

## ORGANIC REACTIONS

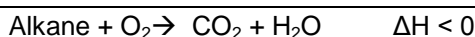
14 APRIL 2015

### Section A: Summary Notes

#### 1. Combustion

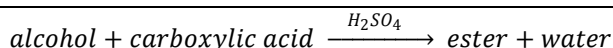
Alkanes are very important fossil fuels. The combustion of alkanes is very exothermic and carbon dioxide and water are produced.

General reaction:



#### 2. Esterification

Esters are produced by the catalysed reaction between an alcohol and a carboxylic acid.



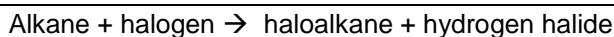
The reaction must be heated as well.

#### 3. Substitution

Substitution reactions can only take place with saturated hydrocarbons.

##### Alkane and a halogen

Halogens such as bromine or chlorine are reacted with an alkane in the presence of sunlight or heat.



##### Alcohols and a hydrogen halide

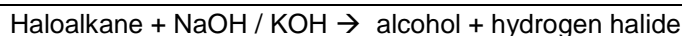
Primary and secondary alcohols react slowly and at high temperatures to produce primary and secondary haloalkanes.

Tertiary alcohols react easily and at room temperature.



##### Haloalkane and a base

Haloalkanes react with a dilute strong base (NaOH / KOH) to produce alcohols and hydrogen halides. The haloalkane must be dissolved in ethanol and the base must be dilute. This reaction happens at room temperature.

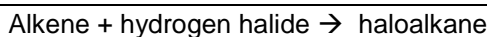


#### 4. Addition

Addition reactions take place with unsaturated hydrocarbons. Double or triple bonds are broken and additional atoms are added to the hydrocarbon.

##### Hydrohalogenation

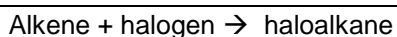
Hydrogen halides are reacted with alkenes to produce haloalkane. The reaction should take place without the presence of water.



The hydrogen atom from the hydrogen halide will attach to the carbon atom that has the greater number of hydrogen atoms.

## Halogenation

Halogens are reacted with alkenes to produce a haloalkane. No catalyst is necessary.



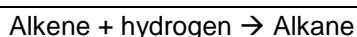
## Hydration

An excess of water is reacted with an alkene to produce an alcohol, in the presence of  $\text{H}_2\text{SO}_4$  as a catalyst. The hydrogen atom from the water will attach to the carbon atom that has the greater number of hydrogen atoms. The  $-\text{OH}$  from the water will attach to the carbon atom with the least number of hydrogen atoms.



## Hydrogenation

Hydrogen is added to alkenes to produce alkanes. The alkene needs to be dissolved in a non-polar solvent such as ethanol and a catalyst (Pt, Ni or Pd) needs to be present. The reaction should also take place in a  $\text{H}_2$  atmosphere (no oxygen present)

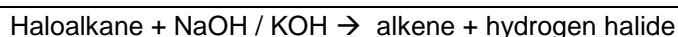


## 5. Elimination

Elimination reactions are reactions where larger molecules are made into smaller molecules. Saturated hydrocarbons become unsaturated hydrocarbons.

### Dehydrohalogenation

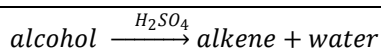
When a haloalkane is reacted with a heated concentrated strong base (NaOH or KOH) in pure ethanol as a solvent then a hydrogen halide is removed from the haloalkane to produce an alkene and a hydrogen halide.



If more than one elimination product is possible, the major product is the one where the H atom is removed from the carbon atom with the least number of hydrogen atoms.

### Dehydration

Water is removed from an alcohol during dehydration. The reaction needs to be heated with excess concentrated  $\text{H}_2\text{SO}_4$  as a catalyst



If more than one elimination product is possible, the major product is the one where the H atom is removed from the carbon atom with the least number of hydrogen atoms.

## Cracking

Cracking is the breaking up of large hydrocarbon molecules into smaller and more useful hydrocarbons.

**Thermal cracking** happens when the reaction takes place at high pressures and high temperatures without the use of a catalyst.

**Catalytic cracking** takes place at lower temperature and pressures in the presence of a catalyst.

## 6. Polymers

Polymers are large molecules, called macromolecules, that consist of many small molecules which repeat to form a long chain. Polymers have a large molecular mass.

