ATOMIC CHEMISTRY

1. $r_n = \frac{n^2h^2}{4\pi^2mZe^2} = 0.529\left(\frac{n^2}{Z}\right)$Å, $r_n = n^2 \times r_1$
2. $E_T = -KE = \frac{PE}{2} = -13.6\frac{Z^2}{n^2}$ eV,
3. $\Delta E = \frac{hc}{\lambda} = \frac{2\pi^2me^2}{h^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$
4. $\bar{\nu} = \frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$, $[R = 1.0968 \times 10^7 m^{-1}]$
5. Total no. of spectrum lines = $\frac{n(n-1)}{2}$
6. Heisenberg Uncertainty Principle $(\Delta x)(\Delta p) \geq h/4\pi$
7. Mosley's law : $\sqrt{\nu} = a(Z - b)$,
8. Energy of electron in n^{th} shell $E_n = -\frac{13.6}{n^2}$ eV / atom
9. Nodes (n – 1) = total nodes, l = angular nodes, (n – l – 1) = Radial nodes
10. Orbital angular momentum : $\sqrt{l(l+1)}\frac{h}{2\pi}$
11. In a shell, maximum no. of sub-shells = n
    Maximum no. of orbitals = n^2
    Maximum no. of electrons = $2n^2$
12. In a sub-shell, maximum no. of orbitals = $(2l + 1)$

CHEMICAL BONDING

1. % ionic character = $\frac{\text{Actual dipole moment}}{\text{Calculated dipole momen}} \times 100$
2. Fajan's Factors: Following factors are helpful in inducing covalent character in Ionic compounds
   a. Small cation
   b. Big anion
   c. High charge on cation
   d. High charge on anion
   e. Cation having pseudo inert gas configuration ($ns^2p^6d^{10}$) e.g. Cu^+, Ag^+, Zn^{+2}, Cd^{+2}
3. $-\Delta H_f = H_s + \frac{1}{2}$ $H_d + IE + \Delta H_{EG} - E_t$.
4. M.O. theory:
   a. Bond order = $\frac{1}{2}(N_b - N_a)$

b. Higher the bond order, higher is the bond dissociation energy, greater is the stability, shorter is the bond length.

c.

Species	Bond order	Magnetic properties
H_2	1	Diamagnetic
H_2^+	0.5	Paramagnetic
Li_2	1	Diamagnetic

5. $Q = \frac{1}{2}[V + SA - (\pm q)]$

6. Formal charge = $V - \left(L + \frac{1}{2}S\right)$

7. VSEPR theory
   a. LP – LP repulsion > (LP – BP) > (BP – BP)
   b. For $NH_3 \rightarrow$ Bond Angle 106° 45' in case of water it decreases to → 104°27' because H_2O molecule contains $2L_P$ and 2BP whereas NH_3 has 1LP and 3BP.
8. Bond angle: Decrease in bond angle down the group is due to LP – BP repulsion
   a. $NH_3 > PH_3 > AsH_3$
   b. $H_2O > H_2S > H_2Se$

CHEMICAL EQUILIBRIUM

1. Equilibrium Constant = $\frac{K_f}{K_b}$

$$= \frac{\text{Active mass of product}}{\text{Active mass of reactants}}$$

Where, K_f = rate constant of forward reaction

Where, K_b = rate constant of backward reaction

2. $K_P = K_c (RT)^{?\Delta ng}$ where $\Delta n_g = n_p - n_r$
3. Free Energy change (ΔG)
   a. If $\Delta G = 0$ then reversible reaction would be in equilibrium.
   b. If ΔG = (+) ve then equilibrium will be displace in backward direction
   c. If ΔG = (–)ve then equilibrium will displace in forward direction.
4. a. K_c unit → $(\text{moles / lit})^{\Delta n}$,
   b. K_p unit → $(\text{atm})^{\Delta n}$.
   c. Total moles at equilibrium = [total initial moles + Δn]
   d. Time required to establish equilibrium $\propto 1/K_c$
   e. If in any heterogeneous equilibrium solid substance is also present then its active mass and partial pressure is assumed to be 1.
5. Le chatelier's principle
   i. Increase of reactant conc. (Shift forward)
   ii. Decrease of reactant conc. (Shift backward)
   iii. Increase of pressure (from more mole to less moles)
   iv. Decrease of pressure (from less moles to more moles)
   v. For exothermic reaction decrease in temp. (Shift forward)

vi. For endothermic increase in temp. (Shift forward)

ACID BASE

1. Bronsted acids (proton donors) → HCl, H_2O, NH_4^+ etc.
   Bronsted bases (proton acceptors) → OH^-, Cl^-, H_2O, NH_3 etc.
2. Amphiprotic species can both donate and accept proton → H_2O, NH_3, HCO_3^- HSO_4^- etc.
3. a. Lewis acid (e^- pair acceptor) → CO_2, BF_3, $AlCl_3$, $ZnCl_2$, $FeCl_3$, PCl_3, PCl_5, $SiCl_4$ SF_6, normal cation
   b. Lewis Base (e^- pair donor) NH_3, ROH, ROR, H_2O, RNH_2, R_2NH, R_3N, normal anion
4. Dissociation of Weak Acid and Weak Base →
   a. Weak Acid → $K_a = C\alpha^2/(1-\alpha)$ or $K_a = C\alpha^2$
   b. Weak Acid → $K_b = C\alpha^2/(1-\alpha)$ or $K_b = C\alpha^2$
5. Buffer solution:
   a. Acidic → $pH = pK_a + \log\{Salt / Acid\}$ for Maximum buffer action $pH = pK_a$
   Range of Buffer $pH = pK_a \pm 1$
   b. Alkaline → $pOH = pK_b + \log\{Salt/Base\}$ for max.
   c. Buffer Capacity = $\frac{\text{Moles/lit of Acid or Base Mixed}}{\text{change in pH}}$

