

- 
- ? Alkenes
 - ? Polymers
 - ? Alkynes
 - ? Alcohols
 - ? Soaps

ORGANIC CHEMISTRY

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ORGANIC CHEMISTRY

Organic chemistry is the study of chemistry of carbon and its compounds excluding its **oxides, carbonates, and bicarbonates**.

Unique properties of carbon

1. Carbon shows catenation i.e. it can form straight chain, branched chain and ring chain compounds.



2. Carbon can form multiple bonds with itself and other elements.

3. Carbon has a valency of 4 which enables it to form bonds with as many as 4 different elements.

Homologous series

Homologous series is a group of organic compounds with the same general formula, similar properties and methods of preparation.



Hydrocarbons

Hydrocarbons are organic compounds that contain carbon and hydrogen only. They satisfy the general formula C_xH_y and include alkanes, alkenes and alkynes.



ALKANES

Alkanes are hydrocarbons which contains a carbon-carbon single bond between two carbon atoms (saturated) with general formula C_nH_{2n+2} ; $n = 1, 2, 3, \dots$

The first four members include:



n	Molecular formula	Structural formula	Name
1	CH ₄	CH ₄ or	Methane
2	C ₂ H ₆	CH ₃ CH ₃ or	Ethane
3	C ₃ H ₈	CH ₃ CH ₂ CH ₃ or	Propane
4	C ₄ H ₁₀	CH ₃ CH ₂ CH ₂ CH ₃ or	Butane

Note

Methane is the main component [about 75%] of biogas. Others are carbon dioxide, ammonia and hydrogen sulphide.

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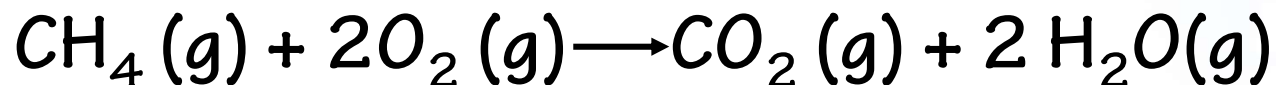
Physical properties of alkanes

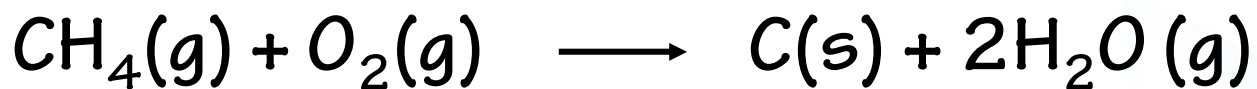
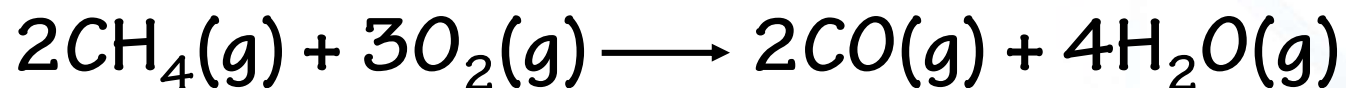
1. The first 4 members are gases, the next 12 are liquids and the rest are waxy solids at room temperature.
2. They are less dense than water.
3. All are insoluble in water but soluble in organic solvents like ethanol.



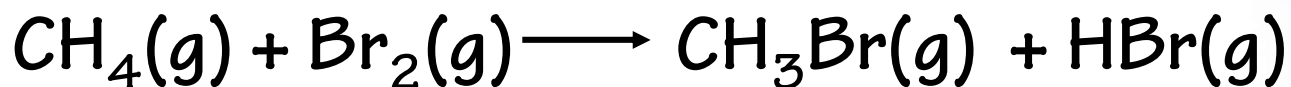
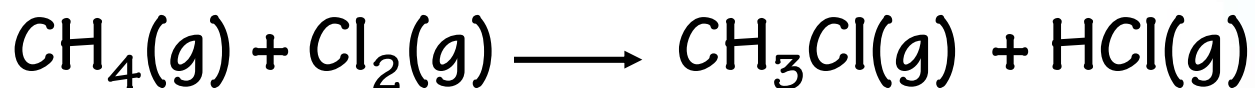
Chemical properties of alkanes

1. Alkanes burn in plenty of air forming carbon dioxide and water and in limited air forming carbon monoxide/carbon and water.





2. Alkanes react with halogens in presence of sunlight to form alkylhalides.



Uses of alkanes

- As fuel for cooking and lighting.
- For making Lubricants.
- For making Printer's ink.
- For making Paints.
- For making Carbon paper.



Cracking

Cracking is the breaking of a long chain hydrocarbon into smaller hydrocarbons, one of which is an alkene.



Cracking is carried out by heating (thermal cracking) or using a catalyst (catalytic cracking).



Check Point 1

1. Alkanes are hydrocarbons with the general formula



2. Which one of the following formulae represents an alkane?



3. Which one of the following hydrocarbons does not belong to the same group?

- A. Ethane. B. Ethene.
C. Methane. D. Propane.



