

CHEMISTRY (862)

Aims:

1. To foster acquisition of knowledge and understanding of terms, concepts, facts, processes, techniques and principles relating to the subject of Chemistry.
2. To develop the ability to apply the knowledge of contents and principles of Chemistry in new or unfamiliar situations.
3. To develop skills in proper handling of apparatus and chemicals.
4. To develop an ability to appreciate achievements in the field of Chemistry and its role in nature and society.
5. To develop an interest in activities involving usage of the knowledge of Chemistry.
6. To develop a scientific attitude through the study of Physical Sciences.
7. To acquaint students with the emerging frontiers and interdisciplinary aspects of the subject.
8. To develop skills relevant to the discipline.
9. To apprise students with interface of Chemistry with other disciplines of Science, such as, Physics, Biology, Geology, Engineering, etc.

CLASS XI

There will be two papers in the subject.

Paper I: Theory- 3 hours ... 70 marks

Paper II: Practical - 3 hours ... 15 marks

Project Work ... 10 marks

Practical File ... 5 marks

PAPER 1- THEORY: 70 Marks

There will be no overall choice in the paper. Candidates will be required to answer **all** questions. Internal choice will be available in two questions of 2 marks each, two questions of 3 marks each and all the three questions of 5 marks each.

S.No.	UNIT	TOTAL WEIGHTAGE
1.	Some Basic Concepts of Chemistry	Physical Chemistry 32 Marks
2.	Structure of Atom	
3.	Classification of Elements and Periodicity in Properties	
4.	Chemical Bonding and Molecular Structure	
5.	States of Matter: Gases and Liquids	
6.	Chemical Thermodynamics	
7.	Equilibrium	
8.	Redox Reactions	Inorganic Chemistry 15 Marks
9.	Hydrogen	
10.	s -Block Elements	
11.	Some p -Block Elements	Organic Chemistry 23 Marks
12.	Organic Chemistry: Some basic Principles and Techniques	
13.	Hydrocarbons	
14.	Environmental Chemistry	
TOTAL		70 Marks

PAPER I –THEORY – 70 Marks

1. Some Basic Concepts of Chemistry

General introduction: Importance and scope of chemistry.

Study of matter. Understanding laws of chemical combination. Dalton's atomic theory: concept of elements, atoms and molecules.

Isotopic (atomic) and molecular masses, mole concept and molar mass, percentage composition, empirical and molecular formula. Stoichiometry and calculations based on chemical reactions.

(i) Precision and accuracy:

Quantities and their measurements in Chemistry, significant figures, SI units.

(ii) Dimensional analysis:

Conversion of units, numericals and applications of units.

(iii) The concept of atoms having fixed properties in explaining the laws of chemical combination.

Study about atoms. Dalton's atomic theory: Main postulates of the theory; its limitations.

Laws of chemical combinations:

- Law of conservation of mass.
- Law of definite proportions.
- Law of multiple proportions.
- Law of reciprocal proportions.
- Gay Lussac's law of gaseous volumes.

Statement, explanation and simple problems based on these laws.

(iv) Atomic (isotopic masses) and molecular mass.

Relative molecular mass and mole:

The atomic mass unit is one of the experimentally determined unit. It is equal to 1/12 of the mass of the carbon 12 isotope.

Numerical problems based on mole concept, Avogadro's number and gram molecular volume.

(v) Empirical and molecular formula: Numericals based on the above.

(vi) Chemical equivalents, volumetric calculations in terms of normality. $C = 12.00$ should be taken as a standard for expressing atomic masses.

Equivalent weight expressing the combining capacity of the elements with the standard elements such as H, Cl, O, Ag, etc.

Variable equivalent weight. Gram equivalent weights, relationship between gram equivalent weight, gram molecular mass and valency.

Determination of equivalent weight of acids, alkalis, salts, oxidising and reducing agents. (experimental details not required).

Terms used in volumetric calculations such as percentage (w/w and w/v), normality, molarity, molality, mole fraction, etc. should be discussed. Students are required to know the formulae and normality and molarity equations.

Simple calculations on the above topics.

(vii) Chemical reactions – stoichiometric calculations based on mass-mass, mass-volume, volume-volume relationships and limiting reagent.

2. Structure of Atom

Discovery of fundamental particles electron, proton and neutron), atomic number, isotopes and isobars. Thomson's model and its limitations. Rutherford's experimental model and its limitations. Dual nature of matter and light. Bohr's atomic model and its limitations (de Broglie's equation, Heisenberg's uncertainty principle), concept of shells, subshells, 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 of maximum multiplicity. Electronic configuration of atoms, stability of half-filled and completely filled orbitals.

(i) Subatomic particles (electrons, protons and neutrons) their charges and masses: Concept of indivisibility of atom as proposed by Dalton does not exist. The atom consists of subatomic fundamental particles. Production of cathode rays and their properties. Production of anode rays and their properties.

Chadwick's experiment for the discovery of neutron and properties of neutron.

- (ii) Rutherford's nuclear model based on the scattering experiment: Rutherford's scattering experiment. Discovery of nucleus. Rutherford's nuclear model of atom. Defects of Rutherford's model. Electromagnetic wave theory and its limitations (Black body radiation and photoelectric effect) Planck's quantum theory. Numericals based on the above.
- (iii) Types of spectra: emission and absorption spectra. Band and line spectra to be discussed.
- (iv) Bohr's atomic model.
Postulates of Bohr's theory – based on Planck's quantum theory.
Merits of Bohr's atomic model and explanation of hydrogen spectra.
Calculations based on Rydberg's formula.
Numericals on Bohr's atomic radii, velocity and energy of orbits (derivation not required).
Defects in Bohr's Model.
- (v) Quantum mechanical model of an atom - a simple mathematical treatment. Quantum numbers; shape, size and orientation of s, p and d orbitals only (no derivation). aufbau principle, Pauli's exclusion principle, Hund's rule of maximum multiplicity. Electronic configuration of elements in terms of s, p, d, f subshells.
- de Broglie's equation. Numericals.
 - Heisenberg's Uncertainty Principle. Numericals.
 - Schrodinger Wave Equation – physical significance of j and j^2 .
 - Quantum numbers – types of quantum numbers, shape, size and orientation of the s, p and d subshells. Information obtained in terms of distance of electron from the nucleus, node, nodal planes and radial probability curve, energy of electron, number of electrons present in an orbit and an orbital.
 - aufbau principle, $(n+1)$ rule.
 - Pauli's exclusion principle.
 - Hund's rule of maximum multiplicity.
 - Electronic configuration of elements and ions in terms of s, p, d, f subshells and stability of half-filled and completely filled orbitals.

3. Classification of Elements and Periodicity in Properties

Significance of classification; study of Mendeleev's periodic law and its limitations; Modern Periodic Law and the present form of periodic table leading to periodic trends in properties of elements - atomic radii, ionic radii, valency, ionisation enthalpy, electron gain enthalpy, electronegativity. Nomenclature of elements with atomic number greater than 100.

(i) Modern Periodic Law

Mendeleev's periodic law, defects in the Mendeleev's periodic table. Advantages and disadvantages. Modern periodic law (atomic number taken as the basis of classification of the elements).

(ii) Long form of Periodic Table.

General characteristics of groups and periods. Division of periodic table as s, p, d and f blocks. IUPAC nomenclature for elements with $Z > 100$.

(iii) Periodic trends in properties of elements.

Atomic radius, ionic radius, ionisation enthalpy, electron gain enthalpy, electronegativity, metallic and non-metallic characteristics.

- Periodic properties such as valence electrons, atomic and ionic radii and their variation in groups and periods.
- The idea of ionisation enthalpy, electron gain enthalpy and electronegativity must be given and their variation in groups and periods may be discussed.
- The factors (atomic number, screening effect and shielding effect, the number of electrons in the outermost orbit) which affect these periodic properties and their variation in groups and periods.

(iv) Periodic trends in chemical properties – periodicity of valence or oxidation states. Anomalous properties of second period elements.

Diagonal relationship; acidic and basic nature of oxides.

NOTE: Recommendations of the latest IUPAC for numbering of groups to be followed. Numbering 1 – 18 replacing old notation of I – VIII. Details given at the end of the syllabus.

4. Chemical Bonding and Molecular structure

Valence electrons, ionic bond character, covalent bond of ionic bond, covalent bond, bond parameters, lewis structure, polar character of covalent bond, VSEPR theory, geometry of covalent molecules, valence bond theory, concept of hybridisation involving s, p and d orbitals and shapes of some simple molecules. Coordinate bond. Molecular orbital theory of homonuclear diatomic molecules (qualitative idea only). Resonance and hydrogen bond.

(i) *Kossel-Lewis approach to chemical bonding. Octet rule, its application to electrovalent and covalent bonds.*

(ii) *Electrovalent or ionic bond: Lewis structures of NaCl, Li₂O, MgO, CaO, MgF₂, and Na₂S.*

Definition of ionic bond.

The conditions necessary for the formation of ionic bonds such as:

- *low ionisation enthalpy of metals.*
- *high electron gain enthalpy of non-metals.*
- *high lattice energy.*
- *electronegativity difference between the reacting atoms.*

All these points must be discussed in detail.

The formation of cations and anions of elements and their positions in the periodic table.