   $B = \frac{d[BOH]}{dpH} = -\frac{d[HB]}{dpH}$
6. Necessary condition for showing neutral colour of Indicator pH = pK/n or [HIn] = [In] or [InOH] = $[In^+]$

IONIC EQULIBRIUM

1. Relation between ionization constant (K_i) and degree of ionization (α):
   $K_i = \frac{\alpha^2}{(1-\alpha)V} = \frac{\alpha^2 C}{(1-\alpha)}$ (Ostwald's dilution law)
   It is applicable to weak electrolytes for which $\alpha << 1$ then
   $\alpha = \sqrt{K_1 V} = \sqrt{\frac{K_i}{C}}$ or $V \uparrow C \downarrow \alpha \uparrow$
2. Common ion effect: By addition of X mole/L of a common ion, to a weak acid (or weak base) α becomes equal to
   $\frac{K_a}{X}\left(\text{or } \frac{K_b}{X}\right)$ [where α = degree of dissociation]
3. $pH = -\log[H^+]$
   Where, $[H^+]$ = molar concentration of H^+ – ion or normality of strong acid solution.
4. At 25° $pH + pO^H = 14$
5. For sparingly soluble electrolyte of formula A_xB_y.
   Solubility product (K_{sp}) = $[A^{y+}]^x \cdot [B^{+x-}]^y$

6. The relation between K_{sp} and molar solubility (s) for A_xB_y is.
   $K_{sp} = x^x \cdot y^x \cdot s^{x+y}$
7. a. If solubility product = ionic product then the solution saturates.
   b. If solubility product > ionic product then the solution is unsaturated and more of the substance can be dissolved in it.
   c. If ionic product > solubility product the solution is super saturated (principle of precipitation) and precipitation occurs.
8. Salt of weak acid and strong base:
   $pH = 0.5 (pK_w + pK_a + \log c)$
   Salt of weak base and strong acid:
   $pH = 0.5 (pK_w - pK_b - \log c)$
   Salt of weak acid and weak base:
   $pH = 0.5 (pK_w + pK_a - pK_b)$

CHEMICAL KINETICS

1. Unit of Rate constant:
   $K = mol^{1-n}\ lit^{n-1}\ sec^{-1}$
2. First Order Reaction:
   $K = \frac{2.303}{t} \log_{10}\frac{a}{(a-x)}$ & $t_{1/2} = \frac{0.693}{K}$
   $[A]_t = [A]_0\ e^{-kt}$
3. Second Order Reaction:
   $K_2 = \frac{1}{2}\left(\frac{x}{a(a-x)}\right)$
   When concentration of A and B are taking different
   $K_2 = \frac{2.303}{t(a-b)} \log \frac{b(a-x)}{a(b-x)}$
4. Zero Order Reaction:
   $K = \frac{a_0 - a_1}{t}$ $X = Kt$ and $t_{1/2} = \frac{a_0}{2K}$
   The rate of reaction is independent of the concentration of the reacting substance.
5. Arrhenius equation:
   $K = Ae^{-Ea/RT}$ & slope $= \frac{-E_a}{2.303R}$
   When $T \to \infty$, then $K = A$ ($\because\ e^{-Ea/RT} = 1$)
6. $\text{Log}\left(\frac{k_2}{k_1}\right) = \frac{E_a}{2.303R}\left(\frac{T_2 - T_P}{T_1T_2}\right)$

OXIDATION REDUCTION

1. Oxidant itself is reduced (gives O_2)
   Oxidant $\longrightarrow$ e^- (s) Acceptor

Reductant itself is oxidized (gives H_2)

Or reductant $\longrightarrow$ e^- (s) donor

2. i. Strength of acid $\propto$ O.N
   ii. Strength of base $\propto$ 1/O.N
3. a. Electro Chemical Series: Li, K, Ba, Sr, Ca, Na, Mg, Al, Mn, Zn, Cr, Fe, Cd, Co, Ni, Sn, Pb, H_2, Cu, I_2, Hg, Ag, Br_2, Cl_2, Pt, Au, F_2.
   b. As we move from top to bottom in this series
      1. Standard Reduction Potential ↑
      2. Standard Oxidation Potential ↓
      3. Reducing Capacity ↓
      4. Ip ↑
      5. Reactivity ↓
4. a. Formal charge = Group No. – [No. of bonds + No. of non-bonded e^- s]
   b. At Anode → Oxidation, Cathode → Reduction

VOLUMETRIC ANALYSIS

1. Equivalent weight of element = $\frac{\text{Atomic wt of the element}}{\text{valency}}$
2. Eq. wt. of compound = $\frac{\text{molecular weight}}{n}$

   Where n = basicity for acids.
   = acidity for bases.
   = total number of +ve charges on cation for salts.
   = total change in O.N. per molecule for oxidant and reductant.
3. Equivalent wt. of an ion = $\frac{\text{formula wt (or At. Wt.) of ion}}{\text{its valency}}$
4. Normality (N) = $\frac{\text{number of equivalents of solute}}{\text{volume of the solution in litres}}$
5. Molarity (M) = $\frac{\text{number of moles of solute}}{\text{volume of the solution in litres}}$
6. When a solution is diluted.

