آغا خان یونیورسٹی ایگزامینیشن بورڈ

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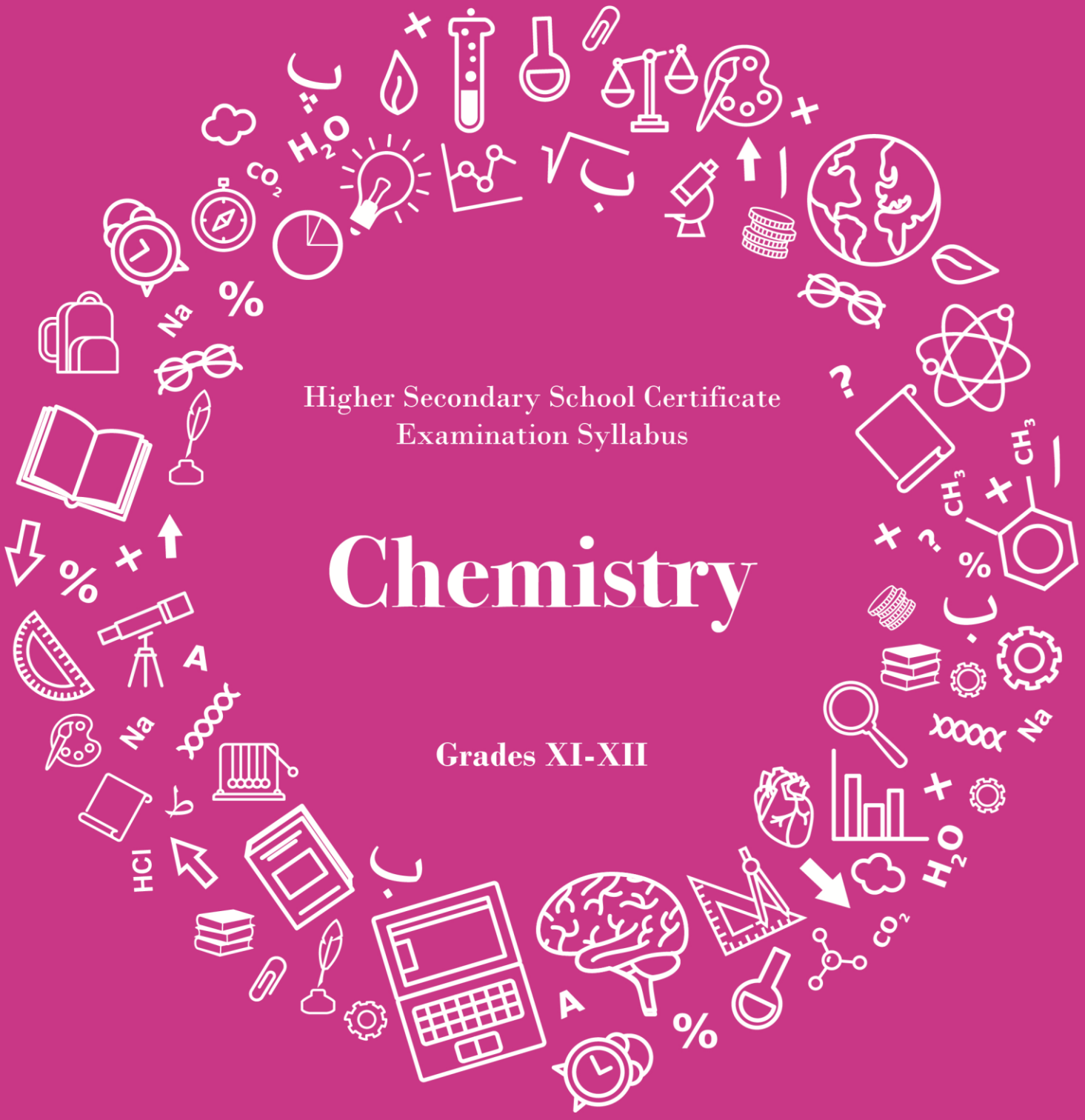

Higher Secondary School Certificate
Examination Syllabus

Chemistry

Grades XI-XII

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Higher Secondary School Certificate Examination Syllabus

CHEMISTRY

GRADES XI-XII

This syllabus will be examined in both Annual and Re-sit Examination sessions from Annual Examinations 2023

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 (SSC) and higher secondary (HSSC) school certifications. 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 are aligned with National/ trans-provincial curricula and international standards. AKU-EB revises its syllabi periodically to support the needs of students, teachers and examiners.

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

- Ensure continued compatibility with the goals of the trans-provincial curricula 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 examiners.
- Enhance and strengthen continuation and progression of content both within and across grades IX - XII (SCC 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 syllabus is organised into topics and subtopics. Each subtopic is further divided into achievable student learning outcomes (SLOs). The SLOs of the cognitive domain are each assigned a cognitive level on which they have to be achieved. These cognitive levels are 'knowledge', 'understanding' and 'application', the latter also including other higher order skills. This is followed by the Exam Specification which gives clear guidance about the weightage of each topic and how the syllabus will be assessed.

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 Dr Sohail Qureshi for his very useful feedback on revising the syllabus review process, to Dr Naveed Yousuf for his continued guidance and support throughout the syllabus revision process and to Raabia Hirani for leading the syllabi revision. 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 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 best international and trans-provincial standards 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 Shehzad Jeeva
Chief Executive Officer (CEO), Aga Khan University Examination Board
Associate Professor of Practice, Faculty of Arts and Sciences, Aga Khan University

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 subtopics and **student learning outcomes (SLOs)**. The subtopics and the SLOs define the depth and the breadth at which each topic 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. The examination questions are framed using the same command words or their connotations to elicit evidence of these competencies in students' responses.

4. The topics of the syllabi are grouped into themes derived from the National/ trans-provincial curricula. The connection between various themes and topics is highlighted in the '**concept map**' provided at the beginning of each syllabus. This ensures that students begin to understand the interconnectedness of knowledge, learn conceptually and think critically.

5. The SLOs are classified under three **cognitive levels**: knowledge (K), understanding (U) and application and other higher order skills (A) for effective planning during teaching and learning. Furthermore, it will help to derive multiple choice questions (MCQs), constructed response questions (CRQs) and extended response questions (ERQs) on a rational basis from the subject syllabi.

6. By focusing on the achievement of the SLOs, these syllabi aim to counter the culture of rote memorisation as the preferred method of examination preparation. While suggesting relevant, locally available textbooks for achieving these outcomes, AKU-EB recommends that teachers and students use multiple teaching and learning resources for achieving these outcomes.

7. The syllabi follow a uniform layout for all subjects to make them easier for students and teachers to follow. They act as a bridge between students, teachers and assessment specialists by providing a common framework of student learning outcomes and **exam specifications**.

8. On the whole, the AKU-EB syllabi for Secondary School Certificate (SSC) provide a framework that helps students to acquire conceptual understanding and learn to critically engage with it. This lays a solid foundation for HSSC and beyond.

Subject Rationale of AKU-EB Chemistry

Why study Chemistry?

Chemistry is not anything which is restricted to schools, books or the science laboratory, it is basically found everywhere around us. The air we respire, the food which cooks in the kitchen, the aroma of perfumes we sense or the storing of food in plants – literally there occur hundreds and thousands of chemical phenomena every day in life which involves chemistry. Chemistry is associated with everything we interact with in our daily routine; such as, the flavourings in our food, the fibres in our clothing, lifesaving drugs for curing threatening diseases, fertilisers enriching soil fertility, pesticides for protection of crops, cement, glass and paints for constructing houses to a huge feedstock of petrochemicals for manufacturing various products. Chemistry could be considered as the core of science subjects, which interlinks different branches of science and strengthens awareness of the environmental changes to resolve environmental issues in order to make this planet a better home for all living organisms.

What will you learn in AKU-EB Chemistry?