Variable electrovalency; reasons for variable electrovalency i.e, due to inert electron pair effect and unstable core, by using suitable examples.

Calculation of lattice enthalpy (Born-Haber cycle).

Characteristics of electrovalent bond.

(iii) *Covalent Bond – Bond parameters, Lewis structure, polar character of covalent bond, shapes.*

Sigma and pi bonds e.g. formation of ammonia, nitrogen, ethene, ethyne, and carbon dioxide.

Definition of covalent bond, conditions for formation of covalent bonds, types of covalent bonds, i.e single, double and triple bonds.

Sigma and pi bonds: H₂, O₂, N₂.

Classification of covalent bonds based on electronegativity of atoms - polar and non-polar covalent bond, dipole moment.

Formation of CH₄, NH₃, H₂O, ethane, ethene, ethyne and CO₂, etc. and their electron dot structure or Lewis structure.

Characteristics of covalent compounds.

Comparison in electrovalency and covalency.

Reason for variable covalency e.g. Phosphorus 3 & 5 and sulphur 2, 4, 6 & chlorine 1, 3, 5 and 7.

Formal charge of ions.

(iv) *Deviation from octet rule and Fajan's rules.*

Definition of octet rule.

Failure of octet rule, due to either incomplete octet or exceeding of octet with suitable examples.

Fajan's rules: statements, conditions for electrovalency and covalency. Polar and non polar bonds should be correlated with Fajan's rules.

(v) *Valence Shell Electron Pair Repulsion (VSEPR) Theory; Hybridisation and shapes of molecules: hybridisation involving s, p and d orbitals only.*

Concept of electron-pair repulsion and shapes of molecules using suitable examples.

Hybridisation and molecular shapes – definition, hybridisation of orbitals involving s, p and d orbitals (using suitable examples).

(vi) *Molecular orbital theory: Qualitative treatment of homonuclear diatomic molecules of first two periods (hydrogen to neon), Energy level diagrams, bonding and antibonding molecular orbitals, bond order, paramagnetism of O₂ molecule. Relative stabilities of O₂, O₂⁻, O₂²⁻, O₂⁺ and N₂, N₂⁺, N₂⁻, N₂²⁻.*

(vii) *Co-ordinate or dative covalent bond, e.g. formation of oxy-acids of chlorine: Co-ordinate or dative covalent bonding: definition, formation of chlorous acid, chloric acid, perchloric acid, ammonium ion, hydronium ion, nitric acid, ozone.*

(viii) *Resonance in simple inorganic molecules: Resonance in simple inorganic molecules like ozone, carbon dioxide, carbonate ion and nitrate ion.*

(ix) *Hydrogen bonding: the examples of hydrogen fluoride, water (ice), alcohol, etc. may be considered.*

H-bonding – definition, types, condition for hydrogen bond formation, examples of inter-molecular hydrogen bonding in detail taking hydrogen fluoride, water and ice and ethanol into account. Intramolecular hydrogen bonding.

5. States of Matter: Gases and Liquids

States of matter and their characteristic properties to establish the concept of the molecule. Boyle's law, Charles law, Gay Lussac's law, Avogadro's law, Avogadro's number, ideal behaviour of gases and derivation of ideal gas equation. Kinetic Theory of gases, kinetic energy and molecular speeds (elementary idea). Deviation from ideal behaviour, van der Waal's equation, liquefaction of gases, critical temperature. Liquid state - vapour pressure, viscosity and surface tension (qualitative idea only, no mathematical derivations).

(i) *Intermolecular interactions (van der Waals forces), types of van der Waals forces, melting and boiling points.*

(ii) *The Gas Laws.*

Boyle's law, Charles' law, Absolute temperature, pressure temperature law, Avogadro's law and Avogadro's constant. Relationship between the mole and Avogadro's number.

Simple numerical problems based on the above laws.

(iii) *Dalton's law, Graham's law of diffusion.*

Dalton's law of partial pressures and its application.

Graham's Law of diffusion and its application.

Numerical problems based on the above.

(iv) *Ideal gas equation and application of this equation.*

Ideal gas equation $PV = nRT$; its application in calculation of relative molecular mass and in the calculation of the value of R.

(v) *Kinetic Theory of gases.*

Characteristics of gases, comparison between solid, liquid and gas. Properties of gases on the basis of kinetic theory of gases.

Postulates of kinetic theory must be discussed to explain gas laws. Concept of average, root mean square and most probable velocities (numericals not required). Non ideal behaviour of gases i.e. deviation from ideal gas equation may be discussed at low and at high temperature and pressure.

van der Waals' equation $(P + a/V^2)(V-b) = RT$ for one mole of a gas. (numericals not required). The pressure correction and volume correction may be explained. significance and units of 'a' and 'b' (van der Waals' constant). Liquefaction of gases, critical temperature.

(vi) *Liquid State - vapour pressure, viscosity and surface tension.*

Qualitative idea only, no mathematical derivations

6. Chemical Thermodynamics

(i) *Introduction, concepts, types of system, surroundings, extensive, intensive properties and state functions.*

Types of system – ideal system, real system, isolated system, closed system, open system. Meaning of surroundings.

Properties of the system: macroscopic, intensive and extensive properties.

State of the system.

Main processes the system undergoes: reversible, irreversible, adiabatic, isothermal, isobaric, isochoric, cyclic.

Meaning of thermodynamic equilibrium. Meaning of thermodynamic process.

- (ii) First Law of Thermodynamics and its significance, work, heat, internal energy, enthalpy (ΔU or ΔE and ΔH), heat capacity and specific heat. Hess's law of constant heat summation, enthalpy of bond dissociation, combustion, formation, atomisation, sublimation, phase transition, ionisation, solution and dilution.

Meaning of: internal energy of the system, work done by the system, by the surroundings at constant temperature, heat absorbed by the system and by the surroundings at constant temperature.

The sign convention for change in internal energy, heat given out or gained, work done by the system or by the surroundings.

State function and path function - meaning with examples. Internal energy change, work done and heat absorbed in a cyclic process.

Internal energy change in an isolated system and in a non-isolated system. Total internal energy change of a system and surroundings. Mathematical statement of the first law.

Significance of first law of thermodynamics. Need for enthalpy – constant pressure or open vessel processes. Enthalpy - a thermodynamic property, state function. Mathematical form of enthalpy.

Heat - the energy in transit. Conditions for the transfer of heat. Limitations in conversion of heat into work. Condition at which heat transfer ceases, unit of heat.

Meaning of work, capacity to do work, types of work. Mathematical form of reversible work and irreversible work. Difference between the reversible and irreversible work done – graphically.

Relationship between C_v and internal energy change. Relationship between C_p and C_v .

Definitions of the following:

Heat of reaction: Heat of formation – standard heat of formation, Heat of solution, Heat of dilution, Heat of neutralization, Heat of combustion.

Constancy in the heat of neutralisation:

Experimental verification in case of strong acids and strong bases. Reason for that observation – ionic neutralisation and the heat evolved.

Definition of Calorific value of a fuel.

Statement of Hess' Law and its application.

Problems based on Hess' Law.

- (iii) Second Law of Thermodynamics and its significance, spontaneity of a chemical change; Entropy, Free Energy. Inadequacy of First Law and need for Second Law; Ideas about reversible (recapitulation), spontaneous and non-spontaneous processes

Meaning of entropy – derived from Second Law – statement of Second Law in terms of entropy; Physical significance of entropy;

State function and not path function. Entropy change of the universe, reversible isothermal process and irreversible process.

Meaning of thermal death, Gibb's free energy of the system and Helmholtz free energy. Relationship between Gibb's free energy and Helmholtz's free energy.

Relationship between change in Gibb's free energy and equilibrium constant of a chemical reaction. Defining the criteria for spontaneity of a chemical change in terms of Gibb's free energy.

Note: Numericals based on the First Law, Second Law of Thermodynamics and Hess' Law.

- (iv) Third Law of Thermodynamics – statement only.

Self-explanatory.

7. Equilibrium

- (i) Chemical Equilibrium.

Introduction of physical and chemical equilibrium and its characteristics

Dynamic nature of equilibrium, law of mass action, equilibrium constant and factors affecting equilibrium. Le Chatelier's principle and its applications.

Irreversible and reversible reactions.

Physical equilibrium: solid-liquid, liquid-vapour, solid-vapour; Characteristics of Physical equilibrium.

Chemical equilibrium: Characteristics of chemical equilibrium; dynamic nature. Law of mass action; Equilibrium constant in terms of concentration K_c . Gaseous reactions; Equilibrium constant in terms of partial pressures K_p . Relationship between K_p and K_c (derivation required); Characteristics of equilibrium constant; Units for equilibrium constant; Simple calculations of equilibrium constant and concentration.

The following examples should be considered to show maximum yield of products:

- *Synthesis of ammonia by Haber's process.*
- *The dissociation of dinitrogen tetra oxide.*
- *Hydrolysis of simple esters.*
- *The contact process for the manufacture of sulphuric acid.*

Le Chatelier's Principle. Statement and explanation.

Factors affecting chemical and physical equilibria should be discussed in the light of Le Chatelier's principle.

- *Change of concentration.*
- *Change of temperature.*
- *Change of pressure.*
- *Effect of catalyst.*
- *Addition of inert gas.*

(ii) Ionic equilibrium

Introduction, electrolyte (strong and weak), non-electrolyte, ionisation, degree of ionisation of polybasic acids, acid strength, concept of pH, pH indicators, buffer solution, common ion effect (with illustrative examples). Henderson equation, hydrolysis of salts, solubility and solubility product.

