OCR
Oxford Cambridge and RSA

Tuesday 2 June 2015 – Afternoon

AS GCE CHEMISTRY B (SALTERS)

F332/01/TEST Chemistry of Natural Resources

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry B (Salters)* (inserted)
- *Advance Notice: 'Catalysis'* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour 45 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Inserts will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **100**.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  – ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  – organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- The insert *'Catalysis'* is provided for use with Question 5.
- A copy of the *Data Sheet for Chemistry B (Salters)* is provided as an Insert with this Question Paper.
- You are advised to show all the steps in any calculations.
- This document consists of **20** pages. Any blank pages are indicated.

Answer **all** the questions.

1 Methanol, CH_3OH, is made industrially by the catalysed reaction between carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -91\,kJ\,mol^{-1} \qquad \textbf{equation 1.1}$$

(a) People dealing with a leak during this process would need to wear protective equipment.

State **one** piece of protective equipment that would be worn **and** state why it is needed.

....

....

.... **[1]**

(b) The process represented by **equation 1.1** can reach a position of dynamic equilibrium.

Explain, in terms of reaction rates and concentrations, what is meant by the term *dynamic equilibrium*.

....

....

.... **[2]**

(c) The maximum equilibrium yield of methanol would be obtained by using high pressures and low temperatures.

What information given in **equation 1.1** suggests that these conditions give the maximum yield?

....

....

....

.... **[2]**

(d) Suggest why the industrial process might not use high pressures and low temperatures.

....

....

....

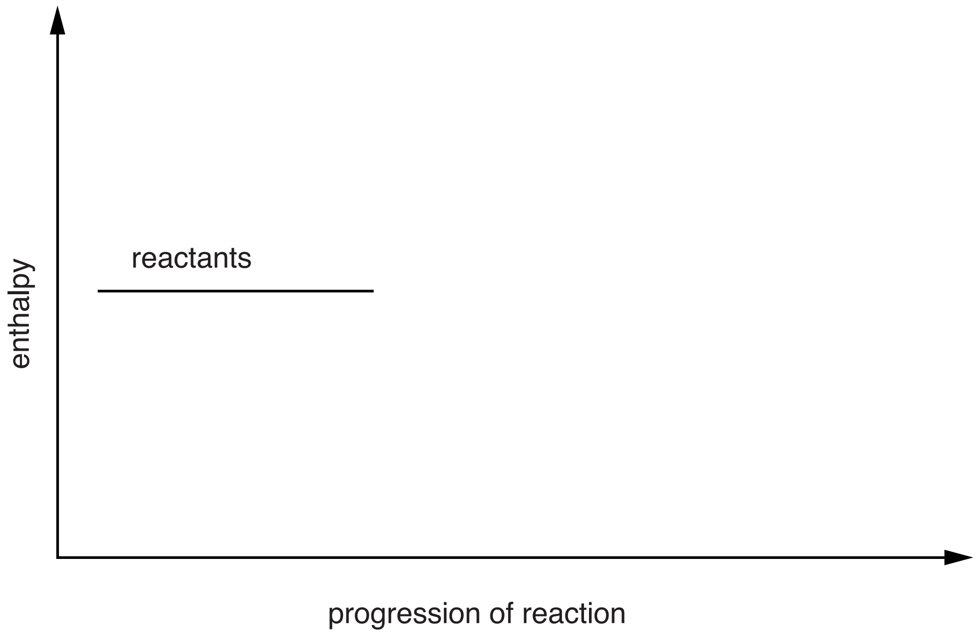
.... **[2]**

(e) A catalyst of copper and zinc oxide is used in this process.

Complete the diagram below to show how a catalyst provides an alternative reaction route for an **exothermic** reaction.

Include on your diagram labels for:

- products
- enthalpy change, ΔH
- activation enthalpy for the uncatalysed route, E_a
- activation enthalpy for the catalysed route, E_c.



[3]

(f) The catalyst is coated onto an inert alumina support.