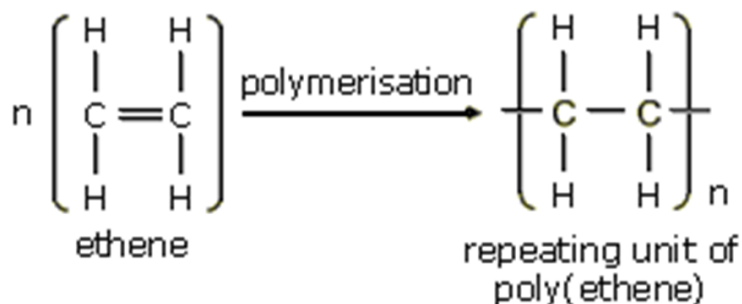
There are two types of synthetic polymers, namely plastics and fibres. The type of polymer produced depends on the reaction used to create it.

## 7. Plastics

Plastics are created during an addition reaction. During this reaction double bonds in a simple molecule are broken and the molecules are added together.

Example: Addition polymerisation of ethane to produce polythene.

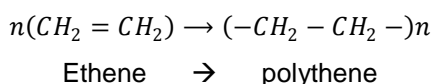
Structural formulae:



Source:

<http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/substancesfromcrudeoil/polymersandethanolrev1.shtml>

General molecular formulae:



(*n* represents any number of units)

The reactions takes place at high pressure must be heated and a small quantity of an organic peroxide such as benzoyl peroxide is used as an initiator.

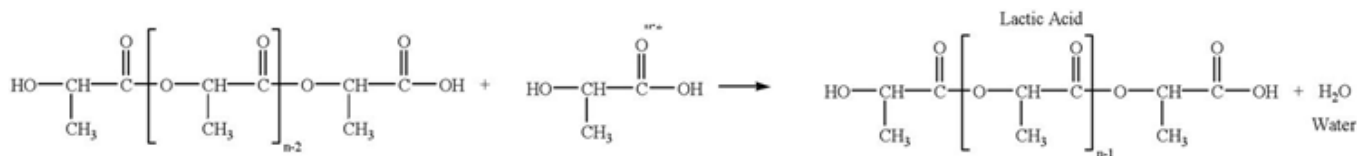
Plastics are strong, light and durable. The can be manufactured in any colour. Plastics are easily shaped. Depending on the manufacturing process the harness and flexibility of the plastic can be manipulated. Plastics cannot conduct electric current and are therefore electric insulators. They are not affected by weather or rust and are extremely versatile.

## 8. Fibres

Fibres are produced by an elimination reaction known as condensation polymerisation. In this reaction two molecules with different functional groups react with each other, and a small molecule is removed (usually water)

Polyactic acid (PLA) is produced from a monomer which comes the fermentation of plant materials and the polymer is biodegradable. The condensation reaction can be shown as follows:

PLA is a very versatile fibre and thus can be used for various products. PLA can used to replace other plastics created from petroleum products and thus it saves fossil fuels. Due to its manufacturing



process it can be manufacture to degrade in about 3 months or over many years. It does not give off toxic gases when it is burned, but it cannot be mixed with other plastics when recycled.

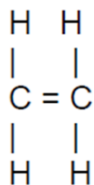
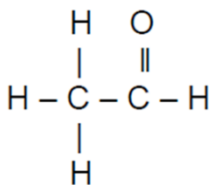
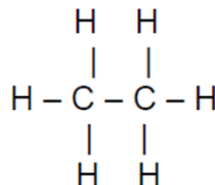
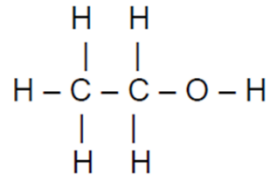
## 9. Monomers

Monomers are the simple molecules used as the bases for the production of polymers. There are several monomers that must be known.

