MET 2021 Test Details

- Mode: Online Remote Proctored Test (RPT)
- Test Duration: **120** minutes
- Total Questions: **60**
    - **Multiple Choice Questions (MCQs):** Mathematics (15), Physics (10), Chemistry (10), and English (10)
    - **Numerical Answer Type (NAT):** Mathematics (5), Physics (5), and Chemistry (5)
- Max Marks: **240**
- Marking Scheme
    - **MCQ: +4** for every correct answer, **-1** for every wrong answer, **0** for every unanswered question
    - **NAT: +4** for every correct answer, **0** for every wrong, **0** for every unanswered question
- MET 2021 Schedule: June 11 – 14, 2021
    - There will be ONE attempt only

CHEMISTRY

Some Basic Concepts of Chemistry: General Introduction: Importance and scope of chemistry, Nature of matter, laws of chemical combination, Dalton's atomic theory: concept of elements, atoms and molecules, Atomic and molecular masses, mole concept and molar mass, percentage composition, empirical and molecular formula, chemical reactions, stoichiometry and calculations based on stoichiometry.

Structure of atom: Bohr's model and its limitations, concept of shells and subshells, dual nature of matter and light, de Broglie's relationship, Heisenberg uncertainty principle, concept of orbitals, quantum numbers, shapes of s, p and d orbitals, rules for filling electrons in orbitals - Aufbau principle, Pauli's exclusion principle and Hund's rule, electronic configuration of atoms, stability of half-filled and completely filled orbitals.

Classification of Elements and Periodicity in Properties: Modern periodic law and the present form of periodic table, periodic trends in properties of elements -atomic radii, ionic radii, inert gas radii, Ionization enthalpy, electron gain enthalpy, electronegativity, valency. Nomenclature of elements with atomic number greater than 100

Chemical Bonding and Molecular structure: Valence electrons, ionic bond, covalent bond, bond parameters, Lewis structure, polar character of covalent bond, covalent character of ionic bond, valence bond theory, resonance, geometry of covalent molecules, VSEPR theory, concept of hybridization, involving s, p and d orbitals and shapes of some simple molecules, molecular orbital theory of homonuclear diatomic molecules (qualitative idea only), hydrogen bond.

States of Matter: Gases and Liquids: Three states of matter, intermolecular interactions, types of bonding, melting and boiling points, role of gas laws in elucidating the concept of the molecule, Boyle's law, Charles law, Gay Lussac's law, Avogadro's law, ideal behaviour, empirical derivation of gas equation, Avogadro's number, ideal gas equation. Deviation from ideal behaviour, liquefaction of gases, critical temperature, kinetic energy and molecular speeds (elementary idea) Liquid State: vapour pressure, viscosity and surface tension (qualitative idea only, no mathematical derivations)

Chemical Thermodynamics: Concepts of System and types of systems, surroundings, work, heat, energy, extensive and intensive properties, state functions. First law of thermodynamics -internal energy and enthalpy, heat capacity and specific heat, measurement of ΔU and ΔH, Hess's law of constant heat summation, enthalpy of bond dissociation, combustion, formation, atomization, sublimation, phase transition, ionization, solution and dilution. Second law of Thermodynamics (brief introduction). Introduction of entropy as a state function, Gibb's energy change for spontaneous and non- spontaneous processes, criteria for equilibrium. Third law of thermodynamics (brief introduction).

Equilibrium: Equilibrium in physical and chemical processes, dynamic nature of equilibrium, law of mass action, equilibrium constant, factors affecting equilibrium- Le Chatelier's principle, ionic equilibrium- ionization of acids and bases, strong and weak electrolytes, degree of ionization, ionization of poly basic acids, acid strength, concept of pH, Henderson Equation, hydrolysis of salts (elementary idea), buffer solution, solubility product, common ion effect (with illustrative examples).

Redox Reactions: Concept of oxidation and reduction, redox reactions, oxidation number, balancing redox reactions, in terms of loss and gain of electrons and change in oxidation number, applications of redox reactions.

Hydrogen: Position of hydrogen in periodic table, occurrence, isotopes, preparation, properties and uses of hydrogen, hydrides-ionic covalent and interstitial; physical and chemical properties of water, heavy water, hydrogen peroxide - preparation, reactions and structure and use; hydrogen as a fuel.

s-Block Elements (Alkali and Alkaline Earth Metals): Group 1 and Group 2 Elements General introduction, electronic configuration, occurrence, anomalous properties of the first element of each group, diagonal relationship, trends in the variation of properties (such as ionization enthalpy, atomic and ionic radii), trends in chemical reactivity with oxygen, water, hydrogen and halogens, uses. Preparation and Properties of Some Important Compounds: Sodium Carbonate, Sodium Chloride, Sodium Hydroxide and Sodium Hydrogen carbonate, Biological importance of Sodium and Potassium. Calcium Oxide and Calcium Carbonate and their industrial uses, biological importance of Magnesium and Calcium

p-Block Elements: General Introduction to p -Block Elements Group 13 Elements: General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous properties of first element of the group, Boron - physical and chemical properties, some important compounds, Borax, Boric acid, Boron Hydrides, Aluminium: Reactions with acids and alkalies, uses. Group 14 Elements: General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous behaviour of first elements. Carbon-catenation, allotropic forms, physical and chemical properties; uses of some important compounds: oxides. Important compounds of Silicon and a few uses: Silicon Tetrachloride, Silicones, Silicates and Zeolites, their uses.

Organic Chemistry - Some Basic Principles and Techniques: General introduction, methods of purification, qualitative and quantitative analysis, classification and IUPAC nomenclature of organic compounds. Electronic displacements in a covalent bond: inductive effect, electromeric effect, resonance and hyper conjugation. Homolytic and heterolytic fission of a covalent bond: free radicals, carbocations, carbanions, electrophiles and nucleophiles, types of organic reactions

Hydrocarbons: Classification of Hydrocarbons Aliphatic Hydrocarbons: Alkanes - Nomenclature, isomerism, conformation (ethane only), physical properties, chemical reactions including free radical mechanism of halogenation, combustion and pyrolysis. Alkenes - Nomenclature, structure of double bond (ethene), geometrical isomerism, physical properties, methods of preparation, chemical reactions: addition of hydrogen, halogen, water, hydrogen halides (Markownikov's addition and peroxide effect), ozonolysis, oxidation, mechanism of electrophilic addition. Alkynes - Nomenclature, structure of triple bond (ethyne), physical properties, methods of preparation, chemical reactions: acidic character of alkynes, addition reaction of - hydrogen, halogens, hydrogen halides and water. Aromatic Hydrocarbons: Introduction, IUPAC nomenclature, benzene: resonance, aromaticity, chemical properties: mechanism of electrophilic substitution. Nitration, sulphonation, halogenation, Friedel Craft's alkylation and acylation, directive influence of functional group in monosubstituted benzene, Carcinogenicity and toxicity.

