Explanatory notes for the Chemistry curriculum

(first implemented in the 2018/19 school year for Secondary 4 students)

25 October 2018

Topic IV Acids and Bases

IV(f)

Students should be able to

- 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.

✘ Chemistry (AL) 2010 Paper 1 Q.7 (c)

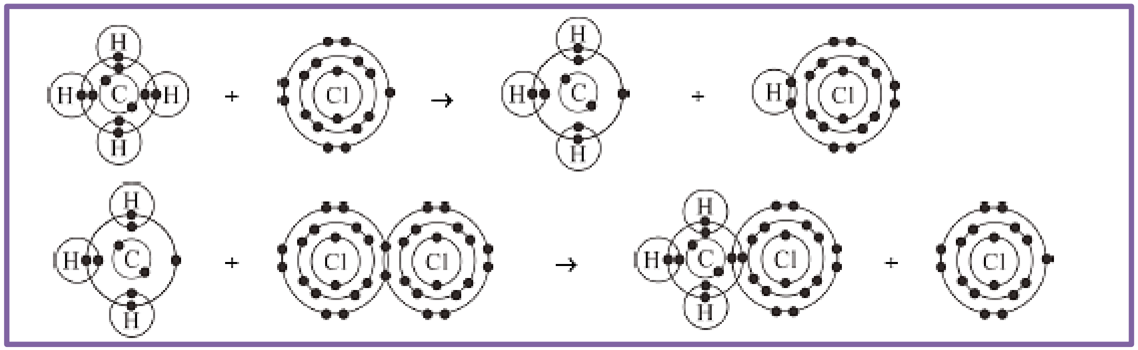
The hardness of a water sample is due to Ca^{2+}*(aq) ions. Outline a method for determining the hardness in the sample.*

Topic V Fossil Fuels and Carbon Compounds

V(c)

Students should be able to

- describe the steps involved in the monosubstitution of methane with chlorine using suitable diagrams or equations



$CH_4 + Cl\cdot \rightarrow CH_3\cdot + HCl$

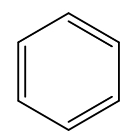
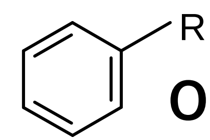
$CH_3\cdot + Cl_2 \rightarrow CH_3Cl + Cl\cdot$

Topic V Fossil Fuels and Carbon Compounds

V(d)

Students should be able to

- understand that alkenes and unsaturated compounds can undergo addition polymerization

✓ Carbon-carbon double bonds in  and 

of the aromatic compounds will not undergo addition polymerisation

✗ Explain the stability of benzene and aromatic compounds

Topic VI Microscopic World II

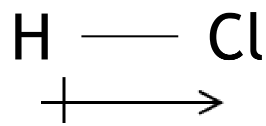
VI(a)

Students should be able to

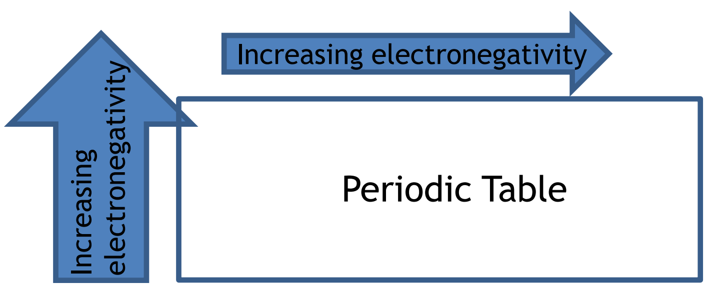
- define the electronegativity of an atom
- describe the general trends in the electronegativities of the main group elements down a group and across a period in the Periodic Table
- explain how the sharing of electrons in covalent bonds leads to non-polar and polar bands
- explain the polar nature of molecules (such as HF, H_2O, NH_3 and $CHCl_3$) and the non-polar nature of molecules (such as CH_4 and BF_3) with reference to electronegativity, polarity of bonds and molecular shape

Topic VI Microscopic World II

- Bond polarity
  - ✗ Dipole moment $\mu = Q \times r$



  - ✗ Electronegativity scales
  - ✓ General trends in the electronegativities of the elements in the Periodic Table