Ostwald's dilution law and its derivation. Strength of acids and bases based on their

dissociation constant. Problems based on the Ostwald's dilution law.

Arrhenius, Brønsted-Lowry and Lewis concept of acids and bases, multistage ionisation of acids and bases with examples.

Ionic product of water – definition, pH, pOH, pK_w of solutions.

pH indicators and their choice in titrimetry.

Numericals on the above concepts.

Common ion effect – definition, examples (acetic acid and sodium acetate; ammonium hydroxide and ammonium chloride), applications in salt analysis.

Salt hydrolysis – salts of strong acids and weak bases, weak acids and strong bases, weak acids and weak bases and the pH formula of the solutions of these salts in water with suitable examples.

Buffer solutions: definition, examples, action; its interpretations based on Le Chatelier's principle. Henderson equation.

Solubility product: definition and application in qualitative salt analysis (Group II, III and IV cations).

Numericals on pH, buffer solutions, solubility and solubility product.

8. Redox Reactions

Concept of oxidation and reduction, redox reactions, oxidation number, change in oxidation number, balancing redox reactions (in terms of loss and gain of electrons). Applications of redox in various types of chemical reactions.

- *Concept of oxidation and reduction in terms of oxygen, hydrogen, electrons.*
- *Redox reactions – examples.*
- *Oxidation number: rules for calculation, simple calculations of oxidation state in molecules and ions like $K_2Cr_2O_7$, $S_2O_3^{2-}$, etc.*
- *Oxidation and reduction in terms of change in oxidation number.*
- *Balancing of redox reactions in acidic and basic medium by oxidation number and ion-electron method.*

9. Hydrogen

Hydrogen and its compounds: hydrides, water, heavy water, hydrogen peroxide.

Position of hydrogen in periodic table, occurrence, isotopes, preparation, properties and uses of hydrogen, hydrides (ionic covalent and interstitial); hydrogen as a fuel.

Physical and chemical properties of water, soft and hard water, and removal of hardness of water, heavy water.

Hydrogen peroxide:

Preparation from peroxide, structure, oxidising properties: reaction with KI, PbS, acidified FeSO₄; reducing properties – reaction with acidified KMnO₄ and chlorine. Calculation of strength of hydrogen peroxide.

10. s-Block Elements (Alkali and Alkaline Earth Metals)

(i) Group 1 and 2 elements

General characteristics of Group 1 and 2 should include the following:

Occurrence; physical state; electronic configuration; atomic and ionic radii; common oxidation state; electropositive / electronegative character; ionisation enthalpy; reducing/oxidising nature; distinctive behaviour of first member of each group (namely Lithium, Beryllium); nature of oxides, hydroxides, hydrides, carbonates, nitrates; chlorides, sulphates.

(ii) Preparation and properties of some important compounds.

Sodium chloride, sodium hydroxide, Sodium carbonate, sodium bicarbonate, sodium thiosulphate; biological importance of sodium and potassium.

Magnesium chloride hexahydrate, calcium oxide, calcium hydroxide, calcium carbonate, plaster of paris and cement. Industrial uses of the above, biological importance of magnesium and calcium.

Group 1:

- Sodium chloride - uses.
- Sodium hydroxide - only the principle of preparation by Castner-Kellner cell. Uses.

- Sodium carbonate – principal and equation of Solvay's process. Uses.
- Sodium bicarbonate - preparation from sodium carbonate. Uses.
- Sodium thiosulphate - preparation from sodium sulphite and its reaction with iodine, dilute acids and silver nitrate. Uses.

Group 2:

- Magnesium chloride hexahydrate - preparation from magnesium oxide. Effect of heat. Uses
- Calcium oxide - preparation from limestone; reaction with water, carbon dioxide and silica. Uses.
- Calcium hydroxide – preparation from calcium oxide and uses.
- Calcium carbonate – preparation from calcium hydroxide and uses.
- Plaster of Paris - preparation from gypsum. Uses.
- Manufacture of cement. Uses.

11. Some p -Block Elements

(i) 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.

(ii) Preparation and properties of some important compounds, borax, boric acid, boron hydrides, aluminium: Reactions with acids and alkalies. Lewis acid character of boron halides; amphoteric nature of aluminium, alums.

Borax- reaction with water and action of heat on hydrated compound (preparation not required).

Borax Bead Test.

Diborane - Preparation properties, structure and uses.

Boric acid – preparation and action of heat.

Aluminium: Reactions with acids and alkalies.

Alums – preparation and uses.

(iii) Group 14 Elements

General characteristics, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous behaviour of first elements.

Carbon-catenation, allotropic forms. Structure of diamond graphite and fullerene; stability of +2 oxidation state down the group in terms of inert pair effect.

(iv) Some important compounds; oxides of carbon and silicon, silicon carbide, silicon tetra chloride, silicones, silicates and zeolites.

Preparation and properties of:

Carbon monoxide - preparation from incomplete combustion of carbon. Hazards of CO. Reducing nature of CO.

Carbon dioxide - preparation from limestone and carbon, limewater test. Uses.

Silicon dioxide - structure, comparison with carbon dioxide. Uses.

Silicon carbide - preparation from silica. Uses.

Silicon tetra chloride - preparation from silicon and uses.

Silicones - general method of preparation. Uses.

Silicates – structure and uses.

Zeolites – formula and use.

12. Organic Chemistry - Some Basic Principles and Techniques

General introduction, classification and IUPAC nomenclature of organic compounds and isomerism.

Methods of purification, qualitative and quantitative analysis. Electron displacement in a covalent bond: inductive effect, electromeric effect, resonance and hyperconjugation.

Homolytic and heterolytic bond fission of a covalent bond: free radicals, carbocations, carbanions, electrophiles and nucleophiles, types of organic reactions.

(i) Introduction to organic chemistry:

Vital force theory, reason for separate study of organic chemistry and its importance, characteristics of carbon atoms (tetra valency), Reasons for large number of organic compounds: catenation, isomerism and multiple bonding, etc.

(ii) Classification of organic compounds: (definition and examples): open chain, closed chain, homocyclic, heterocyclic, aromatic, alicyclic compounds, homologous series and its characteristics, functional groups.

(iii) IUPAC rules for naming organic compounds. Aliphatic, alicyclic and aromatic compounds.

(iv) Definition and classification of isomerism:

Structural isomerism: definition, classification, examples.

Chain isomerism, Positional isomerism, Functional isomerism, Metamerism, Tautomerism - examples for each of the above.

Stereoisomerism: definition and classification, examples.

Geometrical isomerism: Definition. Conditions for compounds to exhibit geometrical isomerism; types and examples, cis and trans, syn and anti. Examples.

Optical isomerism: Definition, Nicol prism, plane polarised light. polarimeter. Method of measuring angle of rotation. Specific rotation. Conditions for optical activity. d, l form; External compensation, Internal compensation, racemic mixture & meso form. Examples – lactic acid and tartaric acid.

(v) Analysis of organic compounds:

Detection of elements (qualitative analysis) such as carbon, hydrogen, nitrogen, halogens and sulphur should be considered by using Lassaigne's test and reactions involved in it.

(vi) Estimation of carbon, hydrogen, nitrogen, halogens, sulphur and phosphorous:

Estimation of carbon and hydrogen – Leibig's method.

Estimation of nitrogen - Kjeldahl's method.

Estimation of halogens sulphur and phosphorous - Carius method. Numericals included. Experimental details required.

(vii) *Types of chemical reactions and their mechanisms.*

Substitution, addition, elimination reactions: definition and examples.

Homolytic and heterolytic fission – definition and examples. Free radicals, carbocation, carbanion (their reactivities and stabilities).

Electrophiles and nucleophiles – definition and examples (including neutral electrophiles and nucleophiles).

Inductive, electromeric, mesomeric effect and hyperconjugation – definition, examples.

(viii) *Free radicals and polar mechanisms*

In terms of fission of the bonds and formation of the new bonds including S_N1 , S_N2 , E_1 and E_2 mechanisms. Explain with relevant examples and conditions.

13. Hydrocarbons

Classification of Hydrocarbons

I. Aliphatic Hydrocarbons

(i) Alkanes - Nomenclature, isomerism, conformation (methane and ethane), physical properties, chemical properties including free radical mechanism of halogenation, combustion and pyrolysis.

Occurrence, conformation (Sawhorse and Newman projections of ethane).

General methods of preparation: from sodium salts of carboxylic acids (decarboxylation and Kolbe's electrolytic method); from alcohols and alkyl halides (Wurtz reaction, Coreyhouse Synthesis). From aldehydes and Grignard's Reagent.

Physical and chemical properties of alkanes.

Physical properties: state, freezing point, melting point, boiling point, density.

Chemical properties: combustibility, reaction with chlorine (free radical mechanism), reaction with oxygen in presence of catalyst (formation of alcohol, aldehyde, and

carboxylic acid). Cyclisation, aromatisation, isomerisation and pyrolysis.

Uses of alkanes.

