

**CHEMISTRY**  
**ADVANCED SUPPLEMENTARY LEVEL**

The syllabus builds on the foundation of the HKCE Chemistry syllabus, a knowledge of which is assumed.

The syllabus has been designed for a two-year chemistry course at advanced supplementary level. It will adequately prepare students for further studies in chemistry-related disciplines.

The syllabus is not a teaching syllabus and the order of the topics listed is not intended to suggest a teaching sequence. Explanatory notes have been included in the syllabus as appropriate to indicate the scope and depth of treatment. However, the length of the notes on any particular section should not be regarded as an indication of the time to be spent on that section.

Experiments and activities suggested in the syllabus are more than enough. Some of the experiments and/or activities are alternative ones which are similar in nature. Teachers are advised to make discretionary choices as appropriate.

**AIMS**

The aims of the syllabus are to enable candidates:

1. to develop an interest in the study of chemistry and scientific literacy for adult life in a changing world;
2. to develop an understanding of the facts and patterns in the empirical world;

3. to develop an understanding of the concepts and principles of chemistry;
4. to develop experimental skills and an awareness of safety problems;
5. to develop skills for scientific investigation, including the ability to observe, to analyse and to interpret data objectively;
6. to develop the ability to communicate using the language of chemistry;
7. to develop the ability to solve problems and to make rational decisions;
8. to develop an appreciation of chemistry and its application in daily life; and
9. to develop an awareness of the social, economic, environmental and technological implications of chemistry.

### **ASSESSMENT OBJECTIVES**

The objectives of the examination are to test the following abilities:

1. to recall and show understanding of chemical facts, patterns, principles, terminology and conventions;
2. to show an understanding of the use of apparatus and materials in performing experiments,
3. to handle materials, manipulative apparatus, carry out experiments safely and make accurate observations;
4. to demonstrate an understanding of the method used in chemical investigation;
5. to analyse and interpret data from various sources, and draw relevant conclusions;
6. to manipulate and translate chemical data and to perform calculations;
7. to apply chemical knowledge to explain observations and to solve problems which may involve unfamiliar situations;
8. to select and organise scientific information from appropriate sources and to communicate this information in an appropriate and logical manner;
9. to understand the social, economic, environmental and technological implications of the applications of chemistry; and
10. to make decisions based on the examination of evidence and arguments.

**MODE OF ASSESSMENT**

The table below outlines the various components of the assessment:

Paper	Description	Weighting	Duration
1	Section A: Short questions ( <i>compulsory</i> questions)	32%	1 hour 30 minutes
	Section B: Essay questions (a choice of 1 out of 2 questions)	8%	
2	Structured questions ( <i>compulsory</i> questions)	40%	1 hour 30 minutes
3	Teacher Assessment Scheme <sup>1</sup>	20%	throughout the AS-level course

<sup>1</sup> The Teacher Assessment Scheme (TAS) is compulsory for all candidates. In the TAS, school candidates will be assessed by their teachers on their abilities in a range of practical skills as well as their attitudes towards the study of Chemistry throughout the AS-level course. The detailed requirements, regulations, assessment criteria, guidelines and methods of assessment are given in the TAS Handbook for Advanced Level Chemistry issued by the Hong Kong Examinations and Assessment Authority to schools.

Only those private candidates, who have TAS marks submitted to HKEAA two years prior to the year of examination, are allowed to sit the AS-level Chemistry Examination. The Paper 3 marks of these candidates will be derived from the marks previously submitted by their schools.

**The Written Papers (Papers 1 and 2)**

The examination papers may contain questions set on unfamiliar situations. In such questions, candidates may be required to study information presented in the form of text, diagrams and graphs, and to apply their chemical knowledge to answer questions set on the information given.

**Teacher Assessment Scheme (Paper 3)**

The minimum number of experiments that should be performed in the AS-level Chemistry course is 13. The assessment of practical abilities covers the following three areas:

Ability area A:

- (a) to use apparatus and to demonstrate appropriate manipulative skills in carrying out experiments;
- (b) to make accurate observations and measurements.

