Combined Science Curriculum and Assessment Guide (Secondary 4 – 6) –

Chemistry Part

(To be first implemented in the 2013/14 school year for Secondary 4 students)

Notes for Teachers

INTRODUCTION

The Curriculum Development Council (CDC), the Education Bureau (EDB) and the Hong Kong Examinations and Assessment Authority (HKEAA) have jointly reviewed the NSS curriculum and assessment, after the first cycle of implementation. Recommendations have been put forward based on the views and suggestions collected from various stakeholders.

This document consists of two parts. Part I aims to illustrate the recommendations for the curriculum contents with the changes on the overviews, learning objectives (students should learn), learning outcomes (students should be able to), suggested learning and teaching activities, values and attitudes, and science-technology-society-environment connections of the curriculum topics. These recommendations will begin to be implemented in the 2013/14 school year for Secondary 4 students who will sit the 2016 HKDSE Examination. Teachers should also make reference to the captioned Guide (or the Guide) published in 2007 by the CDC and the HKEAA when planning the curriculum. The revised curriculum in Part I of this document can replace Part 2 of section 2.3 of the Guide.

Part II aims to highlight some key aspects of the Guide, and to interpret the depth and breadth of some topics of the Curriculum for the reference of teachers. The explanatory notes listed in this part are by no means exhaustive nor intended to dictate the scope of learning and teaching at the classrooms. Instead, the notes serve as a reference for teachers to plan how to implement the curriculum in consideration of their students' interests and abilities, and availability of teaching time and resources.

PART I – UPDATES FOR THE COMBINED SCIENCE (CHEMISTRY PART) CURRICULUM (TO BE FIRST IMPLEMENTED IN THE 2013/14 SCHOOL YEAR FOR SECONDARY 4 STUDENTS)

I Planet Earth

Overview

The natural world is made up of chemicals which can be obtained from the earth's crust, the sea and the atmosphere. The purpose of this topic is to provide opportunities for students to appreciate that we are living in a world of chemicals and that chemistry is a highly relevant and important area of learning. Another purpose of this topic is to enable students to recognise that the study of chemistry includes the investigation of possible methods to isolate useful materials in our environment and to analyse them. Students who have completed this topic are expected to have a better understanding of scientific investigation and chemistry concepts learned in the junior science curriculum.

Students should know the terms "element", "compound" and "mixture", "physical change" and "chemical change", "physical property" and "chemical property", "solvent", "solute" and "saturated solution". They should also be able to use word equations to represent chemical changes, to suggest appropriate methods for the separation of mixtures, and to undertake tests for chemical species.

Students should learn	Students should be able to
a. The atmosphere	
• composition of air • separation of oxygen and nitrogen from liquid air by fractional distillation	• describe the processes involved in fractional distillation of liquid air, and understand the concepts and procedures involved
• test for oxygen	• demonstrate how to carry out a test for oxygen

Students should learn	Students should be able to
b. The ocean	
• composition of sea water • extraction of common salt and isolation of pure water from sea water • tests to show the presence of sodium and chloride in a sample of common salt • test for the presence of water in a sample • electrolysis of sea water and uses of the products	• describe various kinds of minerals in the sea • demonstrate how to extract common salt and isolate pure water from sea water • describe the processes involved in evaporation, distillation, crystallisation and filtration as different kinds of physical separation methods and understand the concepts and procedures involved • evaluate the appropriateness of using evaporation, distillation, crystallisation and filtration for different physical separation situations • demonstrate how to carry out the flame test, test for chloride and test for water

Students should learn	Students should be able to
c. Rocks and minerals	
• rocks as a source of minerals • isolation of useful materials from minerals as exemplified by the extraction of metals from their ores • limestone, chalk and marble as different forms of calcium carbonate • erosion processes as exemplified by the action of heat, water and acids on calcium carbonate • thermal decomposition of calcium carbonate and test for carbon dioxide • tests to show the presence of calcium and carbonate in a sample of limestone/chalk/marble	• describe the methods for the extraction of metals from their ores, such as the physical method, heating alone and heating with carbon • describe different forms of calcium carbonate in nature • understand that chemicals may change through the action of heat, water and acids • use word equations to describe chemical changes • demonstrate how to carry out tests for carbon dioxide and calcium

Suggested Learning and Teaching Activities

Students are expected to develop the learning outcomes using a variety of learning experiences. Some related examples are:

- searching for information on issues related to the atmosphere, such as air pollution and the applications of the products obtained from fractional distillation of liquid air.
- using an appropriate method to test for oxygen and carbon dioxide.
- performing experiments and evaluating methods of physical separation including evaporation, distillation, crystallisation and filtration.
- using appropriate apparatus and techniques to carry out the flame test and test for chloride.
- performing a test to show the presence of water in a given sample.
- doing problem-solving exercises on separating mixtures (e.g. a mixture of salt, sugar

and sand, and a mixture of sand, water and oil).

- extracting silver from silver oxide.
- investigating the actions of heat, water and acids on calcium carbonate.
- designing and performing chemical tests for calcium carbonate.
- participating in decision-making exercises or discussions on issues related to conservation of natural resources.
- describing chemical changes using word equations.

Values and Attitudes

Students are expected to develop, in particular, the following *values and attitudes*:

- to value the need for the safe handling and disposal of chemicals.
- to appreciate that the earth is the source of a variety of materials useful to human beings.
- to show concern over the limited reserve of natural resources.
- to show an interest in chemistry and curiosity about it.
- to appreciate the contribution of chemists to the separation and identification of chemical species.

STSE Connections

Students are encouraged to appreciate and comprehend issues which reflect the interconnections of science, technology, society and the environment. Related examples are:

- Oxygen extracted from air can be used for medicinal purposes.
- Methods involving chemical reactions are used to purify drinking water for travellers to districts without a clean and safe water supply.
- Desalination is an alternative means of providing fresh water to the Hong Kong people rather than importing water from the Guangdong province.
- Mining and extraction of chemicals from the earth should be regulated to conserve the environment.
- Products obtained by the electrolysis of sea water are beneficial to our society.

II Microscopic World

Overview

The study of chemistry involves the linkage between phenomena in the macroscopic world and the interaction of atoms, molecules and ions in the microscopic world. Through studying of the structures of atoms, molecules and ions, and the bonding in elements and compounds, students will acquire knowledge of some basic chemical principles. These can serve to further illustrate the macroscopic level of chemistry, such as patterns of changes, observations in various chemical reactions, the rates of reactions and chemical equilibria. In addition, students should be able to perform calculations related to chemical formulae, which are the basis of mole calculations to be studied in later topics.

Students should also be able to appreciate the interrelation between bonding, structures and properties of substances by learning the properties of metals, giant ionic substances, simple molecular substances and giant covalent substances. With the knowledge of various structures, students should be able to differentiate the properties of substances with different structures, and to appreciate that knowing the structure of a substance can help us decide its applications.

Through activities such as gathering and analysing information about atomic structure and the Periodic Table, students should appreciate the impact of the discoveries of atomic structure and the development of the Periodic Table on modern chemistry. Students should also be able to appreciate that symbols and chemical formulae constitute part of the common language used by scientists to communicate chemical concepts.

