PHYSICS

APPENDIX-A

A.1 SI Units

Base Quantity	SI Base Unit	
	Name	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

A.2 Some Derived SI Units

Quantity	Name	Symbol	Expression in Terms of Base Units	Expression in Terms of SI Units
Plane angle	radian	ω	m/m	
Frequency	hertz	Hz	s^{-1}	
Force	newton	N	$kg \cdot m/s^2$	J/m
Pressure	pascal	Pa	$kg/m \cdot s^2$	N/m^2
Energy	joule	J	$kg \cdot m^2/s^2$	$N \cdot m$
Power	watt	W	$kg \cdot m^2/s^3$	J/s
Electric charge	coulomb	C	$A \cdot s$	
Electric potential	volt	V	$kg \cdot m^2/A \cdot s^3$	W/A
Capacitance	farad	F	$A^2 \cdot s^4/kg \cdot m^2$	C/V
Electric resistance	ohm	Ω	$kg \cdot m^2/A^2 \cdot s^3$	V/A
Magnetic flux	weber	ϕ	$kg \cdot m^2/A \cdot s^2$	$T \cdot m$
Magnetic field	tesla	B	$kg/A \cdot s^2$	Nb/m^2 or tesla
Inductance	henry	L	$kg \cdot m^2/A^2 \cdot s^2$	$T \cdot m^2/A$

APPENDIX-B

B.1 Conversion Factors

Length

	m	cm	km	in.	ft	mi
1 meter	1	10^2	10^{-3}	39.37	3.281	6.214×10^{-4}
1 centimeter	10^{-2}	1	10^{-5}	0.3937	3.281×10^{-2}	6.214×10^{-6}
1 kilometer	10^3	10^5	1	3.937×10^4	3281×10^3	0.6214
1 inch	2.540×10^{-2}	2.540	2.540×10^{-5}	1	8.333×10^{-2}	1.578×10^{-5}
1 foot	0.3048	30.48	3.048×10^{-4}	12	1	1.894×10^{-4}
1 mile	1609	1.609×10^5	1.609	6.336×10^4	5280	1

Mass

	kg	g	slug	u
1 kilogram	1	10^3	6.854×10^{-2}	6.024×10^{26}
1 gram	10^{-3}	1	6.852×10^{-5}	6.024×10^{23}
1 slug	14.59	1.459×10^4	1	8.789×10^{27}
1 atomic mass unit	1.660×10^{-27}	1.660×10^{-24}	1.137×10^{-28}	1

Note : 1 metric ton = 1000 kg.

Time

	s	min	h	day	yr
1 second	1	1.667×10^{-2}	2.778×10^{-4}	1.157×10^{-5}	3.169×10^{-8}
1 minute	60	1	1.667×10^{-2}	6.944×10^{-4}	1.901×10^{-6}
1 hour	3600	60	1	4.167×10^{-2}	1.141×10^{-4}
1 day	8.640×10^{4}	1440	24	1	2.738×10^{-5}
1 year	3.156×10^{7}	5.259×10^{5}	8.766×10^{3}	365.2	1

Speed

	m/s	cm/s	ft/s	mi/h
1 meter per second	1	10^{2}	3.281	2.237
1 centimeter per second	10^{-2}	1	3.281×10^{-2}	2.237×10^{-2}
1 foot per second	0.3048	30.48	1	0.6818
1 mile per hour	0.4470	44.70	1.467	1

Note : 1 mi/min = 60 mi/h = 88 ft/s.

Force

	N	lb
1 newton	1	0.2248
1 pound	4.448	1

Energy, Energy Transfer

	J	ft · lb	eV
1 joule	1	0.7376	6.242×10^{18}
1 foot-pound	1.356	1	8.464×10^{18}
1 electron volt	1.602×10^{-19}	1.182×10^{-19}	1
1 calorie	4.186	3.087	2.613×10^{19}
1 British thermal unit	1.055×10^{3}	7.779×10^{2}	6.585×10^{21}
1 kilowatt-hour	3.600×10^{6}	2.655×10^{6}	2.247×10^{25}

	cal	Btu	kWh
1 joule	0.2389	9.481×10^{-4}	2.778×10^{-7}
1 foot-pound	0.3239	1.285×10^{-3}	3.766×10^{-7}
1 electron volt	3.827×10^{-20}	1.519×10^{-22}	4.450×10^{-26}
1 calorie	1	3.968×10^{-3}	1.163×10^{-6}
1 British thermal unit	2.520×10^{2}	1	2.930×10^{-4}
1 kilowatt-hour	8.601×10^{5}	3.413×10^{2}	1

Pressure

	Pa	atm
1 pascal	1	9.869×10^{-6}
1 atmosphere	1.013×10^{5}	1
1 centimeter mercury[a]	1.333×10^{3}	1.316×10^{-2}
1 pound per square inch	6.895×10^{3}	6.805×10^{-2}
1 pound per square foot	47.88	4.725×10^{-4}

	cm Hg	lb/in.^{2}	lb/ft^2
1 pascal	7.501×10^{-4}	1.450×10^{-4}	2.089×10^{-2}
1 atmosphere	76	14.70	2.116×10^{3}
1 centimeter mercury[a]	1	0.1943	27.85
1 pound per square inch	5.171	1	144
1 pound per square foot	3.591×10^{-2}	6.944×10^{-3}	1

At 0°C and at a location where the free-fall acceleration has its "standard" value, 9.80665 m/s^2.

B.2 Conversions of useful physical quantities

Length

1 in. = 2.54 cm (exact)
1 m = 39.37 in. = 3.281 ft
1 ft = 0.3048 m
12 in. = 1 ft
3 ft = 1 yd
1 yd = 0.9144 m
1 km = 0.621 mi
1 mi = 1.609 km
1 mi = 5280 ft
1 μm = 10^{-6} m = 10^{3} nm
1 light-year = 9.461×10^{15} m

Area

1 m^2 = 10^4 cm^2 = 10.76 ft^2
1 ft^2 = 0.0929 m^2 = 144 $in.^2$
1 $in.^2$ = 6.452 cm^2

Volume

1 m^3 = 10^6 cm^3 = 6.102×10^4 $in.^3$
1 ft^3 = 1 728 $in.^3$ = 2.83×10^{-2} m^3
1 L = 1000 cm^3 = 1.0576 qt = 0.0353 ft^3
1 ft^3 = 7.481 gal = 28.32 L = 2.832×10^{-2} m^3
1 gal = 3.786 L = 231 $in.^3$

Mass

1000 kg = 1 t (metric ton)
1 slug = 14.59 kg
1 u = 1.66×10^{-27} kg = 931.5 MeV/c^2

Force

1 N = 0.2248 lb
1 lb = 4.448 N

Velocity

1 mi/h = 1.47 ft/s = 0.447 m/s = 1.61 km/h
1 m/s = 100 cm/s = 3.281 ft/s
1 mi/min = 60 mi/h = 88 ft/s

Acceleration

1 m/s^2 = 3.28 ft/s^2 = 100 cm/s^2
1 ft/s^2 = 0.3048 m/s^2 = 30.48 cm/s^2

Pressure

1 bar = 10^5 N/m^2 = 14.50 $lb/in.^2$
1 atm = 760 mm Hg = 76.0 cm Hg
1 atm = 14.7 $lb/in.^2$ = 1.013×10^5 N/m^2
1 Pa = 1 N/m^2 = 1.45×10^{-4} $lb/in.^2$

Time

1 yr = 365 days = 3.16×10^7 s
1 day = 24 h = 1.44×10^3 min = 8.64×10^4 s

Energy

1 J = 0.738 ft · lb
1 cal = 4.186 J
1 Btu = 252 cal = 1.054×10^3 J
1 eV = 1.602×10^{-19} J
1 kWh = 3.60×10^6 J

Power

1 hp = 550 ft · lb/s = 0.746 kW
1 W = 1 J/s = 0.738 ft · lb/s
1 Btu/h = 0.293 W

Some Approx imations Useful for Estimation Problems

1 m ≈ 1 yd
1 kg ≈ 2 lb
1 N ≈ $\frac{1}{4}$ lb
1 L ≈ $\frac{1}{4}$ gal
1 m/s ≈ 2 mi/h
1 yr ≈ $\pi \times 10^7$ s
60 mi/h ≈ 100 ft/s
1 km ≈ $\frac{1}{2}$ mi

