10} \bullet 12H_2O$	Agglomeration additive
Borax	Sodium borate	$Na_2B_4O_7 \bullet 10H_2O$	
Clay	Hydrated aluminium silicates		Used in paper making
Cryolite	Sodium aluminium fluoride	Na_3AlF_6	Low melting point
Diamond - industrial	Crystalline carbon	C	The hardest mineral
Diatomite	Hydrated silica	$SiO_2(H_2O)_n$	Marine fossils, large surface area
Feldspar	A mineral group	K, Al silicates	
Fluorspar	Calcium fluoride	CaF_2	Main source of fluorine
Garnet	A group of silicates that crystallize in the cubic system	$Mg_3Fe_2Si_3O_{12}$	Abrasives, gemstones
Graphite	Carbon (crystalline)	C	
Gypsum	Calcium sulphate	$CaSO_4 \bullet 2H_2O$	
Kaolinite	A clay mineral	$Al_4(Si_4O_{10})(OH)_8$	
Limestone	Calcium carbonate	$CaCO_3$	
Magnetite	Magnesium carbonate	$MgCO_3$	
Marble	Calcium carbonate	$CaCO_3$ crystalline	
Mica		K, Al silicates	
Nepheline syenite	Sodium aluminium silicate		

Potash	Potassium chloride and carbonate	KCl, K_2CO_3	Fertilizer
Pumice	Silicate		Porous, light, volcanic rock, large surface area
Quartz	Silica	SiO_2	
Salt	Sodium chloride	NaCl	
Sand and gravel	Silica	SiO_2	
Sulfur	Sulfur	S	
Talc	Hydrated magnesium silicate	$Mg_3(Si_4O_{10})(OH)_2$	Also known as soapstone
Trona	Sodium carbonate	$Na_2CO_3 \bullet NaHCO_3 \bullet 2H_2O$	
Vermiculite	Hydrated silicates	$(Mg,Fe^{2+},Fe^{3+})_3[(Al,Si)_4O_{10}](OH)_2 \cdot 4H_2O$	Expands and swells on heating
Zeolite	Hydrated alkali alumino silicates	$Na_2(AlO_2)_x(SiO_2)_y \bullet nH_2O$	Ion exchanger

APPENDIX-H

Important Metals & their Ores

S.No	Metal	Ores
1	Aluminium(Al)	Bauxite, Corundum, Feldspar, Cryolite, Alunite, Kaolin
2	Antimony(Sb)	Stibnite
3	Barium(Ba)	Barytes
4	Bismuth(Bi)	Bismuthate
5	Cadmium(Cd)	Greenockite
6	Calcium(Ca)	Dolomite, Calcite, Gypsum, Fluorspar, Asbestos
7	Cobalt(Co)	Smelite
8	Copper(Cu)	Cuprite, Copper glance ,Copper pyrites
9	Gold(Au)	Calaverite, Sylvenites
10	Iron(Fe)	Hematite, Limonite, Magnetite, Siderite, Iron pyrite, Copper pyrites
11	Lead(Pb)	Galena
12	Magnesium(Mg)	Magnesite, Dolomite, Epsom salt, Kieserite, Carnalite
13	Manganese(Mn)	Pyrolusite, Magnate
14	Mercury(Hg)	Cinnabar
15	Nickel(Ni)	Millerite
16	Potassium(K)	Nitrate(saltpetre), Carnallite
17	Silver(Ag)	Ruby silver, Horn silver
18	Sodium(Na)	Chile saltpetre , Trona, Borax, Common salt
19	Strontium(Sr)	Strontianite, Silestone
20	Tin(Sn)	Cassiterite
21	Uranium(U)	Carnallite, Pitch blende
22	Zinc(Zn)	Zinc blende, Zincite, Calamine