Students should learn	Students should be able to
a. Atomic structure	
• elements, atoms and symbols • classification of elements into metals, non-metals and metalloids • electrons, neutrons and protons as subatomic particles • simple model of atom • atomic number (Z) and mass number (A) • isotopes • isotopic masses and relative atomic masses based on $^{12}C=12.00$ • electronic arrangement of atoms (up to Z=20) • stability of noble gases related to their electronic arrangements	• state the relationship between element and atom • use symbols to represent elements • classify elements as metals or non-metals on the basis of their properties • be aware that some elements possess characteristics of both metals and non-metals • state and compare the relative charges and the relative masses of a proton, a neutron and an electron • describe the structure of an atom in terms of protons, neutrons and electrons • interpret and use symbols such as $^{23}_{11}Na$ • deduce the numbers of protons, neutrons and electrons in atoms and ions with given atomic numbers and mass numbers • identify isotopes among elements with relevant information • perform calculations related to isotopic masses and relative atomic masses • understand and deduce the electronic arrangements of atoms • represent the electronic arrangements of atoms using electron diagrams • relate the stability of noble gases to the octet rule

Students should learn	Students should be able to
b. The Periodic Table • the position of the elements in the Periodic Table related to their electronic arrangements • similarities in chemical properties among elements in Groups I, II, VII and 0	• understand that elements in the Periodic Table are arranged in order of ascending atomic number • appreciate the Periodic Table as a systematic way to arrange elements • define the group number and period number of an element in the Periodic Table • relate the position of an element in the Periodic Table to its electronic structure and vice versa • relate the electronic arrangements to the chemical properties of the Groups I, II, VII and 0 elements • describe differences in reactivity of Groups I, II and VII elements • predict chemical properties of unfamiliar elements in a group of the Periodic Table
c. Metallic bonding	• describe the simple model of metallic bond
d. Structures and properties of metals	• describe the general properties of metals • relate the properties of metals to their giant metallic structures

Students should learn

e. Ionic and covalent bond

- transfer of electrons in the formation of ionic bond
- cations and anions
- electron diagrams of simple ionic compounds
- names and formulae of ionic compounds
- ionic structure as illustrated by sodium chloride
- sharing of electrons in the formation of covalent bond
- single, double and triple bonds
- electron diagrams of simple covalent molecules
- names and formulae of covalent compounds
- formula masses and relative molecular masses

Students should be able to

- describe, using electron diagrams, the formation of ions and ionic bonds
- draw the electron diagrams of cations and anions
- predict the ions formed by atoms of metals and non-metals by using information in the Periodic Table
- identify polyatomic ions
- name some common cations and anions according to the chemical formulae of ions
- name ionic compounds based on the component ions
- describe the colours of some common ions in aqueous solutions
- interpret chemical formulae of ionic compounds in terms of the ions present and their ratios
- construct formulae of ionic compounds based on their names or component ions
- describe the structure of an ionic crystal
- describe the formation of a covalent bond
- describe, using electron diagrams, the formation of single, double and triple bonds
- describe the formation of the dative covalent bond by means of electronic diagram using H_3O^+ and NH_4^+ as examples
- interpret chemical formulae of covalent compounds in terms of the elements present and the ratios of their atoms

Students should learn	Students should be able to
	• write the names and formulae of covalent compounds based on their component atoms • communicate scientific ideas with appropriate use of chemical symbols and formulae • define and distinguish the terms: formula mass and relative molecular mass • perform calculations related to formula masses and relative molecular masses of compounds
f. Structures and properties of giant ionic substances	• describe giant ionic structures of substances such as sodium chloride and caesium chloride • state and explain the properties of ionic compounds in terms of their structures and bonding
g. Structures and properties of simple molecular substances	• describe simple molecular structures of substances such as carbon dioxide and iodine • recognise that van der Waals' forces exist between molecules • state and explain the properties of simple molecular substances in terms of their structures and bonding
h. Structures and properties of giant covalent substances	• describe giant covalent structures of substances such as diamond, graphite and quartz • state and explain the properties of giant covalent substances in terms of their structures and bonding

Students should learn	Students should be able to
i. Comparison of structures and properties of important types of substances	• compare the structures and properties of substances with giant ionic, giant covalent, simple molecular and giant metallic structures • deduce the properties of substances from their structures and bonding, and vice versa • explain applications of substances according to their structures

Suggested Learning and Teaching Activities

Students are expected to develop the learning outcomes using a variety of learning experiences. Some related examples are:

- searching for and presenting information on the discoveries related to the structure of an atom.
- searching for and presenting information on elements and the development of the Periodic Table.
- performing calculations related to relative atomic masses, formula masses and relative molecular masses.
- drawing electron diagrams to represent atoms, ions and molecules.
- investigating chemical similarities of elements in the same group of the Periodic Table (e.g. reactions of group I elements with water, group II elements with dilute hydrochloric acid, and group VII elements with sodium sulphite solution).
- predicting chemical properties of unfamiliar elements in a group of the Periodic Table.
- writing chemical formulae for ionic and covalent compounds.
- naming ionic and covalent compounds.
- exploring relationship of colour and composition of some gem stones.
- predicting colours of ions from a group of aqueous solutions (e.g. predicting colour of K^+(aq), $Cr_2O_7^{2-}$(aq) and Cl^-(aq) from aqueous solutions of potassium chloride and potassium dichromate).
- investigating the migration of ions of aqueous solutions, e.g. copper(II) dichromate and potassium permanganate, towards oppositely charged electrodes.
- building models of three-dimensional ionic crystals and covalent molecules.
- using computer programs to study three-dimensional images of ionic crystals, simple molecular substances and giant covalent substances.

- building models of diamond, graphite, quartz and iodine.
- predicting the structures of substances from their properties, and vice versa.
- justifying some particular applications of substances in terms of their structures.
- reading articles or writing essays on the applications of materials such as graphite and aluminium in relation to their structures.

Values and Attitudes

Students are expected to develop, in particular, the following *values and attitudes*:

- to appreciate that scientific evidence is the foundation for generalisations and explanations about matter.
- to appreciate the usefulness of models and theories in helping to explain the structures and behaviours of matter.
- to appreciate the perseverance of scientists in developing the Periodic Table and hence to envisage that scientific knowledge changes and accumulates over time.
- to appreciate the restrictive nature of evidence when interpreting observed phenomena.
- to appreciate the usefulness of the concepts of bonding and structures in understanding phenomena in the macroscopic world, such as the physical properties of substances.

STSE Connections

Students are encouraged to appreciate and comprehend issues which reflect the interconnections of science, technology, society and the environment. Related examples are:

- Using the universal conventions of chemical symbols and formulae facilitates communication among people in different parts of the world.
- Common names of substances can be related to their systematic names (e.g. table salt and sodium chloride; baking soda and sodium hydrogencarbonate).
- Some specialised new materials have been created on the basis of the findings of research on the structure, chemical bonding, and other properties of matters (e.g. bullet-proof fabric, superconductors and superglue).

III Metals

Overview

Metals have a wide range of uses in daily life. Therefore, the extraction of metals from their ores has been an important activity of human beings since prehistoric times. This topic provides opportunities for students to develop an understanding of how metals are extracted from their ores and how they react with other substances. Students are expected to establish a reactivity series of metals based on experimental evidence.

The corrosion of metals poses a socioeconomic problem to human beings. It is therefore necessary to develop methods to preserve the limited reserve of metals. An investigation of factors leading to corrosion and of methods to prevent metals from corroding is a valuable problem-solving exercise and can help students develop a positive attitude towards the use of resources on our planet.