  - ✓ Partial charges $\overset{\delta+}{H} — \overset{\delta-}{Cl}$

Topic VI Microscopic World II

VI(b)

Students should be able to

- 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

Van der Waals' force (source: IUPAC GoldBook)

- The attractive or repulsive forces between molecular entities (or between groups within the same molecular entity) other than those due to bond formation or to the electrostatic interaction of ions or of ionic groups with one another or with neutral molecules. The term includes: dipole–dipole, dipole-induced dipole and London (instantaneous induced dipole-induced dipole) forces. The term is sometimes used loosely for the totality of nonspecific attractive or repulsive intermolecular forces.

(http://goldbook.iupac.org/V06597.html)

Topic VI Microscopic World II

VI(e)
Students should be able to

- predict and draw three-dimensional diagrams to represent shapes of (i) molecules with central atoms obeying octet rule; and (ii) molecules with central atoms not obeying octet rule and with no lone pair of electrons (such as BF_3, PCl_5 and SF_6)

No. of e^- pair	No. of lone pair	No. of bonding pair (single bond/double bond/triple bond)	Shape	Example (obeying octet rule)	Example (not obeying octet rule)
2	0	2	Linear	CO_2	$BeCl_2$
3	0	3	Trigonal planar	$COCl_2$	BF_3
4	0	4	Tetrahedral	$SiCl_4$, $CHCl_3$,	
4	1	3	Trigonal pyramindal	NH_3, PH_3	
4	2	2	V-shaped	H_2O, H_2S	
5	0	5	Trigonal bipyramidal		PCl_5, PBr_5
6	0	6	Octahedral		SF_6

2016 HKDSE Chemistry Paper IB Q.4

4. Consider the molecules CO_2, CS_2 and CH_2Br_2.

(a) For each of the following molecules, draw its three-dimensional structure.

(i) CS_2

(ii) CH_2Br_2

(b) Identify, with explanation, the polar bond(s) in CH_2Br_2.

(c) Suggest why, under room temperature and pressure, CO_2 is a gas but CS_2 is a liquid.

Topic VII Redox Reactions, Chemical Cells and Electrolysis

VII(a)

Students should be able to

- 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

✘ Describe structures (e.g, electrodes and electrolytes) and working principles (e.g. reduction and oxidation occurred) of the above cells

Topic VII Redox Reactions, Chemical Cells and Electrolysis

VII(d)
Students should learn

Redox reactions in chemical cells

- 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

Topic VIII Chemical Reactions and Energy

VIII(a)

Students should be able to

- recognise enthalpy change, ΔH, as heat change at constant pressure

✘ Deriving the relation between enthalpy change and heat change at constant

Topic VIII Chemical Reactions and Energy

VIII(b)
Students should be able to
- carry out experimental determination of enthalpy changes using simple calorimetric method

✘ principle and operation procedure of a bomb calorimeter
(*Note the overview)

Topic IX Rate of Reaction

IX(a)
Students should be able to
- select 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 and colour intensity of a mixture

✘ Calculation and instrumentation details of different techniques to follow reaction progress

➢ Calibration curve and related details of colorimetry are covered in Analytical Chemistry

Topic IX Rate of reaction

- Measuring change in volume/pressure of gas:

e.g. $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

- Measuring change in mass of reaction mixture:

e.g. $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

- Measuring change in color intensity of reaction mixture:

e.g. $5H_2C_2O_4(aq) + 2MnO_4^-(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$

> This experiment can't follow the reaction progress, but can be used to study effects of different factors affecting the reaction rate.

