Chemistry

Grades: 11 and 12 **Subject code:** 301 **(Grade 11),** 302 **(Grade 12)**

Credit hrs: 5 **Working hrs: 160**

1. Introduction

This curriculum is of grade 11 and 12 chemistry. This is designed to provide students with general understanding of the fundamental scientific laws and principles that govern the scientific phenomena in the world. It focuses to develop scientific knowledge, skills, and attitudes required at secondary level (grade 11 and 12) irrespective of what they do beyond this level, as envisioned by national goals. Understanding of scientific concepts and their application, in day to day context as well as the process of obtaining new knowledge through holistic approach of learning in the spirit of national qualification framework is emphasized in the curriculum.

This curriculum aims: to provide sufficient knowledge and skills to recognize the usefulness and limitations of laws and principles of chemistry, to develop science related attitudes such as concern for safety and efficiency, concern for accuracy and precision, objectivity, spirit of enquiry, inventiveness, appreciation of ethno-science, and willingness to use technology for effective communication, to provide opportunity for the learners who have deeper interest in the subject to delve into the more advanced contents so that the study of chemistry becomes enjoyable and satisfying to all.

The curriculum prepared in accordance with National Curriculum Framework is structured for two academic years in such a way that it incorporates the level-wise competencies, grade-wise learning outcomes, scope and sequence of contents, suggested practical/project-work activities, learning facilitation process and assessment strategies so as to enhance the learning of the subject systematically.

2. Level-wise competencies

The expected competencies of this course are to:

1. think critically and creatively, communicate effectively in written and oral form and reason quantitatively
2. apply appropriate principles, concepts, theories, laws, models and patterns to interpret the findings, draw conclusion, make generalization, and to predict from chemical facts, observation and experimental data.
3. correlate old principles, concepts, theories, laws, tools, techniques; to the modern, sustainable and cost-effective skills, tools and techniques in the development of scientific attitude.
4. apply the principles and methods of science to develop the scientific skill in an industrial process to produce various chemicals in small as well as in industrial scale that are useful in our daily life and in the service of mankind.
5. explain the social, economic, environmental and other implications of chemistry and appreciate the advancement of chemistry and its applications as essential for the growth of national economy.

6. describe chemistry as a coherent and developing framework of knowledge based on fundamental theories of the structure and process of the physical world.
7. develop skills in safe handling of chemicals, taking into account of their physical and chemical properties, risk, environmental hazards, etc.
8. conduct either a research work or an innovative work in an academic year, under the guidance of teacher, using the knowledge and skills learnt.

4. Scope and Sequence of Contents (Theory)

Grade 11	T H	Grade 12	T H
Content Area: General and Physical Chemistry			
1. Foundation and Fundamentals 1.1 General introduction of chemistry 1.2 Importance and scope of chemistry 1.3 Basic concepts of chemistry (atoms, molecules, relative masses of atoms and molecules, atomic mass unit (amu), radicals, molecular formula, empirical formula) 1.4 Percentage composition from molecular formula	**2**	**1. Volumetric Analysis** 1.1 Introduction to gravimetric analysis, volumetric analysis and equivalent weight 1.2 Relationship between equivalent weight, atomic weight and valency 1.3 Equivalent weight of compounds (acid, base, salt, oxidizing and reducing agents) 1.4 Concentration of solution and its units in terms of : Percentage, g/L , molarity, molality, normality and formality, ppm and	**8**

		ppb 1.5 Primary and secondary standard substances 1.6 Law of equivalence and normality equation 1.7 Titration and its types: Acid-base titration, redox titration (related numerical problems)	
2. Stoichiometry 2.1 Dalton's atomic theory and its postulates 2.2 Laws of stoichiometry 2.3 Avogadro's law and some deductions 2.3.1 Molecular mass and vapour density 2.3.2 Molecular mass and volume of gas 2.3.3 Molecular mass and no. of particles 2.4 Mole and its relation with mass, volume and number of particles 2.5 Calculations based on mole concept 2.6 Limiting reactant and excess reactant 2.7 Theoretical yield, experimental yield and % yield 2.8 Calculation of empirical and molecular formula from % composition (Solving related numerical problems)	**8**	**2. Ionic Equilibrium** **Introduction to Acids and Bases** 2.1. Limitation of Arrhenius concepts of acids and bases 2.2 Bronsted –Lowry definition of acids and bases 2.3 Relative strength of acids and bases 2.4 Conjugate acid –base pairs 2.5 Lewis definition of acids and bases 2.6 Ionization of weak electrolyte (Ostwald's dilution law) 2.7 Ionic product of water(Kw) 2.8 Dissociation constant of acid and base, (Ka& Kb) 2.9 Concept of pKa and pKb 2.10 pH value: pH of strong and weak acids, pH of strong and weak bases 2.11 Solubility and solubility product principle 2.12 Common Ion effect 2.13 Application of solubility product principle and common ion effect in precipitation reactions 2.14 Buffer solution and its application 2.15 Indicators and selection of indicators in acid base titration 2.16 Types of salts: Acidic salts, basic salts, simple salts, complex salts (introduction and examples) 2.17 Hydrolysis of salts	**10**

		2.17.1 Salts of strong acid and strong base 2.17.2 Salts of weak acid and strong base 2.17.3 Salts of weak base and strong acid (solving related numerical problems)	
3. Atomic Structure 3.1 Rutherford's atomic model 3.2 Limitations of Rutherford's atomic model 3.3 Postulates of Bohr's atomic model and its application 3.4 Spectrum of hydrogen atom 3.5 Defects of Bohr's theory 3.6 Elementary idea of quantum mechanical model: de Broglie's wave equation 3.7 Heisenberg's Uncertainty Principle 3.8 Concept of probability 3.9 Quantum Numbers 3.10 Orbitals and shape of s and p orbitals only 3.11 Aufbau Principle 3.12 Pauli's exclusion principle 3.13 Hund's rule and electronic configurations of atoms and ions (up to atomic no. 30)	**8**	**3. Chemical Kinetics** 3.1 Introduction 3.2 Rate of reactions: Average and instantaneous rate of reactions 3.3 Rate law and its expressions 3.4 Rate constant and its unit and significance 3.5 Order and molecularity 3.6 Integrated rate equation for zero and first order reaction 3.7 Half-life of zero and first order reactions 3.8 Collision theory, concept of activation energy and activated complex 3.9 Factors affecting rate of reactions: Effect of concentration, temperature (Arrhenius Equation) and effect of catalyst (energy profile diagram) 3.10 Catalysis and types of catalysis: homogeneous, heterogeneous and enzyme catalysis (solving related numerical problems based on rate, rate constant and order of zero and first order reactions)	**7**
4. Classification of elements and Periodic Table 4.1 Modern periodic law and modern periodic table 4.1.1 Classification of elements into different groups, periods and blocks	**5**	**4. Thermodynamics** 4.1 Introduction 4.2 Energy in chemical reactions 4.3 Internal energy 4.4 First law of thermodynamics 4.5 Enthalpy and enthalpy changes:	**8**

