Chemistry Syllabus,Grade 11

General Objectives of Grade 11 Chemistry

To develop understanding and acquire knowledge of:

- the scope and major fields of chemistry;
- the appropriate use of SI units and uncertainties in measurement;
- atomic theory and structure of the atom;
- the particle and wave nature of electrons;
- the relationship between electronic arrangement of the atoms and periodic trends of the elements;
- formation of chemical bonding and properties of compounds formed by different types of bonds;
- predicting the shapes of molecules and intermolecular forces in covalent compounds;
- rates of chemical reactions and ways of enhancing and controlling it;
- chemical equilibrium in a reversible system and methods of shifting it to the desired direction;
- sources, properties, compositions, structures, names and uses of organic substances such as organic acids, esters, fats and oils.

To develop skills and abilities of:

- using scientific methods in solving problems;
- expressing calculated values using appropriate number of decimal places or significant figures and scientific notation;
- conducting experiments following laboratory procedures;
- solving problems related to atomic structure and chemical equilibrium;
- applying bonding theories to predict properties of substances;
- conducting experiments to observe and analyze the physical properties of substance and determine the type of bonding;
- determining rates of chemical reactions, amounts of reactants and products at any time of a reaction;
- demonstrating experiments to investigate the behaviour of different equilibrium systems and to explain effects of some factors on equilibrium system;
- carrying out laboratory activities involving carboxylic acids, esters, fats and oils;
- preparing soap and testing its cleaning action in different types of water;
- design and conduct simple experiments appropriate to their level.

To develop habits and attitudes of:

- appreciating the importance of chemical kinetics in industrial production and living organisms;
- practicing scientific methods of solving problems;
- appreciating the interrelationship between electronic structure of the atoms and periodic classification of the elements;
- developing personality characteristics such as neatness, exactness, diligence, responsibility and carefulness;
- relating a scientific knowledge to everyday application

Unit 1: Fundamental concepts in chemistry *(15 periods)*

Unit outcomes: Students will be able to:

- Understand the scope of chemistry;
- Select & use appropriate SI units;
- Understand the causes of uncertainty in measurement;
- Express the result of any calculation involving experimental data to the appropriate number of decimal places or significant figures;
- Use scientific methods in solving problems;
- Demonstrate an understanding of experimental skills in chemistry;
- Demonstrate a knowledge of laboratory procedures;
- Describe scientific enquiry skills along this unit: observing, inferring, predicting, comparing & contrasting, communicating, analyzing, classifying, applying, theorizing, measuring, asking question, developing hypothesis, designing experiment, interpreting data, drawing conclusion, making generalizations and problem solving.

Competencies	***Contents***	***Suggested Activities***
Students will be able to:	***1. Fundamental concepts in chemistry*** **1.1 The scope of chemistry** *(2 periods)*	
• Define chemistry	• Definition of chemistry	Students should be able to define chemistry as the study of the properties of substances. Students could be asked to expand on this definition by suggesting what they interpret this definition to mean. These could include: Some of the physical properties of substances The stability of substances The composition of substances The synthesis of substances The chemical reactions of substances The uses of substances
• Distinguish the major fields of chemistry	• Major fields of chemistry	Students should appreciate that chemistry is divided into four major branches and be able to give a brief account of each. Inorganic chemistry – the chemistry of the elements and their compounds including carbon monoxide, carbon dioxide, carbonates and hydrogen carbonates but excluding all other compounds of carbon. Organic chemistry – the chemistry of carbon compounds except for carbon monoxide, carbon dioxide, carbonates and hydrogen carbonates. Physical chemistry – the chemistry of the structure and physical properties of substances and how these are related, and the factors that affect chemical reactions.

Competencies	***Contents***	***Suggested Activities***
		Analytical chemistry – the chemistry of qualitative identification and quantitative determination of the constituents of matter There is also another branch of chemistry which bridges chemistry and biology. Biochemistry is the chemistry of living organisms.
• Distinguish the subdivision of branches of chemistry		Students could investigate how each of these major branches of chemistry can be further subdivided e.g. • Inorganic chemistry – Coordination chemistry, etc. • Organic chemistry – Synthetic organic chemistry, etc. • Physical chemistry – Chemical kinetics, thermodynamics, etc. • Analytical chemistry – Qualitative analysis, quantitative analysis, etc.
	1.2 Measurements and units in Chemistry *(8 periods)*	
• List and describe the seven SI units and their prefixes	• SI units (The International system of units) - Basic SI units	Students should be aware that a common group of units called S.I. units are used by scientists, including chemists, throughout the world. Students could discuss why having a common group of units is an advantage e.g. what is the problem with measuring pressure in Pascal, bars, pounds per square inch and millimetres of mercury? Students should understand that there are seven base S.I. units. Those relevant to chemistry are: Length – metre – m Mass – kilogram – kg Time – second – s Electric current – ampere – A Temperature – Kelvin – K Amount of substance – mole – mol
• Write the names and symbols of derived SI units	- Derived SI units	Students should understand that other units are derived from them. Those relevant to chemistry include: kg/m^3, g/cm^3 (density) mol/dm^3(concentration) N/m^2 = Pa (pressure) Students should be aware that temperature is usually measured in degrees Celsius or centigrade, °C, although this is not the S.I. unit.
		Students should appreciate that it is impractical to use the same unit for expressing all values

Competencies	***Contents***	***Suggested Activities***
• Use the factor label method for solving problems and making conversion of SI units.	• Common prefixes used in SI units	for a particular quantity. Students could discuss why it would be difficult to express the amounts of chemicals used in industrial quantities and the amounts of chemicals present in pharmaceutical preparations both in kg. From this discussion the teacher should develop the idea of using prefixes to express multiples of units: • mega – M - 10^{6} • kilo – k - 10^{3} • milli – m – 10^{-3} • micro - μ - 10^{-6} Students could practice conversion between units e.g. between micrograms, milligrams, grams, kilograms, mega grams (tonnes).
• Describe uncertainty of measurement • Identify the digits that are certain and the ones that are uncertain given a number representing measurement • Identify causes of uncertainty in measurement	• Uncertainty in measurements	Students should be made aware of the appropriate use of upper and lower case e.g. possible confusion between mega and milli. Students should appreciate that, even with careful measurement, there is a limit to the degree of accuracy of an instrument. For example, with skill and practice a student may read a burette to the nearest 0.05 cm^3 but no more accurately than that.
• Define precision and accuracy • Estimate the precision possible for any instrument they use in the laboratory • Explain system and random errors • Analyse given data in terms of precision and accuracy	• Precision and accuracy	Students should have realistic expectations of the accuracy of the instruments they use. Students should have an awareness of the potential sources of errors in taking readings e.g. measuring the temperature of a solution by inserting a thermometer but waiting sufficient time for the thermometer to attain the same temperature as the solution. Students should be able to identify an anomalous reading in a set of data and suggest a reason for it. Students should appreciate the limitations of accuracy in taking measurements. For example, if the mass of a chemical is given as 2.5 g the actual mass may be anything from 2.450 g to 2.549 g. Students should be able to express the uncertainty in any measurement and the limit of accuracy of a calculation using this measurement.
Define decimal places Determine the number of decimal places in a	• Decimal places	Students should understand that numbers are rounded up either to a particular number of decimal places or significant figures. The process for this is similar. Students should know that:

Competencies	***Contents***	***Suggested Activities***
calculated result		to express a value to the n^{th} decimal place they look at the value of the $n+1^{th}$ digit if the $n+1^{th}$ digit is 5 or more they round up the n^{th} digit if the $n+1^{th}$ digit is 4 or less they leave the n^{th} digit unchanged Students should be talked through some examples and then attempt some examples for themselves e.g. express 24.546 g to 1 decimal place the second decimal place digit is 4 so do not round up expressed to 1 decimal place the number is 24.5 g Similarly: express 0.167 mol/dm^3 to 2 decimal places the third decimal place digit is 7 so round up expressed to 2 decimal places the number is 0.17 mol/dm^3
Define significant figures Determine the number of significant figures in a calculated result	• Significant figures	Students should know that a similar system is used for significant figures: to express a value to the n^{th} significant figure they look at the value of the $n+1^{th}$ digit if the $n+1^{th}$ digit is 5 or more they round up the n^{th} digit if the $n+1^{th}$ digit is 4 or less they leave the n^{th} digit unchanged Students should be talked through some examples and then attempt some examples for themselves e.g. express 348 °C to 2 significant figures the third significant digit is 8 so round up expressed to 2 significant figures the number is 350 °C Similarly: express 4.381 g to 3 significant figures the fourth significant digit is 1 so do not round up expressed to 3 significant figures the number is 4.38 g Students should understand that it is not possible to express an answer to a higher degree of accuracy that the data from which it is derived. For example: The mass of a metal block = 15.2 g The volume of the metal block = 5.6 cm^3 The density of the metal = mass/volume = 2.714857 But the mass and the volume are expressed only to one decimal point so the density cannot be given any more accurately than one decimal point = 2.7 g/cm^3
Use the scientific notation in writing very large or very small numbers	• Scientific notation	Students should appreciate the problems of writing very large or very small numbers in terms of the numbers of zeros involved e.g. 2300000, 0.000000154. They should understand that scientific notation involves writing numbers to a common format in which there is: One digit to the left of the decimal point

Competencies	*Contents*	*Suggested Activities*
		The remaining digits to the right of the decimal point The number is multiplied by a power of ten The power of ten is determined by number of places the decimal point must be moved to the left or right regenerate the number in its original format For example: $2300000 = 2.3 \times 10^{6}$ $0.000000154 = 1.54 \times 10^{-7}$ Students should practice writing very large and very small numbers in scientific format.
	1.3 Chemistry as experimental Science *(5 periods)*	
Define scientific method Describe the major steps of the scientific method Use scientific methods in solving problems	The scientific method	Students should appreciate that there are certain important steps to applying the scientific method. Identifying the problem - gathering information, devising a solution Carrying out experiments – observation, measurement, recording, inferring Examining the results of the experiment – analysis, generalisations, synthesis Using conclusions – explanation, prediction Further experiments – checking predictions, accounting for unexpected results
Demonstrate some experimental skills in chemistry	Some experimental skills in chemistry	Students should learn the skills needed to carry out experimental work successfully. These should include: • Manipulation of apparatus • Accurate measurement • Careful observation • Safe practice with regard to themselves and others Students should learn to use common apparatus with care and safety. This should include: Reaction vessels such as beakers, flasks, boiling tubes and test tubes Measuring equipments such as pipettes, burettes, balances and thermometers Support and heating devices such as stand and clamp, tripod and gauze, spirit burner and Bunsen burner
Describe the procedures of writing laboratory report	Writing a laboratory report	Students should learn how to write an accurate and comprehensive report on each piece of work carried out in the laboratory. This should include: • An explanation of the method used • The apparatus used including diagrams if necessary • Accurate observations • Use of tables to record data

Competencies	***Contents***	***Suggested Activities***
		• Conclusions based on observations • Use of graphs or charts to present data • Identification of any patterns which may be evident • Inclusion of chemical equations where appropriate • Calculations if appropriate Students could be given some practical activities to carry out where emphasis is placed on scientific method.

