Chemistry 5070

Name of candidate: _____

11. Organic chemistry

Content

11.1 Alkanes
11.2 Alkenes
11.3 Alcohols
11.4 Carboxylic acids
11.5 Macromolecules

*The use of molecular models is recommended to enable students to appreciate the three-dimensional structures of molecules.

Learning outcomes

Candidates should be able to:

(a) state that the naphtha fraction from petroleum (crude oil) is the main source of hydrocarbons used as the feedstock for the production of a wide range of organic compounds

(b) describe the issues relating to the competing uses of oil as an energy source and as a chemical feedstock

11.1 Alkanes

(a) describe a homologous series as a group of compounds with a general formula, similar chemical properties and showing a gradation in physical properties as a result of increase in the size and mass of the molecules, e.g. melting and boiling points; viscosity.

(b) describe the alkanes as a homologous series of saturated hydrocarbons with the general formula CnH2n + 2

(c) draw the structures of branched and unbranched alkanes, C1 to C4, and name the unbranched alkanes, methane to butane

(d) define isomerism and identify isomers

(e) describe the properties of alkanes (exemplified by methane) as being generally unreactive except in terms of burning and substitution by chlorine

11.2 Alkenes

(a) describe the alkenes as a homologous series of unsaturated hydrocarbons with the general formula CnH2n

(b) draw the structures of branched and unbranched alkenes, C2 to C4, and name the unbranched alkenes, ethene to butene

(c) describe the manufacture of alkenes and hydrogen by cracking hydrocarbons and recognise that cracking is essential to match the demand for fractions containing smaller molecules from the refinery process

(d) describe the difference between saturated and unsaturated hydrocarbons from their structures and by using aqueous bromine

(e) describe the properties of alkenes in terms of combustion, polymerisation and their addition reactions with bromine, steam and hydrogen

(f) state the meaning of *polyunsaturated* when applied to food products

(g) describe the manufacture of margarine by the addition of hydrogen to unsaturated vegetable oils to form a solid product

11.3 Alcohols

(a) describe the alcohols as a homologous series containing the –OH group

(b) draw the structures of alcohols, C1 to C4, and name the unbranched alcohols, methanol to butanol

(c) describe the properties of alcohols in terms of combustion and oxidation to carboxylic acids

(d) describe the formation of ethanol by the catalysed addition of steam to ethene and by fermentation of glucose

(e) state some uses of ethanol, e.g. as a solvent; as a renewable fuel; as a constituent of alcoholic beverages

11.4 Carboxylic acids

(a) describe the carboxylic acids as a homologous series containing the –CO2H group

(b) draw the structures of carboxylic acids, methanoic acid to butanoic acid, and name the unbranched acids, methanoic to butanoic acids

(c) describe the carboxylic acids as weak acids, reacting with carbonates, bases and some metals

(d) describe the formation of ethanoic acid by the oxidation of ethanol by atmospheric oxygen or acidified potassium manganate(VII)

(e) describe the reaction of carboxylic acids from C1 to C4 with alcohols from C1 to C4 to form esters

(f) draw the structures of and name the esters formed from carboxylic acids (see 11.4 (b)) and alcohols (see 11.3 (b))

(g) state some commercial uses of esters, e.g. perfumes; flavourings; solvents

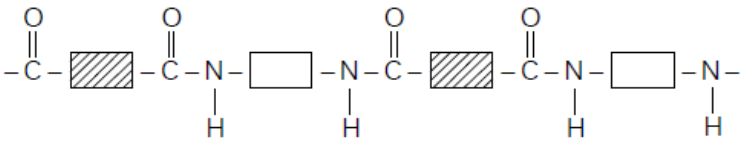
11.5 Polymers

(a) describe polymers as large molecules made from many small units called monomers, different polymers having different units and/or different linkages

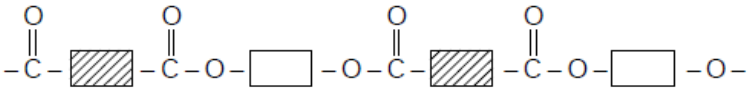
(b) describe the formation of poly(ethene) as an example of addition polymerisation of ethene as the monomer

(c) state some uses of poly(ethene) as a typical plastic, e.g. plastic bags; clingfilm

