Chemistry Curriculum and Assessment Guide (Secondary 4 – 6)

Notes for Teachers

Introduction

The purpose of this document is to highlight some key aspects of the captioned Guide (or the Guide), and to interpret the depth and breadth of some topics of the Curriculum for the reference of teachers. This document is the result of a number of discussion sessions of the following committees:

- Working Group on the Review of Chemistry (S4-6) Curriculum and Assessment
- Working Group on the Review of Combined Science (Chemistry part) (S4-6) Curriculum and Assessment
- CDC-HKEAA Committee on Chemistry (Senior Secondary)
- HKEAA Subject Committee (Senior Secondary Chemistry)

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.

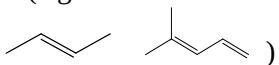
The explanatory notes listed in this document are by no means exhaustive nor intended to dictate the scope of learning and teaching at the classrooms. Instead, it serves as a reference for teachers to plan how to implement the curricula in consideration of their students' interests and abilities, and availability of teaching time and resources. An annex has been included in this document to further elaborate the details of the typical reactions in Topic XI of the Curriculum.

I. 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 14 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 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 123 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 134 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.

II. 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. (Please read the note for back titration involving aspirin on page 7.)
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 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 eight 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.[1] • 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-bromopent-3-en-1-ol.

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

Topic	Students should learn	Students should be able to	Notes
V (d)	Addition 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)	Bond polarity	• define the electronegativity of an atom • explain the unequal sharing of electrons in covalent bonds • identify the partial charges of polar molecules such as HF, H_2O, NH_3 and $CHCl_3$	• Dipole moment is not expected. • Students are not expected to memorise the electronegativity scales. But they should be able to describe the general trend in electronegativity of elements in the Periodic Table so that they can identify the partial charges in polar molecules.
VI (b)	Intermolecular forces • van der Waals' forces	• explain the existence of van der Waals' forces in non-polar and polar covalent substances • state the factors affecting the strength of van der Waals' forces between molecules	• Classifying van der Waals' forces into "dipole-dipole forces", "dispersion forces", "permanent dipole-permanent dipole attractions", "permanent dipole-induced dipole attractions", "instantaneous dipole-induced dipole attractions" etc. is not expected.[2]
VI (e)	Shapes of simple molecules	• describe and draw three-dimensional diagrams to represent shapes of the following molecules: CH_4, NH_3, H_2O, BF_3, PCl_5 and SF_6	• Students should be able to describe the shapes of the six molecules listed. However, they are not expected to be able to predict shapes of other molecules using VSEPR. • Stating bond angles for these six molecules is not expected.
VII (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.

[2] Reference: http://goldbook.iupac.org/V06597.html

Topic	Students should learn	Students should be able to	Notes
VII (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.
VIII (b)	Standard enthalpy change of neutralisation, solution, formation and combustion	• 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).
IX (a)	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: i. titrimetric analysis ii. measurement of the changes in: volume / pressure of gases, mass of a mixture, colour intensity of a mixture and transmittance of light	• Calculation and instrumentation details of different techniques to follow reaction progress are not expected. • For titrimetric analysis, only physical method of quenching is expected (i.e. by lowering of temperature and dilution). • Calibration curve and related details of colorimetry are covered in "Analytical Chemistry".
IX (b)	Factors affecting rate of reaction • concentration • temperature • surface area • catalyst	• explain qualitatively the effect of changes in concentration, surface area and temperature on the rate of reaction • appreciate the importance of catalyst in chemical industries and biological systems	• Maxwell-Boltzmann distribution curve in explaining the effect of changes in temperature on the rate of reaction is covered in "Industrial Chemistry". • Students are expected to be aware of the importance of catalyst, but not to describe specific industrial processes and biological systems (mentioned in the overview of the topic in the Guide).
X (c)	The effect of changes in concentration and temperature on chemical equilibria	• derive inductively the relation of temperature and the value of K_c from given data sets • predict qualitatively the effect of temperature on the position of equilibrium from the sign of ΔH for the forward reaction • deduce the effect of change in concentration on the position of chemical equilibrium	• Only a single homogenous reaction will be referred to when predicting changes in concentration and temperature on chemical equilibria (mentioned in the overview of the topic in the Guide). • $\ln K = \text{constant} - \frac{\Delta H}{RT}$ or $\log K = \text{constant} - \frac{\Delta H}{2.3RT}$ is not expected. • Details of the contact process are not expected.