Ability area B:

- (a) to record and to present data in an appropriate form;
- (b) to interpret experimental results and to draw appropriate conclusions;
- (c) to plan experiments.

Ability area C : attitude towards practical chemistry.

**NOTES**

1. In general, SI units will be used.
2. In naming compounds, the useful references are “Guidelines for Systematic Chemical Nomenclature (2002)” by the Hong Kong Examinations and Assessment Authority, and “Chemical Nomenclature, Symbols and Terminology for Use in School Science” (1985) by the Association for Science Education (U.K.). The overriding rule for the naming of compounds is clarity and lack of ambiguity rather than adherence to strict rules.
3. “An English-Chinese Glossary of Terms Commonly Used in the Teaching of Chemistry in Secondary Schools” (1999) prepared by the Curriculum Development Council, issued by the Education Department is a useful reference for the Chinese terms.
4. All candidates, both school and private candidates, may be required to submit their laboratory books for inspection.

**1. Mole and Stoichiometry**

In this beginning section, students will revisit some of the concepts learnt in the S4-5 curriculum. Students should recognise that owing to the small size of atoms, molecules and ions, properties of these species are often compared on a mole basis and that the Avogadro constant is a number which chemists commonly use in the comparison of physical and chemical properties of substances. Stoichiometry is the study of quantitative composition of chemical substances and the quantitative changes that take place during chemical reactions. Doing calculations on chemical stoichiometry can help students reinforce their concepts learnt in quantitative chemistry.

Students are expected to know the ideal gas equation, which describes the pressure, volume and temperature relationship of gases. However, knowledge of the kinetic theory of gases and the non-ideal behaviour of real gases are *not* required.

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
1.1	The mole concept	Relative isotopic, atomic and molecular masses. The mole and the Avogadro constant. Molar volume of gases. Ideal gas equation, $pV=nRT$ .	
1.2	Empirical and molecular formulae	Derivation of empirical formula using combustion data or composition by mass. Molecular formula derived from empirical formula and relative molecular mass.	

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
1.3	Chemical equation and stoichiometry	The stoichiometric relationship between reactants and products in a reaction. Calculations involving (i) reacting masses, (ii) volumes of gases, and (iii) concentrations and volumes of solutions.	Perform titrations involving acid-base reactions, redox reactions or other changes to illustrate concepts related to stoichiometry.
<b>2. Structure of Atoms and the Periodic Table</b>			
All substances are made up of atoms. Understanding atoms can help us comprehend intriguing phenomena such as bonding and structure, and predict properties of matter.			
The atomic properties of an element are related to its electronic configuration and hence its position in the Periodic Table. Students should appreciate the variation of atomic properties of elements across a period and descending a group. They should also be able to predict properties of an unknown element with reference to its position in the Periodic Table. As topics 2.5 and 7.1 are linked, students may need to refer the two topics from time to time to build up a clear picture about atomic properties and the Periodic Table.			
	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
2.1	The atomic structure	Protons, neutrons and electrons as constituents of the atom. The relative masses and charges of a proton, neutron and electron. The atomic nucleus. Relative size of the atom and atomic nucleus.	

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
2.2	Electronic structure: electron shell and subshell	Evidences of existence of shells and subshells from plots of the following graphs: (i) successive ionisation enthalpies for a particular element, and (ii) first ionisation enthalpies against atomic numbers (up to $Z=20$ ).	
2.3	Atomic orbital	Atomic orbital as a representation of region in space within which there is a high probability of finding an electron. Pictorial representations of s and p orbitals. The number and relative energies of the s, p and d orbitals for the principal quantum numbers 1, 2 and 3, and also of 4s orbital.	
2.4	Electronic configuration	Building up of electronic configurations of atoms based on three principles : (i) electrons enter the orbitals in order of ascending energy (aufbau principle), (ii) orbitals of the same energy must be occupied singly before pairing occurs (Hund's rule), and (iii) electrons occupying the same orbital must have opposite spins (Pauli exclusion principle).	