4.2 IUPAC classification of elements 4.3 Nuclear charge and effective nuclear charge 4.4 Periodic trend and periodicity 4.4.1 Atomic radii 4.4.2 Ionic radii 4.4.3 Ionization energy 4.4.4 Electron affinity 4.4.5 Electronegativity 4.4.6 Metallic characters (General trend and explanation only)		Endothermic and exothermic processes) 4.6 Enthalpy of reaction, enthalpy of solution, enthalpy of formation, enthalpy of combustion 4.7 Laws of thermochemistry (Laplace Law and Hess's law) 4.8 Entropy and spontaneity 4.9 Second law of thermodynamics 4.10 Gibbs' free energy and prediction of spontaneity 4.11 Relationship between ΔG and equilibrium constant (Solving related numerical problems)	
5. Chemical Bonding and Shapes of Molecules 5.1 Valence shell, valence electron and octet theory 5.2 Ionic bond and its properties 5.3 Covalent bond and coordinate covalent bond 5.4 Properties of covalent compounds 5.5 Lewis dot structure of some common compounds of s and p block elements 5.6 Resonance 5.7 VSEPR theory and shapes of some simple molecules (BeF_2, BF_3, CH_4, CH_3Cl, PCl_5, SF_6, H_2O,NH_3,CO_2,H_2S, PH_3) 5.8 Elementary idea of Valence Bond Theory 5.9 Hybridization involving s and p orbitals only 5.10 Bond characteristics: 5.10.1 Bond length 5.10.2 Ionic character 5.10.3 Dipole moment 5.11 Vander Waal's force and molecular solids	**9**	**5. Electrochemistry** 5.1 Electrode potential and standard electrode potential 5.2 Types of electrodes: Standard hydrogen electrode and calomel electrodes 5.3 Electrochemical series and its applications 5.4 Voltaic cell: Zn-Cu cell, Ag- Cu cell 5.5 Cell potential and standard cell potential 5.6 Relationship between cell potential and free energy 5.7 Commercial batteries and fuel cells (hydrogen/oxygen)	**7**

5.12 Hydrogen bonding and its application 5.13 Metallic bonding and properties of metallic solids			
6. Oxidation and Reduction 6.1 General and electronic concept of oxidation and reduction 6.2 Oxidation number and rules for assigning oxidation number 6.3 Balancing redox reactions by oxidation number and ion-electron (half reaction) method 6.4 Electrolysis 6.4.1 Qualitative aspect 6.4.2 Quantitative aspect(Faradays laws of electrolysis)	**5**	-	
7 States of Matter **7.1 Gaseous state** 7.1.1 Kinetic theory of gas and its postulates 7.1.2 Gas laws 7.1.2.1 Boyle's law and Charles' law 7.1.2.2 Avogadro's law 7.1.2.3 Combined gas equation 7.1.2.4 Dalton's law of partial pressure 7.1.2.5 Graham's law of diffusion 7.1.3 Ideal gas and ideal gas equation 7.1.4 Universal gas constant and its significance 7.1.5 Deviation of real gas from ideality (Solving related numerical problems based on gas laws)	**8**	-	

7.2 Liquid state 7.2.1 Physical properties of liquids 7.2.1.1 Evaporation and condensation 7.2.1.2 Vapour pressure and boiling point 7.2.1.3 Surface tension and viscosity (qualitative idea only) 7.2.2 Liquid crystals and their applications **7.3 Solid state** 7.3.1 Types of solids 7.3.2 Amorphous and crystalline solids 7.3.3 Efflorescent, Deliquescent and Hygroscopic solids 7.3.4 Crystallization and crystal growth 7.3.5 Water of crystallization 7.3.6 Introduction to unit crystal lattice and unit cell			
8. Chemical equilibrium 8.1 Physical and chemical equilibrium 8.2 Dynamic nature of chemical equilibrium 8.3 Law of mass action 8.4 Expression for equilibrium constant and its importance 8.5 Relationship between Kp and Kc 8.6 Le Chatelier's Principle (Numericals not required)	**3**	-	
Content Area: Inorganic Chemistry			
9. Chemistry of Non-metals **9.1 Hydrogen** 9.1.1 Chemistry of atomic and nascent hydrogen	**4**	**6. Transition Metals** 6.1 Introduction 6.1.1 Characteristics of transition metals 6.1.2 Oxidation states of transition	**5**

9.1.2 Isotopes of hydrogen and their uses 9.1.3 Application of hydrogen as fuel 9.1.4 Heavy water and its applications **9.2 Allotropes of Oxygen** 9.2.1 Definition of allotropy and examples 9.2.2 Oxygen: Types of oxides (acidic, basic, neutral, amphoteric, peroxide and mixed oxides) 9.2.3 Applications of hydrogen peroxide 9.2.4 Medical and industrial application of oxygen **9.3 Ozone** 9.3.1 Occurrence 9.3.2 Preparation of ozone from oxygen 9.3.3 Structure of ozone 9.3.4 Test for ozone 9.3.5 Ozone layer depletion (causes, effects and control measures) 9.3.6 Uses of ozone		metals 6.1.3 Complex ions and metal complexes 6.1.4 Shapes of complex ions 6.1.5 d-orbitals in complex ions (simple explanation by crystal field theory) for octahedral complex 6.1.6 Reasons for the colour of transition metal compounds 6.1.7 Catalytic properties of transition metals	
9.4 Nitrogen 9.4.1 Reason for inertness of nitrogen and active nitrogen 9.4.2 Chemical properties of ammonia [Action with $CuSO_4$ solution, water, $FeCl_3$ solution, Conc. HCl, Mercurous nitrate paper, O_2] 9.4.3 Applications of ammonia 9.4.4 Harmful effects of ammonia 9.4.5 Oxy-acids of nitrogen (name and formula) 9.4.6 Chemical properties of nitric acid [HNO_3 as an acid and oxidizing agent (action with zinc, magnesium, iron, copper, sulphur, carbon, SO_2 and H_2S) 9.4.7 Ring test for nitrate ion	**5**	**7. Studies of Heavy Metals** **7.1 Copper** 7.1.1 Occurrence and extraction of copper from copper pyrite 7.1.2 Properties (with air, acids, aqueous ammonia and metal ions) and uses of copper 7.1.3 Chemistry (preparation, properties and uses) of blue vitriol 7.1.4 Other compounds of copper (red oxide and black oxide of copper) formula and uses only **7.2 Zinc** 7.2.1 Occurrence and extraction of zinc from zinc blende 7.2.2 Properties (with air, acid, alkali, displacement reaction) and uses	**15**
9.5 Halogens	**5**		