(ii) Alkenes - Nomenclature, structure of double bond (ethene), isomerism; methods of preparation; physical properties, chemical properties; addition of hydrogen, halogen, water, hydrogen halides (Markownikoff's addition and peroxide effect), ozonolysis, oxidation, mechanism of electrophilic addition.

General methods of preparation – dehydration of alcohols, dehydrohalogenation of alkyl halides (from vicinal dihalides), Kolbe's electrolytic method and from alkynes.

Physical Properties: State, freezing point, melting point, boiling point, dipole moment, density.

Chemical properties - addition reactions (hydrogen, halogens, hydrogen halides, sulphuric acid, water).

Markownikoff's rule and anti-Markownikoff's rule with mechanism and examples.

Oxidation: complete combustion, hot and cold alkaline $KMnO_4$ (Baeyer's reagent), ozonolysis.

Polymerisation.

Saytzeff's rule and its application.

Uses of alkenes.

(iii) Alkynes - Nomenclature, structure of triple bond (ethyne), methods of preparation; physical properties, chemical properties: acidic character of alkynes, addition reactions - hydrogen, halogens, hydrogen halides and water.

General methods of preparations of alkynes. Manufacture of ethyne by calcium carbide and from natural gas. Dehydrohalogenation and Kolbe's electrolytic method.

Physical properties of alkynes: State of existence, freezing point, melting point, boiling point, density.

Chemical properties of alkynes – addition reactions (hydrogen, halogens, hydrogen halides and water), acidic nature of alkynes, formation of acetylides.

Oxidation: complete combustion, hot and cold alkaline $KMnO_4$ (Baeyer's reagent), ozonolysis.

Polymerisation.

Uses of alkynes.

Distinguishing test between Alkane, Alkene and Alkyne.

II. Aromatic Hydrocarbons

Introduction, IUPAC nomenclature, benzene: resonance, aromaticity, chemical properties: mechanism of electrophilic substitution. Nitration, sulphonation, halogenation, Friedel Crafts alkylation and acylation, directive influence of functional group in monosubstituted benzene. Carcinogenicity and toxicity.

Structure: Resonance structures (Kekule's) of benzene.

Benzene: Preparation from sodium benzoate and from phenol.

Physical properties: State of existence, freezing point, melting point, boiling point, density.

Chemical properties:

- *Electrophilic substitution reactions with mechanism (halogenation, nitration, sulphonation).*
- *Alkylation, acetylation – Friedel Crafts reaction.*
- *Directive influence (o-, p-, and m-) of substituents in electrophilic and nucleophilic substitutions (with mechanism).*
- *Oxidation: catalytic oxidation, reaction with ozone.*
- *Addition reactions with hydrogen, chlorine, bromine.*
- *Pyrolysis (formation of bi-phenyl).*

Carcinogenicity and toxicity of benzene may be discussed.

Uses.

14. Environmental Chemistry

Types of environmental pollution (air, water and soil pollution); various types of pollutants: smog, acid rain; 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.

Gaseous pollutants: oxides of nitrogen, carbon, sulphur, hydrocarbons; their sources, harmful effects and prevention; Greenhouse effect and global warming; acid rain;

Particulate pollutants: smoke, dust, smog, fumes, mist; their sources, harmful effects and prevention.

Water pollutants: pathogens, organic waste, chemical pollutants; their harmful effects and prevention.

Soil Pollutants: pesticides, herbicides. Green chemistry as an alternative tool for reducing pollution.

PAPER II

PRACTICAL WORK- 15 Marks

Candidates are required to complete the following experiments:

1. Basic laboratory techniques:
 - Cutting a glass tube.
 - Bending a glass tube.
 - Drawing out a glass jet.
 - Boring a cork.
2. Titration: acid-base titration involving molarity.

Titration involving:

 - *Sodium carbonate solution/ dil H_2SO_4 or dil. HCl using methyl orange indicator.*
 - *NaOH or KOH solution/ dil H_2SO_4 or dil. HCl using methyl orange indicator.*
 - *Calculations involving molarity, concentration in grams L^{-1} / number of ions, water of crystallisation and percentage purity.*

NOTE: Calculation of molarity must be upto 4 decimal places at least, in order to avoid error.

OBSERVATION TABLE

S. No.	(A)	(B)	(B – A)
	Initial burette reading (ml)	Final burette reading (ml)	Difference (ml)
1			
2			
3			

- Concordant reading is to be used for titre value. Concordant reading is two consecutive values which are exactly the same. Average will not be accepted as titre value.
- The table is to be completed in ink only. Pencil is not to be used.
- Overwriting will not be accepted in the tabular column.

Observations:

- Pipette size (should be same for all the candidates at the centre):
 - Titre value (concordant).
3. Qualitative analysis: identification of single salt containing one anion and one cation:
- Anions: CO_3^{2-} , NO_2^- , S^{2-} , SO_3^{2-} , SO_4^{2-} , NO_3^- , CH_3COO^- , Cl^- , Br^- , I^- , $\text{C}_2\text{O}_4^{2-}$, PO_4^{3-} .
- Cations: NH_4^+ , Pb^{2+} , Cu^{2+} , Al^{3+} , Fe^{3+} , Zn^{2+} , Mn^{2+} , Ni^{2+} , Co^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , Mg^{2+} .
- Anions: Dilute acid group – CO_3^{2-} , NO_2^- , S^{2-} , SO_3^{2-}
- Concentrated Acid Group – NO_3^- , Cl^- , Br^- , I^- , CH_3COO^- .
- Special Group - SO_4^{2-} , PO_4^{3-} , $\text{C}_2\text{O}_4^{2-}$.
- Cations: Group Zero: NH_4^+
- Group I: Pb^{2+}
- Group II: Cu^{2+} , Pb^{2+}
- Group III: Al^{3+} , Fe^{3+}
- Group IV: Zn^{2+} , Mn^{2+} , Ni^{2+} , Co^{2+}
- Group V: Ba^{2+} , Sr^{2+} , Ca^{2+}
- Group VI: Mg^{2+}

NOTE:

- For wet test of anions, sodium carbonate extract must be used (except for carbonate).
 - Chromyl chloride test not to be performed.
- (Insoluble salts, such as lead sulphate, barium sulphate, calcium sulphate, strontium sulphate should not be given).

4. Preparation of inorganic compounds.

(a) Preparation of potash alum/Mohr's salt.

(b) Preparation of crystalline $\text{FeSO}_4/\text{CuSO}_4$.

5. Paper Chromatography.

Preparation of chromatogram, separation of pigments from extracts of leaves and flowers/ink mixtures; determination of R_f value.

PROJECT WORK AND PRACTICAL FILE -
15 Marks
Project Work – 10 Marks

The candidate is to creatively execute one project/assignment on a selected topic of Chemistry. Teachers may assign or students may choose **any one** project of their choice. (Refer to the suggested topics at the end of Class XII syllabus).

Suggested Evaluation criteria for Project Work:

- Introduction / purpose
- Contents
- Analysis/ material aid (graph, data, structure, pie charts, histograms, diagrams, etc)
- Presentation
- Bibliography

Practical File – 5 Marks

Teachers are required to assess students on the basis of the Chemistry Practical file maintained by them during the academic year.

CLASS XII

There will be two papers in the subject.

Paper I: Theory - 3 hours ... 70 marks

Paper II: Practical: 3 hours ... 15 marks

Project Work ... 10 marks

Practical File ... 5 marks

PAPER 1 (THEORY) - 70 Marks

*There will be no overall choice in the paper. Candidates will be required to answer **all** questions. Internal choice will be available in two questions of 2 marks each, two questions of 3 marks each and all the three questions of 5 marks each.*

S.No.	UNIT	TOTAL WEIGHTAGE
1.	Solid State	Physical Chemistry 25 Marks
2.	Solutions	
3.	Electrochemistry	
4.	Chemical Kinetics	
5.	Surface Chemistry	
6.	General Principles and Processes of Isolation of Elements	Inorganic Chemistry 20 Marks
7.	p -Block Elements	
8.	d -and f -Block Elements	
9.	Coordination Compounds	
10.	Haloalkanes and Haloarenes	Organic Chemistry 25 Marks
11.	Alcohols, Phenols and Ethers	
12.	Aldehydes, Ketones and Carboxylic Acids	
13.	Organic Compounds containing Nitrogen	
14.	Biomolecules	
15.	Polymers	
16.	Chemistry in Everyday Life	
TOTAL		70 Marks

PAPER I –THEORY – 70 Marks

1. Solid State

Solids: their classification based on different binding forces such as: ionic, covalent molecular; amorphous and crystalline solids (difference), metals. Type of unit cell in two dimensional and three dimensional lattices, number of atoms per unit cell (all types). Calculation of density of unit cell, packing in solids, packing efficiency, voids, point defects, electrical and magnetic properties.

Band theory of metals. Conductors, semiconductors (n and p type) and insulators.