   $N_1 \times V_1$ = $N_2 \times V_2$

   (before dilution) (after dilution)
7. Common acid – base indicators

Indicator	Colour in acidic medium	Colour in alkaline	pH range
Methyl orange	Pink	Yellow	3.0 – 4.4

Methyl red	Red	Yellow	4.2 – 6.2
Litmus	Red	Blue	5.5 – 7.5
Phenolphthalein	Colourless	Pink	8.3 – 9.8

8. Choice of indicator

Types of Titration	Indicator
a. Strong acid & strong base	any indicator
b. Strong acid & weak base	Methyl orange
c. Weak acid & strong base	Phenolphthalein
d. Weak acid & weak base	no suitable indicator

MOLE CONCEPT AND CHEMICAL AIRTHEMATICS

1. Mole concept
   GAM = 1 gm atom = 6.02×10^{23} atom.
   GMM = 1 gm molecule = 6.02×10^{23} molecules
   N_A 6.02×10^{23}
2. Moles (gases) at NTP = $\frac{\text{volume (L)}}{22.4}$
3. Molecular mass = 2 × vapour density
4. Determination of atomic weight.
   a. By Dulong and petit law
      $$\text{Atomic weight (approx.)} = \frac{6.4}{\text{specific heat}}$$
   b. By volatile metal chloride method Valency of metal
      $$= \frac{\text{Molecular weight of metal chloride}}{\text{Eq. wt. of metal} + 35.5}$$
5. Determination of molecular weight
   a. By Diffusion method (Graham's law of diffusion)
      $$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$
   b. By victor Meyer's method
      $$\text{Mol. wt (M)} = \frac{mRT}{pV}$$
6. Determination of equivalent weight
   a. By hydrogen displacement method
      $$\text{Eq. wt. of metal} = \frac{\text{wt. of metal}}{\text{wt. of } H_2 \text{ displaced}} \times 1.008$$
   b. By oxide formation method
      $$\text{Eq. wt. of metal} = \frac{\text{wt. of metal}}{\text{wt. of oxygen}} \times 8$$
   c. By chloride formation method

Eq. wt. of metal = $\frac{\text{wt. of metal}}{\text{wt. of chloride}} \times 35.5$

d. By electrolytic method (Faraday's 2nd law)

$$\frac{\text{Eq. wt. of element of A}}{\text{Eq. wt. of element B}} = \frac{\text{wt. of A}}{\text{wt. of B}}$$

e. By volumetric method

Eq. wt. € = $\frac{W \times 1000}{V \times N}$

CHEMICAL INERGETIC

1. First law : $\Delta E = Q + W$

   Maximum work in a reversible expansion:

   $W = -2.303nRT \log \frac{V_2}{V_1} = -2.303nRT \log \frac{P_1}{P_2}$

2. Enthalpy and heat content: $\Delta H = \Delta E + P\Delta V$

   $[q_{(p)} = q_{(v)} + \Delta n_g RT]$ $\Delta H = \Delta E + \Delta n_g RT$

   $[\Delta n_g = n_{p(g)} - n_{r(g)}]$

3. Kirchoff's equation:

   $\Delta E_{T_2} = \Delta H_{T_1} + \Delta C_V (T_2 - T_1)$ [constant V]

   $\Delta H_{T_2} = \Delta H_{T_1} + \Delta C_p (T_2 - T_1)$ [constant P]

4. Entropy(s); Measure of disorder or randomness

   $\Delta S = \Sigma S_p - \Sigma S_R$

   $\Delta S = \frac{q_{rev}}{T}$

5. Free energy change: $\Delta G = \Delta H - T\Delta S$

   $\Delta G < 0$ (spontaneous) [–ve] $\Delta G = 0$ (equilibrium)

   $\Delta G > 0$ (non-spontaneous) [+ve]

   $-\Delta G = W$ (maximum) – $P\Delta V$

6.

ΔH	ΔS	ΔG	Reaction characteristics
–	+	Always Negative	Reaction is spontaneous at all temperature
+	–	Always positive	Reaction is non-spontaneous at all temperature
–	–	Negative at low temperature but positive at high temperature	Spontaneous at low temp. & non spontaneous at high temperature.
+	+	Positive at low temperature but negative at high temperature	Non spontaneous at low temperature & spontaneous at high temperature

ELECTRO CHEMISTRY

1. $m = Z.I.t$
2. Degree of dissociation: $\alpha = \frac{\lambda_{eq}}{\lambda^{\infty}_{eq}}$

   $= \frac{\text{Equivalent conductance at given concentration}}{\text{equivalent conductance at infinite dilution}}$
3. Kohlrausch's law: $\Lambda^0_m = x\lambda^0_A + {}_y\lambda^0_B$
4. Nernst Equation

   $E = E^0 - \frac{0.0591}{n}\log_{10}\frac{[\text{Products}]}{[\text{Reactants}]}$

   $\& E^0_{cell} = E^0_{anode} + E^0_{cathode} \& K_{eq.} = \text{antilog}\left[\frac{nFE^0}{0.0591}\right]$

   $\Delta G = -nFE_{cell} \& \Delta G^0 = -nFE^0_{cell}$

   $-\Delta G^0 = 2.303\ RT \log K_{c=}$

   $\&\ W_{max} = nFE^0 \& \Delta G = \Delta H + T\left(\frac{\partial \Delta G}{\partial T}\right)P$
5. Calculation of pH of an electrolyte by using a calomel electrode: $pH = \frac{E_{cell} - 0.2415}{0.0591}$

SOLUTION AND COLLIGATIVE PROPERTIES

1. Raoult's law
   i. for volatile solute

   $P = P_A + P_B = P^0_A X_A + P^0_B X_B$

   $= (1 - X_B)\,P^0_A + P^0_B X_B = (P^0_B - P^0_A)X_B + P^0_A$

   ii. for non-volatile solute

   $\frac{P_0 - P_S}{P_0} = \frac{n}{n + N} \& \frac{P_0 - P_S}{P_0} = \frac{w.m.}{W.M}$
2. Colligative Properties $\propto$ Number of particles
   $\propto$ Number of molecules (in case of nonelectrolytes)
   $\propto$ Number of ions (in case of electrolytes)
   $\propto$ Number of moles of solute
   $\propto$ Mole fraction of solute
3. Depression of freezing point, $\Delta T_f = K_f m$
4. Elevation in boiling point with relative lowering of vapour pressure