The AKU-EB Chemistry Syllabus is designed in such a way that it provides essential theoretical and practical knowledge of real life Chemistry to students. It focuses on understanding the different themes of Chemistry that will enable students to comprehend the composition, structure, properties of different materials, their interactions and use in the synthesis of new products. The syllabus attempts to develop a logical approach for students to understand different chemical phenomena and solve problems. Furthermore, the use of multiple learning resources such as models, pictures, animations and various reference books are encouraged during study to create interest and provide logical understanding of fundamental concepts of Chemistry.

Where will it take you?

The study of Chemistry enables an individual to play a vital role in the socioeconomic development of our country. In recent years, the impact of Chemistry in our society for future 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 in the industrial sector.

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

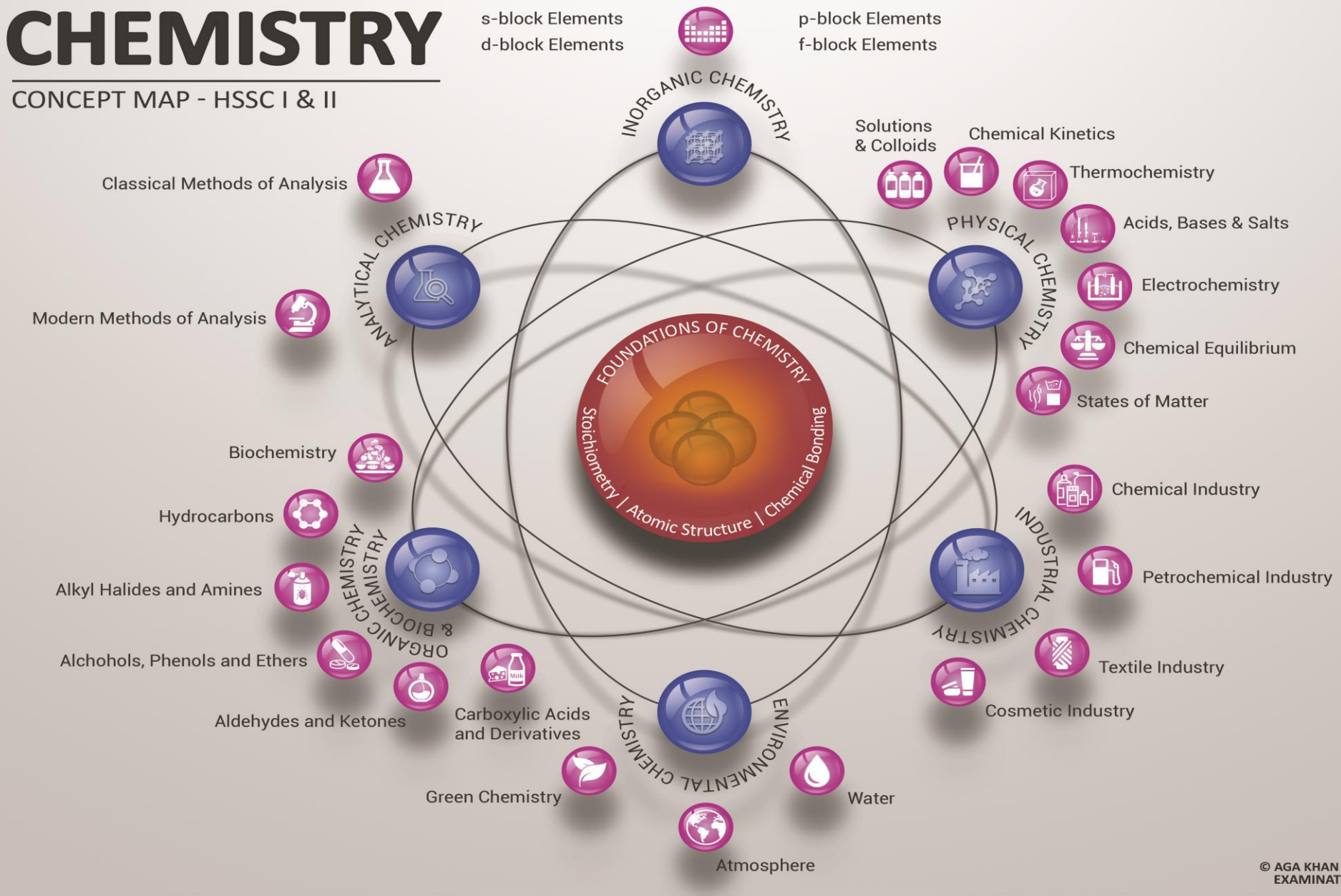
- Engineering
- Medicine
- Pharmacy
- Dentistry
- Nursing
- Veterinary
- Environmental science
- Biotechnology
- Geology
- Biochemistry
- Polymer engineering
- Textile engineering
- Chemical engineering
- Microbiology

How to approach the syllabus?

The concept map of the syllabus gives an overview of the entire syllabus. The topics and the student learning outcomes (SLOs) guide regarding the details about what has to be achieved. And finally, the exam specification guides regarding what will be expected in the examination.

What is the concept map telling you?

AKU-EB HSSC Chemistry syllabus is based on the structure of a carbon atom – the most abundant element in the universe by mass, having a nucleus in the center and 6 electrons revolving around it. An electrostatic force of attraction holds the protons in the nucleus and orbiting electrons together. Similarly, Chemistry and its branches are interlinked with each other. The foundation of Chemistry is represented as the nucleus in a carbon atom and the rest of the themes of Chemistry are represented by its individual electrons. Furthermore, the symbols shown for each theme of Chemistry give a quick impression of the concepts it involves.


CHEMISTRY
CONCEPT MAP - HSSC I & II
s-block Elements
d-block Elements
p-block Elements
f-block Elements
INORGANIC CHEMISTRY
PHYSICAL CHEMISTRY
INDUSTRIAL CHEMISTRY
ENVIRONMENTAL CHEMISTRY
ORGANIC CHEMISTRY & BIOCHEMISTRY
ANALYTICAL CHEMISTRY
FOUNDATIONS OF CHEMISTRY
Stoichiometry | Atomic Structure | Chemical Bonding
Solutions & Colloids
Chemical Kinetics
Thermochemistry
Acids, Bases & Salts
Electrochemistry
Chemical Equilibrium
States of Matter
Chemical Industry
Petrochemical Industry
Textile Industry
Cosmetic Industry
Water
Atmosphere
Green Chemistry
Carboxylic Acids and Derivatives
Aldehydes and Ketones
Alchohols, Phenols and Ethers
Alkyl Halides and Amines
Hydrocarbons
Biochemistry
Modern Methods of Analysis
Classical Methods of Analysis
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Student Learning Outcomes of AKU-EB HSSC Chemistry Syllabus

Part I (Grade XI)

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level[1]		
				K	U	A
1. Stoichiometry		Students should be able to:				
1.1	Chemistry as a Quantitative Science	1.1.1	discuss the significance of Chemistry as a quantitative science in daily life;		*	
1.2	Mole and Avogadro's Number	1.2.1	define 'mole' and 'Avogadro's number';	*		
		1.2.2	relate the concept of mole with Avogadro's number;		*	
		1.2.3	calculate the number of following chemical species/ particles, i.e. a. atoms b. molecules c. moles d. ions e. protons f. neutrons g. electrons;			*
		1.2.4	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);			*
		1.2.5	solve problems based on stoichiometry using mole ratios as conversion factor;			*

[1] K = Knowledge, U = Understanding, A = Application and other higher-order cognitive skills

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
1.3	Formulae and Percentage Composition	1.3.1	calculate percentage (by mass) of: a. elements in compounds b. water of crystallisation in hydrated salts;			*
		1.3.2	deduce empirical and molecular formula of compounds;			*
1.4	Excess and Limiting Reagent	1.4.1	deduce the limiting reagent in chemical reactions;			*
		1.4.2	calculate maximum amount of product produced and amount of any unreacted excess reagent, with the help of limiting reagent in a chemical reaction;			*
1.5	Theoretical, Actual and Percentage Yield	1.5.1	distinguish among theoretical yield, actual yield and percentage yield;		*	
		1.5.2	calculate the percentage yield of a product in a chemical reaction.			*