(d) describe nylon, a polyamide, and *Terylene*, a polyester, as condensation polymers, the partial structure of nylon being represented as



and the partial structure of *Terylene* as



(details of manufacture and mechanisms of these polymerisations are not required)

(e) state some typical uses of synthetic fibres such as nylon and *Terylene*, e.g. clothing; curtain materials; fishing line; parachutes; sleeping bags

(f) deduce the partial structure of the polymer product from a given monomer and vice versa

(g) describe the pollution problems caused by the disposal of non-biodegradable plastics

(h) identify proteins and complex carbohydrates (polysaccharides, e.g. starch) as natural polymers

(i) describe proteins as possessing the same amide linkages as nylon but with different monomer units

(j) describe fats as esters possessing the same linkages as *Terylene* but with different monomer units

(k) describe the hydrolysis of proteins to amino acids and complex carbohydrates (polysaccharides, e.g. starch) to simple sugars

Define Organic Chemistry.

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State what is meant by a Homologous Series.

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Write some examples of a homologous series.

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For your knowledge:

Catenation is the binding of an element to itself through covalent bonds to form chain or ring molecules.

Catenation occurs most readily with carbon, which forms covalent bonds with other carbon atoms to form longer chains and structures. This is the reason for the presence of the vast number of organic compounds in nature.

In chemical nomenclature, the **IUPAC** nomenclature of organic chemistry is a systematic method of naming organic chemical compounds as recommended by the International Union of Pure and Applied Chemistry (**IUPAC**).

Functional group can be taken as an identity of a homologous series. Functional groups are specific groups of atoms within molecules that have very characteristic properties regardless of the other atoms present in a molecule.

S. No.	Homologous Series	Functional Group	Suffix	General Formula
1	Alkane			
2	Alkene			
3	Alkyne			
4	Alcohol			
5	Carboxylic Acids			
6	Esters			

*WE ADD -yl WITH THE NAME OF THE BRANCH

No of Carbon atoms	Prefix
1	
2	
3	
4	
5	
6	Hex
7	Hept
8	Oct
9	Non
10	Dec

Describe what is meant by

1. Alkane:

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2. Alkene:

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Describe the difference between saturated and unsaturated hydrocarbons from their structures. Also describe a chemical test to distinguish them.

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What happens in an oil refinery?

Oil refineries separate the hydrocarbons in petroleum by fractional distillation through the following stages:

