

AS GCE CHEMISTRY B (SALTERS)

Candidates answer on the Question Paper.

OCR supplied materials:

- *Data Sheet for Chemistry B (Salters)* (inserted)
- *Advance Notice: 'Plastic Fantastic'* (inserted)

Other materials required:

- Scientific Calculator

Duration: 1 hour 45 minutes




Candidate forename						Candidate surname					
Centre number						Candidate number					

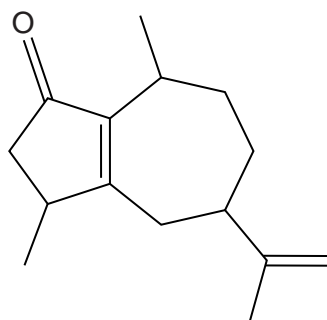
INSTRUCTIONS TO CANDIDATES

- The inserts will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- 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 pages at the end of this booklet. The question number(s) must be clearly shown.
- Answer **all** the questions.
- 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.
-  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 '*Plastic Fantastic*' 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.
- The total number of marks for this paper is **100**.

- 1 The substance 'rotundone' has been found to give a peppery flavour to some spices and wines.



rotundone

- (a) Name **two** functional groups that are present in a molecule of rotundone.

.....
 [2]

- (b) Give the molecular formula of rotundone.

..... [2]

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

- (i) Describe the colour change when rotundone reacts with bromine.

from to [2]

- (ii) Write the equation for the reaction of rotundone with excess bromine.

Represent rotundone by your molecular formula from part (b).

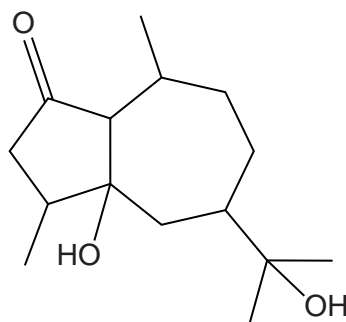
[2]

- (iii) Underline the **two** words that describe the mechanism of the reaction between rotundone and bromine.

addition **electrophilic** **nucleophilic** **radical** **substitution**

[2]

(d) Rotundone reacts with water to form compound **A** as one of the products.



compound A

- (i) Give the reagents and conditions for the reaction of rotundone with water to form compound **A**.

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.....
..... [2]

- (ii) Name the strongest type of intermolecular bond between molecules of compound **A**.

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..... [1]

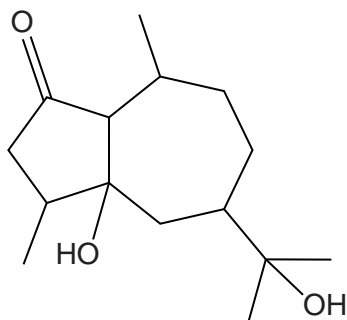
- (iii) Classify the alcohol groups in compound **A** as primary, secondary or tertiary.

..... [1]

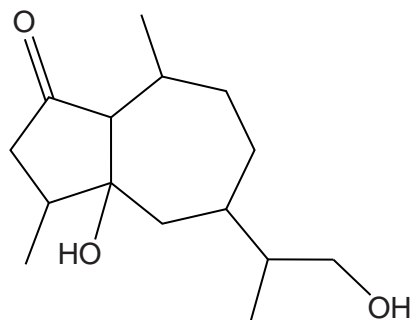
- (iv) Explain your answer to (iii).

.....
.....
..... [1]

(e) Compound **B** is another product of the reaction of rotundone with water.



compound A



compound B

Compounds **A** and **B** are each heated under reflux in separate containers with acidified potassium dichromate(VI) solution.

Describe the colour change, if any, in each case **and** explain your answer in terms of the alcohol groups in compounds **A** and **B**.

..... [5]

[Total: 20]

- 2 The manufacture of chlorofluorocarbons (CFCs) has been banned because they cause ozone depletion in the stratosphere. CFCs have been replaced by a range of compounds, including hydrocarbons and hydrochlorofluorocarbons (HCFCs).