Why is the catalyst spread as a thin layer on the alumina?

....

....

.... **[1]**

(g) Name the strongest type of intermolecular bond present between molecules of methanol.

Explain how these intermolecular bonds form.

....

....

....

....

.... **[3]**

(h) Scientists producing methanol by this process can check the progress of the reaction using infrared spectroscopy.

(i) Give the wavenumber range of **one** peak that is present in the infrared spectrum for methanol and identify the bond that produces this peak.

....

....

....

.... **[1]**

(ii) Give **one** use for the fingerprint region in an infrared spectrum.

....

....

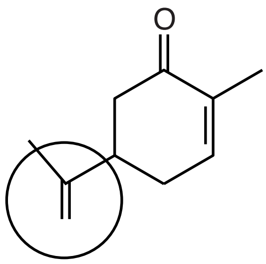
.... **[1]**

[Total: 16]

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

2 ‘Carvone’ can be extracted from some mint plants. It can be used to flavour chewing gum.



carvone

(a) Name the functional group that is circled on the diagram of the carvone molecule.

.... **[1]**

(b) Carvone can be produced in a process in which the reaction mixture requires heating under reflux.

Describe the process of *heating under reflux*.

....

....

....

.... **[2]**

(c) Carvone reacts with bromine at room temperature and pressure.

(i) Write the equation for the reaction of carvone, $C_{10}H_{14}O$, with **excess** bromine.

$C_{10}H_{14}O \qquad\qquad \rightarrow$

[2]

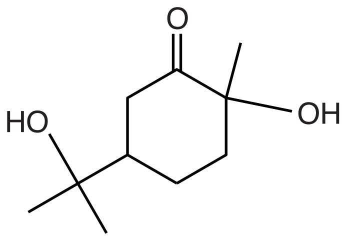
(ii) Ethene reacts with bromine in a similar way to the reaction of carvone with bromine.

Draw the mechanism for the reaction of bromine with ethene to form an **intermediate**.

Add relevant full and partial charges and curly arrows to your diagram.

[4]

(d) Carvone can be converted into **compound A**.



compound A

Give the reagents and conditions for the reaction to convert carvone into **compound A**.

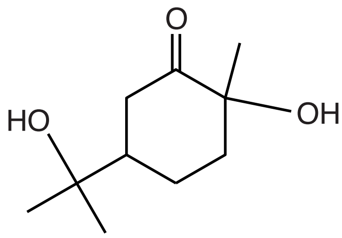
....

.... **[2]**

(e) The reaction in **(d)** can produce other alcohols that have the same molecular formula as **compound A** but different structural formulae.

Draw the structures of **two** of these alcohols.

[2]



compound A

(f) A student does some experiments using a sample of **compound A**.

(i) Describe and explain what the student would **see** when **compound A** is heated with acidified potassium dichromate solution.

....

....

.... **[2]**

(ii) The student does an elimination reaction on **compound A** to form carvone.

Explain what is meant by the term *elimination reaction*.

....

....

....

.... **[2]**

(iii) After the elimination reaction, the student collects a mixture of unreacted **compound A**, carvone and a trace of water. Carvone is miscible with **compound A.**

State how the student would remove the water from the mixture and how carvone and **compound A** could be separated.

Remove trace of water ....

....

Separate carvone and **compound A** ....

.... **[2]**

[Total: 19]

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

3 In 2013, researchers discovered a new hydrothermal vent at a site in the Caribbean. Hydrothermal vents are gaps in the sea floor where very hot water emerges, carrying large amounts of dissolved minerals.

(a) The solution around a hydrothermal vent contains calcium and sulfide ions.

(i) A calcium ion has the same electronic configuration as an argon atom.

Write the electronic configuration, in terms of s and p sub-shells, for a calcium ion.

.... **[1]**

(ii) The calcium and sulfide ions take part in a precipitation reaction to form calcium sulfide.