- (i) *Crystalline and amorphous solids.*
- (ii) *Definition of crystal lattice, unit cell; types of unit cell (scc, fcc, bcc); calculation of the number of atoms per unit cell; relationship between radius, edge length and nearest neighbour distance. Calculation of density of unit cell, formula of the compound – numericals based on it; packing in 3 – D, packing fraction in scc, fcc, bcc with derivation; voids – types, location, formation (derivation of radius of voids).*
- (iii) *Characteristics of crystalline solids; ionic (NaCl), metallic (Cu), atomic (diamond and graphite).*
- (iv) *Point defects: Stoichiometric, non-stoichiometric and impurity defects (F-centres).*
- (v) *Electrical properties: Conductors, semiconductors (n & p types) and insulators (Band Theory), piezoelectricity and pyroelectricity.*
- (vi) *Magnetic properties: diamagnetic, paramagnetic, ferromagnetic, ferrimagnetic and antiferromagnetic.*

2. Solutions

Study of concentration of solutions of solids in liquids, liquid in liquid, solubility of gases in liquids, solid solutions, Colligative properties - Raoult's law of relative lowering of vapour pressure (1st & 2nd), elevation of boiling point, depression of freezing point, osmotic pressure. Use of colligative properties in determining molecular masses of

solutes, abnormal molecular mass association and dissociation, van't Hoff factor.

Normality, molality, molarity, mole fraction, ppm, as measures of concentration. Definition of the above with examples. Simple problems based on the above.

- (i) *Solubility of gases in liquids – Henry's Law, simple numericals based on the above.*
- (ii) *Raoult's Law for volatile solutes and non-volatile solutes, ideal solution, non-ideal solution. Azeotropic mixtures – definition, types, graphical representation, fractional distillation with examples.*
- (iii) *Colligative properties – definition and examples, and its use in determination of molecular mass.*
 - (a) *Relative lowering of vapour pressure: Definition and mathematical expression of Raoult's Law. Determination of relative molecular mass by measurement of lowering of vapour pressure.*
 - (b) *Depression in freezing point: molal depression constant (cryoscopic constant) – definition and mathematical expression (derivation included).*
 - (c) *Elevation in boiling point method: molal elevation constant (ebullioscopic constant) definition and mathematical expression (derivation included).*
 - (d) *Osmotic pressure: definition and explanation. Natural and chemical semipermeable membranes, reverse osmosis, isotonic, hypotonic and hypertonic solutions. Comparison between diffusion and osmosis. Application of osmotic pressure in the determination of relative molecular mass.*

van't Hoff- Boyle's Law, van't Hoff – Charles' Law, van't Hoff - Avogadro's law.
 - (e) *Abnormal molecular mass: Dissociation and Association with suitable examples*
 - (f) *van't Hoff factor for the electrolytes which dissociate and the molecules which associate in solution. Modification of the formula of colligative*

properties based on van't Hoff factor. Simple problems. Calculation of degree of dissociation and association. Experimental details not required.

Numerical problems based on all the above methods. Experimental details not required.

3. Electrochemistry

Electrolytic and electrochemical cells. Redox reactions in electrochemical cells. Electromotive Force (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.

Conductance in electrolytic solutions, specific, equivalent and molar conductivity, variations of conductivity with concentration, graphs; Kohlrausch's Law of electrolysis and Faraday's Laws of electrolysis. Dry cell and lead accumulator, fuel cells, corrosion.

- (i) *Electrochemical cells: introduction, redox reactions (principle of oxidation and reduction in a cell).*
- (ii) *Galvanic cells - introduction; representation, principle - oxidation reduction. Mechanism of production of electric current in a galvanic cell.*
- (iii) *Measurement of potential. Single electrode potentials.*
Standard hydrogen electrode (E°) - definition, preparation, application and limitations.
Standard electrode potential - Measurement of standard electrode potential of Zn^{++}/Zn , Cu^{++}/Cu , half cell (using standard hydrogen electrode).
Cell notation - representation.
Factors affecting electrode potential with explanation - main emphasis on the temperature, concentration and nature of the electrode.
- (iv) *Electrochemical series. Its explanation on the basis of standard reduction potential. Prediction of the feasibility of a reaction.*

- (v) *Nernst equation and correlation with the free energy of the reaction with suitable examples.*

Prediction of spontaneity of a reaction based on the cell emf.

Numericals on standard electrode potential of half-cells, cell emf, relationship between free energy and equilibrium constant, standard electrode potential and free energy.

- (vi) *Comparison of metallic conductance and electrolytic conductance. Relationship between conductance and resistance. Specific resistance and specific conductance.*

Cell constant: Calculation of cell constant. Meaning of equivalent conductance. Meaning of molar conductance. General relationship between specific conductance, molar conductance and equivalent conductance (units and graphs).

Units, numericals.

Molar conductance of a weak electrolyte at a given concentration and at infinite dilution. Kohlrausch's Law - definition, applications and numericals.

- (vii) *Faraday's laws of Electrolysis.*

Faraday's First Law of electrolysis. Statement, mathematical form. Simple problems.

Faraday's Second Law of electrolysis: Statement, mathematical form. Simple problems.

Relation between Faraday, Avogadro's number and charge on an electron. $F = N_A e$ should be given (no details of Millikan's experiment are required).

- (viii) *Batteries: Primary and Secondary Cells: Leclanche cell, mercury cell, Lead storage battery and fuel cell - structure, reactions and uses.*

- (ix) *Corrosion: Concept, mechanism of electrochemical reaction, factors affecting it and its prevention.*

4. Chemical Kinetics

Meaning of Chemical Kinetics - slow and fast reactions. Rate of a reaction - average and instantaneous rate (graphical representation). Factors affecting rate of reaction: surface area,

nature of reactants, concentration, temperature, catalyst and radiation. 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). Concept of threshold and activation energy, Arrhenius equation.

- (i) *Meaning of chemical kinetics, Scope and importance of Kinetics of the reaction, slow and fast reactions – explanation in terms of bonds.*
- (ii) *Rate of Reaction: definition, representation of rate of reaction in terms of reactants and products, determination of rate of reactions graphically, instantaneous and average rate of reaction. Factors affecting rate of reaction.*
- (iii) *Law of mass Action: statement and meaning of active mass. Explanation with an example – general reactions.*
- (iv) *Effect of concentration of reactants on the rate of a reaction: Qualitative treatment, based on the law of mass Action, statement of rate law, General rate equation – $\text{Rate} = k(\text{concentration of the reactant})^n$, where k is rate constant and n is the order of the reaction, relationship between the rate of the reaction with rate constant with respect to various reactants.*
- (v) *Order of a reaction: meaning, relation between order and stoichiometric coefficients in balanced equations, order as an experimental quantity, rate equation for zero order reaction and its unit, mathematical derivation of rate equation for first order reaction, characteristics of first order reaction – rate constant is independent of the initial concentration, units to be derived, definition of half-life period, derivation of expression of half-life period from first order rate equation.*
Problems based on first order rate equation and half-life period.
- (vi) *Molecularity of the reaction: Meaning – physical picture, Relation between order, molecularity and the rate of a reaction, Differences between order and molecularity of a reaction.*

(vii) *The concept of energy: Exothermic and endothermic reactions, concept of energy barrier, threshold and activation energy, formation of activated complex, effect of catalyst on activation energy and reaction rate.*

(viii) *Collision Theory: Condition for a chemical change – close contact, particles should collide. Collisions to be effective – optimum energy and proper orientation during collision. Energy barrier built-up when the collision is about to take place, Activated complex formation, difference in energy of the reactant and the product – exothermic and endothermic reactions with proper graphs and labelling.*

(ix) *Mechanism of the reaction: meaning of elementary reaction, meaning of complex and overall reaction, explanation of the mechanism of the reaction, slowest step of the reaction. Relationship between the rate expression, order of reactants and products at the rate-determining step, units of rate constant – explanation with suitable examples.*

(x) *Effect of temperature on the rate constant of a reaction: Arrhenius equation – $K = Ae^{-E_a/RT}$, Meaning of the symbols of Arrhenius equation, related graph, evaluation of E_a and A from the graph, meaning of slope of the graph, conversion from exponential to log form of the equation, relationship between the increase in temperature and the number of collisions. Numerical based on Arrhenius equation.*

5. Surface Chemistry

Absorption and Adsorption - physisorption and chemisorption, factors affecting adsorption of gases on solids and liquids. Catalysis; homogenous and heterogenous, activity and selectivity, enzyme catalysis.

Colloidal state distinction between true solutions, colloids and suspension; lyophilic, lyophobic multi-molecular, macromolecular and associated colloids; properties of colloids; Brownian movement, Tyndall effect, coagulation and electrophoresis. Emulsion - types of emulsions.

(i) *Difference between absorption and adsorption: definition of physisorption and chemisorption and their differences.*

Factors affecting adsorption of gases on solids, Freundlich adsorption isotherms, graph, expression and application of adsorption.

(ii) *Catalysis: definition, types of catalysts – positive and negative, homogeneous and heterogeneous catalyst based on the state of the reactant and the catalyst, Elementary treatment of intermediate compound formation theory with examples; adsorption Theory, effect of catalyst on the rate of reaction – the change in the energy of activation in the activation energy curve. Characteristics of a catalyst; specificity, activity, surface area of a catalyst. Promoter and poison. Enzyme catalysis – basic idea and lock and key mechanism.*

(iii) *Colloidal State: Thomas Graham classified the substances as crystalloid and colloid, classification of substances on the basis of the particle size i.e. true solution, sol and suspension, colloidal system is heterogeneous. lyophilic and lyophobic colloid; classification of colloidal solutions as micro, macro and associated colloids.*

Preparation of lyophilic colloids. Preparation of lyophobic colloids by colloid mill, peptization, Bredig's arc method, oxidation, reduction, double decomposition and exchange of solvent method, purification of colloids (dialysis, ultra-filtration, and ultracentrifugation).