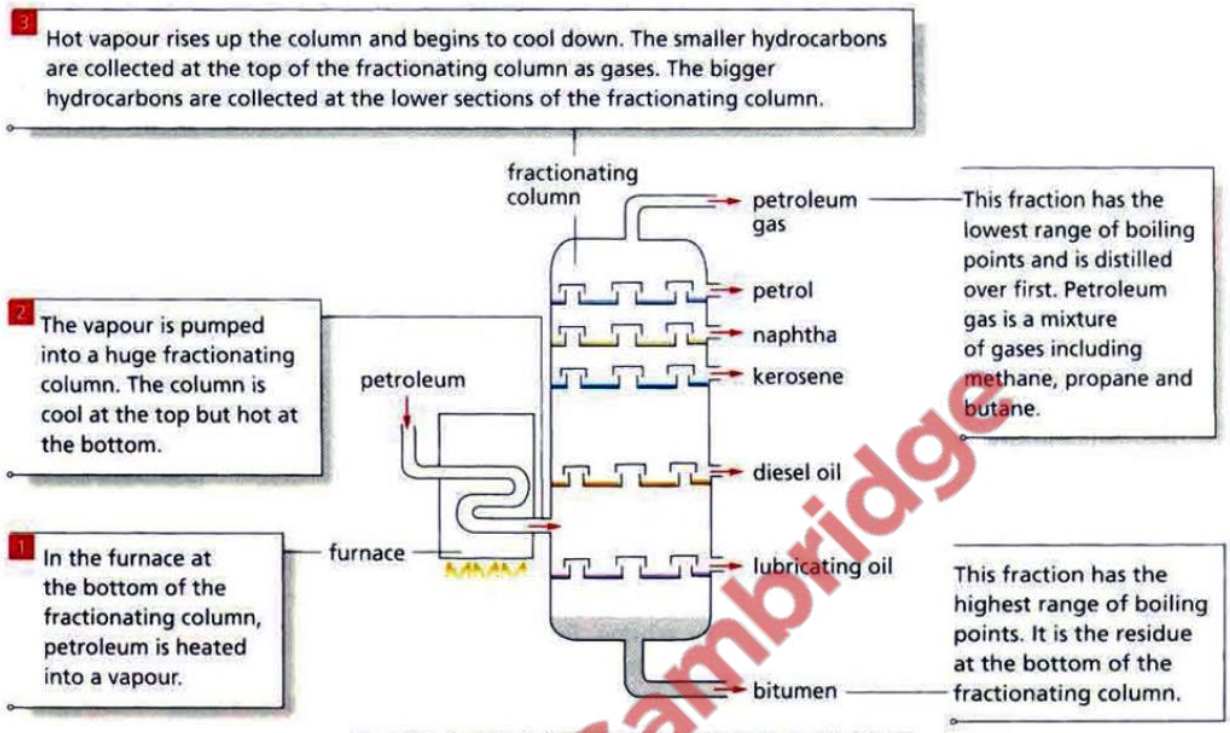
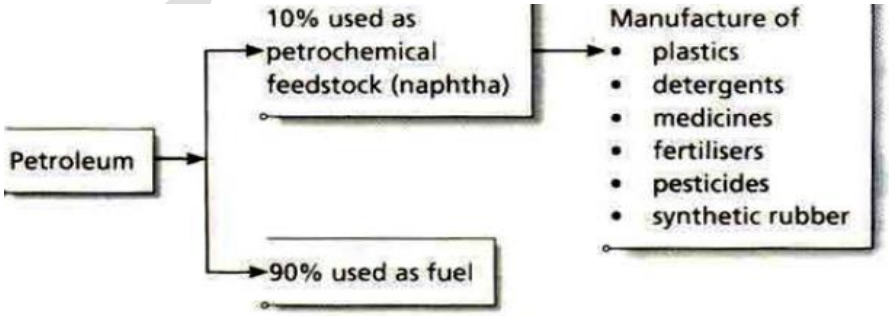


Fig. 21.2 Fractional distillation of petroleum in an oil refinery

petroleum gas	below 40	1 – 4	fuel for cooking and heating
petrol (gasoline)	40 – 75	5 – 10	fuel for car engines
naphtha	75 – 150	7 – 14	feedstock (raw material) for petrochemical industry (which produces plastics, detergents etc.)
kerosene (paraffin)	160 – 250	11 – 16	fuel for aircraft engines; for cooking using oil stoves; for heating purposes
diesel oil	250 – 300	16 – 20	fuel for diesel engines
lubricating oil	300 – 350	20 – 35	for lubricating machines; for making waxes and polishes
bitumen (asphalt/residue)	above 350	more than 70	for paving road surfaces



Describe the general trend in the physical properties the compounds of Alkanes. Also explain the reason behind this trend.

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Alkanes	Boiling Point (° C)	State
Methane CH_4	-164	Gases at RT
Ethane C_2H_6	-89	
Propane C_3H_8	-42	
Butane C_4H_{10}	-0.5	
Pentane C_5H_{12}	36	Liquids at RT
Hexane C_6H_{14}	69	
Heptane C_7H_{16}	98	
Octane C_8H_{18}	125	

Boiling point increases with increasing carbon numbers (increasing chain length) due to increasing temporary dipoles causing stronger van der Waals' forces between the molecules as their size increases

Increase is not linear due to the increase in chain length being proportionally greater in smaller molecules

Other physical properties that show predictable trends with increasing chain length are density and viscosity

Define isomerism.

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Draw the structure of all the possible Isomers of the given compounds. Also write the names of these compounds.

1. Butane

2. Pentane

3. Butene

4. Hexane

State whether Alkanes usually undergo Substitution Reaction or Addition Reaction?

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State whether Alkenes usually undergo Substitution Reaction or Addition Reaction?

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Alkanes usually behave as unreactive. State two common reaction where they (exceptionally) do not behave unreactive.