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
2. Atomic Structure		Students should be able to:				
2.1	Discharge Tube Experiment	2.1.1	explain the construction and working of discharge tube with reference to the discovery of electron and proton;		*	
		2.1.2	describe the properties of: a. cathode rays b. positive 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	describe Bohr's atomic theory;		*	
		2.3.2	calculate the radius and energy of revolving electrons in orbits with reference to Bohr's atomic theory;			*
		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;			*
		2.3.5	discuss the defects of Bohr's atomic theory;		*	
2.4	X-Rays and Atomic Numbers	2.4.1	define 'X-rays';	*		
		2.4.2	explain the production and uses of X-rays;		*	
		2.4.3	describe the relationship between X-ray frequency and atomic number of different elements with reference to Moseley's experiment;		*	
		2.4.4	state Moseley's law and its significance;	*		

		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
2.5	Heisenberg's Uncertainty Principle and Quantum Numbers	2.5.1	describe the concept of orbital on the basis of Heisenberg's uncertainty principle;		*	
		2.5.2	compare orbit and orbital;		*	
		2.5.3	describe the principle quantum number, Azimuthal quantum number, magnetic quantum number and spin quantum number;		*	
		2.5.4	deduce the position and distribution of electrons using the concept of quantum numbers;			*
2.6	Dual Nature of Electron	2.6.1	explain the dual nature of electron with reference to de-Broglie equation;		*	
2.7	Electronic Configuration	2.7.1	state the rules of electronic configuration, i.e. Aufbau principle, Hund's rule, Pauli's exclusion principle;	*		
		2.7.2	determine electronic configuration of elements based on Aufbau principle, Hund's rule and Pauli's exclusion principle.			*

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
3. Theories of Covalent Bonding and Shape of Molecules		Students should be able to:				
3.1	Bond Characteristics	3.1.1	define the term 'bond energy';	*		
		3.1.2	relate bond energy with bond strength;		*	
		3.1.3	define the term 'bond length';	*		
		3.1.4	explain ionic character of covalent bond;		*	
		3.1.5	predict the nature of bonding on the basis of electronegativity;			*
		3.1.6	describe the change in bond length of heteronuclear molecules due to the difference of electronegativity values of bonded atoms;		*	
		3.1.7	exemplify dipole moment;		*	
		3.1.8	predict the molecular polarity from the shapes of molecules;			*
3.2	Shape of Molecules using VSEPR Theory	3.2.1	explain valence shell electron pair repulsion (VSEPR) theory;		*	
		3.2.2	draw the shape of simple covalent molecules using VSEPR theory;			*
3.3	VBT, MOT and Hybridisation	3.3.1	explain valence bond theory (VBT);		*	
		3.3.2	describe the features of sigma and pi bonds;		*	
		3.3.3	explain hybridisation and its types;		*	
		3.3.4	describe the shapes of simple molecules using orbital hybridisation (sp, sp^2, sp^3);		*	
		3.3.5	explain molecular orbital theory (MOT);		*	
		3.3.6	predict the electronic configuration, bond order and magnetic properties of homonuclear diatomic molecules with the help of MOT;			*
		3.3.7	compare VBT and MOT;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
3.4	Effect of Bonding on Physical and Chemical Properties	3.4.1	explain the solubility of ionic and covalent compounds on the basis of nature of bonding;		*	
		3.4.2	explain chemical properties of ionic and covalent compounds;		*	
		3.4.3	compare directional and non-directional nature of ionic and covalent bonds.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
4. States of Matter I: Gases		Students should be able to:				
4.1	Kinetic Molecular Theory of Gases	4.1.1	describe the kinetic molecular theory (KMT) of gases;		*	
		4.1.2	explain the gas laws, i.e. a. Boyle's law b. Charles's law c. Avogadro's law d. Dalton's law of partial pressure e. Graham's law of diffusion/ effusion;		*	
		4.1.3	explain the gas laws with reference to Kinetic Molecular Theory;		*	
		4.1.4	relate effect of temperature to the average kinetic energy of the gas particles;		*	
4.2	Absolute Temperature Scale on the Basis of Charles's Law	4.2.1	explain 'Absolute Zero' with reference to Charles's law;		*	
		4.2.2	convert temperature into different scales, i.e. a. Celsius b. Fahrenheit c. Kelvin;			*
4.3	Ideal Gas Equation	4.3.1	derive ideal gas equation using Boyle's, Charles's and Avogadro's law;			*
		4.3.2	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;			*