Environmental Chemistry: Environmental pollution - air, water and soil pollution, chemical reactions in atmosphere, smog, major atmospheric pollutants, acid rain, ozone and its reactions, effects of depletion of ozone layer, greenhouse effect and global warming-pollution due to industrial wastes, green chemistry as an alternative tool for reducing pollution, strategies for control of environmental pollution.

Solutions: Types of solutions, expression of concentration of solutions of solids in liquids, solubility of gases in liquids, solid solutions, colligative properties - relative lowering of vapour pressure, Raoult's law, elevation of boiling point, depression of freezing point, osmotic pressure, determination of molecular masses using colligative properties, abnormal molecular mass, Van't Hoff factor.

Electrochemistry: Redox reactions, conductance in electrolytic solutions, specific and molar conductivity, variations of conductivity with concentration, Kohlrausch's Law, electrolysis and law of electrolysis (elementary idea), dry cell-electrolytic cells and Galvanic cells, lead accumulator, EMF of a cell, standard electrode potential, Nernst equation and its application to chemical cells, Relation between Gibbs energy change and EMF of a cell, fuel cells, corrosion.

Chemical Kinetics: Rate of a reaction (Average and instantaneous), factors affecting rate of reaction: concentration, temperature, catalyst; order and molecularity of a reaction, rate law and specific rate constant, integrated rate equations and half-life (only for zero

and first order reactions), concept of collision theory (elementary idea, no mathematical treatment). Activation energy, Arrhenius equation.

Surface Chemistry: Adsorption - physisorption and chemisorption, factors affecting adsorption of gases on solids, catalysis, homogenous and heterogenous activity and selectivity; enzyme catalysis colloidal state distinction between true solutions, colloids and suspension; lyophilic, lyophobic multi-molecular and macromolecular colloids; properties of colloids; Tyndall effect, Brownian movement, electrophoresis, coagulation, emulsion - types of emulsions.

General Principles and Processes of Isolation of Elements: Principles and methods of extraction - concentration, oxidation, reduction - electrolytic method and refining; occurrence and principles of extraction of aluminium, copper, zinc and iron.

p-Block Elements: Group 16 Elements: General introduction, electronic configuration, oxidation states, occurrence, trends in physical and chemical properties, dioxygen: Preparation, Properties and uses, classification of Oxides, Ozone, Sulphur - allotropic forms; compounds of Sulphur: Preparation Properties and uses of Sulphur-dioxide, Sulphuric Acid: industrial process of manufacture, properties and uses; Oxoacids of Sulphur (Structures only). Group 17 Elements: General introduction, electronic configuration, oxidation states, occurrence, trends in physical and chemical properties; compounds of halogens, Preparation, properties and uses of Chlorine and Hydrochloric acid, interhalogen compounds, Oxoacids of halogens (structures only). Group 18 Elements: General introduction, electronic configuration, occurrence, trends in physical and chemical properties, uses.

'd' and 'f' Block Elements: General introduction, electronic configuration, occurrence and characteristics of transition metals, general trends in properties of the first-row transition metals - metallic character, ionization enthalpy, oxidation states, ionic radii, colour, catalytic property, magnetic properties, interstitial compounds, alloy formation, preparation and properties of K2Cr2O7 and KMnO4. Lanthanoids - Electronic configuration, oxidation states, chemical reactivity and lanthanoid contraction and its consequences. Actinoids - Electronic configuration, oxidation states and comparison with lanthanoids.

Coordination Compounds: Coordination compounds - Introduction, ligands, coordination number, colour, magnetic properties and shapes, IUPAC nomenclature of mononuclear coordination compounds. Bonding, Werner's theory, VBT, and CFT; structure and stereoisomerism, importance of coordination compounds (in qualitative inclusion, extraction of metals and biological system).

Haloalkanes and Haloarenes: Haloalkanes: Nomenclature, nature of C-X bond, physical and chemical properties, mechanism of substitution reactions, optical rotation. Haloarenes: Nature of C-X bond, substitution reactions (Directive influence of halogen in monosubstituted compounds only). Uses and environmental effects of - dichloromethane, trichloromethane, tetrachloromethane, iodoform, freons, DDT.

Alcohols, Phenols and Ethers: **Alcohols**: Nomenclature, methods of preparation, physical and chemical properties (of primary alcohols only), identification of primary, secondary and tertiary alcohols, mechanism of dehydration, uses with special reference to methanol and ethanol. **Phenols**: Nomenclature, methods of preparation, physical and chemical properties, acidic nature of phenol, electrophilic substitution reactions, uses of phenols. **Ethers**: Nomenclature, methods of preparation, physical and chemical properties, uses

Aldehydes, Ketones and Carboxylic Acids: Aldehydes and Ketones: Nomenclature, nature of carbonyl group, methods of preparation, physical and chemical properties, mechanism of nucleophilic addition, reactivity of alpha hydrogen in aldehydes, uses. Carboxylic Acids: Nomenclature, acidic nature, methods of preparation, physical and chemical properties; uses.

Organic compounds containing Nitrogen: Amines: Nomenclature, classification, structure, methods of preparation, physical and chemical properties, uses, identification of primary, secondary and tertiary amines. Cyanides and Isocyanides - will be mentioned at relevant places in text. Diazonium salts: Preparation, chemical reactions and importance in synthetic organic chemistry.

Biomolecules: Carbohydrates - Classification (aldoses and ketoses), monosaccharides (glucose and fructose), D-L configuration oligosaccharides (sucrose, lactose, maltose), polysaccharides (starch, cellulose, glycogen); Importance of carbohydrates. Proteins - Elementary idea of - amino acids, peptide bond, polypeptides, proteins, structure of proteins - primary, secondary, tertiary structure and quaternary structures (qualitative idea only), denaturation of proteins; enzymes. Hormones - Elementary idea excluding structure. Vitamins - Classification and functions. Nucleic Acids: DNA and RNA.

Polymers: Copolymerization, some important polymers: natural and synthetic like polythene, nylon polyesters, bakelite, rubber. Biodegradable and nonbiodegradable polymers.