Properties of colloidal solutions: Brownian movement, Tyndall effect, coagulation, electrophoresis (movement of dispersed phase), Protection of colloids, Gold number and Hardy- Schulze rule. Emulsions, surfactants, micelles (only definition and examples).

Application of colloids and emulsions in daily life.

6. General Principles and Processes of Isolation of Elements

Metals: metallurgy, ores, principles and methods of extraction - concentration, oxidation, reduction, electrolytic refining.

Occurrence and principles of extraction of aluminium, copper, zinc, iron and silver.

(i) *Definition of minerals, ores and metallurgy; principle ores of aluminium, iron, copper, zinc and silver.*

Methods of concentration of ores: hydraulic washing, magnetic separation, froth floatation method, leaching.

Extraction of metal from concentrated ore – calcination, roasting and thermal reduction.

Thermodynamic principle of metallurgy - Gibb's energy (Ellingham diagram – significance only).

Metallurgy of aluminium, iron, copper, zinc and silver.

Refining of metals - distillation, liquation, electrolysis, vapour phase refining (nickel), zone refining.

(ii) *Uses of metals and their alloys.*

7. p-Block Elements

Group-15 Elements

Position in the periodic table, occurrence, electronic configuration, oxidation states, trends in physical and chemical properties. Nitrogen: preparation properties and its uses; compounds of nitrogen: oxides of nitrogen. Ammonia and nitric acid – preparation and properties. Phosphorus - allotropic forms, compounds of phosphorus: preparation and properties of phosphine, halides and oxoacids.

(i) *General introduction, electronic configuration, occurrence, oxidation states. Trends in physical properties; chemical properties with hydrogen, oxygen and halogens.*

(ii) *Nitrogen - Laboratory preparation, decomposition (ammonium dichromate, barium azide). Properties and uses.*

(iii) *Oxides of nitrogen (N_2O , NO , N_2O_3 , N_2O_4 , N_2O_5) - preparation, structure and uses.*

(iv) *Ammonia – Preparation and manufacture. Properties: reaction with oxygen, copper oxide, chlorine, hydrochloric acid, formation of complexes. Uses.*

(v) *Nitric Acid - Preparation and manufacture. Properties: reaction with copper (dilute and*

concentrated HNO_3), carbon and sulphur. Uses.

- (vi) Allotropes of phosphorus and their structures.

Phosphine – preparation from phosphorus and properties: reaction with halo acids).

Phosphorus trichloride - Preparation from phosphorous. Uses.

Phosphorus pentachloride - preparation from PCl_3 . Thermal dissociation and hydrolysis. Uses, properties.

Oxoacids of phosphorus (structures and preparation only).

Group-16 Elements

Position in the periodic table, occurrence, electronic configuration, oxidation states, trends in physical and chemical properties. Oxygen: methods of preparation, properties and uses, classification of oxides. Ozone – methods of preparation. Sulphur -allotropic forms. Compounds of sulphur: preparation, properties and uses of sulphur-dioxide, sulphuric acid (industrial process of manufacture). Oxoacids of sulphur (structures only).

- (i) Electronic configuration, oxidation states, occurrence. Trends in physical properties; chemical properties with hydrogen, oxygen and halogens.
- (ii) Oxygen – lab method of preparation, formation of oxides with metals and non-metals and their common nature.
- (iii) Ozone: manufacture by Siemen's ozoniser, thermal decomposition of ozone, its oxidising nature – reaction with lead sulphide, potassium iodide and mercury, its uses.
- (iv) Sulphur: allotropes of sulphur - rhombic, monoclinic, structure of sulphur and action of heat; extraction by Frasch process.
- (v) Sulphur dioxide: laboratory and industrial preparation from sulphites and sulphide ores, reaction of sulphur dioxide with NaOH , Cl_2 , KMnO_4 and structure of SO_2 .
- (vi) Oxoacids of sulphur: structures only.

Sulphuric Acid: manufacture by Contact Process (equations, conditions and diagram), properties - acidic nature, mode of dilution, oxidising action, dehydrating nature and uses of sulphuric acid in industry.

Group-17 Elements

Position in the periodic table, occurrence, electronic configuration, oxidation states, trends in physical and chemical properties; Preparation, properties and uses of chlorine and hydrochloric acid. Compound of halogen, oxoacids of halogens (structures only), Interhalogen compounds.

- (i) General introduction, electronic configuration, oxidation states. Trends in physical properties and chemical properties (hydrogen, oxygen, halogens and metals).
- (ii) Chlorine – preparation from MnO_2 and HCl , from NaCl , MnO_2 and conc. H_2SO_4 (only equations), reactions of chlorine with H_2S , NH_3 , cold, dilute NaOH and hot, concentrated NaOH .
- (iii) Hydrochloric acid: Lab preparation, its acidic nature, reaction with ammonia, carbonates and sulphites, formation of aqua regia and its uses.
- (iv) Oxoacids of halogens: structures and acidic property.
- (v) Interhalogen compounds – structure, hybridisation and shapes: XX , XX_3 , XX_5 , XX_7 .

Group-18 Elements

Position in the periodic table, occurrence, electronic configuration, trends in physical and chemical properties, inert nature, uses.

- (i) General introduction, electronic configuration, occurrence, trends in physical; chemical properties, state and low reactivity.
- (ii) Formation of xenon compounds with fluorine and oxygen (equations only), hybridisation, shape and structure of compounds.
- (iii) Uses of noble gases.

8. d and f Block Elements

Position in the periodic table, occurrence, electronic configuration and characteristics of transition metals, general trends in properties of the 3d-series of transition metals - metallic character, ionisation enthalpy, oxidation states, ionic radii, colour of ions, catalytic property, magnetic properties, interstitial compounds, alloy formation, preparation and properties of $K_2Cr_2O_7$ and $KMnO_4$.

Lanthanoids and actinoids.

(i) d-Block: 3d, 4d and 5d series

Study in terms of metallic character, atomic and ionic radii, ionisation enthalpy, oxidation states, variable valency, formation of coloured compounds, formation of complexes, alloy formation.

(ii) f-Block: 4f and 5f series

Electronic configuration, atomic and ionic radii, oxidation states, formation of coloured compounds, formation of complexes, alloy formation. Lanthanoid contraction and its consequences. Chemical reactivity – with oxygen, hydrogen, halogen, sulphur, nitrogen, carbon and water.

Actinoids - oxidation states and comparison with lanthanoids.

(iii) Potassium permanganate: structure, shape, equation of extraction from pyrolusite ore, its oxidising nature in acidic, basic and neutral medium, use in redox titration.

Oxidising nature in acidic [$FeSO_4$, $(COOH)_2 \cdot 2H_2O$, KI], basic (KI) and neutral (H_2S) mediums to be done.

(iv) Potassium dichromate: structure, shape, equation of extraction from chromite ore and its use in titration. Oxidising nature in acidic, basic and neutral medium, use in redox titration. Interconversion of chromate and dichromate ion (effect of pH).

9. Coordination Compounds

Concept of complexes, definition of ligands, coordination number, oxidation number. IUPAC nomenclature of mononuclear coordination compounds. Isomerism (structural and stereo). Bonding, Werner's theory, VBT and CFT.

Colour, magnetic properties and shapes. Importance of coordination compounds (in qualitative analysis, extraction of metals and biological system).

(i) *Definition of coordination compounds / complex compounds, differences with a double salt, study of ligands – mono-, bi-, tri-, tetra-, penta-, hexa- and polydentate, chelating ligands, definition of coordination number, its calculation for a complex coordination sphere, study of oxidation state of an element in a complex, its calculation, IUPAC rules of nomenclature of coordination compounds.*

(ii) *Isomerism – structural, stereo types and examples.*

(iii) *Valence bond theory of coordination compounds – examples of formation of inner orbital and outer orbital complexes (high and low spin, octahedral, tetrahedral and square planar), prediction of magnetic character.*

(iv) *Crystal field theory – crystal field splitting in tetra and octahedral systems. Explanation of colour and magnetic character.*

(v) *Stability of coordination compounds (explain stability on the basis of magnitude of K) as mentioned above).*

(vi) *Importance and uses.*

10. Haloalkanes and Haloarenes.

Haloalkanes: General formula, nomenclature and classification. Nature of C–X bond, physical and chemical properties, mechanism of substitution reactions, optical rotation.

Haloarenes: Basic idea, 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 and DDT.

Nature of C-X bond

Naming the halogen derivatives of alkanes by using common system and IUPAC system for mono, di and tri-halo derivatives.

Preparation of haloalkanes from:

- Alkane and halogen.
- Alkene and hydrogen halide.

- Alcohols with PX_3 , PCl_5 and $SOCl_2$.
- Halide exchange method (Finkelstein and Swarts)
- Silver salt of fatty acids (Hunsdiecker).

Physical properties: State, melting point, boiling point and solubility.

Chemical properties: nucleophilic substitution reactions (S_N1 , S_N2 mechanism in terms of primary, secondary and tertiary halides) Reaction with: sodium hydroxide, water, sodium iodide, ammonia, primary amine, secondary amine, potassium cyanide, silver cyanide, potassium nitrite, silver nitrite, silver salt of fatty acid and lithium-aluminium hydride.