APPENDIX-C

C.1 Important Constants

Symbol	Meaning	Best Value	Approximate Value
c	Speed of light in vacuum	2.99792458×10^8 m/s	3.00×10^8 m/s
G	Gravitational constant	$6.67408(31) \times 10^{-11}$ N . m^2/kg^2	6.67×10^{-11} N . m^2/kg^2
N_A	Avogadro's number	$6.02214129(27) \times 10^{23}$	6.02×10^{23}
k	Boltzmann's constant	$1.3806488(13) \times 10^{-23}$ J/K	1.38×10^{-23} J/K
R	Gas constant	8.3144621(75) J/ mol . K	8.31 J/ mol · K = 1.99 cal / mol . K = 0.0821 atm . L/mol . K
σ	Stefan-Boltzmann constant	$5.670373(21) \times 10^{-8}$ W/m^2 . K	5.67×10^{-8} W/m^2 · K
k	Coulomb force constant	$8.987551788\ldots \times 10^9$ N . m^2/C^2	8.99×10^9 N . m^2/C^2
q_e	Charge on electron	$-1.602176565(35) \times 10^{-19}$ C	-1.60×10^{-19} C
ε_0	Permittivity of free space	$8.854187817\ldots \times 10^{-12}$ C^2/N . m^2	8.85×10^{-12} C^2/N . m^2
μ_0	Permeability of free space	$4\pi \times 10^{-7}$ T . m/A	1.26×10^{-6} T . m/A
h	Planck's constant	$6.62606957(29) \times 10^{-34}$ J . s	6.63×10^{-34} J . s

C.2 Submicroscopic Masses

Symbol	Meaning	Best Value	Approximate Value
m_e	Electron mass	$9.10938291(40) \times 10^{-31}$ kg	9.11×10^{-31} kg
m_p	Proton mass	$1.672621777(74) \times 10^{-27}$ kg	1.6726×10^{-27} kg
m_n	Neutron mass	$1.674927351(74) \times 10^{-27}$ kg	1.6749×10^{-27} kg
u	Atomic mass unit	$1.660538921(73) \times 10^{-27}$ kg	1.6605×10^{-27} kg

C.3 Solar System Data

Sun	mass	1.99×10^{30} kg
	average radius	6.96×10^{8} m
	Earth-sun distance (average)	1.496×10^{11} m
Earth	mass	5.9736×10^{24} kg
	average radius	6.376×10^{6} m
	orbital period	3.16×10^{7} s
Moon	mass	7.35×10^{22} kg
	average radius	1.74×10^{6} m
	orbital period (average)	2.36×10^{6} s
	Earth-moon distance (average)	3.84×10^{8} m

C.4 Metric Prefixes for Powers of Ten and Their Symbols

Prefix	Symbol	Value	Prefix	Symbol	Value
tera	T	10^{12}	deci	d	10^{-1}
giga	G	10^{9}	centi	c	10^{-2}
mega	M	10^{6}	milli	m	10^{-3}
kilo	k	10^{3}	micro	μ	10^{-6}
hecto	h	10^{2}	nano	n	10^{-9}
deka	da	10^{1}	pico	p	10^{-12}
–	–	10^{0} (= 1)	femto	f	10^{-15}

C.5 Selected British Units

Length	1 inch (in.) = 2.54 cm (exactly)
	1 foot (ft) = 0.3048 m
	1 mile (mi) = 1.609 km
Force	1 pound (ld) = 4.448 N
Energy	1 British thermal unit (Btu) = 1.055×10^{3} J
Power	1 horsepower (hp) = 746 W
Pressure	1 lb / in^2 = 6.895×10^{3} Pa

C.6 Other Units

Length	1 light year (ly) = 9.46×10^{15} m
	1 astronomical unit (au) = 1.50×10^{11}m
	1 nautical mile = 1.852 km
	1 angstrom (Å) = 10^{-10} m
Area	1 acre (ac) = 4.05×10^{3} m^2
	1 square foot (ft^2) = 9.29×10^{-2} m^2
	1 barn (b) = 10^{-28} m^2
Volume	1 liter (L) = 10^{-3} m^3
	1 U.S. gallon (gal) = 3.785×10^{-3} m^3
Mass	1 solar mass = 1.99×10^{30} kg
	1 metric ton = 10^{3} kg
	1 atomic mass unit (u) = 1.6605×10^{-27} kg
Time	1 year (y) = 3.16×10^{7} s
	1 day (d) = 86,400 s
Speed	1 mile per hour (mph) = 1.609 km/h
	1 nautical mile per hour (naut) = 1.852 km/h
Angle	1 degree (°) = 1.745×10^{-2} rad
	1 minute of arc (′) = 1 / 60 degree
	1 second of arc (″) = 1 / 60 minute of arc
	1 grad = 1.571×10^{-2} rad
Energy	1 kiloton TNT (kT) = 4.2×10^{12} J
	1 kilowatt hour (kW . h) = 3.60×10^{6} J
	1 food calorie (kcal) = 4186 J

	1 calorie (cal) = 4.186 J
	1 electron volt (eV) = 1.60×10^{-19}J
Pressure	1 atmosphere (atm) = 1.013×10^5 Pa
	1 millimeter of mercury (mm Hg) = 133.3 Pa
	1 torricelli (torr) = 1 mm Hg = 133.3 Pa
Nuclear decay rate	1 curie (Ci) = 3.70×10^{10} Bq

C.7 Useful Formulae

Circumference of a circle with radius r or diameter d	$C = 2\pi r = \pi d$
Area of a circle with radius r or diameter d	$A = \pi r^2 = \pi d^2/4$
Area of a sphere with radius r	$A = 4\pi r^2$
Volume of a sphere with radius r	$V = (4/3)(\pi r^3)$

C.8 The Greek Alphabet

Alpha	A	α	Eta	H	η	Nu	N	ν	Tau	T	τ
Beta	B	β	Theta	Θ	θ	Xi	Ξ	ξ	Upsilon	ϒ	υ
Gamma	Γ	γ	Iota	I	ι	Omicron	O	*o*	Phi	Φ	ϕ
Delta	Δ	δ	Kappa	K	κ	Pi	Π	π	Chi	X	χ
Epsilon	E	ε	Lambda	Λ	λ	Rho	P	ρ	Psi	ψ	ψ
Zeta	Z	ζ	Mu	M	μ	Sigma	Σ	σ	Omega	Ω	ω

APPENDIX-D

Symbols, Dimensions, and Units of Physical Quantities

Quantity	Common Symbol	Unit	Dimensions	Unit in Terms of Base SI Units
Acceleration	$\vec{a}$	m/s^2	L/T^2	m/s^2
Amount of substance	n	MOLE		mol
Angle	θ, ϕ	radian (rad)	1	
Angular acceleration	$\vec{\alpha}$	rad/s^2	T^{-2}	s^{-2}
Angular frequency	ω	rad/s^2	T^{-1}	s^{-1}
Angular momentum	$\vec{L}$	$kg.m^2/s$	ML^2/T	$kg\ .\ m^2/s$
Angular velocity	$\vec{\omega}$	rad/s	T^{-1}	s^{-1}
Area	A	m^2	L^2	m^2
Atomic number	Z			
Capacitance	C	farad (F)	Q^2T^2/ML^2	$A^2.s^4/kg.m^2$
Charge	q, Q, e	coulomb (C)	Q	A.s
Line Charge density	λ	C/m	Q/L	A·s/m
Surface Charge density	σ	C/m^2	Q/L^2	$A·s/m^2$
Volume Charge density	ρ	C/m^3	Q/L^3	$A·s/m^3$
Conductivity	σ	$1/\Omega·\ m$	Q^2T/ML^3	$A^2·s^3/kg·m^3$
Current	I	AMPERE	Q/T	A
Current density	J	A/m^2	Q/TL^2	A/m^2
Density	ρ	kg/m^3	M/L^3	kg/m^3
Dielectric constant	κ			
Electric dipole moment	P	C · m	QL	A·s·m
Electric field	$\vec{E}$	V/m	ML/QT^2	$kg·m/A·s^3$