Chemistry in Everyday life: Chemicals in medicines - analgesics, tranquilizers antiseptics, disinfectants, antimicrobials, antifertility drugs, antibiotics, antacids, antihistamines. Chemicals in food - preservatives, artificial sweetening agents, elementary idea of antioxidants, Cleansing agents- soaps and detergents, cleansing action.

Chemistry

41. The number of electrons in an atom with atomic number 105 having (n + *l*) = 8 are:

(a) 30 (b) 17 (c) 15 (d) 18

42. The ratio $\frac{a}{b}$ (a and b being the van der Waal's constant of real gases) has the dimensions of

(a) atm mol^{-1} (b) L mol^{-1} (c) atm L mol^{-1} (d) atm L mol^{-2}

43. Resultant molarity of H^+ ion in a mixture of 100 mL of 0.1 M H_2SO_4 and 200 mL of 0.1 M H_3PO_3 is:

(a) 0.1 M (b) 0.2 M (c) 0.267 M (d) 0.133 M

44. The chemical reaction, $2O_3 \longrightarrow 3O_2$ proceeds as follows:

$O_3 \rightleftharpoons O_2 + O$ … (fast)

$O + O_3 \longrightarrow 2O_2$ … (slow)

The rate law expression should be:

(a) $r = K[O_3]^2$ (b) $r = K[O_3]^2 [O_2]^{-1}$ (c) $r = K [O_3] [O_2]$ (d) unpredictable

45. For the reaction in equilibrium,

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$

the concentrations, of N_2O_4 and NO_2 at equilibrium are 4.8×10^{-2} and 1.2×10^{-2} mol L^{-1} respectively. The value of K_c for this reaction is:

(a) 3×10^{-3} mol L^{-1} (b) 3×10^{3} mol L^{-1} (c) 3.3×10^{2} mol L^{-1} (d) 3×10^{-1} mol L^{-1}

46. Which one of the following is tribasic acid?

(a) H_3PO_2 (b) H_3PO_3 (c) H_3PO_4 (d) $H_4P_2O_7$

47. In CsBr crystal structure edge length of unit cell is 4.3Å. The shortest interionic distance between Cs^+ and Br^- ions is

(a) 3.72 Å (b) 1.86 Å (c) 7.44 Å (d) 4.3 Å

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48. Which is deliquescent?

(a) $MgCl_2$ (b) NaOH (c) $CaCl_2$ (d) All

49. For which change $\Delta H \neq \Delta U$?

(a) $H_{2(g)} + I_{2(g)} \longrightarrow 2HI_{(g)}$ (b) $CH_{4(g)} + 2O_2 \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$

(c) $C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$ (d) $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$

50. Which one of the following is incorrect for spontaneous adsorption of gas on solid surface?

(a) ΔH decreases for system (b) ΔS (total) increases

(c) ΔS decreases for gas (d) ΔG increases for system

51. According to MO Theory,

(a) O_2^+ is paramagnetic and bond order greater than O_2

(b) O_2^+ is paramagnetic and bond order less than O_2

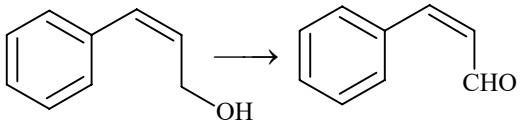
(c) O_2^+ is diamagnetic and bond order is less than O_2

(d) O_2^+ is diamagnetic and bond order is more than O_2

52. How many chiral compounds are possible on mono chlorination of 2-methyl butane?

(a) 2 (b) 4 (c) 6 (d) 8

53. Which of the following reagents can be used for the following conversions



(a) CrO_3 / Pyridine (b) H_2/Pd-C (c) $LiAlH_4$ (d) $KMnO_4$ / OH^-

54. Which of the following is fully fluorinated polymer?

(a) Neoprene (b) Teflon (c) Thiokol (d) PVC

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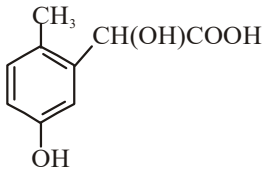
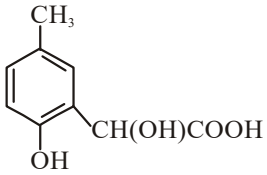
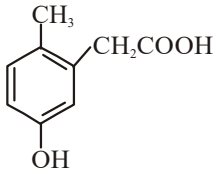
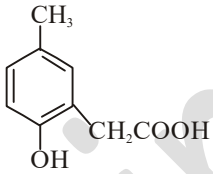
55. p-cresol reacts with chloroform in alkaline medium to give the compound A which adds hydrogen cyanide to form, the compound B. The latter on acidic hydrolysis gives chiral carboxylic acid. The structure of the carboxylic acid is

(a) 

(b) 

(c) 

(d) 

56. Which method of purification is represented by the following equation?

$$Ni + 4CO \xrightarrow{70^{o}\,C} Ni(CO)_4 \xrightarrow{180^{o}\,C} Ni + 4CO$$

(a) van Arkel (b) zone refining (c) mond process (d) cupellation

57. Which of the following has –O–O– linkage

(a) $H_2S_2O_6$ (b) $H_2S_2O_8$ (c) $H_2S_2O_3$ (d) $H_2S_4O_6$

58. 2-Methylbutane on reacting with bromine in the presence of sunlight gives mainly

(a) 1-bromo-2-methylbutane (b) 2-bromo-2-methylbutane

(c) 2-bromo-3-methylbutane (d) 1-bromo-3-methylbutane

59. Acid catalyzed hydration of alkenes except ethene leads to the formation of

(a) primary alcohol (b) secondary or tertiary alcohol

(c) mixture of primary and secondary alcohols (d) mixture of secondary and tertiary alcohols

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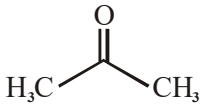
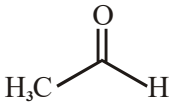
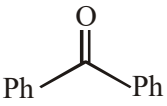
60. The material used in semiconductors

(a) Si (b) Sn (c) Ti (d) Cs

61. The order of reactivity of Phenyl Magnesium Bromide with the following compounds is

(i) 

(ii) 

(iii) 

(a)(ii) > (iii) > (i) (b) (i) > (iii) > (ii) (c) (ii) > (i) > (iii) (d) all react with same rate