Assessment

The teacher should assess each student's work continuously over the whole unit and compare it with the following description, based on the Competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level
Students working at the minimum requirement level will be able to: define chemistry & distinguish the major fields of chemistry and the subdivision of branches of chemistry; describe the SI units & their prefixes; write the names & symbols of derived SI units; identify causes of uncertainty in measurement; define precision & accuracy & analyze given data in terms of them; explain system & random errors; define decimal places & determine the number of decimal places in a calculated result; define significant figures & determine the number of significant figures in a calculated result; use the scientific notation in writing very small or very large numbers; define scientific method &, describe the major steps of the scientific method & use scientific methods in solving problems; demonstrate some experimental skills in chemistry & describe the producers of writing laboratory report.

Students above minimum requirement level
Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level
Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 2: Atomic Structure and Periodic Table *(28 Periods)*

Unit outcomes: students will be able to:

- Understand the historical development of atomic structure;
- Explain the experimental observations & inferences made by some famous scientists to characterize the atom;
- List and describe the subatomic particles;
- Explain the terms atomic mass & isotope;
- Understand electromagnetic radiation, atomic spectra & Bohr models of the atom;
- Do calculations involving atomic structure;
- Describe the quantum mechanical model of the atom & the related postulates and principles;
- Demonstrate an understanding of periodic law & how electronic configurations of atoms are related to the orbital diagrams & can explain periodic trends;
- Describe scientific enquiry skills along this unit: inferring, predicting, classifying, comparing & contrasting, communicating, asking questions and making generalization.

Competencies	***Contents***	***Suggested Activities***
Students will be able to:	***2. Atomic Structure and Periodic Table***	
• State briefly the history of development of atomic nature of substances	**2.1 Historical development of the atomic nature of substances *(1 period)***	Students should be able to appreciate: early Greek concepts of the composition of matter based on visionary beliefs but not on evidence (Democritus Vs Zeno of Elea)
• State postulates of Dalton's Atomic Theory	**2.2 Dalton's Atomic Theory and the Modern Atomic Theory** *(2 periods)* • Postulates of Dalton's Atomic Theory	why Dalton's Atomic theory is considered scientific even though it had errors how scientific ideas develop based on previous scientific findings (in this case the law of conservation of mass by Lavoisier, the law of definite composition by Proust and the law of multiple proportions by Dalton himself and the first modern list of elements published by Lavoisier)
	• Postulates of Modern Atomic Theory	Students need to see the Postulates of Dalton's Atomic theory as they were formulated by Dalton himself then the modified version of it(the so called Modern Atomic Theory) as it stands today
• State Postulates of Modern Atomic Theory	• How the theory explains the mass laws	The mass laws (law of conservation of mass, law of definite composition, and law of multiple proportions) should be discussed together so that students can see the connection between each one of them.
• State the laws of conservation of mass, definite proportions and multiple		You may act as the Devil's advocate by telling the students that you don't believe in the law of conservation of mass by raising issues the students are most likely to raise as ' evidences' against the law. The mass of a piece of wood before and after it is burnt, in an ordinary stove, to ashes is not the same- showing that mass can be created. A seedling

Competencies	***Contents***	***Suggested Activities***
proportions and the basis of each		growing shows increase in mass which can be taken as 'evidence' that mass can increase during a biochemical reaction. Then work backwards to show them that indeed mass is conserved by showing them if one burned the wooden log inside a completely closed chamber, that does not allow any gases or otherwise to leave the chamber, then there would not be mass loss. Look for more similar examples that the students take as 'evidences' against the law and guide them so that they correct the misconceptions they earlier formulated, on their own. Guide the students understand how Dalton's postulates explain the mass laws one by one.
• Discuss the discovery of electron • Describe the properties of cathode rays • Define the terms: radioactivity, radioactive decay and radio-isotope. • Describe the common types of radioactive emissions. • Discuss the alpha scattering experiment. • Describe the major contribution of experiments by Thomson, Millikan and Rutherford concerning atomic structure.	**2.3 Early experiments to characterize the atom** *(3 periods)* • Discovery of *the* electron • Radioactivity and discovery of nucleus • Discovery of neutron	Students should appreciate the experiments carried out and how the lessons learned from their findings (the discoveries of fundamental subatomic particles and the atomic nucleus) helped in understanding the composition and structure of the atom • J.J. Thompson-electron • Ernest Rutherford-nucleus & proton • Chadwick-neutron Students should able to give a brief summary of the famous scientist carried out by Thomson. That is if two wires are subjected to a high electric potential and then brought close together, a spark or arc jumps from one wire to the other. If the two ends sealed in a glass tube (Cathode Ray) that is then highly evacuated, the discharge from one wire to the other is gentler. This discharges called a cathode ray, causes the glass tube to emit a faint yellowish green glow. Students should also appreciate the properties of the cathode ray and realize that cathode rays (Electrons) are fundamental particles found in all matter. Students should be aware that though Rutherford, from his alpha scattering experiment, concluded that an atom must possess a very tiny nucleus that contains all of the positive charge in the atom and nearly all its mass, this is the only way he could account for the scattering of some α-particles at large angles from thin metal foils, and the fact that most of the α-particles passed through the foil nearly unaffected. Students should understand that the mass of the nucleus could not be accounted for with only protons and this became evident when Chadwick, another student of Rutherford, discovered a nuclear particle, without electrical charge-hence named neutron. Note the continuity of ideas (and the importance of being in the right place at the right time) considering the pivotal role Rutherford and his students played in discovering the constituents of the nucleus observe how the discovery of radioactivity by Becquerel was necessary for the discovery of the nucleus of the atom see how the discovery of the neutron helped discover the presence of isotopes

Competencies	***Contents***	***Suggested Activities***
• Describe make up of the nucleus	**2.4 Make up of the nucleus** *(2 periods)* • Constituents of the nucleus	Students should be very comfortable in using atomic number, mass number and atomic mass. Students should know that atomic number was discovered (not protons) by a young British physicist, Mosley in 1913 by correlating x-ray spectrum of each metal with its order in the periodic table (its atomic number) and realized that the nuclear charge increased by one unit for each element. In other words atomic number is an element's position number in the periodic table and is numerically equal to the number of protons in the nucleus of an atom. Students should know that the total number of nucleons (protons and neutrons) found in the nucleus is called mass number.
• Define atomic mass. • Define isotope. • Calculate the relative atomic mass (atomic mass) of naturally occurring isotopic elements.	• Atomic mass and isotopes	Numerically mass number and atomic mass are very close but they should not be taken to be one and the same. Atomic mass is the average of the naturally occurring isotopes of an element weighted according to their abundances. Students need to be given group assignments to calculate the atomic mass of few elements like chlorine, bromine, carbon and hydrogen from the masses and abundances of the corresponding isotopes. Ask students to find the number of naturally occurring isotopes. Students should be aware that isotopes are different atoms (not identical) of the same element. Analogies would be helpful here to make the concept clear. The word isotope comes from the Mendel eve's periodic law (atomic properties of elements are periodic functions of their atomic masses.) When he tried to arrange the hydrogen atoms that differ in number of protons, hence mass number (or carbon atoms with different masses for that matter) in to different boxes of the Periodic table, he saw that their properties warranted them same position despite what the law predicted. They are called isotopes because different atoms (of the same element) occupy the same position in the table. Students should be able to see that isotopes of an element are different atoms not identical. Students should be able to see that our models (mental perceptions) of the atom become more accurate with new findings emerging that help scientists formulate new models that agree with facts waiting to be explained. Students should be able to see that the nature of the nucleus has been known for quite some time since the days of Rutherford and his associates. What has been elusive is the position and velocity of electrons.

Competencies	***Contents***	***Suggested Activities***
• Characterize Electromagnetic Radiation (EMR) in terms of wave length, frequency and speed. • Calculate the wavelength and frequency of the EMR.	**2.5 Electromagnetic Radiation (EMR) and Atomic Spectra** *(9 periods)* • Electromagnetic Radiation	Students should have appreciation for electromagnetic radiations and express the energies of waves (photons) in terms of wave length (λ) & frequency (ν). Students should carry out calculations on the wavelength and frequency of EMR.
• Explain that light has both wave and particle nature. • Define photon as a unit of light energy. • Explain how photon theory explains the photoelectric effect and the relation between photon absorbed and electron released.	• The quantum theory and photon	Students should be aware that light has both wave and particle nature. This section has to be treated lightly as the concept of waves treated as particles and vice versa is difficult for the students. Students should focus on the meaning of the word quantum which is a packet of energy equal to hv. It is the smallest quantity of energy that can be emitted or absorbed. Energy related to emissions or absorptions are whole number multiples of this quantum, E = nhv.
• Explain that the emission spectra of atoms consist of series of lines	• Atomic Spectra	Students should understand that atomic or line spectra (plural of spectrum) are produced from emission but not absorption of distinct frequencies of photons. This implies that the dissociated molecules into atoms have to be excited either thermally or electrically. As excited states are not stable indefinitely they emit radiations (photons) of definite frequencies upon returning to the ground state. A line spectrum that consists of only relatively few wavelengths that is produced from light emitted by excited atoms is a unique feature of an element that can be used for identification purposes.
• State Bohr's assumption of energy of electron in hydrogen atom. • Explain that the line spectrum of hydrogen demonstrates the quantized nature of the energy of its electron.	• The Bohr Model of the Hydrogen atom • Limitations of the Bohr Theory	Students should know that the Rutherford model of an atom could not explain why the emission spectrum of an atom was not a continuous one instead of being discrete. Students should not try to see how the empirical data generated using the Rydberg's formula correlate with Bohr's atomic model for hydrogen. Soon after the nuclear model of the atom was proposed, which failed to account for the atomic spectra of elements, Bohr suggested a model for the H-atom that predicted the existence of line spectra. The Bohr model of an atom was successful in accounting for the spectral lines of H-atom, which indicated he was on the right track. His model, however, failed to predict the wavelengths of spectral lines of atoms more complicated than hydrogen demonstrated that there