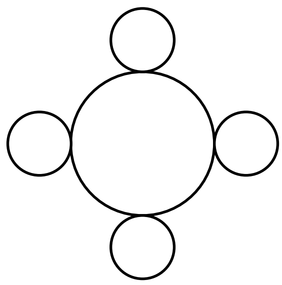
Write the ionic equation for the precipitation reaction. Include state symbols.

	$\rightarrow$

[2]

(iii) Pure calcium sulfide and sodium chloride have a similar lattice structure. The diagram below shows part of a layer of the calcium sulfide lattice.

Complete the diagram by drawing enough particles to show the structure of the **layer** clearly. Label each type of particle.



[3]

(b) Seawater produced from hydrothermal vents is acidic because it contains H^+ ions. A scientist analyses a sample of the seawater by titrating 40.0 cm^3 of the seawater with sodium hydroxide, NaOH, solution.

(i) The titration requires 15.70 cm^3 of a 0.0250 mol dm^{-3} solution of sodium hydroxide. Calculate the number of moles of hydroxide ions, OH^-, used.

moles = ... **[1]**

(ii) Give the number of moles of H^+ ions in the 40.0 cm^3 sample of seawater.

moles = ... **[1]**

(iii) Calculate the concentration of H^+ ions in the seawater in mol dm^{-3}.

Give your answer to **three** significant figures.

concentration = ... mol dm^{-3} **[3]**

(c) The solution around the hydrothermal vent also contains Group 1 metal ions.

(i) Write an equation representing the first ionisation enthalpy of lithium.

$\rightarrow$

[1]

(ii) The first ionisation enthalpy of lithium is greater than that of any other Group 1 element.

Explain why.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

....

....

.... **[2]**

(d) Scientists analysed a sample of seawater collected near the hydrothermal vent. They found that the sample contained calcium ions at a concentration of 1.70 %. On average, ocean water contains calcium ions at a concentration of 400 ppm.

How much more concentrated is the calcium ion in the hydrothermal vent seawater than in average ocean water?

calcium ion in hydrothermal vent water is .... times more concentrated **[2]**

(e) Reactions that occur in seawater happen more quickly near hydrothermal vents.

Explain why.

....

....

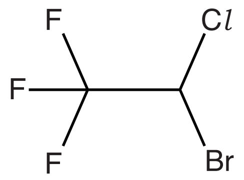
....

....

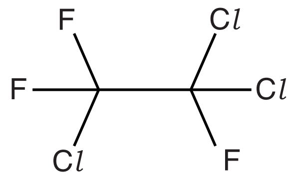
.... **[3]**

[Total: 19]

4 Halogenated organic compounds have been used in many ways. 'Fluothane' and $CHCl_3$ can both be used as anaesthetics. CFC-113 has been used as a refrigerant.



Fluothane



CFC-113

(a) Give the systematic name for CFC-113.

.... **[2]**

(b) When fluothane goes into the Earth's atmosphere it can be broken down by electromagnetic radiation from the Sun.

(i) Suggest which bond in the fluothane molecule is most likely to break.

.... **[1]**

(ii) Name the type of electromagnetic radiation that is emitted from the Sun that causes this bond to break.

.... **[1]**

(iii) In a particular part of the Earth's atmosphere, the available radiation has a maximum frequency of 5.30×10^{14} Hz. The weakest bond in the fluothane molecule has a bond enthalpy of $+290\,kJ\,mol^{-1}$.

Explain whether or not this bond will break.

Include a calculation in your answer.

Avogadro constant, $N_A = 6.02 \times 10^{23}\,mol^{-1}$

Planck constant, $h = 6.63 \times 10^{-34}\,J\,Hz^{-1}$

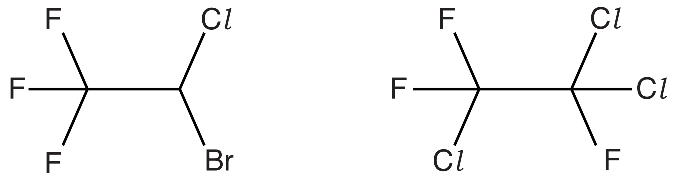
....