4. The main component of biogas is

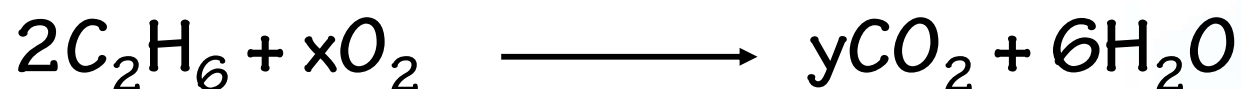
- | | | | |
|----|--------|----|---------|
| A. | butane | B. | ethane |
| C. | ethene | D. | methane |



5. Which one of the following is the molecular formula of ethane?



6. Ethane burns in oxygen according to the following equation

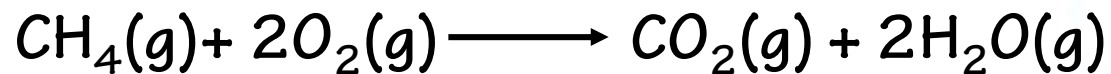


The values of x and y in the equation are

- A. $x = 2$ and $y = 2$ B. $x = 7$ and $y = 6$
C. $x = 7$ and $y = 4$ D. $x = 4$ and $y = 6$



7. Methane burns in oxygen according to the following equation



The volume of oxygen required for the complete combustion of 20cm^3 of methane is (all volumes are measured at standard conditions)

- | | | | |
|----|-----------------|----|-----------------|
| A. | 10cm^3 | B. | 20cm^3 |
| C. | 30cm^3 | D. | 40cm^3 |



8. Which one of the following statements is not true about butane?

- A. It is used as fuel
- B. It is a hydrocarbon
- C. It decolourises bromine water
- D. It is a saturated compound

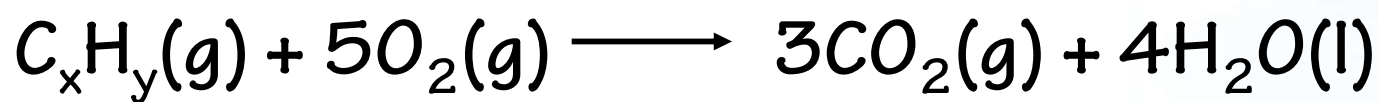


9. Which one of the following pairs of hydrocarbons can be represented by the same general formula?

- A. Ethane and ethene
- B. Ethane and propane
- C. Ethene and methane
- D. Ethene and Butane



10. A hydrocarbon C_xH_y burns in oxygen according to the following equation.



Which one of the following are the values of x and y respectively.

A. 1 and 4

B. 2 and 4

C. 3 and 8

D. 4 and 10



11. Which one of the following sets of compounds belongs to the same homologous series?

- A. C_2H_4 , C_3CH_6 and C_4H_8
- B. C_2H_6 , C_2CH_2 and C_3H_8
- C. C_2H_2 , C_3CH_6 and C_4H_{10}
- D. C_2H_6 , C_5CH_{10} and C_3H_8



12. (a) Explain term **cracking**.
- (b) Draw a fully labelled diagram of the apparatus that can be used to crack liquid paraffin in the laboratory.
- (c) A hydrocarbon, R (molecular mass = 30) contains 80% carbon by mass.
- (i) Determine the molecular formula of R.
- (ii) Write an equation for the complete combustion of R.



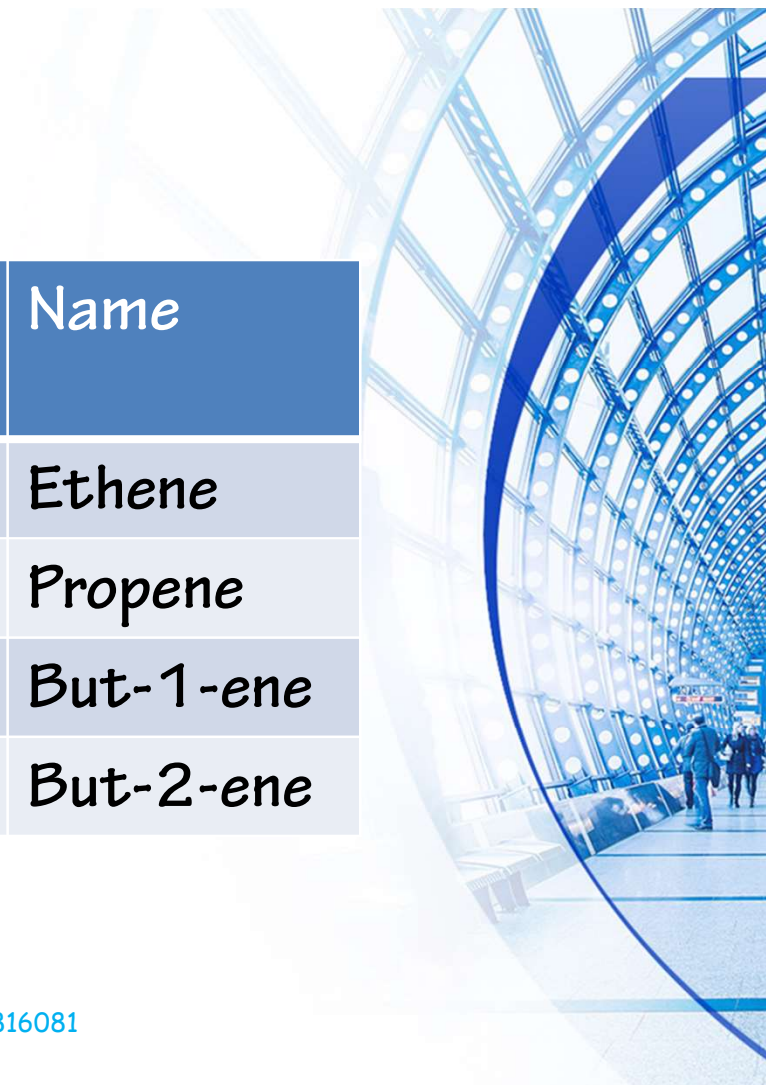
ALKENES

Alkenes are unsaturated hydrocarbons which contains at least a carbon-carbon double bond between two carbon atoms with general formula C_nH_{2n} .