   $\Delta T_b = \frac{1000K_b}{M_1}\left(\frac{P^0 - P}{P^0}\right)$ (M_1 = mol. wt. of solvent)

5. Osmotic pressure (P) with depression in freezing point ΔT_f

$$P = \Delta T_f \times \frac{dRT}{1000K_f}$$

6. $$i = \frac{\text{Normal molar mass}}{\text{Observed molar mass}}$$

$$= \frac{\text{Observed colligative property}}{\text{Normal colligative property}}$$

$$i = \frac{\text{Observed osmotic pressure}}{\text{Normal osmotic pressure}}$$

$$= \frac{\text{Actual number of particles}}{\text{No. of particles for no. ionisation}}$$

degree of association $(\alpha) = (1 - i)\frac{n}{n-1}$

& degree of dissociation $(\alpha) = \frac{i-1}{n-1}$

NUCLEAR CHEMISTRY

1. Radius of the nucleus : $R = R_0 A^{1/3}$
   Where, $R_0 = 1.3 \times 10^{-13}$ cm
2. The amount N of the radioactive substance left after
   'n' half- lives $= \frac{N_0 \text{ (initial amount)}}{2^n}$
3. Half – life period $t_{1/2} = \frac{0.693}{\lambda}$
4. Rate of disintegration:
   $-\frac{dN}{dt} = \lambda \,.\, N$ &$\lambda = \frac{2.303}{t}\log_{10}\frac{N_0}{N}$ or $N = N_0 e^{-\lambda t}$
5. Average life $(t_{AV}) = \frac{\text{Total life time of all the atoms}}{\text{Total number of atoms}}$

$$= \int_0^\infty \frac{tdN}{N_0} = \frac{1}{2} = 1.44t_{1/2}$$

GASEOUS STATE

1. Ideal gas equation : PV = nRT
   i. R = 0.0821 litre atm. K^{-1} $mole^{-1}$
   ii. R = 62.4 litres mm HgK^{-1} $mole^{-1}$
   iii. $R = 8.314 \times 10^7$ ergs K^{-1} $mole^{-1}$
   iv. R = 2 cals K^{-1} $mole^{-1}$
   v. R = 8.314 JK^{-1} $mole^{-1}$
2. Velocities related to gaseous state

RMS velocity $C = \sqrt{\frac{3PV}{M}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3P}{d}}$

Average speed $= \sqrt{\frac{8RT}{M}}$

and Most probable speed $= \sqrt{\frac{2RT}{M}}$

Average speed = 0.9213 × RMS speed
RMS speed = 1.085 × Average speed
MPS = 0.816 × RMS; RMS = 1.224 MPS
MPS : A.V. speed : RMS = 1: 1.128 : 1.224

3. Rate of diffusion $\propto \frac{1}{\sqrt{\text{density of gas}}}$

4. Van der Waal's equation

$\left(P + \frac{n^2a}{V^2}\right)(V - nb) = nRT$ for n moles

5. Z (compressibility factor) $= \frac{PV}{nRT}$; Z = 1 for ideal gas

SOLID AND LIQUID STATE

1. Types of Crystal system.

Crystal system	Parameters	Examples
1. Cubic	a = b= c α = β = γ = 90°	NaCl, KCl, diamond
2. Tetragonal	a = b ≠ c, α = β = γ = 90°	TiO_2, ZnO, Sn
3. Orthorhombic	a ≠ b ≠ c α = β = γ = 90°	Rhombic sulphur, KNO_3
4. Monoclinic	a ≠ b ≠ c, α = γ = 90° &β≠ 90°	Monoclinic S, Na_2, $SO_4.10H_2O$
5. Hexagonal	a = b ≠ c, α = β = 90° &γ = 120°	Graphite, CdS, PbI_2
6. Rhomobohedral or Trigonal	a = b = c, α = β = γ≠ 90°	Calcite, $NaNO_3$
7. Triclinic	a ≠ b ≠ c α≠β≠γ≠ 90°	$CuSO_4$, $5H_2O$, $K_2Cr_2O_7$, H_3BO_3

2. Available space filled up by hard spheres (packing fraction):

Simple cubic $= \frac{\pi}{6} = 0.52$

bcc $= \frac{\pi\sqrt{3}}{8} = 0.68$ fcc. $= \frac{\pi\sqrt{2}}{6} = 0.74$

hcp = $\frac{\pi\sqrt{2}}{6}$ = 0.74 diamond = $\frac{\pi\sqrt{3}}{6}$ = 0.34

3. Radius ratio and co-ordination number (CN)

Limiting radius	**CN**	**Geometry**
[0.155 – 0.225]	3	[plane triangle]
[0.225 – 0.414]	4	[tetrahedral]
[0.414 – 0.732]	6	[octahedral]
[0.732 – 1]	8	[bcc]

4. Atomic radius r and the edge of the unit cell:
   Pure elements:
   Simple cubic (r) = $\frac{a}{2}$ bcc (r) = $\frac{\sqrt{3a}}{4}$ fcc (r) = $\frac{\sqrt{2a}}{4}$
5. Relationship between radius of void (r) and the radius of the sphere (R)
   r (tetrahedral) = 0.225R ; r (octahedral) = 0.414R
6. Paramagnetic: Presence of unpaired electrons
   [attracted by magnetic field]
7. Ferromagnetic : Permanent magnetism [↑↑↑↑]
8. Antiferromagnetic : net magnetic moment is zero [↑↓↑↓]
9. Ferrimagnetic : net magnetic moment is three [↑↓↓↑↑]

SURFACE CHEMISTRY & COLLOIDAL STATE

1. By Freudlich's isotherm,
   $\frac{x}{m} = Kp^{1/n}$ (for adsorption of gas on solid adsorbent)
   $\frac{x}{m} = KC^{1/n}$ (for adsorption of solute from solution on solid adsorbent)
2. Types of colloid system.