The following table gives information about a CFC, an alkane and a HCFC.

compound	formula	boiling point/K	flammable	ODP*	price
C	CFCl_3	297	no	1.0	medium
D	$\text{CH}_3\text{CH}_2\text{CH}_3$	231	yes	0.0	low
E	$\text{CF}_3\text{CCl}_2\text{H}$	301	no	0.02	high

* ODP is the ozone depletion potential.

- (a) Give the systematic name for compound **E**.

..... [2]

- (b) Suggest why compound **D** is much cheaper than compounds **C** and **E**.

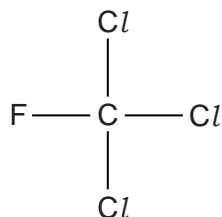
.....
 [1]

- (c) Suggest why compound **D** cannot be used as a cleaning solvent.

.....
 [1]

- (d) Compound **C**, CFCl_3 , contains polar bonds.

- (i) Mark **all** the partial charges on the atoms in the diagram of the CFCl_3 molecule shown below.



[1]

- (ii) Explain why the molecule CFCl_3 has the partial charges you have shown in (i).



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

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.....

.....

..... [2]

- (iii) Draw a diagram to represent the **shape** of a molecule of CFCl_3 .

[1]

- (iv) Use your answers to (i) and (iii) to explain whether or not there is an overall permanent dipole for the CFCl_3 molecule.

.....

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..... [2]

- (e) Explain why CFCs like compound **C**, CFCI_3 , are not broken down in the troposphere and how CFCs contribute to the breakdown of ozone in the stratosphere.



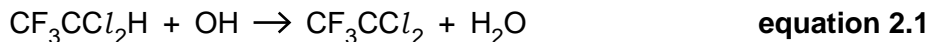
In your answer, you should make it clear how the steps you describe are linked to one another.

..... [5]

- (f)** Explain why the presence of ozone in the stratosphere is important for humans.

[3]

- (g) Compound **E**, $\text{CF}_3\text{CCl}_2\text{H}$, is broken down in the troposphere. The first step in the breakdown of compound **E** involves a reaction with OH radicals.



Draw a 'dot-and-cross' diagram for an OH radical.

Show outer shell electrons only.

[1]

(h) OH radicals are formed from water molecules in the stratosphere.

(i) The bond enthalpy of the O–H bond in water is $+463 \text{ kJ mol}^{-1}$.

Calculate the minimum energy, **in J**, required to break a single O–H bond.

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

energy = J [2]

(ii) Calculate the minimum frequency of radiation needed to break the O–H bond.

Give the appropriate units.

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

frequency = units [3]

(iii) What **type** of bond breaking occurs when OH radicals are produced from water molecules?

..... [1]