Competencies	***Contents***	***Suggested Activities***
- Explain that atoms emit or absorb energy when they undergo transitions from one state to another - Explain the short comings of Bohr's theory. - Calculate the radius of electron orbit, the electron velocity and the energy of an electron using Bohr model.		was a basic flaw somewhere in the theory. Students should know the relationship between atomic (line) spectra nd Bohr model of the hydrogen atom. Students should be helped to see what the Bohr model of the atom looks like including what make it a better model than the previous ones and its limitations in explaining certain facts. Ask students to draw pictures of elements individually whose atomic number is less than 30 and then discuss them in groups. Students should carryout calculations on the radius of electron orbit, the electron velocity and the energy of an electron using Bohr model.
	2.6 The Quantum Mechanical Model of the Atom *(5 periods)*	
- State Heinsberg's uncertainty principle - Describe the significance of electron probability distribution	- The Heinsberg's Principle	Students should know the breakdown of classical mechanics in relation to subatomic particles like the electrons, hence necessity for a new theory-the Quantum mechanical model of the atom.
- Explain the quantum numbers n, l, m_l, m_s - Write all possible sets of quantum numbers of electrons in an atom.	- Quantum numbers.	Students should understand that according to the quantum mechanical model of the atom an electron is described in terms of 4 quantum numbers, of which three describe the orbital- the space the electron is supposed to occupy and the 4th relates to the spin of the electron. Students should appreciate the set of the quantum numbers as a street address of a person in a country. The four quantum numbers are principal quantum number, subsidiary quantum number, magnetic quantum number, and spin quantum numbers.
- Describe the shapes of orbital designated by s, p and d	- Shapes of atomic orbitals	Students should be aware that there are different shapes of atomic orbital. For example, S-spherical, P-dumbbell. They also differ in size depending upon their energy. It is very important to make students aware of the way scientific ideas progress. At this point ask the students to form groups and discuss to see how our beliefs about structure of matter evolved. What was once believed to be continuous is now without doubt particulate (atom). Dalton's atom was considered indivisible; now we know there are fundamental particles inside the atom. It is now clear what is found in the nucleus but there is still some ambiguity about the

Competencies	***Contents***	***Suggested Activities***
		exact location and energy of the electrons that are known to move around the nucleus. The era of modern atomic theory begins with Dalton's model of the atom. This should not make the students think that his model is the best of all similar models. Ask students to list down what has been retained in the modern atomic theory from Dalton's postulates. Help students organize a debate to award a prize to one prominent scientist from among the many who contributed to the current model of the structure of the atom. This will give them a chance to revise the unit. You could tell them that you are Manchester United fan in the England's foot ball premier league because Dalton was from Manchester area.
• Explain Aufbau principle. • Explain Pauli-exclusion principle. • Explain Hund's rule • Write ground state electron configurations of multi-electron atoms.	**2.7 Electronic configurations and orbital diagrams** *(2 periods)* • Aufbau principle • Pauli-exclusion principle • Hund's rule • Ground state electronic configuration of the elements.	Students need to have appreciation for the following principles to be used in writing electron configurations of atoms along with the quantum numbers • Aufbau's principle • Pauli's Exclusion principle • Hund's principle Giving clear and concise definitions for new terms from the beginning simplifies the effort students put to learn complex concepts. You may tell them that these are German words- Aufbau means building order and both Pauli and Hund are names of scientists. Ground state electronic configurations of the elements can be solved if students are given the atomic number in conjunction with the charge of the atom using Aufbau principle as there is only one of its kinds. However, to check that they know the difference between excited and ground states ask students individually to write excited electronic configurations for some elements or ions.
• Correlate the electron configuration of elements with the periodicity of elements. • Give a reasonable explanation for shape of the periodic table. • Classify elements as representative, transition and inner-transition elements. • Explain the general	**2.8 Electronic Configurations and The Periodic table of The Elements** *(4 periods)* • The modern periodic table • Classification of the elements • Periodic properties • Advantages of periodic	Do not take it for granted that students know the difference between the Mendeleve's and Modern periodic laws. Ask them to state these laws prior to teaching this section. They should be able to use the electronic configurations of elements to locate the position in the periodic table and vice versa and their properties. Give assignments individually and then ask them to iron out the differences, if there are any. Students should be aware that elements can be classified in the periodic table according to their electronic configurations. Students should appreciate the general trends in periodic properties of elements across the period and along the group in the periodic table. Ask students to study all the chemistry there is for all elements. You can also ask them if they think there is a person who tries to study by heart all the facts summarized in the Periodic table.

Competencies	***Contents***	***Suggested Activities***
trends in atomic radius, ionization energy, electron affinity, electro negativity and metallic character of elements within a period and a group of the periodic table. • Write the advantages of periodic classification of elements.	classification of elements.	Can they suggest any tool or means of simplifying this task? If they know the property of an element at the top of a group they can give an educated guess of the property of an element down the group if they understand the trends in change. Students should use the periodic table for further study of elements and their compounds.

Assessment

The teacher should assess each student's work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

Students working at the minimum requirement level will be able to: narrate the historical development of atomic nature of substances; state postulates of Dalton's atomic theory & modern atomic theory; discuss the discovery of electron & the alpha scattering experiment, & describe the properties of cathode rays; define radioactivity, radioactive decay & radioisotope & describe the common types of radioactive emissions; describe makeup of nucleus; define atomic mass & isotope; calculate the relative atomic mass of naturally occurring isotopic elements; characterize EMR in terms of wavelength, frequency & speed & calculate the wavelength & frequency of the EMR; explain that light has both wave & particle nature; explain that emission spectra of atoms consist of series of lines; state Bohr's assumption of energy of electron in hydrogen atom and calculate the radius of electron orbit, the electron velocity & the energy of an electron using Bohr model; explain that the line spectrum of hydrogen demonstrates that quantized nature of the energy of its electron; explain that atoms emit or absorb energy when they undergo transitions from one state to another; explain the short coming of Bohr's theory; state Heinsberg's uncertainty principle & describe the significance of electron probability distribution; explain the quantum numbers n,l,m_l & m_s & write all possible of electrons in an atom; describe the shapes of orbital designated by s,p,d, and f ; explain Aufbau principle, Pauli-exclusion principle and Hund's rule; write ground state electronic configurations of multielectron atoms and correlate the electron configuration of elements with the periodicity of elements; classify elements as representative , transition and inner-transition elements; explain the general trends in atomic radius , ionization energy, electron affinity, electronegativity,and metallic character of elements within a period and a group of the periodic table and write the advantages of periodic classification of elements.

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 3: Chemical Bonding and Structure *(32 Periods)*

Unit outcomes: Students will be able to:

- Understand that a chemical bond is an attractive force between particles;
- Demonstrate an understanding of the formation & general properties of substances containing ionic, covalent & metallic bond;
- Draw Lewis structure for simple ionic & covalent compounds;
- Understand the origin of polarity within molecules;
- Describe the formation & nature of hydrogen bonds, dipole-dipole forces and London forces;
- Know the three different but related bonding models(Lewis model, valence bond model & molecular orbital model) & recognize the usefulness of the bonding theories in explaining & predicting molecular properties (bond angle, bond length, bond energy ,etc…);
- Explain how the properties of a substance (solid or liquid) depends on the nature of the particles present and the type of intermolecular forces;
- Appreciate the importance of intermolecular forces in plant & animal life:
- Explain how the Valence Shell Electron Pair Repulsion(VSEPR) model can be used to predict molecular shape;
- Know the types of crystalline solid (ionic, molecular, covalent network, or metallic) formed by a substance & describe their properties;
- Conduct experiments to observe & analyze the physical properties of different substance to determine the type of bonding present;
- Describe scientific enquiry skills along this unit: observing, inferring, predicting, classifying, comparing & contrasting, making models, communicating, asking questions, applying concepts, relating cause & effect and making generalization.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Describe the reason why atoms form chemical bonds • State octet rule • Define chemical bonding	**3. Chemical Bonding and Structure** **3.1. Introduction** *(1 period)* • Octet rule	Students should be able to define chemical bonding in the simplest way such as: i. that holds the parts of a chemical structure together or ii. a force which holds chemical species together. You might sometimes refer to bonding as a ‘chemical bond’, and at other occasions refer to it as ‘an interaction’ or ‘the force’ holding molecules together. Yet different students may well have their own idiosyncratic ways of using these various terms that teachers are not aware of. All these terms which mean the same thing could be used interchangeably but students may not see it that way. Besides students should appreciate how bonding has resulted in the formation of an ever increasing number of substances from a limited number of elements substances with different properties from the elements they are formed substances accompanied with energy change(energy consuming or releasing) Students often believe that atoms will spontaneously form species with octet structures regardless of the chemical context. This could arise from the notion that species with octet electronic configurations or full outer shells are always more stable than species with other configurations. Such judgments are sometimes made regardless of the context and any other factors that might be relevant. It is clear that the complete shell of electrons dominates students thinking even after looking at stability in terms of energy changes and forces between charged particles. ¯. The octet rule is an observation that correlates atomic stability with outer shell

Competencies	***Contents***	***Suggested Activities***
• Describe the types of chemical bonding and their mechanisms of the bonding processes	• Types of chemical bonding	carrying eight electrons. Students should learn the types of chemical bonding and how they relate to the electronic structures of the atoms that are bonded together. In addition to knowing what each of the bonds is, students should appreciate the similarities and differences among them with especial emphasis to the covalent and ionic ones. This of course should not down-play the importance of other types of bonding, especially in biological systems.
• Define ionic bonding.	**3.2 Ionic Bonding** *(5 periods)*	Students should know that an ionic compound is stable because of the very large lattice energy that is released when the oppositely charged ions come together to produce the ionic solid. If it were not for this lattice energy, ionic compounds would not exist. Thus in the gas phase the ions, Li^+ (g) and F^-(g), are less stable (i.e., of higher energy) than Li(g) and F(g) and therefore Li(g) and F(g) would not react spontaneously to produce the ions. This is a good indication how easily students revert to simple and familiar ideas. Students need to attempt chemical stability assignments individually and discuss them in groups. Eg. Na^+/Na/Na^{7-}; Cl^{7+}/Cl/Cl^- and C^{4+}/C/C^4.
• Use Lewis electron dot symbols to depict main group elements. • Describe ionic bonding using Lewis electron dot symbols.	• Lewis electron dot symbols	When discussing this section focus should be on: • Showing the structures of elements using the Lewis dot formulas as entry to showing what constitutes ionic bonds.
• List the favorable conditions for the formation of ionic bond. • Explain the formation of ionic bonding	• Formation of ionic bonding - The Born-Haber cycle	• Formation and set of criteria for the formation of ionic bonding • Appreciating how transfer of electrons between the atoms forming an ionic bond results in the formation of stable ions, isoelectronic to nearby noble gas elements • Illustrating the use of Born-Haber cycle
• Give examples of ionic compounds • Define lattice energy • Calculate lattice energy of ionic crystal from a given data using the Born-Haber cycle	- Factors affecting formation of ionic bonding	• Factors that influence the formation of ionic compounds need to be appreciated(one needs to be of low ionization energy and electron affinity and the second with high ionization energy and electron affinity and when the lattice energy of the resultant compound is high)
• Discuss the exceptions to octet rule	• Exceptions to octet rule	Students should be aware of the problem of over generalizing the Octet Rule; it works beautifully for period 2 elements but has limitations elsewhere