....

....

.... **[4]**

(c) Both CFC-113 and fluothane could cause ozone depletion in the stratosphere.



Fluothane **CFC-113**

Suggest why CFC-113 and fluothane can cause ozone depletion and why CFC-113 has a greater ozone depletion potential than fluothane.

....

....

....

....

.... **[3]**

(d) $CHCl_3$ can be made industrially from a mixture of chlorine and methane.

Chlorine and methane are pollutants in the atmosphere.

Give **one** reason why each chemical is classed as a pollutant.

Chlorine ....

....

Methane..

.... **[2]**

(e) Draw a '*dot-and-cross*' diagram for a $CHCl_3$ molecule.

Show outer electron shells only.

[1]

(f) Draw a diagram of the shape of a $CHCl_3$ molecule.

Give a value for the bond angle.

[2]

(g) $CHCl_3$ is described as a 'greenhouse gas'.

Explain how $CHCl_3$ molecules are involved in the processes of energy transfer that start with UV radiation from the Sun and result in warming of the troposphere.

In your answer, you should make clear how the steps you describe are linked to one another.

[5]

(h) Scientists have collected evidence for the relationship between the concentration of greenhouse gases and global warming.

(i) Describe **two** different methods that scientists have used to find evidence for this relationship.

....

....

....

.... **[2]**

(ii) Describe the relationship that scientists have worked out from this evidence.

....

....

.... **[1]**

(i) Some compounds like CFC-113 have now been replaced by HFCs.

Give **one** advantage and **one** disadvantage of using HFCs in place of CFCs, other than ozone depletion potential.

....

....

....

.... **[2]**

[Total: 26]

5 This question is based on the Advance Notice article, '***Catalysis***'.

(a) The manufacture of propanone is outlined in **Table 1** of the article.

(i) Draw the full structural formula for a molecule of propanone.

[1]

(ii) Name the functional group in a molecule of propanone.

.... **[1]**

(b) Using the information in **Fig. 1**, name the **mechanism** of the first step of the reaction that produces ethane-1,2-diol from epoxyethane.

.... **[1]**

(c) **Fig. 2** shows part of a reaction mechanism.

(i) Name the type of organic ion that is produced from 2-methylpropene in **Fig. 2**.

.... **[1]**

(ii) Give the atom economy for the overall reaction sequence shown in **Fig. 2**.

.... **[1]**

(d) The article describes the hydrogenation of 2,4,4-trimethylpent-2-ene using nickel as a catalyst.

Give the conditions that are required for this reaction and name another catalyst that can be used for this reaction.

....

.... **[2]**

(e) The article describes two different methods for the production of 2,2,4-trimethylpentane from 2-methylpropene.

Give **three** differences between the two methods.

....

....

....

....

.... **[3]**

(f) Some polymers are shown in **Table 2**.

Name the **polymer** that has a chain containing an arene group.

.... **[1]**

(g) Some polymers are made by a reaction that involves radicals.

(i) Describe how radicals form from a molecule.

....

.... **[1]**

(ii) Write an equation for a propagation reaction in the formation of poly(propene).

[1]

(h) Both the atactic and isotactic forms of poly(propene) have the same type of intermolecular bond, but they have different physical properties.

Explain why these two forms of poly(propene) have different physical properties.

In your explanation, you should include:

- **one** physical property for each of these two forms of poly(propene)
- the name of the type of intermolecular bond in these two forms of poly(propene).

In your answer, you should make clear how the points you describe are linked to one another.

[7]

[Total: 20]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page. The question number(s) must be clearly shown in the margin.