Electric flux	Φ_E	V · m	ML^3/QT^2	$kg{\cdot}m^3/A{\cdot}s^3$
Electromotive force	ε	volt (V)	ML^2/QT^2	$kg{\cdot}m^2/A{\cdot}s^3$
Energy	E, U, K	joule (J)	ML^2/T^2	$kg{\cdot}m^2/s^2$
Entropy	S	J/K	ML^2/T^2K	$kg{\cdot}m^2/s^2{\cdot}K$
Force	$\vec{F}$	newton (N)	ML/T^2	$kg{\cdot}m/s^2$
Frequency	f / ν	hertz (Hz)	T^{-1}	s^{-1}
Heat	Q	joule (J)	ML^2/T^2	$kg{\cdot}m^2/s^2$
Inductance	L	henry (H)	ML^2/Q^2	$kg{\cdot}m^2/A^2{\cdot}s^2$
Length	ℓ , L	Meter	L	m
Displacement	Δx , $\Delta\vec{r}$			
Distance	d, h			
Position	$x, y, z, \vec{r}$			
Magnetic dipole moment	$\vec{\mu}$	N · m/T	QL^2/T	$A{\cdot}m^2$
Magnetic field	$\vec{B}$	tesla (T) (=Wb/m^2)	M/QT	$kg/A{\cdot}s^2$
Magnetic flux	Φ_B	weber (Wb)	ML^2/QT	$kg{\cdot}m^2/A{\cdot}s^2$
Mass	m, M	Kilogram	M	kg
Molar specific heat	C	J/mol · K		$kg{\cdot}m^2/s^2{\cdot}mol{\cdot}K$
Moment of inertia	I	kg · m^2	ML^2	$kg{\cdot}m^2$
Momentum	$\vec{P}$	kg · m/s	ML/T	kg·m/s
Time Period	T	S	T	s
Permeability of free space	μ_0	N/A^2 (=H/m)	ML/Q^2	$kg{\cdot}m/A^2{\cdot}s^2$
Permittivity of free space	ε_0	$C^2/N \cdot m^2$ (=F/m)	Q^2T^2/ML^3	$A^2{\cdot}s^4/kg{\cdot}m^3$
Potential	V	volt (V) (=J/C)	ML^2/QT^2	$kg{\cdot}m^2/A{\cdot}s^3$
Power	P	watt (W)(=J/s)	ML^2/T^3	$kg{\cdot}m^2/s^3$
Pressure	P	pascal (Pa)(=N/m^2)	M/LT^2	$kg/m{\cdot}s^2$
Resistance	R	ohm (Ω)(=V/A)	ML^2/Q^2T	$kg{\cdot}m^2/A^2{\cdot}s^3$
Specific heat	c	J/kg · K	L^2/T^2K	$m^2/s^2{\cdot}K$
Speed	v	m/s	L/T	m/s
Temperature	T	Kelvin	K	K
Time	t	Second	T	s
Torque	$\vec{\tau}$	N · m	ML^2/T^2	$kg{\cdot}m^2/s^2$
Velocity	$\vec{v}$	m/s	L/T	m/s
Volume	V	m^3	L^3	m^3
Wavelength	λ	m	L	m
Work	W	joule (J) (=N· m)	ML^2/T^2	$kg{\cdot}m^2/s^2$

APPENDIX-E

Indian Space Research Organisation (ISRO) - - - - [1975 to 2020]

India has been successfully launching satellites of many types since 1975.

Satellites have been launched from various vehicles, including those launched by American, Russian and European rockets, as well as those launched indigenously by India.

The organization responsible for India's satellite program is the **Indian Space Research Organisation (ISRO).**

Satellites	Launch Date	Launch Vehicle
Aryabhata	19-Apr-75	u-11 Interkosmos
Bhaskara-I	07-Jun-79	C-1 Interkosmos
Rohini Technology Payload	10-Aug-79	SLV-3
Rohini RS-1	18-Jul-80	SLV-3
Rohini RS-D1	31-May-81	SLV-3
Ariane Passenger Payload Experiment	19-Jun-81	Ariane-1 (V-3)
Bhaskara-II	20-Nov-81	C-1 Intercosmos
INSAT-1A	10-Apr-82	Delta 3910 PAM-D
Rohini RS-D2	17-Apr-83	SLV-3
INSAT-1B	30-Aug-83	Shuttle [PAM-D]
Stretched Rohini Satellite Series (SROSS-1)	24-Mar-87	ASLV
IRS-1A	17-Mar-88	Vostok
Stretched Rohini Satellite Series (SROSS-2)	13-Jul-88	ASLV
INSAT-1C	21-Jul-88	Ariane-3
INSAT-1D	12-Jun-90	Delta 4925
IRS-1B	29-Aug-91	Vostok
INSAT-2DT	26-Feb-92	Ariane-44L H10
Stretched Rohini Satellite Series (SROSS-C)	20-May-92	ASLV
INSAT-2A	10-Jul-92	Ariane-44L H10
INSAT-2B	23-Jul-93	Ariane-44L H10+
IRS-1E	20-Sep-93	PSLV-D1
Stretched Rohini Satellite Series (SROSS-C2)	04-May-94	ASLV
IRS-P2	15-Oct-94	PSLV-D2
INSAT-2C	07-Dec-95	Ariane-44L H10-3
IRS-1C	29-Dec-95	Molniya
IRS-P3	21-Mar-96	PSLV-D3
INSAT-2D	04-Jun-97	Ariane-44L H10-3
IRS-1D	29-Sep-97	PSLV-C1
INSAT-2E	03-Apr-99	Ariane-42P H10-3
Oceansat-(IRS-P4)	26-May-99	PSLV-C2
INSAT-3B	22-Mar-2000	Ariane-5G
GSAT-1	18-Apr-01	GSLV-D1
Technology Experiment Satellite (TES)	22-Oct-01	PSLV-C3
INSAT-3C	24-Jan-02	Ariane-42L H10-3
Kalpana-1(METSAT)	12-Sep-02	PSLV-C4
INSAT-3A	10-Apr-03	Ariane-5G
GSAT-2	08-May-03	GSLV-D2
INSAT-3E	28-Sep-03	Ariane-5G
RESOURCESAT-1(IRS-P6)	17-Oct-03	PSLV-C5
EDUSAT	20-Oct-04	GSLV-F01
HAMSAT	05-May-05	PSLV-C6
CARTOSAT-1	05-May-05	PSLV-C6
INSAT-4A	22-Dec-05	Ariane-5GS
INSAT-4C	10-Jul-06	GSLV-F02
CARTOSAT-2	10-Jan-07	PSLV-C7
Space Capsule Recovery Experiment(SRE-1)	10-Jan-07	PSLV-C7
INSAT-4B	12-Mar-07	Ariane-5ECA
INSAT-4CR	02-Sep-07	GSLV-F04
CARTOSAT-2A	28-Apr-08	PSLV-C9