9.5.1 General characteristics of halogens 9.5.2 Comparative study on preparation (no diagram and description is required), 9.5.2.1 Chemical properties [with water, alkali, ammonia, oxidizing character, bleaching action] and uses of halogens (Cl_2, Br_2 and I_2) 9.5.3 Test for Cl_2, Br_2 and I_2 9.5.4 Comparative study on preparation (no diagram and description is required), properties (reducing strength, acidic nature and solubility) and uses of haloacids (HCl, HBr and HI)		of zinc 7.2.3 Chemistry (preparation, properties and uses) of white vitriol **7.3 Mercury** 7.3.1 Occurrence and extraction of mercury from cinnabar 7.3.2 Properties of mercury 7.3.3 Chemistry (preparation, properties and uses) of calomel and corrosive sublimate **7.4 Iron** 7.4.1 Occurrence and extraction of iron 7.4.2 Properties and uses of iron 7.4.3 Manufacture of steel by Basic Oxygen Method and Open Hearth Process 7.4.4 Corrosion of iron and its prevention **7.5 Silver** 7.5.1 Occurrence and extraction of silver by cyanide process 7.5.2 Preparation and uses of silver chloride and silver nitrate	
9.6 Carbon 9.6.1 Allotropes of carbon (crystalline and amorphous) including fullerenes (structure, general properties and uses only) 9.6.2 Properties (reducing action, reaction with metals and nonmetals) and uses of carbon monoxide **9.7 Phosphorus** 9.7.1 Allotropes of phosphorus (name only) 9.7.2 Preparation (no diagram and description is required), properties (basic nature ,reducing nature , action with halogens and oxygen) and uses of phosphine	**3**		
9.8 Sulphur 9.8.1 Allotropes of sulphur (name only) and uses of sulphur 9.8.2 Hydrogen sulphide (preparation from Kipp's apparatus with diagram,) properties (Acidic nature, reducing nature, analytical reagent) and uses 9.8.3 Sulphur dioxide its properties (acidic nature, reducing nature,	**5**	-	

oxidising nature and bleaching action) and uses 9.8.4 Sulphuric acid and its properties (acidic nature, oxidising nature, dehydrating nature) and uses 9.8.5 Sodium thiosulphate (formula and uses)			
10 Chemistry of Metals **10.1 Metals and Metallurgical Principles** 10.1.1 Definition of metallurgy and its types (hydrometallurgy, pyrometallurgy, electrometallurgy) 10.1.2 Introduction of ores 10.1.3 Gangue or matrix, flux and slag, alloy and amalgam 10.1.4 General principles of extraction of metals (different processes involved in metallurgy) – concentration, calcination and roasting, smelting, carbon reduction, thermite and electrochemical reduction 10.1.5 Refining of metals (poling and electro-refinement)	**5**	**-**	
10.2 Alkali Metals 10.2.1 General characteristics of alkali metals 10.2.2 Sodium [extraction from Down's process, properties (action with Oxygen, water, acids nonmetals and ammonia) and uses] 10.2.3 Properties (precipitation reaction and action with carbon monooxide) and uses of sodium hydroxide 10.2.4 Properties (action with CO_2, SO_2, water, precipitation reactions) and uses of sodium carbonate 10.3 Alkaline Earth Metals 10.3.1 General characteristics of alkaline	**5**	**-**	

earth metals 10.3.2 Molecular formula and uses of (quick lime, bleaching powder, magnesia, plaster of paris and epsom salt) 10.3.3 Solubility of hydroxides, carbonates and sulphates of alkaline earth metals (general trend with explanation) 10.3.4 Stability of carbonate and nitrate of alkaline earth metals (general trend with explanation)			
11. Bio-inorganic Chemistry **11. Introduction to Bio-inorganic Chemistry** 11.1 Introduction 11.2 Micro and macro nutrients 11.3 Importance of metal ions in biological systems (ions of Na, K, Mg, Ca, Fe, Cu, Zn, Ni, Co, Cr) 11.4 Ion pumps (sodium-potassium and sodium-glucose pump) 11.5 Metal toxicity (toxicity due to iron, arsenic, mercury, lead and cadmium)	**3**	-	
Content Area: Organic Chemistry			
12 Basic Concept of Organic Chemistry 12.1 Introduction to organic chemistry and organic compounds 12.2 Reasons for the separate study of organic compounds from inorganic compounds 12.3 Tetra-covalency and catenation properties of carbon 12.4 Classification of organic compounds 12.5 Alkyl groups, functional groups and homologous series 12.6 Idea of structural formula,	**6**	**8. Haloalkanes** 8.1 Introduction 8.2 Nomenclature, isomerism and classification of monohaloalkanes 8.3 Preparation of monohaloalkanes from alkanes, alkenes and alcohols 8.4 Physical properties of monohaloalkanes 8.5 Chemical properties, substitution reactions SN1 and SN2 reactions (basic concept only) 8.6 Formation of alcohol, nitrile, amine, ether, thioether,	**8**

contracted formula and bond line structural formula 12.7 Preliminary idea of cracking and reforming, quality of gasoline, octane number, cetane number and gasoline additive		carbylamines, nitrite and nitro alkane using haloalkanes 8.7 Elimination reaction (dehydrohalogenation- Saytzeff's rule), Reduction reactions, Wurtz reaction 8.8 Preparation of trichloromethane from ethanol and propanone 8.9 Chemical properties of trichloromethane: oxidation, reduction, action on silver powder, conc. nitric acid, propanone, and aqueous alkali	
13 Fundamental Principles of Organic Chemistry 13.1 IUPAC Nomenclature of Organic Compounds (upto chain having 6-carbon atoms) 13.2 Qualitative analysis of organic compounds (detection of N, S and halogens by Lassaigne's test) 13.3 Isomerism in Organic Compounds 13.4 Definition and classification of isomerism 13.5 Structural isomerism and its types: chain isomerism, position isomerism, functional isomerism, metamerism and tautomerism 13.6 Concept of geometrical isomerism (cis & trans) & optical isomerism (d & l form) **13.7 Preliminary Idea of Reaction Mechanism** 13.7.1 Homolytic and heterolytic fission 13.7.2 Electrophiles, nucleophiles and free- radicals 13.7.3 Inductive effect: +I and –I effect 13.7.4 Resonance effect: +R and –R effect	**10**	**9. Haloarenes** 9.1 Introduction 9.2 Nomenclature and isomerism of haloarenes 9.3 Preparation of chlorobenzene from benzene and benzene diazonium chloride 9.4 Physical properties 9.5 Chemical properties 9.5.1 Low reactivity of haloarenes as compared to haloalkanes in term of nucleophilic substitution reaction 9.5.2 Reduction of chlorobenzene 9.5.3 Electrophilic substitution reactions 9.5.4 Action with Na (Fittig and Wurtz- Fittig reaction) 9.5.5 Action with chloral 9.6 Uses of haloarenes	**3**
14. Hydrocarbons **14.1 Saturated Hydrocarbons**	**8**	**10. Alcohols** 10.1 Introduction	**7**