	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
		Electronic configurations of isolated atoms from H to Zn. Electronic configurations of atoms represented by (i) notations using 1s, 2s, 2p, ... etc., and (ii) 'electrons-in-boxes' diagrams.	
2.5	The Periodic Table and the atomic properties of the elements	The Periodic Table, showing the s-, p-, d- and f-blocks. Interpretation of the trends of ionisation enthalpies and atomic radii of the elements in the Periodic Table. (Linked with Section 7.1)	Search and present information about different versions of the Periodic Table.

### 3. Energetics

Chemical reactions are accompanied by energy changes. The energy absorbed or released by a chemical system may take different forms. This section begins by introducing the basic concepts of chemical energetics and enthalpy terms commonly encountered. Carrying out experiments using simple calorimetric methods can help students better understand the concepts of energetics. The use of equipment like bomb calorimeter is *not* expected.

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
3.1	Energy changes in chemical reactions	Conservation of energy. Endothermic and exothermic reactions and their relationship to breaking and forming of bonds.	Search and present information about the use of chemical energy in daily life.
3.2	Standard enthalpy changes	Enthalpy change, $\Delta H$ , as heat change at constant pressure. Standard enthalpy change of: (i) neutralisation, (ii) solution, (iii) formation, and (iv) combustion. Experimental determination of enthalpy changes of reactions using simple calorimetric method.	Determine the enthalpy changes of neutralisation, solution or combustion.
3.3	Hess's law	Use of Hess's law to determine enthalpy changes which cannot be easily obtained by experiment directly. Enthalpy level diagrams. Calculations involving enthalpy changes of reactions.	Determine the enthalpy change of formation of metal oxides, metal carbonates or the enthalpy change of hydration of metal salts.

#### 4. Bonding and Structure

This section builds on Section 2 of the S4-5 Chemistry curriculum. Students should appreciate that the existence of the vast variety of substances in the material world is related to bonding and structure. They will learn how to draw Lewis structures of simple chemical species and to account for the properties of simple compounds in terms of the interaction between particles involved.

In this section, students should learn that the octet rule has its limitations. The formation of chemical bonds should better be explained in terms of the electrostatic interactions. The energetics for the formation of a compound can provide us some quantitative information about the relative stability of the compound. Studying the pressure-temperature diagrams of water and carbon dioxide can help students understand the change of phases in relation to intermolecular forces and kinetic energy of molecules. However, the phase rule is *not* required.

This section is concluded by a study of the relationship between structures and properties of substances. As the properties of a substance are related to the nature of particles it contains as well as its structure, knowing the structure of a substance can help us decide its application. Sometimes materials are designed to have specific properties.

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
4.1	The nature of forces holding atoms together	Electrostatic interactions between electrons and nuclei leading to different types of bonding.	
4.2	Metallic bonding	Metallic bonding illustrated by a model consisting of cationic lattice and mobile valence electrons. Strength of metallic bond in relation to metallic radius and the number of valence electrons per atom.	

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
	Alloys	Properties of alloys as compared with their constituents.	Search and present information about the properties and uses of alloys.
4.3	Ionic bonding	Formation of ions – the tendency for atoms of elements in Groups I, II, VI and VII to attain electronic configurations of noble gases.	
	Energetics of formation of ionic compounds	Born-Haber cycles for the formation of ionic compounds in terms of enthalpy changes of atomisation and ionisation, electron affinities and lattice enthalpies.	Compare the standard enthalpy changes of formation of $\text{MgCl}(\text{s})$ , $\text{MgCl}_2(\text{s})$ and $\text{MgCl}_3(\text{s})$ to establish the formula of magnesium chloride.
4.4	Covalent bonding	Formation of covalent bond by overlap of atomic orbitals. Dative covalent bond. Multiple bonds.	
	Bond enthalpy	Estimation of bond enthalpies using data from energetics. Bond enthalpies as a comparison of the strength of covalent bonds.	