- Measuring change in turbidity of reaction mixture:

e.g. $Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + SO_2(aq) + H_2O(l) + S(s)$

Topic IX Rate of Reaction

IX(b)
Students should be able to
- 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

✘ Activation energy & Maxwell-Boltzmann distribution curve
(to be discussed in Topic XIII Industrial Chemistry)

✘ *Recalling* specific industrial process and biological systems that are not covered in other topics: Contact process, catalytic converters in car exhaust systems, fermentation… (*Note the overview)

Topic X Chemical Equilibrium

X(c)
Students should be able to
- 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

✘ $\ell n \, K = \text{constant} - \frac{\Delta H}{RT}$ (The van't Hoff equation)

✘ Details of contact process

✓ Use reaction quotient to deduce effect of change in concentration on chemical equilibrium position

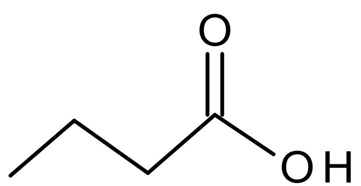
Topic X Chemical Equilibrium

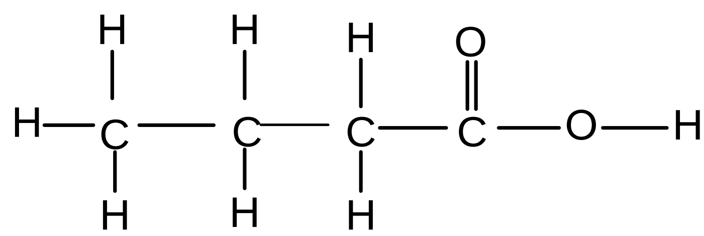
✓ Predicting changes in concentration and temperature on chemical equilibria – for reactions with chemical species in the same phase.

✗ Predicting changes in equilibrium position due to the introduction of species not involved in the chemical reaction (*Note the overview)

Topic V Fossil Fuels and Carbon Compounds
Topic XI Chemistry of Carbon Compounds

- Structural formulae of organic compounds





$CH_3CH_2CH_2COOH$

- Systematic naming of organic compounds

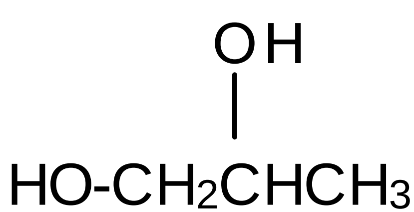
  ✓ Naming carbon compounds with one functional group or more than one functional group of the same type

$CH_2{=}CHCH_2OH$

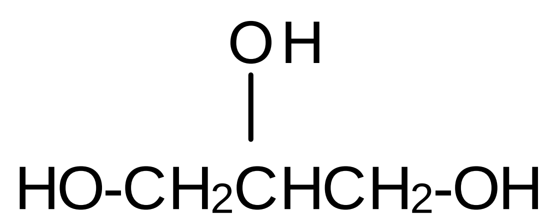
prop-2-en-1-ol

$H_2N(CH_2)_6NH_2$

hexane-1,6-diamine



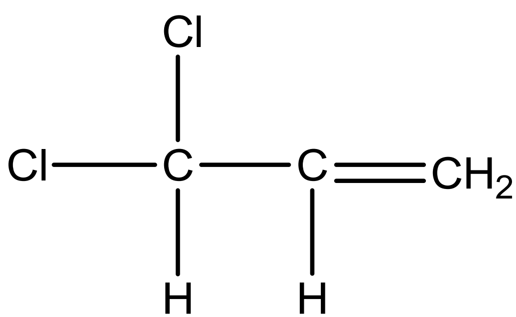
propane-1,2-diol



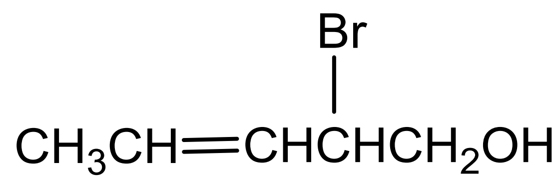
propane-1,2,3-triol

- Systematic naming of organic compounds

✓Naming carbon compounds with unsaturated carbon-carbon bonds and/or halogen substituents