62. Which one of the following types of drugs reduces fever ?

(a)Analgesic (b) Antipyretic (c) Antibiotic (d) Tranquiliser

63. Tertiary alkyl halides are practically inert to substitution by mechanism because of

(a)insolubility (b) instability (c) inductive effect (d) steric hindrance

64. Which of the following oxides is amphoteric in character?

(a)CaO (b) CO_2 (c) SiO_2 (d) SnO_2

65. Among the following acids which has the lowest pK_a value ?

(a)CH_3COOH (b) HCOOH

(c)$(CH_3)_2CH – COOH$ (d) CH_3CH_2COOH

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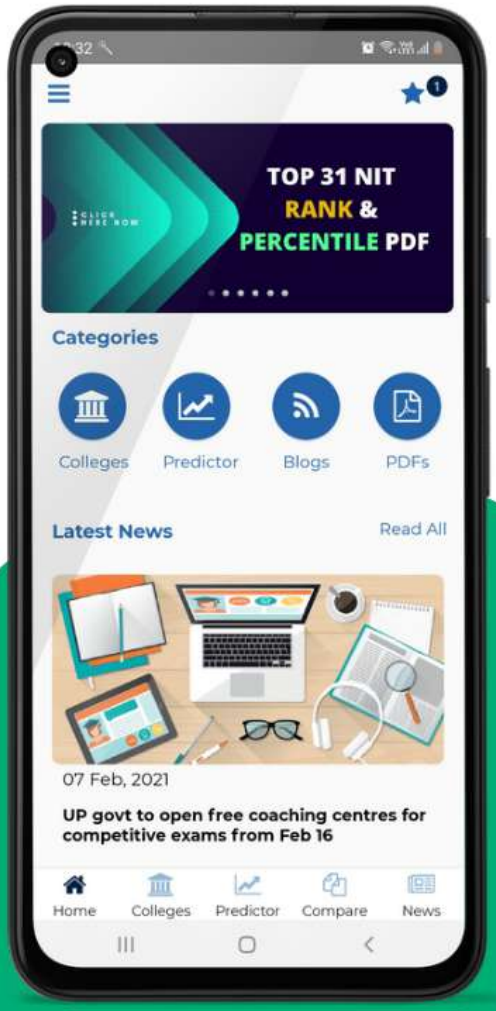

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Chap-01 - Some Basic Concepts of Chemistry

Formulae Chart

1. $T(K) = T(°C) + 273.15$
2. $T(°F) = \frac{9}{5}T(°C) + 32$
3. Relative atomic mass $= \frac{\text{Mass of an atom of the element}}{\frac{1}{12} \times \text{Mass of an atom of carbon (C-12)}}$
4. Number of gram atoms $= \frac{W(g)}{GAM}$ (GAM → gram atomic mass)
5. Number of gram molecules $= \frac{W(g)}{\text{Gram molecular mass}}$
6. Avogadro's No. $N_A = 6.022 \times 10^{23}$
7. Mass of 1 atom of element $= \frac{GAM}{N_A}$
8. Mass of 1 molecule of substance $= \frac{GMM}{N_A}$ (MM → Molar mass)
9. Number of molecules in W(g) of substance $= \frac{W(g) \times N_A}{GMM}$
10. Number of molecules in V litre of gas at S.T.P. $= \frac{VN_A}{22.4}$
11. Number of molecules in n moles of substance $= n \times N_A$
12. Mass % of an element in a compound $= \frac{\text{Mass of that element in 1 mole of the compound}}{\text{Molar mass of the compound}} \times 100$
13. Mass percent $= \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$
14. Mole fraction of A $= \frac{\text{No. of moles of A}}{\text{No. of moles of solution}}$
15. Molarity(M) $= \frac{\text{No. of moles of solute}}{\text{Volume of solution in litres}}$ mole/L
16. Dilution formula : $M_1V_1 = M_2V_2$
For mixing two solutions of the same substance
$M_1V_1 + M_2V_2 = M_3(V_1 + V_2)$
Molarity can be directly calculated from % by mass (W/W) if density is known
Molarity $= \frac{\% \times 10 \times d}{GMM}$
17. Molality(m) $= \frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$
18. Molecular mass = 2 × vapour density
19. $\frac{X_B}{1 - X_B} = \frac{\text{molality} \times M_A}{1000}$ where M_A - mass of solvent

Chap-02 - Structure of Atom

Formulae Chart

1. **Atomic number (Z)** = Number of protons in the nucleus of an atom
= Number of electrons in a neutral atom
2. **Mass number (A)** = Number of protons + Number of neutrons
3. **Number of neutrons** = A – Z
4. Speed of light is equal to the product of frequency and wavelength of light
$c = \nu\lambda$
5. Energy of quantum of radiation according to Planck's quantum theory $E = h\nu$.
6. $h\nu = h\nu_0 + \frac{1}{2}m_e v^2$. Einstein's photoelectric equation
7. **Line spectrum of hydrogen**
$\bar{\nu} = 109677\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) cm^{-1}$ where $\bar{\nu}$ is wave number and $\bar{\nu} = \frac{1}{\lambda}$.
where $n_1 = 1, 2, ...$
$n_2 = n_1 + 1, n_1 + 2, ...$
8. **Bohr's model of hydrogen atom**
(a) **Frequency** of radiation absorbed or emitted during transition; $\nu = \frac{\Delta E}{h}$
$\nu = \frac{E_2 - E_1}{h}$
E_1 = Energy of lower energy state
E_2 = Energy of higher energy state
(b) **Orbit angular momentum** of an electron, $m_e vr = n \cdot \frac{h}{2\pi}$; n = 1, 2, 3, ...
(c) **Energy** of stationary states $E_n = -2.18 \times 10^{-18}\left(\frac{Z^2}{n^2}\right) J$
(d) **Radii** of the stationary states/orbits $r_n = 52.9 \times \left(\frac{n^2}{Z}\right) pm$
9. Energy gap between the two orbits
$\Delta E = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$ where $R_H = 2.18 \times 10^{-18}$
Where, n_i = initial orbit
n_f = final orbit

10. Wavelength of matter wave
$\lambda = \frac{h}{mv}$; $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2Em}}$ where E = Kinetic Energy
11. Heisenberg's uncertainty principle
$\Delta x \times \Delta p \geq \frac{h}{4\pi}$; $\Delta x \times m\Delta v \geq \frac{h}{4\pi}$
12. Number of subshells in n^{th} shell = n
Number of orbitals in n^{th} shell = n^2
Number of electrons in n^{th} shell = $2n^2$
Number of orbitals in subshell = 2l + 1
Number of electrons in subshell = 2(2l + 1)
13. Total number of nodes = n – 1
Radial nodes = n – l – 1
Angular nodes = l