<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
Shapes of molecules and of polyatomic ions	The directional nature of covalent bonds. Explanation and prediction of the shapes of simple molecules and polyatomic ions (as illustrated by $\text{BF}_3$ , $\text{CH}_4$ , $\text{NH}_3$ , $\text{H}_2\text{O}$ , $\text{PCl}_5$ , $\text{SF}_6$ , $\text{NH}_4^+$ and $\text{NH}_2^-$ ) using the Valence Shell Electron Pair Repulsion Theory. Bond angles.	Display/Build models of simple molecules.
Polar covalent bond	Displacement of an electron cloud leading to the formation of a polar covalent bond. Dipole moment as evidence for bond polarisation in simple molecules. Unequal sharing of bonded electron pairs explained in terms of the electronegativity difference between bonded atoms. Electronegativity (Pauling's scale) introduced as an arbitrary measure of an atom's tendency in a molecule to attract electrons.	Investigate the effect of a non-uniform electrostatic field on a jet of liquid.
4.5 Intermolecular forces		
van der Waals forces	Brief discussion of the origin of van der Waals forces in terms of permanent, instantaneous and induced dipoles. The pressure-temperature diagram of carbon dioxide.	

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
	Hydrogen bonding	<p>A study of the boiling points and enthalpy changes of vaporization of the hydrides of Groups IV, V, VI and VII and compounds like alcohols and carboxylic acids leading to the idea of hydrogen bonding.</p> <p>Nature of hydrogen bonding.</p> <p>Relative strength of van der Waals forces and hydrogen bonding.</p> <p>Hydrogen bonding in ice, proteins and DNA (deoxyribonucleic acid).</p> <p>The pressure-temperature diagram of water.</p>	<p>Determine the strength of the hydrogen bond formed between ethanol molecules.</p> <p>Investigate the effect of hydrogen bond on liquid flow.</p>
4.6	Structures and properties of substances	Interpretation of the physical properties of substances based on their structures and bonding.	

## 5. Chemical Kinetics

We know from our experience that some reactions take a long time to occur, while others happen extremely rapidly. Chemical kinetics is the study of reaction rates, factors that affect reaction rates and reaction mechanisms.

In this section, students will learn different methods commonly used in following the progress of a reaction and how rate equations can be obtained from experimental results. With the use of more sophisticated instruments such as data-loggers, practical work can be performed more effectively and yield better results.

Students should know that rate equations are based on experimental results, while reaction mechanisms are suggested pathways of reactions. The simple collision theory provides an explanation for single-step gaseous reactions in terms of collision between molecules. The transition state theory describes how reacting species react to give the transition state and then the products. However, mathematical treatment involving the two theories is *not* required.

Catalysts play an important role both in research and in chemical industries. Students should know the two classes of catalysis, namely homogeneous catalysis and heterogeneous catalysis, and draw an appropriate energy profile for a catalytic reaction. They should also be aware that practically all reactions occurring in living systems are catalysed by enzymes and that each enzyme is specific for a particular process.

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
5.1	Rate of chemical reaction	The meaning of the rate of a chemical reaction. Following a reaction by chemical and physical methods, viz. following the change in amount of reactant/product by titration, determining the volume of gas formed, or colorimetric measurement of light intensity at different times.	

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
5.2	Factors influencing reaction rate	Effects of concentration, temperature, pressure, surface area and catalyst on reaction rate.	Design and perform experiments to investigate the factors affecting reaction rate.
5.3	Rate equation and order of reaction	Simple rate equations determined from experimental results. Zeroth, first and second order reactions. Rate constants. Half-life of a first order reaction.	Determine the order of a reaction.
5.4	Arrhenius equation	Explanation of the effect of temperature change on reaction rate in terms of activation energy. Application of the Arrhenius equation $\ln k = \text{constant} - \frac{E_a}{RT}$ to determine the activation energy of a reaction.	Determine the activation energy of a reaction.
5.5	The interpretation of reaction rate at molecular level	Elementary and multi-step reactions. Rate determining step. Application of simple collision theory to gaseous systems and its limitation. Transition state and energy profile.	
5.6	Catalysis	Catalysts can change the rate of a reaction by providing an alternative pathway for the reaction.	