The first three members include:



n	Molecular formula	Structural formula	Name
2	C_2H_4	$H_2C=CH_2$ or	Ethene
3	C_3H_6	$CH_3CH=CH_2$ or	Propene
4	C_4H_8	$CH_3CH_2CH=CH_2$ or	But-1-ene
		$CH_3CH=CHCH_3$ or	But-2-ene



Note

But-1-ene and but-2-ene are isomers of C_4H_8 .

Isomers are compounds having the same molecular formulae but different structural formulae.

The occurrence of two or more compounds with the same molecular formula but different structural formulae is called **isomerism**.

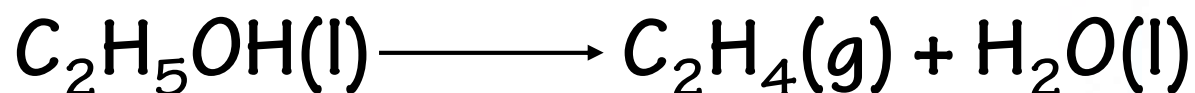


ETHENE

Ethene is prepared in the laboratory by dehydration of ethanol.

A mixture of ethanol and excess concentrated sulphuric acid is put in a round bottomed flask. The flask is fitted with a delivery tube and a thermometer. The mixture is heated (170°C) and ethene is produced according to the equation.





The gas is passed through solution of concentrated sodium hydroxide/ potassium hydroxide solution (caustic soda) to remove sulphur dioxide and is collected over water.



Physical properties of ethene

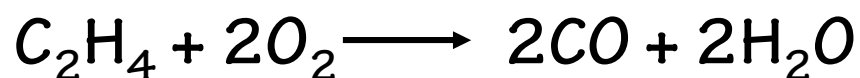
- (i) It is a colourless gas.
- (ii) It is slightly soluble in water.
- (iii) It has a faint smell.
- (iv) Its density is about the same as that of air.
- (v) It undergoes polymerization.



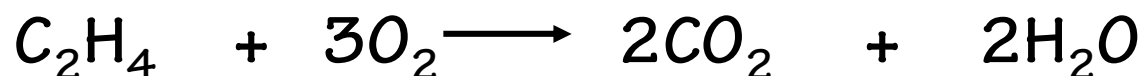
Chemical properties of alkenes

1. Combustion

Alkenes burn in a limited supply of air (oxygen) to form carbon monoxide and water (incomplete).

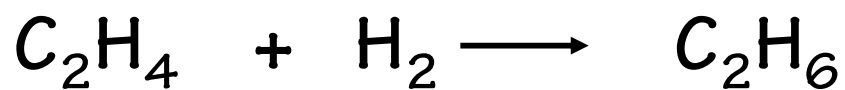


Alkenes burn completely in excess oxygen to form carbon dioxide and water (complete).



2. Addition reactions

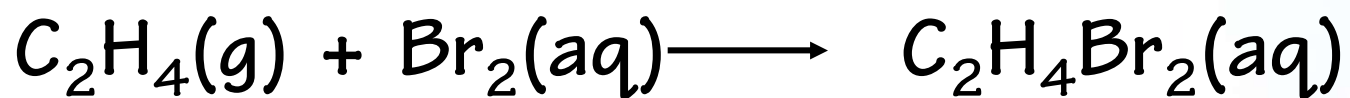
(a) Alkenes react with hydrogen at 150°C in the presence of nickel catalyst to form alkanes [**hydrogenation**].



Note: The reaction is used to change vegetable oil to margarine (blue band).



(b) When an alkene is bubbled into bromine water [or bromine in CCl_4], reddish-brown bromine solution turns colourless (decolourised).



Test for Alkenes

Reagent 1: Bromine in tetrachloromethane.

Observation: Reddish-brown solution turns colourless.

Reagent 2: Acidified potassium manganate(VII) solution.

Observation: The purple solution turns colourless.



Check Point 2

1. The reaction between ethanol and concentrated sulphuric acid to form ethene is called

- A. hydrogenation. B. catalysis.
C. dehydration. D. hydration.



2. Which one of the following substances decolourises bromine water?

- A. Ammonia. B. Ethene.
C. Methane. D. Chlorine.



3. Concentrated sulphuric acid reacts with ethanol to form ethene. This shows that
- A. the acid is an oxidising agent.
 - B. ethene can be converted to ethanol.
 - C. ethene has a higher affinity for the acid.
 - D. the acid is dehydrating agent.



4. A gas that when bubbled through bromine water changes the colour of bromine water from reddish-brown to colourless is

- | | |
|-------------|--------------|
| A. methane. | B. ethene. |
| C. ethane. | D. hydrogen. |



5. A colourless gas which decolourises bromine water is

A. chlorine.

B. ethene.

C. sulphur dioxide.

D. ethane.



6. Which one of the following can be used to test for ethene?

- A. Lime water.
- B. Bromine water.
- C. Glowing water.
- D. Potassium dichromate paper.