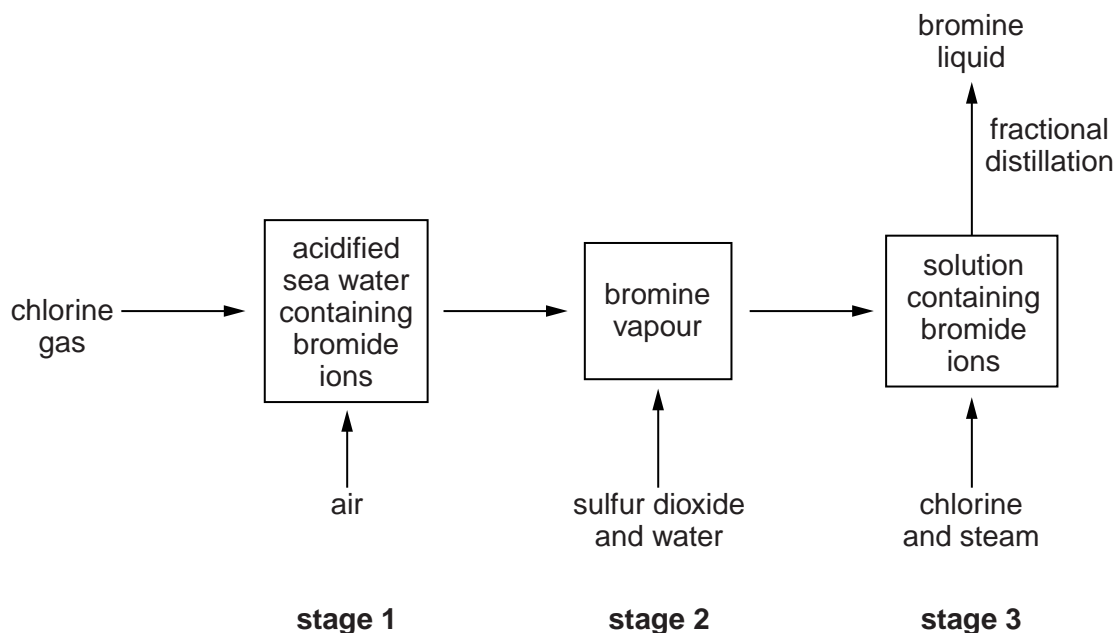
(iv) Suggest why OH radicals are not produced in the **troposphere** by the action of sunlight on water molecules.

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..... [1]

[Total: 26]

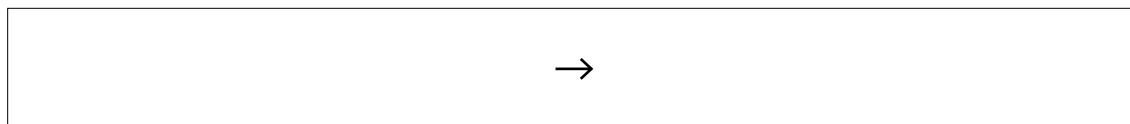
- 3 Bromine can be extracted from sea water. One method of making bromine is shown in the flow chart below.



- (a) In **stage 1**, chlorine reacts with bromide ions in the sea water.

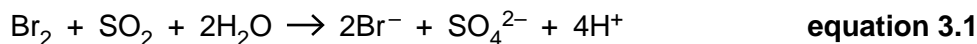
Write an **ionic** equation for the reaction of chlorine gas with bromide ions to produce bromine vapour.

Include state symbols.



[2]

- (b) In **stage 2**, bromine vapour is treated with sulfur dioxide and water to produce an aqueous solution containing bromide ions.



- (i) Complete the table below to show the oxidation states for bromine and sulfur in **equation 3.1**.

element	initial oxidation state	final oxidation state
Br		
S		

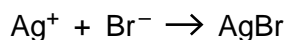
- (ii) Give the formula of the reducing agent in the reaction shown in **equation 3.1** and explain your answer.

reducing agent:

explanation:

..... [2]

- (c) A student is given a solution of bromide ions. The concentration of bromide ions in the solution is the same as that found in a sample of sea water. The student adds acidified silver nitrate to the solution of bromide ions.



equation 3.2

Describe what the student **sees** when the reaction shown in **equation 3.2** occurs.

.....

..... [2]

- (d) The student titrates a 25.0cm^3 sample of the solution of bromide ions, Br^- , with 0.0200mol dm^{-3} silver nitrate solution, AgNO_3 . The reaction requires 32.60cm^3 of silver nitrate solution to reach the end-point.

- (i) Calculate the number of moles of AgNO_3 the student uses in the titration.

answer = mol [1]

- (ii) Use your answer to (i) and **equation 3.2** to give the number of moles of Br^- ions that react.

answer = mol [1]

- (iii) Calculate the concentration of Br^- ions in the sample.

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

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

[Total: 14]

- 4 Carbon monoxide and hydrogen are produced industrially by reacting methane with steam in the presence of a powdered solid catalyst. Chemists are now investigating the use of *nanoparticles* of the catalyst coated onto an inert wire mesh. Nanoparticles are particles the size of a few thousand atoms.



