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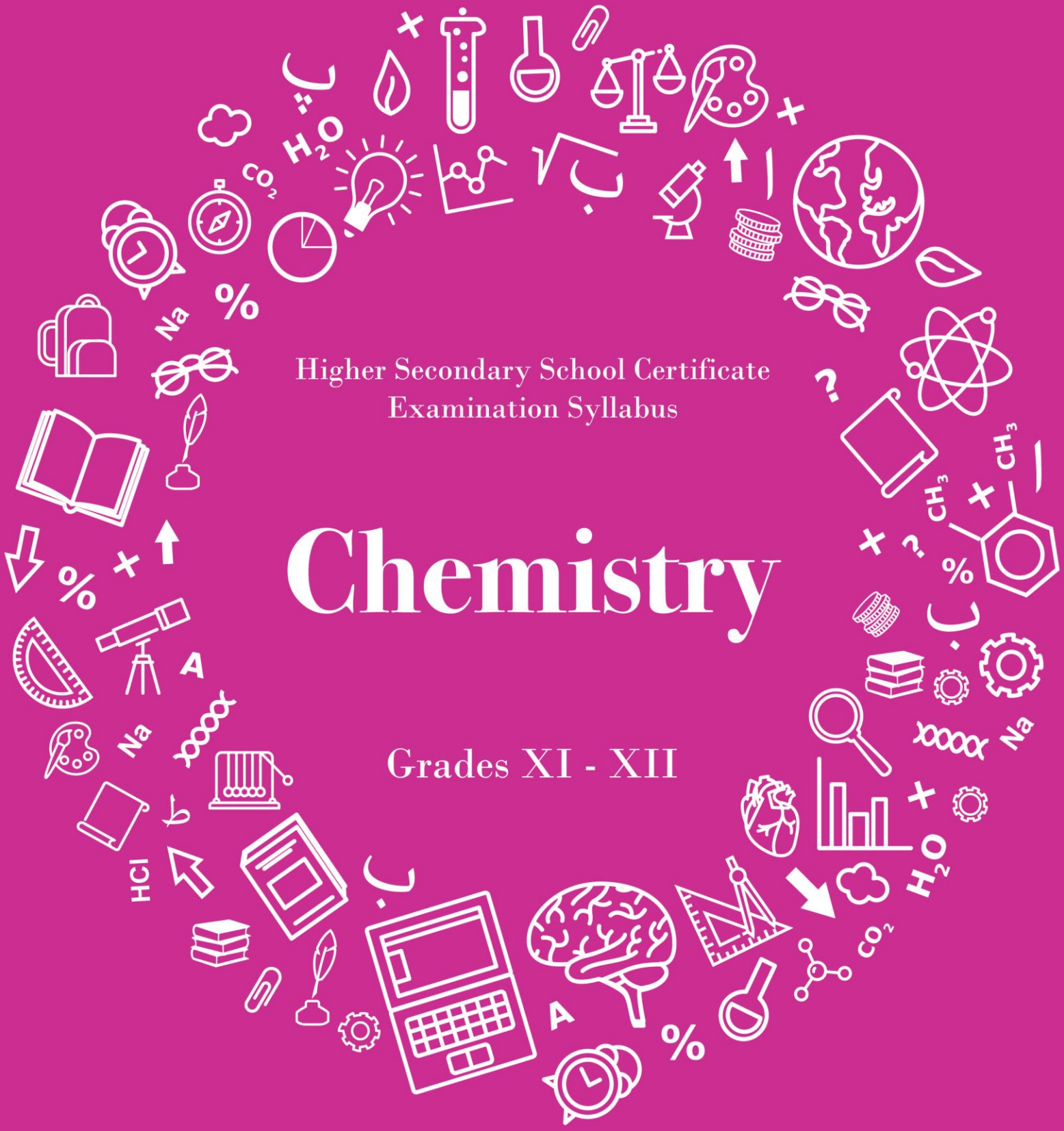

Higher Secondary School Certificate
Examination Syllabus

Chemistry

Grades XI - XII

(Based on New National Curriculum 2022-2023)

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Higher Secondary School Certificate Examination Syllabus

CHEMISTRY

GRADES XI-XII

This syllabus will be examined in both Annual and September Examination sessions from Annual Examinations 2026 for Grade XI and Annual Examination 2027 for Grade XII

For queries and feedback

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Preface

Established in 2002 through the Pakistan government's ordinance, the Aga Khan University Examination Board (AKU-EB) is country's first private autonomous qualification awarding body for Secondary School Certificate (SSC) and Higher Secondary School Certificate (HSSC). Its vision is to be a model of excellence and innovation in education in Pakistan and the developing world.

AKU-EB achieves its vision by developing examination syllabi which inculcate conceptual thinking and higher order learning and is aligned with the National Curriculum and mapped with provincial curricula and international standards. AKU-EB revises its syllabi periodically to support the needs of students, teachers and society.

The aims of the syllabus review of SSC and HSSC are to:

- Ensure continued compatibility with the goals of the National Curriculum of Pakistan.
- Review the content for inclusion of new knowledge and deletion of obsolete knowledge.
- Review the content for clarity and relevance as per the changing needs of students, teachers and society.
- Enhance and strengthen continuation and progression of content both within and across grades IX - XII (SSC and HSSC).
- Ensure the readiness of students for higher education.

During the syllabus review, the needs of all the stakeholders were identified through a needs-assessment survey. Students and teachers of AKU-EB affiliated schools from across Pakistan participated in the survey. Thereafter, a revision panel, which consisted of examiners, teachers of affiliated and non-affiliated schools, teacher trainers and university academicians, reviewed and revised the syllabus following a planned, meticulous and standardised syllabi review process.

The development of the revised syllabus has been made possible by the creativity and relentless hard work of Curriculum and Examination Development unit and the constant support provided by all the other units of AKU-EB. We are particularly thankful to our Principal Syllabus Reviewers, Syllabus Revision Panellists and all other reviewers for their contribution. We are also thankful to all the students and teachers who took part in the needs-assessment survey and to the principals of AKU-EB affiliated schools who made this endeavour possible by facilitating and encouraging their teachers and students to be a part of the survey and the syllabus revision panel.

With your support and collective hard work, AKU-EB has been able to take the necessary steps to ensure effective implementation of the National Curriculum of Pakistan through this syllabus. We are confident that this syllabus will continue to provide the support that is needed by students to progress to the next level of education, and we wish the very best to our students and teachers in implementing this syllabus.

Dr Naveed Yousuf
Chief Executive Officer (CEO), Aga Khan University Examination Board
Associate Professor of Practice, Educational Development, Faculty of Health Science,
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Understanding of AKU-EB Syllabi

1. The AKU-EB syllabi guide the students, teachers, parents and other stakeholders regarding the topics that will be taught and examined in each grade (IX, X, XI and XII). In each syllabus document, the content progresses from simple to complex, thereby, facilitating a gradual, conceptual learning of the content.

2. The topics of the syllabi are divided into sub-topics and **student learning outcomes** (**SLOs**). The SLOs define the depth and the breadth at which each topic or subtopic will be taught, learnt and examined. The syllabi also provide enabling SLOs where needed to scaffold student learning.

3. Each SLO starts with an achievable and assessable **command word** such as describe, relate, evaluate, etc. The purpose of the command words is to direct the attention of teachers and students to specific tasks that the students are expected to undertake in the course of their studies.

4. The SLOs are classified under the following **cognitive levels** of Bloom's Taxonomy: Remember (R), Understand (U), Apply and beyond [Apply (A), Analyse (An), Evaluate (E), Create (C)]. This is to facilitate effective planning for teaching, learning and assessment. In addition, some SLOs are identified as Formative Assessments (FA), where applicable.

5. Where applicable, **Practical Activities** section is provided to elaborate the assessment in the Practical Examination.

6. The **Examination Specification** is provided which elucidates the weightage of each topic in the examinations determined on the basis of the content as well as the relevance of the topic.

7. To implement this syllabus, students and teachers can take support from additional material provided by the board to its affiliated schools including **Learning Resource Guides**, **Pacing Guides** and **Model Papers**.

8. The AKU-EB syllabi for Secondary School Certificate (SSC) and Higher Secondary School Certificate (HSSC) are designed to foster not only conceptual understanding but also critical thinking and problem-solving skills. These syllabi ensure students develop the cognitive, affective and psychomotor skills essential for success at the university and beyond.

Subject Rationale of AKU-EB Chemistry

Why study Chemistry?

Chemistry is all about fundamental understanding of the natural world. It is not restricted to schools, books or the science laboratory, it is found everywhere around us. The air we respire, the food in the kitchen, the aroma of perfumes, the fibres in our clothing, the medicines we take, the fertilisers in the soil, the environment we live in, the construction materials in our houses, the petrochemical industries – literally there occur hundreds and thousands of chemical phenomena every day in life which involves chemistry. By studying chemistry, students learn about the composition, properties, and changes of matter, which are crucial for comprehending how substances interact in everyday life. It also teaches practical skills involving the usage of chemicals and sophisticated analytical instruments for the interpretation of chemical phenomena. Chemistry, often called the "central science," bridges other natural sciences, including physics, biology, and geology, creating a cohesive understanding of various phenomena.