Elimination reaction (Saytzeff's rule) / elimination.

Reaction with metals: sodium and magnesium (Wurtz's reaction, Grignard's reagent preparation).

Chloroform and iodoform: preparation and properties.

Structure of freons.

Preparation of haloarenes by Sandmeyer's and Gattermann's reaction, by electrophilic substitution.

Physical properties: State, melting point, boiling point and solubility.

Chemical properties:

- Electrophilic substitution (chlorination nitration and sulphonation) with mechanism.
- Nucleophilic substitution (replacement of chlorine with $-OH$, $-NH_2$) with mechanism.
- Reduction to benzene.
- Wurtz-Fittig reaction.
- Fittig reaction.
- Addition reaction with magnesium (formation of Grignard reagent).
- Structure of DDT.

11. Alcohols, Phenols and Ethers

Alcohols: Classification, general formula, structure and 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.

(i) Classification into monohydric, dihydric and polyhydric alcohols, general formulae, structure and nomenclature of alcohols. Difference between primary, secondary and tertiary alcohols in terms of structure, physical properties and chemical properties.

(ii) Methods of preparation:

- Hydration of Alkenes – direct hydration, indirect hydration, hydroboration oxidation.
- From Grignard's reagent.
- Hydrolysis of alkyl halides.
- Reduction of carbonyl compounds.
- From primary amines.

Manufacture of methanol by Bosch process and ethanol by fermentation of carbohydrates, chemical equations required (only outline of the method of manufacture, detail not required).

Properties:

- Acidic nature of alcohols:
- Reaction with sodium.
- Esterification with mechanism.
- Reaction with hydrogen halides.
- Reaction with PCl_3 , PCl_5 , and $SOCl_2$.
- Reaction with acid chlorides and acid anhydrides
- Oxidation.
- Dehydration with mechanism.

Uses of alcohols.

(iii) Conversion of one alcohol into another.

(iv) Distinction between primary, secondary and tertiary alcohols by Lucas' Test.

Phenols: Classification and nomenclature. Methods of preparation, physical and chemical properties, acidic nature of phenol, electrophilic substitution reactions, uses of phenols.

Preparation of phenol from diazonium salt, chlorobenzene (Dow's process) and from benzene sulphonic acid.

Manufacture from Cumene.

Physical properties: state and solubility.

Chemical properties:

- Acidic character of phenol.
- Reaction with sodium hydroxide.
- Reaction with sodium.
- Reaction with zinc.
- Reaction with acetyl chloride and acetic anhydride.
- Reaction with phosphorus penta chloride.
- Bromination, nitration and sulphonation (Electrophilic substitution reactions).
- Kolbe's reaction (formation of salicylic acid).
- Reimer – Tiemann reaction
- Test for phenol – $FeCl_3$ test, azo dye test.

Aliphatic Ethers: General formula, structure and nomenclature. Methods of preparation, physical and chemical properties, uses.

Ethers: structure of ethereal group.

Preparation from alcohol (Williamson's synthesis).

Physical properties: state, miscibility.

Chemical properties:

- Reaction with chlorine.
- Oxidation (peroxide formation).
- Reaction with HI.
- Reaction with PCl_5 .

Aryl ethers

Physical properties – state and solubility.

Chemical properties – preparation of anisole (Williamson's synthesis), electrophilic substitution (halogenation, nitration and Friedel-Crafts reaction.)

Uses of ether.

12. Aldehydes, Ketones and Carboxylic Acids

Aldehydes and Ketones: Nomenclature, structure of methods of preparation of aldehydes and ketones, physical and chemical properties, mechanism of nucleophilic addition, reactivity of alpha hydrogen in aldehydes and uses.

Preparation:

- From alcohol.
- From alkenes (ozonolysis).

- From alkynes (hydration).
- From acid chlorides (Rosenmund's reduction, reaction with dialkyl cadmium).
- From calcium salt of carboxylic acids.
- From nitriles (Stephen reaction, Grignard's reagent).
- From esters.

Physical properties – state and boiling point.

Chemical properties:

- Nucleophilic addition reactions with mechanism (ammonia and its derivatives, HCN, $NaHSO_3$ and Grignard's reagent).
- Oxidation reactions, iodoform reaction.
- Reduction: reduction to alcohol and alkanes (Clemmensen's reduction, Wolff-Kishner reduction, Red phosphorus and HI).
- Base catalysed reactions (with mechanism): Aldol condensation, cross Aldol condensation, Cannizzaro's reaction.

Tests: difference between formaldehyde and acetaldehyde; aldehydes and ketones.

Uses of aldehydes and ketones.

Aromatic aldehyde (Benzaldehyde)

Lab preparation from toluene by oxidation with chromyl chloride.

Physical properties: state and stability.

Chemical properties:

- Oxidation and reduction.
- Nucleophilic addition reaction (hydrogen cyanide and sodium bisulphite).
- Reactions with ammonia and its derivatives (hydroxyl amine, hydrazine and phenyl hydrazine).
- Reaction with phosphorus pentachloride.
- Cannizzaro reaction.
- Benzoin condensation.
- Perkin's reaction.
- Electrophilic substitution - halogenation, nitration and sulphonation.

Test: distinction between aromatic and aliphatic aldehydes.

Uses of benzaldehyde.

Carboxylic Acids: Classification, general formula and structure of carboxylic group. Nomenclature, acidic nature, methods of preparation, physical and chemical properties and uses.

Classification of mono and di carboxylic acids with examples.

Preparation of aliphatic and aromatic carboxylic acid:

- From alcohols, aldehydes.
- From nitriles.
- From Grignard's reagent.

Physical properties: state, boiling point and solubility.

Chemical properties:

- Acidic character: (aliphatic, aromatic carboxylic acids with the effect of substituents on the acidic character – to be dealt with in detail)
- Reaction with active metals, alkalis, carbonates and bicarbonates,
- Formation of acid derivatives.
- Decarboxylation (chemical and Kolbe's electrolytic reaction).
- HVZ reactions.
- Substitution of benzene ring (meta directive effect of carboxylic acid group) nitration and sulphonation.

Tests for acids: formic acid, acetic acid and benzoic acid.

Uses of formic acid, acetic acid and benzoic acid.

13. Organic compounds containing Nitrogen

Aliphatic Amines: General formula and, classification of amines. Structure of the amino group, nomenclature. Methods of preparation, physical and chemical properties, uses, identification of primary, secondary and tertiary amines.

- Amines
Nomenclature, classification with examples, structure, general formula.

Methods of preparation:

- From alcohol.
- From alkyl halide.
- From cyanide.
- From amide (Hofmann's degradation).
- From nitro compounds.
- Gabriel phthalimide Synthesis.

Physical properties: comparison between primary, secondary and tertiary amines in terms of – state, solubility, boiling point (hydrogen bonding), comparison with alcohols.

Chemical properties:

- Basic character of amines – comparison between primary, secondary and tertiary alkyl amines/ ammonia/ aniline. Effect of substituents on the basic strength of aniline
- Alkylation and acylation with mechanism.
- Reaction with nitrous acid.
- Carbylamine reaction.

Distinction between primary, secondary and tertiary amines (Hinsberg's Test).

Aniline

Preparation reduction of nitrobenzene.

Physical properties – state, solubility and boiling point.

Chemical properties:

- Reaction with HCl and H₂SO₄.
- Acetylation, alkylation.
- Benzoylation.
- Carbylamine reaction.
- Diazotisation.
- Electrophilic substitution (bromination, nitration and sulphonation).

Tests for aniline.

Uses of aniline.

Cyanides and Isocyanides

Methods of preparation:

Cyanides:

- From alkyl halide.

- From amide.
- Isocyanides:
 - From alkyl halide.

From primary amines

Diazonium salts: Preparation, chemical reactions and importance in synthetic organic chemistry.

Preparation from aniline;

Properties: Sandmeyer's reaction, Gattermann reaction and Balz – Scheimann reaction, replacement of diazo group by – H, –OH, –NO₂, coupling reaction with phenol and aniline.

14. Biomolecules

Carbohydrates – Definition, Classification (aldoses and ketoses), monosaccharides (glucose and fructose), D-L configuration oligosaccharides (sucrose, lactose, maltose), polysaccharides (starch, cellulose, glycogen); Importance of carbohydrates.

Carbohydrates: definition, classification - mono (aldose, ketose), oligo (di, tri, tetra saccharides) and polysaccharides with examples: reducing sugars and non-reducing sugars – examples and uses.

Establishment of structures for glucose and fructose (open and cyclic) heating with HI, reaction with hydroxylamine, bromine water, acetic anhydride, nitric acid and phenyl hydrazine.

Test for glucose and fructose (bromine water test with equation).

Disaccharides – structures of sucrose, maltose and lactose (glycosidic linkage).

Polysaccharides – starch, cellulose, glycogen.

Proteins – structural units of proteins. Basic 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 only.

Proteins: Amino acids – general structure, classification and zwitter ion formation.

Isoelectric point.

Classification of proteins on the basis of molecular shape; primary, secondary, tertiary

and quaternary, structures of proteins, denaturation of proteins. (Definitions only. Details and diagrams are not required).

Vitamins - Classification and functions.

Vitamins A, B, C, D, E and K: classification (fat soluble and water soluble), deficiency diseases. (Chemical names and structures are not required).