	Colloid system	**Dispersed phase**	**Dispersion medium**
1.	Foam	Gas	Liquid
2.	Solid foam	Gas	Solid
3.	Emulsion	Liquid	Liquid
4.	Gel	Liquid	Solid
5.	Aerosol	Liquid	Gas
6.	Smoke (solid aerosol)	Solid	Gas
7.	Sol	Solid	Liquid
8.	Solid sol	Solid	Solid

3. Higher is the valency of active ion, the greater is its coagulating power.
4. Emulsion: Colloidal soln. of two immiscible liquids [O/W emulsion, W/O emulsion]

5. Emulsifier: Long chain hydrocarbons are added to stabilize emulsion.
6. Lyophilic colloid: Starchy gum, gelatin have greater affinity for solvent. Solution can be easily prepared by bringing in contact with solvent and warming.
7. Lyophobic colloid: No affinity for solvent, specialmethods are used to prepare sol. [e.g. As_2S_3, $Fe(OH)_3$ sol]
8. Preparation of colloidal solution:
   i. Dispersion methods
   ii. Condensation methods
9. Properties of colloidal solution:
   i. Tyndall effect
   ii. Brownian movement
   iii. Filtrability
10. Protective nature of lyophilic sol is compare in terms of gold number.
11. The process of separating electrolyte from colloid using semi-permeable membrane is dialysis.

INORGANIC CHEMISTRY

PERIODIC TABLE

1. General electronic configuration (of outer orbits) s-blocks ns^{1-2} p-bloc ns^2np^{1-6}
   d-block $(n-1)d^{1-10}\ ns^{1-2}$
   f-block $(n-2)s^2p^6d^{10}f^{1-14}$ $(n-1)s^2p^6d^{0\text{ or }1}\ ns^2$
2.

Properties	Period (L to R)	Group (T to B)
a. atomic radius	↓	↑
b. ionization potential	↑	↓
c. electron affinity	↑	↓
d. electro negativity	↑	↓
e. metallic character or electropositive character	↓	↑
f. alkaline character of hydroxides	↓	↑
g. acidic character	↑	↓
h. density	i. firstly increases ii. in between max iii. then decreases	
i. reducing property	↓	↑
j. oxidizing property	↑	↓
k. non metallic character	↑	↓

3. $IP \propto \frac{1}{\text{metallic character}} \propto \frac{1}{\text{Reducing character}}$

$$\propto \frac{1}{\text{Basic Nature of oxide}} \propto \frac{1}{\text{Basic nature of Hydroxide}}$$

4. EA $\propto \frac{1}{\text{size}} \propto$ nuclear charge.

   Second electron affinity is always positive.
   Electron affinity of chlorine is greater than fluorine.
5. The first element of a group has similar properties with the second element of the next group. This is called diagonal relationship.

EXTRACTIVE METALLURGY

1. Floatation is a physical method of separating a mineral from the gangue depending on differences in their wettabilities by a liquid solution.
2. Roasting is the process of heating a mineral in the presence of air.
3. Calcination is the process of heating the ore in the absence of air.
4. Electrolytic reduction : Highly electropositive metals are extracted by the electrolysis of their halides.

S-BLOCK ELEMENTS

1. Atomic radii : Li < Na < K < Rb < Cs
2. Ionic radii : $Li^+ < Na^+ < Rb^+ < Cs^+$
3. Electronegativity : Li > Na > K > Rb > Cs
4. First ionization potential : Li > Na > K > Rb > Cs
5. Melting point : Li > Na > K > Rb > Cs
6. Density : Li > Na > K > Rb > Cs
7. Colour of the flame Li – Red, Na – Golden, K – Violent, Rb – Red, Cs – Blue, Ca – Brick red, Sr – Blood red, Ba – Apple green
8. Rb and Cs show photoelectric effect.
9. Stability of hydrides:
   LiH > NaH > KH > RbH > CsH
10. Basic nature of hydroxides:
    [LiOH < NaOH < KOH < RbOH < CsOH]

BORON FAMILY

1. Stability of +3 oxidation state:
   B > Al > Ga > In > Tl
2. Stability of +1 oxidation state : Ga < In < Tl
3. Reducing nature : Al > Ga > In > Tl
4. Basic nature of the oxides and hydroxides:
   B < Al < Ga < In < Tl
5. Relative strength of Lewis acid:

$BF_3 < BCl_3 < BBr_3 < BI_3$

CARBON FAMILY

1. Reactivity : C < Si < Ge < Sn < Pb
2. Metallic character : C < Si < Ge < Sn < Pb
3. Acidic character of the oxides:
   $CO_2 > SiO_2 > GeO_2 > SnO_2 > PbO_2$
   Weaker acidic (amphoteric)
4. Thermal stability and volatility of hydrides:
   $CH_4 > SiH_4 > GeH_4 > SnH_4 > PbH_4$
5. Reducing nature of hydrides
   $CH_4 < SiH_4 < GeH_4 < SnH_4 < PbH_4$
6. Thermal stability of tetrahalides
   $CCl_4 > SiCl_4 > GeCl_4 > SnCl_4 > PbCl_4$
7. Thermal stability and volatility of tetrahalide with a common central atom
   $MF_4 > MCl_4 > MBr_4 > MI_4$
8. Oxidising character of M^{+4} species
   $GeCl_4 < SnCl_4 < PbCl_4$
9. Ease of hydrolysis of tetrahalides
   $SiCl_4 > GeCl_4 > SnCl_4 > PbCl_4$
10. Reducing character of dihalides
    $GeCl_2 > SnCl_2 > PbCl_2$