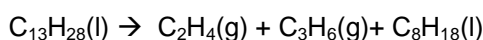
Monomer	Polymer
<p>Chloroethene</p> $\begin{array}{c} \text{Cl} \quad \text{H} \\ \diagdown \quad / \\ \text{C} = \text{C} \\ / \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$	<p>Polyvinyl chloride (PVC)</p> $\begin{array}{cccccc} \text{Cl} & \text{H} & \text{Cl} & \text{H} & \text{Cl} & \text{H} \\   &   &   &   &   &   \\ -\text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \\   &   &   &   &   &   \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$
<p>Styrene</p> $\begin{array}{c} \text{H} \quad \text{H} \\   \quad   \\ \text{C} = \text{C} \\ / \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$	<p>Polystyrene</p> $\begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\   &   &   &   &   &   \\ \text{C} = \text{C} & - & \text{C} = \text{C} & - & \text{C} = \text{C} & - & \text{C} = \text{C} & - & \text{C} = \text{C} \\ / \quad \diagdown & & / \quad \diagdown & & / \quad \diagdown & & / \quad \diagdown & & / \quad \diagdown \\ \text{H} \quad \text{H} & & \text{H} \quad \text{H} & & \text{H} \quad \text{H} & & \text{H} \quad \text{H} & & \text{H} \quad \text{H} \\   &   &   &   &   &   &   &   &   \\ \text{R} - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{R} \\   &   &   &   &   &   &   &   &   \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$
<p>Ethene</p> $\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad / \\ \text{C} = \text{C} \\ / \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$	<p>Polyethene</p> $\begin{array}{cccccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\   &   &   &   &   &   &   &   &   &   \\ \text{R} - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{R} \\   &   &   &   &   &   &   &   &   &   \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$
<p>Vinyl acetate</p> $\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad / \\ \text{C} = \text{C} \\ / \quad   \\ \text{H} \quad \text{O} \\   \\ \text{O} = \text{C} \\   \\ \text{H} - \text{C} - \text{H} \\   \\ \text{H} \end{array}$	<p>Polyvinyl acetate (PVA)</p> $\begin{array}{cccc} \text{H} & \text{H} & \text{H} \\   &   &   \\ \text{R} - \text{C} = \text{C} & - & \text{C} = \text{C} & - & \text{C} = \text{C} & - & \text{R} \\   &   &   &   &   \\ \text{O} = \text{C} & & \text{O} = \text{C} & & \text{O} = \text{C} \\   &   &   \\ \text{H} - \text{C} - \text{H} & & \text{H} - \text{C} - \text{H} & & \text{H} - \text{C} - \text{H} \\   &   &   \\ \text{H} & \text{H} & \text{H} \end{array}$

**MULTIPLE CHOICE QUESTIONS**

1. Which one of the following compounds will decolourise bromine water the fastest under normal conditions?

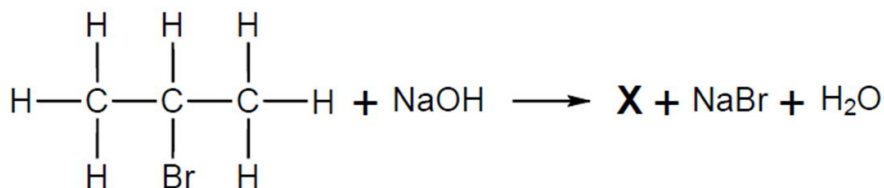

**A.**

**B.**

**C.**

**D.**

2. The reaction represented by the equation below takes place in the presence of a catalyst



This reaction is an example of ....

- A. addition  
 B. cracking  
 C. substitution  
 D. polymerisation
3. Which ONE of the following hydrocarbons always gives a product with the same IUPAC name when ANY ONE of its hydrogen atoms is replaced with a chlorine atom?
- A. Hexane  
 B. Hex-1-ene  
 C. Cyclohexane  
 D. Cyclohexene
4. The equation below represents the reaction that takes place when an organic compound and concentrated sodium hydroxide are strongly heated. X represents the major organic product formed.



Which ONE of the following is the correct IUPAC name for compound X?

- A. Prop-1-ene  
 B. Prop-2-ene  
 C. Propan-1-ol  
 D. Propan-2-ol
5. Which ONE of the following polymers is the product of a condensation polymerisation reaction?
- A. Polypropylene  
 B. Polyvinyl chloride  
 C. Polytetrafluoroethene  
 D. Polyactic acid

## Section B: Exam practice questions

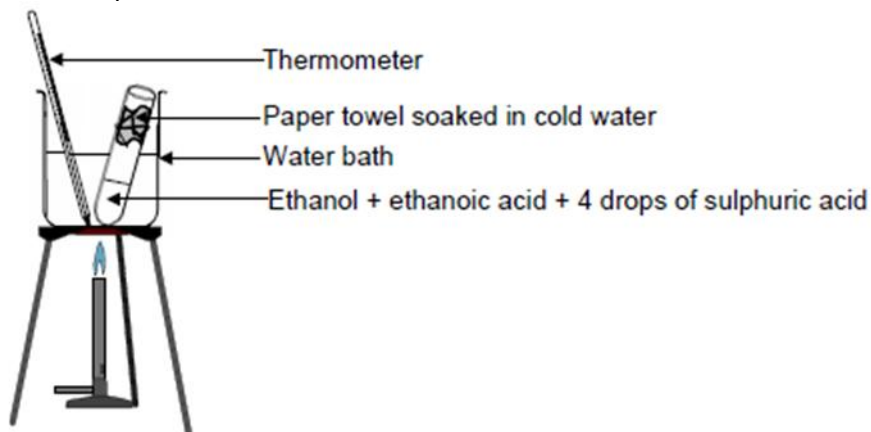
### Question 1

(Taken from Feb – March 2010)