A chemical equation is a concise and universally adopted way to represent a chemical reaction. Students should be able to transcribe word equations into chemical equations and appreciate that a chemical equation shows a quantitative relationship between reactants and products in a reaction. Students should also be able to perform calculations involving the mole and chemical equations. The mole concepts acquired from this topic prepare students for performing further calculations in other topics of the curriculum.

Students should learn	Students should be able to
a. Occurrence and extraction of metals	
• occurrence of metals in nature in free state and in combined forms • obtaining metals by heating metal oxides or by heating metal oxides with carbon • extraction of metals by electrolysis	• state the sources of metals and their occurrence in nature • explain why extraction of metals is needed • understand that the extraction of metals involves reduction of their ores • describe and explain the major methods of extraction of metals from their ores

Students should learn	Students should be able to
• relation of the discovery of metals with the ease of extraction of metals and the availability of raw materials • limited reserves of metals and their conservations	• relate the ease of obtaining metals from their ores to the reactivity of the metals • deduce the order of discovery of some metals from their relative ease of extraction • write word equations for the extraction of metals • describe metal ores as a finite resource and hence the need to recycle metals • evaluate the recycling of metals from social, economic and environmental perspectives

Students should learn	Students should be able to
b. Reactivity of metals	
• reactions of some common metals (sodium, calcium, magnesium, zinc, iron, lead, copper, etc.) with oxygen/air, water, dilute hydrochloric acid and dilute sulphuric acid • metal reactivity series and the tendency of metals to form positive ions • displacement reactions and their interpretations based on the reactivity series • prediction of the occurrence of reactions involving metals using the reactivity series • relation between the extraction method of a metal and its position in the metal reactivity series	• describe and compare the reactions of some common metals with oxygen/air, water and dilute acids • write the word equations for the reactions of metals with oxygen/air, water and dilute acids • construct a metal reactivity series with reference to their reactions, if any, with oxygen/air, water and dilute acids • write balanced chemical equations to describe various reactions • use the state symbols (s), (l), (g) and (aq) to write chemical equations • relate the reactivity of metals to the tendency of metals to form positive ions • describe and explain the displacement reactions involving various metals and metal compounds in aqueous solutions • deduce the order of reactivity of metals from given information • write balanced ionic equations • predict the feasibility of metal reactions based on the metal reactivity series • relate the extraction method of a metal to its position in the metal reactivity series

Students should learn	Students should be able to
c. Reacting masses	
• quantitative relationship of the reactants and the products in a reaction as revealed by a chemical equation • the mole, Avogadro's constant and molar mass • percentage by mass of an element in a compound • empirical formulae and molecular formulae derived from experimental data • reacting masses from chemical equations	• understand and use the quantitative information provided by a balanced chemical equation • perform calculations related to moles, Avogadro's constant and molar masses • calculate the percentage by mass of an element in a compound using appropriate information • determine empirical formulae and molecular formulae from compositions by mass and molar masses • calculate masses of reactants and products in a reaction from the relevant equation and state the interrelationship between them • solve problems involving limiting reagents

Students should learn	Students should be able to
d. Corrosion of metals and their protection	
• factors that influence the rusting of iron • methods used to prevent rusting of iron • socioeconomic implications of rusting of iron • corrosion resistance of aluminium • anodisation as a method to enhance corrosion resistance of aluminium	• describe the nature of iron rust • describe the essential conditions for the rusting of iron • describe and explain factors that influence the speed of rusting of iron • describe the observations when a rust indicator (a mixture of potassium hexacyanoferrate(III) and phenolphthalein) is used in an experiment that investigates rusting of iron • describe and explain the methods of rusting prevention as exemplified by i. coating with paint, oil or plastic ii. galvanising iii. tin-plating iv. electroplating v. cathodic protection vi. sacrificial protection vii. alloying • be aware of the socio-economic impact of rusting • understand why aluminium is less reactive and more corrosion-resistant than expected • describe how the corrosion resistance of aluminium can be enhanced by anodisation

Suggested Learning and Teaching Activities

Students are expected to develop the learning outcomes using a variety of learning experiences. Some related examples are:

- searching for and presenting information about the occurrence of metals and their uses in daily life.

- analysing information to relate the reactivity of metals to the chronology of the Bronze Age, the Iron Age and the modern era.
- designing and performing experiments to extract metals from metal oxides (e.g. silver oxide, copper(II) oxide, lead(II) oxide, iron(III) oxide).
- deciding on appropriate methods for the extraction of metals from their ores.
- transcribing word equations into chemical equations.
- performing experiments to investigate reactions of metals with oxygen/air, water and dilute acids.
- constructing a metal reactivity series based on experimental evidence.
- performing experiments to investigate the displacement reactions of metals with aqueous metal ions.
- writing ionic equations.
- performing experiments to determine the empirical formula of magnesium oxide or copper(II) oxide.
- performing calculations related to moles and reacting masses.
- designing and performing experiments to investigate factors that influence rusting.
- performing experiments to study methods that can be used to prevent rusting.
- deciding on appropriate methods to prevent metal corrosion based on social, economic and technological considerations.
- searching for and presenting information about the metal-recycling industry of Hong Kong and the measures for conserving metal resources in the world.

Values and Attitudes

Students are expected to develop, in particular, the following *values and attitudes*:

- to appreciate the contribution of science and technology in providing us with useful materials.
- to appreciate the importance of making fair comparisons in scientific investigations.
- to value the need for adopting safety measures when performing experiments involving potentially dangerous chemicals and violent reactions.
- to show concern for the limited reserve of metals and realise the need for conserving and using these resources wisely.

- to appreciate the importance of the mole concept in the study of quantitative chemistry.
- to appreciate the contribution of chemistry in developing methods of rust prevention and hence its socio-economic benefit.

STSE Connections

Students are encouraged to appreciate and to comprehend issues which reflect the interconnections of science, technology, society and the environment. Related examples are:

- Although the steel industry has been one of the major profit-making industries in mainland China, there are many constraints on its growth, e.g. the shortage of raw materials in China.
- New technologies are being implemented to increase the efficiency of the metal extraction process and at the same time to limit their impacts on the environment.
- Conservation of metal resources should be promoted to arouse concern for environmental protection.
- The development of new alloys to replace pure metals is needed in order to enhance the performance of some products, such as vehicles, aircrafts, window frames and spectacles frames.

IV Acids and Bases

Overview

Acids and bases/alkalis are involved in numerous chemical processes that occur around us, from industrial processes to biological ones, and from reactions in the laboratory to those in our environment. Students have encountered acids and alkalis in their junior science courses. In this topic, they will further study the properties and reactions of acids and bases/alkalis, and the concept of molarity. Students should also be able to develop an awareness of the potential hazards associated with the handling of acids and alkalis.

Students will learn to use an instrumental method of pH measurement, to prepare salts by different methods~~,~~ and to perform volumetric analysis involving acids and alkalis. ~~, and to follow the progress of a reaction by different methods~~. Through these experimental practices students should be able to demonstrate essential experimental techniques, to analyse data and to interpret experimental results. Students are also expected to state the effects of concentration, temperature, surface area and the use of catalyst on the rate of reaction, and interpret results qualitatively from experiments of investigating factors affecting the rate of reaction. However, an interpretation at the molecular level and calculations are not expected.