*Topics*

*Explanatory Notes*

*Relevant Activities*

Homogeneous and heterogeneous catalysis.

- Investigate the catalytic effect of
- (a) acid on the iodination of propanone
  - (b) manganese(IV) oxide on the decomposition of hydrogen peroxide
  - (c)  $\text{Mn}^{2+}(\text{aq})$  on the reaction between  $\text{MnO}_4^- (\text{aq})$  and  $\text{C}_2\text{O}_4^{2-} (\text{aq})$  in acidic medium.

Applications of catalysis: iron in the Haber process, catalytic converters in car exhaust systems and enzymes in the production of alcoholic drinks.

Search and present information about the importance of catalysis.

## 6. Chemical Equilibrium

The concept of a state of equilibrium is fundamental in chemistry. Students should appreciate the dynamic nature of chemical equilibrium, in particular the constancy of intensive properties and the shifting of equilibrium position when a system at equilibrium is subjected to change. It is therefore important to control variables such as pressure, concentration and temperature in an industrial process so that the optimal reaction conditions can be established.

The equilibrium law provides a quantitative relationship of the concentrations of the reactants and products in system at equilibrium. Students should know the equilibrium constants,  $K_c$ , and the application of the equilibrium law to acid-base systems.

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
6.1	Dynamic equilibrium	Characteristics of dynamic equilibrium.	Investigate some equilibrium systems: (a) Effect of pH on an aqueous solution of Br <sub>2</sub> (b) Effect of pH on the K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> (aq)/K <sub>2</sub> CrO <sub>4</sub> (aq) system.
	The equilibrium law	Equilibrium constants expressed in terms of concentrations ( $K_c$ ). Calculations of $K_c$ .	Determine $K_c$ for a reaction: $\text{CH}_3\text{CO}_2\text{H}(\ell) + \text{C}_2\text{H}_5\text{OH}(\ell) \rightleftharpoons \text{CH}_3\text{CO}_2\text{C}_2\text{H}_5(\ell) + \text{H}_2\text{O}(\ell)$ or $\text{Fe}^{3+}(\text{aq}) + \text{NCS}^-(\text{aq}) \rightleftharpoons \text{FeNCS}^{2+}(\text{aq})$

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
	Effect of concentration, pressure and temperature on equilibrium	<p>Changes in concentration and pressure result in the adjustment of the system without changing the value of equilibrium constant, <math>K</math>.</p> <p>Calculations on equilibrium composition involving changes in concentration.</p> <p>A change in temperature results in the adjustment of the system to a new equilibrium constant.</p> <p>Relation of temperature and the value of <math>K</math> illustrated by the equation:</p> $\ln K = \text{constant} - \frac{\Delta H}{RT}$ <p>Equilibrium and kinetic considerations in industrial processes as exemplified by the Haber process. (Linked with Section 5)</p>	<p>Predict the shift in equilibrium position by calculating the reaction quotient.</p> <p>Investigate the effect of temperature and pressure change on the following reaction:</p> $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$
6.2	Acid-base Equilibrium		
	Concept of acid/base	<p>Brønsted-Lowry theory.</p> <p>Acid-base properties of organic compounds exemplified by carboxylic acids, alcohols and amines.</p>	
	Dissociation of water and pH	<p>Ionic product of water, <math>K_w</math>.</p> <p>pH and its measurement.</p>	

<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
Strong and weak acids/bases	Dissociation constants for weak acids ( $K_a$ ) and weak bases ( $K_b$ ). Use of $K_a$ and $K_b$ ( $pK_a$ and $pK_b$ ) values to compare the strength of weak acids or weak bases. Calculations involving pH, $K_a$ and $K_b$ . (For dissociation involving more than one step, calculations are limited to one of these steps only.)	Determine $K_a$ of a weak acid/ $K_b$ of a weak base by pH measurement.
Buffer	Principle of buffer action. Calculations involving the composition and pH of buffer solutions.	Compare the effects of acid/alkali on the pH of buffered and unbuffered solutions.
Acid-base titration and the choice of indicator	pH titration curves. Simple theory of acid-base indicators. Choice of indicators in relation to their pH range of colour changes.	Determine the pH ranges of some acid-base indicators. Perform acid-base titrations using method of double indicator.