Nucleic Acids - DNA and RNA.

Nucleic acids: basic unit – purine and pyrimidine, DNA – structure (double helical), RNA (No chemical structure required). Differences between DNA and RNA.

15. Polymers

Definition and classification on different parameters. Methods of polymerisation (addition and condensation), copolymerisation, and some important polymers: natural and synthetic like polythene, nylon polyesters, bakelite, rubber. Biodegradable and non-biodegradable polymers.

Classification based on source, on structure, on mode of polymerisation, on molecular forces, on growth (with free radical mechanism).

Preparation of important addition polymers - Polythene, polypropene, PVC, PTFE, polystyrene.

Rubber – natural and synthetic (Buna-N and Buna-S), vulcanisation of rubber.

Preparation of important condensation polymers - polyester, Nylon 66, Nylon 6, Bakelite, melamine (to be learnt in terms of monomers and equations).

Biodegradable polymers – PHBV, Nylon 2 - Nylon 6.

Uses.

16. Chemistry in Everyday life

Chemicals in medicines - analgesics, tranquilizers antiseptics, disinfectants, antimicrobials, antifertility drugs, antibiotics, antacids, antihistamines.

In medicine: antipyretics, analgesics, tranquillisers, antiseptics, disinfectants,

anti-microbials, anti-fertility drugs, antihistamines, antibiotics, antacids. Definition, common examples, uses. Differences between antiseptics and disinfectants. Structure not required.

Chemicals in food - preservatives, artificial sweetening agents, elementary idea of antioxidants.

Preservatives: role, example (Sodium benzoate). Artificial sweetening agents: role, examples (aspartame, saccharine, sucralose and alitame).

Soaps and detergents - Classification and their cleansing action.

Soaps and detergents: classification, structure and some important examples.

Advantage of detergents over soaps; classification of detergents into anionic/biodegradable, cationic/non-biodegradable and non-ionic.

PAPER II

PRACTICAL WORK – 15 Marks

Candidates are required to complete the following experiments:

1. Titrations

Oxidation-reduction titrations: potassium manganate (VII) / ammonium iron (II) sulphate; potassium manganate (VII) / oxalic acid.

The candidate may be required to determine the percentage purity of a compound and the number of molecules of water of crystallization in hydrated salts. In such experiments sufficient working details including recognition of the end point will be given.

Candidates will be required to calculate:

- Molarity
- Concentration in grams L^{-1} / molecular mass
- Number of molecules of water of crystallisation/ percentage purity.

NOTE: Molarity must be calculated upto 4 decimal places at least, in order to avoid error.

OBSERVATION TABLE

S. No.	(A)	(B)	(B – A)
	Initial burette reading (ml)	Final burette reading (ml)	Difference (ml)
1			
2			
3			

- Concordant reading is to be used for titre value. Concordant reading is two consecutive values which are exactly the same. Average will not be accepted as titre value.
- The table is to be completed in ink only. Pencil is not to be used.
- Overwriting will not be accepted in the tabular column.

Observations:

- Pipette size (should be same for all the candidates at the centre).
- Titre value (concordant value).

2. Study of the rate of reaction

The candidates will be required, having been given full instructions, to carry out an experiment on the rate of reaction, e.g. reaction between sodium thiosulphate and hydrochloric acid (using different concentrations for either), magnesium and dil. sulphuric acid/ dil. hydrochloric acid (using different concentrations).

1. Graph of volume vs. time and its interpretation.
2. Relationship between concentration and rate, volume and rate and time and rate.

3. Identification of the following compounds and functional groups based on observations

- Alcoholic group - glycerol
- Aldehyde group- formaldehyde
- Ketonic group – acetone
- Carboxylic group – benzoic acid
- Amino group - aniline

***Please Note: Carbylamine and acrolein tests should not be performed.**

The student should learn to differentiate between colours, solution, ring and precipitate.

4. Characteristic tests of carbohydrates and proteins

- Carbohydrates – glucose
- Proteins – powdered milk

Identification should be of 'Carbohydrate' and 'Protein' not of individual substances.

5. Experiments related to pH change using pH paper or universal indicator.

- Determination of pH of some solutions obtained from fruit juice, solutions of known and varied concentrations of acids, bases and salts.
- Comparison of pH of the solutions of strong and weak acids of the same concentration.

Use of universal indicator/pH paper must be taught to the students.

6. Electrochemistry

Setting up a simple voltaic cell.

Variation of cell potential in $Zn/Zn^{2+}/Cu^{2+}/Cu$ with change in concentration of electrolyte ($CuSO_4$, $ZnSO_4$) at room temperature.

7. Qualitative analysis

Qualitative analysis: identification of single salt containing one anion and one cation:

Anions: CO_3^{2-} , NO_2^- , S^{2-} , SO_3^{2-} , SO_4^{2-} , NO_3^- , CH_3COO^- , Cl^- , Br^- , I^- , $C_2O_4^{2-}$, PO_4^{3-} .

Cations: NH_4^+ , Pb^{2+} , Cu^{2+} , Al^{3+} , Fe^{3+} , Zn^{2+} , Mn^{2+} , Ni^{2+} , Co^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , Mg^{2+} .

NOTE:

Chromyl chloride test not to be performed.

For wet test of anions, sodium carbonate extract must be used (except for carbonate).

(Insoluble salts such as lead sulphate, barium sulphate, calcium sulphate, strontium sulphate will not be given).

Anions: Dilute acid group – CO_3^{2-} , NO_2^- , S^{2-} , SO_3^{2-} .

Concentrated Acid Group – NO_3^- , Cl^- , Br^- , I^- , CH_3COO^- .

Special Group - SO_4^{2-} , PO_4^{3-} , $C_2O_4^{2-}$.

Cations: Group Zero: NH_4^+

Group I: Pb^{2+}

Group II: Cu^{2+} , Pb^{2+}

Group III: Al^{3+} , Fe^{3+}

Group IV: Zn^{2+} , Mn^{2+} , Ni^{2+} , Co^{2+}

Group V: Ba^{2+} , Sr^{2+} , Ca^{2+}

Group VI: Mg^{2+}

NOTE:

- Formal analytical procedure is required for Qualitative Analysis.
- Specific solvent for O.S. to be used;
- Before adding Group III reagents to the filtrate of Group II, H_2S must be removed followed by boiling with conc. Nitric acid.
- The right order for buffer (NH_4Cl and NH_4OH) must be used.
- The flame test with the precipitate obtained in Group V for Ba^{2+} , Sr^{2+} , Ca^{2+} will also be accepted as a confirmatory test.

For wet test of anions, sodium carbonate extract must be used (except for carbonate).

PATTERN OF CHEMISTRY

PRACTICAL PAPER

Questions in the practical paper will be set as follows:

Question 1	Volumetric Analysis
Question 2	Any one or a combination of the following experiments:
	<ul style="list-style-type: none"> • Study of the rate of reaction.
	<ul style="list-style-type: none"> • Identification of the organic compounds and functional groups based on observations.
	<ul style="list-style-type: none"> • Characteristic tests of carbohydrates and proteins.
	<ul style="list-style-type: none"> • Experiments related to pH determination using pH paper or universal indicator.
	<ul style="list-style-type: none"> • Electrochemistry.
Question 3	Qualitative Analysis (single salt).

**PROJECT WORK AND PRACTICAL FILE -
15 Marks**

Project Work – 10 Marks

The project work is to be assessed by a Visiting Examiner appointed locally and approved by the Council.

The candidate is to creatively execute **one** project/assignment on an aspect of Chemistry. Teachers may assign or students may select a topic of their choice. Following is only a suggestive list of projects.

Suggested Evaluation criteria for Project Work:

- Introduction / purpose
- Contents
- Analysis/ material aid (graph, data, structure, pie charts, histograms, diagrams, etc.)
- Presentation
- Bibliography

Suggested Assignments:

1. Amino acids: Peptides, structure and classification, proteins structure and their role in the growth of living beings.
2. Nucleic Acid: DNA and RNA – their structure. Unique nature. Importance in evolution and their characteristic features.
3. Carbohydrates and their metabolism, Blood - haemoglobin and respiration.
4. Vitamins and hormones

5. Simple idea of chemical evolution.
6. Natural polymers (any **five**) - structure, characteristics, uses. Synthetic polymers (any **five**) - method of preparation, structure, characteristics and uses.
7. Types of Dyes - methods of preparation, characteristics and uses.
8. Chemicals in medicines: antiseptics, antibiotics, antacids, etc. and their uses.
9. Preparation of soap, nail polish, boot polish, varnish, nail polish remover, shampoo and perfumes.
10. Chemicals and chemical processes in forensic studies.
11. Insecticides, pesticides and chemical fertilisers.
12. Ancient Indian medicines and medicinal plants.
13. Organic Chemistry in Nutrition, Food Science and Biotechnology.
14. Effect of Green House Gases.
15. How Plastics have changed the world, both socially and economically.

Practical File – 5 Marks

The Visiting Examiner is required to assess students on the basis of the Chemistry Practical file maintained by them during the academic year.

NOTE: According to the recommendation of International Union of Pure and Applied Chemistry (IUPAC), the groups are numbered from 1 to 18 replacing the older notation of groups IA VIIA, VIII, IB VIIB and 0. However, for the examination both notations will be accepted.

Old notation	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
New notation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18