7. The reaction in which vegetable oil is changed to margarine is called

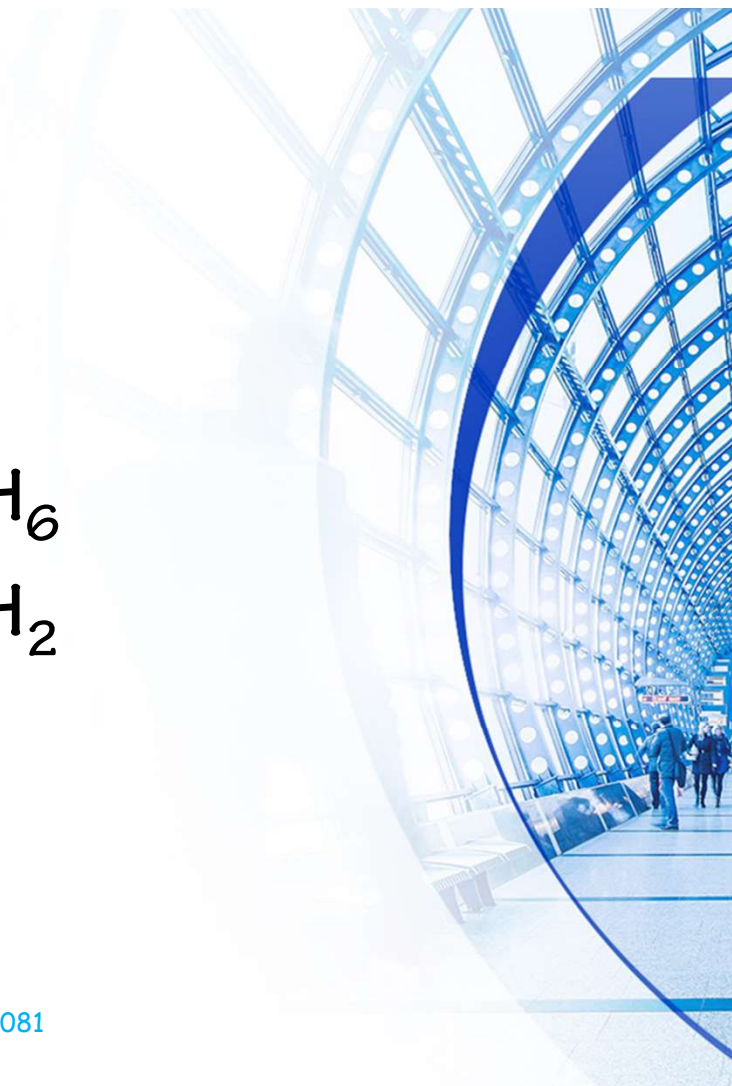
- A. Dehydration
- B. Hydrogenation
- C. Hydration
- D. Saponification



8. Which one of the following is the molecular formula of ethene?



9. Which of the following formula represents an alkene?



10. Which one of the following is **not** a property of ethene?

- A. Ethene turns potassium permanganate colourless.
- B. Ethene has a double bond between carbon atoms.
- C. Ethene undergoes addition reaction with bromine.
- D. Ethene dissolves in water to form a basic solution.



11. Hot excess concentrated sulphuric acid reacts with ethanol to give a gas which decolourises bromine water. The gas is

A. methane.

B. ethene.

C. ethyne.

D. ethane.



12. The gas which decolourises both potassium manganate(VII) and bromine water is

A. ethene.

B. methane.

C. carbon monoxide. D. hydrogen chloride.



13. Which one of the following reagents can be used to distinguish between ethene and ethane ?

- A. Bromine water.
- B. Lime water.
- C. Potassium dichromate.
- D. Barium nitrate.



14. Which one of the following processes is used to convert vegetable oil into fats?

A. Saponification.

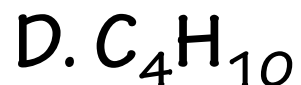
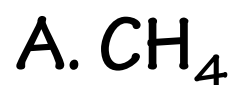
B. Cracking.

C. Hydrogenation.

D. Polymerisation.



15. Which one of the following compounds can undergo polymerisation reaction?



16. Which one of the following compounds will turn bromine from reddish-brown to colourless?



17. Which one of the following hydrocarbons is unsaturated?



18. Which one of the following substances is formed when ethanol is dehydrated by concentrated sulphuric acid?

- A. C_2H_4 B. C_3H_8
C. CO D. C



- 2000/P2/10
- 2004/P2/9
- 2006/P2/11
- 2010/P2/13
- 2012/P2/8
- 2013/P2/7
- 2014/P2/12
- 2015/P2/3
- 2016/P2/6, 8
- 2017/P2/7
- 2018/P2/6

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POLYMERS

Polymers are long chain molecules made by joining together many small molecules (monomers).

There are two types of polymers:

Natural polymers: These are naturally occurring polymers made from naturally occurring monomers.