IMS-1 (Third World Satellite – TWsat)	28-Apr-08	PSLV-C9
Chandrayaan-1	22-Oct-08	PSLV-C11
RISAT-2	20-Apr-09	PSLV-C12
ANUSAT	20-Apr-09	PSLV-C12
Oceansat-2(IRS-P4)	23-Sep-09	PSLV-C14
GSAT-4	15-Apr-10	GSLV-D3
CARTOSAT-2B	12-Jul-10	PSLV-C15
StudSat	12-Jul-10	PSLV-C15
GSAT-5P /INSAT-4D	25-Dec-10	GSLV-F06
RESOURCESAT-2	20-Apr-11	PSLV-C16
Youthsat	20-Apr-11	PSLV-C16
GSAT-8 / INSAT-4G	21-May-11	Ariane-5VA-202
GSAT-12	15-Jul-11	PSLV-C17
Megha-Tropiques	12-Oct-11	PSLV-C18
Jugnu	12-Oct-11	PSLV-C18
RISAT-1	26-Apr-12	PSLV-C19
SRMSAT	26-Apr-12	PSLV-C18
GSAT-10	29-Sep-12	Ariane-5VA-209
SARAL	25-Feb-13	PSLV-C20
IRNSS-1A	01-Jul-13	PSLV-C22
INSAT-3D	26-Jul-13	Ariane-5
GSAT-7	30-Aug-13	Ariane-5
Mars Orbiter Mission (MOM)	05-Nov-13	PSLV-C25
GSAT-14	05-Jan-14	GSLV-D5
IRNSS-1B	04-Apr-14	PSLV-C24
IRNSS-1C	16-Oct-14	PSLV-C26
GSAT-16	07-Dec-14	Ariane-5
IRNSS-1D	28-Mar-15	PSLV-C27
GSAT-6	27-Aug-15	GSLV-D6
Astrosat	28-Sep-15	PSLV-C30
GSAT-15	11-Nov-15	Ariane 5 VA-227
IRNSS -1E	20-Jan-16	PSLV-C31
IRNSS -1F	10-Mar-16	PSLV-C32
IRNSS-1G	28-Apr-16	PSLV-C33
Cartosat-2C	22-Jun-16	PSLV-C34
CartoSat-2E	8 September 2016,	INSAT-3DR
Pratham	26 September 2016,	PSLV-C35
GSAT-18	6 October 2016,	Ariane-5 ECA
ResourceSat-2A	7 December 2016,	PSLV-C36
CartoSat-2D	15 February 2017,	PSLV-C37
South Asia Satellite (GSAT-9)	5 May 2017,	GSLV Mk.II[3
GSAT-19	05-Jun-17	GSLV Mk.III-D1
NIUSat[	23-June 2017,	PSLV-C38
GSAT-17	29 June 2017,	Ariane-5 ECA
IRNSS-1H	02-Sep-17	PSLV–C39
CartoSat-2F	10-January 2018,	PSLV-C40
GSAT-6A	29-Mar-18	GSLV-F08
IRNSS-11	12-Apr-18	GSLV-F08, PSLV-C41
GSAT-29	01-Nov-18	GSLV Mk III D2
HySIS	29-Nov-18	PSLV-C43
GSAT-7A	19-Dec-18	GSLV Mk.II-F11
Microsat-R	23-Jan-19	PSLV-C44
EMISAT	01-Apr-19	PSLV-C45
PS4 Stage attached with ExseedSat-2, AMSAT, ARIS and AIS payloads	01-Apr-19	PSLV-C45
Risat-2B	21-May-19	PSLV-C46
Chandrayaan-2	22-Jul-19	Chandrayaan-2

●●

CHEMISTRY

APPENDIX-A

A Table of Greek letters

Upper case	Lower case	In English
A	α	alpha
B	β	beta
Γ	γ	gamma
Δ	δ	delta
E	ε	epsilon
Z	ζ	zeta
H	η	eta
Θ	θ	theta
I	ι	iota
K	κ	kappa
Λ	λ	lambda
M	μ	mu
N	υ	nu
Ξ	ξ	csi
O	o	omicron
Π	π	pi
P	ρ	rho
Σ	σ	sigma
T	τ	tau
ϒ	υ	upsilon
Φ	ϕ	phi
Ψ	ψ	psi
X	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	$0.529 \times 10^{-10} m$
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)	$m_e c^2$	8.187×10^{-14} J
Electron mass energy (MeV)	$m_e c^2$	0.511 MeV
Electron rest mass	m_e	9.109×10^{-31} kg
Faraday constant	F	$9.649 \times 10^4\ C mol^{-1}$
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	$m_n c^2$	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	$6.626 \times 10^{-34}\ J\ s$
Proton mass energy	$m_p c^2$	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 so 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
Codiscovered 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 IA	2 IIA	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												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	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											13 Al Aluminium 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulphur 32.056	17 Cl Chlorine 35.453	10 Ne Neon 20.180
11 Na Sodium 22.99	12 Mg Magnesium 24.305																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 Darmstadium (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 237.064	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 Lawrencium (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.

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

Finkelstein Reaction

In the Finkelstein Reaction Alkyl iodides are prepared easily by the reaction of alkyl chlorides with Nal 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

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

Wurtz Reaction

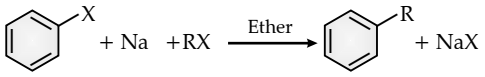
When Alkyl halides get reacted with sodium with dry ether, we get hydrocarbons that include the double number of carbon atoms present in the halide. This is known as the Wurtz Reaction.

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

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

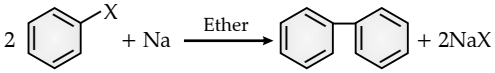
Wurtz-Fittig Reaction

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



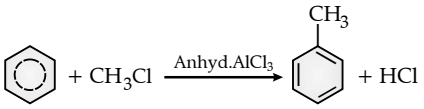
Fittig Reaction

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

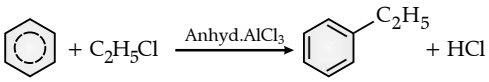


Friedel-Crafts Alkylation Reaction

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



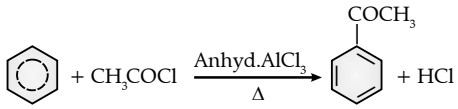
Toluene (13.75)



Ethylbenzene

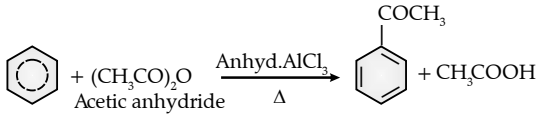
Friedel-Crafts Acylation Reaction

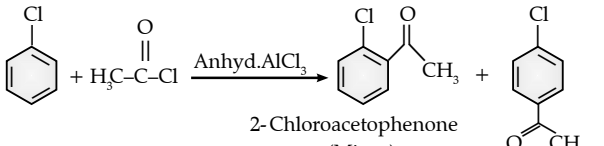
We get acyl benzene when an acyl halide is reacted with benzene in the presence of Lewis acids.



Acetophenone

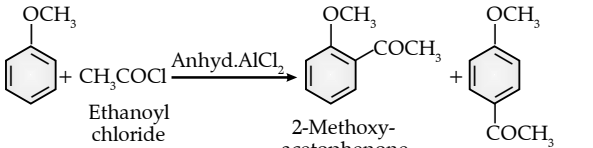
(13.77)





2-Chloroacetophenone (Minor)

4-Chloroaceto phenone(Major)



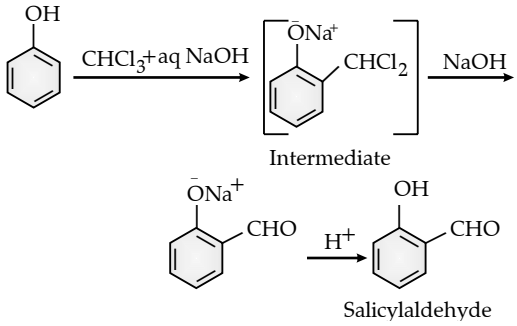
Ethanoyl chloride

2-Methoxy-acetophenone (Minor)

4-Methoxy-acetophenone (Major)

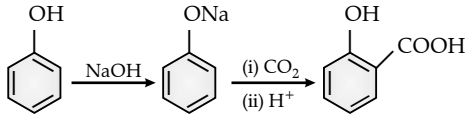
Reimer-Tiemann Reaction

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

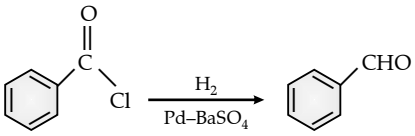
Phenol reacts with sodium hydroxide to give sodium phenoxide which then reacts with carbon dioxide in acidic medium to give 2-hydroxybenzoic acid.



2-Hydroxybenzoic acid
(Salicylic acid)

Rosenmund Reduction

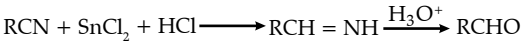
When Acyl chloride is hydrogenated to an aldehyde over a catalyst, known as Rosenmund catalyst which is either palladium or barium sulfate.