**7. Periodic Properties of the Elements in the Periodic Table**

Through the study of this section, students can develop an understanding about the importance of the periodic table in Chemistry. Knowledge and concepts about the periodic trends of physical properties of some elements and periodic relationship of properties of selected oxides are required.

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
7.1	Periodic variation in physical properties of the elements H to Ar	Variations in first ionisation enthalpies, atomic radii, electronegativities and melting points. Interpretation of these variations in terms of structure and bonding. (Linked with Section 2.5)	
7.2	Periodic relationship among the oxides of the elements Li to Cl	Bonding and stoichiometric composition of the oxides of these elements, and their behaviour with water, dilute acids and dilute alkalis.	Investigation of the properties of the oxides of the Period 3 elements.

## 8. Organic Chemistry

Organic chemistry is a very important branch of chemistry as judged from the uniqueness of carbon and ubiquitousness of organic compounds. Together with the basic concepts and knowledge acquired in previous learning, students can build up concepts related to the structural characteristics of some common organic compounds. Furthermore, students are expected to be able to use systematic names and common trivial names of organic compounds to communicate knowledge and understanding in study and in daily life.

Students will learn about the chemistry of a number of functional groups. Through a study of the reactions of the functional groups (including the reagents, reaction conditions and observations), students will know the chemical methods on distinguishing different functional groups and identification of unknown organic compounds. Besides, students should recognise the relationships between different functional groups and be aware of the most important applications of organic chemistry, i.e. the synthesis of useful organic compounds through inter-conversions between different functional groups. Students should carry out experimental work, including simple chemical tests and preparations of organic compounds, to illustrate the reactions included in this section.

After studying this section, students should have a basic understanding of organic chemistry. However, the use of reaction mechanisms to explain how organic compounds react is *not* required.

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
8.1	Functional groups and homologous series	<p>Studies of the following functional groups:  <math>\text{&gt;C=C&lt;}</math> , <math>-\text{X}</math> , <math>-\text{OH}</math> , <math>-\text{O}-</math> , <math>-\text{CHO}</math> , <math>\text{&gt;C=O}</math> , <math>-\text{CO}_2\text{H}</math> ,  <math>-\text{NH}_2</math> , <math>-\text{NHR}</math> , <math>-\text{CN}</math> , <math>-\text{CO}_2\text{R}</math> , and <math>-\text{CONH}_2</math> .</p> <p>Effects of functional groups and the length of carbon chains on physical properties of organic compounds.</p>	<p>Display/Build models of compounds with different functional groups.</p> <p>Compare physical properties of the following compounds: propane, butanes, pentanes, methoxymethane, methoxyethane, ethoxyethane, ethanol, propan-1-ol and butan-1-ol.</p>

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
8.2	Systematic nomenclature	Systematic nomenclature of compounds containing carbon chains of <i>not</i> more than eight carbon atoms.	Search trivial names of common organic compounds.
8.3	Isomerism	Structural isomerism. Isomers containing the same functional group and isomers containing different functional groups.  Geometrical isomerism. Rigidity of C=C bond leading to <i>cis/trans</i> isomers in acyclic organic compounds.  Enantiomerism as exemplified by compounds with one chiral carbon.	Display/Build models of but-2-enes. Compare the properties of <i>cis</i> and <i>trans</i> -butenedioic acids. Illustrate optical activity using crossed polaroids or a polarimeter. Study three-dimensional models of compounds with chiral carbons. Search and present information on 'chiral drugs'.