(Alkanes) 14.1.1 Alkanes: Preparation from haloalkanes (Reduction and Wurtz reaction), Decarboxylation, Catalytic hydrogenation of alkene and alkyne 14.1.2 Chemical properties: Substitution reactions (halogenation, nitration & sulphonation only), oxidation of ethane **14.2 Unsaturated hydrocarbons (Alkenes & Alkynes)** 14.2.1 Alkenes: Preparation by Dehydration of alcohol, Dehydrohalogenation, Catalytic hydrogenation of alkyne 14.2.1.1 Chemical properties: Addition reaction with HX (Markovnikov's addition and peroxide effect), H_2O, O_3, H_2SO_4 only **14.3 Alkynes: Preparation from carbon and hydrogen, 1,2 dibromoethane, chloroform/iodoform only** 14.3.1 Chemical properties: Addition reaction with (H_2, HX, H_2O), Acidic nature (action with Sodium, ammoniacal $AgNO_3$ and ammoniacal Cu_2Cl_2) **14.4 Test of unsaturation (ethene & ethyne): bromine water test and Baeyer's test** **14.5 Comparative studies of physical properties of alkane, alkene and alkyne** 14.6 Kolbe's electrolysis methods for the preparation of alkane, alkene and alkynes		10.2 Nomenclature, isomerism and classification of monohydric alcohol 10.3 Distinction of primary, secondary and tertiary alcohols by Victor Meyer's Method 10.4 Preparation of monohydric alcohols from Haloalkane, primary amines, and esters 10.5 Industrial preparation alcohol from: oxo process, hydroboration-oxidation of ethene & fermentation of sugar 10.6 Definition of common terms: Absolute alcohol, power alcohol, denatured alcohol (methylated spirit), rectified spirit; alcoholic beverage 10.7 Physical properties monohydric alcohols 10.8 Chemical properties of monohydric alcohols 10.8.1 Reaction with HX, PX_3, PCl_5, $SOCl_2$ 10.8.2 Action with reactive metals like Na, K, Li 10.8.3 Dehydration of alcohols 10.8.4 Oxidation of primary, secondary and tertiary alcohol with mild oxidizing agents like acidified $KMnO_4$ or $K_2Cr_2O_7$ 10.8.5 Catalyic dehydrogenation of 1^0 and 2^0 alcohol and dehydration of 3^0 alcohol 10.8.6 Esterification reaction 10.8.7 Test of ethanol	
15. Aromatic Hydrocarbons 15.1 Introduction and characteristics of aromatic compounds 15.2 Huckel's rule of aromaticity	**6**	**11. Phenols** 11.1 Introduction and nomenclature 11.2 Preparation of phenol from i. chlorobenzene ii. Diazonium salt and iii. benzene sulphonic acid	**4**

15.3 Kekule structure of benzene 15.4 Resonance and isomerism 15.5 Preparation of benzene from decarboxylation of sodium benzoate, phenol, and ethyne only 15.6 Physical properties of benzene 15.7 Chemical properties of benzene: Addition reaction: hydrogen, halogen, Electrophilic substitution reactions: orientation of benzene derivatives (o, m & p), nitration, sulphonation, halogenations, Friedal-Craft's reaction (alkylation and acylation), combustion of benzene (free combustion only) and uses		11.3 Physical properties of phenol 11.4 Chemical properties 11.4.1 Acidic nature of phenol (comparison with alcohol and water) 11.4.2 Action with NH_3, Zn, Na, benzene diazonium chloride and phthalic anhydride 11.4.3 Acylation reaction, Kolbe's reaction, Reimer-Tiemann's reaction 11.4.4 Electrophilic substitution: nitration, sulphonation, brominaiton and Friedal-Craft's alkylation 11.5 Test of phenol: ($FeCl_3$ test, aq. Bromine test & Libermann test) 11.6 Uses of phenol	
-		**12. Ethers** 12.1 Introduction 12.2 Nomenclature, classification and isomerism of ethers 12.3 Preparation of aliphatic and aromatic ethers from Williamson's synthesis 12.4 Physical properties of ether 12.5 Chemical properties of ethoxyethane: action with HI , Conc. HCl, Conc. H_2SO_4, air and Cl_2 12.6 Uses of ethers	**2**
-		**13. Aldehydes and Ketones** **13.1 Aliphatic aldehydes and ketones** 13.1.1 Introduction, nomenclature and isomerism 13.1.2 Preparation of aldehydes and ketones from: Dehydrogenation and oxidation of alcohol, Ozonolysis of alkenes, Acid chloride, Gem dihaloalkane,	**10**

		Catalytic hydration of alkynes 13.1.3 Physical properties of aldehydes and ketones 13.1.4 Chemical properties 13.1.4.1 Structure and nature of carbonyl group 13.1.4.2 Distinction between aldehyde and ketones by using 2,4- DNP reagent, Tollen's reagent, Fehling's solution 13.1.4.3 Addition reaction: addition of H2, HCN and $NaHSO_3$ 13.1.4.4 Action of aldehyde and ketone with ammonia derivatives; NH_2OH, NH_2-NH_2, phenyl hydrazine, semicarbazide, 13.1.4.5 Aldol condensation 13.1.4.6 Cannizzaro's reaction 13.1.4.7 Clemmensen's reduction 13.1.4.8 Wolf-Kishner reduction 13.1.4.9 Action with PCl_5 and action with $LiAlH_4$ 13.1.4.10 Action of methanal with ammonia and phenol 13.1.5 Formalin and its uses **13.2 Aromatic aldehydes and Ketones** 13.2.1 Preparation of benzaldehyde from toluene and acetophenone from benzene 13.2.2 Properties of benzaldehyde 13.2.2.1 Perkin condensation 13.2.2.2 Benzoin condensation 13.2.2.3 Cannizzaro's reaction 13.2.2.4 Electrophilic substitution reaction	
-		**14. Carboxylic Acid and its Derivaties** **14.1 Aliphatic and aromatic carboxylic acids**	**9**

		14.1.1 Introduction, nomenclature and isomerism 14.1.2 Preparation of monocarboxylic acids from: aldehydes, nitriles, dicarboxylic acid, sodium alkoxide and trihaloalkanes 14.1.3 Preparation of benzoic acid from alkyl benzene 14.1.4 Physical properties of monocarboxylic acids 14.1.5 Chemical properties: Action with alkalies, metal oxides, metal carbonates, metal bicarbonates, PCl_3, $LiAlH_4$ and dehydration of carboxylic acid 14.1.6 Hell-Volhard-Zelinsky reaction 14.1.7 Electrophilic substitution reaction of benzoic acid - bromination, nitration and sulphonation) 14.1.8 Effect of constituents on the acidic strength of carboxylic acid 14.1.9 Abnormal behaviour of methanoic acid **14.2 Derivatives of Carboxylic acids (acid halides, amides, esters and anhydrides)** 14.2.1 Preparation of acid derivatives from carboxylic acid 14.2.2 Comparative physical properties of acid derivatives 14.2.3 Comparative chemical properties of acid derivatives (hydrolysis, ammonolysis, amines (RNH_2), alcoholysis, and reduction only) 14.2.4 Claisen condensation 14.2.5 Hofmann bromamide reaction 14.2.6 Amphoteric nature of amide 14.2.7 Relative reactivity of acid derivatives	