Benzoyl chloride Benzaldehyde

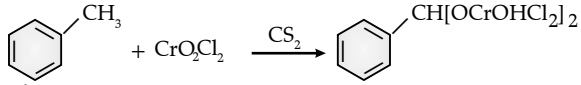
Stephen Reaction

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

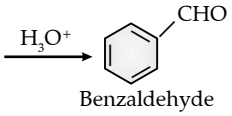


Etard Reaction

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



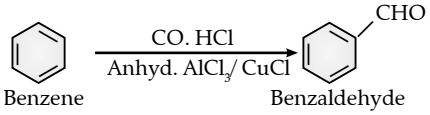
Toluene Chromium complex



Benzaldehyde

Gatterman – Koch Reaction

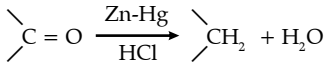
Benzene is prepared with carbon monoxide and hydrogen chloride in the presence of anhydrous aluminium chloride to give benzaldehyde.



Benzene Benzaldehyde

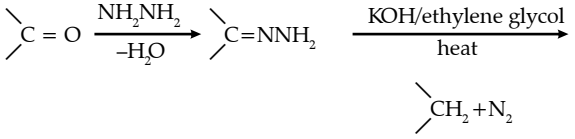
Clemmensen Reduction

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 which on heating with sodium hydroxide in a high boiling solvent (ethylene glycol) reduced 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.

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.

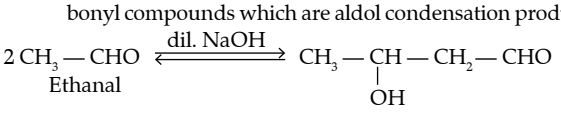
Reddish-brown ppt

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.

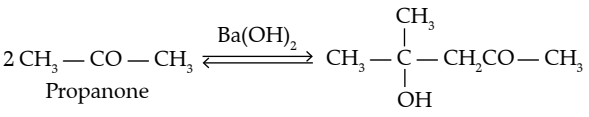


Ethanal

3 –Hydroxybutanal
(Aldol)

But – 2 –enal

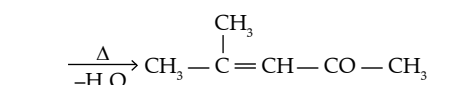
(Aldol condensation product)



Propanone

(Ketol)

4-Hydroxy-4-methylpentan-2-one

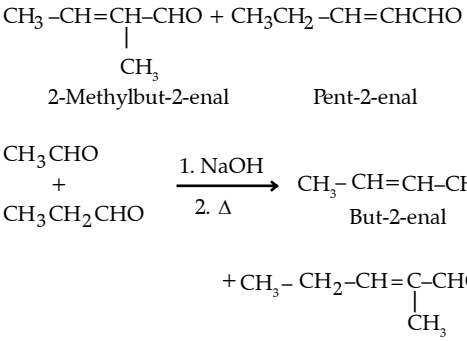


4 -Methylpent -3 -en- 2 -one

(Aldol condensation product)

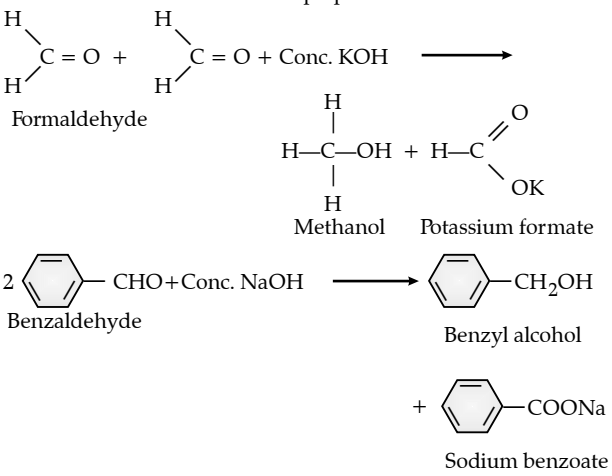
(ii) Cross aldol condensation

Aldol condensation is carried out between two different aldehydes and ketones. It gives a mixture of four products if both of them includes α-hydrogen atoms.



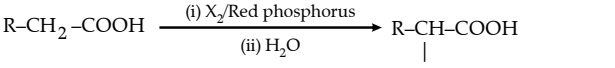
Cannizzaro Reaction

Aldehydes without α-hydrogen atom undergo self-oxidation and reduction reaction when prepared with concentrated alkali.



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.

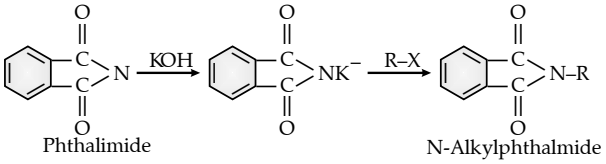


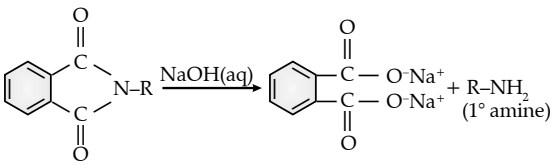
Hell-Volhard-Zelinsky (HVZ) Reaction

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.

Gabriel Phthalimide Synthesis

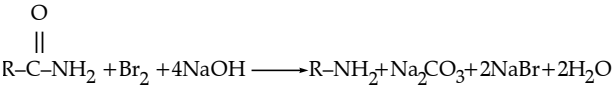
Phthalimide prepared with ethanolic potassium hydroxide produces potassium salt of phthalimide when heated with alkyl halide followed by alkaline hydrolysis forms the corresponding primary amine.





Hoffmann Bromamide Degradation Reaction

An amide with bromine in an aqueous solution of sodium hydroxide produces primary amines. 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.



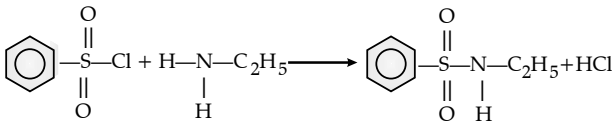
Carbylamine Reaction

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

Hinsberg's Test

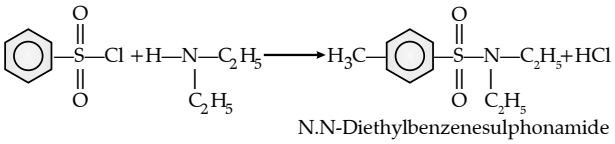
Benzenesulfonyl chloride ($C_6H_5SO_2Cl$) reacts with primary and secondary amines to produce sulphonamides.

(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.

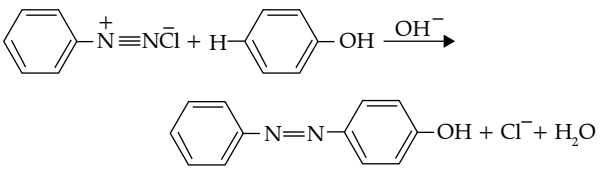


N.N-Diethylbenzenesulphonamide

(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.