Students should learn	**Students should be able to**
a. Introduction to acids and alkalis	
• common acids and alkalis in daily life and in the laboratory • characteristics and chemical reactions of acids as illustrated by dilute hydrochloric acid and dilute sulphuric acid • acidic properties and hydrogen ions ($H^+(aq)$) • role of water in exhibiting properties of acid • basicity of acid • characteristics and chemical reactions of alkalis as illustrated by sodium hydroxide and aqueous ammonia • alkaline properties and hydroxide ions ($OH^-(aq)$) • corrosive nature of concentrated acids and concentrated alkalis	• recognise that some household substances are acidic • state the common acids found in laboratory • describe the characteristics of acids and their typical reactions • write chemical and ionic equations for the reactions of acids • relate acidic properties to the presence of hydrogen ions ($H^+(aq)$) • describe the role of water for acids to exhibit their properties • state the basicity of different acids such as HCl, H_2SO_4, H_3PO_4, CH_3COOH • define bases and alkalis in terms of their reactions with acids • recognise that some household substances are alkaline • state the common alkalis found in the laboratory • describe the characteristics of alkalis and their typical reactions • write chemical and ionic equations for the reactions of alkalis • relate alkaline properties to the presence of hydroxide ions ($OH^-(aq)$) • describe the corrosive nature of acids and alkalis and the safety precautions in handling them

Students should learn	Students should be able to
b. Indicators and pH	
• acid-base indicators as exemplified by litmus, methyl orange and phenolphthalein	• state the colours produced by litmus, methyl orange and phenolphthalein in acidic solutions and alkaline solutions
• pH scale as a measure of acidity and alkalinity pH = $-\log[H^+(aq)]$	• describe how to test for acidity and alkalinity using suitable indicators
• use of universal indicator and an appropriate instrument to measure the pH of solutions	• relate the pH scale to the acidity or alkalinity of substances
	• perform calculations related to the concentration of $H^+(aq)$ and the pH value of a strong acid solution
	• suggest and demonstrate appropriate ways to determine pH values of substances
c. Strength of acids and alkalis	
• meaning of strong and weak acids as well as strong and weak alkalis in terms of their extent of dissociation in aqueous solutions	• describe the dissociation of acids and alkalis
	• relate the strength of acids and alkalis to their extent of dissociation
• methods to compare the strength of acids/alkalis	• describe acids and alkalis with the appropriate terms: strong and weak, concentrated and dilute
	• suggest and perform experiments to compare the strength of acids or alkalis

Students should learn	Students should be able to
d. Salts and neutralisation	
• bases as chemical opposites of acids	• write chemical and ionic equations for neutralisation
• neutralisation as the reaction between acid and base/alkali to form water and salt only	• state the general rules of solubility for common salts in water
• exothermic nature of neutralisation	• describe the techniques used in the preparation, separation and purification of soluble and insoluble salts
• preparation of soluble and insoluble salts	• suggest a method for preparing a particular salt
• naming of common salts	• name the common salts formed from the reaction of acids and alkalis
• applications of neutralisation	• explain some applications of neutralisation
e. Concentration of solutions	
• concentration of solutions in mol dm^{-3} (molarity)	• convert the molar concentration of solutions to g dm^{-3}
	• perform calculations related to the concentration of solutions

Students should learn	Students should be able to
f. Volumetric analysis involving acids and alkalis	
• standard solutions • acid-alkali titrations	• describe and demonstrate how to prepare solutions of required concentration by dissolving a solid or diluting a concentrated solution • calculate the concentration of the solutions prepared • describe and demonstrate the techniques of performing acid-alkali titration • apply the concepts of concentration of solution and use the results of acid-alkali titrations to solve stoichiometric problems • communicate the procedures and results of a volumetric analysis experiment by writing a laboratory report

Students should learn	Students should be able to
g. Rate of chemical reaction	
• ~~methods of following the progress of a chemical reaction~~	• ~~describe and justify the following techniques to follow the progress of a reaction:~~
• ~~instantaneous and average rate~~	~~i. titrimetric analysis~~
• factors affecting rate of reaction: i. concentration ii. temperature iii. surface area iv. catalyst	~~ii. measurement of the changes in: volume / pressure of gases, mass of a mixture, colour intensity of a mixture and transmittance of light~~
	• ~~interpret a graph showing the progress of a reaction~~
	• ~~determine instantaneous and average rate from a suitable graph~~
	• interpret results (e.g. graphs) qualitatively from experiments on factors affecting rate of reaction: changes in volume / pressure of gases, mass of a mixture and turbidity of a mixture
	• state the effect of concentration, temperature, surface area and the use of catalyst on the rate of reaction

Suggested Learning and Teaching Activities

Students are expected to develop the learning outcomes using a variety of learning experiences. Some related examples are:

- searching for examples of naturally occurring acids and bases, and their chemical composition.
- investigating the actions of dilute acids on metals, carbonates, hydrogencarbonates, metal oxides and metal hydroxides.
- designing and performing experiments to study the role of water in exhibiting properties of acids.
- searching for information about the hazardous nature of acids/alkalis.
- investigating the action of dilute alkalis on aqueous metal ions to form metal hydroxide precipitates.

- investigating the action of dilute alkalis on ammonium compounds to give ammonia gas.
- performing experiments to investigate the corrosive nature of concentrated acids/alkalis.
- searching for information about the nature of common acid-base indicators.
- performing experiments to find out the pH values of some domestic substances.
- measuring pH values of substances by using data logger or pH meter.
- designing and performing experiments to compare the strengths of acids/alkalis.
- investigating the temperature change in a neutralisation process.
- preparing and isolating soluble and insoluble salts.
- searching for and presenting information on applications of neutralisation.
- preparing a standard solution for volumetric analysis.
- performing calculations involving molarity.
- performing acid-alkali titrations using suitable indicators/pH meter/data logger.
- using a titration experiment to determine the concentration of acetic acid in vinegar or the concentration of sodium hydroxide in drain cleaner.
- performing calculations on titrations.
- writing a detailed report for an experiment involving volumetric analysis.
- searching for information on accident(s) caused by the failure to control reaction rate.
- ~~selecting and explaining the appropriateness of using different techniques to follow the progress of the chemical reactions such as:~~

  ~~(a) base hydrolysis of esters~~
  ~~(b) reaction of $CaCO_3$(s) or Mg(s) with dilute acids~~
  ~~(c) oxidation of $C_2O_4^{2-}$(aq) ion by acidified $KMnO_4$(aq)~~
  ~~(d) reaction of $S_2O_3^{2-}$(aq) ion with dilute acids~~
- ~~discussing the nature of rate studies with respect to methods of “quenching” and “on-going”.~~
- ~~using appropriate methods, skills and techniques, like the micro-scale chemistry technique and data loggers, to study the progress of a reaction.~~
- performing experiments to study the effect of concentration, temperature and surface area; and the use of catalyst on the rate of reaction.
- searching for information or reading articles on airbags of vehicles.