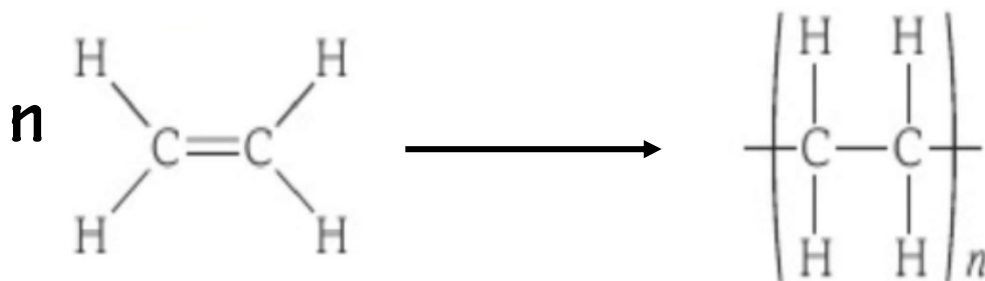


E.g. protein fibres (wool, silk), cellulose (cotton, wood, paper, sisal).

Synthetic polymers: These are man-made polymers made from man-made monomers e.g. polyethene, polypropene, nylon.



Polyethene/polythene: Is formed by heating **ethene** at 200°C and 1500atm with oxygen as a catalyst.

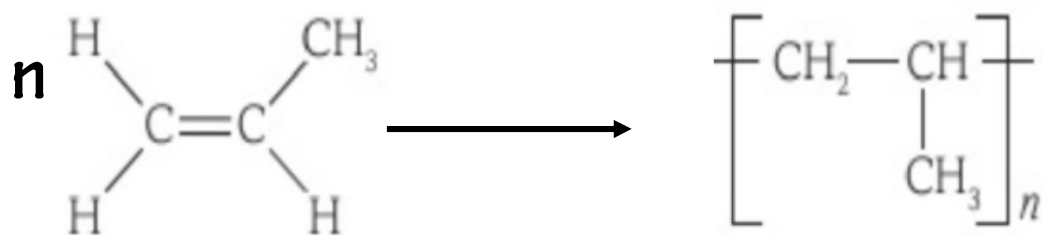


Polyethene is used for

- (i) making plastic bags and bottles
- (ii) making insulating covers
- (iii) making packaging material

Polypropene is formed from **propene** under similar conditions.





It is used for making ropes and crates.



Natural rubber is formed from 2-methybuta-1,3-diene found in latex trees.

It is soft and sticky when in crude form.

Its property is improved by vulcanisation.

During vulcanization, crude rubber and Sulphur are heated together.



The Sulphur atoms are introduced between the chains and double bonds of rubber molecules giving rubber greater elasticity, durability and strength.

Vulcanised rubber is used to make tyres.



POLYMERISATION

Polymerisation is the joining together of small molecules (monomers) to form long chain molecules (polymers).

The two types of polymerisation are addition polymerisation and condensation polymerisation.



Addition polymerisation is the combination of many small molecules of the same kind containing double bonds to make very large molecule without loss of other molecules.

Addition polymers include polyethene, polypropene.



Condensation polymerisation is the combination of two monomers to form a large molecule with elimination of small molecules like water.

Condensation polymers include polyester, nylon, protein, starch.



Plastics

Plastics are synthetic polymers which can easily be moulded at higher temperature.

Plastics are tough and resistant to action of alkali.

The two types of plastics are:



Thermosoftening plastics/ thermoplasts
are plastics which soften on heating and
can be remoulded e.g. polythene, rubber.
They undergo physical change when
heated.



Thermosetting plastics/ thermosets are plastics which do not soften on heating and decompose completely on strong heating e.g. bakelite.

They undergo chemical change when heated.



Advantages of plastics

- Colourful and attractive
- Cheaper
- Resistant to corrosion
- Light, thus portable
- Good insulators
- malleable



Disadvantages of plastics

- Poor heat resistance
- Non-biodegradable
- Poor weather resistance
- Have low strength
- Some give off poisonous gas
- Causes global warming when burnt



Check point 3

1. Ethene can react to form a solid whose molecular mass is more than 10,000. The reaction is called

- A. cracking. B. hydrogenation.
C. vulcanisation. D. polymerisation.



2. Which one of the following sets contains neutral fibres only?

A. Nylon, wool, cotton.

B. Cotton, nylon, silk.

C. Silk, nylon, wool.

D. Cotton, wool, silk.



3. Which one of the following polymers can be remoulded?

A. Polyester

B. Nylon

C. Polythene.

D. Rubber



4. The process by which property of rubber is improved by heating it with sulphur is called

A. polymerisation.

B. vulcanisation.

C. catalysis.

D. dehydration.



5. Which one of the following is a synthetic polymer?

- | | |
|-----------|------------|
| A. Wool. | B. Cotton. |
| C. Sisal. | D. Nylon. |



6. Which one of the following pairs of polymers are synthetic polymers?

A. Polythene and silk

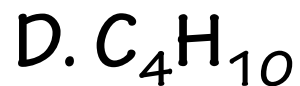
B. wool and cotton

C. Perspex and nylon

D. Wool and polythene



7. Which one of the following compounds can undergo polymerisation reaction?



8. In which one of the following processes does ethane form a plastic?

A. Polymerisation.

B. Precipitation.

C. Neutralisation.

D. Electrolysis.



9. Which of the following is a thermosetting plastic?

- A. Polyethene B. Perspex
C. Nylon D. Rubber



In each of the questions 10 to 13 one or more of the answers given may be correct. Read each question carefully and then indicate the correct answer according to the following:

- A. If 1, 2 and 3 only are correct.
- B. If 1 and 3 only are correct.
- C. If 2 and 4 only are correct.
- D. If 4 only is correct.