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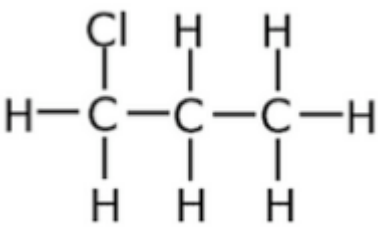
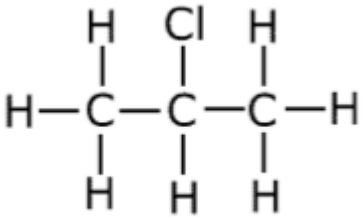
What is the correct relationship between the two molecules shown below?





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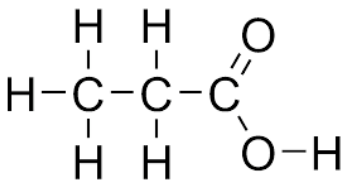
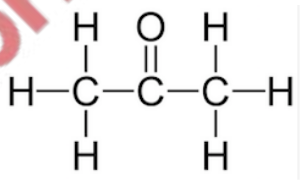
Which of the following Compounds (A,B,C,D) are the isomers of each other? Justify your answer.



A



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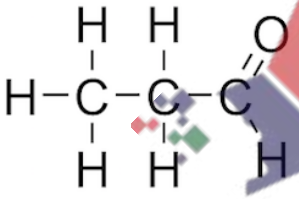
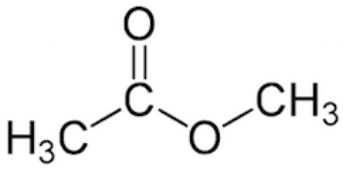


C



D

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Write a general word equation for the combustion of Alkane.

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Write a balanced equation for the combustion of Methane.

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Write a balanced equation for the combustion of Ethane.

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Write a balanced equation for the combustion of Pentane.

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Write balanced equation for the Chlorination of Methane. Show all the chain reactions.

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State what condition is necessary to conduct the above reaction.

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Write a balanced equation for the combustion of Ethene.

Write a balanced equation for the Addition of Steam in Ethene.

Write a balanced equation for the Addition of Hydrogen in Ethene.

Write a balanced equation for the Addition of Bromine in Ethene.

Write a balanced equation for the Addition of Steam in Propene.

Write a balanced equation for the Addition of Bromine in Butene.

Write a balanced equation for the Addition of Hydrogen in 2-Methyl Propene.

State the meaning of **polyunsaturated** when applied to food products.

Describe how Margarine can be manufactured, using unsaturated vegetable oils.

Describe the most common method of manufacture of Alkanes. Also, write about the side products being produced in this reaction.

State what is meant by Alcohols.

Write a general word equation for the combustion of Alcohol.

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Write a general word equation for the oxidation of Alcohol.

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Write the names of some suitable oxidizing reagents for the oxidation of Alcohols.

_____

Write a balanced equation for the combustion of Methanol.

Write a balanced equation for the combustion of Ethanol.

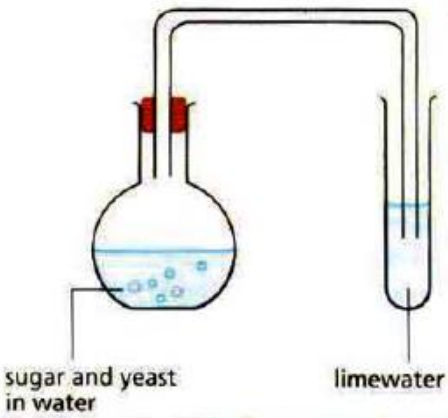
Write a balanced equation for the combustion of Propanol.

Write a balanced equation for the combustion of Butanol

Explain how Ethanol can be produced by fermentation:

glucose solution $\xrightarrow{\text{yeast}}$ ethanol + carbon dioxide

$C_6H_{12}O_6(aq) \xrightarrow{\text{yeast}} 2C_2H_5OH(aq) + 2CO_2(g)$



1 In fermentation, carbon dioxide is produced. Hence, frothing (formation of foam) can be observed in the flask. A white precipitate can be also observed to form in the limewater.

2 Fermentation can only take place in the absence of oxygen. Hence, the apparatus needs to be air-tight. This is ensured by the following precautions:
- The rubber bung is secured tightly to the flask.
- The limewater in the test tube prevents air from entering the apparatus.

Fig. 24.4 The apparatus for fermentation of glucose solution

The enzymes in yeast work best at around 37 °C. If the temperature is raised beyond 37 °C, the enzymes will die and fermentation stops.