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
		4.3.3	calculate mass, pressure, volume, temperature and density of a gas using the ideal gas equation;			*
		4.3.4	calculate the molar mass of a gas from density measurement of gases at STP;			*
		4.3.5	explain the effect of pressure on scuba divers at varying depths;		*	
4.4	Deviation from Ideal Behaviour	4.4.1	explain deviation of gases from their ideal behaviour;		*	
4.5	Vander Waal's Equation	4.5.1	explain pressure and volume correction for non-ideal gas with reference to Vander Waal's equation;		*	
		4.5.2	derive Vander Waal's equation;			*
4.6	Liquefaction of Gases	4.6.1	explain the general principle of liquefaction of gases using Joule Thomson's effect;		*	
		4.6.2	discuss Linde's method for the liquefaction of gases;		*	
4.7	Fourth State of Matter: Plasma	4.7.1	define the term'plasma';	*		
		4.7.2	explain the formation of plasma;		*	
		4.7.3	describe the characteristics and applications of plasma.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
5. States of Matter II: Liquids		Students should be able to:				
5.1	Kinetic Molecular Interpretation of Liquid	5.1.1	describe the following properties of liquids with reference to kinetic molecular theory, i.e. a. diffusion b. compression c. expansion d. motion of molecules e. intermolecular forces f. kinetic energy;		*	
5.2	Intermolecular Forces	5.2.1	explain applications of dipole-dipole forces, hydrogen bonding and London forces;		*	
		5.2.2	explain the physical properties of liquids, i.e. a. evaporation b. vapour pressure c. boiling point d. viscosity e. surface tension;		*	
		5.2.3	explain the following properties of water using the concept of hydrogen bonding, i.e. a. surface tension b. specific heat c. vapour pressure d. heat of vaporisation e. boiling point f. when it shows maximum density at 4°C;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
		5.2.4	compare the volatility of different liquids at same temperature based on intermolecular forces;		*	
5.3	Energetic of Phase Changes	5.3.1	define the terms: a. molar heat of fusion b. heat of vaporisation c. molar heat of sublimation;	*		
		5.3.2	relate energy changes with changes in intermolecular forces;		*	
		5.3.3	describe dynamic equilibrium between different physical states of matter;		*	
5.4	Liquid Crystals	5.4.1	define the term 'liquid crystals';	*		
		5.4.2	explain the formation of liquid crystals;		*	
		5.4.3	differentiate liquid crystals from pure liquids and crystalline solids;		*	
		5.4.4	discuss the use of liquid crystals as temperature sensors, in thermometers, skin thermography, electrical circuits and devices, chromatographic separations, calculator screen and as display screens.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
6. States of Mater III: Solids		Students should be able to:				
6.1	Kinetic Molecular Interpretation of Solids	6.1.1	describe the following properties of solids with reference to kinetic molecular theory, i.e. a. diffusion b. compression c. expansion d. motion of molecules e. intermolecular forces f. kinetic energy;		*	
6.2	Types and properties of Solids	6.2.1	describe the characteristics of crystalline solids, i.e. a. symmetry b. melting point c. anisotropy d. cleavage plane e. crystal growth f. geometrical shape g. habit of crystals;		*	
		6.2.2	distinguish between crystalline and amorphous solids;		*	
		6.2.3	differentiate between isomorphism and polymorphism;		*	
		6.2.4	relate polymorphism with allotropy;		*	
		6.2.5	exemplify transition temperature;		*	
6.3	Crystal Lattice	6.3.1	define ‘unit cell’ and ‘lattice energy’;	*		
		6.3.2	exemplify seven crystal systems;		*	
		6.3.3	explain energy changes in the formation of sodium chloride crystal lattice;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
6.4	Types of Crystalline Solid	6.4.1	differentiate among types of crystalline solids, i.e. a. ionic b. molecular c. metallic d. covalent;		*	
		6.4.2	discuss the use of crystalline and amorphous solids in daily life.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
7. Chemical Equilibrium		Candidates should be able to:				
7.1	Reversible Reaction and Dynamic Equilibrium	7.1.1	define the term 'reversible reaction';	*		
		7.1.2	define the term 'dynamic equilibrium';	*		
		7.1.3	determine equilibrium constant (K_c) expression for given reactions;			*
		7.1.4	determine the equilibrium constant expression in terms of concentration, partial pressure, number of moles and mole fraction;			*
		7.1.5	determine expression for reaction quotient of given reactions;			*
		7.1.6	predict the direction of a reaction by relating equilibrium constant with the ratio between concentration of products and reactants;			*
		7.1.7	predict the extent of chemical reaction from the given value of K_c;			*
7.2	Le-Chatelier's Principle and its Application	7.2.1	state Le-Chatelier's principle;	*		
		7.2.2	predict the effect of catalyst, temperature, pressure, volume and concentration on the equilibrium state and yield of industrial products using Le-Chatelier's principle;			*
7.3	Solubility Product and Precipitation Reactions	7.3.1	define the term 'solubility product';	*		
		7.3.2	distinguish between solubility and solubility product;		*	
		7.3.3	explain the reasons for difference in solubility of different substances;		*	
		7.3.4	calculate the solubility product (K_{sp}) from the solubility of compounds;			*
		7.3.5	calculate concentration of ions of slightly soluble salts;			*
7.4	Common Ion Effect	7.4.1	define the term 'common ion effect';	*		
		7.4.2	discuss common ion effect and its application.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
8. Acids, Bases and Salts		Students should be able to:				
8.1	Acids, Bases and Amphoteric Substances	8.1.1	compare Arrhenius and Brønsted-Lowry concept of acids and bases;		*	
		8.1.2	exemplify amphoteric compounds;		*	
		8.1.3	explain the significance of acid base reactions in daily life (food preservation, allergic reactions, gastric acidity, curdling of milk);		*	
		8.1.4	calculate molarity, molality and strength of sample solutions based on acid-base titration;			*
8.2	Conjugate Acids and Bases	8.2.1	define the terms 'conjugate acid' and 'conjugate base';	*		
		8.2.2	compare the strength of conjugate acids and bases;		*	
8.3	Strengths of Acids and Bases	8.3.1	derive the ionisation constant of water (K_w);			*
		8.3.2	calculate the pH and pOH of solutions by using the given hydrogen or hydroxide ion concentration;			*
		8.3.3	compare the strength of acids and bases using pH and pOH;		*	
		8.3.4	derive the ionisation constants of acid (K_a) and base (K_b);			*
		8.3.5	show the relationship between K_a and K_b;			*
		8.3.6	calculate the H_3O^+ concentration by using the given K_a and molar concentration of weak acid;			*
		8.3.7	explain the 'levelling effect' with reference to the strength of acids;		*	
8.4	Lewis Concept of Acids and Bases	8.4.1	exemplify 'Lewis acids' and 'Lewis bases';		*	
		8.4.2	classify compounds (e.g. NH_3, $AlCl_3$, BF_3, etc.) as Lewis acids or bases;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
8.5	Buffer Solution	8.5.1	define ‘buffer solution’;	*		
		8.5.2	discuss the importance of buffer solutions in daily life;		*	
		8.5.3	describe the preparation of different types of buffer;		*	
		8.5.4	explain the application of buffers to maintain pH of solutions using chemical equations;		*	
		8.5.5	calculate the pH of buffer solutions using Henderson’s equation;			*
8.6	Hydrolysis and Hydration	8.6.1	define the term ‘hydrolysis’;	*		
		8.6.2	explain the types of salts on the basis of hydrolysis;		*	
		8.6.3	differentiate between hydrolysis and hydration.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
9. Chemical Kinetics		Students should be able to:				
9.1	Chemical Kinetics	9.1.1	define 'chemical kinetics';	*		
9.2	Rate and Order of Reaction	9.2.1	define the terms: a. rate of reaction b. rate law c. order of reaction d. rate constant e. rate determining step;	*		
		9.2.2	explain the significance of the rate determining step on the overall rate of a multistep reaction;		*	
		9.2.3	determine the rate law for the given reactions;			*
		9.2.4	deduce the order of reaction using the method of initial rate;			*
9.3	Collision Theory, Transition State and Activation Energy	9.3.1	relate activation energy and activated complex to the rate of reaction;		*	
		9.3.2	calculate the initial rate using concentration data of given reactions;			*
		9.3.3	draw a labelled energy diagram for a chemical reaction representing the activation energy and the effect of catalyst;			*
		9.3.4	describe collision theory;		*	
		9.3.5	explain the effect of concentration, temperature and surface area on rate of reaction by using collision theory;		*	
9.4	Catalysis	9.4.1	define the term 'catalyst';	*		
		9.4.2	explain homogeneous and heterogeneous catalysis;		*	
		9.4.3	explain the effect of catalyst on the rate of reaction.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
10. Solution and Colloids		Students should be able to:				
10.1	Colloid, Suspension and Solution	10.1.1	describe the properties of colloid, suspension and solution;		*	
		10.1.2	explain the types of colloids;		*	
		10.1.3	compare the characteristics of colloids and suspension that distinguish these from solution;		*	
		10.1.4	classify given substances as solutions, colloids or suspensions;		*	
10.2	Concentration Units	10.2.1	calculate the concentration units of solutions, i.e. 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);			*
10.3	General Properties of Solution and Solubility	10.3.1	differentiate between hydrophilic and hydrophobic molecules;		*	
		10.3.2	predict the nature of solutions in liquid phase as miscible, immiscible and partially miscible solution;			*
		10.3.3	interpret the solubility graph to check the effect of temperature on solubility;			*
10.4	Raoult's Law	10.4.1	state Raoult's law (all three definitions);	*		
		10.4.2	explain relationship between composition and vapour pressures of two volatile components using a graph;		*	
		10.4.3	discuss ideal and non-ideal solutions with reference to Raoult's law using a graph;		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			K	U	A
	Students should be able to:				
10.5 Colligative Properties	10.5.1	define the term ‘colligative properties’;	*		
	10.5.2	explain the colligative properties of liquids, i.e. a. lowering of vapour pressure b. elevation of boiling point c. depression of freezing point d. osmotic pressure;		*	
	10.5.3	calculate molar mass of a substance using ebullioscopic and cryoscopic methods.			*

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
11. Thermochemistry		Students should be able to:				
11.1	Thermodynamics	11.1.1	define 'thermodynamics';	*		
		11.1.2	define the terms: a. system b. surrounding c. state function d. heat e. internal energy f. work g. enthalpy;	*		
11.2	First Law of Thermodynamics	11.2.1	explain the first law of thermodynamics with the help of daily life examples;		*	
		11.2.2	relate change in internal energy of system with thermal energy at constant volume and pressure;		*	
		11.2.3	calculate internal energy and work done of a system by applying the first law of thermodynamics;			*
11.3	Hess's Law	11.3.1	explain Hess's law of heat summation;		*	
		11.3.2	construct energy cycles by using Hess's law for any given reactions;			*
		11.3.3	calculate standard heat of formation and heat of reaction by using Hess's law;			*
11.4	Measurement of Enthalpy of a reaction	11.4.1	explain working of a calorimeter (glass and bomb calorimeter);		*	
		11.4.2	calculate the heat of reaction in a calorimeter from given experimental data;			*