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Chap-03 - States of Matter

Formulae Chart

1. **Boyle's Law :** $P_1V_1 = P_2V_2$ (at constant T and n)
2. **Charles' Law :** $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (at constant P and n)
3. **Avogadro's Law :** V = kn (at constant P and T)
4. **Ideal gas equation :** PV = nRT
$M = \frac{dRT}{P}$
5. **Combined Gas Equation :** $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$; (n, R constant)
6. **Dalton's Law of partial pressures :** $P_{Total} = P_1 + P_2 + P_3 + ...$
7. **Partial Pressure in Terms of Mole Fraction :** $P_i = x_i P_{total}$
8. **van der Waals Equation :** $\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$
9. Compressibility factor $Z = \frac{PV}{RT}$ (for 1 mole of Gas)

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Chap-04 - Thermodynamics

Formulae Chart

- **Energy changes** $\Delta U = q_v$, $\Delta H = q_p$
q_v → heat exchange at constant volume
q_p → heat exchange at constant pressure
- **Enthalpy**
H = U + pV
- **Relation between ΔH and ΔU**
$\Delta H = \Delta U + p\Delta V$
or $\Delta H = \Delta U + \Delta n_g RT$
- **Heat capacity** $C = \frac{q}{\Delta T}$
specific heat capacity $c_s = \frac{q}{m\Delta T}$
molar heat capacity $c_m = \frac{q}{n\Delta T}$
- **First law of thermodynamics**
$\Delta U = q + W$
- **Enthalpy of reaction**
$\Delta H = \Sigma\Delta_f H°$ (products) – $\Sigma\Delta_f H°$ (reactants)
By convention heat of formation of every element in its standard state is arbitrarily assumed to be zero.
$\Delta_{sub}H° = \Delta_{fus}H° + \Delta_{vap}H°$
- $C_p - C_v = R$
$\Delta S = \frac{q_{rev}}{T}$
$\Delta G = \Delta H - T\Delta S$
$\Delta G° = -RT \ln K$

Atomicity	γ	Cp	Cv
Monoatomic	5/3	5R/2	3R/2
Diatomic	7/5	7R/2	5R/2
Triatomic non linear	4/3	4R	3R

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Chap-05 - Equilibrium

Formulae Chart

1. Equilibrium constant, $K_{eq} = \frac{K_f}{K_b}$
2. $K_p = K_c(RT)^{\Delta n}$
3. Concentration quotient, $Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$
4. $\Delta G° = -2.303\ RT \log K$
5. $K_i = \frac{[A^+][B^-]}{[AB]}$
6. $K_w = [H^+][OH^-] = 10^{-14}$ at 25°C
7. $pH = -\log[H^+]$
8. $pK_w = pH + pOH = 14$ at 25°C
9. $K_a = \frac{[A^-][H_3O^+]}{[HA]}$
$K_b = \frac{[B^+][OH^-]}{[BOH]}$
10. K_a or $K_b = c\alpha^2$
11. $K_w = K_a \times K_b$
12. Hydrolysis of salts
(i) For a salt of strong acid and weak base
$pH = \frac{1}{2}[pK_w - pK_b - \log c]$
(ii) For a salt of weak acid and strong base
$pH = \frac{1}{2}[pK_w + pK_a + \log c]$
(iii) For salts of weak acid and weak base
$pH = \frac{1}{2}[pK_w + pK_a - pK_b]$
13. $K_{sp} = [A^{y+}]^x[B^{x-}]^y$

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Chap-06 - Solid State

Formulae Chart

1. **Packing Fraction (p.f.)** $= \frac{\text{Volume occupied by particles (per unit cell)}}{\text{Volume of unit cell}}$
Contribution of each atom present on the corner $= \frac{1}{8}$
Contribution of each atom present on the centre of face $= \frac{1}{2}$
Contribution of each atom present on the body centre = 1
Contribution of each atom present on the edge centre $= \frac{1}{4}$
2.

Crystal	Radius of atom(r)	No. of atoms per unit cell	p.f.
Simple Cubic	$\frac{a}{2}$	1	52.4%
F.C.C.	$\frac{a}{2\sqrt{2}}$	4	74%
B.C.C.	$\frac{\sqrt{3}}{4}a$	2	68%

3. Density of Cubic Crystal Systems
ρ (or d) $= \frac{Z \times M}{a^3 \times N_A} g.cm^{-3}$
Z = number of atoms per unit cell
N_A = Avogadro's Number
M = Gram atomic weight of element $(g.mol^{-1})$
a = edge - length
5. **Radius-ratio in ionic solids**

Voids	Triangular	Tetrahedral	Octahedral	Cubical
Radius-ratio	$0.155 \leq \frac{r^+}{r^-} < 0.225$	$0.225 \leq \frac{r^+}{r^-} < 0.414$	$0.414 \leq \frac{r^+}{r^-} < 0.732$	$0.732 \leq \frac{r^+}{r^-} < 0.999$

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Chap-07 - Solutions

Formulae Chart

1. Molality (m) $= \frac{\text{Number of moles of solute}}{\text{Weight of solvent (kg)}}$ mole / Kg
Molarity(M) $= \frac{\text{Number of moles of solute}}{\text{Volume of solution (L)}}$ mole / L
Normality (N) $= \frac{\text{Number of gram equivalent of solute}}{\text{Volume of solution (L)}}$ g equiv / L
Formality (F) $= \frac{\text{Number of gram formula mass}}{\text{Volume of solution (L)}}$
PPM = mole fraction × 10^6 = mass fraction × 10^6
2. **Henry's law**
$p = K_H.X$
p = partial pressure of gas in vapour phase
K_H = Henry's law constant
X = Mole fraction of gas
3. $P_{sol} = P_A^o X_A + P_B^o X_B = (P_B^o - P_A^o)X_B + P_A^o$ Raoult's Law
4. $Y_A = \frac{P_A}{P_T}$; $Y_B = \frac{P_B}{P_T}$
where Y_A and Y_B are mole fractions in vapour phase and $P_A = P_A^o X_A$; $P_B = P_B^o X_B$
5. $\frac{1}{P_{sol}} = \frac{Y_A}{P_A^o} + \frac{Y_B}{P_B^o}$
6. **Relative lowering of vapour pressure**
$\frac{P_A^o - P}{P_A^o} = \chi_B$ {χ_B = mole fraction of solute}
7. **Osmotic pressure**
$\pi = CRT$
For isotonic solution, $\pi_1 = \pi_2$
8. **Elevation of boiling point**
$\Delta T_b = K_b \times m$
$K_b = \frac{RT_b^2}{1000\ l_{vapour}} = \frac{M_A RT_b^2}{1000\ \Delta H_{vapour}}$ where m = molality, M_A = molecular mass of sovlent
9. **Depression in freezing point**
$\Delta T_f = K_f \times m$