The fermentation of sugars produces only a dilute solution of ethanol (up to about 15%). This is because when the alcohol content exceeds this value, the yeast dies and fermentation stops. Ethanol can be obtained from this liquid mixture by fractional distillation.

Explain how Ethanol is manufactured on high scale in industries.

State some uses of Ethanol.

State what is meant by Carboxylic Acid.

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Draw the complete displayed structure of the following

Name of Compound	Displayed Structure
Methanoic acid	
Ethanoic acid	
Propanoic acid	
Butanoic acid	
*	
*	

State whether Carboxylic acid are strong acids or weak acids

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Write a balanced equation to show the reaction between Methanoic Acid and Sodium metal.

Write a balanced equation to show the reaction between Ethanoic Acid and Potassium metal.

Write a balanced equation to show the reaction between Methanoic Acid and magnesium metal.

Write a balanced equation to show the reaction between Ethanoic Acid and Calcium metal.

Write a balanced equation to show the reaction between Ethanoic Acid and Calcium Carbonate.

Write equation for the formation of Ethanoic acid from Ethanol by oxidation through atmospheric oxygen.

Write equation for the formation of Ethanoic acid from Ethanol by oxidation through $KMnO_4$

*A vinegar smell is detected.

Write equation for the formation of Propanoic acid from Alcohol by oxidation through atmospheric oxygen.

Suggest how ethanol can be converted into Ethanoic acid. Write the relevant equation.

Suggest how Methanol can be converted into Methanoic acid. Write the relevant equation.

Suggest how Butanol can be converted into Butanoic acid. Write the relevant equation.

Write general equation for the reaction between Carboxylic Acid and Alcohol.

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Write the name given to the equation (of above type).

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Write important conditions for the above reaction.

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Write a balanced equation for the reaction between Ethanoic Acid and Methanol.

Write a balanced equation for the reaction between Ethanoic Acid and Ethanol.

Write a balanced equation for the reaction between Propanoic Acid and Ethanol.

Write a balanced equation for the reaction between Propanoic Acid and Propanol.

Write a balanced equation for the reaction between Propanoic Acid and Butanol.

Write a balanced equation for the reaction between Ethanoic Acid and Butanol.

Describe what is meant by a polymer.

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Describe what is meant by Polymerisation.

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Define Addition Polymerisation.

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Define Condensation Polymerisation.

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Describe how polyethene can be formed through polymerization.

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State some uses of Polyethene.

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Write an equation to show polymerisation of propene.

Write an equation to show polymerisation of 2-methyl propene.

Write an equation to show polymerisation of But-1-ene.

Write an equation to show polymerisation of But-2-ene.

Describe what Nylon is and, how it can be manufactured. Also show their partial structure.

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Describe what Terylene is and, how it can be manufactured. Also show their partial structure.

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Write some common uses of Nylon.

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Write some common uses of Terylene.

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Describe the problems caused by disposal of non-biodegradable plastics.

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State any one similarity and any one difference between proteins and nylons.

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State any one similarity and any one difference between esters and Terylene.