What will you learn in AKUEB Chemistry?

The AKU-EB Chemistry Syllabus is designed to provide students with essential theoretical and practical knowledge of real-life Chemistry. It focuses on understanding the different themes of Chemistry including Organic Chemistry, Environmental Chemistry, Inorganic Chemistry, Biochemistry, Analytical Chemistry etc.

The syllabus attempts to develop a logical approach for students to understand different chemical phenomena and solve authentic problems. This is not only academically enriching but also helps to develop 21st century skills in students such as critical thinking and problem-solving skills. Additionally, it also focuses on laboratory skills and safety practices, preparing students for future scientific endeavours.

Furthermore, the use of multiple learning resources included in Learning Resource Guide such as models, pictures, animations and various reference books create interest and provide logical understanding of fundamental concepts of Chemistry. Overall, AKU-EB Chemistry syllabus is not just about memorising reactions and formulas; it’s about developing a scientific mindset and curiosity to explore the world.

Where will it take you?

The study of Chemistry enables an individual to play a vital role in the socio-economic development of our country. In recent years, the impact of Chemistry in our society for prospects has been excellent. It has opened doors for careers in a variety of professions and occupations in academia, government, and industry, and in diverse fields such as environmental sciences, pharmaceuticals, medicine, oceanography, aerospace, engineering and education. More employment opportunities are available as compared to the past and the academic sector is becoming well-equipped with highly qualified staff to transfer valuable knowledge to students. Furthermore, government officials have paid more attention to raise the standard of higher education in our country, which has resulted in significant provision of research opportunities to experience problem solving, information handling, organisation, interpretation and presentation skills in discovering new scientific knowledge. It teaches practical skills involving the usage of chemicals and sophisticated analytical instruments for

the interpretation of chemical phenomena. The results of the research are of immediate benefit to the chemists, other scientists in related disciplines and the industrial sector.

Moreover, students on acquiring the knowledge of Chemistry are expected to be able to pursue tertiary education in various fields including:

- Engineering
- Medicine
- Pharmacy
- Dentistry
- Nursing
- Veterinary
- Environmental science
- Biotechnology
- Geology
- Biochemistry
- Polymer engineering
- Textile engineering
- Chemical engineering
- Microbiology

How to approach the syllabus?

The AKU-EB syllabus is carefully designed with a reader-friendly approach to ensure that students and teachers can easily comprehend it, making it functional for teaching, learning and assessment purposes. The syllabus includes the following parts:

Subject Rationale	It is an introductory document for students.
Student Learning Outcomes (SLOs)	These guide students about what must be achieved.
Exam Specification	It guides regarding what is expected in the examination.
Practical Activities	These include laboratory activities to be performed during an academic year.
Additional Resources	
Pacing Guide	It ensures smooth transition and curricular continuity of a school's academic year. It also predicts the time and pace of the syllabus implementation.
Resource Guide	It includes teaching and learning resources for students and teachers.
Model Paper	It guides regarding exam pattern, types of questions and marking scheme.
Command Word Guide	It clarifies expectations regarding the cognitive levels and skills that should be acquired by the students, and which are assessed in examinations.

Student Learning Outcomes of AKU-EB HSSC Chemistry Syllabus

Part I (Grade XI)

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level[1]		
				R	U	A and beyond
1. Stoichiometry		Students should be able to:				
1.1	Nature of Science and Technology	1.1.1	compare the fields of STEAM, i.e., 'science', 'technology', 'engineering', 'arts' and 'mathematics' by giving examples from the physical sciences.		FA[2]	
1.2	Chemistry as a Quantitative Science	1.2.1	explain the significance of stoichiometry in the following areas: a. pharmaceuticals, b. food and beverage industries;		*	
1.3	Mole and Avogadro's Number	1.3.1	relate the concept of mole with Avogadro's number;		*	
		1.3.2	apply the rules for rounding a number to a given number of significant figures to solve stoichiometric problems;			A
		1.3.3	calculate the number of following chemical species/ particles: a. atoms, b. molecules, c. moles, d. ions, e. protons, f. neutrons, g. electrons;			A

[1]R = Remember, U = Understand, A = Apply and beyond [Apply (A), Analyse (An), Evaluate (E), Create (C)]
[2]FA= Formative Assessment, not to be assessed under examination conditions

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
1.4	Reacting Masses and Volumes	1.4.1	calculate, using a balanced chemical equation, the a. interacting moles, b. representative particles, c. masses and volume of gases at STP (22.4 L) and RTP (24 L);			A
		1.4.2	solve problems based on stoichiometric relationships using mole ratios as conversion factor (up to 3 significant figures);			A
1.5	Formulae and Percentage Composition	1.5.1	calculate the percentage (by mass) of: a. elements in compounds, b. water of crystallisation in hydrated salts;			A
		1.5.2	calculate empirical and molecular formulae of compounds;			A
1.6	Excess and Limiting Reagent	1.6.1	deduce the limiting reagent in chemical reactions;			E
		1.6.2	calculate the maximum amount of product produced and the amount of any unreacted excess reagent, using the concept of the limiting reagent in a chemical reaction;			A
1.7	Theoretical, Actual and Percentage Yield	1.7.1	distinguish among theoretical yield, actual yield and percentage yield;		*	
		1.7.2	calculate the percentage yield of a product in a chemical reaction.			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
2. Atomic Structure		Students should be able to:				
2.1	Discharge Tube Experiment	2.1.1	explain the construction and working of the discharge tube with reference to the discovery of electron and proton;		FA	
		2.1.2	explain the properties of: a. cathode rays, b. positive/ anode/ canal rays;		*	
2.2	Planck's Quantum Theory	2.2.1	explain the relationship among energy, frequency, wavelength and wave number using Planck's quantum theory;		*	
2.3	Bohr's Atomic Theory	2.3.1	explain Bohr's atomic theory and its defects;		*	
		2.3.2	calculate the radius and energy of revolving electrons in orbits with reference to Bohr's atomic theory;			A
		2.3.3	explain spectral lines of hydrogen atom;		*	
		2.3.4	calculate wave numbers of photons of various spectral series with reference to Bohr's atomic theory;			A
2.4	X-Rays and Atomic Numbers	2.4.1	explain the production and uses of X-rays;		FA	
		2.4.2	relate the X-ray frequency to the atomic number of different elements, with reference to Moseley's experiment;		FA	
		2.4.3	state Moseley's law and its significance;	FA		

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
2.5	Heisenberg's Uncertainty Principle and Quantum Numbers	2.5.1	explain the concept of an orbital based on Heisenberg's uncertainty principle;		*	
		2.5.2	compare orbit and orbital;		*	
		2.5.3	describe the principal quantum number, Azimuthal quantum number, magnetic quantum number and spin quantum number;		*	
		2.5.4	draw the shapes of degenerate orbitals (p and d);			A
		2.5.5	deduce the position and distribution of electrons using the concept of quantum numbers;			E
2.6	Dual Nature of Electron	2.6.1	explain the dual nature of an electron with reference to de-Broglie equation;		FA	
2.7	Ionisation Energy	2.7.1	explain the variation in successive ionisation energies of an element;		*	
		2.7.2	deduce the electronic configuration and position of representative elements using successive ionisation energy data;			E
2.8	Energy Levels and Electronic Configuration	2.8.1	describe the rules of electronic configuration, i.e., Aufbau principle, Hund's rule, Pauli's exclusion principle;		*	
		2.8.2	explain the electronic configurations in terms of electron's energy and inter-electron repulsion;		*	
		2.8.3	determine electronic configuration of elements based on Aufbau principle, Hund's rule and Pauli's exclusion principle;			A
		2.8.4	explain the properties of silicon, including its electronic configuration, energy band gap, and doping ability, that make it suitable for use as a semiconductor in electronic devices.		FA	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
3. Theories of Covalent Bonding and Shape of Molecules		Students should be able to:				
3.1	Electronegativity and Bonding	3.1.1	relate bond energy, bond strength, and bond length to the stability of chemical bonds in molecules;		*	
		3.1.2	compare the reactivity of covalent molecules using bond length and bond energy values;		*	
		3.1.3	define the term 'electronegativity';	*		
		3.1.4	explain the factors influencing the electronegativities of elements in terms of nuclear charge, atomic radius and shielding effect;		*	
		3.1.5	explain the change in bond length of heteronuclear molecules due to the difference in electronegativity values of bonded atoms;		*	
		3.1.6	predict the nature of bonding based on the electronegativity difference of bonded atoms using Linus Pauling scale;			E
3.2	Effect of Bonding on Physical and Chemical Properties	3.2.1	explain the ionic character of covalent bond;		*	
		3.2.2	explain the solubility of ionic and covalent compounds on the basis of the nature of bonding;		*	
		3.2.3	explain the chemical properties of ionic and covalent compounds;		*	
		3.2.4	compare the directional and non-directional nature of ionic and covalent bonds;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
3.3	Shape of Molecules using VSEPR Theory	3.3.1	explain valence shell electron pair repulsion (VSEPR) theory;		*	
		3.3.2	illustrate the shapes and bond angles of simple covalent molecules and ions using VSEPR theory;			A
		3.3.3	explain the expanded octets in polyatomic ions, for example, sulphate and nitrate;		FA	
3.4	Covalent Bonding, VBT, MOT and Hybridisation	3.4.1	explain valence bond theory (VBT);		*	
		3.4.2	explain the formation and characteristics of sigma (σ) and pi (π) bonds;		*	
		3.4.3	explain hybridisation and its types;		*	
		3.4.4	illustrate the shapes of simple molecules using the concept of orbital hybridisation (sp, sp^2, sp^3);			A
		3.4.5	explain molecular orbital theory (MOT);		*	
		3.4.6	deduce the electronic configuration, bond order and magnetic properties of homonuclear diatomic molecules with the help of MOT;			E
3.5	Dipole Moment	3.5.1	exemplify dipole moment;		*	
		3.5.2	predict the molecular polarity from the shapes of molecules.			E