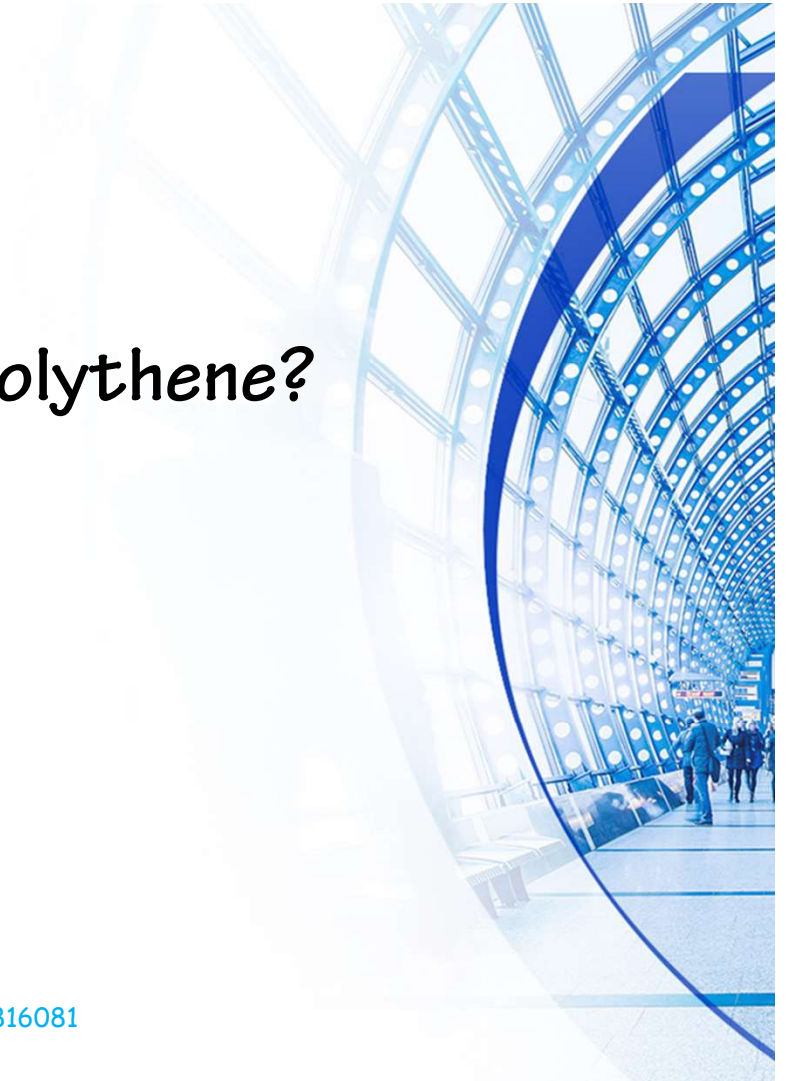
10. The following is/are correct about polyethene.

1. It is a thermosoftening plastic.
2. It is a thermosetting plastic.
3. It is a hydrocarbon.
4. It conducts heat and electricity.



1 1. Which one of the following statements is/are true about polythene?

- 1. It is biodegradable.
- 2. it is a man-made polymer.
- 3. It is a natural polymer.
- 4. It can be remolded.



12. Which of the following is/are natural polymers?

1. Cellulose
2. Terylene
3. Protein
4. Nylon



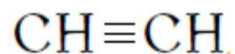
13. Which of the following is/are true about polyethene? Polyethene

- 1. is biodegradable
- 2. is a synthetic polymer
- 3. is a thermosetting plastic
- 4. Can be recycled



ALKYNES

Alkynes are unsaturated hydrocarbons which contain at least one carbon-carbon triple bond with general formula C_nH_{2n-2} . The first member is ethyne with molecular formula C_2H_2 and structural formula



Ethyne is used in welding as oxyacetylene flame.

Alkynes have similar chemical properties with alkenes.



ALCOHOLS

Alcohols are saturated organic compounds containing hydroxyl group (-OH) with general formula $C_nH_{2n+1}OH$, $n = 1, 2, 3, \dots$

The first three members are:

Methanol, CH_3OH

Ethanol, C_2H_5OH or CH_3CH_2OH

Propanol, C_3H_7OH or $CH_3CH_2CH_2OH$

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Fermentation

Fermentation is the breakdown of carbohydrates by yeast, bacteria and enzymes to form an alcohol and carbon dioxide.

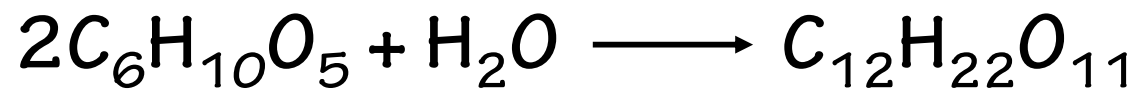
Preparation of ethanol by fermentation

Starch (from millet, bananas, cassava, molasses, potatoes) is roasted to release



starch granules and then treated with malt at 60°C.

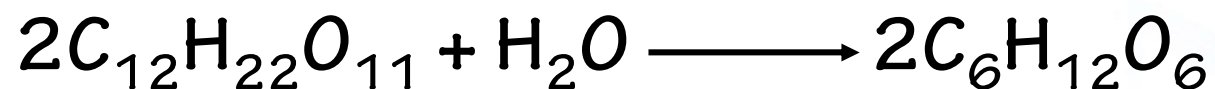
The starch is hydrolysed by diastase enzyme to maltose (sugar).