$K_f = \frac{RT_f^2}{1000\ l_{fusion}} = \frac{M_A RT_f^2}{1000\ \Delta H_{fusion}}$

10. **van't Hoff factor**
$i = \frac{\text{Experimental colligative property (observed)}}{\text{Calculated (normal) colligative property}}$
$\frac{P_A^o - P}{P_A^o} = \frac{(i \times n_B)}{(i \times n_B) + n_A}$
$\Delta T_b = i \times K_b \times m$
$\Delta T_f = i \times K_f \times m$
$\pi = iCRT$
11. **Association of solute**
$nA \rightarrow (A)_n$
$i = \frac{(1 - \alpha) + \frac{\alpha}{n}}{1}$ {α = degree of association}
12. **Dissociation of solute**
$(A)_n \rightarrow nA$
$i = \frac{1 + (n - 1)\alpha}{1}$ {α = degree of dissociation}

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Chap-08 - Electrochemistry

Formulae Chart

1. **Ohm's law** ⇒ V = RI
$R = \rho\frac{\ell}{a}$
V = Potential difference
R = Resistance
I = Current
ρ = Specific resistance (resistivity)
ℓ, a = length and cross-section area of conductor
2. **Conductance** $G = \frac{1}{R}$
Specific conductance (conductivity) $\kappa = \frac{1}{\rho}$
3. **Cell constant** $\sigma = \frac{\ell}{a}$
$\kappa = G.\sigma$
4. **Molar conductance** Λ_M (or Λ_C) $= \frac{1000 \times \kappa}{C\ (\text{or } M)}$ {C = concentration of electrolyte in terms of molarity}
5. **Equivalent conductance** Λ_N (or Λ_C) $= \frac{1000 \times \kappa}{C\ (\text{or } N)}$ {C = concentration (normality)}
$\Lambda_M = \Lambda_N \times$ (n-factor)
$\Lambda_0 = \lim_{C \to 0} \Lambda_C$ {Λ_0 = equivalent conductance at infinite dilution (or zero concentration)}
6. For weak electrolyte, $\Lambda_C \propto \frac{1}{\sqrt{C}}$
For strong electrolyte, $\Lambda_C = \Lambda_0 - B(C)^{1/2}$ {B = constant}
7. **At infinite dilution**, for an electrolyte A_xB_y,
$A_xB_y \rightleftharpoons xA^{y+} + yB^{x-}$
$\Lambda^o_{A_xB_y} = x\lambda_A^o + y\lambda_B^o$ {λ_A^o, λ_B^o = equivalent conductance at infinite dilution of cation and anion}
$= x\lambda_+^o + \lambda_-^o$
$\lambda_C^o = k\mu_C^o$ {μ = ionic mobility, K = 96500 coulomb}
$\mu = \frac{\text{Ionic velocity}}{\text{Potential gradient}}$

8. For a weak electrolyte, ($CH_3COOH \rightleftharpoons CH_3COO^- + H^+$)
Degree of dissociation, $\alpha = \frac{\Lambda_M}{\Lambda_0}$, $K_{eq} = \frac{C(\Lambda_M/\Lambda_0)^2}{1 - (\Lambda_M/\Lambda_0)}$
9. For solubility of a salt ($AgCl \rightleftharpoons Ag^+ + Cl^-$)
$K_{sp} = \left(\frac{1000K}{\Lambda_0}\right)^2$
10. For a **cell reaction** in an electrochemical cell,
$Zn + CuSO_4 \rightleftharpoons Cu + ZnSO_4$
Cell representation ⇒ $\underset{\text{Anode}(-)}{Zn|Zn^{2+}(aq.)}||\underset{\text{Cathode}(+)}{Cu^{2+}(aq.)|Cu}$
11. For **half cell reaction** $M \rightarrow M^{n+}(aq.) + ne^{(-)}$; $E_{OX} = E_{M/M^+}$
$M^{n+}(aq) + ne^- \rightarrow M$; $E_{red} = E_{M^+/M}$
emf of cell, $E^o_{cell} = E^o_{right} - E^o_{left}$
$= E^o_{\underset{(R.P.)}{cathode}} - E^o_{\underset{(R.P.)}{anode}}$ {R.P. = Reduction potential}
12. $\Delta G = -nFE_{cell}$
$= -W$
$= \Delta G° + 2.303\ RT \log Q$
$\Delta G° = -nFE^o_{cell}$
$E_{cell} = E^o_{cell} - \frac{2.303RT}{nF}\log Q$
At room temperature (25°C)
ΔG = Change in free energy
W = Useful work done
n = Number of electrons exchanged
F = Faraday constant (96500 coulomb)
Q = Reaction quotient
⇒ **Nernst's equation** ⇒ $E_{cell} = E^o_{cell} - \frac{0.0591}{n}\log Q$
13. **For electrode concentration cell**, $(\underset{anode}{Pt, H_2(P_1)}|H^+||\underset{cathode}{H_2(P_2), Pt})$
$E_{cell} = \frac{0.0591}{2}\log\frac{P_1}{P_2}$ (P = Pressure)
For electrolyte concentration cell $(\underset{anode(-)}{Cu|Cu^{2+}(C_1)}||\underset{cathode(+)}{Cu^{2+}(C_2)|Cu})$
$E_{cell} = \frac{0.0591}{2}\log\frac{C_2}{C_1}$
For concentration cells, $E^o_{cell} = 0$
14. At equilibrium, $E_{cell} = 0$ (as ΔG = 0)
15. **Temperature coefficient** (T.C.) $= \left(\frac{\partial}{\partial T}E_{cell}\right)_P$