Competencies	*Contents*	*Suggested Activities*
- Describe the properties ionic compounds - Carryout an activity to demonstrate the effect of electricity on ionic compounds (PbI_2 and NaCl) - Carryout an activity to investigate the melting point and solubility of some ionic compounds (NaCl and $CuCl_2$)	- Properties of ionic compounds	Students should grasp the concept that properties of ionic compounds reflect the kinds of particles that are within them. Students should be aware that the strong attractive forces between ions cause ionic compounds to have their characteristic properties (it is important to highlight that ionic compounds conduct electricity when melted but not in the solid state) Students should be given samples of ionic compounds (PbI_2, NaCl, $CuCl_2$)and asked to investigate their conductivity, solubility ,and melting points. Students should understand the high melting points are not exclusive to ionic substances. They need to be made aware that metals high melting points , as do macromolecular solids, and the high boiling points in both cases result from the three dimensional attraction of each atom to its neighbors; this is the same factor occurs for ionic solids
- Define covalent bonding - Explain the formation of covalent bonding - Give examples of covalent molecules	**3.3 Covalent Bonding** *(15 periods)* - Formation of covalent bonding	Students should be able to see that covalent bond is very different from ionic bond and this in turn gives rise to very different properties from ionic compounds sharing a pair of electrons between two atoms lowers their energy hence making the association more stable than the starting atoms covalent bonding is favored when the difference between the ionization energies and electron affinities of the combining atoms is not large it is important from the outset to stress that substances containing covalent bonds only are called molecules with ample examples
- Draw Lewis structures or electron dot formulas of some covalent molecules	- Representation of covalent bond. - drawing Lewis structures	Students must see the connection between structure and properties of molecules early on and therefore must grasp the techniques of drawing Lewis structures of simple molecules. the need to determine skeletal structure be sure the students learn and use the rules of counting and distributing valence electrons among the bonds and atoms in the skeletal structure
- Illustrate the formation of coordinate covalent bonding using examples	- Coordinate covalent bonding.	It is important to make clear to the students that the electrons to be shared by the two nuclei connected by a covalent bond need not be always contributed by both atoms; one could donate and the second accept. This is how the Coordinate Covalent bond is formed. Difference in the source of the electrons may not result in difference in the covalent bonds formed. (eg the bonds in H_3O^+ are all identical even if it is formed from a reaction between H^+ and H_2O)
- Define resonance structures	- Resonance structures	Students have to see the limitations of the Resonance concept and see it only as a last resort to give a structure of a molecule when there is more than one reasonable way of distributing electron pairs in a molecule

Competencies	***Contents***	***Suggested Activities***
- Draw resonance structures of some covalent molecule and polyatomic ions.		
- Discuss the exceptions to the octet rule in covalent bonding	- Exceptions to the octet rule in covalent bonding	Students need to be made aware that there are exceptions to the octet rule by giving them few simple examples.
- Distinguish between polar and non-polar covalent molecules.	- Polar and non-polar covalent molecules	Students should be able to see that ionic substances are always polar (the extreme case of polarity is ionic bond) but that molecules could be either very polar, weakly polar or non-polar at all which dependence on the composition and shape of the molecule. It is important that ample examples should be given here to determine the net dipole moments which ultimately decide polarity. Using the electro negativity table, students must predict bond stability (large electro negativity) and dipole formation of molecule.
- Describe the properties of covalent molecules - Carryout an activity to investigate the effects of heat, electricity and some solvents on covalent compounds (naphthalene, graphite, iodine and ethanol)	- Properties of covalent compounds	Students should discuss general properties of covalent compounds. Students should grasp the concept that properties of covalent compounds reflect the kinds of particles that are within them. Students should appreciate how the properties of molecules depend on the net dipole moment in particular. Students should be given samples of covalent compounds (naphthalene, graphite, iodine and ethanol) and asked to investigate their conductivity and solubility.
- Describe the valence shell electron pair repulsion theory (VSEPR) - Distinguish the bonding pairs and non-bonding pairs of electrons.	**3.3.1. Molecular Geometry** - Valence shell electron pair repulsion (VSEPR) Theory - Electron pair arrangement and molecular shape	Students should appreciate VSEPR theory and its connection to Lewis diagrams of molecules in describing molecular shapes. Here it might be helpful to resemble Lewis structure with the blueprint of a building (which reveals part of the information) and Molecular shape derived using VSEPR theory with the model of a building which is a miniature copy of the actual building that reveals vivid 3-D information in addition to what you get from the blueprint. Students can visualize the concept of lonepair-lonepair repulsion> lonepair-bondpair repulsion>bondpair-bondpair repulsion using a balloon model of water. Give assignments to the students individually to construct the five shapes of molecules and discuss them in groups.
- Describe how electron pair arrangements of and shapes of molecules can be predicted from the number of electron pairs.	- Guidelines for applying VSEPR model.	Students should use guidelines for applying VSEPR theory to draw the shapes of molecules. Ball and stick models are helpful to students as they attempt to visualize the geometry of molecules.

Competencies	***Contents***	***Suggested Activities***
• Explain why double bonds and lone pairs cause deviation from ideal bond angles. • Explain the term dipole moment with the help of a diagram • Describe the relationship between dipole moment and molecular geometry • Describe how bond polarities and molecular shapes combine to give molecular polarity.	• Molecular shape and molecular polarity - Bond polarity - Bond angle - Dipole moment	Students should be given assignments to determine shapes and polarity of molecules by combining the Lewis and VSEPR theories. When considering bond polarity dipole moments should be treated qualitatively in conjunction to geometry of the bonds. Students should understand how some properties of similar compounds differ because of varying molecular shapes and structures.
• Predict the geometrical shapes of some simple molecules • Construct models to represent shapes of some simple molecules.	• Predicting the shapes of Molecules	Students should be aware that the ability to predict avoids the necessity of memorizing hundreds of individual molecular shapes. Students should be asked to construct models to represent shapes of simple molecules.
• Define intermolecular forces • Name the different types of intermolecular forces • Explain dipole-dipole interactions. • Give examples of dipole-dipole interaction • Define hydrogen bonding. • Explain the effects of hydrogen bond on the properties of substances • Give reason why H-bonding is stronger than	**3.3.2. Inter molecular forces in covalent compounds** • Dipole- dipole force -hydrogen bonding	It is very important to help students see that the particles in molecular substances are molecules whereas in ionic substances the particles are positive and negative ions. The fact that molecular substances are either gases, liquids or soft solids whereas ionic substances are usually hard solids with high melting point does not imply that covalent bonds are in general weaker than ionic bonds; the forces that should be considered in molecular substances is the various types of intermolecular associations or bonds with varying strength. Students often do not count intermolecular forces as bonds and these needs to be corrected. Students should know that an intermolecular force is a force of attraction between molecules. Students be aware that Dipole-Dipole force and hydrogen bonding occur in some molecules, but Dispersion or London forces are common to all molecules. Students should use polarity to explain hydrogen bonding and should understand the properties of substances having hydrogen bonding. It is important to help that students recognize that the hydrogen bonding that causes ice to occupy more volume and therefore less dense is important both to ice skaters and to aquatic plants and animal. If ice were denser, the ponds and streams would freeze from the bottom up. The plants and animals would die.

Competencies	***Contents***	***Suggested Activities***
ordinary dipole-dipole interaction. • Explain dispersion (London) forces • Give examples of dispersion forces • Predict the strength of inter molecular forces for a given pair of molecules.	• Dispersion or London force	Students should know that the weak attractions due to instantaneous induced dipoles were described first in 1930s by the German physicist Fritz London, so they are called London forces. Students should be aware that substances with molecules that are attracted to one another only by London forces have low boiling and low freezing points, compared with other substances of about the same molecular weight. If their molecules are small they usually exist as gases at room temperature
• Explains how metallic bond is formed. • Explain the properties of metals related to the concept of bonding. • Carryout an activity to investigate the conductivity, malleability and ductility of some metals and nonmetals(Al, Cu, Fe, Sn, Zn, S, C- charcoal, C- graphite and Si)	**3.4. Metallic Bonding** *(2 periods)* • Formation of metallic bond • Electron Sea Model • Properties of metals related to the concept of bonding.	If all chemical bonding is understood only in terms of striving to obtain a full outer shell by sharing (covalent bonding) or transferring (ionic bonding) electrons, then we run into problem when we consider the force that holds metallic atoms together. It might help here to tell the students that it is not a model as easy as the covalent or ionic ones. Metallic bonding is not the sharing or loss or gain of electrons. It is just a loose association of metal ions and electrons they have lost. Students should know that the electron Sea model depicts metallic bonding as a situation where all the metal atoms in a sample pool their valence electrons into an evenly distributed 'sea' of electrons that 'flows' between and around the metal-ion cores and attracts them together. Unlike the localized electrons in covalent bonding, electrons in metallic bonding are delocalized, moving freely throughout the piece of metal. Students should be aware that the physical properties of metals vary over a wide range. Almost all are solids with moderate to very high melting and extremely high boiling points. Periodic trends are consistent with the model. Ca has higher melting point than K- a reflection of 2 vs 1 valence electrons. They are malleable and ductile-the metal ions slide past each other when force is applied. They are good conductors of electricity and heat-because of the mobility of the delocalized electrons. Students could be given samples of metals and non-metals (Aluminum, copper, iron, tin, zinc, charcoal, graphite and silicon) and asked to investigate their conductivity , malleability and ductility.
• Name the two chemical bond theories. • Explain the valence bond theory. • Distinguish between the	**3.5.Chemical Bonding Theories** *(8 periods)* **3.5.1.Valence Bond Theory (VBT)**	Extra care has to be taken to present that both MOT and VBT are complementary and therefore should be used when one has more advantage than the other. Students could get frustrated as they would like one that works best all the time. This section describes the modern theories of chemical bonding and how they can account for (or predict, in some cases) molecular structure. The thing to keep in mind throughout discussions of the different approaches is that each theory is attempting to describe the same thing and each, in its own way, succeeds to a degree. The theories, then, present alternative

Competencies	*Contents*	*Suggested Activities*
Lewis model and the valence bond model. • Discuss the overlapping of orbital in covalent bond formation • Explain hybridization • Show the process of hybridization involved in some covalent molecules • Draw hybridization diagram for the formation of sp, sp^2, sp^3, sp^3d and sp^3d^2 hybrids. • Suggest the kind of hybrid orbitals on the basis of the electron structure of the central atom. • Predict the geometrical shapes of some simple molecules on the bases of hybridization and the nature of electron pairs. • Discuss the hybridization involved in compounds containing multiple bonds. • Explain bond strength and bond length.	- Overlap of atomic orbitals (sigma and Pi bonds) - Hybridization of orbitals	views of the same phenomenon. Students have to be aware that they complement one another; what VBT may not be conversant with could be explained by MOT and vice versa. Students should be aware that VBT is a theory that explains covalent bond formation by hybridization and overlapping of atomic orbitals. The concept of orbital hybridization is so involved it has to be kept to the minimum possible. Students could draw hybridization diagram and predict the geometrical shapes of some simple molecules.
• Explain the molecular orbital theory. • Describe molecular orbital using atomic orbitals. • Describe bonding and	**3.5.2.Molecular Orbital Theory (MOT)** • Combination of atomic orbitals • Bonding and anti bonding molecular orbital	This section presents an elementary treatment of the molecular orbital theory. Students are certain to encounter this theory in more advanced courses. Students should be aware that MOT is a theory of the electron structure of molecules in terms of molecular orbitals , which may spread atoms or the entire molecule. Students should learn the differences between bonding and antibonding molecular orbitals and how the electronic structure of a molecule is obtained by filling molecular orbitals. They should