Values and Attitudes

Students are expected to develop, in particular, the following *values and attitudes*:

- to develop a positive attitude towards the safe handling, storage and disposal of chemicals, and hence adopt safe practices.
- to appreciate the importance of proper laboratory techniques and precise calculations for obtaining accurate results.
- to appreciate that volumetric analysis is a vital technique in analytical chemistry.
- to appreciate the importance of controlling experimental variables in making comparisons.
- to appreciate the use of instruments in enhancing the efficiency and accuracy of scientific investigation.
- to value the need to control reaction rates for human advancement.
- to appreciate that a problem can be solved by diverse approaches.

STSE Connections

Students are encouraged to appreciate and comprehend issues which reflect the interconnections of science, technology, society and the environment. Related examples are:

- Measures involving neutralisation have been implemented to control the emission of nitrogen oxides and sulphur dioxide from vehicles, factories and power stations.
- Caustic soda is manufactured by the chloroalkali industry which is a traditional chemical raw materials industry.
- Volumetric analysis, as an essential technique in analytical chemistry is applied in testing laboratories and forensic chemistry.
- Antacid is a common drug which contains base(s) for neutralising stomach acid and therefore relieving stomach ache.
- Control of metal corrosion has socio-economic importance and environmental relevance.
- Research into reaction rates has made a positive contribution to society, e.g. airbags in vehicles.
- Research into reaction rates is closely linked with the development of lethal weapons.

V Fossil Fuels and Carbon Compounds

Overview

Carbon compounds play an important role in industry and in daily life. Coal and petroleum are two major sources of carbon compounds. In this topic, the main focus is placed on the use of petroleum fractions as fuel and as a source of hydrocarbons. Students should appreciate that the use of fossil fuels has brought us benefits and convenience, such as providing us with domestic fuels and raw materials for making ~~plastics~~ synthetic polymers like plastics and synthetic fibers, alongside environmental problems such as air pollution, acid rain, and the global warming. Eventually, they should realise that human activities can have a significant impact on our environment.

This topic also introduces some basic concepts of organic chemistry such as homologous series, functional group, general formula and structural formula. Students should be able to give systematic names of alkanes, alkenes, alkanols and alkanoic acids with carbon chains not more than four carbon atoms. In addition, they are expected to learn the chemical reactions of alkanes, alkenes, alkanols and alkanoic acids. By illustrating the formation of monosubstituted halomethane with electron diagrams, students should realise that chemical reactions often take place in more than one step and involve reactive species.

~~Plastics are remarkably useful materials mainly derived from fossil fuels. Many objects used in daily life are made of plastics. Students should know that "plastics" is a collective term which embraces a large number of polymers, and that the uses of different plastics can be related to their physical properties which are, in turn, related to their structures. Students should understand the formation of addition and condensation polymers. Moreover, they should appreciate that durability is one of the great advantages of using plastics over other materials, but that this advantage is also a drawback, as most plastics do not readily degrade in a natural environment. It is therefore necessary to explore appropriate ways to dispose of plastic waste.~~ Polymers can be synthesised by reacting small organic molecules (monomer) together in a chemical reaction. This process is called polymerisation. Students should understand the formation of addition and condensation polymers. Also, they should realise that the uses of some common polymers can be related to their physical properties which are, in turn, related to their structures.

Students should learn	**Students should be able to**
a. Hydrocarbons from fossil fuels	
• coal, petroleum and natural gas as sources of fossil fuels and carbon compounds	• describe the origin of fossil fuels
• composition of petroleum and its separation	• describe petroleum as a mixture of hydrocarbons and its industrial separation into useful fractions by fractional distillation
• gradation in properties of the various fractions of petroleum	• recognise the economic importance of petroleum as a source of aliphatic and aromatic hydrocarbons (e.g. benzene)
• heat change during combustion of hydrocarbons	• relate the gradation in properties (e.g. colour, viscosity, volatility and burning characteristics) with the number of carbon atoms in the molecules of the various fractions
• major uses of distilled fractions of petroleum	• explain the demand for the various distilled fractions of petroleum
• consequences of using fossil fuels	• recognise combustion of hydrocarbons as an exothermic chemical reaction
	• recognise the pollution from the combustion of fossil fuels
	• evaluate the impact of using fossil fuels on our quality of life and the environment
	• suggest measures for reducing the emission of air pollutants from combustion of fossil fuels

Students should learn	Students should be able to
b. Homologous series, structural formulae and naming of carbon compounds	
• unique nature of carbon	• explain the large number and diversity of carbon compounds with reference to carbon's unique combination power and ability to form different bonds
• homologous series as illustrated by alkanes, alkenes, alkanols and alkanoic acids	• explain the meaning of a homologous series
	• understand that members of a homologous series show a gradation in physical properties and similarity in chemical properties
• structural formulae and systematic naming of alkanes, alkenes, alkanols and alkanoic acids	• write structural formulae of alkanes
	• give systematic names of alkanes
	• extend the knowledge of naming carbon compounds and writing structural formulae to alkenes, alkanols and alkanoic acids

Students should learn	Students should be able to
c. Alkanes and alkenes	
• petroleum as a source of alkanes • alkanes • cracking and its industrial importance • alkenes	• distinguish saturated and unsaturated hydrocarbons from the structural formulae • describe the following reactions of alkanes and write the relevant chemical equations: i. combustion ii. substitution reactions with chlorine and bromine, as exemplified by the reaction of methane and chlorine (or bromine) • describe the steps involved in the monosubstitution of methane with chlorine using electron diagrams • recognise that cracking is a means to obtain smaller molecules including alkanes and alkenes • describe how to carry out laboratory cracking of a petroleum fraction • explain the importance of cracking in the petroleum industry • describe the reactions of alkenes with the following reagents and write the relevant chemical equations: i. bromine ii. potassium permanganate solution • demonstrate how to carry out chemical tests for unsaturated hydrocarbons
d. Alcohols, alkanoic acids and esters	
• Uses of alcohols • Reactions of alkanols • Uses of esters	• state some common uses of alcohols, e.g. in drinks, as solvents and fuels • describe the reactions of alkanols with i. acidified potassium dichromate to produce

Students should learn	Students should be able to
	alkanoic acids ii. alkanoic acids to produce esters
	• state some common uses of esters, e.g. as fragrances, flavourings and solvents
e. Addition polymers and condensation polymers	
• ~~plastics as important materials in the modern world~~	• ~~recognise that plastics are mainly manufactured from chemicals derived from petroleum~~
• monomers, polymers and repeating units	• ~~explain the terms "thermoplastics" and "thermosetting plastics"~~
• addition polymerisation	• recognise that ~~plastics~~ synthetic polymers are ~~polymers~~ built up from small molecules called monomers
• condensation polymerisation	
• structure, properties and uses of polymers as illustrated by polyethene, polypropene, polyvinyl chloride, polystyrene, Perspex, nylon~~,~~ and polyesters ~~and urea-methanal~~	• recognise that alkenes, unsaturated compounds obtainable from cracking of petroleum fractions, can undergo addition reactions • understand that alkenes and unsaturated compounds can undergo addition polymerisation
• ~~environmental issues related to the use of plastics~~	• deduce the type of polymerisation reaction for a given monomer or a pair of monomers
	• write equations for the formation of addition and condensation polymers
	• deduce the repeating unit of a polymer obtained from a given monomer or a pair of monomers
	• deduce the monomer or a pair of monomers from a given section of a formula of a polymer
	• ~~explain the effect of heat on thermoplastics and thermosetting plastics in terms of their structures~~
	• ~~understand the economic importance of plastics and pollution problems associated with the use~~