3,3-dichloropropene



2-bromopent-3-en-1-ol

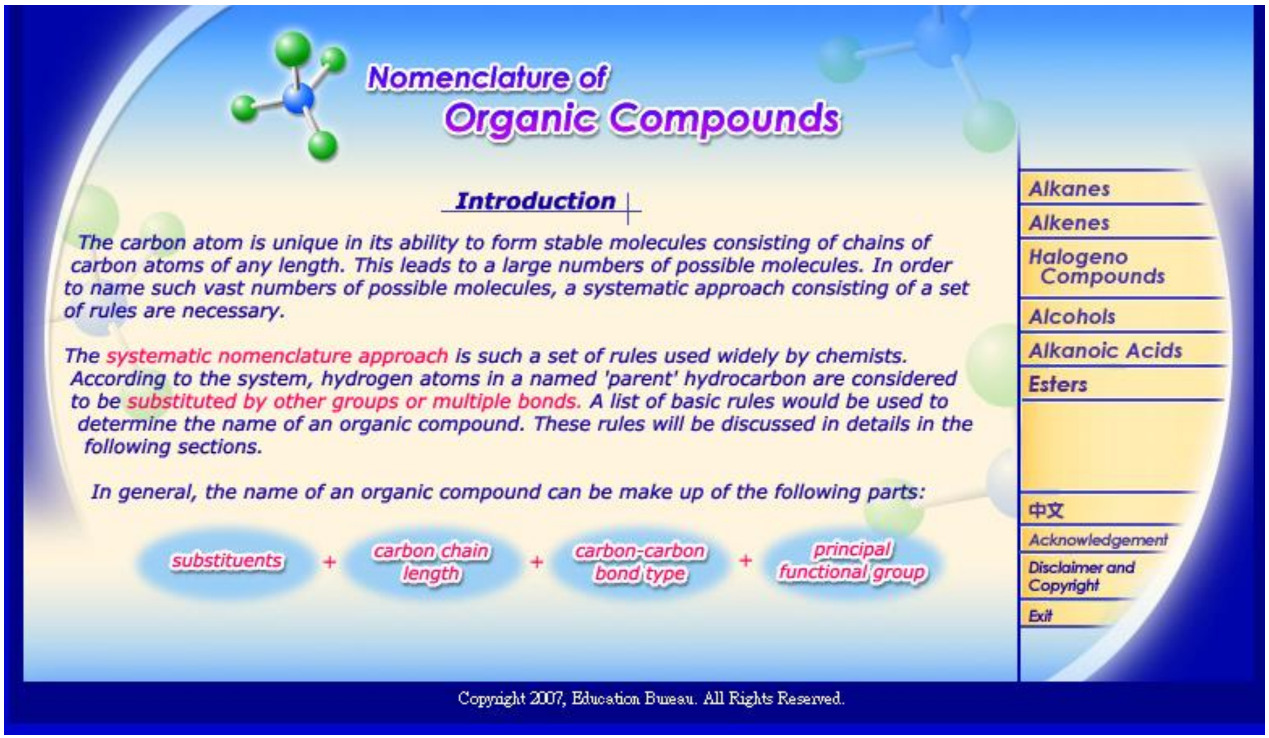
- Systematic naming of organic compounds

  - Naming carbon compounds with multiple functional groups with the use of priority of principal functional groups

Priority	Homologous series	Functional group	Prefix	Suffix
1	Carboxylic acids	-COOH	carboxy-	-oic acid
2	Esters	-COOR	R-oxycarbonyl	-yl -oate
3	Amides	$-CONH_2$	aminocarbonyl	-amide
4	Aldehydes	-CHO	formyl-	-al
5	Ketones	>C=O	oxo-	-one
6	Alcohols	-OH	hydroxy-	-ol
7	Amines	$-NH_2$	amino-	-amine

Nomenclature of Organic Compound (EDB)

https://cd1.edb.hkedcity.net/cd/science/chemistry/resource/naming/mainpage.htm



Topic XI Chemistry of Carbon Compounds

XI(b)

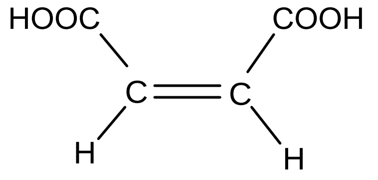
Students should be able to

- Recognise the existence of cis-trans isomerism in acyclic carbon compounds resulting from restricted rotation about a C=C bond

