10.2 Functional Group Chemistry

Question Paper

Course	DP IB Chemistry
Section	10. Organic Chemistry
Topic	10.2 Functional Group Chemistry
Difficulty	Medium

Time allowed: 80

Score: /63

Percentage: /100

Question 1a

a) Ethene, C_2H_4, can be made into a number of useful compounds. A reaction sequence for this is shown below:

$$C_2H_4 \xrightarrow{\text{step 1}} C_2H_5Cl \xrightarrow{\text{step 2}} C_2H_6O \xrightarrow{\text{step 3}} C_2H_4O$$

i) Name the type of reaction shown in step 1.

ii) Write an equation, using structural formulas, for the reaction in step 2 in which C_2H_5Cl reacts with aqueous NaOH to form C_2H_6O.

[2 marks]

Question 1b

b) The product of step 2 can undergo combustion.

i) Write a balanced equation for the *complete* combustion of the product of step 2.

ii) Write a balanced equation for the *incomplete* combustion of the product of step 2.

[2 marks]

Question 1c

c) Give the reagents and conditions needed to carry out step 3.

[2 marks]

Question 1d

d) The product of step 2 has a higher boiling point than the product of step 3.

State the names of the products of step 2 and 3, and explain the difference in their boiling points.

[3 marks]

Question 2a

a) Phenylethene, $C_6H_5CH=CH_2$, is a substance that can be polymerized. Draw a section of the polymer showing three repeat units and name the resulting polymer.

[2 marks]

Question 2b

b) A solution of bromine in hexane reacts with phenylethene.

i) Draw the displayed structure of the product.

ii) Name the product of the reaction.

iii) State the reaction conditions.

iv) State what observations would be seen in this reaction.

[4 marks]

Question 2c

c) Phenylethene can undergo catalytic hydrogenation. Draw the displayed structure of the product of the reaction, name the product, and state the reaction conditions.

[3 marks]

Question 2d

d) 2-phenylethanol, $C_6H_5CH_2CH_2OH$, is a colourless liquid with a pleasant floral smell widely found in nature. Under the right conditions, it can be made from phenylethene in a two-step reaction using sulfuric acid.

State the reaction conditions and write balanced equations for the two-step reactions.

[3 marks]

Question 3a

a) Alkanes are generally unreactive and do not react with acids, bases, or with oxidising or reducing agents. However, they will react with halogens under suitable conditions, to form halogenoalkanes.

Methane reacts with chlorine in this way to form chloromethane.

i) State the name of this type of reaction mechanism.

ii) Write an overall equation for the reaction and give the reaction conditions.

[3 marks]

Question 3b

b) The reaction described in part (a) consists of three steps. In the first step, the C*l*-C*l* bond is broken to form two chlorine free radicals.

i) State and explain the type of bond breaking that occurs in the initiation step.

ii) Define the term *free radical*.

iii) Explain why the C-H bond in the alkane does not break in the initiation step instead of the Cl-Cl bond.

[3 marks]

Question 3c

c) Give the equations for each step of the reaction between methane and chlorine as described in part (a).

Label each equation with the name of the correct step. You only need to provide one equation for the final step.

[4 marks]

Question 3d

d) Chlorofluorocarbons (CFCs) are organic compounds consisting of carbon, chlorine, and fluorine atoms. They are believed to destroy the ozone layer in a similar reaction to the one described in part (a).

Ozone can be broken down by radicals formed in the atmosphere. The ozone layer is important to protecting the Earth from harmful exposure to ultraviolet light. Without this ozone layer, life on Earth would be very different.

An example of a CFC which can damage the ozone layer is CCl_3F.

i) Explain why these free radicals act as catalysts in the breakdown of ozone to oxygen. Support your answer by writing suitable equations.

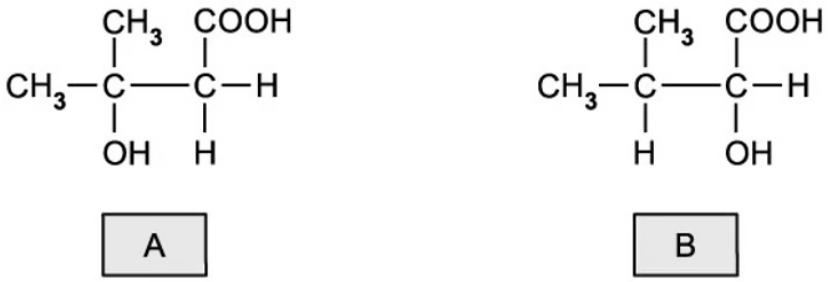
ii) Draw the three-dimensional structure of CCl_3F and name the shape of the molecule.

[4 marks]

Question 4a

a) Two isomeric compounds are shown below in **Figure 1**.

Figure 1



i) State the name of each isomer.

ii) Suggest a chemical reagent to distinguish between these isomers and deduce the type of reaction taking place.

iii) State the observations made in each case.

[5 marks]

Question 4b

b) Compound B, $CH_3CH(CH_3)CH(OH)COOH$, can be oxidized into compound C.

i) Deduce the half-equation for the conversion of compound B into C.

ii) The half equation for the oxidation reaction using acidified potassium dichromate(VI) is as follows:

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{2+}(aq) + 7H_2O(l)$$

Deduce the overall redox equation for the conversion of B into C.

[3 marks]

Question 4c

c) The same reaction in part (b) can be used to oxidize ethanol into ethanal or ethanoic acid, depending on the reaction conditions.

Outline how the reaction conditions can be changed to produce ethanal or ethanoic acid.

[2 marks]

Question 4d

d) Under the right conditions, the two molecules of compound A can react together to produce a dimer.

i) Name the type of reaction taking place and state the reaction conditions.

ii) Draw the structure of the product, showing clearly how the two molecules are joined.

[3 marks]

Question 5a

a) Benzene, C_6H_6, typically undergoes *electrophilic substitution* reactions.

i) State the meaning of the term *electrophile*.

ii) Write an equation for the reaction between benzene and concentrated nitric acid.

iii) Identify the electrophile in the reaction and show, by means of an equation, how it is generated.

[4 marks]

Question 5b

b) Benzene is a highly unsaturated molecule.

i) Discuss why benzene undergoes substitution reactions rather than addition reactions.

ii) Show, by means of an equation, the reaction of benzene with chlorine and state any necessary conditions.

[5 marks]

Question 5c

c) An aromatic organic compound with molecular formula C_7H_8 reacts with bromine in the presence of UV light to produce a compound with molecular formula C_7H_7Br.

i) Name the type of reaction taking place.

ii) Deduce the structures of the reactant and product.

iii) Give the formula of an additional organic product that could be obtained in the reaction.

[3 marks]

Question 5d

d) The same aromatic compound in part (c), C_7H_8, can be reacted with concentrated nitric acid to produce a multiple substituted product, with molecular formula $C_7H_5N_3O_6$.

i) Deduce the systematic IUPAC name for this compound.

ii) Draw the structure of $C_7H_5N_3O_6$.

iii) Name a use for the product.

[3 marks]