Students should learn	Students should be able to
	~~and disposal of plastic items~~

Suggested Learning and Teaching Activities

Students are expected to develop the learning outcomes using a variety of learning experiences. Some related examples are:

- searching for and presenting information about the locations of deposits of coal, petroleum and natural gases in China and other countries.
- investigating colour, viscosity, volatility and burning characteristics of petroleum fractions.
- searching for and presenting information about petroleum fractions regarding their major uses and the relation between their uses and properties.
- discussing the relationship between global warming and the use of fossil fuels.
- drawing structural formulae and writing systematic names for alkanes, alkenes, alkanols and alkanoic acids.
- building molecular models of simple alkanes, alkenes, alkanols and alkanoic acids.
- performing experiments to investigate the typical reactions of alkanes and alkenes.
- studying the nature of the substitution reaction of methane and halogen with the aid of relevant video or computer animation.
- performing an experiment on cracking of a petroleum fraction and testing the products.
- searching for information and presenting arguments on the risks and benefits of using fossil fuels to the society and the environment.
- discussing the pros and cons of using alternative sources of energy in Hong Kong.
- preparing ethanoic acid or ethyl ethanoate.
- searching for information or reading articles about the discovery of polyethene and the development of addition polymers.
- investigating properties such as the strength and the ease of softening upon heating of different plastics.
- writing chemical equations for the formation of polymers based on given information.
- building physical or computer models of polymers.
- deducing the monomer(s) from the structure of a given polymer.

- performing an experiment to prepare an addition polymer e.g. polystyrene, Perspex.
- performing an experiment to prepare a condensation polymer e.g. nylon.
- ~~searching for and presenting information on environmental issues related to the use of plastics.~~
- ~~conducting a survey to investigate the quantities and types of solid wastes generated at home/school and suggesting methods to reduce these wastes.~~
- ~~discussing or debating the issue "Incineration is the best way to handle the solid waste in Hong Kong".~~
- ~~discussing the environmental advantages and disadvantages of the use of plastics for packaging, and suggesting ways in which the disadvantages could be minimised, and exploring any add-on effects arising from the suggestions.~~

Values and Attitudes

Students are expected to develop, in particular, the following *values and attitudes*:

- to appreciate the importance of organising scientific information in a systematic way.
- to recognise the benefits and impacts of the application of science and technology.
- to value the need for the conservation of the Earth's resources.
- to appreciate the need for alternative sources of energy for sustainable development of our society.
- to value the need for the safe use and storage of fuels.
- to appreciate the versatility of synthetic materials and the limitations of their use.
- to show concern for the environment and develop a sense of shared responsibility for sustainable development of our society.

STSE Connections

Students are encouraged to appreciate and comprehend issues which reflect the interconnections of science, technology, society and the environment. Related examples are:

- The petroleum industry provides us with many useful products that have improved our standard of living. However, there are risks associated with the production, transportation, storage and usage of fossil fuels.
- Emissions produced from the burning of fossil fuels are polluting the environment and

are contributing to long-term and perhaps irreversible changes in the climate.

- There are many examples of damages uncovered after using the applications of science and technology for a long period, e.g. the pollution problem arising from using leaded petrol and diesel; and the disposal problem for plastics. Therefore, it is essential to carefully assess the risks and benefits to society and the environment before actually using those applications of science and technology in daily life.

VI Redox Reactions, Chemical Cells and Electrolysis

Overview

Chemical reactions involve the release or absorption of energy, which often appear in the form of heat, light or electrical energy. In a chemical cell, chemical energy is converted to electrical energy. The flow of electrons in an external circuit indicates the occurrence of reduction and oxidation (redox) at the electrodes. To help students understand the chemistry involved in a chemical cell, the concept of redox reactions is introduced in this topic. Students will carry out investigations involving common oxidising and reducing agents. They will also learn how to write chemical equations for redox reactions.

With the concepts related to redox reactions, students should be able to understand the reactions occurring in more complicated chemical cells and the processes involved in electrolysis. Students should also appreciate that the feasibility of a redox reaction can be predicted by comparing the different positions of the species in the electrochemical series. In addition, students should be able to predict products in electrolysis according to the different factors affecting the preferential discharge of ions.

The concepts of redox reactions have a number of applications in industrial chemistry and daily life. ~~Through searching for information and critically reading articles about electrochemical technology,~~ Students should appreciate the contribution of ~~chemical knowledge~~ electrochemistry to technological innovations, which in turn improve our quality of life. Students should also be able to assess the environmental impact and safety issues associated with these technologies.

Students should learn	Students should be able to
a. Chemical cells in daily life	
• primary cells and secondary cells	• distinguish between primary and secondary cells
• uses of chemical cells in relation to their characteristics such as size, voltage, capacity, rechargeability and price	• describe the characteristics of common primary and secondary cells: i. zinc-carbon cell ii. alkaline manganese cell iii. silver oxide cell iv. lithium ion cell v. nickel metal hydride (NiMH) cell vi. lead-acid accumulator
	• justify uses of different chemical cells for particular purposes
	• understand the environmental impact of using dry cells

Students should learn	Students should be able to
b. Reactions in simple chemical cells	
• chemical cells consisting of: i. two metal electrodes and an electrolyte ii. metal-metal ion half cells and salt bridge/porous device • changes occurring at the electrodes and electron flow in the external circuit • half equations and overall cell equations	• describe and demonstrate how to build simple chemical cells using metal electrodes and electrolytes • measure the voltage produced by a chemical cell • explain the problems associated with a simple chemical cell consisting of two metal electrodes and an electrolyte • explain the functions of a salt bridge/porous device • describe and demonstrate how to build simple chemical cells using metal-metal ion half cells and salt bridges/porous devices • explain the differences in voltages produced in chemical cells when different metal couples are used as electrodes • write a half equation representing the reaction at each half cell of a simple chemical cell • write overall equations for simple chemical cells • predict the electron flow in the external circuit and the chemical changes in the simple chemical cells

Students should learn	Students should be able to
c. Redox reactions	
• oxidation and reduction • oxidation numbers • common oxidising agents (e.g. $MnO_4^-(aq)/H^+(aq)$, $Cr_2O_7^{2-}(aq)/H^+(aq)$, $Fe^{3+}(aq)$, $Cl_2(aq)$, $HNO_3(aq)$ of different concentrations and conc. $H_2SO_4(l)$) • common reducing agents (e.g. $SO_3^{2-}(aq)$, $I^-(aq)$, $Fe^{2+}(aq)$, $Zn(s)$) • balancing equations for redox reactions	• identify redox reactions, oxidising agents and reducing agents on the basis of i. gain or loss of oxygen/hydrogen atom(s) ii. gain or loss of electron(s) iii. changes in oxidation numbers • assign oxidation numbers to the atoms of elements and compounds • construct a general trend of the reducing power of metals and the oxidising power of metal ions • describe the chemical changes of some common oxidising agents and reducing agents • relate the trends of the reducing power and oxidising power of chemical species to their positions in a given electrochemical series • balance half equations of reduction and oxidation balance redox equations by using half equations or changes in oxidation numbers
d. Redox reactions in chemical cells	
• zinc-carbon cell • chemical cells with inert electrodes • fuel cell	• describe the structure of a zinc-carbon dry cell • write the half equation for reaction occurring at each electrode and the overall equation for reaction in a zinc-carbon dry cell • describe and construct chemical cells with inert electrodes • predict the chemical changes at each half cell of the chemical cells with inert electrodes • write half equation for reaction occurring at each half cell and the overall ionic equation for reaction