Many of the flavours and odours of fruits are esters. Ethyl ethanoate is the most common ester found in wines and contributes to the perception of the fruitiness of wines.

A learner wants to prepare ethyl ethanoate in the school laboratory. She follows the instructions below.

- Mix 1 cm<sup>3</sup> ethanoic acid and 1 cm<sup>3</sup> ethanol thoroughly in a test tube
- Slowly add 4 drops of concentrated sulphuric acid while swirling the test tube
- Soak a paper towel in cold water and fasten it around the test tube close to its mouth with an elastic band
- Place the test tube in a water bath and heat the water with a flame to a temperature of about 60°C
- Leave the test tube in the hot water bath for about 15 minutes
- Cool the test tube by placing it in a beaker of cold water
- Smell the vapour in the test tube after 10 minutes



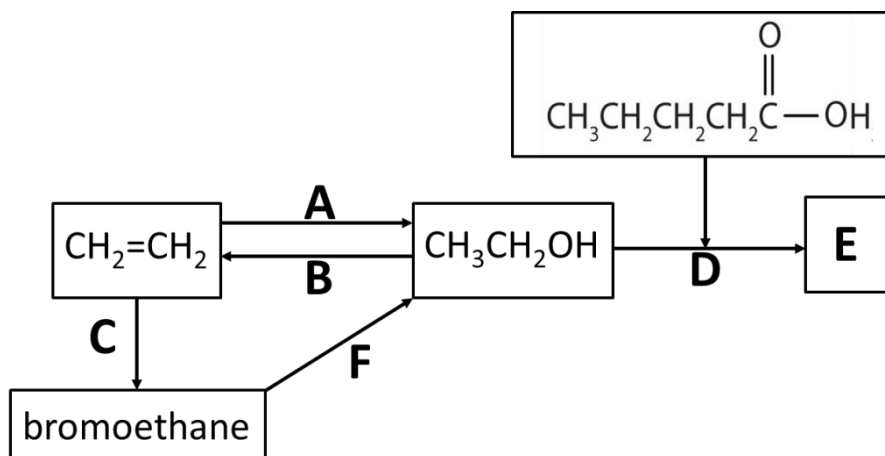
- 1.1. To which homologous series does ethanol belong? (1)
- 1.2. Use structural formulae to write a balanced equation for the reaction taking place in the test tube. (5)
- 1.3. What is the function of the sulphuric acid in the above reaction? (1)
- 1.4. Why does the method use a water bath instead of direct heating over an open flame? (1)
- 1.5. State ONE function of the wet paper towel at the top of the test tube. (1)

[9]

### Question 2

(Taken from Gauteng Preparatory Exam 2010)

The letters A – F in the flow diagram below, represent types of organic reactions.

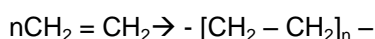


- 2.1. Name the type of reaction (addition, substitution or elimination) represented by
    - 2.1.1. B (1)
    - 2.1.2. F (1)
  - 2.2. Both A and C represent addition reactions. Name the type of addition reaction represented by:
    - 2.2.1. A (1)
    - 2.2.2. C (1)
  - 2.3. Reaction A represents the conversion of an alkene to an alcohol. Apart from the alkene, another reactant and a catalyst are needed. Write down the NAME of this
    - 2.3.1. reactant (1)
    - 2.3.2. catalyst (1)
  - 2.4. Use structural formulae and write down a balanced chemical equation for the reaction represented by C. (4)
  - 2.5. Reaction D represents the conversion of the alcohol to compound E. Write down the...
    - 2.5.1. NAME given to this type of reaction. (1)
    - 2.5.2. FORMULA of the catalyst added. (1)
    - 2.5.3. Structural formula of compound E. (2)
    - 2.5.4. IUPAC name of compound E. (1)
  - 2.6. Apart from the alcohol, write down the NAME of a reactant needed for reaction B to take place. (1)
- [16]**