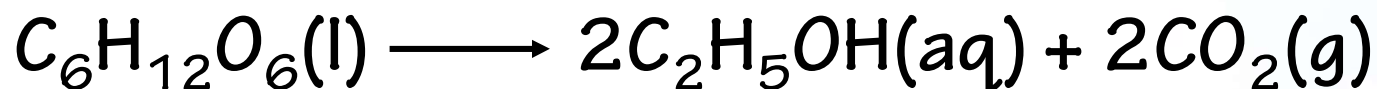
Yeast is added at room temperature and maltose is hydrolysed by maltase enzyme



to glucose.



Glucose is then decomposed to ethanol and carbon dioxide by zymase enzyme.



Local Brewing of Ethanol

Maize(cassava, millet) flour are mixed with water.

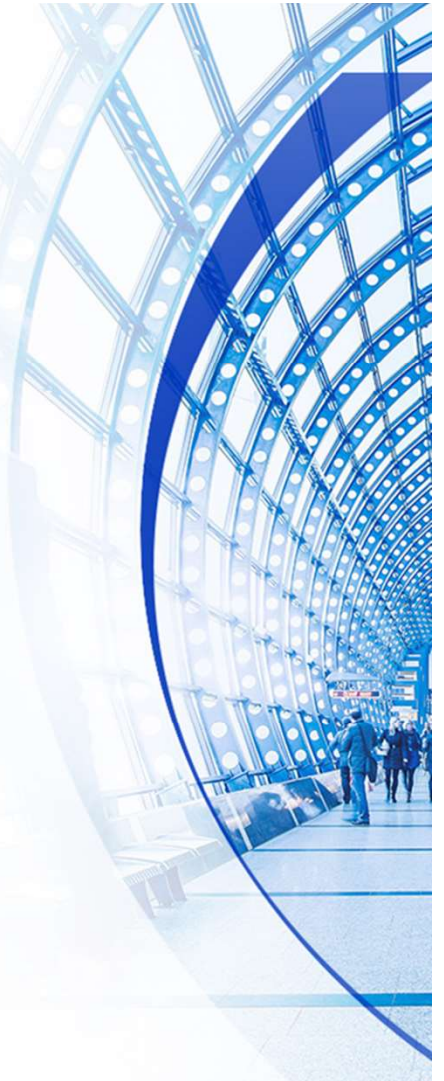
The product is soaked in a pot or buried in the ground for about a week to allow starch to be converted into sugar.

The mixture is then removed, roasted and dried.

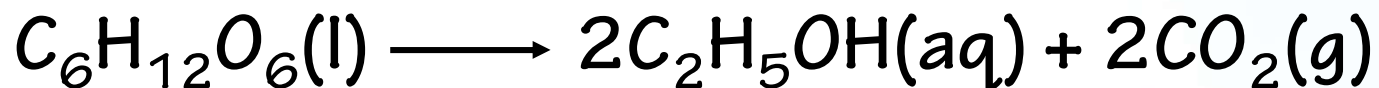


The dried product is then mixed with water and yeast and the mixture allowed to ferment for several days to form crude ethanol.

sucrase in yeast catalyses the hydrolysis of sucrose to glucose and fructose.



Zymase enzyme catalyses the decomposition of glucose to ethanol and carbon dioxide.



Concentrating ethanol

The ethanol obtained is fractionally distilled at 78°C – 82°C to a liquid containing about 95% of ethanol and 5% water.

The water can be absorbed by quicklime (CaO) to form 100% ethanol.



Uses of ethanol

- Used as fuel
- Used as beverage
- Used as thermometric liquid
- Used as medicine
- Source of income
- Used as solvent



CARBOXYLIC ACIDS

Carboxylic acids are compounds containing carboxyl group (-COOH) as their reactive part with general formula RCOOH .

The first two members include:

Methanoic acid with molecular formula CH_2O_2 and structural formula HCOOH



Ethanoic acid with molecular formula $C_2H_4O_2$ and structural formula CH_3COOH .

Carboxylic acids (organic acids) are weak acids, thus partially ionizes in water to form a solution which turns **blue** litmus paper **red**.

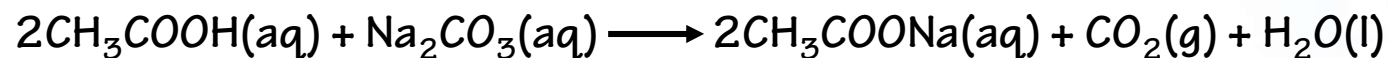


Test for carboxylic acids

Reagent: sodium carbonate solution or sodium hydrogencarbonate solution.

Observation: Bubbles of a colourless gas.

Equation of reaction:



Example (545/2 Qn 6 of 2018)

Compound T contains 40.0% carbon, 6.7% hydrogen and the rest being oxygen.

- (a)(i) Calculate the empirical formula of T.
(ii) Determine the molecular formula of T (Relative formula mass of T = 60).
- (b) T dissolved in water to form a solution which turned blue litmus paper red.



- (i) State what would be observed when a few drops of T were added to sodium carbonate.
- (ii) Write an ionic equation for the reaction that takes place in b(i).



Example (545/2 Qn 2 of 2012)

A compound Q of formula mass 60, contains carbon, 40%, hydrogen 6.7% and the rest being oxygen.