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-		**16. Amines** **16.1 Aliphatic amines** 16.1.1 Introduction, nomenclature, classification and isomerism 16.1.2 Separation of primary, secondary and tertiary amines by Hoffmann's method 16.1.3 Preparation of primary amines from haloalkane, nitriles, nitroalkanes and amides 16.1.4 Physical properties 16.1.5 Chemical properties: basicity of amines, comparative study of basic nature of 10, 20 and 30 amines 16.1.6 Reaction of primary amines with chloroform, conc. HCl, R-X, RCOX and nitrous acid ($NaNO_2$ / HCl) 16.1.7 Test of 10, 20 and 30 amines (nitrous acid test) **16.2 Aromatic amine (Aniline)**	**7**

		16.2.1 Preparation of aniline from nitrobenzene, phenol 16.2.2 Physical properties 16.2.3 Chemical properties: basicity of aniline, comparison of basic nature of aniline with aliphatic amines and ammonia, alkylation, acylation, diazotization, carbylamine and coupling reaction, electrophilic substitution: Nitration sulphonation and bromination 16.2.4 Uses of aniline	
-		**17. Organometallic Compounds** 17.1 Introduction, general formula and examples of organolithium, organocopper and organocadmium compounds 17.2 Nature of Metal-Carbon bond 17.3 Grignard reagent 17.3.1 Preparation (using haloalkane and haloarene) 17.3.2 Reaction of Grignard reagent with water, aldehydes and ketones (preparation of primary, secondary and tertiary alcohols), carbon dioxide, HCN, RCN, ester and acid chloride	**2**
Content Area: Applied Chemistry			
Unit: 16 Fundamentals of Applied Chemistry **16.1 Fundamentals of Applied Chemistry** 16.1.2 Chemical industry and its importance 16.1.3 Stages in producing a new product 16.1.4 Economics of production 16.1.5 Cash flow in the production cycle 16.1.6 Running a chemical plant	**4**	**18. Chemistry in the service of mankind** **18.1 Polymers** 18.1.1 Addition and condensation polymers 18.1.2 Elastomers and fibres 18.1.3 Natural and synthetic polymers 18.1.4 Some synthetic polymers (polythene, PVC, Teflon, polystyrene, nylon and bakelite **18.2 Dyes**	**4**

16.1.7 Designing a chemical plant 16.1.7 Continuous and batch processing 16.1.8 Environmental impact of the chemical industry		18.2.1 Introduction 18.2.2 Types of dyes on the basis of structure and method of application **18.3 Drugs** 18.3.1 Characteristics of drugs 18.3.2 Natural and synthetic drugs 18.3.3 Classification of some common drugs 18.3.4 Habit forming drugs and drug addiction **18.4 Pesticides** 18.4.1 Introduction to insecticides, herbicides and fungicides	
Unit: 17 Modern Chemical Manufactures **17.1 Modern Chemical Manufactures (principle and flow sheet diagram only)** 17.1.1 Manufacture of ammonia by Haber's process, 17.1.2 Manufacture of nitric acid by Ostwald's process, 17.1.3 Manufacture of sulphuric acid by contact process, 17.1.4 Manufacture of sodium hydroxide by Diaphragm Cell 17.1.5 Manufacture of sodium carbonate by ammonia soda or Solvay process **17.2 Fertilizers (Chemical fertilizers, types of chemical fertilizers, production of urea with flow-sheet diagram)**	**11**	**19. Cement** 19.1 Introduction 19.2 Raw materials for cement production 19.3 Main steps in cement production (crushing and grinding, strong heating and final grinding) 19.4 Types of cement- OPC and PPC 19.5 Portland cement process with flow-sheet diagram 19.6 Cement Industry in Nepal	**4**
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		20.5 Flow-sheet diagram for paper production 20.6 Quality of paper	
-		**21 Nuclear Chemistry and Applications of Radioactivity** 21.1 Natural and artificial radioactivity 21.2 Units of radioactivity 21.3 Nuclear reactions 21.4 Nuclear fission and fusion reactions 21.5 Nuclear power and nuclear weapons 21.6 Industrial uses of radioactivity 21.7 Medical uses of radioactivity 21.8 Radiocarbon dating 21.9 Harmful effects of nuclear radiations	**2**

SYLLABUS OF THE INTERNATIONAL CHEMISTRY OLYMPIAD

Theoretical part

1. The atom

2. Chemical bonding

3. Chemical calculations

4. Periodic trends

4.1.	***Electron configuration***	
4.1.1.	**Pauli exclusion principle**	**1**
4.1.2.	**Hund's Rule**	**1**
4.1.3.	**Main group elements**	**1**
4.1.4.	**Transition metal elements**	**1**
4.1.5.	**Lanthanide and actinide metals**	**3**
4.2.	***Electronegativity***	**1**
4.3.	***Electron affinity***	**2**
4.4.	***First ionization energy***	**1**
4.5.	***Atomic size***	**1**
4.6.	***Ion size***	**1**
4.7.	***Highest oxidation number***	**1**

5. Inorganic Chemistry

5.1.	***Introduction***	
5.1.1.	**Trends in physical properties of elements (Main groups)**	
5.1.1.1.	**melting point**	**1**
5.1.1.2.	**boiling point**	**1**
5.1.1.3.	**metal character**	**1**
5.1.1.4.	**magnetic properties**	**3**
5.1.1.5.	**electrical conductivity**	**2**
5.1.2.	**Oxidation number**	**1**
5.1.3.	**Nomenclature**	
5.1.3.1.	**main group compounds**	**1**
5.1.3.2.	**transition metal compounds**	**1**
5.1.3.3.	**simple metal complexes**	**3**
5.2.	***Groups 1 and 2***	
5.2.1.	**Trend in reactivity of (heavy elements more reactive)**	**1**
5.2.2.	**Products of reaction with**	
5.2.2.1.	**water**	**1**
5.2.2.2.	**halogens**	**1**
5.2.2.3.	**oxygen**	**2**
5.2.3.	**Basicity of oxides**	**1**
5.2.4.	**Properties of hydrides**	**3**
5.2.5.	**Other compounds, properties and oxidation states**	**3**
5.3.	***Groups 13 – 18 and Hydrogen***	
5.3.1.	**Binary molecular compounds of hydrogen**	
5.3.1.1.	**Formulae**	**1**
5.3.1.2.	**Acid-base properties of CH_4, NH_3, H_2O, H_2S**	**1**
5.3.1.3.	**Other properties**	**3**
5.3.2.		
	Group 13	
5.3.2.1	**The oxidation state of boron and aluminium in their oxides and chlorides is +3**	**1**
5.3.2.2.	**The acid-base properties of aluminium oxide/hydroxide**	**2**
5.3.2.3.	**Reaction of boron(III) oxide with water**	**3**
5.3.2.4.	**Reaction of boron(III) chloride with water**	**3**
5.3.2.5.	**Other compounds, properties and oxidation states**	**3**