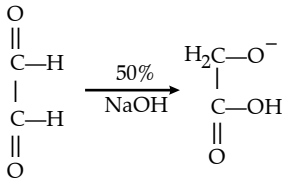
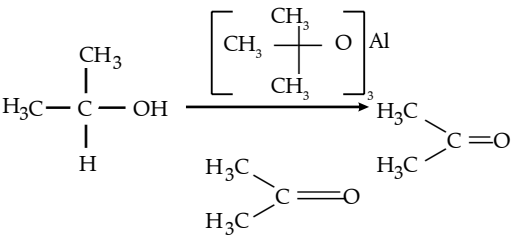
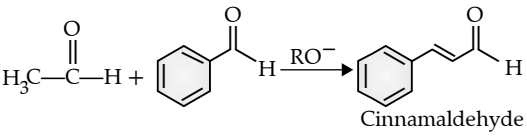
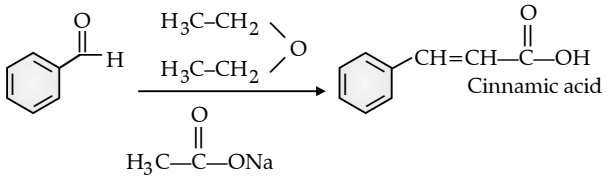
p – Hydroxyazobenzene (orange dye)

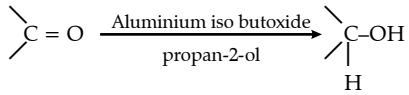
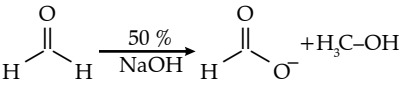
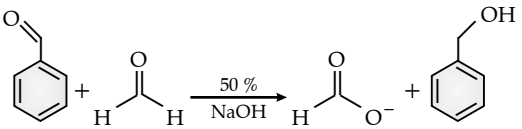
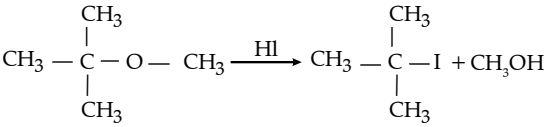
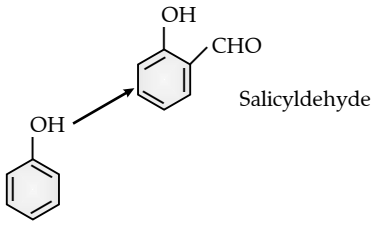
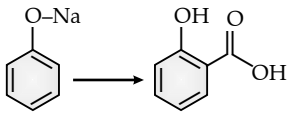
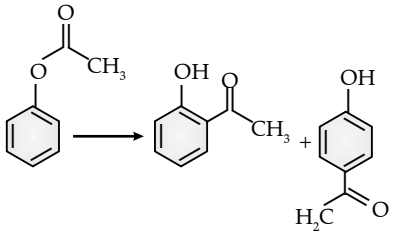
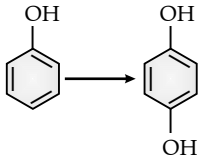
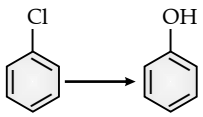
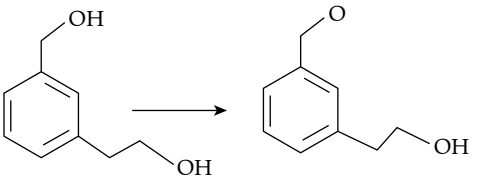
APPENDIX-F

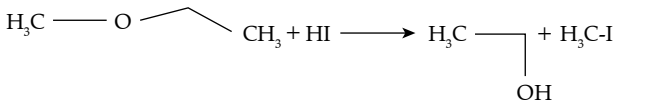
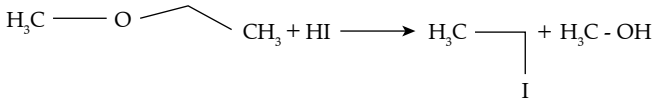
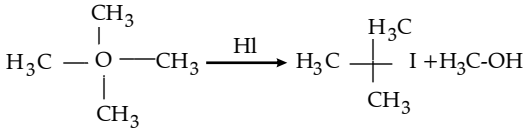
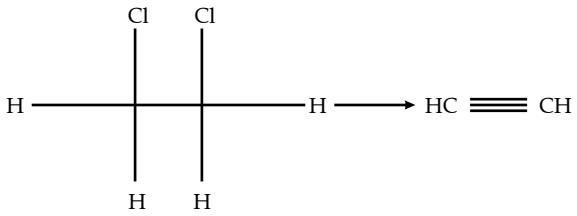
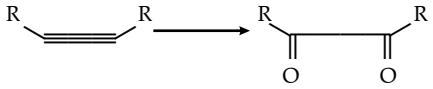
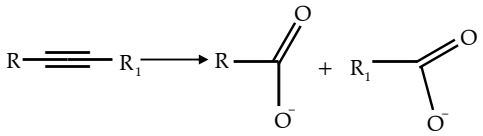
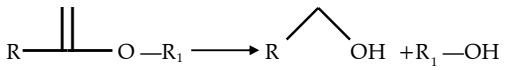
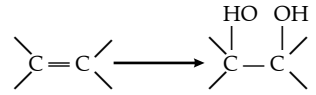
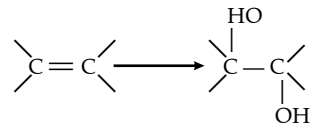
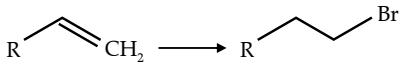
Important Reagents

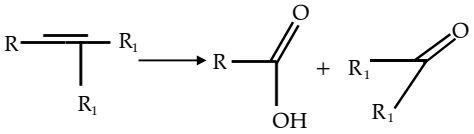
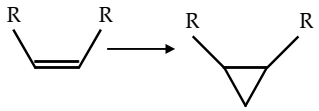
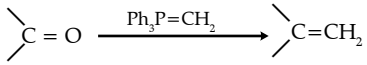
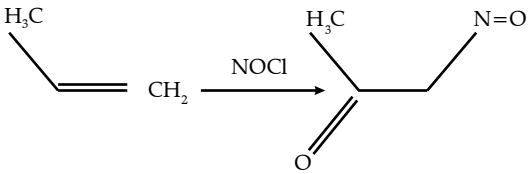
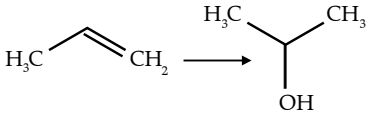
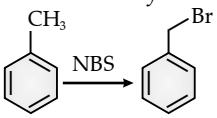
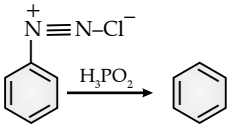
List of Organic Reagents

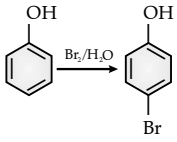
Aqueous NaOH	Reflux	Nucleophilic substitution, converts haloalkanes to alcohols.
Mg in dry ether	Reflex	Used to make Grignard reagents with haloalkanes.
PCI_5	Room temperature	Chlorinating agent, reacts with OH group in alcohols and carboxylic acids.
HNO_3 and H_2SO_4	55°C	Adds NO_2 group into benzene ring.
CI_2 and $AICl_3$	Warm gently	Adds Cl group into benzene ring.
CH_3CH_2Cl and $AICl_3$	Warm gently	Adds CH_3CH_2 group into benzene ring.
HCI and $NaNO_2$	Below 5°C	Forms diazonium salts with phenylamine.

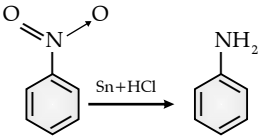
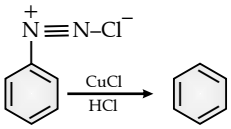
Name of Reagent	Conditions	Example of its Use
$K_2Cr_2O_7$ with conc. H_2SO_4	Warm gently	**Oxidising agent,** used commonly for oxidising secondary alcohols to ketones.
Excess conc. H_2SO_4	Heat to 170°C	Dehydrating agent, used to dehydrate alcohols to alkenes.
$Cl_2(g)$	Ultra violet light	Free radical 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 atmosphereic 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 H contains no water		
(i) $CHCH_3$ - Alc KOH **(ii)** H_3O^+ (Riemann Tiemann reaction)		
(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		

HI		
For 1 degree carbon		
For 3 degree carbon		
Conc HI contains very less water		
(i) Alc KOH **(ii)** $NaNH_2$		
X_2/CCI_4		Adds both X on compound having double or triple bond
Cold Dil $KMnO_4$		
Hot $KMnO_4$		
$CF_3SO_3^-$		Super Leaving Group
$LiAH_4$–ether		Reduces ester to alcohol
$NaBH_4$– ROH (protic solvent)		Reduces to alcohol but cannot act on ester
Cr_2O_2-Cu_2O	Heat, High pressure	Causes cleavage and reduction of ester 
OsO_4 + H_2O-$NaHSO_3$ 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-I_2, ZnCu		Adds methyl group in cyclic manner 
Alcoholic KOH		Removes HX from compound and adds double bond
Zn dust		Removes all HX
H_2 $Pd/BaSO_4$ or S-Quinoline (Lindlar's catalyst) or BH_3-THF		Reduces alkyne to alkene
$Ph_3P = CH_2$		Replaces O of Carbonyl with methyl 
NOX		
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_2 CuL (Lithium dialkylcuprate)		Removes halogen from RX and adds R
Mg-ether		Adds Mg between R & X
Red P + HI		Reduces all to corresponding alkanes