OCR
Oxford Cambridge and RSA

For issue on or after: 13 March 2015

AS GCE CHEMISTRY B (SALTERS)

F332/01 Chemistry of Natural Resources

ADVANCE NOTICE

Duration: 1 hour 45 minutes

5000861339

NOTES FOR GUIDANCE (CANDIDATES)

1 This leaflet contains an article which is needed in preparation for a question in the externally assessed examination F332.

2 You will need to read the article carefully and also have covered the learning outcomes for Unit F332 (*Chemistry of Natural Resources*). The examination paper will contain questions on the article. You will be expected to apply your knowledge and understanding of the work covered in Unit F332 to answer these questions. There are 20 marks available on the paper for these questions.

3 You can seek advice from your teacher about the content of the article and you can discuss it with others in your class. You may also investigate the topic yourself using any resources available to you.

4 For the examination on **2 June 2015** you will be given a fresh copy of this article, together with a Question Paper. You will **not** be able to bring your copy of the article, or other materials, into the examination.

5 You will not have time to read this article for the first time in the examination if you are to complete the examination paper within the specified time. However, you should refer to the article when answering the questions.

This document consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- Do not send this Advance Notice for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to reuse this document.

Catalysis

Article: Taken from Chemistry Review magazine, published by Philip Allan, February 2014, pages 21–25.

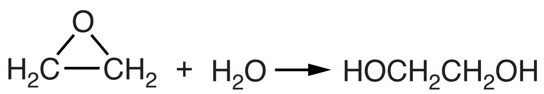
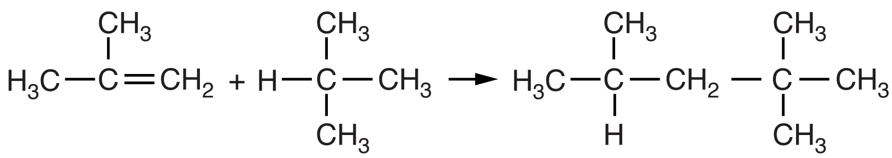
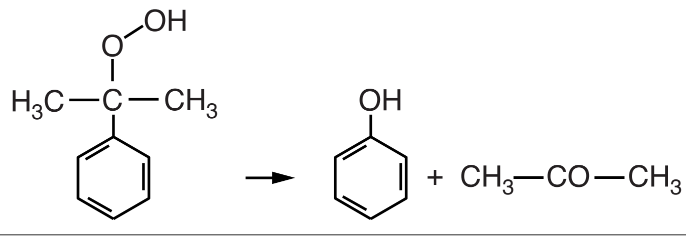
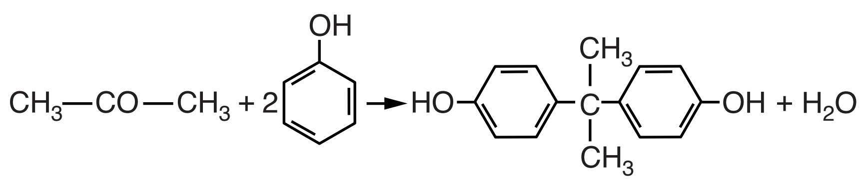
In this article, we look at examples of homogeneous catalysis and the variety of catalysts employed in polymerisation reactions to produce polymers with specific structures and physical properties.

Heterogeneous catalysts are widely used in industry: they are in a different phase to the reactants and products so are easily removed from the products. Disadvantages of using certain heterogeneous catalysts are that they are not always specific in terms of the reactions they promote and can produce unwanted by-products. *Homogeneous* catalysts are in the same phase as the reactants. This article will discuss some of their roles and their inherent advantages and disadvantages.

Homogeneous catalysis

Homogeneous catalysts are used less frequently in industry than heterogeneous catalysts, as on completion of the reaction they have to be separated from the products, a process that can be expensive. However, there are several important industrial processes that are catalysed homogeneously, often using an acid or base (**Table 1**).