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
4. States of Matter: Gases, Liquids and Solids		Students should be able to:				
4.1	Kinetic Molecular Interpretation of Gases, Liquids and Solids	4.1.1	compare the following physical properties of gases, liquids and solids with reference to kinetic molecular theory: a. diffusion, b. compression, c. expansion, d. motion of molecules, e. intermolecular forces, f. kinetic energy;		*	
4.2	Gas laws, Ideal Gas Equation and Deviation from Ideal Behaviour	4.2.1	explain the following gas laws: a. Dalton's law of partial pressure, b. Graham's law of diffusion/ effusion;		*	
		4.2.2	explain Boyle's law, Charles's law and Avogadro's law;		FA	
		4.2.3	derive ideal gas equation using Boyle's, Charles's and Avogadro's law;			A
		4.2.4	calculate the values of ideal gas constant if a. pressure is measured in atm and volume in dm^3, b. pressure is measured in mm of Hg or torr and volume in cm^3, c. pressure is measured in Nm^{-2} and volume in m^3;			A
		4.2.5	calculate mass, pressure, volume, temperature and density of a gas using the ideal gas equation;			A
		4.2.6	calculate the molar mass of a gas from density measurement of gases at STP;			A
		4.2.7	explain the deviation of gases from their ideal behaviour;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
4.3	Intermolecular Forces and Their Impact on the Physical Properties of Liquids	4.3.1	describe the types of intermolecular forces;		FA	
		4.3.2	compare the strength and applications of Van der Waals forces (London dispersion forces and dipole-dipole interactions) and hydrogen bonding;		*	
		4.3.3	explain the following physical properties of liquids: a. evaporation, b. vapour pressure, c. boiling point, d. viscosity, e. surface tension;		*	
		4.3.4	analyse the anomalous behaviour of H_2O (ice and water) using the concept of hydrogen bonding, including the following specific properties: a. surface tension, b. specific heat, c. vapour pressure, d. heat of vaporisation, e. melting and boiling points, f. density of solid ice compared with liquid water;			An
		4.3.5	compare the volatility of different liquids at the same temperature based on intermolecular forces;		*	
4.4	Energetics of Phase Changes	4.4.1	define the following terms: a. molar heat of fusion, b. heat of vaporisation, c. molar heat of sublimation;	*		
		4.4.2	explain the importance of the heat of fusion in studying glaciers and ice sheets, particularly in the context of polar ice caps;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
4.5	Liquid Crystals	4.5.1	describe the formation of liquid crystals;		*	
		4.5.2	differentiate liquid crystals from pure liquids and crystalline solids;		*	
		4.5.3	explain the various applications of liquid crystals, including temperature sensors, thermometers, skin thermography, electrical circuits, chromatographic separations, calculator screens and display screens;		*	
4.6	Types and Properties of Solids	4.6.1	explain the following characteristics of crystalline solids: a. symmetry, b. melting point, c. anisotropy, d. cleavage plane, e. crystal growth, f. geometrical shape, g. habit of crystals;		*	
		4.6.2	distinguish between crystalline and amorphous solids;		*	
		4.6.3	differentiate between isomorphism and polymorphism;		*	
		4.6.4	relate polymorphism with allotropy;		*	
		4.6.5	exemplify transition temperature;		*	
4.7	Types of Crystalline Solid	4.7.1	differentiate among the following types of crystalline solids: a. ionic, b. molecular, c. metallic, d. covalent;		*	
		4.7.2	exemplify the use of crystalline and amorphous solids in daily life.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
5. Chemical Equilibrium		Candidates should be able to:				
5.1	Reversible Reaction and Dynamic Equilibrium	5.1.1	describe 'dynamic equilibrium' in terms of reversible reaction;		FA	
		5.1.2	explain the necessary conditions for equilibrium and the ways through which equilibrium can be recognised;		FA	
		5.1.3	explain dynamic equilibrium between different physical states of matter;		*	
		5.1.4	differentiate between microscopic and macroscopic events in a reversible reaction with examples;		*	
		5.1.5	determine the equilibrium constant expression (K_c) for the given reactions;			A
		5.1.6	calculate the equilibrium constant expression in terms of concentration, partial pressure, number of moles and mole fraction;			A
		5.1.7	determine expression for reaction quotient of given reactions;			A
		5.1.8	predict the direction of a reaction by relating equilibrium constant with the ratio between concentration of products and reactants;			E
		5.1.9	predict the extent of chemical reaction from the given value of K_c;			E
5.2	Le-Chatelier's Principle and Its Application	5.2.1	explain Le-Chatelier's principle;		*	
		5.2.2	deduce the effect of catalyst, temperature, pressure, volume and concentration on the equilibrium state and yield of industrial products using Le-Chatelier's principle;			E

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
5.3	Solubility Product and Common Ion Effect	5.3.1	describe the term ‘solubility product’;		*	
		5.3.2	distinguish between solubility and solubility product;		*	
		5.3.3	determine the solubility product (K_{sp}) expression for the given reactions;			A
		5.3.4	determine the solubility product (K_{sp}) from the given solubility of compounds;			A
		5.3.5	calculate the concentration of ions present in slightly soluble salts;			A
		5.3.6	describe the term ‘common ion effect’;		*	
		5.3.7	analyse the impact of common ions on the solubility of substances in a solution.			An

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
6. Acids, Bases and Salts		Students should be able to:				
6.1	Acid-Base Titration	6.1.1	compare Arrhenius and Brønsted-Lowry's concept of acids and bases;		FA	
		6.1.2	explain amphoteric compounds;		*	
		6.1.3	explain the significance of acid-base reactions in daily life (food preservation, allergic reactions, gastric acidity, curdling of milk);		*	
		6.1.4	calculate molarity, molality and strength of sample solutions based on acid-base titration;			A
		6.1.5	determine suitable indicators for acid-base titrations based on the given data;			A
6.2	Conjugate Acids and Bases	6.2.1	define the terms 'conjugate acid' and 'conjugate base';	*		
		6.2.2	identify conjugate acid-base pairs in the given reaction;		*	
		6.2.3	compare the strength of conjugate acids and bases;		*	
6.3	Strengths of Acids and Bases	6.3.1	derive the ionisation constant of water (K_w);			A
		6.3.2	calculate the pH and pOH of solutions by using the given hydrogen or hydroxide ion concentration;			A
		6.3.3	compare the strength of acids and bases using pH and pOH;		*	
		6.3.4	derive the ionisation constants of an acid (K_a) and a base (K_b);			A
		6.3.5	determine the relationship between K_a and K_b;			A
		6.3.6	calculate the H_3O^+ concentration using the given K_a and molar concentration of the weak acid;			A
		6.3.7	explain the 'levelling effect' with reference to the strength of acids;		*	
6.4	Lewis Concept of Acids and Bases	6.4.1	explain 'Lewis acids' and 'Lewis bases';		*	
		6.4.2	classify compounds as Lewis acids or bases;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
6.5	Buffer Solution	6.5.1	describe 'buffer solution';		*	
		6.5.2	explain the significance of buffers to maintain the pH of solutions using chemical equations, including the role of HCO_3^- in controlling pH in the blood;		FA	
		6.5.3	illustrate the preparation of different types of buffer;			A
		6.5.4	calculate the pH of buffer solutions using Henderson Hasselbalch equation;			A
6.6	Hydrolysis and Hydration	6.6.1	define the following terms: a. hydrolysis, b. hydration;	*		
		6.6.2	explain the types of salts on the basis of hydrolysis;		*	
		6.6.3	differentiate between hydrolysis and hydration;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
7. Chemical Kinetics		Students should be able to:				
7.1	Rate and Order of Reaction	7.1.1	describe the terms: a. chemical kinetics, b. rate of reaction, c. rate law, d. order of reaction, e. rate constant, f. rate-determining step;		*	
		7.1.2	explain the significance of the rate-determining step on the overall rate of a multistep reaction;		*	
		7.1.3	determine the rate law for the given reactions;			A
		7.1.4	calculate the initial rate using concentration data for given reactions;			A
		7.1.5	deduce the rate of reaction and order of reaction using the method of initial rates;			E
		7.1.6	determine the rate constant using the method of initial rates and the half-life method;			A
7.2	Factors Influencing Reaction Rates and Energy Considerations in Chemical Reactions	7.2.1	relate activation energy and activated complex to the rate of reaction;		*	
		7.2.2	describe collision theory;		*	
		7.2.3	discuss the effect of concentration, temperature and surface area on the rate of reaction using collision theory;			E
		7.2.4	interpret the effect of temperature change on the rate constant and the rate of a reaction using the Boltzmann distribution curve;			E
7.3	Catalysis	7.3.1	explain homogeneous and heterogeneous catalysis;		*	
		7.3.2	illustrate the effect of a catalyst on the rate of a reaction using a labelled energy diagram showing the activation energy and the influence of the catalyst.			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
8. Solution and Colloids		Students should be able to:				
8.1	Colloids, Suspensions and Solutions	8.1.1 8.1.2 8.1.3	compare the properties of colloids, suspensions and solutions; explain the types of colloids; classify substances as solutions, colloids or suspensions;		* * *	
8.2	Concentration Units	8.2.1	solve problems involving different concentration units of solutions: a. percentage composition, b. molarity, c. molality, d. mole fraction, e. parts per million (ppm), f. parts per billion (ppb), g. parts per trillion (ppt);			A
8.3	General Properties of Solution and Solubility	8.3.1 8.3.2 8.3.3	differentiate between hydrophobic and hydrophilic molecules; predict the nature of solutions in the liquid phase as miscible, immiscible and partially miscible; interpret the effect of temperature on solubility using a graph;		*	 E E
8.4	Raoult's Law	8.4.1 8.4.2 8.4.3	explain Raoult's law and its role in the vapour pressures of ideal solutions; illustrate vapour pressure variations of ideal solutions as composition changes using a graph based on Raoult's law; illustrate deviations from Raoult's law in non-ideal solutions using a graph;		*	 A A

