Chemistry

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.			*

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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		
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		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		
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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		
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		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		
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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;			*

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		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.		*	

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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 $4^{\circ}C$;		*	

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		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.		*	

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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		
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		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.		*	

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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.		*	

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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;		*	

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		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.		*	

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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		
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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;		*	

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	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.			*

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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;			*

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	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.		*	

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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;			*

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	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		
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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		
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		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);			*	

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	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.		*	

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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		
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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		
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		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		
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	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		
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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		
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	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		
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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		
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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.		*	

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