Competencies	***Contents***	***Suggested Activities***
anti-bonding orbitals.		also see that MOT avoids the idea of resonance which is part and parcel of VBT. The discussion of how molecular orbitals are formed from electron waves of atomic orbitals has to be qualitative and introductory.
• Draw molecular orbital energy level diagrams for mononuclear diatomic molecules. • Write the electron configuration of simple molecules using molecular orbital model.	• Electron configuration of diatomic molecule	Show the students the similarity between atomic orbitals in atoms and molecular orbitals in molecules regarding filling with electrons. Construct molecular orbitals for diatomic molecules such as H_2, He_2,N_2 and O_2.
• Define bond order and determine the bond order of some simple molecules and ions • Determine the stability of a molecule or an ion using its bond order.	• Bond order	Students should learn how to calculate the net bond orders from the number of bonding and antibonding electrons. It is wise to see the similarity with that of the Lewis formula. Students should note that the bond order can only be used qualitatively for purpose of comparison. For example, two electrons in a sigma molecular orbital or two electrons in a bonding pi orbital would have a bond order of one. Yet these two bonds must differ in bond strength and bond length because of the difference extent of overlap of atomic orbitals.
• Predict magnetic properties of molecule.	• Magnetic properties	Give some examples to show the strengths of MOT (eg magnetism).
• Define crystal • Name the four types of crystalline solids and give examples. • Mention the type of attractive forces that exist within each type of crystalline solids • Describe the properties of each type of crystalline solids • Build a model of sodium chloride crystal structure	**3.6.Types of crystals** *(1 period)* • Ionic crystal • Molecular crystal • Covalent network crystal • Metallic crystal	Students should know that types of crystals are distinguished from each other by the type of intermolecular forces between the individual molecular particles or ions which in turn determine physical properties like melting and boiling points and solubility in different solvents. Students should be asked to construct a model of NaCl structure from ball and sticks or other locally available materials.

Assessment

The teacher should assess each student’s work continuously over the whole unit and compare it with the following description, based on the Competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

Students working at the minimum requirement level will be able to: Describe the reason why atoms form chemical bonds; define chemical bonding, ionic bonding, lattice energy, covalent bonding, resonance structures, intermolecular force, hydrogen bonding & metallic bonding; describe the types of chemical bonding & their mechanisms of the bonding processes; explain the formation of ionic bonding & covalent bonding, & give examples of ionic & covalent compounds; calculate lattice energy of ionic crystal from a given data using Born-Haber-cycle; discuss the exceptions to Octet rule in ionic & covalent bonding; describe ionic bonding using Lewis electron dot symbols & the Lewis properties of ionic compounds; draw Lewis structures & resonance structures for some covalent molecules & polyatomic ions; illustrate the formation of coordinate covalent bonding using examples; describe the properties of covalent molecules; distinguished between polar & non-polar molecules; describe the VSEPR theory & how electron pair arrangements of molecules can be predicted from the number of electron pairs; define the bonding & non-bonding pairs of electrons; explain dipole moment and describe the relationship between dipole moment & molecular geometry; predict the geometrical shapes of some simple molecules; explain that the VSEPR theory is used to explain the molecular parameters like bond angle & polarity of the molecule; construct models to represent shapes of some simple molecules; name the different types of intermolecular forces; explain dipole-dipole interactions & dispersion forces & give examples of them; explain the effect of hydrogen bonding; explain the valence bond & molecular orbital theories; discuss the overlapping of orbitals in covalent bond formation; explain hybridization, show its process, draw hybridization diagrams for the formation of hybrids & discuss the hybridization involving multiple bonds; describe molecular orbitals; write the bonding and antibonding orbitals; write the electron configuration of simple molecules using MOT; define bond order & determine the bond order of same simple molecules & ions; determine the stability of a molecule or an ion using its bond order; explain the properties of metals;
define crystal, name the four types of crystals & give examples mention the type of attractive forces, & properties of each types of crystals; build a model of Nacl crystal structure;

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 4: Chemical Kinetics *(19 periods)*

Unit outcomes: Students will able to:

- Explain what is meant by reaction rate & perform the activities to determine it;
- Demonstrate an understanding of the dependence of reaction rate on nature of reactants , surface area of solid reactants, concentration of reactants or pressure of a system, temperature of a system and catalysts;
- Determine the reaction rates using experimental data and calculations;
- Describe how reaction rate theories (collision theory & transition state theory) can be used to explain changes in reaction rates;
- Determine the rate laws & order of reactions from data on initial concentrations and reaction rates;
- Understand that most reactions occur as a series of elementary steps in reaction mechanisms;
- Appreciate the importance of chemical kinetics in industry and in living organisms;
- Describe scientific enquiry skills along this unit: observing, predicting, comparing & contrasting, communicating, asking questions, drawing conclusion, applying concepts, relating cause & effect, making generalization and problem solving.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • define chemical kinetics; • define reaction rate; • express the reaction rate in terms of the disappearance of the reactants and the appearance of the products;	**4. Chemical kinetics** **4.1 Rate of Reaction** *(5 periods)*	Students should be able to see how applied this topic is in their daily life as well as in many other scientific disciplines. Students should appreciate that chemical kinetics is the study of the rates and mechanisms of chemical reactions. Iron rusts in moist air faster than in dry air; foods spoil faster when left unrefregerated; and one's skin becomes tanned more readily in the summer than in the winter. These are three common examples of complex chemical changes with rates that vary according to the reaction condition. To enhance rates of chemical reactions whose products are valuable, or to slow down rates of chemical reactions whose products are harmful, one has to understand how chemical rates are affected. Knowledge of reaction rates of chemical reactions can also be used in conjunction with factors that influence them to get insight into the sequence of chemical steps that occurs to produce the overall net reaction. Students should be aware that the reaction rate is expressed as a change in the concentration of reactants or products per unit time
• perform an activity to measure rate of reaction; • calculate the reaction rate from a given data	• Determination of reaction rate	Students could perform an activity to measure the rate of reaction between marble chips($CaCO_3$) and dilute HCl acid. Students should be given the chance to generate rate data from experimental as well as hypothetical change of concentration of reactants/products in time. Students should work in groups and individually to plot graphs and calculate rates by determining slopes at different periods of time.
• list the factors that affect reaction rate	• Factors that affect the reaction rate	The factors that affect rates of chemical reactions should be given due coverage with examples. Students need to see how rates of chemical reactions change with temperature, concentration,

Competencies	***Contents***	***Suggested Activities***
• explain how nature of reactants, surface area of solid reactants, temperature and concentration or pressure affect the rate of reaction by giving examples • explain activation energy • define catalyst, positive catalyst and negative catalyst • distinguish between homogeneous and heterogeneous catalysis • distinguish between biological and non-biological catalysts • draw energy diagram that represents activation energy and show the effect of catalysts • distinguish between homogeneous and heterogeneous reactions		nature of the reactant, surface area and availability of a catalyst. • The temperature of the system is important because all chemical reaction rates increase markedly with increasing temperature • The concentrations of the reactants continually decrease as the reaction progresses; in most cases this also means that the instantaneous rate of reaction decreases with time • The nature of reactants can account for enormous differences in reaction rates • The increased surface area of solid reactants increaser the rate of reaction • A catalyst can increase the reaction rate by forming an intermediate compound with a relatively low activation energy for a reaction (Homogeneous Catalysis), or by absorbing reacting species on its surface(Heterogeneous Catalysis) Students can be assigned one concentration each and then pool their data together to see the effect. This could be applied to the other factors as well to minimize the amount of time it could possibly take.
• perform an activity to show the effect of nature of reactants on reaction rate • perform an activity to show effect of surface area on reaction rate • perform an activity to show the effect of concentration on reaction rate		Students can perform activities to show the effect of Nature of reactants on reaction rate i) $Cu + HCl \longrightarrow$ ii) $Mg + HCl \longrightarrow$ Surface area of reactants on reaction rate $CaCO_3$ (cube chalk) + HCl (dilute) $\longrightarrow$ $CaCO_3$ (powdered chalk) + HCl(dilute) $\longrightarrow$ Concentration of reactants on reaction rate $CaCO_3$ + 1M HCl $\longrightarrow$ $CaCO_3$ + 2M HCl $\longrightarrow$ Temperature on reaction rate

Competencies	*Contents*	*Suggested Activities*
- perform an activity to show the effect of temperature on reaction rate - Perform an activity to show the effect of catalysts on reaction rate		i) $H_2SO_3 + NaS_2O_3 \longrightarrow$ (At low temperature) ii) $H_2SO_3 + NaS_2O_3 \longrightarrow$ (At high temperature) Catalyst on reaction rate (Decomposition of hydrogen peroxide, H_2O_2) i) H_2O_2(without catalyst) $\longrightarrow$ $H_2O + O_2$(amount ?) ii) H_2O_2(with catalyst, MnO_2) $\longrightarrow$ $H_2O + O_2$(amount ?)
	4.2 Theories of Reaction Rates *(4 periods)*	Students should know that there are two theories running parallel that attempt to explain how rates of reactions are affected by the - nature of the reactants and products - concentration of the reactants - temperature - influence of catalysts and - surfaces area of solid reactants The two theories are distinct but in complete agreement, each emphasizing on different aspects of the reaction process.
- state collision theory - define activation energy' - describe how collision theory can be used to explain changes in reaction rate;	- Collision theory - Concentration and collision theory	Students should know that collision theory views the reaction rate as the result of particles colliding with a certain frequency and minimum energy. The basis for the collision theory is the notion that molecules must collide in order to react. We can predict the rate law if we know what collisions take place during a reaction.. Factors that increase collision frequency, hence, increase the rate of the reaction. As a corollary to this, students should know that if there is no collision at all then there is no reaction at all and its rate becomes zero. Out of the factors that affect rates mentioned above, concentration and temperature have direct relevance in this theory. Students could see how collision frequency increases if concentration is increased.
	- Temperature and collision theory	Students should be aware that higher temperature implies higher kinetic energy from physics. Remind students that $K.E = \frac{1}{2} mv^2$, which implies that the molecules will collide frequently and effectively which in turn implies higher rate. The minimum kinetic energy required between colliding molecules in order to produce an effective collision is called the activation energy, E_a.
- state transition state theory - define activated complex (transition state) - describe how transition state theory can be used	- Transition state theory	Students should know that transition state theory views chemical kinetic of energy and geometry of the activated complex that once it has formed come apart to yield reactants again go to produce the products .