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and beyond
8.5 Colligative Properties	8.5.1	define the term 'colligative properties';	*		
	8.5.2	explain the following colligative properties of liquids: a. lowering of vapour pressure, b. elevation of boiling point, c. depression of freezing point, d. osmotic pressure;		*	
	8.5.3	calculate molar mass of a substance using ebullioscopic and cryoscopic methods;			A
8.6 Partition Coefficient	8.6.1	define the term 'partition coefficient' (K_{pc});	*		
	8.6.2	explain the factors influencing the numerical value of a partition coefficient in relation to the polarities of the solute and the solvents used;		*	
	8.6.3	calculate the partition coefficient of a system where the solute is present in the same physical state in the two solvents;			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
9. Chemical Energetics		Students should be able to:				
9.1	Fundamentals of Thermodynamics and Enthalpy Calculations in Chemical Reactions	9.1.1	define the following terms: a. thermodynamics, b. system, c. surrounding, d. state function, e. heat, f. internal energy, g. work, h. enthalpy;	*		
		9.1.2	explain the energy transfer that occurs in breaking and making chemical bonds during a chemical reaction;		*	
		9.1.3	interpret the reaction pathway diagram with respect to enthalpy change and activation energy;			E
		9.1.4	define the following terms: a. standard conditions, b. enthalpy change of reaction (ΔH^{o}_{r}), c. enthalpy change of formation (ΔH^{o}_{f}), d. enthalpy change of combustion (ΔH^{o}_{c}), e. enthalpy change of neutralisation (ΔH^{o}_{neut}), f. heat capacity, g. specific heat capacity, h. molar heat capacity;	*		
		9.1.5	calculate the standard enthalpy change (ΔH^{o}) for the given reactions using bond energy values;			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
9.2	First Law of Thermodynamics	9.2.1	explain the first law of thermodynamics with the help of daily life examples;		*	
		9.2.2	relate the change in internal energy of the system with thermal energy at constant volume and pressure;		*	
		9.2.3	calculate the change in internal energy and the work done by a system using the first law of thermodynamics;			A
9.3	Entropy and Gibbs Free Energy	9.3.1	define the term 'entropy';	*		
		9.3.2	explain the direction of entropy changes during various processes: changes in state, temperature variations, and reactions involving changes in the number of gaseous molecules;		*	
		9.3.3	explain Gibbs free energy;		*	
		9.3.4	solve problems related to the feasibility of reactions using Gibbs free energy;			A
9.4	Hess's Law	9.4.1	explain Hess's law of heat summation;		*	
		9.4.2	construct energy cycles by using Hess's law for any given reactions;			An
		9.4.3	calculate the standard heat of formation and the heat of reaction using Hess's law;			A
9.5	Measurement of Enthalpy of a Reaction	9.5.1	explain the working of a calorimeter (glass and bomb calorimeter);		*	
		9.5.2	calculate the heat of a reaction in a calorimeter using the given experimental data;			A

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and beyond
9.6 Born-Haber Cycle	9.6.1	define the following terms: a. enthalpy change of atomisation (ΔH^{o}_{at}), b. enthalpy change of sublimation (ΔH^{o}_{sub}), c. bond dissociation enthalpy (ΔH^{o}_{D}), d. lattice energy (ΔH^{o}_{L}), e. electron affinity (EA), f. ionisation energy (I);	*		
	9.6.2	explain the reaction pathway diagram in terms of enthalpy changes of reactions (for ionic compounds involving up to divalent ions) using Born-Haber cycle;		*	
	9.6.3	construct Born-Haber cycles for the given ionic solids (up to divalent cations and anions);			An
	9.6.4	calculate lattice energy and enthalpy of formation of ionic compounds from the given set of appropriate data.			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
10. Electrochemistry		Students should be able to:				
10.1	Oxidation – Reduction	10.1.1	define the following terms: a. reduction, b. oxidation, c. oxidation number, d. reducing agent, e. oxidising agent, f. disproportionation reaction;	*		
		10.1.2	determine the oxidation number of an atom in a substance;			A
		10.1.3	deduce reducing and oxidising agents using the oxidation number change method;			E
		10.1.4	balance a chemical equation using the oxidation number change method;			An
		10.1.5	identify the oxidation and reduction half-reactions;		*	
		10.1.6	balance a chemical equation using the half-reaction method;			An
		10.1.7	solve problems based on oxidation-reduction titrations;			A
		10.1.8	discuss the use of redox reactions in daily life;			FA
10.2	Activity Series	10.2.1	explain the concept of the activity series of metals and its relation to the ease of oxidation and reduction;		*	
		10.2.2	analyse the feasibility of redox reactions using the activity series;			An
10.3	Electrode Potential and Electrochemical Cells	10.3.1	define the following terms: a. standard electrode potential, b. standard cell potential;	*		
		10.3.2	explain Standard Hydrogen Electrode (SHE) and its application;		*	
		10.3.3	determine the potential of an electrochemical cell using the given standard electrode potential values of species;			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
10.4	Electrochemical Principles and Applications	10.4.1	explain Faraday's first and second law of electrolysis;		*	
		10.4.2	explain the conversion of electrical energy into chemical energy in electrolytic cells;		*	
		10.4.3	calculate the quantity of charge passed in an electrochemical cell during electrolysis;			A
		10.4.4	calculate the mass or volume of a substance produced during electrolysis;			A
		10.4.5	explain the Avogadro's Constant by using the electrolytic method;		FA	
		10.4.6	explain the conversion from spontaneous, exothermic chemical processes to electrical energy using Galvanic cells;		*	
		10.4.7	explain chemical reactions occurring within lead storage batteries.		*	

Part II (Grade XII)

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level[1]		
				R	U	A and beyond
11. s- and p-Block Elements		Students should be able to:				
11.1	Elements and Periodicity	11.1.1	explain the demarcation of the periodic table into s, p, d and f-blocks;		*	
		11.1.2	determine the group, period and block of the given elements by using electronic configuration;			A
		11.1.3	explain the periodicity of physical properties (i.e., atomic radius, ionic radius, ionisation energy, electronegativity, electron affinity, melting and boiling points) of elements within groups and periods in the periodic table with exceptions/ irregularity;		*	
11.2	Periodicity of Physical and Chemical Properties of Period 3 Elements	11.2.1	explain the variation in melting point and electrical conductivity with respect to the structure and bonding of the period 3 elements;		*	
		11.2.2	describe the reaction of period 3 elements with water, oxygen and chlorine;		*	
		11.2.3	describe the reaction of oxides and chlorides of period 3 elements with water;		*	
		11.2.4	explain the acid-base characteristics of oxides and chlorides of period 3 elements;		*	

[1]R = Remember, U = Understand, A = Apply and beyond [Apply (A), Analyse (An), Evaluate (E), Create (C)]

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
11.3	Group 1	11.3.1	describe the chemical reaction of group 1 elements with water, oxygen and chlorine;		*	
		11.3.2	explain the trends in solubility of hydroxides, sulphates and carbonates of group 1 elements;		*	
		11.3.3	explain the trends in thermal stability of nitrates and carbonates of group 1 elements;		*	
11.4	Group 2	11.4.1	describe the chemical reaction of group 2 elements with oxygen, water and dilute hydrochloric acid and sulphuric acid;		*	
		11.4.2	illustrate the reactions of the oxides, hydroxides and carbonates of group 2 with water and dilute hydrochloric acid and sulphuric acid using chemical equations;			A
		11.4.3	compare the trends in solubility of hydroxides, sulphates and carbonates of group 2 with group 1 elements;		*	
		11.4.4	explain the trends in the thermal stability of nitrates and carbonates of group 2 elements;		*	
11.5	Group 4	11.5.1	describe the reaction of water with chlorides of carbon, silicon and lead;		*	
		11.5.2	compare the structure and stability of chlorides of carbon, silicon and lead;		*	
		11.5.3	compare the molecular structure of CO_2 and SiO_2;		*	
11.6	Group 7	11.6.1	relate the oxidation states of group 7 elements to their electronic configuration;		*	
		11.6.2	compare the strength of halide ions as reducing agents;		*	
		11.6.3	compare the relative reactivity of the halogen elements as oxidising agents;		*	
		11.6.4	illustrate the reactions of halide ions with aqueous silver ions and concentrated sulphuric acid;			A