- (a)(i) Calculate the empirical formula of Q .
(ii) Determine the molecular formula of Q .



- (b) Q dissolves in aqueous sodium hydrogen carbonate with effervescence.
- (i) Suggest the chemical nature of Q.
 - (ii) Write an ionic equation for the reaction between Q and aqueous sodium hydrogencarbonate.



Soaps

Soaps are sodium/potassium salts of long chain carboxylic acid, RCOONa e.g. sodium stearate, $\text{C}_{17}\text{H}_{35}\text{COONa}$.

Soap is formed by heating vegetable oils or animal fats with sodium hydroxide/potassium hydroxide.



NOTE

Differences between oils and fats

Oils

- Liquids at RT
- Low Mpt
- Unsaturated
- Found in plants

Fats

Solids at RT
High Mpt
Saturated
Found in animals



Manufacture of soap

Soap is manufactured by a process called **saponification**.

Vegetable oil is heated with sodium hydroxide or potassium hydroxide.

Concentrated solution of sodium chloride (brine) is added to precipitate the soap.



The mixture is left to cool and the soap is removed and purified.

The soap is perfumed, dyed, allowed to dry and cut into parts.



The cleansing action of soap

Soap is dispersed in water in spherical clusters each of which contains hundreds of soap molecules.

As a result of crowding of soap of negative charges in water, repulsion between the negative charges occur.



This repulsion reduce the surface tension of water and help to lift the dirt from the material.

Agitation helps the lifting up process which may be achieved by placing the material in boiling water.



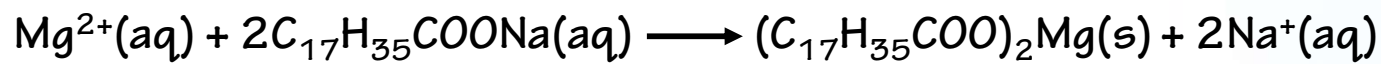
Advantages of soaps

- Used for bathing and washing.
- Inexpensive
- Friendly to the environment.



Disadvantages of soaps

- Does not form lather with hard water.
- It reacts with Ca^{2+} and Mg^{2+} to form scum.



Soapless detergent

Synthetic/soapless detergent are sodium or potassium salts of alkyl benzene sulphonic acid or alkyl sulphates.

Soapless detergents have a similar structure to soap molecules.



Advantages of synthetic detergents over soap

- Synthetic detergents are more soluble in water than soap.
- Synthetic detergents don't form scum with hard water unlike soap.



Advantages of soap over synthetic detergents

- Soap is cheaper than detergents.
- Soap is biodegradable while some detergents are non-biodegradable.
- Unlike soaps, detergent contains fertilizer material which nourishes algae



Check point 4

1. One of the disadvantages of using detergents for washing is, they

- A. are precipitated in hard water to form scum.
- B. sometimes cause stains on clothes.
- C. cause water pollution in rivers and lakes.
- D. wash away the colour of clothes.



2. The reaction in which soap is manufactured from oils and fats is known as

A. fermentation.

B. hydrogenation.

C. polymerisation.

D. saponification.



3. What name is given to the reaction leading to the formation of soap from oil?

A. Hydrogenation.

B. Polymerisation.

C. Saponification.

D. Degradation.



4. Which one of the following samples of water forms scum with soap?

A. Rain water

B. Distilled water

C. Deionised water

D. Sea water



5. Which of the following ions will form a precipitate with soap solution?

- A. Lead(II) ions
- B. Magnesium ions
- C. Copper(II) ions
- D. Sodium ions



6. The process by which glucose can be converted into ethanol is called

- A. Fermentation
- B. Hydrogenation
- C. Dehydration
- D. Polymerisation



Manufacture of sugar crystals

Sugarcane is cut into pieces and crushed to form juice which contains sucrose.

Lime is added to prevent hydrolysis of sucrose to simple sugars (glucose & maltose) or to collect sludge (insoluble impurities).



The mixture is filtered and the filtrate is diluted in water, concentrated by evaporation and cooled. The brown sugar crystals are formed.

The brown sugar can be converted to white sugar by dissolving in water and boiling solution with **animal charcoal**



(bubbling of sulphur dioxide).

The mixture is filtered to remove the animal charcoal and other solid materials.

The solution is then concentrated to form crystals of white sugar.



NOTE

- Evaporation(low pressure) produces a mixture of sugar crystals and molasses.
- The impure sugar crystals are separated from molasses by centrifuge.
- Molasses are used to make alcoholic drink (rum) and used as animal feed.



- Sugar crystals are dehydrated by concentrated sulphuric acid to form black solid.



Check Point 5

1. Which one of the following substances is used to bleach sugar?

- A. Chlorine
- B. Calcium chloride
- C. Sulphur dioxide
- D. Sodium sulphite



2. The colourless gas produced during fermentation of sugar is

- A. ammonia.
- B. carbon dioxide.
- C. hydrogen.
- D. oxygen.



3. During the manufacture of sugar, which one of the following processes is used to remove the brown colour?

A. Recrystallisation.

B. Filtration.

C. Evaporation.

D. Precipitation.



4. Which one of the following allotropes of carbon is used during the manufacture of sugar?

- A. Lampblack
- B. Wood charcoal
- C. Sugar charcoal
- D. Animal charcoal



END

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