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
8.4	Typical reactions of various functional groups	<p>Studies of the reactions of the following functional groups:</p> <ul style="list-style-type: none"><li>(i) Alkane: substitution with halogens</li><li>(ii) Alkene: addition of hydrogen, halogens and hydrogen halides</li><li>(iii) Haloalkanes: substitution with <math>\text{OH}^-</math> and <math>\text{CN}^-</math></li><li>(iv) Alcohols: substitution with halides; dehydration to alkenes; oxidation of primary alcohols to aldehydes and carboxylic acids; oxidation of secondary alcohols to ketones</li><li>(v) Aldehydes and ketones: reactions with HCN and hydrazines</li><li>(vi) Carboxylic acids: esterification, reduction and amide formation</li><li>(vii) Esters: hydrolysis</li><li>(viii) Amides: hydrolysis</li></ul> <p>Inter-conversions between the functional groups.</p>	<p>Detect the presence of functional groups by simple chemical tests.</p> <p>Prepare 2-chloro-2-methylpropane from 2-methylpropan-2-ol.</p> <p>Identify a carbonyl compound by preparing its derivatives.</p> <p>Analyse commercial aspirin tablets.</p> <p>Inspect reaction schemes and important synthetic routes in organic chemistry.</p>



**9. Chemistry in Action**

One of the contributions of chemists to our society is to synthesise a range of very useful materials like plastics. Chemists also play an indispensable role in the development of new drugs for the well being of humans. Students are expected to view structures of some common drugs, but recitation of the structures is *not* required. A study of the science of polymers and the active ingredients of some commonly used drugs facilitates students to develop a better understanding of the relation of science, technology, society and the environment. Finally, students are expected to have an appreciation of the role of chemists on the sustainable development through the study of concepts and applications related to green chemistry.

<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
9.1 Synthetic polymers	<p>Addition polymerisation. Formation and uses of addition polymers as exemplified by polyethene (PE), polypropene (PP), polystyrene (PS), polyvinyl chloride (PVC), polytetrafluoroethene (PTFE) and polymethyl methacrylate (PMMA).</p> <p>Condensation polymerisation. Formation and uses of polyamides and polyesters as exemplified by nylon, Kevlar and Dacron and urea-methanal.</p>	<p>Watch video on fabrication of plastics.</p> <p>Discuss the impacts of synthetic polymers on our society.</p>

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
		Effect of structure on properties such as density, hardness, rigidity, elasticity and biodegradability as exemplified by (i) high density polyethene and low density polyethene, (ii) nylon and Kevlar, (iii) vulcanisation of polymers, and (iv) biodegradable plastics.	Search and present information related to structure and properties of polymeric materials used as adhesives, semiconductors and drug-carriers.
9.2	Drugs	Key stages of drug development as exemplified by the development of aspirin: (i) lead compound discovery, (ii) molecular modification, (iii) formulation development, (iv) safety tests and human trials, and (v) approval for marketing.	Study the structures and uses of over-the-counter drugs like aspirin, acetaminophen and vitamin C.  Search and present information on the historical development of aspirin.  Extract acetylsalicylic acid from commercial aspirin tablets.

	<i>Topics</i>	<i>Explanatory Notes</i>	<i>Relevant Activities</i>
		Narcotic drugs such as morphine and heroin, and their adverse effects. Stimulants such as ketamine and phenylethylamine, and their adverse effects.	Discuss physiological action and psychological effect of common narcotic and stimulant drugs like morphine, codeine, heroin, cannabis, lysergic acid diethylamide (LSD), Ecstasy and ketamine.  Discuss the pros and cons on using drugs.
9.3	Green Chemistry	Principles of green chemistry for promoting sustainable development.  Green chemistry practices as exemplified by (i) decaffeination using supercritical carbon dioxide, and (ii) the use of H <sub>2</sub> O <sub>2</sub> in the presence of manganese based catalyst as bleaching agent.	Discuss the feasibility of using the principles of green chemistry for daily life applications of chemistry  Search and present information on the application of green chemistry in practices.