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			K	U	A
	Students should be able to:				
11.5 Born-Haber Cycle	11.5.1	define Born-Haber's cycle;	*		
	11.5.2	explain reaction pathway diagram in terms of enthalpy changes of reactions (of ionic compounds) using Born-Haber's cycle;		*	
	11.5.3	calculate lattice energy and enthalpy of formation of ionic compounds from given set of appropriate data;			*
11.6 Heat Capacity	11.6.1	describe the terms: a. heat capacity b. specific heat capacity c. molar heat capacity.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
12. Electrochemistry		Students should be able to:				
12.1	Oxidation - Reduction Concept	12.1.1	define the terms: a. reduction b. oxidation c. oxidation number d. reducing agent e. oxidising agent;	*		
		12.1.2	determine oxidation number of an atom in pure substance;			*
		12.1.3	determine reducing and oxidising agent by using oxidation number change method;			*
		12.1.4	balance a chemical equation using oxidation number change method;			*
		12.1.5	identify oxidation and reduction half reaction;		*	
		12.1.6	balance a chemical equation using half reaction method;			*
		12.1.7	discuss the uses of redox reactions in daily life;		*	
		12.1.8	solve problems based on oxidation-reduction titrations;			*
12.2	Electrode, Electrode Potential and Electrochemical Series	12.2.1	define the terms: a. cathode b. anode c. electrode potential d. standard electrode potential e. electrochemical series;	*		
		12.2.2	describe Standard Hydrogen Electrode (SHE);		*	
12.3	Types of Electrochemical Cells	12.3.1	define the term ‘cell potential’;	*		
		12.3.2	determine the potential of an electrochemical cell from the given standard electrode potential values of substances;			*

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			K	U	A
	Students should be able to:				
	12.3.3	describe chemical reactions occurring within lead storage batteries;		*	
	12.3.4	explain the process of production of electrical energy in a fuel cell;		*	
12.4 Faraday's Law	12.4.1	explain Faraday's first and second law of electrolysis;		*	
	12.4.2	calculate the quantity of charge passed in an electrochemical cell during electrolysis;			*
	12.4.3	calculate the mass or volume of substance produced during electrolysis.			*

Part II (Grade XII)