- (a) The reaction shown in **equation 4.1** is in a state of dynamic equilibrium.

Explain what is meant by *dynamic equilibrium*.

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..... [2]

- (b) Explain why the use of nanoparticles of catalyst, rather than the powdered solid, could further increase the rate of the reaction.

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..... [2]

- (c) Using a catalyst has an effect on the activation enthalpy for the reaction.

Explain what is meant by the term *activation enthalpy*.

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.....
..... [2]

- (d) In addition to looking at different catalysts, chemists have also studied how changing pressure and temperature affect the rate and equilibrium yield of the reaction shown in **equation 4.1**.

- (i) Describe and explain the effect, if any, of an increase in **pressure** on the **rate** of reaction.

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.....
.....
..... [3]

- (ii) Describe and explain the effect, if any, of an increase in **pressure** on the equilibrium **yield** of the reaction.

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..... [3]

- (iii) Describe and explain the effect, if any, of an increase in **temperature** on the equilibrium **yield** of the reaction.

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..... [3]

- (e) Methane contributes to the greenhouse effect. There is a low concentration of methane in our atmosphere.

- (i) Give an agricultural activity that acts as a source of methane.

..... [1]

- (ii) Methane acts as a greenhouse gas because it can absorb infrared radiation.

Explain how increased concentrations of methane in the troposphere could be linked to global warming.

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..... [2]

- (iii) A sample of air is analysed and found to contain 1.8 ppm of methane and 21% oxygen by volume.

How much more abundant is oxygen than methane in this sample of air?

answer = times more abundant [2]

[Total: 20]

5 This question is based on the Advance Notice article '**Plastic Fantastic**' which is provided as an insert to this paper.

- (a) Explain what is meant by the term *addition polymer*. Give an example of an addition polymer **from the article**, other than poly(ethene).

Explanation:

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.....

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Example: [3]

- (b) Classify the **type** of reaction shown in the forward reaction in **Figure 1** in the article.

..... [1]

- (c) Gibson and Fawcett used infrared spectroscopy to show that the product of the reaction contained only carbon and hydrogen.

- (i) Explain how infrared spectroscopy produces a spectrum for a compound and how the spectrum would confirm the presence of only carbon and hydrogen in the product.

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..... [4]

- (ii) Describe a feature of the infrared spectrum that Gibson and Fawcett would have expected from the product if the reaction shown in **Figure 1** of the article had occurred. Give an appropriate wavenumber range.

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..... [2]

- (d) The article describes the involvement of oxygen in the polymerisation of ethene, which starts with an initiation reaction.

(i) What is an **initiation** reaction?

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..... [1]

(ii) Suggest a meaning for a 'half curly arrow' as shown in the equation on page 3 of the article.

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..... [1]

(iii) Write an equation, which is shown in the article, representing a **termination** reaction.

[1]

- Explain why a heavier weight can be hung on a thread of HDPE, compared to a similar thread of LDPE.

- how instantaneous dipole–induced dipole bonds form;
- how the structures of the two polymers affect the strength of their instantaneous dipole–induced dipole bonds.



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

..... [7]

[Total: 20]

END OF QUESTION PAPER

Plastic Fantastic

From RSC's Education in Chemistry 'Infochem' supplement, Jan 2005.

You can't miss the addition polymer poly(ethene) (PE, polythene). It's in your house, in the streets and roads, in supermarkets, in your garden and maybe even in you. The list of PE products is endless – shampoo and detergent bottles, gas and plumbing supply pipes, electrical insulation, car wheel arches and petrol tanks, food packaging and crates, and milk, ketchup and healthcare bottles. Poly(ethene) is also used in bullet proof vests, in hip and bone replacements, and as a waterproof coating on skis, sail boards, and canoes. So ubiquitous is this plastic – PE is the most widely used plastic, commanding ca. 36 per cent of the total European market – that it's hard to imagine life without it. And yet, like many other products we have come to rely on for our current lifestyles, poly(ethene) was discovered by accident.