Competencies	***Contents***	***Suggested Activities***
to explain changes in reaction rate; • sketch and label the energy profiles of reactions which are exothermic and endothermic	• Energy profiles of exothermic and endothermic reaction.	Students should draw and label energy diagrams for both exothermic and endothermic reactions the terms transition state, activated complex, activation energy barrier for the forward and re reactions and heat of reaction.
• define rate law, order of reaction and rate constant • determine reaction order • calculate rate constants from a given experimental data • describe the role of the rate constant in the theoretical determination of a reaction rate	**4.3 Rate Equation or Rate Law** *(7 periods)* • Order of reaction • Rate constant	Students should understand the effect of concentration of reactants on rates of reaction by using rate law. The rate law for a reaction such as: $A + B \rightarrow$ Products is Rate = $k[A]^x [B]^y$ where k is the rate constant. The exponents, x and y, are called the order of the reaction with respect to A and B, respectively. The overall order is (x + y). Emphasize the fact that the actual values of x and y can only be obtained by experiment. They have no connection to the coefficients of the balanced chemical equation. If they happen to be the same then it is mere chance. These experiments involve observing what effect altering the concentrations of the reactants has on the rate of reaction. For a reaction, $A \rightarrow B$, i. if doubling the concentration of A doubles the rate, the exponent is 1. Rate = $k[A]^1$ ii. if doubling the concentration of A quadruples the rate, the exponent is 2. Rate = $k[A]^2$. Students should be given mixed exercises so that they are able to see orders with values zero and fractions. The rate constant is the proportionality constant, k, in the rate law given above. Its value is the rate of the reaction when all the reactant concentrations are 1M. The rate constant is the one variable that gives the information about the nature of the reactants. According to Arrhenius $k = Ae^{-Ea/RT}$, A is related about the shape and overall nature of the reactant, Ea is the activation energy, T is the temperature in Kelvin, R is the universal gas constant and e is base of natural logarithm.. Students should be guided to see how big k becomes when A and T are big and Ea low and vice versa. Discussion should be limited to qualitative explanations.
• explain the zero, first and second order reactions using concentrations versus time curve	• Concentration - Time Equation	A rate law tells us the rate of reaction depends on reactant concentrations at a particular moment. But students should be aware that there is another mathematical relationship which shows how a reactant concentration changes over a period of time; that is Concentration-Time equation.

Competencies	***Contents***	***Suggested Activities***
• calculate that concentration and time of the reaction mixture for different order reactions and plot their graphs • define half-life • calculate the half lives of zero order, first order and second order reactions from experimental data	• Half - life of a reaction	Students should know that the concentration of the reactant decreases as a reaction proceeds because it is being consumed. The time that takes for the reactant concentration to decrease to one-half of its initial value is called the half-life of a reaction. Students could determine the half-life of the first and the second order reactions.
• explain reaction mechanism • explain molecularity of a reaction	**4.4 Reaction Mechanism** *(3 periods)* • Molecularity of an elementary reaction - Unimolecular - Bimolecular - Termolecular	Students should be aware that one of the objectives of studying reaction rates of chemical reactions is to get an insight into the sequence of chemical steps (reaction mechanism) that occurs to produce the overall net reaction. The individual reactions that make up a mechanism are called elementary steps. An elementary step is one of the individual steps in a reaction mechanism, which can be either • **unimolecular**: involving the decomposition or rearrangement of a single particle • **bimolecular**: involving collision of two particles and • **termolecular**: involving collision of three particles all at one time Higher molecularities are not believed to take place because of low probability. When we have to choose between alternative mechanisms for a reaction the one with lower molecularity are preferred, all other things being equal. Obtaining a satisfactory mechanism for a reaction is a very difficult task even for experienced chemists; therefore this has to be limited only to qualitative treatment.
• explain what is meant by rate determining step • give specific examples to illustrate rate determining step • • explain the relationship between the reaction path way and the rate law • use rate equation to suggest possible reaction mechanism for a reaction	• Rate determining step	Students should be aware that when there are more than one step in a mechanism of a reaction, the slowest step is called the rate-determining step because the final products can not be formed any faster than the products of the slowest step. Students should know that the predicted rate law only includes the reactants in the overall equation. Neither intermediates nor catalysts appear in the rate law.

Assessment

The teacher should assess each student's work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

Students working at the minimum requirement level will be able to: define chemical kinetics & reactions rate; express the reaction rate in terms of the disappearance of reactants & the appearance of the products & calculate the reaction rate from a given data; perform an activity to measure rate of reaction; list the factors that affect reaction rate & explain how they affect using examples; define catalyst, positive catalyst & negative catalyst; distinguish between homogeneous & heterogeneous catalysts, biological & non-biological catalysts, & homogeneous & heterogeneous reactions; perform activities to show the effect of nature of reactants, surface area of solid reactants, concentration, temperature & catalysts on rate of reaction; state collision theory & describe how it can be used to explain changes in reaction rate; state transition state theory & describe how it can be used to explain changes in reaction rate; define activation energy, activated complex, rate law, order of reaction & rate constant; sketch & label the energy profiles of reactions which are exothermic & endothermic; determine reaction order & calculate rate constants from a given experimental data; explain the zero, first & second order reactions using concentrations verses time curve; define half-life & calculate the half-lives of zero, first & second orders reactions from experimental data; explain reaction mechanism & molecularity of a reaction; explain rate determining step & give examples to illustrate it; explain the path way & the rate law & use rate equation to suggest possible reaction mechanism for a reaction;

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 5: Chemical Equilibrium and Phase Equilibrium *(18 periods)*

Unit outcomes: Students will be able to:

- Understand how equilibrium is established;
- Explain characteristics of dynamic equilibrium;
- State the law of mass action and write an expression for equilibrium constants, K_c and K_p, from a given chemical reaction;
- Apply the law of mass action to calculate K_c , K_p, concentration and pressure of substances in equilibrium;
- Understand how the reaction quotient is used to indicate position of the equilibrium;
- State Le-Chatliers' principle and use it to predict and explain the effects of changes in temperature, pressure, concentration and presence of a catalyst on a reaction;
- Perform an activity to demonstrate the effects of changes in concentration on the position of equilibrium and to determine Kc or K_p values;
- Explain how equilibrium principles may be applied to optimize the production of industrial chemicals (e.g. production of ammonia and sulphuric acid);
- Describe scientific enquiry skills along this unit: observing, predicting, comparing & contrasting, communicating, asking questions and making generalization.

Competencies	***Contents***	***Suggested Activities***
Students will be able to:	**5. Chemical Equilibrium and phase equilibrium**	
• explain reversible and irreversible reactions • define dynamic chemical equilibrium	**5.1 Chemical equilibrium** *(14 periods)* • Reversible and irreversible reactions	Since students may form a misconception of chemical equilibrium easily while thinking it is simple, enough explanation of the definition with the help of examples needs to be given from the beginning.
• state the necessary conditions for attainment of equilibrium • describe the microscopic event that occur when a chemical system is in equilibrium	• Attainment and characteristics of chemical equilibrium	Students should appreciate that chemical equilibrium applies only to reversible chemical reactions and is a dynamic one (not static), that what remain unchanged in a chemical reaction at equilibrium are the rates of both the forward and reverse reactions and that they are equal; hence no shift in position of equilibrium, concentrations of reactants and concentration of products remain the same (but concentration of reactants are not necessarily equal to concentration of products; if they are it is mere coincidence)
• explain the characteristics of chemical equilibrium		Students should be aware that dynamic chemical equilibrium has three properties. They are:- ▪ Dynamic chemical equilibrium can be reached from either direction ▪ Energy change at dynamic chemical equilibrium is zero ▪ Reactants and products have different quantities than were present initially
• state the law of mass action	▪ Equilibrium expression and equilibrium constant - The law of mass action - Equilibrium constant	Students should know that there is a simple relationship between the concentrations of reactants and products in an equilibrium system.

Competencies	***Contents***	***Suggested Activities***
• define equilibrium constant • write the equilibrium constant expression for chemical reactions that involve concentration • calculate values for equilibrium constant involving concentration • state the relationship of K_{eq} to the relative amounts of products and reactants in a given reaction	expression involving concentration, K_C	The relationship between mass action expression, reaction quotient and equilibrium constant has to be appreciated by students. They must be able to see that the equilibrium constant is a special reaction quotient which itself is a numerical value of mass action expression that is determined when the system is at equilibrium. The use of reaction quotient in relation to the equilibrium constant, as an indicator which way a reaction will go to reach equilibrium, has to be stressed. Applications of the equilibrium constant in determining the composition of the equilibrium mixture needs highlighting. At equilibrium, at a given temperature, the mass action expression for a given reaction is always equal to the same number, the equilibrium constant. Remember, there are no restrictions on the individual equilibrium concentrations. The only requirement is that when they are substituted into the mass action expression, the resulting fraction must equal the equilibrium constant. For the general reaction $aA + bB \leftrightarrow mM + nN$ the mass action expression is: $\frac{[M]^m [N]^n}{[A]^a [B]^b} = K_c$
	- Equilibrium constant expression involving partial pressure, K_P	Where Kc is equilibrium constant, when all concentrations are equilibrium concentrations.
• write the equilibrium constant expression for chemical reactions that involve partial pressure; • calculate values for equilibrium constant involving partial pressure; • show the relationship between K_C and K_P		Students should note that for reactions involving gases, partial pressures can be used in place of molar concentrations. Remember the relationship $K_p = K_c(RT)^{\Delta n}$ which is used to interchange K_p and K_c. Δn is change in the number of moles of gases.
• distinguish between homogeneous and heterogeneous reactions;	- Equilibrium constant for heterogeneous reaction	Students should understand that in heterogeneous reactions the reactants and products are not all in the same phase. The concentrations of pure liquid and solid are not included in the mass action expression of the heterogeneous reactions. This is because they are constant and are included in the equilibrium constant.
• define reaction quotient • use the equilibrium quotient to predict the direction of the reaction	- Reaction quotient (Q_C) - Predicting the direction of reaction - Applications of equilibrium constant ○ Predicting the position of	Students should know that reaction quotient, Q_C, is the numerical value of the mass action. It is used to predict whether a reaction has reached or not and if it has not which direction it will proceed. If $K_c = Q_C$, system is at equilibrium, $K_c < Q_C$, reaction proceeds toward reactants and $K_c > Q_C$, reaction proceeds toward products.