Table 1 Examples of industrial processes using homogeneous catalysis

Manufacture	Catalyst	Equation
Ethane-1,2-diol	Sulfuric acid	
2,2,4-trimethylpentane	Hydrogen fluoride	
Phenol and propanone	Sulfuric acid	
Bisphenol A	Sulfuric acid	

One example is in the manufacture of ethane-1,2-diol (ethylene glycol, used in antifreeze and as an intermediate in the manufacture of polyesters) from epoxyethane, where the catalyst is a trace of acid (**Fig. 1**). In the mechanism for this reaction a hydrogen ion is added at the start and lost at the end. This ion functions as a catalyst.

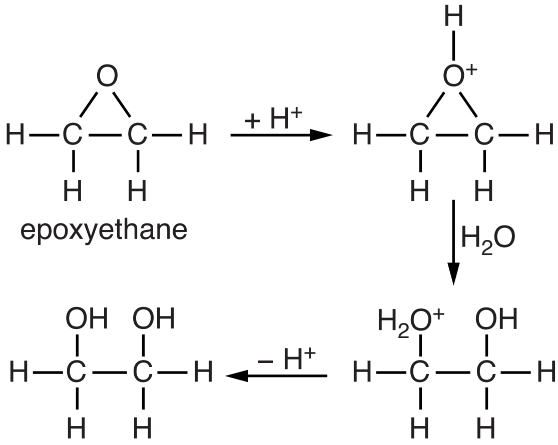


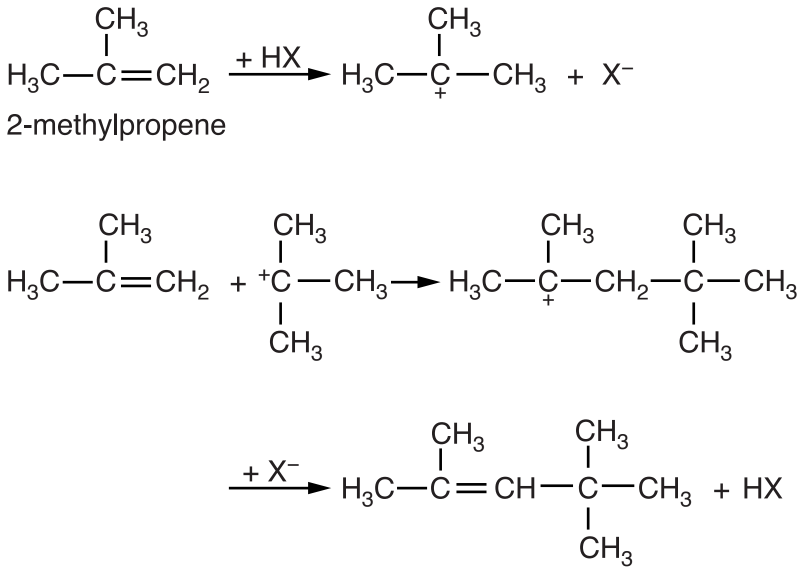
Fig. 1 A mechanism for the formation of ethane-1,2-diol from epoxyethane

Ethylene glycol is used in antifreeze.

Two other examples are concerned with the production of 2,2,4-trimethylpentane from 2-methylpropene, again using an acid as the catalyst. One method uses 2-methylpropane (**Table 1**), which yields the alkane in a one-step process. The other method uses only 2-methylpropene:

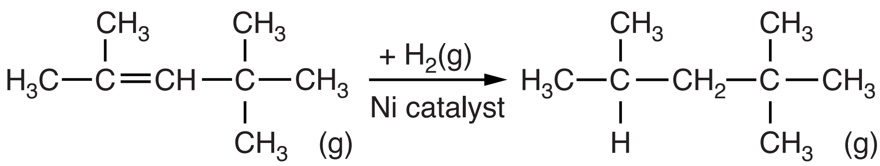
- The mechanism of the reaction also involves the addition of a hydrogen ion, from aqueous sulfuric acid, to a reactant (**Fig. 2**).
- The alkene is hydrogenated (using nickel as the catalyst) to 2,2,4-trimethylpentane (isooctane, **Fig. 3**).