NITROGEN FAMILY

1. Acidic strength of trioxides : $N_2O_3 > P_2O_3 > As_2O_3$
2. Acidic strength of pentoxides
   $N_2O_5 > P_2O_5 > As_2O_5 > Sb_2O_5 > Bi_2O_5$
3. Acidic strength of oxides of nitrogen
   $N_2O < NO < N_2O_3 < N_2O_4 < N_2O_5$
4. The stability of pentoxides
   $P_2O_5 < As_2O_5 > Sb_2O_5 > N_2O_5 > Bi_2O_5$
5. Basic nature, bond angle thermal stability and dipole moment of hydrides
   $NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_5$
6. Reducing power, covalent nature of hydrides:
   $NH_3 < PH_3 < AsH_3 < SbH_3 < BiH_3$
7. Stability of trihalides of nitrogen :
   $NF_3 > NCl_3 > NBr_3$
8. Ease of hydrolysis of trichlorides
   $NCl_3 > PCl_3 > AsCl_3 > SbCl_3 > BiCl_3$
9. Lewis acid strength of trihalides of P, As and Sb $PCl_3 > AsCl_3 > SbCl_3$
10. Lewis acid strength among phosphorus trihalides
    $PF_3 > PCl_3 > PBr_3 > PI_3$

11. Bond angle, among the halides of phosphorus
$PF_3 < PCl_3 < PBr_3 < PI_3$

OXYGEN FAMILY

1. Melting and boiling point of hydrides
$H_2O > H_2Te > H_2Se > H_2S$
2. Volatility of hydrides
$H_2O < H_2Te < H_2Se < H_2S$
3. Thermal stability of hydrides
$H_2O > H_2S > H_2Se > H_2Te$
4. Reducing nature of hydrides
$H_2S < H_2Se < H_2Te$
5. Covalent character of hydrides
$H_2O < H_2S < H_2Se < H_2Te$
6. Bond angle & Dipole moment of hydrides
$H_2O < H_2S < H_2Se < H_2Te$
(104°) (92°) (91°) (90°)
7. Ease of hydrolysis of hexahalides:
$SF_6 > SeF_6 > TeF_6$
8. The acidic character of oxides (elements in the same oxidation state)
$SO_2 > SeO_2 > TeO_2 > PoO_2$
$SO_3 > SeO_3 > TeO_3$
9. Acidic character of oxide of a particular element (e.g. S)
$SO_2 < SO_3$
10. Stability of dioxides
$SO_2 > TeO_2 > SeO_2 > PoO_2$

HALOGEN FAMILY

1. Bond energy of halogens : $Cl_2 > Br_2 > F_2 > I_2$
2. Bond length in X_2 molecule : $F_2 < Cl_2 < Br_2 < I_2$
3. Solubility of halogen in water : $F_2 > Cl_2 > Br_2 > I_2$
4. Oxidising power : $F_2 > Cl_2 > Br_2 > I_2$
5. Enthalpy of hydration of X^- ion: $F^- > Cl^- > Br^- > I^-$
6. Reactivity of halogens: F > Cl > Br > I
7. Ionic character of M – X bond in halides
M – F > M – Cl > M – Br > M – I
8. Reducing character of X^- ion : $I^- > Br^- > Cl^- > F^-$
9. Thermal stability of hydrides: HF > HCl > HBr > HI
10. Acidic strength of halogen acids:
SHI > HBr > HCl > HF
11. Conjugate base strength of halogen acids

I-< Br < CJ-< F-

12. Reducing power of hydrogen halides HF < HCl< HBr < HI
13. Dipole moment of hydrogen halides HF > HCl>HBr > HI
14. Oxidising power of oxides of chlorine Cl_2O > ClO >ClO_2> Cl_2O_6> Cl_2O_7
15. Acidic character of oxyacids of chlorine HclO < $HClO_2$< HCl_2< HCO_3< $HClO_4^-$
16. Strength of conjugate bases of oxyacids of chlorine clO^-> ClO_2 –> ClO_2^-> ClO_4–
17. Oxidising power of oxyacids of chlorine
    HClO > $HClO_2$> $HClO_3$> $HClO_3$> $HClO_4$
18. Thermal stability of oxyacids of chlorine HClO < $HClO_2$< $HClO_3$< $HClO_4$
19. Stability of anions of oxyacids of chlorine ClO < ClO_2 – < ClO_3– < ClO_4^-

TRANSITION ELEMENTS
(d-bLOCKELEMENTS)

1. The element with exceptional configuration are
   Cr^{24} [Ar] $3d^5$ $4s^1$, cu^{29} [Ar] $3d^{10}$ $4s^1$
   Mo^{42} [Kr] $4d^5$ $5s^1$, pd^{46} [Kr] $4d^{10}$ $5s^0$
   Ag^{47} [Kr] $4d^{10}$ $5s^1$, pt^{78} [Xe] $4f^{14}5d^{10}6s^0$
   Au^{79} [Xe] $4f^{14}4d^{10}6s^1$
2. Ferromagnetic substances are those in which there are large number of electrons with unpaired spins and whose magnetic moments are aligned in the same direction.

COORDINATION COMPOUNDS

1. Coordination number is the number of the nearest atoms or groups in the coordination sphere.
2. Ligand is a Lewis base donor of electrons that bonds to a cenbtral atom in a coordination compound.
3. Paramagnetic substance is one that is attracted to the magnetic field, this results on account of unpaired electrons present in the atom/ molecule/ion.
4. Effect atomic number EAN
   = (z –Oxidation number) + (2× Coordination number)
5. Factors affecting stability of complex
   i. Greater the charge on the central metal ion, greater is the stability
   ii. Greater the ability of the ligand to donate electron pair (basic strength) greater is the stability.
   iii. Formation of chelate rings increases the stability.