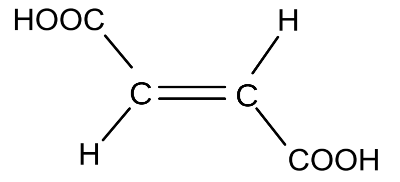
✓ Apply their knowledge acquired in Topic VI to relate structures of cis-trans isomers to their properties

Examples

- ✘ Explain properties of specific examples of cis-trans isomers

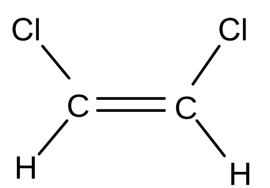


cis-butenedioic acid
m.p. = 130°C

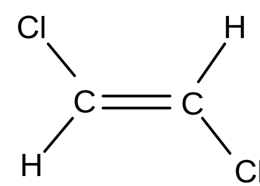


trans-butenedioic acid
m.p. = 286°C

- ✓ Explain the difference in boiling point of these two isomers



cis-1,2-dichloroethene
b.p. = 60°C



trans-1,2-dichloroethene
b.p. = 48°C

Topic XI Chemistry of Carbon Compounds

XI(b)

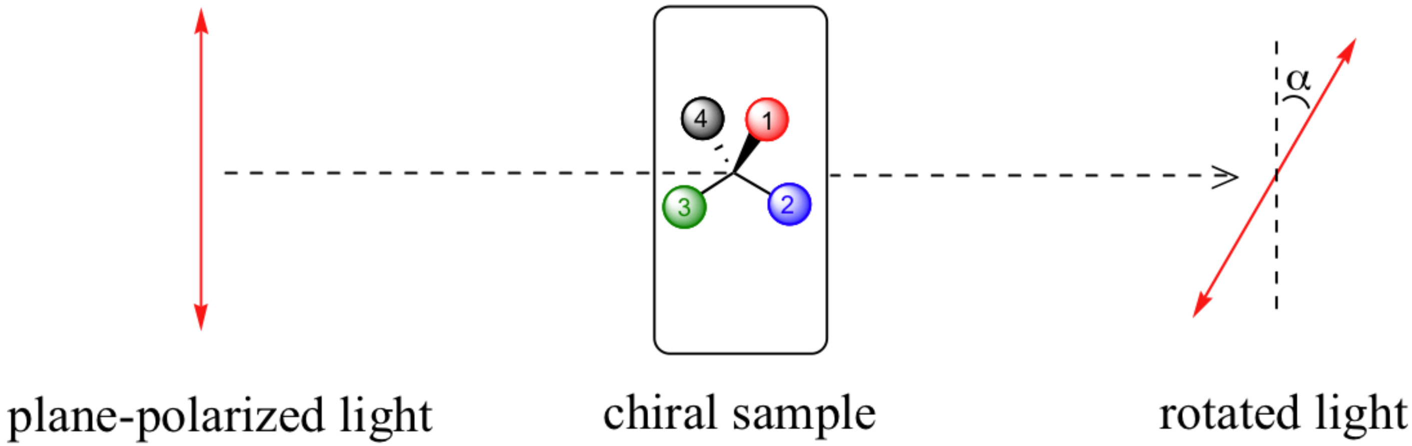
Students should be able to

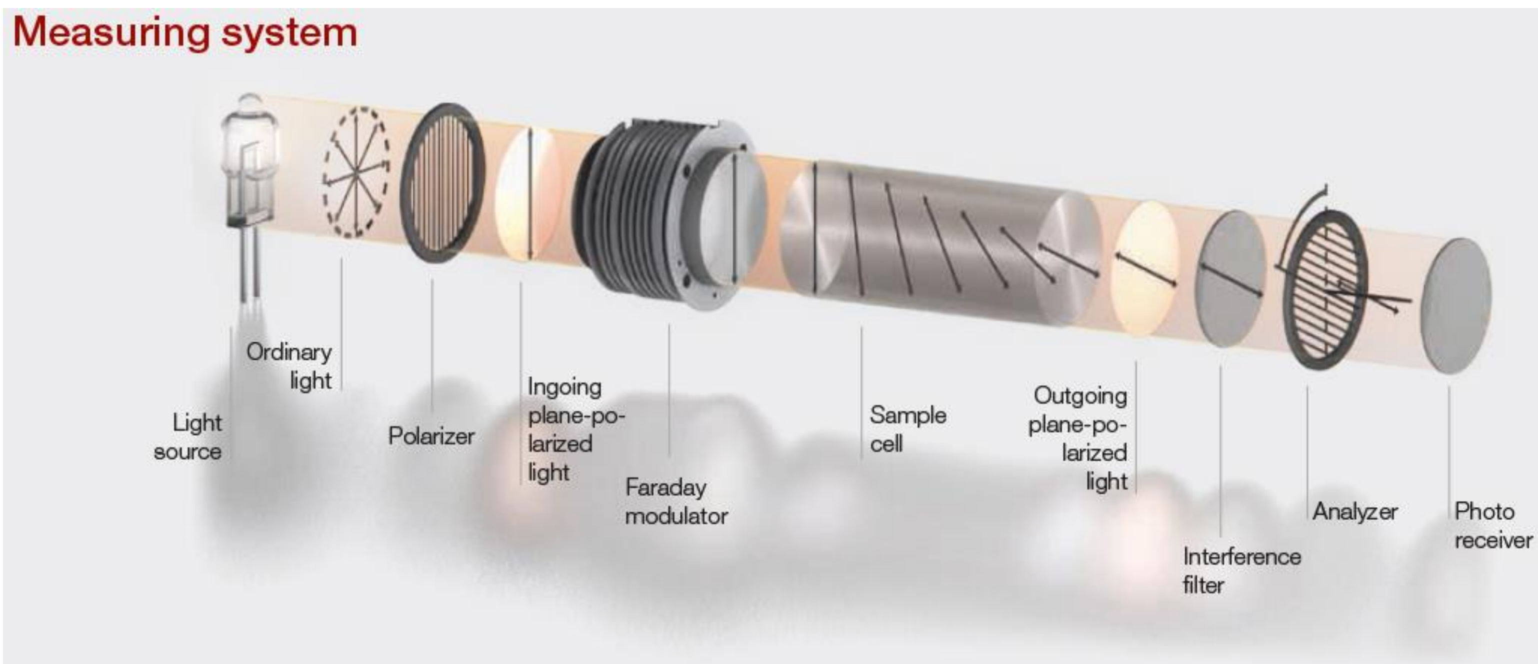
- Recognise the existence of enantiomerism in compounds with only one chiral carbon