Students should learn	Students should be able to
	in the chemical cells with inert electrodes • understand the principles of ~~fuel cells as exemplified by the~~ hydrogen-oxygen fuel cell • write the half equation for reaction occurring at each electrode and the overall equation for reaction in a hydrogen-oxygen fuel cell ~~• justify the use of fuel cells for different purposes~~ • state the pros and cons of a hydrogen-oxygen fuel cell
e. Electrolysis • electrolysis as the decomposition of substances by electricity as exemplified by electrolysis of i. dilute sulphuric acid ii. sodium chloride solutions of different concentrations iii. copper(II) sulphate solution • anodic and cathodic reactions • preferential discharge of ions in relation to the electrochemical series, concentration of ions and nature of electrodes • industrial applications of electrolysis: i. electroplating ii. purification of copper	• describe the materials needed to construct an electrolytic cell • predict products at each electrode of an electrolytic cell with reference to the factors affecting the preferential discharge of ions • describe the anodic and cathodic reactions, overall reaction and observable changes of the electrolyte in electrolytic cells • understand the principles of electroplating and the purification of copper • describe the anodic and cathodic reactions, overall reaction and observable changes of electrolyte in electroplating and the purification of copper • understand the environmental impact of the electroplating industry

Students should learn	Students should be able to
~~**f. Importance of redox reactions in modern ways of living**~~	
• ~~development of new technology applying concepts related to redox reactions as exemplified by fuel cell technology and rechargeable lithium cells~~	• ~~recognise the use of redox reactions in a wide range of industries and technological development~~ • ~~discuss the importance of redox reactions in modern ways of living~~

Suggested Learning and Teaching Activities

Students are expected to develop the learning outcomes using a variety of learning experiences. Some related examples are:

- making decisions on the choice of chemical cells in daily life based on available information.
- making simple chemical cells and measuring their voltages.
- writing ionic half equations.
- performing experiments to investigate redox reactions with common oxidising and reducing agents.
- determining oxidation numbers of atoms in elements and compounds.
- balancing redox equations by using ionic half equations or by using oxidation numbers.
- investigating redox reactions of concentrated sulphuric acid with metals.
- investigating redox reactions of nitric acid of different concentrations with metals.
- searching for and presenting information about the applications of fuel cells.
- investigating the working principles of a fuel cell model car.
- performing experiment to investigate the working principles of a lead-acid accumulator.
- predicting changes in chemical cells based on given information.
- viewing or constructing computer simulations illustrating the reactions in chemical cells.
- performing experiments to investigate changes in electrolysis.
- performing experiments to investigate factors affecting preferential discharge of ions during electrolysis.

- searching for and presenting information about the possible adverse impact of the electroplating industry on the environment.
- designing and performing electroplating experiments.
- reading articles about the industrial processes involved in the extraction of aluminium from aluminium ore.
- ~~reading articles about new developments in fuel cell technology and lithium cells.~~
- ~~discussing the feasibility of using alcohol fuel cells in portable electronic devices.~~
- discussing the pros and cons of using hydrogen-oxygen fuel cells in vehicles.
- investigating the chemistry involved in oxygen absorbers of packaged food.

Values and Attitudes

Students are expected to develop, in particular, the following *values and attitudes*:

- to value the contribution of technological innovations to the quality of life.
- to appreciate the usefulness of the concept of oxidation number in the study of redox reactions.
- to develop a positive attitude towards the safe handling, storage and disposal of chemicals, and hence adopt safe practices.
- to value the need for assessing the impact of technology on our environment.

STSE Connections

Students are encouraged to appreciate and comprehend issues which reflect the interconnections of science, technology, society and the environment. Related examples are:

- Various breath-testing technologies, such as passive alcohol sensors, preliminary breath tests, and evidentiary breath tests (e.g. the intoximeter EC/IR) all utilise fuel cell technology to detect alcohol.
- ~~Different fuel cells are being developed for possible commercial uses, such as providing power to electrical appliances, automobiles, home and factories.~~
- Hydrogen-oxygen fuel cells are being used for some areas like space missions and vehicles, but not widely for commercial or domestic purposes.
- Lithium cell chemistry variants, such as lithium-ion battery, lithium-ion polymer battery, lithium cobalt battery, lithium manganese battery and lithium nickel battery, have been

developed to cope with the need for a wide range of consumer products.

- Many electrolytic processes are involved in industrial processes, e.g. refining of metals, the chloroalkali industry and the aluminium production from ore (bauxite).
- The development of electrolysis in extracting reactive metals is closely related to human history.

VII Chemical Reactions and Energy

Overview

Chemical reactions are accompanied by energy changes, which often appear in the form of heat. In fact, energy absorbed or released by a chemical system may take different forms. Basic concepts of chemical energetics and enthalpy terms are introduced in this topic. Practical work on the simple calorimetric method and quantitative treatment of Hess's law can help students to better understand the concepts of energetics. However, the use of equipment such as the bomb calorimeter is not expected at this level of study.

~~It is assumed that students will have prior knowledge of the quantitative treatment of heat change based on heat capacity calculation.~~

Students should learn	Students should be able to
a. Energy changes in chemical reactions	
• conservation of energy	• explain energy changes in chemical reactions in terms of the concept of conservation of energy
• endothermic and exothermic reactions and their relationship to the breaking and forming of bonds	• describe enthalpy change, ΔH, as heat change at constant pressure • explain diagrammatically the nature of exothermic and endothermic reactions in terms of enthalpy change • explain the nature of exothermic and endothermic reactions in terms of the breaking and forming of chemical bonds

Students should learn	Students should be able to
b. ~~Standard enthalpy change of neutralisation, solution, formation and combustion~~ **Standard enthalpy changes of reactions**	• explain and use the terms: enthalpy change of reaction and standard conditions, with particular reference to neutralisation, ~~solution,~~ formation and combustion • carry out experimental determination of enthalpy changes using simple calorimetric method • calculate enthalpy changes from experimental results
c. Hess's law • use of Hess's law to determine enthalpy changes which cannot be easily determined by experiment directly ~~• enthalpy level diagrams~~ • calculations involving enthalpy changes of reactions	• apply Hess's law to construct simple enthalpy change cycles ~~and enthalpy level diagrams~~ • perform calculations involving such cycles and relevant energy terms, with particular reference to determining enthalpy change that cannot be found directly by experiment

Suggested Learning and Teaching Activities

Students are expected to develop the learning outcomes using a variety of learning experiences. Some related examples are:

- using appropriate methods and techniques to design and carry out determination of standard enthalpy change of (a) acid-base neutralisation and (b) combustion of alcohols.
- constructing enthalpy change cycles ~~and enthalpy level diagrams~~ to quantitatively relate, according to Hess's law, reaction enthalpy changes and other standard enthalpy changes.
- discussing the limitations of simple calorimetric methods as opposed to other more sophisticated techniques.
- performing calculations on standard enthalpy change of reactions involving (a) standard enthalpy change of formation, (b) standard enthalpy change of combustion and (c) other standard enthalpy terms.
- performing experiments to determine the enthalpy change of formation of metal oxides or metal carbonates.