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
	11.6.5	explain the disproportionation reaction of chlorine with cold and hot aqueous sodium hydroxide;		*	
	11.6.6	explain bond enthalpies and the acidic strength of hydrogen halides.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
12. Transition Metals		Students should be able to:				
12.1	General Feature of Transition Elements	12.1.1	determine the electronic configuration of elements and ions of d-block;			A
		12.1.2	explain the anomalous behaviour of chromium and copper with respect to their electronic configuration;		*	
		12.1.3	explain the following features of transition elements: a. variable oxidation states, b. formation of complex ions, c. role as a catalyst, d. magnetic property, e. formation of interstitial compounds;		*	
		12.1.4	explain redox reactions and uses of vanadium, nickel, manganese and iron as catalysts;		*	
12.2	Coordination Chemistry: Ligands, Complexes, and Nomenclature	12.2.1	define the following terms: a. ligands, b. chelates, c. complex, d. coordination sphere, e. coordination number;	*		
		12.2.2	classify different types of ligands based on the following features: a. charge, b. denticity, c. nature of bonding;		*	
		12.2.3	explain the reaction of transition elements with ligands to form complexes such as complexes of copper(II) and cobalt(II) ions with water and ammonia molecules;		*	
		12.2.4	predict the geometry of transition element complexes based on the coordination number;			E

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
		12.2.5	apply the rules of nomenclature in the naming of coordination compounds;			A
		12.2.6	determine the formula of a complex ion using: a. the metal ion and its charge or oxidation state, b. the type of ligand and its charge, c. the coordination number or geometry of the complex ion;			A
		12.2.7	determine the charge of a complex ion using: a. the charge of the metal ion, b. the total charge contributed by the ligands;			A
12.3	Electronic Structure and Colour in Transition Metal Complexes	12.3.1	explain degenerate and non-degenerate 'd' orbitals including their shapes;		*	
		12.3.2	illustrate the splitting of degenerate d orbitals into two non-degenerate sets of d orbitals of higher energy in: a. octahedral complexes, b. tetrahedral complexes;			A
		12.3.3	explain the formation of coloured compounds based on the frequency of light absorbed when an electron moves between two non-degenerate d orbitals;		*	
12.4	Stereoisomerism in Transition Metal Complexes	12.4.1	explain stereoisomerism in the following complexes: a. geometrical (cis-trans) isomerism, e.g., square planar such as $[Pt(NH_3)_2Cl_2]$ and octahedral such as $[Co(NH_3)_4(H_2O)_2]^{2+}$ and $[Ni(H_2NCH_2CH_2NH_2)_2(H_2O)_2]^{2+}$, b. optical isomerism, e.g. $[Ni(H_2NCH_2CH_2NH_2)_3]^{2+}$ and $[Ni(H_2NCH_2CH_2NH_2)_2(H_2O)_2]^{2+}$.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
13. Organic Compounds		Students should be able to:				
13.1	Classification and Functional Groups of Organic Compounds	13.1.1 13.1.2 13.1.3 13.1.4	classify organic compounds based on their structure; explain the destructive distillation of coal; explain coal as a source of both aliphatic and aromatic hydrocarbons; determine a molecule's functional group (i.e., alkane, alkene, alkyne, arene, halide, alcohol, ether, amine, nitrile, nitro, sulphide, sulphoxide, sulphone, thiol, aldehyde, ketone, carboxylic acid, ester, acid amide, acid chloride, acid anhydride);		* * * 	 A
13.2	Nomenclature	13.2.1	explain the systematic nomenclature of organic compounds, including International Union of Pure and Applied Chemistry (IUPAC) rules;		*	

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and beyond
	13.2.2	apply IUPAC and trivial systems for the naming of: a. alkane, b. cycloalkane, c. alkene, d. alkynes, e. substituted benzene, f. alkyl halides, g. amines, h. alcohols, i. phenols, j. ethers, k. aldehydes, l. ketones, m. carboxylic acids, n. esters, o. amides, p. acyl halides, q. anhydrides;			A
13.3 Structural and Stereoisomerism	13.3.1	exemplify isomerism, stereoisomerism and structural isomerism;		*	
	13.3.2	draw the geometrical (cis/trans) isomers of alkenes and cycloalkanes;			A
	13.3.3	define chiral centre;	*		
	13.3.4	explain optical isomerism as a result of chiral centre;		*	
	13.3.5	determine chiral centres in the structural formula of a molecule;			A
	13.3.6	identify compounds as ‘optically active’, ‘racemic mixture’ or ‘mesocompounds’;		*	
	13.3.7	determine isomerism in alkyl halides, amines, alcohols, phenols, aldehydes, ketones, carboxylic acids and esters.			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
14. Hydrocarbons		Students should be able to:				
14.1	Shape of Molecules and Types of Organic Reactions	14.1.1	illustrate the shape of molecules (i.e. alkanes, alkenes, cycloalkanes, alkynes, benzene and substituted benzene) based on sigma and pi carbon-carbon bonds;			A
		14.1.2	define the following types of organic reactions: a. substitution reaction, b. elimination reaction, c. addition reaction, d. radical reaction;	*		
14.2	Alkanes	14.2.1	explain the unreactive nature of alkanes towards polar reagents;		*	
		14.2.2	explain homolytic and heterolytic fission, free radical initiation, propagation and termination;		*	
		14.2.3	illustrate the mechanism of free radical substitution for methane and ethane;			A
14.3	Alkenes	14.3.1	explain the preparation of ethene using chemical equations from: a. dehydration of alcohol, b. dehydrohalogenation of alkyl halide;		*	
		14.3.2	explain the following reactions of ethene: a. hydrogenation, b. hydration, c. hydrohalogenation, d. halogenation, e. halohydration, f. epoxidation, g. ozonolysis, h. polymerisation;		*	
		14.3.3	apply Markovnikov's rule to the addition reactions of asymmetrical alkenes;			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
14.4	Alkynes	14.4.1	compare the reactivities of alkynes, alkenes and alkanes;		*	
		14.4.2	illustrate the preparation of alkynes using elimination reaction;			A
		14.4.3	explain the acidic strength of alkynes based on their reactions with metals;		*	
		14.4.4	illustrate the following reactions of alkynes: a. hydrogenation, b. hydrohalogenation, c. hydration, d. bromination, e. ozonolysis;			A
14.5	Benzene and Substituted Benzene	14.5.1	compare the conjugation in alkenes and benzene in terms of their stability;		*	
		14.5.2	explain the phenomenon of resonance and stability of benzene;		*	
		14.5.3	compare the reactivity of benzene with alkane and alkene;		*	
		14.5.4	illustrate the mechanism for the following electrophilic substitution reactions of benzene: a. nitration, b. sulphonation, c. halogenation, d. Friedal-Crafts alkylation and acylation;			A
		14.5.5	explain the orientation and reactivity of a mono-substituted benzene ring;		*	
		14.5.6	illustrate the mechanism for the following electrophilic substitution reactions of methylbenzene and nitrobenzene: a. nitration, b. sulphonation, c. halogenation, d. Friedel-Crafts alkylation and acylation;			A

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
	14.5.7	explain the following reactions: a. oxidation reaction of alkyl benzene, b. hydrogenation of benzene.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
15. Alkyl Halides and Amines		Students should be able to:				
15.1	Alkyl Halides	15.1.1	draw alkyl halides based on the type and position of the halogen atom in the carbon chain;			A
		15.1.2	explain the physical properties and reactivity of different alkyl halides based on bond energy;		*	
		15.1.3	illustrate the preparation of alkyl halides by the reaction of alcohol with HX, $SOCl_2$, PCl_3 and PCl_5;			A
15.2	Nucleophilic Substitution and Elimination Reactions	15.2.1	identify nucleophile (Lewis base), substrate and leaving group in the given nucleophilic substitution reactions;		*	
		15.2.2	explain the stability of carbocation in terms of inductive effect, hyperconjugation and mesomeric effect;		*	
		15.2.3	describe the following types of reaction: a. nucleophilic substitution reaction, b. elimination reaction;		*	
		15.2.4	illustrate the mechanism of nucleophilic substitution (S_N1 and S_N2) reactions for the given alkyl halide;			A
		15.2.5	illustrate the mechanism of elimination (E1 and E2) reactions for the given alkyl halide;			A
		15.2.6	compare the following reactions: a. S_N1 and S_N2, b. E1 and E2, c. substitution reaction with elimination reaction;		*	
15.3	Organo-Metallic Compounds (Grignard Reagent)	15.3.1	explain the preparation and reactivity of Grignard reagent;		*	
		15.3.2	illustrate the chemical reaction of Grignard reagent with aldehydes, ketones, esters and carbon dioxide;			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
15.4	Amines	15.4.1	draw the structure of amines (primary, secondary and tertiary) from their formulae;			A
		15.4.2	explain physical properties of amines (melting point, boiling point and solubility);		*	
		15.4.3	explain basicity (basic character) of amines in both phases (gaseous and aqueous);		*	
		15.4.4	explain the preparation of amines by: a. alkylation of NH_3, b. reduction of nitriles, c. reduction of nitro compounds, d. reduction of amides;		*	
15.5	Phenyl Amines	15.5.1	explain the reaction of phenylamine with HNO_2 or $NaNO_2$ to form a diazonium salt;		*	
		15.5.2	explain the coupling reaction between benzene diazonium chloride and phenol to form an azo compound.		*	