✘ Details of polarimetry

✘ Racemic mixture

✓ Rotation of the plane of plane-polarised light for enantiomers





Courtesy: Wikipedia - polarimeter measuring system

Topic XI Chemistry of Carbon Compounds

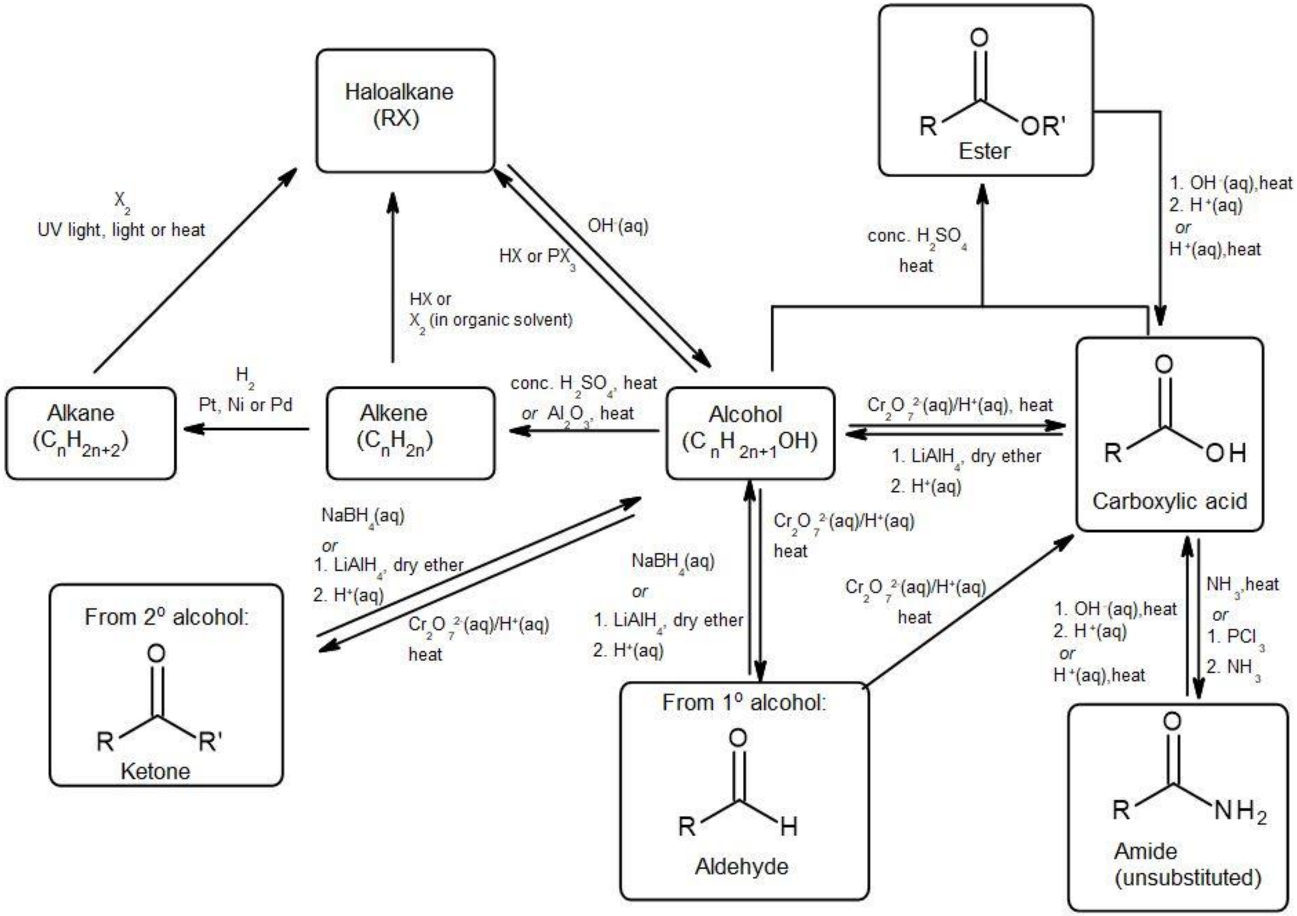
(iii) Haloalkanes: substitution with OH^-(aq)

✘ Order of reactivity: RI > RBr > RCl

(iv) Alcohols: substitution with halides using hydrogen halides or phosphorus trihalides

✘ PCl_5 ; NaBr/conc H_2SO_4; P/Br_2 ; $SOCl_2$; NaI/conc.H_3PO_4 ; P/I_2

✓ HX or PX_3



Chemistry Edblog 化學科教師專業發展交流平台

http://edblog.hkedcity.net/nsschem/2018/10/10/organic-reactions-in-topic-xi-c/

Topic XI Chemistry of Carbon Compounds

XI(e)
Students should be able to

- 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

✘ Analysing aspirin tablets by back titration is not expected

Topic XIII Industrial Chemistry

XIII(a)

Students should be able to

- 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

(iii) Which one of the following species can be a raw material for manufacturing vitamin C in industry ?

DSE 2018 Paper 2 Q1

acetic acid, acetone, formaldehyde, glucose

(1 mark)

✘ Details of industrial processes of the production of vitamin C

Topic XIII Industrial Chemistry

XIII(b)
Students should learn
Rate equation
- rate equation determined from experimental results

✘ Half-life of a reaction

XIII(f)
Students should be able to
- Relate principles of green chemistry and practices adopted in the industrial processes as exemplified by the manufacture of acetic acid (ethanoic acid)

✘ Recalling the details of industrial processes of the manufacture of acetic acid

(b) Reaction (I) below shows a process of producing methanol using catalyst at 100 atm and 250°C in industry :

Reaction (I) : $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

(i) (1) Suggest a suitable catalyst for the reaction.

(2) Suggest why the reaction would proceed slowly in the absence of a catalyst.