ORGANIC CHEMISTRY

General organic chemistry

1. The order of decreasing electronegativity of hybrid orbitals is sp > sp^2> sp^3

2. Conformational isomers are those isomers which arise due to rotation around a single bond.
3. A meso compound is optically inactive, even though it has asymmetric centers. (due to internal compensation or rotation of plane polarized light)
4. An equimolar mixture of enantiomers is called racemic mixture, which is optically inactive.
5. Tautomerism is the type of isomerism arising by the migration of hydrogen.
6. Reaction intermediates and reagents:
   Homolytic fission → Free radicals
   Heteroytic fission → Carbocation and carbanion
7. Nucleophiles – electron rich
   Two types :1.a nions 2. Neutral molecules with lone pair of electronis (Lewis bases)
   electrophiles: electron deficient.
   Two types: 1. Cations 2. Neutral molecules with vacant orbitals (Lewis acids)
8. Inductive effect is due to σ electron displacement along a chain and is permanent effect.
9. + I (inductive effect) increases basicity, –I effect increases acidity of compounds.
10. Resonance is a phenomenon in which two or more structures can be written for the same compound but none of them actually exists.

ALKANES

1. Pyrolytic cracking is a process in which alkane decomposes to a mixture of smaller hydrocarbons, when it is heated strongly, in the absence of oxygen.
2. Combustion is a process in which hydrocarbons form carbon dioxide and $H_2O(l)$ when they are completely burnt in air\ O_2.

ALKENES

1. In dehydration and dehydrohalogenation the preferential order for removal of hydrogen is 3°> 2°> 1° (Saytzeff's rule).
2. The lower the ΔH_h (heat of hydrogenation the more stable the alkene is.
3. Alkenes undergo anti-marknikov addition only with HBr in the presence of peroxides.

ALKYNES

1. Alkynes add water molecule in presence of mercuric sulphate and dil. H_2SO_4 and form carbonyl compunds.
2. Terminal alkynes have acidic H-atoms, so they form metal olkylides with Na, ammonical cuprous chloride solution and ammonical silver nitrate solution.
3. Alkynes are acidic because of H-atoms which are attached to sp hybridized 'C' atom has more electronegativity as it has more 's' character than sp^2 and sp^3 hybridised 'C' atoms.

ARENES

1. All o and p-directing groups are ring activating groups (except – X)
   They are: – OH,–NH_2, –X, –R, –OR,– etc.
2. All m-directing groups are ring deactivating groups.
   They are– CHO, –COOH, – NO_2, – NR_3etc.

HALOGEN COMPOUNDS

1. The order reactivity is
a. RI > RBr > RC*l*>RF
b. Ally halide > Alkyl halide > Vinyl halide
c. Alkyl halide > Aryl halide
2. S_N 1 reaction: Mainly 3° alkyl halides undergo this reaction and form racemic mixture. S_Nl is favoured by polar solvent and low concentration of nucleophile.
3. S_N^2 reaction: Mainly 1° alkyl halides undergo this substitution. S_N^2 reaction is preferred by non-polar solvents and high concentration of nucleophile.

ALCOHOLS

1. Alkenes are converted to alcohol in different ways as follows
   Reagent Types of addition
   dil H_2SO_4 –Markovnikov
   B_2H_6 and H_2O_2,OH – Anti-Markovnikov
   oxymercuration demercuration – Markovnikov
2. Oxidation of
   1° alcohol → aldehyde → carboxylic acid
   (with same no. (with same no.
   of C atom of C atom)

   2° alcohol → ketone → carboxylic acid
   (with same no. (with lens no.
   of C atom of Carbon)

PHENOLS

1. Phenol $CHCl_3$/OH Salicyladehyde
   (Reimer-Tieman reaction)
2. Phenol CO_2/Base Salicylic acid (Kolbe reaction)
3. Acidity of phenols
a) Increases by electron withdrawing substituents like
   –NO_2, –CN, –CHO,–COOH, –X, –N^+R_3
4. Decrease by electron releasing substituents like –R,–OH,–NH_2,–NR,–OR

ETHERS

1. $2ROH \xrightarrow[250^\circ C]{Al_2O_3} R-O-R + H_2$
2. $RON_a + X-R' \longrightarrow ROR' + NaX$
   (Williamson's synthesis)
3. $ROR + 2H_2SO_4 \xrightarrow[(conc.)]{\Delta} 2RHSO_4 + H_2O$
4. $ROR + H_2O \xrightarrow[\Delta]{dil.\ H_2SO_4} 2ROH$

CARBONYL COMPOUNDS

1. Formation of alcohols using RM_gX

a) Formaldehyde + $RM_gX \xrightarrow{Hydrolysis}$ 1° alcohol

b) Aldehyde + $RM_gX \xrightarrow{Hydrolysis}$ 2° alcohol

c) Ketone + $RM_gX \xrightarrow{Hydrolysis}$ 3° alcohol

2. Cannizzaro reaction (Disproportionation)
   Aldehyde $\xrightarrow[alkali]{Hot,\ conc.}$ Alcohol + Salt of acid (no α H-atom)
   Crossed-Cannizzaro reaction gives alcohol with aryl group or bigger alkyl group.
3. Aldol condensation:
   Carbonyl compound + dil. Alkali $\longrightarrow$ β-hydroxy (with α H-atom) carbonyl comound
4. Benzoin condensation
   Benzaldehyde NaCN(alc) Benzoin

CARBOXYLIC ACIDS

1. The rate of esterification decreases when alcohol, acid or both have branched substituents.
2. Ortho effect: All ortho substituted benzoic acids (irrespective of type of substituent) are stronger then benzoic acid. As this group decreases outer resonance of ring towards acid which increases acidic nature.