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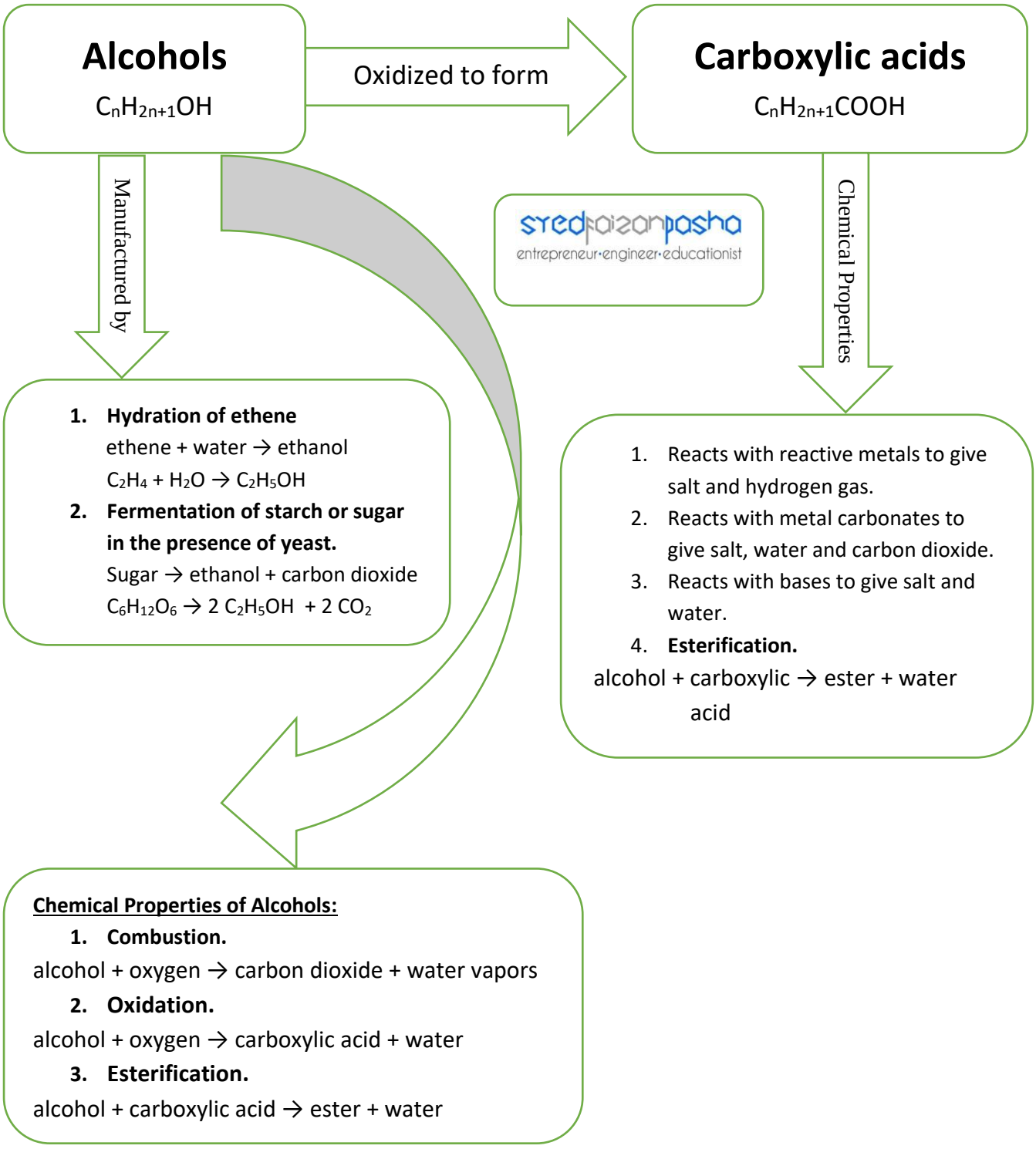
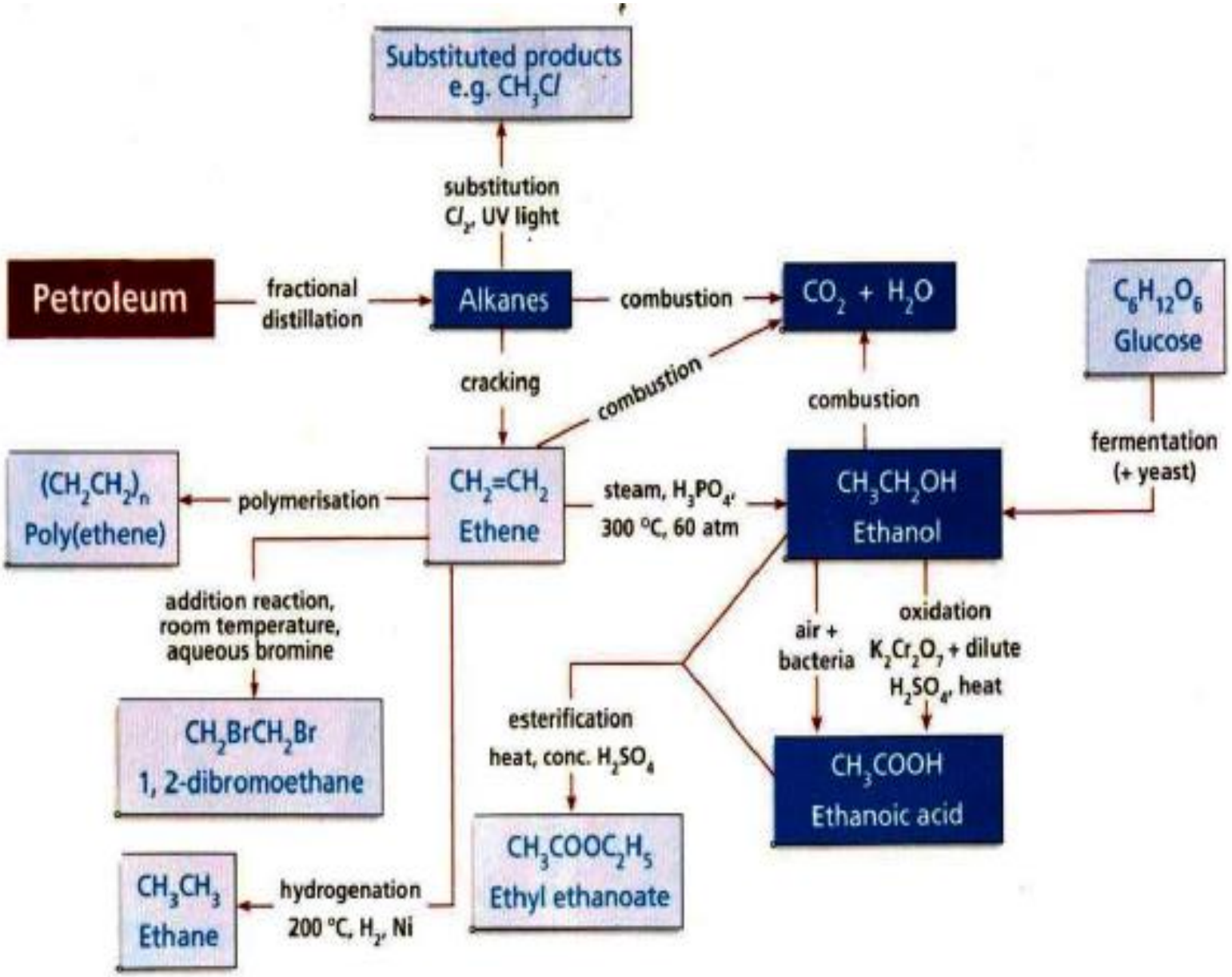