Change in entropy, ΔS = +nF × (T.C.) {ΔH = heat of cell-reaction}
$E_{cell} = \left(\frac{-\Delta H}{nF}\right) + T.(T.C.)$
T.C. > 0 ⇒ Cell-reaction is endothermic and vice-versa.
16. **Faraday's 1st law of electrolysis**
m = Zit
m = mass of substance deposited
Z = electrochemical equivalent
i = current
t = time
$Z = \frac{\text{Atomic mass}}{n \times F}$
Faraday's 2nd law of electrolysis
$\frac{m_1}{m_2} = \frac{E_1}{E_2}$ (E = equivalent weight)
17. **Oxidation potential** for half-cell reaction : $M \rightarrow M^{n+} + ne^-$
$E_{ox} = E^o_{ox} - \frac{2.303}{nF}\log[M^{n+}]$
Reduction potential for half-cell reaction : $M^{n+} + ne^- \rightarrow M$
$E_{red} = E^o_{red} - \frac{2.303RT}{nF}\log\frac{1}{[M^{n+}]}$

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Chap-09- Chemical Kinetics and Nuclear Chemisty

Formulae Chart

1. For a general chemical transformation
$nA + mB \rightarrow pC + qD$
Rate $= \frac{-1}{n}\frac{d[A]}{dt} = \frac{-1}{m}\frac{d[B]}{dt} = \frac{1}{p}\frac{d[C]}{dt} = \frac{1}{q}\frac{d[D]}{dt}$
2. For elementary chemical reaction
$mA + nB \rightarrow$ Products
Theoretical rate $= \frac{dx}{dt} = k[A]^m \times [B]^n$
3. For a general reaction: $aA + bB \rightarrow$ Products
Rate $= \frac{dx}{dt} = k[A]^m[B]^n$
Order of reaction w.r.t. A = m overall order of reaction = (m + n)
Order of reaction w.r.t. B = n
4. Unit of rate constant = $(mole)^{1-n}(litre)^{n-1}\ time^{-1}$
where, n = order of reaction
5. For a zero order reaction: A → B
Rate $= \frac{-d[A]}{dt} = k[A]^0 = k$ (constant) $K = \frac{[A_0] - [A]}{t}$
6. For a first order reaction: A → B
Rate $= \frac{-d[A]}{dt} = k[A]$
$k = \frac{2.303}{t}\log\frac{[A]_0}{[A]_t} = \frac{2.303}{t}\log\left(\frac{a}{a - x}\right)$
7. For a zero order reaction, $t_{1/2} = \frac{[A]_0}{2k}$
For a first order reaction, $t_{1/2} = \frac{0.693}{k}$
For an nth order reaction, $t_{1/2} \propto \frac{1}{[A]_0^{n-1}}$ (for n ≥ 2)
8. For a parallel reaction
$A \xrightarrow{k_B} B$, $A \xrightarrow{k_C} C$
$\frac{-d[A]}{dt} = (k_B + k_C)[A]$
9. For a first order reaction : A → B + C, a reagent reacts with all A, B and C
$k = \frac{2.303}{t}\log\left(\frac{V_\infty - V_0}{V_\infty - V_t}\right)$ (V = vol. of reagent)

10. Temperature coefficient $= \frac{k_{t+10°C}}{k_t}$
Arrhenius equation, $k = Ae^{-E_a/RT}$
$\log\frac{k_2}{k_1} = \frac{E_a}{(2.303\ R)}\left(\frac{T_2 - T_1}{T_1T_2}\right)$
A = Arrhenius's constant
E_a = Activation energy
$\log k = \log A - \frac{E_a}{2.303\ RT}$
12. Binding energy, B.E. = Δm × 931.5 MeV
Δm = mass defect = calculated At. mass – observed At. mass
B.E. per nucleon $= \frac{\text{B.E. (total)}}{\text{mass number}}$
1 MeV = 9.6×10^{10} Joule mol^{-1}
13. Packing fraction, P.F. $= \frac{\text{Isotopic atomic mass - mass no.}}{\text{mass number}} \times 10^4$
14. In a radioactive decay, $N_t = N_0 e^{-\lambda t}$
Amount of radioactive substance after 'n' half-life periods
$N = \left(\frac{1}{2}\right)^n N_0$
15. Activity, $A_t = A_0 e^{-\lambda t}$, $A = \lambda N$

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Chap-10 - Surface Chemistry

Formulae Chart

1. **Freundlich Adsorption Isotherm**
$\left(\frac{x}{m}\right) = Kp^{1/n}$; n ≥ 1
2. **Langmuir Adsorption Isotherm**
$\theta = \frac{KP}{1 + KP}$
or, $\frac{x}{m} = \frac{aP}{1 + bP}$ or $\frac{m}{x} = \frac{1}{a}\cdot\frac{1}{P} + \frac{b}{a}$
3. $\frac{x}{m} = KC^{1/n}$; C = Concentration of solute in solution.
4. Zeta potential, $Z = \frac{4\pi\eta u}{D}$

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Chap-11 - Hydrogen

Formulae Chart

1. At. wt. of H $= \frac{\%\ H^1 \times 1 + \%\ H^2 \times 2 + \%\ H^3 \times 3}{100}$
2. Vapour density of a gas $= \frac{\text{molar mass of gas}}{\text{molar mass of } H_2}$
LHS and RHS both are unitless
3. Molecular wt. = 2 × (V.D.)
4. Vol. strength of H_2O_2 = Molarity × 11.2
= Normality × 5.6

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Chap-12 - S-Block Elements

Formulae Chart

1. General Electronic Configuration ns^{1-2}
2. Atomic Radii increases down the group
3. Hydration enthalpy decreases down the group
4. Ionisation enthalpy decreases down the group
5. On reaction with oxygen give oxide, peroxide and superoxides.
6. On reaction with water produces hydroxide and hydrogen
7. Some important compounds and their general names.