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
13. s- and p-Block Elements		Students should be able to:				
13.1	Elements and periodicity	13.1.1	describe the demarcation of the periodic table into s, p, d and f-blocks;		*	
		13.1.2	determine group, period and block of given elements by using electronic configuration;			*
		13.1.3	explain the periodicity of physical properties (i.e. atomic radius, ionisation energy, electronegativity, electron affinity, electrical conductivity, melting and boiling points) of elements within groups and periods in the periodic table;		*	
13.2	Period 3 (Na to Ar)	13.2.1	list the elements in period 3;	*		
		13.2.2	describe the reaction of period 3 elements with water, oxygen and chlorine;		*	
		13.2.3	describe the reaction of oxides and chlorides of period 3 elements with water;		*	
		13.2.4	describe physical properties (i.e. bonding, conductivity of liquid and solubility) and acid-base characteristics of oxides and chlorides of period 3 elements;		*	
13.3	Group 1	13.3.1	describe oxidation states and trends in physical properties in group 1 elements (i.e. ionisation energy, electronegativity, atomic radius, melting and boiling point);		*	
		13.3.2	describe the chemical reaction of group 1 elements with water, oxygen and chlorine;		*	
		13.3.3	discuss the trends in solubility of hydroxides, sulphates and carbonates of group 1 elements;		*	
		13.3.4	discuss the trends in thermal stability of nitrates and carbonates of group 1 elements;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
13.4	Group 2	13.4.1	describe oxidation states and trends in physical properties in group 2 elements (i.e. ionisation energy, electronegativity, atomic radius, melting and boiling point);		*	
		13.4.2	describe the chemical reaction of group 2 elements with water, oxygen and nitrogen;		*	
		13.4.3	compare the trends in solubility of hydroxides, sulphates and carbonates of group 2 with group 1 elements;		*	
		13.4.4	discuss the trends in thermal stability of nitrates and carbonates of group 2 elements;		*	
		13.4.5	differentiate beryllium from other members of its group;		*	
13.5	Group 4	13.5.1	describe variation in oxidation states and trends in physical properties of group 4 elements (i.e. ionisation energy, electronegativity, atomic radius, metallic character, melting and boiling point);		*	
		13.5.2	describe the reaction of water with chlorides of carbon, silicon and lead;		*	
		13.5.3	compare the structure and stability of chlorides of carbon, silicon and lead;		*	
		13.5.4	describe the molecular structure of CO_2 and SiO_2;		*	
		13.5.5	discuss the acid-base characteristics of oxides of group 4 elements;		*	
13.6	Group 7	13.6.1	discuss oxidation states and trends in physical properties of group 7 elements (i.e. atomic radius, electronegativity, electron affinity, bond energy, melting and boiling point);		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			K	U	A
	Students should be able to:				
	13.6.2	discuss bond enthalpies and acidic strength of hydrogen halides;		*	
	13.6.3	compare the strength of halide ions as reducing agents;		*	
	13.6.4	explain the significance of halogens in daily life.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
14. d- and f- Block Elements		Students should be able to:				
14.1	General Feature of Transition Elements	14.1.1	describe the general features of transition elements (i.e. colour, variable oxidation states, use as catalyst);		*	
14.2	Electronic Structure	14.2.1	explain anomalous behaviour of chromium and copper with respect to electronic configuration;		*	
		14.2.2	determine the electronic configuration of elements and ions of d-block;			*
14.3	Chemistry of Some Specific Transition Elements	14.3.1	describe redox reactions and uses of vanadium, chromium, copper, manganese and iron as catalyst;		*	
		14.3.2	describe properties of alloys with reference to the metals that compose them;		*	
		14.3.3	describe the reaction of $K_2Cr_2O_7$ with $FeSO_4$, and H_2S;		*	
		14.3.4	describe the reaction of $KMnO_4$ with $FeSO_4$, and H_2S;		*	
14.4	Coordination Compounds	14.4.1	define the terms: a. ligands b. coordination number c. coordination sphere d. chelates;	*		
		14.4.2	describe different types of ligands;		*	
		14.4.3	explain shapes, colour and nomenclature of coordination compounds;		*	
		14.4.4	relate the coordination number of ions to the crystal structure of the compound of which they are a part.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
15. Organic Compounds		Students should be able to:				
15.1	Coal as a Source of Organic Compound	15.1.1	explain the destructive distillation of coal;		*	
		15.1.2	explain coal as a source of both aliphatic and aromatic hydrocarbons;		*	
15.2	Classification of Organic Compounds	15.2.1	classify organic compounds on the basis of their structure;		*	
		15.2.2	identify 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);		*	
15.3	Isomerism	15.3.1	exemplify isomerism, stereo-isomerism and structural isomerism;		*	
		15.3.2	define chiral centre;	*		
		15.3.3	explain optical isomerism as a result of chiral centre;		*	
		15.3.4	determine chiral centres in the structural formula of a molecule;			*
		15.3.5	explain isomerism in alkyl halides, amines, alcohols, phenols, aldehydes, ketones, carboxylic acids and esters.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
16. Hydrocarbons		Students should be able to:				
16.1	Nomenclature, Shape of Molecules and Resonance	16.1.1	describe the nomenclature and shapes of molecule (i.e. alkane, alkene, cycloalkane, alkynes, benzenes and substituted benzene) based on sigma and pi carbon-carbon bonds;		*	
		16.1.2	explain the phenomenon of resonance and stability of benzene;		*	
16.2	Types of Organic Reactions	16.2.1	define different types of organic reactions, i.e. a. substitution reaction b. elimination reaction c. addition reaction d. radical reaction	*		
16.3	Alkanes	16.3.1	explain unreactive nature of alkanes towards polar reagents;		*	
		16.3.2	explain homolytic and heterolytic fission, free radical initiation, propagation and termination;		*	
		16.3.3	describe the mechanism of free radical substitution with reference to methane and ethane;		*	
16.4	Alkenes	16.4.1	describe the preparation of ethene (using chemical equations) from: a. dehydration of alcohol b. dehydrohalogenation of alkyl halide;		*	
		16.4.2	describe the reactions of ethene, i.e. a. hydrogenation b. hydration c. hydrohalogenation d. halogenation e. halohydration f. epoxidation g. ozonolysis h. polymerisation;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
16.5	Alkynes	16.5.1	compare the reactivities of alkynes, alkenes and alkanes;		*	
		16.5.2	describe the preparation of alkynes using elimination reaction;		*	
		16.5.3	explain the acidic strength of alkynes with reference to its reaction with metals;		*	
		16.5.4	explain the chemistry of alkynes by hydrogenation, hydrohalogenation, hydration, bromination and ozonolysis;		*	
		16.5.5	discuss the combustion reactions of alkanes, alkenes and alkynes with reference to energy production;		*	
16.6	Benzene and Substituted Benzene	16.6.1	compare the reactivity of benzene with alkene and alkane;		*	
		16.6.2	describe the mechanism of electrophilic substitution reaction of benzene;		*	
		16.6.3	explain orientation in benzene with reference to resonating structures, i.e. effect of ortho, meta and para directing groups in electrophilic substitution reactions;		*	
		16.6.4	discuss the chemistry of benzene and methyl benzene by nitration, sulphonation, halogenation, Friedal-Crafts alkylation and acylation.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
17. Alkyl halides and Amines		Students should be able to:				
17.1	Alkyl halides	17.1.1	apply IUPAC and trivial systems for naming alkyl halides;			*
		17.1.2	discuss physical properties and reactivity of different alkyl halides on the basis of bond energy;		*	
		17.1.3	draw the structure of different alkyl halides using their formulae;			*
		17.1.4	describe the preparation of alkyl halides by the reaction of alcohol with HX, $SOCl_2$, PCl_3 and PCl_5;		*	
17.2	Nucleophilic Substitution Reaction	17.2.1	describe the mechanism of nucleophilic substitution (S_N1 and S_N2) reactions;		*	
		17.2.2	discuss carbocation and its stability;		*	
		17.2.3	compare S_N1 and S_N2 reactions;		*	
		17.2.4	deduce the mechanism of nucleophilic substitution (S_N1 and S_N2) reaction for the given alkyl halide;			*
		17.2.5	identify nucleophile (base), substrate and leaving group in the given nucleophilic substitution reactions;		*	
17.3	Elimination Reaction	17.3.1	describe the mechanism of elimination (E1 and E2) reaction;		*	
		17.3.2	compare E1 and E2 reaction;		*	
		17.3.3	deduce the mechanism of elimination (E1 and E2) reaction for the given alkyl halide;			*
		17.3.4	compare substitution reaction with elimination reaction;		*	
17.4	Organo-Metallic Compounds (Grignard Reagent)	17.4.1	describe the preparation and reactivity of Grignard reagent;		*	
		17.4.2	describe chemical reaction of Grignard reagent with aldehydes, ketones, esters and carbon dioxide;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
17.5	Amines	17.5.1	apply IUPAC and trivial system for naming amines;			*
		17.5.2	discuss physical properties of amines (melting point, boiling point and solubility);		*	
		17.5.3	draw the structure of amines (primary, secondary and tertiary) from their formulae;			*
		17.5.4	explain basicity (basic character) of amines;		*	
		17.5.5	describe the preparation of amines by: a. alkylation of NH_3 b. reduction of nitriles c. reduction of nitro compounds d. reduction of amides;		*	
		17.5.6	describe chemical reaction of amines, i.e. a. alkylation with RX b. reaction with aldehydes and ketones;		*	
		17.5.7	describe the preparation of amides and diazonium salts.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
18. Alcohols, Phenols and Ethers		Students should be able to:				
18.1	Alcohols	18.1.1	apply IUPAC and trivial system for naming different alcohols;			*
		18.1.2	describe the physical properties and structure of alcohol;		*	
		18.1.3	distinguish among primary, secondary and tertiary alcohols using Lucas reagent test;		*	
		18.1.4	differentiate between methanol and ethanol using iodoform test (haloform reaction);		*	
		18.1.5	describe the preparation of alcohol by reduction of aldehydes, ketones, carboxylic acids and esters using chemical equations;		*	
		18.1.6	discuss the acidic character of alcohols;		*	
		18.1.7	describe the reactions of alcohol, i.e. a. preparation of ethers b. preparation of esters c. oxidative cleavage of 1,2-diols;		*	
		18.1.8	define thiols (RSH);	*		
		18.1.9	describe the uses of alcohol as disinfectant and antiseptic;		*	
18.2	Phenols	18.2.1	apply IUPAC and trivial system for naming different phenols;			*
		18.2.2	discuss the physical properties, structure and acidic characteristics of phenol (with reference to its resonance only);		*	
		18.2.3	describe the preparation of phenols from the given compounds (benzene sulphonic acid, chlorobenzene, acidic oxidation of cumene and hydrolysis of diozomium salts) using chemical equations;		*	
		18.2.4	discuss the reactivity of phenol with reference to electrophilic aromatic substitution, reaction with Na metal and oxidation;		*	
		18.2.5	differentiate between alcohols and phenols;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
18.3 Ethers	18.3.1	apply IUPAC and trivial system for naming different ethers;				*
	18.3.2	describe the physical and chemical properties of ethers;			*	
	18.3.3	describe 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;			*	
	18.3.4	describe the use of ether in the field of medicine.			*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
19. Carbonyl Compound I: Aldehydes and Ketones		Students should be able to:				
19.1	Nomenclature and Structure	19.1.1	apply IUPAC and trivial system for naming aldelydes and ketones;			*
		19.1.2	draw the structure of given aldehydes and ketones;			*
		19.1.3	describe glucose and fructose as examples of aldehydes and ketones;		*	
19.2	Physical Properties	19.2.1	explain the physical properties of aldehydes and ketones;		*	
19.3	Preparation of Aldehydes and Ketones	19.3.1	describe 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 compound;		*	
19.4	Reaction of Aldehydes and Ketones	19.4.1	describe the base catalysed nucleophilic addition reaction of aldehydes and ketones, i.e. a. addition of hydrogen cyanide b. addition of Grignard reagent c. addition of sodium bisulphate d. Aldol condensation e. Cannizzaro's reaction f. haloform (iodoform) reaction;		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			K	U	A
	Students should be able to:				
	19.4.2	describe the acid catalysed nucleophilic addition reaction of aldehydes and ketones, i.e. a. polymerisation b. addition of ammonia derivatives c. addition of alcohols;		*	
	19.4.3	describe the reduction of aldehydes and ketones using: a. Clemensen reduction method b. Wolff-Kishner reduction method c. hydride reagents d. carbon nucleophiles e. nitrogen nucleophiles f. oxygen nucleophiles;		*	
	19.4.4	describe the oxidation reactions of aldehydes and ketones;		*	
19.5 Uses and Effects	19.5.1	discuss the uses of formaldehyde in daily life;		*	
	19.5.2	discuss the health hazards associated with the exposure to formalin.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
20. Carbonyl Compound II: Carboxylic Acid and Functional Derivatives		Students should be able to:				
20.1	Nomenclature	20.1.1	apply IUPAC and trivial system for naming carboxylic acid and their derivatives;			*
20.2	Structure and Physical Properties	20.2.1	describe the structure and physical properties (solubility, melting point and boiling point) of carboxylic acid;		*	
		20.2.2	draw the structure of given compounds of carboxylic acids and their derivatives;			*
20.3	Acidity	20.3.1	discuss the acidity of carboxylic acids;		*	
20.4	Preparation of Carboxylic Acid	20.4.1	describe the preparation of carboxylic acid by Grignard reagent, hydrolysis of nitriles, oxidation of primary alcohol, aldehydes and alkyl benzene using chemical equations;		*	
20.5	Reactivity	20.5.1	describe the reactions of carboxylic acid involving a. hydrogen atom of the carboxyl group b. hydroxyl group of carboxyl group c. carboxyl group as a whole;		*	
		20.5.2	compare the reactivity of different derivatives of carboxylic acid (i.e. acyl halides, acid anhydrides, esters and amides);		*	
20.6	Reactions of Carboxylic Acid	20.6.1	describe the preparation of acyl halides, acid anhydrides, esters and amides;		*	
		20.6.2	describe the inter-conversion reactions of the carboxylic acid derivatives (acyl halides, acid anhydrides, esters and amides);		*	