2,2,4-trimethylpentane is often added to petrol to enhance its anti-knock properties, now that methyl t-butyl ether (MTBE) is being phased out.



2,4,4-trimethylpent-2-ene

Fig. 2 Part of a mechanism for the formation of 2,4,4-trimethylpent-2-ene from 2-methylpropene



2,4,4-trimethylpent-2-ene 2,2,4-trimethylpentane

Fig. 3 The hydrogenation of 2,4,4-trimethylpent-2-ene to 2,2,4-trimethylpentane

Catalysts for polymerisation reactions

Ziegler–Natta catalysts

Ziegler–Natta catalysts are organometallic compounds prepared from titanium compounds with an aluminium trialkyl, which acts as a promoter (**Fig. 4**).

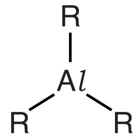


Fig. 4 Trialkylaluminium (R = alkyl group, –(C_nH_{2n+1}))

The alkyl groups used include ethyl, hexyl and octyl. Their use makes the polymer molecule 'grow' in a linear, unbranched fashion, which makes its properties different from that of branched polymer molecules.

Not only do Ziegler-Natta catalysts allow for linear polymers to be produced, they can also give stereochemical control. Propene, for example, could polymerise in three ways (even if linear) to produce *isotactic* (where all the substituted carbons have the same stereochemical configuration), *syndiotactic* (where the substituted carbons have alternating stereochemical configurations) or *atactic* (where the stereochemistry of the carbons along the chain is random) poly(propene) (**Fig. 5**).

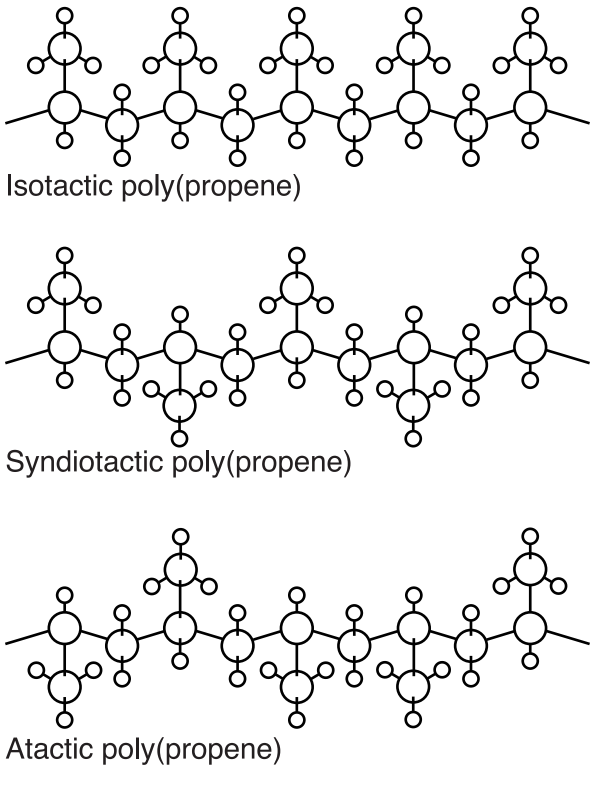


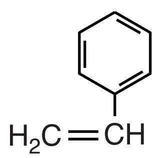
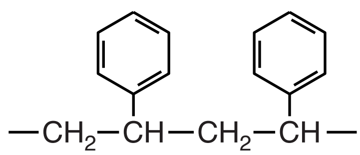
Fig. 5 Molecular structures of poly(propene)

The different stereochemical forms of poly(propene) have different properties. Isotactic poly(propene) is strong, hard and has excellent resistance to stress and cracking. The atactic form is a soft and rubbery polymer. However, the Ziegler–Natta catalyst only allows the propene to react so that isotactic poly(propene) is produced. Even greater control of the polymerisation is obtained using a new class of catalysts, the *metallocenes*. Using a metallocene catalyst is the only way currently available commercially for the production of syndiotactic poly(propene). Atactic poly(propene) can be formed by the radical polymerisation of propene.