Topic	Students should learn	Students should be able to	Notes
XI (a)	Introduction to selected homologous series • homologous series • structural formulae and systematic naming	• give systematic names, general formulae, condensed formulae and structural formulae for: alkanes, alkenes, haloalkanes, alcohols, aldehydes and ketones, carboxylic acids, esters, unsubstituted amides and primary amines • draw the structures of the compounds based on their systematic names	• Students should be able to give systematic names of alkanes, alkenes, haloalkanes, alcohols, aldehydes and ketones, carboxylic acids, esters, unsubstituted amides and primary amines with carbon chains not more than eight 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.[3] • 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-bromopent-3-en-1-ol.
XI (b)	Isomerism • structural isomerism • geometrical isomerism as exemplified by acyclic carbon compounds containing one C=C bond • enantiomerism as exemplified by compounds containing one chiral carbon	• recognise the existence of geometrical (*cis-trans*) isomerism in acyclic carbon compounds resulting from restricted rotation about a C=C bond • recognise the existence of enantiomerism in compounds with only one chiral carbon	• Describing and explaining properties of specific examples of *cis-trans* isomers such as butenedioic acid are not expected. However, students are expected to apply their knowledge acquired in Topic VI to relate structures of *cis-trans* isomers to their properties. • Students should be able to recognise that enantiomers of a chiral compound can rotate the plane of plane-polarised light by the same extent, but in opposite directions. However, details of polarimetry and concepts related to racemic mixture are not expected.

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

Topic	Students should learn	Students should be able to	Notes
XI (c)	Typical reactions of various functional groups (Annex)	• describe the following reactions, in terms of reagents, reaction conditions and observations, and write the relevant chemical equations: i. alkanes: substitution with halogens ii. alkenes: addition of hydrogen, halogens and hydrogen halides iii. haloalkanes: substitution with OH^-(aq) iv. alcohols: substitution with halides using hydrogen halides or phosphorus trihalides; dehydration to alkenes; oxidation of primary alcohols to aldehydes and carboxylic acids; oxidation of secondary alcohols to ketones v. aldehydes and ketones: oxidation and reduction using $K_2Cr_2O_7$ and $LiAlH_4$ respectively vi. carboxylic acids: esterification, reduction and amide formation vii. esters: hydrolysis viii. amides: hydrolysis	• Reactions included are summarised in Annex. • Reactivity of haloalkanes in their substitution with hydroxide ions is not expected. • Amide formation from carboxylic acids is confined to unsubstituted amide. • For describing the substitution reactions of alcohols with halides, the use of the notations HX and PX_3 as the reagents is acceptable at this level of study (X = Cl, Br or I). However, experimental details of how to produce HX and PX_3 for the reactions are not expected.
XI (e)	Important organic substances • structure and medical applications of acetylsalicylic acid (aspirin) • structures and uses of nylon and polyesters • carbon compounds found in living things: carbohydrates, lipids and proteins	• identify the functional groups of the acetylsalicylic acid molecule • recognise that aspirin is used as a drug to relieve pain, reduce inflammation and fever, and the risk of heart attack • describe the structures of nylon and polyesters • state the uses of nylon and polyesters • recognise the structures of glucose and fructose • recognise the functional groups present in fats, oils and polypeptides	• Analysing aspirin tablets by back titration is not expected. (Please read the note for back titration on page 3.) • Condensation polymerisation for nylon and polyesters are covered in “Materials Chemistry”. • The classification of carbohydrates such as monosaccharides, disaccharides and polysaccharides is not expected.
XIII (a)	Importance of industrial processes • development of synthetic products for modern ways of living	• discuss the advantages and disadvantages of using industrial processes such as petrochemistry for manufacturing products from social, economic and environmental perspectives • understand the recent progress in industrial processes such as the production of vitamin C to solve problems of inadequate or shrinking supply of natural products	• Details of industrial processes of the production of vitamin C are not expected.