5.3.3.	**Group 14**		
	5.3.3.1.	**The oxidation state of Si in its chloride and oxide is +4**	**1**
	5.3.3.2.	**The +2 and +4 oxidation states of carbon, tin and lead, the acid-base and redox properties of the oxides and chlorides**	**2**
	5.3.3.3.	**Other compounds, properties and oxidation states**	**3**
5.3.4.	**Group 15**		
	5.3.4.1.	**Phosphorus(+5) oxide and chloride, and their reaction with water**	**2**
	5.3.4.2.	**Phosphorus(+3) oxide and chloride, and their reaction with water**	**2**
	5.3.4.3.	**Oxides of nitrogen**	
		a. Reaction of NO to form NO_2	**1**
		b. Dimerization of NO_2	**1**
		c. Reaction of NO_2 with water	**1**
	5.3.4.4.	**Redox properties of**	
		a. HNO_3 and nitrates	**1**
		b. HNO_2 and NH_2NH_2	**3**
	5.3.4.5.	**Bi(+5) and Bi(+3)**	**3**
	5.3.4.6.	**Other compounds, properties and oxidation states**	**3**
5.3.5.	**Group 16**		
	5.3.5.1.	**The +4 and +6 oxidation states of sulfur, reaction of their oxides with water, properties of their acids**	**1**
	5.3.5.2.	**Reaction of thiosulfate anion with I_2**	**3**
	5.3.5.3.	**Other compounds, properties and oxidation states**	**3**
5.3.6.	**Group 17 (Halogens)**		
	5.3.6.1.	**Reactivity and oxidant strength decreases from F_2 to I_2**	**1**
	5.3.6.2.	**Acid-base properties of the hydrogen halides**	**1**
	5.3.6.3.	**The oxidation state of fluorine in its compounds is –1**	**1**
	5.3.6.4.	**The –1, +1, +3, +5, +7 oxidation states of chlorine**	**1**
	5.3.6.5.	**Mononuclear oxoanions of chlorine**	**2**
	5.3.6.6.	**Reactions of halogens with water**	**3**
	5.3.6.7.	**Reaction of Cl_2O and Cl_2O_7 with water**	**3**
	5.3.6.8.	**Other compounds, properties and oxidation states**	**3**
5.3.7.	**Group 18**		**3**
5.4.	***Transition elements***		
5.4.1.	**Common oxidation states of common transition metals: Cr(+2), Cr(+3) Mn(+2), Mn(+4), Mn(+7) Ag(+1) Fe(+2), Fe(+3) Co(+2) Zn(+2) Hg(+1), Hg(+2) Cu(+1), Cu(+2) Ni(+2)**		**1**
5.4.2.	**Colours of ions listed above in aqueous solution**		**2**
5.4.3.	**Insolubility of Ag, Hg and Cu in HCl**		**2**
5.4.4.	**M^{2+} arising by dissolution of the other metals in HCl**		**2**
5.4.5.	**$Cr(OH)_3$ and $Zn(OH)_2$ are amphoteric and the other +2 oxides/hydroxides of the metals listed above are basic**		**2**
5.4.6.	**MnO_4^- and $Cr_2O_7^{2-}$ are strong oxidants in acid solution**		**1**
5.4.7.	**pH dependence of products of MnO_4^- acting as oxidant**		**2**
5.4.8.	**Interconversion between CrO_4^{2-} and $Cr_2O_7^{2-}$**		**3**
5.4.9.	**Other compounds, properties and oxidation states**		**3**
5.5.	***Lanthanides and actinides***		**3**

5.6.	***Coordination chemistry including stereochemistry***	
5.6.1.	**Definition of coordination number**	**1**
5.6.2.	**Writing equations for complexation reactions given all formulae**	**1**
5.6.3.	**Formulae of common complex ions**	
5.6.3.1.	**$Ag(NH_3)_2^+$**	**1**
5.6.3.2.	**$Ag(S_2O_3)_2^{3-}$**	**3**
5.6.3.3.	**$FeSCN^{2+}$**	**3**
5.6.3.4.	**$Cu(NH_3)_4^{2+}$**	**1**
5.6.3.5.	**Other complex ions**	**3**
5.6.4.	**(6.5) Ligand field theory (*e*g and *t*2g terms, high and low spin)**	**3**
5.6.5.	**Stereochemistry**	
5.6.5.1.	**(6.7) *cis* and *trans***	**3**
5.6.5.2.	**enantiomers**	**3**
5.7.	***Selected industrial processes***	
5.7.1.	**Preparation of H_2SO_4**	**1**
5.7.2.	**Preparation of NH_3**	**1**
5.7.3.	**Preparation of Na_2CO_3**	**2**
5.7.4.	**Preparation of Cl_2 and NaOH**	**2**
5.7.5.	**Preparation of HNO_3**	**2**

6. Physical chemistry

6.1.	***Gases***	
6.1.1.	**Ideal gas law**	**1**
6.1.2.	**van der Waal's gas law**	**3**
6.1.3.	**definition of partial pressure**	**2**
6.1.4.	**Dalton's Law**	**3**
6.2.	***Thermodynamics***	
6.2.1.	**First Law**	
6.2.1.1.	**Concept of system and surroundings**	**2**
6.2.1.2.	**Energy, heat and work**	**2**
6.2.2.	**Enthalpy**	
6.2.2.1.	**Relationship between internal energy and enthalpy**	**3**
6.2.2.2.	**Definition of heat capacity**	**2**
6.2.2.3.	**Difference between C_p and C_v (ideal gas only)**	**3**
6.2.2.4.	**Enthalpy is a state property (Hess's Law)**	**2**
6.2.2.5.	**Born-Haber cycle for ionic compounds**	**3**
6.2.2.6.	**Use of standard formation enthalpies**	**2**
6.2.2.7.	**Enthalpies of solution and solvation**	**3**
6.2.2.8.	**Bond enthalpies (definition and use)**	**2**
6.2.3.	**Second Law (Entropy and Free Energy)**	
6.2.3.1.	**Entropy definition (dq / T)**	**3**
6.2.3.2.	**Entropy and disorder**	**3**
6.2.3.3.	**Entropy definition ($S = k \ln W$)**	**3**
6.2.3.4.	**Gibbs energy definition ($\Delta G = \Delta H - T\Delta S$)**	**3**
6.2.3.5.	**Using ΔG to predict direction of natural change**	**3**
6.2.3.6.	**Relationship between ΔG° and equilibrium constant K**	**3**
6.3.	***Equilibrium***	
6.3.1.	**Acid-base**	
6.3.1.1.	**Arrhenius definitions of acids and bases**	**1**
6.3.1.2.	**Bronsted-Lowry definitions**	**1**