Alcohols
$C_nH_{2n+1}OH$
Oxidized to form
Carboxylic acids
$C_nH_{2n+1}COOH$
Manufactured by
Chemical Properties
1. Hydration of ethene
ethene + water → ethanol
$C_2H_4 + H_2O \rightarrow C_2H_5OH$
2. Fermentation of starch or sugar in the presence of yeast.
Sugar → ethanol + carbon dioxide
$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$
1. Reacts with reactive metals to give salt and hydrogen gas.
2. Reacts with metal carbonates to give salt, water and carbon dioxide.
3. Reacts with bases to give salt and water.
4. Esterification.
alcohol + carboxylic → ester + water
acid
Chemical Properties of Alcohols:
1. Combustion.
alcohol + oxygen → carbon dioxide + water vapors
2. Oxidation.
alcohol + oxygen → carboxylic acid + water
3. Esterification.
alcohol + carboxylic acid → ester + water


Substituted products
e.g. CH_3Cl
substitution
Cl_2, UV light
Petroleum
fractional distillation
Alkanes
combustion
$CO_2 + H_2O$
$C_6H_{12}O_6$
Glucose
cracking
combustion
combustion
fermentation
(+ yeast)
$(CH_2CH_2)_n$
Poly(ethene)
polymerisation
$CH_2=CH_2$
Ethene
steam, H_3PO_4,
300 °C, 60 atm
CH_3CH_2OH
Ethanol
addition reaction,
room temperature,
aqueous bromine
air +
bacteria
oxidation
$K_2Cr_2O_7$ + dilute
H_2SO_4, heat
CH_2BrCH_2Br
1, 2-dibromoethane
esterification
heat, conc. H_2SO_4
CH_3COOH
Ethanoic acid
CH_3CH_3
Ethane
hydrogenation
200 °C, H_2, Ni
$CH_3COOC_2H_5$
Ethyl ethanoate