NITROGEN COMPOUNDS

1. Order of basicity: (R = – CH_3 or – C_2H_5) 2°>1° 3°> degradation
   Amides $\xrightarrow{Br_2/KOH}$ 1° amine (Hoffmann)
3. The basicity of amines is
   a) decreased by electron withdrawing groups
   b) increased by electron releasing groups
4. Reduction of nitrobenzene in different media gives different products

Medium	Products
Acidic	Aniline
Basic	Azoxy, Azo and finally hydrazobenzene
Neutral	Phenyl hydroxylamine

CARBOHYDRATES, AMINO AND POLYMERS

1. Carbhydrates are polyhydroxy aldehydes or ketones.
2. Oligosaccharides are simple sugars, containing three to nine carbon atoms.
3. Polymers is a chemical species of high molecular weight made up from repeating units of low molecular weight.

CHARACTERISTIC REACTIONS OF DIFFERENT ORGANIC COMPOUNDS

Homologous Series		**Types of reactions**
a)	Alkanes	Substitution (Mostly free radical)
b)	Alkenes and alkynes	Electrophillic addition
c)	Arenes	Electrophillic substitution
d)	alkyl halides	Nucleophillic substitution
e)	Aldehyde and ketones	Necleophillic addition

Tests to Differentiate

1°, 2°, and 3° alcohols	Lucas test, Victor Mayer's test
1°,2°, and 3° mines	Hinsberg test
1°, 2°, and 3° nitro	Test with HNO_2 & KOH compounds
Aryl halides and alkyl	Test with $AgNO_3$ halides Solution
Aldehydes and ketones	Tollen's test\Fehling's test

IMPORTANT REAGENT

1. Dil H_2SO_4[or Conc. H_2SO_4 + H_2O]
   Use → Dehydrating agent (+ HOH)
   (a) $CH_2 = CH_2 \xrightarrow{dil.H_2SO_4} CH_3 - CH_2 - OH$
   (b) $C_2H_5OC_2H_5 \xrightarrow{dil.H_2SO_4} 2C_2H_5OH$
2. Alc.KOH or $NaNH_2$ (Use → HX)
   $CH_3CH_2 - \underset{HCl}{\xrightarrow{alc.KOH}} CH_2 = CH_2$
3. Cu or ZnO\300°C
   1° alc $\xrightarrow{''}$ ald, 2° alc $\xrightarrow{''}$ ketone, 3° alc $\xrightarrow{''}$ alkene (exception)
4. Lucas reagent $ZnCl_2$ + conc. HCl
   Use → for distinction between 1°, 2°& 3° alcohol
5. Tilden Reagent NOCl (Nitrosyl choloride)
   $C_2H_5NH_2 \xrightarrow{NOCl} C_2H_5Cl$

6. Alkaline $KMnO_4$ (Strong oxidant)
   Toluene → Benzoic acid
7. Bayer's Reagent
   1 % alkaline $KMnO_4$ (Weak oxidant)
   Use : → For test of $> C = C <$ or $- C = C - CH_2 = CH_2 + H_2O + [O] \longrightarrow CH_2OH-CH_2OH$
8. Acidic $K_2Cr_2O_7$ (Strong oxidant)
   $RCH_2OH \xrightarrow{[o]} RCHO$
9. $SnCl_2 | HC |$ or $Sn | HCl$ use → for reduction of nitrobenzene in acidic medium.
   $C_6H_5NO_2 \xrightarrow[6H]{snSl_2 | HCl} C_6H_5NH_2$
10. Lindlar's Catalyst = Pd \ $CaCO_3$ + in small quantity $(CH_3 COOO)_2$ Pb
    2– butyne + $H_2 \xrightarrow{''}$ Cis –2 – butane (main product)
11. Zeigler –Natta Catalyst $(C_2H_5)_3 Al + TiCl_4$
    Use — In addition polymerization
    Propene $\xrightarrow{''}$ Poly propene

MAIN USE OF COMPOUNDS

Alknae → Fuel,
Alkene → Polymer,
Alkyne → Solvent making westron,
Westrosol, General alky1 halide → as solvents,
$CHCl_3$ → Anaesthetic, Germicide,
CCl_4 → Pyrene & Fire extinguisher,
CH_3OH→ Antifreeze, deforming of alcohol,
$C_2 H_5OH$ → Tonic, wine preparation, power alcohol,
$C_2H_5 -O- C_2H_5$→Antiseptic, Natelllite,
HCHO → as solvent,
$CH_3 COOC_2H_5$→Artificial silk & flavor,
CH_3NH_2→Refrigerating agent,
$C_2H_5NH_2$→in development of photography.

SMELL OF SOME COMPOUNDS

$CH_3COOC_2H_5$ →Fruity
$CHCl_3$, CH_3I, C_2H_5I → sweet smell
$C_6H_5NO_2$& C_6H_5CHO → Like bitter almonds
CH_3COOH → Like vinegar,
HCHO, CH_3CHO, CH_3NH_2& $C_6H_5NH_2$→ Fishy,
Impure CH_3CONH_2mice like,

ROH → wine
RNCS → Mustard oil, methyl salicylate → wintergreen oil,
RNC → Foul smell.

INDENTIFICATION TESTS

a. Unsaturated compound (Bayer's reagent) Decolourising the regent
b. Alcohols (Ceric ammonium nitrate solution)
   Red colouration
c. Phenols (Neutral $FeCl_3$ solution)
   Violet/deep blue colouration
d. Aldehydes and ketones (2, 4-D.N.P.)
   Orange precipitate
e. Acids ($NaHCO_3$ solution)
   Brisk effervescence ($CO_2$is evolved)
d. 1° amine ($NaNO_2$ + Hcl + KOH)
   Foul smell (isocyanide)
g. 2° amine ($NaNO_2$ + Hcl)
   Yellow oily liquid (Nitrosoamine)