Competencies	***Contents***	***Suggested Activities***
and the position of equilibrium • calculate equilibrium concentrations given initial concentrations • determine whether the reactants or products are favored in a chemical reaction given the equilibrium constant;	equilibrium mixture ○ Calculating the equilibrium concentrations of reactants and products	There are basically two kinds of calculations that students have to learn. One is to calculate K from either equilibrium concentrations or information from which you can deduce equilibrium concentrations. The other is to calculate information about equilibrium concentrations, given the value of K. Students should be given exercises until they become conversant. Students should understand the concepts behind the mathematical manipulation of equilibrium problems.
• list factors that affect chemical equilibrium • state Le-chatliers principle • use le-chatliers principle to explain the effect of changes in temperature, pressure, concentration and presence of catalyst on a reaction; • state the effect of changes in concentration, pressure/volume and temperature on K_{eq}	▪ Changing equilibrium conditions: Le- chatleries principle	One important application of this topic is described as the LeChatelliers principle. As much as it is useful it is easily confused by students. It needs to be defined clearly in simple language. One common point confused here is that after new equilibrium is established right after subjecting a system in equilibrium to stress , the equilibrium constant remains unchanged but the individual concentrations of reactants and products could change. The point that, equilibrium constant for a given reaction changes only with temperature but not with concentration or pressure of reactants/products has to be appreciated by students. Students should be able to see the application of LeChatelier's principle in industrial production of important substances such as ammonia and sulfuric acid. ▪ When a reactant or product is added to a system at equilibrium, the position of equilibrium shifts toward the opposite side of the equation. ▪ Decreasing the concentration of a reactant or product causes the position of equilibrium to shift in the direction of the substance removed. ▪ Increasing the pressure by decreasing the volume shifts the position of equilibrium in the direction of the fewest number of moles of gas. ▪ An increase in temperature causes the position of equilibrium to shift in the direction of the endothermic reaction. ▪ A decrease in temperature causes the position of equilibrium to shift in the direction of the exothermic reaction. ▪ A very important point to remember is that the only thing that changes K for a reaction is a change in temperature!! ▪ Adding an inert (unreactive) gas to a system, without changing the volume, has no effect on the position of equilibrium. ▪ A catalyst has no effect on the position of equilibrium. It only increases the speed with which the system reaches equilibrium. Students could perform activities to demonstrate the effects of changes -In concentration on the position of equilibrium.

Competencies	***Contents***	***Suggested Activities***
• perform an activity to demonstrate the effect of changes in concentration on the position of equilibrium • perform an activity to demonstrate the effect of changes in temperature on the position of equilibrium		Eg. Take 0.01M, 0.02M, 0.03M and 0.04M $Fe(NO_3)_3$ (aq) to react with 0.01M KSCN(aq) -In temperature on the position of equilibrium. Eg. The reaction between iodine, I_2 and starch Students could perform activities to determine equilibrium constant. Eg. Kc for esterification of an organic acid
• Perform an activity to determine K_C for esterification of an organic acid • define optimum conditions • explain how Le-Chatliers principle is applied - in the Haber process (production of NH_3) - in the Contact process (production of H_2SO_4)	▪ Equilibrium and Industry - Equilibrium in the Haber process - Equilibrium in the contact process	Students should know that chemical equilibrium along with LeChatelier's principle has applications in industrial production of important substances. In order to optimize production of ammonia in the Haber process and sulfuric acid in the contact process, chemists or chemical engineers exploit fully the principles in this unit.
• explain the interplay between kinetic and potential energy underlies the properties of the three states of matter and their phase changes • explain the process involved, both within a phase and through a phase change when heat is added or removed	**5.2 Phase equilibrium** *(4 periods)* **5.2.1 Common terms - phase components, degree of freedom** **5.2.2 Phase rule and phase diagram** - Phase diagram of water	This topic is a difficult one. Hence its coverage should be limited to introducing the terms: phase, phase rule, degree of freedom, etc. You could ask students to draw and label phase diagrams for water and CO_2 to show the triple point and critical point.

Competencies	***Contents***	***Suggested Activities***
from a pure substance • explain the meaning of vapor pressure and how phase changes are dynamic equilibrium processes; • explain the relation between vapor pressure and boiling point; • describe how a phase diagram shows a phase of a substance at differing conditions of pressure and temperature; • use a phase diagram, determine melting point, boiling point, critical temperature, critical pressure and triple point of a substance		

Assessment

The teacher should assess each student's work continuously over the whole unit and compare it with the following description, based on the Competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

Students working at the minimum requirement level will be able to: Explain reversible & irreversible reactions; define dynamic equilibrium & state the necessary conditions for attainment of equilibrium; explain the characteristics of chemical equilibrium; state the law of mass action & define equilibrium constant & reaction quotient; write the equilibrium constant expression for chemical reaction that involve concentration & partial pressure, & calculate the values for equilibrium constant; determine whether the reactants or products are favored in a chemical reaction given the equilibrium constant; distinguish between homogeneous & heterogeneous reactions; show the relationship between K_C & K_P; use the equilibrium quotient to predict the direction of the reaction & the position of equilibrium; calculate equilibrium concentrations of reactants & products; list factors that affect chemical equilibrium; state Le-chatlier's principle, use it to explain the effect of changes in temperature, pressure, concentration & presence of catalyst on a reaction & perform activities to demonstrate them; explain how Le-chatlier's principle is applied in the Haber & Ostwald's processes; explain the properties of the three states of matter & their phase changes; explain vapor pressure & the relation between vapor pressure & phase changes; describe how phase changes are dynamic equilibrium processes; describe how a phase diagram shows a phase of a substance at differing conditions of pressure & temperature;

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 6: Carboxylic Acids, Esters, Fats and Oils *(20 periods)*

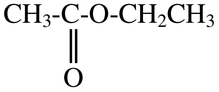
Unit outcomes: Students will be able to:

- Write the structural formula and IUPAC names of given carboxylic acids and esters;
- Describe some physical and chemical properties of carboxylic acids and esters;
- Predict and correctly name the products of organic reactions, including substitution, addition, elimination, esterification, hydrolysis and oxidation reactions;
- Carry out activities to prepare a carboxylic acid and an ester;
- List some important fatty acids;
- Test for the carboxylic acid and ester functional groups;
- Understand the structures, properties and uses of fats and oils;
- Describe and explain reactions in soap making (saponification);
- Describe and explain the cleaning action of soap and detergents;
- Understand the harmful effects of detergents on the environment when improperly disposed;
- Describe scientific enquiry skills along this unit: observing, classifying, comparing & contrasting, asking questions, drawing conclusion, applying concepts and problem solving.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • List common organic acids and mention their sources; • Write the general formula of saturated monocarboxylic acids; • Write the molecular formulas and names of the first six members of saturated monocarboxylic acids; • Give the structural formula for the first four members of saturated mono carboxylic acids. • Give examples for mono carboxylic, dicarbcxylic and tricarboxylic acids;	**6. Carboxylic acids, Esters, Fats and Oils** **6.1 Carboxylic acids** *(8 periods)* • Nomenclature and structure	This unit deals with a narrow range of oxygen containing hydrocarbons that are abundant in nature, especially in living organisms. Students should know that carboxylic acids contain the carboxyl group attached to hydrogen (HCOOH), an alkyl group (RCOOH), or an aryl group (ArCOOH). The aliphatic carboxylic acids have been known for a long time, and as a result have common names that refer to their sources rather than to their chemical structures. You could motivate the students if you relate common names of some carboxylic acids to the source they were isolated from initially. Example is butyric acid from rancid butter. You should not spend more time than is necessary on trivial or common names. As the number of both natural and synthetic organic compounds, carboxylic acid included, has reached thousands, and is still on the rise by the day; one can not rely on common names. Students should appreciate the need for a nomenclature system that is systematic, easy to use, and remember. This could then be followed by the IUPAC nomenclature system lesson. Even though IUPAC should be at the center of nomenclature, it is useful to introduce the α, β, γ, δ…position of attachment. Direct the students attention to the fact that the carboxyl carbon is always considered as C-1, and hence C-2 corresponds to α of the common names, C-3 to β, and so on. (Caution: Do not mix Greek letters with IUPAC names, or Arabic numerals with common names.) Hence the α-carbon is the one bearing the carboxyl group. This is commonly used in biochemical literature.

Competencies	***Contents***	***Suggested Activities***
- Name some branched carboxylic acids;		$\overset{\gamma}{C}-\overset{\beta}{C}-\overset{\alpha}{C}-COOH$ (used in common names) Students should be able to discern the structural differences between the aromatic carboxylic acids and aliphatic acids with phenyl ring substituents. The aromatic acids are usually named as derivatives of the parent acid, benzoic acid, C_6H_5COOH. Since the IUPAC names for the acids follow the usual pattern, you could give assignments to the students to see if they still remember what they learned earlier about organic nomenclature. Ask the students if they can point out the parent structures correctly and give accurate names.
- describe the physical properties of saturated mono carboxylic acids - explain why "tella" or "tej" turns sour	- Physical properties	Ask students to list down some physical properties using the chemical knowledge they have mastered so far. You might hint that properties of molecules follow structure, to the students at this point and see how this might help them. **Solubility**: Carboxylic acids have two distinct parts in terms of associating with water. Ask the students to identify them. They could discuss this in groups. The hydrocarbon part is hydrophobic whereas the carboxyl group is hydrophilic. The aliphatic acids, therefore, show very much the same solubility behavior as the alcohols: the first four or five are miscible with water and the higher acids are virtually insoluble. Water solubility undoubtedly arises from hydrogen bonding between the carboxylic acid and water. The simplest aromatic acid, benzoic acid, contains too many carbon atoms to show appreciable solubility in water. Carboxylic acids are soluble in less polar solvents like ether, alcohol, benzene, etc. **Boiling Point**: As a class the carboxylic acids are even higher boiling than alcohols. For example propionic acid (b.p. 141 ◦C) boils more than 20 ◦C higher than the alcohol of comparable molecular weight, n-butyl alcohol(b.p. 118 ◦C). These very high boiling points are due to the fact that a pair of carboxylic acid molecules are held together not by one but by two hydrogen bonds. Ask your students to see if they can draw structure of two carboxylic acids with two intermolecular H-bonds between them. **Odor**: Ask the students to list down odors of some carboxylic acids that they might have encountered in laboratories or elsewhere. (Caution: Students are not allowed to inhale vapors of chemicals; if it is important that they smell chemicals it has to be supervised by the instructor and they should only blow the vapor with their hand in the direction of their noses.) The odors of the lower aliphatic acids progress from the sharp, irritating odors of methanoic acid and ethanoic acids to the distinctly unpleasant odors of butanoic, pentanoic and hexanoic acids; the higher acids have little odor because of their low volatility.
- explain the chemical properties of saturated mono carboxylic acids	- Chemical properties	Students should be aware that the characteristic chemical behavior of carboxylic acids is, of course, determined by their functional group, carboxyl, -COOH. This group is made up of a carbonyl group (C=O) and a hydroxyl group (-OH). It is the –OH that actually undergoes nearly every reaction-loss of H^+, or replacement by another group-but it does so in a way that is

Competencies	***Contents***	***Suggested Activities***
		possible only because of the effect of the C=O. The most important chemical property of carboxylic acids is their acidity. They form salts when treated with strong bases like OH^- and even with weaker bases such as HCO_3^- and NH_3. The rest of the molecule undergoes reactions characteristic of its structure; it may be aliphatic or aromatic, saturated or unsaturated, and may contain a variety of other functional groups.
• explain the general methods of preparation of saturated mono carboxylic acids; • explain the industrial and laboratory preparation of acetic acid • conduct an experiment to prepare acetic acid in the laboratory	• Preparation	Students should understand preparation of carboxylic acids. You may pick few appropriate chemical reactions to illustrate their preparations. 1. Oxidation of Primary alcohols $\mathrm{R\text{-}CH_2OH} \xrightarrow{\mathrm{KMnO4}} \mathrm{R\text{-}COOH}$ 2. Oxidation of alkyl benzenes $\mathrm{Ar\text{-}R} \xrightarrow{\quad} \mathrm{Ar\text{-}COOH}$ Oxidation is the most direct and is generally used when possible, some lower aliphatic acids being made from the available alcohols, and substituted aromatic acids from substituted toluenes.
• name and write structural formulas of some fatty acids	• Fatty acids	Students should know fatty acids are carboxylic acids with a long hydrocarbon chain that are found in all cells. The hydrocarbon chains of animal fatty acids are more saturated than those of vegetable origin. With only a few exceptions, the fatty acids are all straight-chain compounds. Most fatty acids contain an even number of carbon atoms.
• describe some uses of common carboxylic acids	• Uses	Let the students mention some uses of common carboxylic acids like acetic acid
• list common sources of esters;	**6.2 Esters** *(6 periods)* • Sources of esters	Students should appreciate that esters are found abundantly in living organisms.
• write the general structural formula of esters • write the molecular formulas and names of some simple esters	• Nomenclature	Students should know that an ester is made by replacing the H of an –OH acid with an R group. Carboxylic esters derived from carboxylic acids, therefore, have the formula RCOOR'. They are named as derivatives of the corresponding carboxylic acids, and the best way to begin is by 1. Naming the acid, using either the IUPAC name or the common name. 2. After that, the procedure is the same as for naming salts. The "-ic acid" is changed to "ate," and this word is the second word in the ester name. 3. The first word is the name of the R' group.