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and beyond
16. Alcohols, Phenols and Ethers		Students should be able to:			
16.1 Alcohols	16.1.1	illustrate the physical properties and structure of an alcohol;			A
	16.1.2	distinguish between alcohols based on the following tests: a. Lucas reagent test, b. iodoform test;		*	
	16.1.3	illustrate the preparation of alcohol by the following methods using chemical equations: a. reaction of alkenes with dilute acidified potassium manganate(VII), b. reduction of aldehydes, ketones, carboxylic acids and esters;			A
	16.1.4	explain the acidic character of alcohols;		*	
	16.1.5	illustrate the following reactions of alcohol: a. preparation of ethers, b. preparation of esters, c. preparation of aldehydes and ketones with mild and strong oxidising agents, d. oxidative cleavage of 1,2-diols;			A
	16.1.6	explain the uses of alcohols as a/ an: a. disinfectant, b. antiseptic, c. solvent, d. fuel;		FA[2]	

[2]FA= Formative Assessment, not to be assessed under examination conditions

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
16.2	Phenol	16.2.1	explain the physical properties, structure and acidic characteristics of phenol (with reference to its resonance only);		*	
		16.2.2	compare the relative acidities of water, phenol and ethanol;		*	
		16.2.3	differentiate between alcohols and phenols;		*	
		16.2.4	describe the preparation of phenols from the given compounds (benzene sulphonic acid, chlorobenzene, acidic oxidation of cumene and hydrolysis of diazonium salts) using chemical equations;		*	
		16.2.5	explain the reactivity of phenol with reference to electrophilic aromatic substitution, reaction with Na-metal and oxidation;		*	
16.3	Ethers	16.3.1	explain the physical and chemical properties of ethers;		*	
		16.3.2	illustrate the preparation of ethers by the following methods using chemical equations: a. Williamson synthesis, b. reaction of alkyl halides with dry silver oxide, c. reaction of alcohols with excess H_2SO_4;			A

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
17. Carbonyl Compound I: Aldehydes and Ketones		Students should be able to:				
17.1	Structure and Physical Properties	17.1.1	explain the physical properties of aldehydes and ketones;		*	
		17.1.2	draw the structure of given aldehydes and ketones;			A
17.2	Preparation of Aldehydes and Ketones	17.2.1	illustrate the preparation of aldehydes and ketones by: a. ozonolysis of alkene, b. hydration of alkyne, c. oxidation of alcohol, d. Friedal-Crafts acylation of aromatic compounds;			A
17.3	Reaction of Aldehydes and Ketones	17.3.1	illustrate the mechanism of the base-catalysed nucleophilic addition reaction of aldehydes and ketones, i.e.: a. addition of hydrogen cyanide, b. Aldol condensation, c. Cannizzaro's reaction;			A
		17.3.2	illustrate the acid-catalysed nucleophilic addition reaction of aldehydes and ketones, i.e.: a. polymerisation, b. addition of ammonia derivatives, c. addition of alcohols;			A
		17.3.3	Illustrate the reduction of aldehydes and ketones using: a. Clemensen reduction method, b. Wolff-Kishner reduction method, c. hydride reagents;			A
		17.3.4	explain the oxidation reactions of aldehydes and ketones;		*	
		17.3.5	distinguish between aldehydes and ketones using the haloform test.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
18. Carbonyl Compound II: Carboxylic Acid and Functional Derivatives		Students should be able to:				
18.1	Structure and Physical Properties	18.1.1	explain the physical properties (solubility, melting point and boiling point) of carboxylic acids;		*	
		18.1.2	draw the structure of given compounds of carboxylic acids and their derivatives;			A
18.2	Preparation of Carboxylic Acid	18.2.1	explain the preparation of carboxylic acid by the following methods using chemical equations: a. Grignard reagent, b. hydrolysis of nitriles, c. oxidation of primary alcohol, aldehydes and alkyl benzene;		*	
18.3	Reactions of Carboxylic Acid	18.3.1	illustrate the reactions of carboxylic acid with: a. alcohols to form esters (with mechanism), b. reducing agents (LiAlH4, HI and red phosphorus), c. carbonates and bicarbonates, d. alkalis, e. reactive metals;			A
		18.3.2	distinguish between methanoic acid and ethanoic acid using Fehling's reagent;		*	
18.4	Acidity	18.4.1	explain the acidity of carboxylic acids;		*	
		18.4.2	compare the relative acidities of carboxylic acids, phenols and alcohols;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
18.5	Carboxylic Acid Derivatives	18.5.1	illustrate the preparation and inter-conversion reactions of the carboxylic acid derivatives (acyl halides, acid anhydrides, esters and amides);			A
		18.5.2	compare the reactivity of different derivatives of carboxylic acid (i.e., acyl halides, acid anhydrides, esters and amides);		*	
		18.5.3	compare the relative ease of hydrolysis of acyl chlorides, alkyl chlorides and aryl chlorides;		*	
		18.5.4	compare the basicity of amides and amines;		*	
		18.5.5	identify carboxylic acids present in fruits and vegetables;		*	
		18.5.6	discuss the applications of carboxylic acids, i.e., in plastic, leather, rubber, and soap industries and as preservatives in food products.			FA

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
19. Biochemistry		Students should be able to:				
	19.1 Carbohydrates, Proteins and Lipids	19.1.1	classify carbohydrates based on their: a. taste, b. functional group, c. number of carbon atoms, d. molecular structure, e. reducing nature;		*	
		19.1.2	classify proteins based on their: a. structure, b. solubility;		*	
		19.1.3	explain different types of lipids based on their structure: a. simple, b. compound, c. derived (or associated including steroids);		*	
		19.1.4	explain the nutritional importance of carbohydrates, proteins and lipids;		*	
		19.1.5	explain the effect of lowering pH (using lemon juice) on milk proteins;		*	
		19.1.6	explain the role of biochemical compounds such as insulin and cholesterol in a human body;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
19.2	Enzymes	19.2.1	explain the role of enzymes as biological catalysts, i.e., in the digestion of food;		*	
		19.2.2	explain the factors that affect enzyme activity;		*	
		19.2.3	explain the role of inhibitors (competitive and non-competitive) in enzyme-catalysed reactions;		*	
19.3	Nucleic Acids	19.3.1	differentiate between DNA and RNA based on their structure and function;		*	
19.4	Minerals of Biological Significance	19.4.1	explain the role of iron, calcium, zinc and phosphorous as nutrients.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
20. Industrial Chemistry		Students should be able to:				
20.1	Introduction	20.1.1	explain the significance of the chemical and petrochemical industries for the economies of Pakistan and the world;		*	
		20.1.2	identify raw materials for various chemical and petrochemical industries;		*	
20.2	Safety Measures	20.2.1	explain safety measures and precautions to be followed in chemical industries;		*	
20.3	Petrochemical Industry	20.3.1	explain the following processes: a. refining of petroleum (fractional distillation), b. cracking (with its types), c. reforming of petroleum;		*	
20.4	Polymer Chemistry: Synthesis, Applications, and Environmental Impact	20.4.1	explain the chemical processes of addition and condensation polymerisation;		*	
		20.4.2	explain the formation, properties and uses of polyvinyl chloride (PVC) and nylon;		*	
		20.4.3	predict the type of polymerisation reaction based on a given monomer or pair of monomers;			E
		20.4.4	deduce the following from a given polymerisation equation: a. the repeating unit of the polymer, b. the polymer formed from the given monomer;			E
		20.4.5	explain the challenges associated with the disposal of non-biodegradable polymers;		FA	
		20.4.6	explain the use of polymers in developing artificial organs in biomedical sciences;		FA	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and beyond
20.5	Pharmaceutical Industry	20.5.1 20.5.2 20.5.3	illustrate the chemical structure of aspirin and penicillin; explain the function of aspirin and penicillin in a human body; explain pH regulation in the stomach through non-specific reactions and active metabolites;		 FA *	A
20.6	Pesticides	20.6.1 20.6.2 20.6.3	define pesticides; explain the types of pesticides used in agriculture based on their mode of action; analyse the potential benefits and risks of using pesticides on the environment in agricultural practices;	*	 * 	 An
20.7	Genetic Engineering	20.7.1 20.7.2 20.7.3	define the term ‘genetic engineering’; explain the uses of genetic engineering in the development of genetically modified crops; explain the advantages and disadvantages of using genetically modified crops;	FA	 FA FA	
20.8	Dyes and Pigments	20.8.1 20.8.2 20.8.3	differentiate between dyes and pigments; explain the types of dyes based on their application; explain the importance of dyes and pigments in paints and textile industry;		* * *	
20.9	Synthetic Adhesive	20.9.1	explain the following types of synthetic adhesives: a. epoxy adhesives, b. polyurethane adhesives, c. acrylic adhesives, d. silicone adhesives, e. hot melt adhesives;		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			R	U	A and beyond
	20.9.2	discuss the use of synthetic adhesives mentioned in SLO 20.9.1 in the following industries: a. construction, b. automotive, c. aerospace, d. electronics, e. packaging;			FA