- finding out different approaches to solving problems of standard enthalpy changes in chemical reactions.
- investigating the chemistry involved in hand-warmers or cold-packs.

Values and Attitudes

Students are expected to develop, in particular, the following *values and attitudes*:
- to value the need to understand heat changes in chemical reactions in a systematic way.
- to appreciate the importance of interdisciplinary relevance, e.g. knowledge of quantitative treatment in thermal physics is involved in enthalpy change calculations.
- to accept quantitative experimental results within tolerance limits.

STSE Connections

Students are encouraged to appreciate and comprehend issues which reflect the interconnections of science, technology, society and the environment. Related examples are:
- Humans have been making efforts to discover more efficient release of thermal energy from chemical reactions, e.g. combustion of fuels.
- The ever-increasing use of thermal energy from chemical reactions has impacts on technology and the environment, e.g. energy crisis and global warming.
- Energy changes in chemical reactions have been utilised in many daily life products, e.g. hand-warmers, physiotherapy heat-packs, cold-packs, self-heating coffee and lunchboxes.
- The difficulty in harnessing solar energy, and in storing it chemically are the challenges in using alternative energy sources.

PART II – EXPLANATORY NOTES FOR THE COMBINED SCIENCE (CHEMISTRY PART) CURRICULUM
(TO BE FIRST IMPLEMENTED IN THE 2013/14 SCHOOL YEAR FOR SECONDARY 4 STUDENTS)

Introduction

This part aims to highlight some key aspects of the Guide, and to interpret the depth and breadth of some topics of the Curriculum for the reference of teachers.[1]

The Curriculum is neither intended to be a one-size-fit-all one, nor a prescription for all. With this in mind, teachers have to make professional judgement according to their own school contexts, student aspirations, etc. in planning their own curricula.

A. General Notes

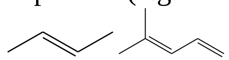
- **Breadth and depth of the curriculum**
  - **"Overview", "What students should learn" and "What students should be able to"** – The three parts in each of the topics of the Guide are intended to describe the breadth and depth of the curriculum, and should be taken as the key focuses of learning, teaching and assessment for all.
  - **Suggested Learning and Teaching Activities** – This part in each of the topics of the Guide lists possible activities that may enable students to acquire some of the skills associated with the topic. The list is a guide for teachers rather than a mandatory list. Some activities are challenging for students of average abilities and can be a starting point of an investigative study in chemistry. Teachers are encouraged to select and adopt some of these activities according to the learning targets and other school specific factors. Teachers are encouraged to read page 12 of the Guide for details.
- **Curriculum Planning** – This chapter of the Guide provides suggestions for teachers on how to integrate different topics for better learning, strategies for catering for learner diversities, etc. Teachers are encouraged to read Chapter 3 of the Guide for details.
- **Application of Knowledge and Concepts** – One of the scientific thinking skills expected in this Curriculum is that students should be able to integrate new concepts into their existing knowledge framework, and apply them to new situations. With this in mind and if deemed appropriate, teachers are encouraged to provide opportunities for students to apply chemical knowledge to explain observations and solve problems

[1] This explanatory notes for the Combined Science (Chemistry part) curriculum is only applicable to the 2016 HKDSE examination and thereafter. For students who will sit the 2014 or 2015 HKDSE examinations, teachers should refer to the explanatory notes disseminated in late 2012. The notes can be downloaded at http://cd1.edb.hkedcity.net/cd/science/NSS/supplement_CSChem_e_31Oct2012.pdf.

which may involve unfamiliar situations. In such a case, students should be provided with sufficient information or required scaffolds. Please read page 9 and page 122 of the Guide for more information.

- **Role of Textbooks for Learning and Teaching** – Among all the resource materials designed for the Curriculum, textbooks are perhaps the most important one. Textbooks do provide a good support to students and teachers. However, textbooks should not be regarded as the manifested breadth and depth of the curriculum. Teaching with the textbooks from cover to cover is not necessarily the best means to help students master the curriculum. Rather, textbooks can be used in different ways: e.g. selected parts of the textbooks are used as pre- and post- lesson reading materials, as scaffold for interactive learning during lessons, and as resources for consolidation of learning after schools or at home. Teachers are encouraged to read page 140 of the Guide and make professional judgement such that the intended curriculum can be implemented, with the support of textbooks, appropriately in their classrooms for their own groups of students.

B. Topic Specific Notes

Topic	Students should learn	Students should be able to	Notes
IV (f)	Volumetric analysis involving acids and alkalis • standard solutions • acid-alkali titrations	• apply the concepts of concentration of solution and use the results of acid-alkali titrations to solve stoichiometric problems	• With sufficient information given, students should be able to solve problems involving back titration.
V (b)	Homologous series, structural formulae and naming of carbon compounds • unique nature of carbon • homologous series as illustrated by alkanes, alkenes, alkanols and alkanoic acids • structural formulae and systematic naming of alkanes, alkenes, alkanols and alkanoic acids	• write structural formulae of alkanes • give systematic names of alkanes • extend the knowledge of naming carbon compounds and writing structural formulae to alkenes, alkanols and alkanoic acids	• The use of different kinds of notations in drawing structural formulae of organic compounds (e.g. ) is expected. • Students should be able to give systematic names of alkanes, alkenes, alkanols and alkanoic acids with carbon chains not more than four carbon atoms (mentioned in the Overview of the topic in the Guide). • Students should be able to give systematic names for organic compounds with multiple functional groups of the same type, e.g. propane-1,2,3-triol. For other compounds with multiple functional groups, the use of order of priority of principal functional groups is not expected. [2] • Students should be able to give systematic names for organic compounds with unsaturated carbon-carbon bonds and/or halogen substituents, e.g. 3,3-dichloropropene and 2-bromobut-3-en-1-ol.

[2] Reference: http://www.acdlabs.com/iupac/nomenclature/93/r93_326.htm

Topic	Students should learn	Students should be able to	Notes
V (e)	Addition polymers and condensation polymers	• understand that alkenes and unsaturated compounds can undergo addition polymerisation	• Students should be reminded that the carbon-carbon double bonds in benzene and phenyl group of the aromatic compounds will not undergo addition polymerisation. • Students are not expected to explain the stability of benzene and aromatic compounds.
VI (a)	Chemical cells in daily life • primary cells and secondary cells • uses of chemical cells in relation to their characteristics such as size, voltage, capacity, rechargeability and price	• describe the characteristics of common primary and secondary cells: i. zinc-carbon cell ii. alkaline manganese cell iii. silver oxide cell iv. lithium ion cell v. nickel metal hydride (NiMH) cell vi. lead-acid accumulator	• Describing structures and working principles of alkaline manganese cell, silver oxide cell, lithium ion cell, nickel metal hydride (NiMH) cell and lead-acid accumulator are not expected.
VI (d)	Redox reactions in chemical cells • zinc-carbon cell • chemical cells with inert electrodes • fuel cell		• With sufficient information given, students should be able to apply the concepts of electrochemistry to solve problems involving more complicated chemical cells.
VII (b)	Standard enthalpy change of reactions	• carry out experimental determination of enthalpy changes using simple calorimetric method	• Principle and operation procedure of a bomb calorimeter are not expected (mentioned in the Overview of the topic in the Guide).