### Question 3

(Taken from Eastern Cape Preparatory Exam 2014)

The polymerisation of ethene to produce polythene is represented by the equation below:



- 3.1. Define the term macromolecule (1)
  - 3.2. Classify this type of polymerisation. (1)
  - 3.3. Name TWO industrial uses of polythene. (2)
- [4]**

**Question 4**

(Taken from KZN Preparatory Exam 2014)

A manufacturer makes a polymer, polythene from the monomer, ethene by means of addition polymerisation. The polymer produced has an average relative molecular mass of  $1,0 \times 10^4$ .

- 4.1. What is meant by the following terms?
- 4.1.1. monomer (2)
- 4.1.2. polymerisation (2)
- 4.2. Write down the equation for the polymerisation of ethene to produce polythene. (3)
- 4.3. How many monomer units are joined together to give polyethene with a relative molecular mass of  $1,0 \times 10^4$ ? (2)
- 4.4. Most plastic bags are made from polyethene. Give one negative impact of the use of plastics on the environment. (1)

[10]

**Section C: Solutions**
**Multiple Choice**

1. A
2. B
3. C
4. D
5. D

**Exam Practice Questions**
**Question 1**

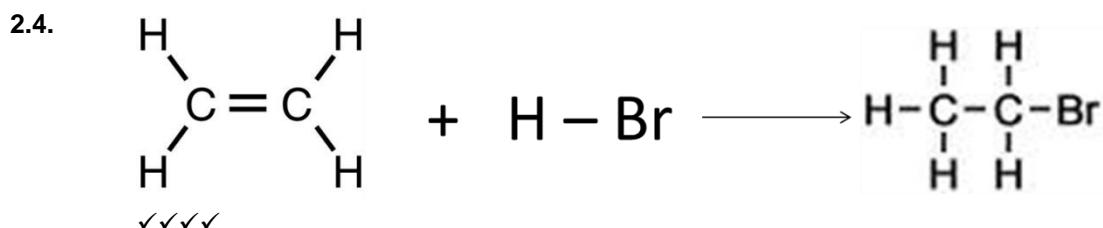
- 1.1. Alcohols ✓ (1)
- 1.2. (5)
- 1.3. Catalyst ✓ (1)
- 1.4. Ethanol is flammable ✓ (1)
- 1.5. Prevents the vapours from leaving the test tube. ✓ (1)

**Question 2**

- 2.1.1. Elimination ✓ (1)
- 2.1.2. Substitution ✓ (1)
- 2.2.1. Hydration ✓ (1)
- 2.2.2. Hydrohalogenation ✓ (1)
- 2.3.1. Water ✓ (1)
- 2.3.2. Sulphuric acid ✓ OR phosphoric acid (1)



notes for...



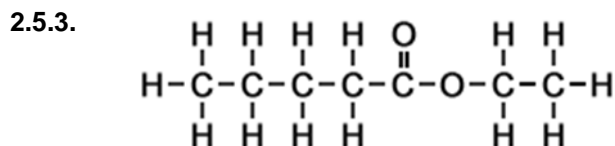
(4)

2.5.1. Esterification ✓

(1)

2.5.2.  $\text{H}_2\text{SO}_4$  ✓

(1)



(2)

2.5.4. Ethyl pentanoate ✓

(1)

2.6. Sulphuric acid ✓

(1)

### Question 3

3.1. A molecule containing a large number of atoms ✓

(1)

3.2. Addition polymerisation ✓

(1)

3.3. Used to make plastic bags,  
Make squeeze bottles  
Make cling wrap ✓✓ (any two)

(2)

### Question 4

4.1.1. A molecule that can be bonded to other identical molecules to form a polymer molecule ✓✓

(2)

4.1.2. The process of converting a monomer into a polymer ✓✓

(2)

4.2.  $n\text{CH}_2 = \text{CH}_2 \rightarrow -[\text{CH}_2 - \text{CH}_2]_n$  ✓✓✓

(3)

4.3.  $M(\text{C}_2\text{H}_4) = 2(12) + 4(1)$   
 $= 28 \text{ g.mol}^{-1}$

$$\text{number of monomers} = \frac{1 \times 10^4}{28} \checkmark$$

$$= 357,14$$

Approximately 357 monomers ✓

(2)

4.4. They aren't biodegradable. Fill up landfills etc ✓

(1)