Name	Condition	Example
Br_2 + CS_2		Causes Br to go on ring
Br_2 + H_2O	Compound should be more activated than benzene	

Sn + HCI		Reduces nitro group 
CuCI + HCI		Removes Diazo group 
NH_4H or NaS or Na_2S		Special regents which reduce only NO_2 group
$CrO_2CI_2 + H_3O^+$		Converts toluene to benzaldehyde

APPENDIX-G

Important Minerals, Compositions & their Chemical Formula

Mineral	Composition		Remarks
Apatite	Calcium phosphate	$Ca_{10}(PO_4)_4X_2$ (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
Barite	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		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		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	$Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$	
Vermiculite	Hydrated silicates		Expands and swells on heating
Zeolite	Hydrated alkali alumino silicates	$Na_2(AlO_2)_x(SiO_2)_y \cdot nH_2O$	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

●●

BIOLOGY

APPENDIX-A

List of Medicinal Plants and their uses

	Name of plant	Source of plant (Scientific)	Uses
1	Aconite	*Aconitum ferox* –plant root	Leprosy, cholera, catarrh
2	Aloe vera	*Aloe barbadensis*- succulent leaves.	Used as hydrating agent for smooth skin
3	Arjuna	*Terminalia arjuna*- dry Bark	Correct Blood pressure, heart beat, congestive heart failure, OPD for easy breath
4	Ashwagandha	*Withania somnifera*-roots & stem bases.	Neurotonic, Rheumatism, gout, hypertension, cancer
5	Belladonna	*Atropa accuminata*-leaves & flowers	Anti-spasmodic, anticholinergic, antidote for chloral hydrate & opium poisoning
6	Black pepper	*Piper nigrum*-unripe fruits	As stomachic (enhances hunger), carminative (enhances eructation)
7	Caraway	*Carum carvi*-dry ripe fruits	Expels gas by eructation
8	Cardamom	*Elettaria cardamomum*-dry-ripe fruits	Expels gas by eructation (carminative)
11	Castor oil	Ricinus communis-seed's fixed oil	Catharatic (in constipation), hair growth promoter
12	Cinnamon	*Cinnamomum zeylanicum*-bark	Carminative (enhances eructation)
13	Citronella oil	*Cymbopogan nardus*-volatile oil from leaves	Mosquito repellent
14	Clove	*Eugenia caryophyllus*-dry flower bud	Dental analgesic, anti-septic, carminative
15	Coriander	*Coriandrum sativum*-dry fruits	Carminative
16	Digitalis	*Digitalis purpurea*-dried leaves	Treatment of heart failure and cardiac arrhythmia
17	Egyptian Henbane	*Hyoscyamus niger*-leaves & flower tip	Relieve spasm of urinary tract & gripping effect of purgatives
18	Eucalyptus oil	*Eucalyptus citriodara*-leaf oil	Has essential oils with uses like Expectorant (Removes phlegm), counter-irritant.
19	Fennel	*Foeniculum vulgare*-dry ripe fruit	Expels gas by eructation
20	Garlic	*Allium sativum*-bulbs	To enhance libido, expel phlegm, for eructation
21	Ginger	*Zingiber officinale*, dried rhizome	Anti-emetic, anti-inflammatory.
22	Glycyrrhiza (Liquorice)	*Glycyrrhiza glabra*; dried roots and stolons	Expectorant and anti-inflammatory
23	Senna	Cassia angustifolia-dried leaflets	For purgation of bowels.
24	Isapgol	*Plantago ovata*-crushed seeds	To relieve constipation (laxative)
25	Jira	*Cuminum cyminum*-dry ripe fruit	Stimulant, carminative
26	Lemon grass Oil	*Cymbopogan flexosus*-volatile oil of leaves & other plant parts	Vitamin-A precursor
27	Opium poppy	*Papaver somniferum*-dry latex from unripe seed capsule	To relieve severe pains, cough, & also as hypnotic
28	Peruvian bark	*Cinchona ledgeriana*-dried bark	Anti-malarial drug
29	Rauwolfia	*Rauwolfia serpentina*-Dry roots	As an anti-hypertensive agent
30	Sandal wood oil	*Santalum album*-volatile oil	Decreases frequent urination tendency.
31	Tulsi	*Ocimum sanctum*-fresh & dry leaves	Uses of tulsi are Anti-bacterial, insecticide and immune modulator
32	Turmeric	*Curcuma longa*-dry rhizomes	Anti-septic, anti-oxidant, condiment
33	Vinca	*Catharanthus roseus*-entre plant	medicinal plants for cancer treatment, anticancer herbs

APPENDIX-B

Spices Yielding Plants

	English Common Name	Botanical Name	Family Name	Part used as spice
1.	Cardamom (Small)	*Elettaria cardamomum* Maton	Zingiberaceae	Fruit,Seed
	Cardamom (Large)	*Amomum subulatum* Roxb.	Zingiberaceae	Fruit,Seed
2.	Pepper	*Piper nigrum* L.	Piperaceae	Fruit
3.	Chilli, Bird's Eye	*Capsicum frutescens* L.	Solanaceae	Fruit
	Capsicum	*Capsicum annuum* L.	Solanaceae	Fruit
4.	Ginger	*Zingiber officinale* Rosc.	Zingiberaceae	Rhizome
5.	Turmeric	*Curcuma longa* L.	Zingiberaceae	Rhizome
6.	Coriander	*Coriandrum sativum* L.	Apiaceae	Leaf & Fruit
7.	Cumin	*Cuminum cyminum* L.	Apiaceae	Fruit
8.	Fennel	*Foeniculum vulgare* Mill.	Apiaceae	Fruit
9.	Fenugreek	*Trigonella foenum-graecum* L.	Fabaceae	Seed
10.	Celery	*Apium graveolens* L.	Apiaceae	Leaf, Fruit & Stem
11.	Aniseed	*Pimpinella anisum* L.	Apiaceae	Fruit
12.	Ajowan	Trachyspermum ammi L.	Apiaceae	Fruit
13.	Caraway	*Carum carvi* L.	Apiaceae	Fruit
14.	Cinnamon	*Cinnamomum zeylanicum*	Lauraceae	Bark
15.	*Garlic*	*Allium sativum* L.	Alliaceae	Bulb
16.	Curry leaf	*Murraya koenigii*(L) Sprengel	Rutaceae	Leaf
17.	Mint	*Mentha piperita* L.	Lamiaceae	Leaf
18.	Saffron	*Crocus sativus* L.	Iridaceae	Stigma
19.	Tejpat	*Cinnamomum tamala* (Buch Ham)	Lauraceae	Bark & Leaf
20.	Pepper Long	*Piper longum* L.	Piperaceae	Fruit
21.	Star Anise	*Illicium verum* Hook.	Illiciaceae	Fruit
22.	Clove	*Syzygium aromaticum*(L)	Myrtaceae	Unopened Flower bud
23.	Asafoetida	*Ferula asafoetida* L.	Apiaceae	resin from rhizome,root
24.	Nutmeg	*Myristica fragrans* Houtt.	Myristicaceae	Seed
25.	Mace	*Myristica fragrans* Houtt.	Myristicaceae	Aril

APPENDIX-C

Difference between Scanning Electron Microscopy and Transmission Electron Microscopy

Properties	Scanning Electron Microscopy (SEM)	Transmission Electron Microscopy (TEM)
Light Source	SEM is based on scattered electrons, i.e., electrons emitted from the surface of a specimen.	Electrons are used as "light source". TEM uses transmitted electrons (electrons which are passing through the sample) to create an image.
Purpose	SEM provides detailed images of the surfaces of cells so SEM shows only the morphology of samples.	TEM is used to view thin specimens (tissue sections, molecules, etc). TEM can show many characteristics of the sample, such as internal composition, morphology, crystallization etc.
Sample Preparation	Sample is coated with a thin layer of a heavy metal such as gold or palladium.	The sample in TEM has to be cut thinner (70-90 nm) because electrons cannot penetrate very far into materials.
Resolution	SEM can resolve objects as close as 20 nm.	TEM has much higher resolution than SEM and can resolve objects as close as 1 nm.
Magnification	The magnifying power of SEM is up to 50,000X.	The magnifying power of TEM is up to 2 million times.
Processing of sample (s)	SEM allows for large amount of sample to be analyzed at a time	With TEM only small amount of sample can be analysed at a time.
3D picture	SEM provides a 3-dimensional image	TEM provides a 2-dimensional picture.
Applications	To study the topography and atomic composition of specimens, process control and also, for example, the surface distribution of immuno-labels	To image the interior of cells (in thin sections), the structure of protein molecule, the organization of molecules in viruses and cytoskeletal filaments.