Name	Chemical Formula	Prepared by
Caustic Soda	NaOH	Electrolysis in costner kellner cell
Washing Soda	$Na_2CO_3.10H_2O$	Solvay's Process
Baking Soda	$NaHCO_3$	Solvay's Process
Glauber's Salt	$Na_2SO_4.10H_2O$	NaCl + H_2SO_4
Microcosmic salt	$Na(NH_4)HPO_4$	$NH_4Cl + Na_2HPO_4$
Potash or Pearl Ash	K_2CO_3	Leblanc Process
Caustic Potash	KOH	Electrolysis of KCl
Quick Lime	CaO	Decomposition of $CaCO_3$
Slaked lime	$Ca(OH)_2$	Hydrolysis of CaO
Gypsum	$CaSO_4.2H_2O$	$CaCl_2 + H_2SO_4$
Plaster of Paris	$CaSO_4.\frac{1}{2}H_2O$	by heating gyposum

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Chap-13 - P-Block Elements

Formulae Chart

1. In general metallic character, electropositive character, atomic radii, basic character, reducing character decreases on moving left to right in a period and increases down the group.
2. Some important compounds of p-block elements
Borax (Tincal) $Na_2B_4O_7.10H_2O$
Colemanite $Ca_2B_6O_{11}.5H_2O$
Kernite $Na_2B_4O_7.4H_2O$
Sassolite or boric acid H_3BO_3
Diborane B_2H_6
Borazole $B_3N_3H_6$
Alumina Al_2O_3
Lithium aluminium hydride $LiAlH_4$
Potash Alum $K_2SO_4.Al_2(SO_4)_3.24H_2O$

Chap-14 - Coordination Compound

Formulae Chart

1. **Magnetic moment**, $\mu = \sqrt{n(n+2)}$ B.M.
2. $\Delta_t(CFSE) = [(-4 \times n_{t_{2g}}) + (+6 \times n_{e_g})]Dq$
3. $\Delta_o(CFSE) = [(-4 \times n_{t_{2g}}) + (+6 \times n_{e_g})]Dq$
4. $\Delta_t = \frac{4}{9}\Delta_o$
5. For the reaction : $M + 4L \rightleftharpoons ML_4$, overall stability constant of complex (ML_4) is $\beta_4 = \frac{[ML_4]}{[M][L]^4}$
6. $\underset{\text{(of metal atom/ion)}}{EAN} = Z - O.N. + 2(C.N.)$

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Chap-15_Organic Chemistry

Formulae Chart

Relations for the estimation of elements in organic compounds.

$\%\ of\ C = \frac{12}{44} \times \frac{\text{Mass of } CO_2 \text{ formed}}{\text{Mass of the compound}} \times 100$

$\%\ of\ H = \frac{2}{18} \times \frac{\text{Mass of } H_2O \text{ formed}}{\text{Mass of the compound}} \times 100$

$\underset{\text{(Dumas method)}}{\%\ of\ N} = \frac{28}{22400} \times \frac{\text{Volume of } N_2 \text{ at NTP}}{\text{Mass of compound}} \times 100$

$\underset{\text{(Kjeldahl's method)}}{\%\ of\ N} = \frac{1.4 \times \text{Normality of acid used} \times \text{Volume of acid used}}{\text{Mass of the compound}}$

$\%\ of\ X(Halogens) = \frac{\text{At. mass of X}}{(108 + \text{At. mass of X})} \times \frac{\text{Mass of Agx formed}}{\text{Mass of the compound}} \times 100$

$\%\ of\ S = \frac{32}{233} \times \frac{\text{Mass of } BaSO_4 \text{ formed}}{\text{Mass of the compound}} \times 100$

$\%\ of\ P = \frac{62}{222} \times \frac{\text{Mass of } Mg_2P_2O_7 \text{ formed}}{\text{Mass of the compound}} \times 100$

1. Inductive effect
(+I efffect) $CH_3 < C_2H_5 < C_3H_7 < R_2CH < R_3C < -\dot{O}-R$
(–I efffect) $R_4N > NO_2 > -CN > SO_3H > COOH > -F > Cl > 1 > -OR > -OH > -NH_2 > -C_6H_5$
2. Relative basic strength in aqueous medium.

$R = CH_3$	2° > 1° > 3° > NH_3
$R = C_2H_5$	2° > 3° > 1° > NH_3
Me_2CH	1° > NH_3 > 2° > 3°
M_3C	NH_3 > 1° > 2° > 3°

3. Stability of free radical
$\underset{3°}{Me_3\dot{C}} > \underset{2°}{Me_2\dot{C}H} > \underset{1°}{Me\dot{C}H_2} > \underset{1°}{\dot{Me}}$
4. Heat of hydrogentation of alkenes
1-butene > cis-2-butene > trans-2-butene

5. Leaving nature in, Nucleophilic substitution reaction
$ArSO_3^- > ROSO_2^- > CH_3COO^- > CN^- > O^-H > MeO^- > H^- > R^-$
6. Number of product formed during crossed aldol condensation

S.No.	Carbonyl Compound (I)	Carbonyl Compound (II)	Self Condensation Product	Cross Condensation Product	Total Product
1	One type of similar α H-atom $CH_3-C(=O)-H$	One type of similar α H-atoms CH_3-CH_2-CHO	2	2	4
2	Two different types of dissimilar α H-atoms $CH_3-COCH_2CH_3$	One type of similar α H-atoms CH_3-CH_2-CHO	3	3	6
3	Two different types of dissimilar α H-atoms $CH_3CO-CH_2-CH_3$	Two different types of dissimilar α H-atoms $PhCH_2-CO-CH_2-CH_3$	4	4	8

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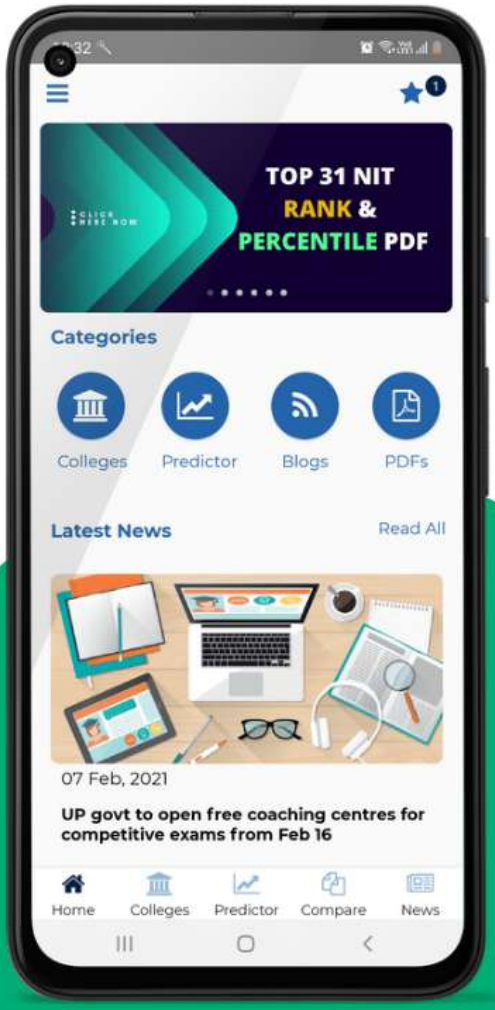

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