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and Beyond
21. Environmental Chemistry		Students should be able to:				
21.1	Energy Sources and their Impact on the Environment	21.1.1	compare the energy density and specific energy of various energy sources;		*	
		21.1.2	explain the formation and properties of fossil fuels;		*	
		21.1.3	explain nuclear fusion and fission reactions;		*	
		21.1.4	explain electricity generation using solar energy;		*	
		21.1.5	analyse the advantages and disadvantages of the following energy sources in the modern world: a. fossil fuels, b. nuclear energy, c. solar energy;			An
		21.1.6	discuss climate change in terms of the greenhouse effect and global warming;			E
21.2	Air Quality: Sources, Impacts, Measurement, and Management	21.2.1	discuss the sources and effects of air pollutants, including: a. ozone (O_3), b. polycyclic aromatic hydrocarbons (PAHs), c. persistent organic pollutants (POPs), d. greenhouse gases, e. chlorofluorocarbons (CFCs), f. volatile organic compounds (VOCs), g. peroxyacyl nitrates (PANs), h. heavy metals (such as lead, mercury, and cadmium);			E
		21.2.2	analyse the impact of human activities, such as burning of fossil fuels and deforestation, on the atmosphere;			An
		21.2.3	discuss causes and effects of oxidising and reducing smogs;			E
		21.2.4	discuss methods and techniques for measuring and monitoring air quality;			FA

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and Beyond
		21.2.5	design an experiment to investigate the factors affecting air quality by: a. collecting relevant data through observations and measurements, b. formulating and testing hypotheses based on scientific principles, c. analysing the collected data for patterns and relationships, d. interpreting measurements and trends in air quality dynamics, e. drawing evidence-based conclusions to represent the results;			FA
		21.2.6	suggest measures to control air pollution based on governmental rules and regulations to improve air quality;			E
		21.2.7	evaluate the effectiveness of pollution control measures to refine strategies for improving air quality;			E
21.3	Water Pollution: Types, Sources, Analysis, Purification, and Conservation	21.3.1	explain the different types of water pollution, including point source and non-point source pollution;		*	
		21.3.2	discuss the effects of water pollution on human health and the environment;			E
		21.3.3	discuss the parameters used in water analysis;			E
		21.3.4	explain methods of water purification, including the zeolite process and reverse osmosis;		*	
		21.3.5	recommend strategies for water pollution management and conservation of water resources at the community level;			E

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and Beyond
21.4 Green Chemistry	21.4.1 21.4.2	describe the twelve principles of green chemistry; discuss the importance of green chemistry in: a. reducing carbon footprints, b. minimising environmental impacts, c. promoting sustainable energy sources.			*	E

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				R	U	A and Beyond
22. Analytical Chemistry		Students should be able to:				
22.1	Analytical Techniques and Spectroscopic Methods	22.1.1	compare the classical and modern methods of structural analysis of compounds;		*	
		22.1.2	define the term 'spectroscopy';	*		
		22.1.3	explain the various regions of the electromagnetic spectrum based on wavelength;		*	
		22.1.4	explain the principles and differences between atomic emission and atomic absorption spectra;		*	
22.2	IR Spectroscopy	22.2.1	describe the basic principles of infrared (IR) spectroscopy, including the absorption of infrared (IR) radiation, molecular rotation, molecular vibrations and vibrational coupling;		*	
		22.2.2	interpret the infrared (IR) spectra of simple molecules, including benzene, phenol, acetone, acetic acid and ethanol;			E
22.3	UV-Visible Spectroscopy	22.3.1	describe the basic terms related to ultraviolet (UV) spectroscopy, including absorbance, transmittance, monochromator, chromophore, auxochrome, delocalisation, and conjugation;		*	
		22.3.2	determine the ability of a given molecule to absorb in the UV-visible region;			A
		22.3.3	interpret the UV-visible spectra of methylene blue and $[Ti(H_2O)_6]^{3+}$ based on the colours of these compounds;			E
22.4	NMR (^{1}H NMR) Spectroscopy	22.4.1	describe the basic principles of proton nuclear magnetic resonance (^{1}H NMR) spectroscopy, including the purpose, the need for deuterated solvents, nuclear spin, splitting of nuclear energy levels, chemical shift, and spin-spin coupling (peak splitting patterns), in simple terms;		*	

Topics and Sub-topics		Student Learning Outcomes	Cognitive Level		
			R	U	A and Beyond
	22.4.2	deduce the following using the ^{1}H NMR spectrum of methanol and ethanol: a. the different chemical environments of protons, b. the number of each type of proton, c. the equivalence of protons on adjacent carbon atoms;			E
22.5 Mass Spectrometry	22.5.1 22.5.2	explain the instrumentation and working of a mass spectrometer (MS); interpret the peaks in mass spectra to reveal isotopic masses and relative abundances of carbon, chlorine, and bromine.		*	 E

Practical Activities of AKU-EB HSSC Chemistry Syllabus

Student Learning Outcomes

Content Covered	Actions Performed	Attitude Developed
• Separation Techniques • Volumetric Analysis • Salt Analysis • Functional Group Identification • Calorimetry • Organic Synthesis • Element Detection • Biochemical Tests	• Follow the safety precautions provided in the Lab Guidelines. • Collect the required apparatus/ equipment/ chemicals for the experiments. • Handle the apparatus/ equipment/ chemicals appropriately. • Perform the experiments with the help of given method/ steps. • Modify the steps to perform a similar experiment in real-life settings. • Take reading with precision.	• Ensure safety of yourself, others around you and your surroundings. • Demonstrate a scientific mindset by asking questions and planning further investigations. • Display ethical dealings and practices while performing experiments. • Show willingness to solve problems and challenges. • Show self-reliance and cooperation when working independently and in a group setting respectively. • Revise judgements and change behaviour considering new evidence.

Topic Wise Practical Activities

Part I (Grade XI)

S. No.	Topic-Wise Practical Activity	Equipment	Chemical
	Topic 5: Chemical Equilibrium		
1.	Purify a given sample of sodium chloride by passing HCl gas. (Application of common ion effect)	Beaker 500 mL, funnel, round-bottom flask, glass tubing, wire gauze, thistle funnel, burner, stirrer, graduated cylinder and physical/ digital balance	Distilled water, common salt, concentrated H_2SO_4
	Topic 6: Acids, Bases and Salts		
2.	Measure the exact molarity of the given solution of H_2SO_4 and the volume of this acid required to prepare 500 mL of 0.02 M acid by volumetric method.	Burette, pipette, funnel, conical flasks, beakers, iron stand with clamp	Phenolphthalein/ methyl orange, 0.1M NaOH/ Na_2CO_3, 0.2 M H_2SO_4 distilled water
3.	Measure the percentage of NaOH in the given solution (such as a mixture of NaCl and NaOH or a sample of soap solution) by volumetric method.	Burette, pipette, funnel, conical flasks, beakers, iron stand with clamp	Phenolphthalein, 0.1M NaOH, 0.1M HCl, distilled water, solution containing 8 g of a mixture of NaCl and NaOH/ 250 mL solution of 10 g soap.
4.	Measure the percentage purity of the sample solution, containing 6 g of Na_2CO_3 dissolved per dm^3, using the volumetric method.	Burette, pipette, funnel, conical flasks, beakers, iron stand with clamp	Methyl orange, 0.1M Na_2CO_3, 0.1M HCl, distilled water, solution of 6 g of Na_2CO_3 in 1L.