APPENDIX-D

The Nobel Prize in Physiology or Medicine awarded between 1901 and 2019

(2019) William G. Kaelin Jr, Sir Peter J. Ratcliffe and Gregg L. Semenza "for their discoveries of how cells sense and adapt to oxygen availability"

(2018) James P. Allison and Tasuku Honjo "for their discovery of cancer therapy by inhibition of negative immune regulation"

By stimulating the inherent ability of our immune system to attack tumor cells they established an entirely new principle for cancer therapy.

(2017) Jeffrey C. Hall, Michael Rosbash and Michael W. Young "for their discoveries of molecular mechanisms controlling the circadian rhythm"

(2016) Yoshinori Ohsumi "for his discoveries of mechanisms for autophagy"

Ohsumi's discoveries led to the understanding of how the cell recycles its content. His discoveries opened the path to understanding the fundamental importance of autophagy in many physiological processes, such as in the adaptation to starvation or response to infection. Mutations in autophagy genes can cause disease, and the autophagic process is involved in several conditions including cancer and neurological disease.

(2015) William C. Campbell and Satoshi Ōmura "for their discoveries concerning a novel therapy against infections caused by roundworm parasites"

Tu Youyou "for her discoveries concerning a novel therapy against Malaria"

(2011) Bruce A. Beutler and Jules A. Hoffmann "for their discoveries concerning the activation of innate immunity"

Ralph M. Steinman "for his discovery of the dendritic cell and its role in adaptive immunity"

(2010) Robert G. Edwards "for the development of *in vitro* fertilization"

(2009) Elizabeth H. Blackburn, Carol W. Greider and Jack W. Szostak "for the discovery of how chromosomes are protected by telomeres and the enzyme telomerase"

The long, thread-like DNA molecules that carry our genes are packed into chromosomes, the telomeres being the caps on their ends. Elizabeth Blackburn and Jack Szostak discovered that a unique DNA sequence in the telomeres protects the chromosomes from degradation. Carol Greider and Elizabeth Blackburn identified telomerase, the enzyme that makes telomere DNA. These discoveries explained how the ends of the chromosomes are protected by the telomeres and that they are built by telomerase.

(2008) Harald zur Hausen"for his discovery of human papilloma viruses causing cervical cancer", the second most common cancer among women.

Françoise Barré-Sinoussi and Luc Montagnier "for their discovery of human immunodeficiency virus"

(2006) Andrew Z. Fire and Craig C. Mello "for their discovery of RNA interference – gene silencing by double-stranded RNA"

(2005) Barry J. Marshall and J. Robin Warren "for their discovery of the bacterium *Helicobacter pylori* and its role in gastritis and peptic ulcer disease"

(2001) Leland H. Hartwell, Tim Hunt and Sir Paul M. Nurse "for their discoveries of key regulators of the cell cycle"

(1997) Stanley B. Prusiner "for his discovery of Prions – a new biological principle of infection"

(1993) Richard J. Roberts and Phillip A. Sharp "for their discoveries of split genes"

(1986) Stanley Cohen and Rita Levi-Montalcini "for their discoveries of growth factors"

(1983) Barbara McClintock "for her discovery of mobile genetic elements"

(1978) Werner Arber, Daniel Nathans and Hamilton O. Smith "for the discovery of restriction enzymes and their application to problems of molecular genetics"

(1975) David Baltimore, Renato Dulbecco and Howard Martin Temin"for their discoveries concerning the interaction between tumour viruses and the genetic material of the cell"

(1972) Gerald M. Edelman and Rodney R. Porter "for their discoveries concerning the chemical structure of antibodies"

(1971) Earl W. Sutherland, Jr. "for his discoveries concerning the mechanisms of the action of hormones"

(1969) Max Delbrück, Alfred D. Hershey and Salvador E. Luria "for their discoveries concerning the replication mechanism and the genetic structure of viruses"

(1968) Robert W. Holley, Har Gobind Khorana and Marshall W. Nirenberg "for their interpretation of the genetic code and its function in protein synthesis"

(1966) Peyton Rous "for his discovery of tumour-inducing viruses"

Charles Brenton Huggins "for his discoveries concerning hormonal treatment of prostatic cancer"

(1965) François Jacob, André Lwoff and Jacques Monod "for their discoveries concerning genetic control of enzyme and virus synthesis"

(1962) Francis Harry Compton Crick, James Dewey Watson and Maurice Hugh Frederick Wilkins "for their discoveries concerning the molecular structure of nucleic acids and its significance for information transfer in living material"

(1959) Severo Ochoa and Arthur Kornberg "for their discovery of the mechanisms in the biological synthesis of ribonucleic acid and deoxyribonucleic acid"

(1958) George Wells Beadle and Edward Lawrie Tatum "for their discovery that genes act by regulating definite chemical events"

Joshua Lederberg "for his discoveries concerning genetic recombination and the organization of the genetic material of bacteria"

(1953) Hans Adolf Krebs "for his discovery of the citric acid cycle"

Fritz Albert Lipmann "for his discovery of co-enzyme A and its importance for intermediary metabolism"

(1952) Selman Abraham Waksman "for his discovery of streptomycin, the first antibiotic effective against tuberculosis"

(1946) Hermann Joseph Muller "for the discovery of the production of mutations by means of X-ray irradiation"

(1945) Sir Alexander Fleming, Ernst Boris Chain and Sir Howard Walter Florey "for the discovery of penicillin and its curative effect in various infectious diseases"

(1936) Sir Henry Hallett Dale and Otto Loewi "for their discoveries relating to chemical transmission of nerve impulses"

(1933) Thomas Hunt Morgan "for his discoveries concerning the role played by the chromosome in heredity"

(1932) Sir Charles Scott Sherrington and Edgar Douglas Adrian "for their discoveries regarding the functions of neurons"

(1930) Karl Landsteiner "for his discovery of human blood groups"

(1924) Willem Einthoven "for his discovery of the mechanism of the electrocardiogram"

(1923) Frederick Grant Banting and John James Rickard Macleod "for the discovery of insulin"

(1922) Archibald Vivian Hill "for his discovery relating to the production of heat in the muscle"

Otto Fritz Meyerhof "for his discovery of the fixed relationship between the consumption of oxygen and the metabolism of lactic acid in the muscle"

(1905) Robert Koch "for his investigations and discoveries in relation to tuberculosis"

(1904) Ivan Petrovich Pavlov "in recognition of his work on the physiology of digestion, through which knowledge on vital aspects of the subject has been transformed and enlarged"

(1902) Ronald Ross "for his work on malaria, by which he has shown how it enters the organism and thereby has laid the foundation for successful research on this disease and methods of combating it"

There are basically three kinds of microscopy: light microscopy, transmission electron microscopy (TEM), and scanning electron microscopy (SEM).

Light microscopes use normal light; it can magnify transparent things 1,000 times.

Transmission electron microscopes give a more detailed view of the internal organization of cells and organelles. They use an electronic beam, which kills objects as it passes through.

In addition, for examination under a TEM, objects are often stained with heavy metals like osmium, and for SEM with gold which is highly reflective for electronic rays.

A TEM can magnify things 10,000,000 times. Scanning electron microscopes show an image of the surface of cells and organisms using reflected electronic beam. It can magnify things 1,000,000 times.