Topics and Sub-topics	Student Learning Outcomes		Cognitive Level		
			K	U	A
	Students should be able to:				
	20.6.3	describe the reactions of carboxylic acid derivatives, i.e. a. Friedel-Crafts acylation using acyl halide b. hydrolysis in acid anhydrides, esters and amides c. reduction of esters and amides d. reaction of Grignard reagent with esters;		*	
20.7 Uses	20.7.1 20.7.2	identify carboxylic acids present in fruits and vegetables; describe the uses of carboxylic acids, i.e. in plastic, leather, rubber, soap industries and as preservatives in food and food products.		* *	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
21. Biochemistry		Students should be able to:				
21.1	Carbohydrates, Proteins and Lipids	21.1.1	describe the basis of classification of carbohydrates, proteins and lipids;		*	
		21.1.2	describe the structure of carbohydrates, proteins and lipids;		*	
		21.1.3	explain the role of carbohydrates in health and disease;		*	
		21.1.4	discuss the nutritional importance of proteins and lipids;		*	
		21.1.5	explain different types of lipids (simple, compound, derived or associated including steroids);		*	
		21.1.6	describe the effect of lowering pH (using lemon juice) on milk proteins;		*	
		21.1.7	describe the role of biochemical compounds such as insulin and cholesterol in human body;		*	
21.2	Enzymes	21.2.1	describe the role of enzymes as biological catalyst, i.e. in digestion of food;		*	
		21.2.2	explain the factors that affect enzyme activity;		*	
		21.2.3	explain the role of inhibitors in enzyme catalysed reactions;		*	
21.3	Nucleic Acids	21.3.1	differentiate between the structure of DNA and RNA;		*	
		21.3.2	describe the role of a. DNA in storing genetic information b. RNA in terms of protein synthesis;		*	
21.4	Minerals of Biological Significance	21.4.1	describe the role of iron and phosphorous as nutrients.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
22. Industrial Chemistry		Students should be able to:				
22.1	Introduction	22.1.1	discuss the importance of chemical industries for the economy of Pakistan;		*	
		22.1.2	list the raw materials available in Pakistan for various chemical and petrochemical industries;	*		
22.2	Safety Measurement	22.2.1	list safety precautions that should be followed in chemical industries;	*		
22.3	Dyes and Pigments	22.3.1	describe the types of dyes;		*	
		22.3.2	discuss the importance of dyes and pigments in cosmetic, textile, paints and food industry;		*	
22.4	Petro-chemicals	22.4.1	describe the process of: a. fractional distillation b. refining of petroleum;		*	
		22.4.2	explain the processes of cracking (with its types) and reforming of petroleum;		*	
		22.4.3	identify (in a given equation) the petrochemicals and chemicals derived from them (monomer and polymer);		*	
		22.4.4	list some major petrochemicals;	*		
22.5	Synthetic Polymers (PVC and Nylon)	22.5.1	describe the chemical processes of addition and condensation polymerisation;		*	
		22.5.2	describe the formation and uses of polyvinyl chloride (PVC) and nylon;		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
		Students should be able to:				
22.6	Synthetic Adhesive	22.6.1	describe types and applications of synthetic adhesives;		*	
22.7	Pesticides	22.7.1	define pesticides;	*		
		22.7.2	discuss the types of pesticides on the basis of their uses in daily life;		*	
		22.7.3	discuss the advantages and disadvantages of using pesticides for the environment.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
23. Environmental Chemistry		Students should be able to:				
23.1	Chemistry of Troposphere and Stratosphere	23.1.1	describe the chemical reactions occurring in the atmosphere with reference to formation of acid rain, ozone, ammonium nitrates and sulphates and carbon dioxide;		*	
		23.1.2	discuss the release of oxides of carbon, sulphur, nitrogen, and volatile organic compounds (VOCs) which are associated with combustion of hydrocarbon based fuel;		*	
		23.1.3	discuss problems associated with the release of pollutants, i.e. oxides of carbon, sulphur, nitrogen, VOCs and peroxyacetyl nitrate (PAN);		*	
		23.1.4	describe causes and impacts of oxidising and reducing smogs;		*	
		23.1.5	describe the role of chlorofluorocarbons (CFCs) in destroying ozone in the stratosphere;		*	
		23.1.6	list possible alternatives to the use of CFCs;	*		
		23.1.7	explain climate change as a result of greenhouse effect and global warming;		*	
23.2	Water Pollution and Water Treatment	23.2.1	describe the parameters of water analysis;		*	
		23.2.2	explain the methods of water purification, i.e. raw water treatment, sewage treatment, zeolite process and reverse osmosis;		*	
23.3	Green Chemistry	23.3.1	describe the principles of green chemistry;		*	
		23.3.2	discuss the significance of green chemistry.		*	

Topics and Sub-topics		Student Learning Outcomes		Cognitive Level		
				K	U	A
24. Analytical Chemistry		Students should be able to:				
24.1	Classical and Modern Methods of Analysis	24.1.1	compare the classical and modern methods of structural analysis of compounds;		*	
		24.1.2	describe the procedure of combustion analysis of hydrocarbon;		*	
		24.1.3	define the term 'spectroscopy';	*		
		24.1.4	discuss application of spectroscopy in analytical chemistry;		*	
		24.1.5	explain the different regions of electromagnetic spectrum (according to wavelength);		*	
		24.1.6	explain atomic emission and atomic absorption spectrum;		*	
		24.1.7	describe the basic principles of infrared (IR) spectroscopy (i.e. absorption of infrared (IR) radiations, molecular rotation, molecular vibrations, vibrational coupling);		*	
		24.1.8	interpret the infrared (IR) spectra of benzene, acetone, acetic acid and ethanol;			*
		24.1.9	predict whether a given molecule will absorb in the UV-Visible radiations;			*
		24.1.10	predict the colours of compounds (methylene blue and $[Ti(H_2O)_6]^{3+}$) from their UV-Visible spectra;			*
		24.1.11	explain instrumentation and working of a mass spectrometer (MS);		*	
		24.1.12	discuss the use of MS in determination of relative isotopic masses.		*	

Scheme of Assessment

Grade XI

Table 1: Number of Student Learning Outcomes by Cognitive Level

Topic No.	Topics	No. of Sub-Topics	SLOs			Total
			K	U	A	
1.	Stoichiometry	5	1	3	8	12
2.	Atomic Structure	7	3	12	4	19
3.	Theories of Covalent Bonding and Shapes of Molecules	4	2	14	4	20
4.	States of Matter I: Gases	7	1	12	6	19
5.	States of Matter II: Liquids	4	2	10	0	12
6.	States of Matter III: Solids	4	1	10	0	11
7.	Chemical Equilibrium	4	5	3	8	16
8.	Acids, Bases and Salts	6	3	13	7	23
9.	Chemical Kinetics	4	3	6	4	13
10.	Solution and Colloids	5	2	8	4	14
11.	Thermochemistry	6	3	6	5	14
12.	Electrochemistry	4	3	6	8	17
	Total	**60**	**29**	**103**	**58**	**190**
	Percentage		**15**	**54**	**31**	**100**