Competencies	***Contents***	***Suggested Activities***
		E.g.  $CH_3-\underset{\underset{O}{\|}}{C}-O-CH_2CH_3$ 1. Name of acid: Ethanoic acid or acetic acid 2. Change "-ic acid to "ate,": Ethanoate or Acetate 3. Name of R' comes first: Ethyl Hence full name is: Ethyl ethanoate or Ethyl acetate. Ask students to give names for few common carboxylic esters. (Remember there are inorganic esters like phosphoesters as well.) You may ask them also to identify the acid and alcohol (or phenol) portions of these carboxylic esters.
• describe physical properties of esters;	• Physical properties	**Boiling points**: Ask students to guess whether esters will have higher, lower or similar boiling points compared to compounds of comparable molecular mass that do form hydrogen bonds. Because ester molecules cannot form hydrogen bonds with each other, esters have lower boiling points than compounds of comparable molecular mass that are capable of forming hydrogen bonds. **Solubility**: Since carboxylic esters can form hydrogen bonds with water, it is not surprising that their solubility in water is about the same as that of carboxylic acids of the same molecular weight. **Odor**: In sharp contrast to the disagreeable odors of carboxylic acids, esters have pleasant odors. Many of the odors of fruits and flowers result from mixtures of carboxylic esters, and many of them are used in perfumes and food flavorings.
• explain the chemical properties of esters;	• Chemical properties	Students should be aware that the most important reaction of carboxylic esters is their hydrolysis, which may be catalyzed by either acids or bases. For synthetic purposes, base catalysis is often preferred because the reaction is not reversible. Base catalyzed ester hydrolysis is called saponification. In biological systems, ester hydrolysis is catalyzed by enzymes.
• explain the general methods of preparation of esters	• Preparation	Students should know preparation of esters. Carboxylic esters can be considered as a combination of a carboxylic acid and an alcohol (or phenol). In fact, they can be synthesized by heating a mixture of a carboxylic acid and an alcohol in the presence of an acid catalyst such as H_2SO_4.
• describe some uses of common esters;	• Uses	Students should appreciate that esters have numerous uses: - Solvent - Medicine - Clothing eg polyesters (Dacron)

Competencies	***Contents***	***Suggested Activities***
		- Fragrance in perfumes - Plasticizers eg octyl phthalate
• define fats and oils • write the general structural formula for fats and oils • write the structures of some common triglycerides	**6.3 Fats and Oils** *(6 periods)* • Structure	Fats and oils are esters. Students should be able to see that they are widely found in nature especially in living things as esters of glycerol, in fact triacylglycerols. Fats and oils are triacylglycerols whose hydrocarbon tails, derived from carboxylic acids, are long enough to make them hydrophobic. As the hydrocarbon tail gets longer, they become more fatty i.e. less water soluble. The degree of unsaturation of the fatty acid tail portion of triacylglycerol is responsible for the physical states of the fats and oils.
• describe physical properties of fats and oils	• Physical properties	Students should know that animal fats are generally solids at room temperature and those from plants are usually liquids (oils). Warn students not to confuse the edible vegetable oils with mineral oils which are entirely different; mineral oils (petroleum) which are long chains of alkanes.
• explain hardening of oils (process of converting oils to hard fats)	• Hardening of oils	Giving local examples would bring chemistry closer to the students and this should be done when situations allow. It would be interesting to show how hydrogenation of vegetable oils results in the formation of solid fat (eg SHENO LEGA) which is not different in composition from animal fat. Ask students if it is OK to consume Sheno Lega during fasting season. It is also useful to show how to calculate oxidation numbers of the various carbon atoms in both fats and oils and use oxidation number as an indicator of energy content; the lower the oxidation number the higher the energy content of the substance. Reference could also be made to the type of hybridization of the carbon atoms. Vegetable oils differ from animal fats in possessing higher degree of unsaturation, but could have double bonds. You should ask the students to check if they know that numerous fats contain sites of unsaturation like vegetable oils. This is a common misconception in students at this level. It is known, other things being equal, unsaturation in fat tends to lower its melting point and thus tends to make it a liquid at room temperature. Hydrogenation of some of the double bonds in oils converts these liquids into solids having a consistency comparable to that of butter. The accompanying change of state is called hardening of oils.
• explain rancidity	• Rancidity	Students should be aware that hydrogenation not only changes the physical properties of a fat, but also-and this even is more important-changes the chemical properties: a hydrogenated fat becomes rancid much less readily than does a non-hydrogenated fat. Rancidity is due to the presence of volatile, bad-smelling acids and aldehydes. Here you could engage your students with discussion in groups on concepts related to reactivity

Competencies	***Contents***	***Suggested Activities***
		of alkenes vs alkanes. Fats and oils become rancid if left un refrigerated. This can be used to show how the numerous bacteria produce enough catabolic enzymes that break the long fatty acids into smaller pieces of lower boiling point that vaporize at room temperature, hence the bad odor. Mothers purify butter (animal fat) by heating it to boiling which kills the bacteria and also denature the enzymes responsible for rancidity of butter.
• define soap	• Soaps and detergents - Soap	Students should be aware that the making of soap is one of the oldest of chemical syntheses. Soaps are the alkali salts of fatty acids. (It is not nearly as old as the production of ethyl alcohol; may be his desire to get intoxicated is older than his desire to be clean.) Soap may vary in composition and method of processing: - alcohol can be added to make it transparent; - air can be beaten in to it to make it float; - perfumes, dyes, and germicides can be added; if potassium salt (instead of sodium salt), it is soft soap Chemically, however, soap remains pretty much the same, and does its job in the same way.
• define detergent	- Detergents	Of the straight-chain primary alcohols obtained from fats-or in other ways-the C_{12} to C_{18} alcohols are used in enormous quantities in the manufacture of detergents (synthetic soap- like molecules). Although the synthetic detergents vary considerably in their chemical structure, the molecules of all of them have one common feature, a feature they share with ordinary soap: they are amphipathic, and have a large non-polar hydrocarbon end that is oil-soluble, and a polar end that is water-soluble. The C_{12} to C_{18} alcohols are converted into the salts of alkyl hydrogen sulfates when treated with H_2SO_4. The alkyl sulfates, when treated with NaOH, produce the detergent, sodium alkyl sulfate. There are also non ionic detergents to be used when the ionic detergents are not effective. These detergents act in essentially the same way as soap does. They are used because they have certain advantages. For example, the sulfates retain their efficiency in hard water, since the corresponding calcium and magnesium salts are soluble. Ask the students if they know what makes water temporary or permanent hard water. (This can be raised again in grade 12 chemistry in the context of hydrolysis of neutral salts and basic salts: detergents are neutral whereas soaps are basic.) But detergents are not without drawbacks: some are non biodegradable, which makes them environmentally non-friendly. (The new detergents are better in being more biodegradable than the older generation.)
• explain saponification • prepare soap	- saponificaiton (soap-making)	Students should be aware that soap making (saponification) is one of the oldest chemical technologies. Man first boiled goat tallow and wood ash to give a lathering and cleansing product. The goat tallow contained the ester, and the wood ash the necessary alkali. Chemicals with same reactive groups are the main raw materials still used in traditional and modern soap

Competencies	***Contents***	***Suggested Activities***
		manufacture. Students should know that saponification is the chemical process of an alkali breaking down an alkyl alkanoate or ester to form soap. Demonstrate preparation of soap. The students should also appreciate the main continuous processes for manufacturing of soap in modern industries. Students should be able to see the differences and similarities between Soaps and Detergents. They should also be guided to be aware of the advantages and disadvantages of soaps and detergents in relation to hard water and biodegradability of detergents.
• explain the cleaning action of soaps	- Cleaning action of soap	At this point ask students if they expect soaps and detergents to be water soluble. If they answer in the affirmative help them see that it is the polar head that associates with polar water-hydrophilic. The non-polar end is water-insoluble, and is thus hydrophobic (or lipophilic). Such molecules are called amphipathic: they have both polar and non-polar ends and, in addition, are big enough for each end to display its own solubility behavior. In line with the rule of "like dissolves like", each non-polar end seeks a non-polar environment; in this situation, the only such environment about is the non-polar ends of other soap molecules, which therefore clump together in the center of the micelle. Negatively charged carboxylate groups bind to the surface of the micelle and it is surrounded by an ionic atmosphere. Water alone can not dissolve fat and grease that make up and contain the dirt; oil droplets in contact with water tend to coalesce so that there is a water layer and oil layer. But the presence of soap changes this. The non-polar ends of soap molecules dissolve in the oil droplet, leaving the carboxylate ends projecting into the surrounding water layer. As can be seen, this emulsifying, and hence cleansing, property is not limited to carboxylate salts, but is posed by other amphipathic molecules.

Assessment

The teacher should assess each student's work continuously over the whole unit and compare it with the following description, based on the Competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

Students working at the minimum requirement level will be able to: List common organic acids & mention their sources; write the general formula of saturated monocarbocylic acids, the molecular formulas & names of the first six members & the structural formulas for the first four members; give examples for monocarboxylic, dicarboxylic & tricarboxylic acids; explain the general methods of preparation of acetic acid, & conduct experiment to prepare acetic acid in the laboratory; describe the physical & chemical properties of saturated monocarbaxylic acids; name & write structural formulas of some fatty acids; describe some uses of common carboxylic acids; list common sources of esters; write the general structural formula of esters & the molecular formulas & names of some simple esters; explain the general methods of preparation of esters; describe the physical & chemical properties of esters, & some uses of common esters; define fats, oils, soap & detergent; write the general structural formulas of fats & oils, & the structures of some common triglycerides; describe physical properties of fats & oils; explain rancidity & hardening of oils, explain saponification & prepare soap, & explain the cleaning action of soap.

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.