Topic	Students should learn	Students should be able to	Notes
XIII (b)	Rate equation • rate equation determined from experimental results	• understand the interrelationship between reaction rate, rate constant, concentration of reactants and order of reaction • determine the rate equation of a chemical reaction by method of initial rate	• Half-life of a reaction is not expected.
XIII (f)	Green chemistry • principles of green chemistry • green chemistry practices	• describe the relation between sustainable development and green chemistry • calculate the atom economy of a chemical reaction • relate principles of green chemistry and practices adopted in the industrial processes as exemplified by the manufacture of acetic acid (ethanoic acid) • evaluate industrial processes using principles of green chemistry	• Details of industrial processes of the manufacture of acetic acid are not expected.
XIV (d)	Synthetic materials in modern life • liquid crystals	• describe the chemical structures and different phases of organic liquid crystals • identify the structural features of substances that exhibit liquid-crystalline behaviour • relate the uses of liquid crystals to their properties	• Recall of molecular formulae of substances that exhibit liquid-crystalline behaviour is not expected.
XV (c)	Quantitative methods of analysis • gravimetric analysis • volumetric analysis	• gather data with appropriate instruments and apparatus in quantitative analysis • record observations and data accurately and systematically • be aware of and take necessary steps to minimise possible sources of error • perform calculations on data obtained to draw evidence-based conclusions • present observations, data, results, conclusions and sources of error either orally or in written form • justify the choice of an appropriate quantitative method for the determination of the quantity of a substance • assess possible risks associated with quantitative analysis	• Details of specific chemical processes involved in gravimetric analysis and volumetric analysis, other than those included in the previous topics, are not expected.

Reactions in Topic XI (c)	Remarks
Alkane $\xrightarrow[\text{UV light or heat}]{X_2}$ Haloalkane	X_2 : Br_2 or Cl_2
Alkene $\xrightarrow{X_2 \text{ (in organic solvent)}}$ Haloalkane	X_2: Cl_2, Br_2, I_2
Alkene $\xrightarrow{H_2, Pt}$ Alkane	
Alkene $\xrightarrow{HX}$ Haloalkane	HX: HF, HBr, HCl, HI Prediction of major product by Markovnikov's Rule is required
Haloalkane $\xrightarrow{NaOH(aq)}$ Alcohol	Relative reactivity of different haloalkanes is not required
Alcohol $\xrightarrow{HX \text{ or } PX_3}$ Haloalkane	HX: HCl, HBr, HI PX_3: PCl_3, PBr_3, PI_3
Alcohol $\xrightarrow[\text{or conc. } H_2SO_4, \text{ heat}]{Al_2O_3, \text{ heat}}$ Alkene	
1^o Alcohol $\xrightarrow[\text{heat}]{K_2Cr_2O_7 / H^+}$ Aldehyde or Carboxylic acid	
2^o Alcohol $\xrightarrow[\text{heat}]{K_2Cr_2O_7 / H^+}$ Ketone	
Ketone or Aldehyde $\xrightarrow[2.\ H^+]{1.\ LiAlH_4, \text{ dry ether}}$ Alcohol	

Reactions in Topic XI (c)	Remarks
Aldehyde $\xrightarrow[\text{heat}]{K_2Cr_2O_7 / H^+}$ Carboxylic acid	
Carboxylic acid + Alcohol $\underset{}{\overset{\text{conc. } H_2SO_4, \text{ heat}}{\rightleftharpoons}}$ Ester + Water	
Carboxylic acid $\xrightarrow[2.\ H^+]{1.\ LiAlH_4, \text{ dry ether}}$ Alcohol	
Carboxylic acid $\xrightarrow[2.\ NH_3]{1.\ PCl_3}$ Unsubstituted amide	
Ester $\xrightarrow[2.\ H^+]{1.\ OH^-, \text{ heat}}$ Carboxylic acid + Alcohol Ester $\underset{}{\overset{H^+, \text{ heat}}{\rightleftharpoons}}$ Carboxylic acid + Alcohol	
Amide $\xrightarrow[2.\ H^+]{1.\ OH^-, \text{ heat}}$ Carboxylic acid + Alkylammonium salt Amide $\xrightarrow{H^+, \text{ heat}}$ Carboxylic acid + Alkylammonium salt	