S. No.	Topic-Wise Practical Activity	Equipment	Chemical
5.	Perform volumetric analysis to determine the value of X in the given sample of 6.3 g of $(COOH)_2.XH_2O$ dissolved per L.	Burette, pipette, funnel, conical flasks, beakers, iron stand with clamp	Phenolphthalein, 0.1M NaOH, 0.1M $(COOH)_2.2H_2O$, distilled water
6.	Demonstrate the solubility of oxalic acid at room temperature volumetrically.	Burette, pipette, funnel, conical flasks, beakers, iron stand with clamp	Phenolphthalein, 0.1M NaOH, 0.1M $(COOH)_2.2H_2O$, distilled water
	Topic 9: Chemical Energetics		
7.	Measure the heat of neutralisation of NaOH and HCl.	Calorimeter with stirrer, thermometer, balance (physical/ digital)	1M NaOH, 1M HCl, distilled water
	Topic 10: Electrochemistry		
8.	Standardise the given solution of $KMnO_4$ and calculate the volume of $KMnO_4$ required for preparing 1 L of 0.01M $KMnO_4$ solution volumetrically.	Burette, pipette, funnel, conical flasks, beakers, iron stand with clamp, Bunsen burner/ spirit lamp, test tube	0.1M $FeSO_4$ solution/ 0.05M oxalic acid, 0.02M $KMnO_4$solution, dilute H_2SO_4, distilled water
9.	Measure the amount of iron in the given sample volumetrically.	Burette, pipette, funnel, conical flasks, beakers, iron stand with clamp, test tube	0.05M $FeSO_4$ solution, 0.01M $KMnO_4$ solution, dilute H_2SO_4, distilled water
10.	Measure the percentage composition volumetrically of a solution mixture of $K_2C_2O_4$ and K_2SO_4.	Burette, pipette, funnel, conical flasks, beakers, iron stand with clamp, test tube	Solution mixture of $K_2C_2O_4$ and K_2SO_4, 0.01M $KMnO_4$ solution, dilute H_2SO_4, distilled water
11.	Demonstrate the solubility of Mohr's salt at room temperature volumetrically.	Burette, pipette, funnel, conical flasks, beakers, iron stand with clamp, test tube	0.05M Mohr's salt solution, 0.01M $KMnO_4$ solution, dilute H_2SO_4, distilled water

Part II (Grade XII)

S. No.	Topic-Wise Practical Activity	Equipment	Chemical
	Topic 11: s- and p-Block Elements		
1.	Detect the following cations: NH_4^+, Mg^{2+}, Al^{3+}, Ca^{2+}, Ni^{2+}, Co^{2+}, Fe^{2+}, Fe^{3+}, Cu^{2+}, Zn^{2+}, Ba^{2+}, Pb^{2+}. Detect the following anions: CO_3^{2-}, NO_3^-, NO_2^-, SO_4^{2-}, SO_3^{2-}, Cl^-, Br^-, I^-.	Test tubes, test tube holder, test tube rack, delivery tube, measuring cylinder, match box, wooden splint, Bunsen burner/ spirit lamp, safety goggles, glass rod, filter paper, litmus paper	Sodium hydroxide, ammonium hydroxide, dilute acids, barium, lead, silver salt solutions, Aluminium foil, lime water and other necessary chemical solutions for the identification of these ions and gases
	Topic 12: Transition Metals		
2.	Prepare pure sample of copper amine complex (tetra amine cupric sulphate, $Cu(NH_3)_4SO_4$).	Beaker, watch glass, glass rod/ stirrer, filter paper, funnel	2.5 g copper sulphate, concentrated ammonia, H_2SO_4, ethyl alcohol
	Topic 13: Organic Compounds		
3.	Detect elements in an organic compound (nitrogen, sulphur and halogen).	Test tubes, test tube holder, test tube rack, safety goggles, Bunsen burner/ spirit lamp, tripod stand, wire guaze, china dish, dropper	**For Lassaigne's solution:** Sodium metal, organic compound containing nitrogen, sulphur and halogen, distilled water. (Provide the prepared solution to the students)
			For N: Lassaigne's solution, sodium hydroxide, freshly prepared $FeSO_4$, dilute H_2SO_4

			For S: Lassaigne's solution, acetic acid, lead acetate, sodium nitroprusside solution *For combined test of nitrogen and sulphur can also use $FeCl_3$ **For Halogen:** Lassaigne's solution, $AgNO_3$, concentrated HNO_3, NH_4OH
	Topic 15: Alkyl Halides and Amines		
4.	Prepare azo dye from amine.	Test tubes, test tube rack, test tube holder, measuring cylinder, balance, filter paper, funnel	Amine (aniline), phenol, hydrochloric acid, ice, sodium nitrite, alcohol, distilled water
	Topic 16: Alcohols, Phenols and Ethers		
5.	Prepare iodoform.	Test tubes, test tube holder, test tube rack, Bunsen burner/ spirit lamp, safety goggles	Alcohol, sodium hydroxide, water, solution of iodine in potassium iodide
6.	Detect the phenol functional group.	Test tubes, test tube holder, test tube rack, measuring cylinder, safety goggles.	Litmus solution, ferric chloride solution
	Topic 17: Carbonyl Compound I: Aldehydes and Ketones		
7.	Detect the aldehyde and ketone functional group.	Beakers, test tubes, measuring cylinders, Bunsen burner/ spirit lamp, match box, funnel, filter papers	Fehling's solution, Tollen's reagent, Benedict solution
	Topic 18: Carbonyl Compound II: Carboxylic Acid and Functional Derivatives		
8.	Detect the carboxylic acid functional group.	Test tubes, beakers, balance, measuring cylinders, funnel, filter paper	Dilute sodium hydroxide, saturated potassium bicarbonate

S. No.	Topic-Wise Practical Activity	Equipment	Chemical
	Topic 19: Biochemistry		
9.	Demonstrate the denaturation of protein by urea.	Test tubes, beakers, conical flask, pipette	Urea, egg white
10.	Detect glucose as reducing sugar in urine sample of diabetic patients/ any glucose containing compound.	Test tubes, beaker conical flask, pipette	Benedict Reagent, Fehling's Solution
11.	Demonstrate the digestion of starch with salivary amylase.	Test tubes, beakers, conical flask, pipette, slides.	Freshly prepared starch solution, iodine solution

Scheme of Assessment

Table 1: Exam Specifications

Topic No.	Topics	Marks Distribution			Total Marks
		MCQs	CRQs	ERQs	
1.	Stoichiometry	5		7 Marks Choose any ONE from TWO	16
10.	Electrochemistry	4			
2.	Atomic Structure	4	Total 4 Marks (1 CRQ)		8
3.	Theories of Covalent Bonding and Shapes of Molecules	5	Total 3 Marks (1 CRQ)		8
4.	States of Matter: Gases, Liquids and Solids	9	Total 4 Marks (1 CRQ)		13
5.	Chemical Equilibrium	4	Total 4 Marks (1 CRQ)		8
6.	Acids, Bases and Salts	5		7 Marks Choose any ONE from TWO	16
8.	Solution and Colloids	4			
7.	Chemical Kinetics	5	Total 2 Marks (1 CRQ)		7
9.	Chemical Energetics	5	Total 4 Marks (1 CRQ)		9
	Total	**50**	**21**	**14**	**85**
	Practical*				**15**
	Total				**100**

Note: The cognitive distribution of marks for Chemistry HSSC are as follows:
Remember: 0 to 15 %
Understand: 45 to 60 %
Apply and beyond: 25 to 40 %

Grade XII

Table 2: Exam Specifications

Topic No.	Topics	Marks Distribution			Total Marks
		MCQs	CRQs	ERQs	
11.	s- and p-Block Elements	6			6
12.	Transition Metals	4	Total 2 Marks (1 CRQ)		6
13.	Organic Compounds	4	Total 3 Marks (1 CRQ)		7
14.	Hydrocarbons	4		7 Marks Choose any ONE from TWO	15
15.	Alkyl Halides and Amines	4			
16.	Alcohols, Phenols and Ethers	5	Total 2 Marks (1 CRQ)		7
17.	Carbonyl Compound I: Aldehydes and Ketones	3	Total 4 Marks (1 CRQ)		7
18.	Carbonyl Compound II: Carboxylic Acid and Functional Derivatives	4		7 Marks Choose any ONE from TWO	15
21.	Environmental Chemistry	4			
20.	Industrial Chemistry	4	Total 3 Marks (1 CRQ)		7
19.	Biochemistry	4	Total 3 Marks (1 CRQ)		7
22.	Analytical Chemistry	4	Total 4 Marks (1 CRQ)		8
	Total	**50**	**21**	**14**	**85**
	Practical*				**15**
	Total				**100**

Note: The cognitive distribution of marks for Chemistry HSSC are as follows:
Remember: 0 to 15 %
Understand: 45 to 60 %
Apply and beyond: 25 to 40 %

Examination Structure and Practical Requirements for Grades XI and XII

Theory:

- Multiple Choice Question (MCQ) requires candidates to choose one best/ correct answer from four options for each question. Each MCQ carries ONE mark.
- Constructed Response Question (CRQ) requires students to respond with a short text (few phrases/ sentences), calculations or diagrams.
- Extended Response Question (ERQ) requires students to answer in a more descriptive form. The answer should be in paragraph form, with diagrams where needed, and address all parts of the question.
- Table 1 and 2 contains the mark distribution for each topic.
- There will be two examinations, one at the end of grade XI and one at the end of grade XII.
- In each grade, the theory paper will be of 3 hours and will consist of two parts: paper I and paper II.
- Paper I theory will consist of 50 compulsory, multiple choice items. These questions will involve four responses options. The answer sheet for paper I will be provided separately.
- Paper II theory will carry 35 marks and consist of Constructed Response Questions (CRQs) and Extended Response Questions (ERQs). Each extended response question will be presented in an either/ or form.
- The booklet for paper II will serve as an answer script.

Practical:

- In each grade, practical examination (Paper III) will be conducted separate from the theory paper and will consist of 15 marks.
- Practical examination (Paper III) will be based on the list of practical activities given in the examination syllabus. Schools may design their own practical manuals based on these activities for teaching and learning purpose.
- Practical journal/ portfolio should be developed by students and endorsed by a figure of authority, such as a teacher or principal, and submitted at the time of the practical examination (Paper III).
- It is essential for each school to equip its laboratories with chemicals, instruments, apparatus, specimens etc. according to the requirements of the practical activities. Each school will be responsible to make sure that each student is provided the opportunity to do the practical activities.

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