(3) Explain why the operation pressure in industry for the reaction is set at 100 atm but not at atmospheric pressure.

(4 marks)

(ii) Methanol can also be produced from carbon dioxide, a side product of some industrial processes, using another catalyst as shown in Reaction (II) below :

Reaction (II) : $CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g)$

Based on the given information :

(1) Suggest one reason why Reaction (II) can be considered as greener than Reaction (I).

(2) Suggest a potential benefit of Reaction (II) to the environment.

(2 marks)

(iii) One of the industrial applications of methanol is to produce ethanoic acid. Write a chemical equation for the reaction involved.

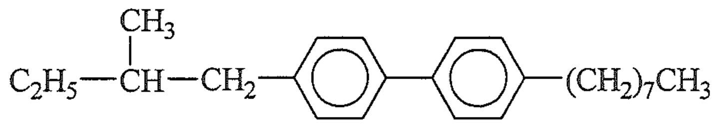
(1 mark)

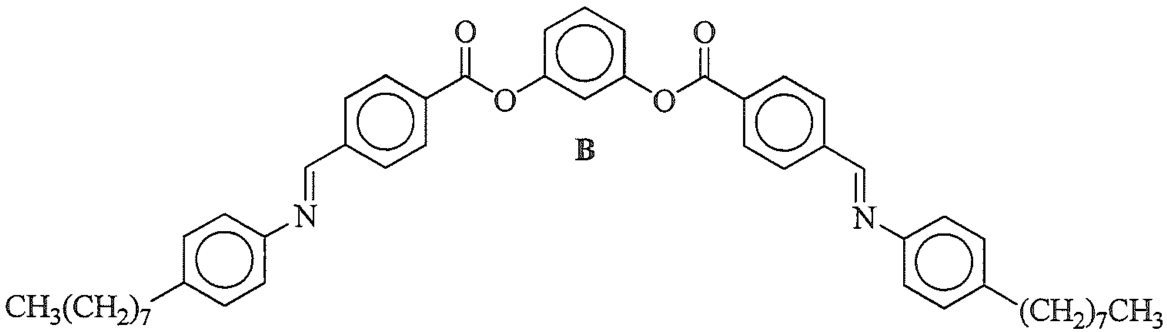
Topic XIV Materials Chemistry

XIV(d)
Students should learn
- Liquid crystals

✘ Recalling molecular formulae of substances that exhibit liquid-crystalline behaviour

(ii) Explain which of the following compounds, **A** or **B**, would form cholesteric phase liquid crystals.

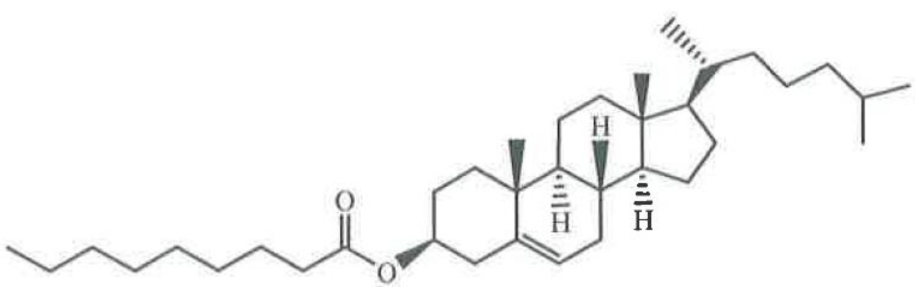




(1 mark)

2013 DSE Paper II Q2

(iii) The structure of compound **A** is shown below :



Explain whether **A** would exhibit liquid crystal behaviour.

(2 marks)

2017 DSE Paper II Q2

Topic XV Analytical Chemistry

XV(c)
Students should learn
- volumetric analysis

✘ Describing details of specific chemical processes involved in quantitative analysis

✓ With sufficient information given, students should be able to apply the concepts of quantitative methods of analysis to perform calculations, draw evidence-based conclusions, identify sources of error, etc.

Combined Science (Chemistry part)

Topic	Notes
V (b) Fossil Fuels and Carbon Compounds	- 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).