Table 2: Exam Specifications

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

Grade XII

Table 3: Number of Student Learning Outcomes by Cognitive Level

Topic No.	Topics	No. of Sub-Topics	SLOs			Total
			K	U	A	
13.	s- and p-Block Elements	6	1	23	1	25
14.	d- and f- Block Elements	4	1	9	1	11
15.	Organic Compounds	3	1	7	1	9
16.	Hydrocarbons	6	1	16	0	17
17.	Alkyl halides and Amines	5	0	16	6	22
18.	Alcohols, Phenols and Ethers	3	1	14	3	18
19.	Carbonyl Compound I: Aldehydes and Ketones	5	0	9	2	11
20.	Carbonyl Compound II: Carboxylic Acid and Functional Derivatives	7	0	10	2	12
21.	Biochemistry	4	0	13	0	13
22.	Industrial Chemistry	7	4	11	0	15
23.	Environmental Chemistry	3	1	10	0	11
24.	Analytical Chemistry	1	1	8	3	12
	Total	**54**	**11**	**146**	**19**	**176**
	Percentage		**6**	**83**	**11**	**100**

Table 4: Exam Specifications

Topic No.	Topics	Marks Distribution			Total Marks
		MCQs	CRQs	ERQs	
13.	s- and p-Block Elements	5			5
14.	d- and f- Block Elements	4			4
15.	Organic Compounds	3	Total 3 Marks (1 CRQ)		6
16.	Hydrocarbons	4		7 Marks Choose any ONE from TWO	15
23.	Environmental Chemistry	4			
17.	Alkyl halides and Amines	4		7 Marks Choose any ONE from TWO	15
20.	Carbonyl Compound II: Carboxylic Acid and Functional Derivatives	4			
18.	Alcohols, Phenols and Ethers	5	Total 4 Marks (1 CRQ)		9
19.	Carbonyl Compound I: Aldehydes and Ketones	5	Total 4 Marks (1 CRQ)		9
21.	Biochemistry	4	Total 3 Marks (1 CRQ)		7
22.	Industrial Chemistry	5	Total 3 Marks (1 CRQ)		8
24.	Analytical Chemistry	3	Total 4 Marks (1 CRQ)		7
	Total	**50**	**21**	**14**	**85**
	Practical*				**15**
	Total				**100**

- 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.

- Tables 1 and 3 indicate the number and nature of SLOs in each topic in grades XI and XII. This will serve as a guide in the construction of the examination paper. It also indicates that more emphasis has been given to Understanding (54% in HSSC I and 83% in HSSC II), Application and higher order skills (31% in HSSC I and 11% in HSSC II) to discourage rote memorisation. Tables 1 and 2 however do not translate directly into marks.

- 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 in two parts: paper I and paper II. Both papers will be of duration of 3 hours.

- Paper I theory will consist of 50 compulsory, multiple choice items. These questions will involve four response options.

- Paper II theory will carry 35 marks and consist of a number of compulsory, structured questions and a number of extended response questions. Each extended response question will be presented in an either/or form.

- All constructed response questions will be in a booklet which will also serve as an answer script.

***Practical:**

- In each grade, practical examination will be conducted separate from the theory paper and will consist of 15 marks.
- Practical examination 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.
- 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.
- 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.

Annex A: Practical Activities

Grade XI

S. No.	SLO No.	PRACTICAL ACTIVITY	EQUIPMENT	CHEMICAL
		Topic 1: Stoichiometry		
1.	1.4.2	Estimate the amount of Ba^{+2} in the given solution of $BaCl_2$ gravimetrically.	Analytical balance, oven, funnel, wash bottle, Whatman filter paper No. 42, glass rod, beakers, desiccators, pipette, burner, match box, safety goggles	Distilled water, potassium chromate solution, barium chloride solution
		TOPIC 5: States of Matter II: Liquids		
2.	5.1.1	Separate the given mixture of inks by paper chromatography.	Whatman filter paper No. 1, glass cylinder with a glass support, rubber bung, capillary tubes, lead pencil	Developing solvents (water – alcohol mixture/ n-butanol, ethanol and ammonia), mixture of inks (blue, green, red)
		Topic 7: Chemical Equilibrium		
3.	7.4.2	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

S. No.	SLO No.	PRACTICAL ACTIVITY	EQUIPMENT	CHEMICAL
		Topic 8: Acids, Bases and Salts		
4.	8.1.4	Determine 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
5.	8.1.4	Determine 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.
6.	8.1.4	The given solution contains 6 g of Na_2CO_3 dissolved per dm^3. Determine the percentage purity of the sample solution by 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.
7.	8.1.4	Determine the value of X by volumetric method 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
8.	8.1.4	Determine 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

S. No.	SLO No.	PRACTICAL ACTIVITY	EQUIPMENT	CHEMICAL
		TOPIC 9: CHEMICAL KINETICS		
9.	9.4.3	Show that the addition of a catalyst increases the rate of reaction.	100 mL gas syringe (OR 100 mL graduated cylinder, Beehive shelf, large water trough), conical flask with suitable stopper, delivery tube, stop-clock, small test tube, thread, teat pipette (dropper), safety goggles	10% H_2O_2, 0.5 g MnO_2
		Topic 11: Thermochemistry		
10.	11.4.2	Determine the heat of neutralisation of NaOH and HCl.	Calorimeter with stirrer, thermometer, balance (physical/ digital)	1M NaOH, 1M HCl, distilled water
		Topic 12: Electrochemistry		
11.	12.1.8	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
12.	12.1.8	Determine 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
13.	12.1.8	Determine the percentage composition volumetrically of a solution mixture of $K_2C_2O_4$ and K_2SO_4.	Burette, pipette, funnel, conical flask, 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
14.	12.1.8	Determine 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

Grade XII

S. No.	SLO No.	PRACTICAL ACTIVITY	EQUIPMENT	CHEMICAL
		Topic 13: s- and p-Block Elements		
1.	13.2.4, 13.3.4, 13.4.2, 13.4.3, 13.5.5 and 13.6.2	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^-, CrO_4^{2-}. Perform tests for the following gases: NH_3, CO_2, Cl_2, H_2, O_2, SO_2.	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 14: d- and f- Block Elements		
2.	14.3.1	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

S. No.	SLO No.	PRACTICAL ACTIVITY	EQUIPMENT	CHEMICAL
		Topic 15: Organic Compounds		
3.	15.2.2	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.
				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 17: Alkyl halides and Amines		
4.	17.5.3	Identify the amine functional group.	Test tubes, test tube rack, test tube holder, measuring cylinder, balance, filter paper, funnel	Hinsberg test: benzenesulfonyl chloride, sodium hydroxide, HCl
5.	17.5.7	Prepare azo dye from amine.	Test tubes, test tube rack, test tube holder, measuring cylinder, balance, filter paper, funnel	Amine, phenol, hydrochloric acid, ice, sodium nitrite, alcohol, distilled water

S. No.	SLO No.	PRACTICAL ACTIVITY	EQUIPMENT	CHEMICAL
		Topic 18: Alcohols, Phenols and Ethers		
6.	18.1.4	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
7.	18.2.2	Identify the phenol functional group.	Test tubes, test tube holder, test tube rack, measuring cylinder, safety goggles.	Litmus solution, ferric chloride solution
		Topic 19: Carbonyl Compound I: Aldehydes and Ketones		
8.	19.1.2	Identify 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 20: Carbonyl Compound II: Carboxylic Acid and Functional Derivatives		
9.	20.2.1	Identify the carboxylic acid functional group.	Test tubes, beakers, balance, measuring cylinders, funnel, filter paper	Dilute sodium hydroxide, saturated potassium bicarbonate
		Topic 21: Biochemistry		
10.	21.1.2	Detect the denaturation of protein by urea.	Test tubes, beakers, conical flask, pipette	Urea, egg white
11.	21.1.3	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.
12.	21.2.1	Observe the digestion of starch with salivary amylase.	Test tubes, beakers, conical flask, pipette, slides.	Freshly prepared starch solution, iodine solution

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