		6.3.1.3. Conjugate acids and bases	1
		6.3.1.4. pH definition	1
		6.3.1.5. K_w definition	1
		6.3.1.6. K_a and K_b as a measure of acid and base strength	1
		6.3.1.7. Acidity or basicity of ions	1
		6.3.1.8. Calculation of pH from pK_a(weak acid)	1
		6.3.1.9. Calculation of pH of a simple buffer solution	2
	6.3.2.	Gas phase	
		6.3.2.1. Equilibrium constant in partial pressures	3
		6.3.2.2. Relating K_p and K_c	3
	6.3.3.	Solubility	
		6.3.3.1. Solubility constant (product) definition (K_{sp})	2
		6.3.3.2. Calculation of solubility in water from K_{sp}	2
	6.3.4.	Complexiметric	
		6.3.4.1. Complex formation constant (definition)	3
		6.3.4.2. Problems involving complexiметric equilibria	3
		6.3.4.3. Lewis acids and bases	3
		6.3.4.4. Hard and soft Lewis acids and bases	3
	6.3.5.	Phase	
		6.3.5.1. Temperature dependence of vapour pressure	3
		6.3.5.2. Clausius-Clapeyron equation	3
		6.3.5.3. Single component phase diagrams	
		a. triple point	3
		b. critical point	3
		6.3.5.4. liquid-vapour system	
		a. ideal and nonideal systems	3
		b. diagram	3
		c. use in fractional distillation	3
		6.3.5.5. Henry's Law	3
		6.3.5.6. Raoult's Law	3
		6.3.5.7. Deviation from Raoult's Law	3
		6.3.5.8. Boiling point elevation	3
		6.3.5.9. Freezing point depression	3
		6.3.5.10. Osmotic pressure	3
		6.3.5.11. Partition coefficient	3
		6.3.5.12. Solvent extraction	3
	6.3.6.	Multiple	
		6.3.6.1. Calculation of pH for multiprotic acids	3
		6.3.6.2. Calculation of pH for weak acid mixtures	3
6.4.	*Electrochemistry*		
	6.4.1.	Electromotive force (definition)	1
	6.4.2.	First kind electrodes	1
	6.4.3.	Standard electrode potential	1
	6.4.4.	Nernst equation	3
	6.4.5.	Second kind electrodes	3
	6.4.6.	Relationship between ΔG and electromotive force	3

7. Chemical kinetics (Homogeneous reactions)

8. Spectroscopy

8.4.3. Identification of *o*- and *p*-disubstituted benzene 3
8.4.4. Interpretation of simple spectra of 13C (proton decoupled) and other 1/2 spin nuclei 3

8.5. Mass spectrometry

8.5.1.1. Recognition of molecular ion 3
8.5.1.2. Recognition of fragments with the help of a table 3
8.5.1.3. Recognition of typical isotope distribution 3

9. Organic Chemistry

9.1. Introduction

9.1.1. (3.1.1) Alkane naming (IUPAC) 1
9.1.2. Trends in boiling points of
9.1.2.1. (3.1.3) alkanes with structure 1
9.1.2.2. (3.7.1) alcohols *vs* ethers due to hydrogen-bonding 1
9.1.3. (3.3.1, 3.4.1) Geometry at singly, doubly, and triply bonded carbon 1
9.1.4. Identification of common functional groups 1
9.1.5. Isomerism of alkenes
9.1.5.1. *cis*-*trans* 1
9.1.5.2. *E*/*Z* 3
9.1.6. Enantiomers
9.1.6.1. Optical activity 2
9.1.6.2. *R*/*S* nomenclature 3

9.2. Reactivity

9.2.1. Alkanes
9.2.1.1. reaction with halogens
a. products 1
b. free radical mechanism (initiation, termination) 2
9.2.1.2. Cycloalkanes
a. names 2
b. Strain in small rings 3
c. chair/boat conformations of cyclohexane 3
9.2.2. Alkenes
9.2.2.1. Products from Br_2, HBr and H_2O/H^+ 1
9.2.2.2. Markownikoff's rule 2
9.2.2.3. Mechanism involving carbocation intermediates 3
9.2.2.4. Relative stability of carbocations 3
9.2.2.5. 1,4 addition to dienes 3
9.2.3. Alkynes
9.2.3.1. Acidity relative to alkenes 3
9.2.3.2. Differences in chemical properties from alkenes 2
9.2.4. Benzene
9.2.4.1. formula 1
9.2.4.2. stabilization by resonance 1
9.2.4.3. electrophilic substitution (nitration, halogenation)
a. directing effect of first substituent 3
b. effect of first substituent on reactivity 3
c. explanation of substituent effects 3
9.2.5. Halogen compounds
9.2.5.1. Nomenclature of monofunctional 1
9.2.5.2. Substitution reactions

		a. giving alcohols	3
		b. in which halogen is exchanged	3
		c. reactivity	
		i. primary *vs* secondary *vs* tertiary	3
		ii. aliphatic *vs* aromatic	3
		d. S_N1 and S_N2 mechanisms	3
	9.2.5.3.	Elimination reactions	2
	9.2.5.4.	Competition of elimination and substitution	2
9.2.6.	Alcohols		
	9.2.6.1.	Nomenclature of monofunctional	1
	9.2.6.2.	Comparison of acidity of alcohols and phenols	2
	9.2.6.3.	Dehydration to alkenes	1
	9.2.6.4.	Esters with inorganic acid	2
	9.2.6.5.	Oxidation reactions	1
9.2.7.	Aldehydes and ketones		
	9.2.7.1.	Nomenclature of monofunctional	1
	9.2.7.2.	Oxidation of aldehydes	1
	9.2.7.3.	Reduction to alcohols ($LiAlH_4$, $NaBH_4$)	3
	9.2.7.4.	Keto/enol tautomerism	3
	9.2.7.5.	Nucleophilic addition reactions with	
		a. HCN	3
		b. RNH_2 (R = alkyl, HO, NH_2)	3
		c. enolate anions (aldol condensation)	3
		d. alcohols to form acetals/ketals	3
		e. Grignard reagents	3
9.2.8.	Carboxylic acids and their derivatives		
	9.2.8.1.	Nomenclature of carboxylic acids and their derivatives (esters, acid halides, amides)	2
	9.2.8.2.	Acidity strength related to inductive effects	3
	9.2.8.3.	Preparation of carboxylic acids by hydrolysis of	
		a. esters (including soaps)	1
		b. amides	2
		c. nitriles	3
	9.2.8.4.	Reaction of carboxylic acids	
		a. with alcohols to form esters	1
		b. to form acid chlorides	3
		c. to form anhydrides	3
	9.2.8.5.	Reaction of acid chlorides to form amides	3
	9.2.8.6.	Mechanism of esterification	3
	9.2.8.7.	Multifunctional acids (hydroxyacids, ketoacids)	3
	9.2.8.8.	Polycarboxylic acids	3
9.2.9.	Amines		
	9.2.9.1.	Nomenclature	
		a. simple amines	1
		b. recognition of primary, secondary, tertiary	1
	9.2.9.2.	Basicity	
		a. As a property of an amine	1
		b. Comparison of basicity of aliphatic and aromatic	3
		c. Comparison of basicity of amines and amides	3
		d. Preparation of amines	

		i. from halides	3
		ii. from aromatic nitro compounds	3
		iii. from amides (by hydrolysis)	3
	9.2.9.3.	Diazotization	
		a. of aliphatic amines	3
		b. of aromatic amines	3