Radical polymerisation

Many polymers are produced using radical initiators, which act as catalysts (**Table 2**).

Table 2 Examples of polymers produced using free radical polymerisation

Monomer	**Formula**	**Polymer**	**Structure**
Ethene	$H_2C{=}CH_2$	Low density poly(ethene) (LDPE)	$-CH_2-CH_2-CH_2-CH_2-$
Chloroethene	$H_2C{=}CH(Cl)$	Poly(chloroethene) (poly(vinyl chloride), PVC)	$-CH_2-CH(Cl)-CH_2-CH(Cl)-$
Propene	$H_2C{=}CH(CH_3)$	Poly(propene) (polypropylene, PP)	$-CH_2-CH(CH_3)-CH_2-CH(CH_3)-$
Propenonitrile	$H_2C{=}CH(CN)$	Poly(propenonitrile)(polyacrylonitrile)	$-CH_2-CH(CN)-CH_2-CH(CN)-$
Methyl 2-methylpropenoate	$H_2C{=}C(CO_2CH_3)-CH_3$	Poly(methyl 2-methylpropenoate) (polymethyl methacrylate, PMMA)	$-CH_2-C(CO_2CH_3)(CH_3)-CH_2-C(CO_2CH_3)(CH_3)-$
Phenylethene		Poly(phenylethene) (poly(styrene))	
Tetrafluoroethene	$F_2C{=}CF_2$	Poly(tetrafluoroethene) (PTFE)	$-CF_2-CF_2-CF_2-CF_2-$

For example, the polymerisation of chloroethene to poly(chloroethene) is started by warming it with a minute trace of a peroxide (R–O–O–R, see **Fig. 6**).

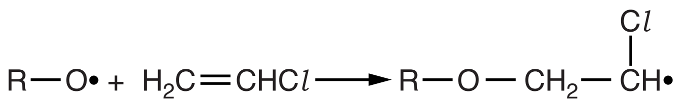
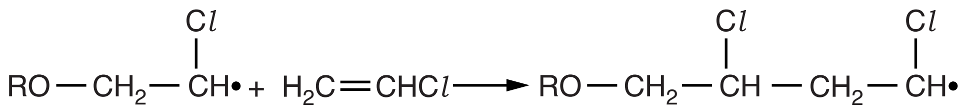
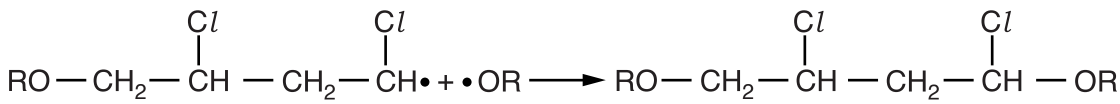
The reaction starts with the decomposition of the peroxide.	$R—O—O—R \longrightarrow 2R—O\bullet$
The resulting radicals add to molecules of chloroethene to make new radicals.	
As more chloroethene molecules are added one at a time, the chain continues to grow.	
Termination occurs when, for example, any two radicals react with each other.	

Fig. 6 A mechanism for the free radical polymerisation of chloroethene to poly(chloroethene).

These reactions lead to side chains, so that the molecules of the polymer cannot pack together in a regular way. Thus the branched polymer has a lower melting point and lower density than high density poly(ethene) (HDPE), allowing for different uses of the two polymers. For example, HDPE can be used to make rigid bottles while LDPE is suitable for flexible polythene bags.

Looking forward

The search for catalysts will continue to be one of the highest priorities for the chemical industry, as it seeks to run processes at as low a temperature and as near atmospheric pressure as possible, commensurate with a reasonable rate of reaction.

Catalysts are sought that will favour one specific reaction over another, thus making the process much more economical. The gains from improving catalysts are both financial and environmental, leading to lower fuel costs and the reduction of harmful waste gases.