10. Polymers

10.1.	***Synthetic***		
	10.1.1.	Addition polymers	
		10.1.1.1. polystyrene	2
		10.1.1.2. polyethene	1
		10.1.1.3. chain mechanism of formation	2
	10.1.2.	Condensation polymers	
		10.1.2.1. polyesters	2
		10.1.2.2. polyamides	2
	10.1.3.	Silicones	3
	10.1.4.	Concept of cross-linking and its affect on properties	3
10.2.	***Natural***		
	10.2.1.	Silicates	3
	10.2.2.	Rubber	3

11. Biochemistry

11.1.	***Carbohydrates***		
	11.1.1.	Glucose and fructose	
		11.1.1.1. chain formulae	1
		11.1.1.2. Fischer projections	2
		11.1.1.3. Haworth formulae	3
	11.1.2.	Difference between starch and cellulose	2
	11.1.3.	Difference between α- and β- D glucose	2
11.2.	***Fats***		
	11.2.1.	Structure of fats in relationship to properties	2
	11.2.2.	Formula of glycerol	1
11.3.	***Nitrogen-containing Compounds of Biological Importance***		
	11.3.1.	Amino acids	
		11.3.1.1. Ionic structure	1
		11.3.1.2. Isoelectric point	3
		11.3.1.3. 20 amino acids (classification with structures provided)	2
		11.3.1.4. Separation by electrophoresis	3
		11.3.1.5. The peptide linkage	1
	11.3.2.	Proteins	
		11.3.2.1. Primary structure	1
		11.3.2.2. –S-S- bridges	3
		11.3.2.3. Sequence analysis	3
		11.3.2.4. Secondary structure	3
		11.3.2.5. Details of α-helix structure	3
		11.3.2.6. Tertiary structure	3
		11.3.2.7. Denaturation (change in pH, temperature, metals, ethanol)	2

11.3.3. Nuclei Acids and Protein Synthesis

11.3.3.1.	Pyrimidine and purine	3
11.3.3.2.	Nucleosides and nucleotides	3
11.3.3.3.	Formulae of pyrimidine and purine bases	3
11.3.3.4.	Difference between ribose and 2-deoxyribose	3
11.3.3.5.	Base combination CG and AT (hydrogen-bonding)	3
11.3.3.6.	Difference between DNA and RNA	3
11.3.3.7.	Difference between mRNA and tRNA	3

11.4. Enzymes

11.4.1.1.	General properties, active centers	3
11.4.1.2.	Nomenclature, kinetics, coenzymes, function of ATP	3

12. Analytical chemistry

12.1. Titrations

12.1.1. acid-base

12.1.1.1.	Titration curve; pH (strong and weak acid)	2
12.1.1.2.	Choice of indicators for acidimetry	2

12.1.2. Redox titration 3

12.2. Qualitative analysis

12.2.1. Ions (Inorganic)

12.2.1.1.	Identification of Ag^+, Ba^{2+}, Cl^-, SO_4^{2-}	2
12.2.1.2.	Identification of other anions and cations	3

12.2.2. Organic functional groups

12.2.2.1.	Lucas reagent (1-, 2-, 3-alcohols)	3
12.2.2.2.	Iodoform reaction	3
12.2.2.3.	Identification of primary, secondary, tertiary, quarternary amines in the laboratory	3

12.3. Chromatographic methods of separation 3

Experimental part

Level 1: is assigned to the basic experimental activities which are supposed to be mastered by competitors very well

Level 2: is assigned to the activities which are parts of school experimental exercises in developed countries and the authors of IChO tasks may incorporate them into the tasks without being bounded to mention it in advance

Level 3: is assigned to such activities which are not in the chemistry syllabus in the majority of participating countries and the authors are obliged to mention them in the set of preparatory tasks

If the organizer wants to apply a technique which is not mentioned in the above syllabus, this technique is set to level 3 automatically.

1. Synthesis of inorganic and organic compounds

1.1.	Heating with burners and hotplates	1
1.2.	Heating of liquids	1
1.3.	Handling the work with inflammable substances and materials	1
1.4.	Measuring of masses (analytical balance)	1
1.5.	Measuring of volumes of liquids (measuring cylinder, pipette, burette)	1

1.6.	Preparation of solutions from a solid compound and solvent	1
1.7.	Mixing and dilution of solutions	1
1.8.	Mixing and stirring of liquids	1
1.9.	Using mixer and magnetic stirrer	2
1.10.	Using a dropping funnel	1
1.11.	Syntheses in flat bottom vessels – general principles	1
1.12.	Syntheses in round bottom vessels – general principles	1
1.13	Syntheses in a closed apparatus – general principles	1
1.14.	Using microscale equipment for synthesis	3
1.15.	Apparatus for heating of reaction mixture under reflux	2
1.16.	Apparatus for distillation of liquids at normal pressure	2
1.17.	Apparatus for distillation of liquids at reduced pressure	2
1.18.	Apparatus for steam distillation	3
1.19.	Filtration through flat paper filter	1
1.20.	Filtration through a folded paper filter	1
1.21.	Handling a water vacuum pump	1
1.22.	Filtration through a Büchner funnel	1
1.23.	Suction through a glass filter	1
1.24.	Washing of precipitates by decantation	1
1.25.	Washing of precipitates on a filter	2
1.26.	Drying of precipitates on a filter with appropriate solvents	2
1.27.	Recrystallization of substances from aqueous solution	1
1.28.	Recrystallization of substances from a known organic solvent	2
1.29.	Practical choice of an appropriate solvent for recrystallization of a substance	3
1.30.	Drying of substances in a drying box	2
1.31.	Drying of substances in a desiccator	2
1.32.	Connecting and using of a gas washing bottle	2
1.33.	Extraction with an inmiscible solvent	1

2. Identification of inorganic and organic compounds: general principles

2.1.	Test-tube reactions	1
2.2.	Technique of reactions performed in a dot dish and on a filter paper	1
2.3.	Group reactions of some cations and anions specified by the organizer	2
2.4.	Selective reactions of some cations and anions specified by the organizer	2
2.5.	Specific reactions of some cations and anions specified by the organizer	3
2.6.	Identification of elements by flame coloration (using a platinum wire/MgO rod, Co-glass)	2
2.7.	Using a hand spectroscope/Bunsen spectroscope	3
2.8.	Melting point determination with Kofler or similar type of apparatus	3
2.9.	Qualitative evidence of basic functional groups of organic substances specified by the organizer	2
2.10.	Exploitation of some specific reactions for identification of organic compounds (specified by the organizer)	3

3. Determination of some inorganic and organic compounds: general principles

3.1.	Quantitative determinations using precipitation reactions	2
3.2.	Igniting of a precipitate in a crucible	1