A serendipitous discovery

In 1933, Reginald Gibson and Eric Fawcett, two research chemists at ICI's Winnington Laboratory in Cheshire, were working on high pressure and high temperature reactions. They were trying to develop new products for ICI's rapidly growing dyestuffs industry. They tried to react ethene and benzaldehyde (benzenecarbaldehyde) at 2000 atm (1 atm = 101325 Pa) and 170 °C in the hope of producing potential intermediates in the manufacture of dyes.

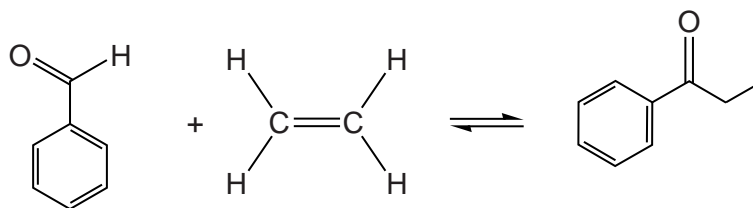


Figure 1: The equation for the reaction expected to occur between benzaldehyde and ethene

The high pressure apparatus had a mercury gas compressor. Benzaldehyde was contained in an inverted glass tube, sealed with mercury and placed in a steel tube in a reaction vessel. The vessel was sealed and put in an oil thermostat, regulated to 170 °C. Ethene was bubbled through the mercury into the benzaldehyde – mercury separated the gas from benzaldehyde rather like a piston.

Gibson and Fawcett started the experiment on Friday afternoon, and left it to run over the weekend. On the Monday morning, they found that the pressure in the system had fallen to ca. 500 atm because of a small leak in the oil system. Ethene had expanded and forced the benzaldehyde through the mercury into the oil system. They couldn't replace the benzaldehyde so, having fixed the leak, they restored the pressure by adding more ethene. After a few hours they stopped the reaction and allowed it to cool. No liquid product had formed, but instead a trace amount – 0.2 g – of a waxy solid had formed on the inside wall of the glass tube. Spectroscopic analysis revealed that this contained only hydrogen and carbon in the same ratio as ethene. They had discovered poly(ethene).

Unfortunately, when they tried to repeat the experiment, decomposition of ethene to carbon occurred, which being exothermic caused an explosion, bursting a pressure joint near the oil thermostat and setting it on fire. ICI management immediately stopped high pressure work on ethene until safer premises could be found. That might have been the end of the story but ...

Poly(ethene) – rediscovered

Two years later, and in an isolated building with walls one-foot thick, Michael Perrin, another research chemist, decided to do some more experiments with ethene.

Frank Bebbington, now 94 years old and one of Perrin's research assistants at the time, told *Education in Chemistry*, 'On 20 December 1935 I assembled equipment in a deliberate attempt to polymerise ethylene [ethene] under the same conditions that Gibson and Fawcett had used, but on a smaller scale. Immediately we put the pressure up to 2000 atm the pressure in the reaction vessel started to fall away very slowly, and again we thought there was a small leak in the system. I felt embarrassed because I had assembled the equipment. I compressed more ethylene to take the pressure back up to 2000 atm. At 1.00 pm everybody, except me, went to lunch; I was left to keep the pressure at 2000 atm. When they came back we stopped the experiment, and cooled the vessel. We opened it up, and to our amazement, it contained white powder – 8.5 g of the stuff to be precise. We had rediscovered poly(ethene). We immediately called the research director, Dr J. Swallow, who took the powder in his fingers and said "I wonder if it's a plastic?"'.

The next couple of attempts to repeat the experiment, however, gave only 0.5 g, 1 g and an explosive decomposition reaction. 'But', says Bebbington, 'once you've made 8.5 g of something, you know you can do it and we were determined to find out how'.

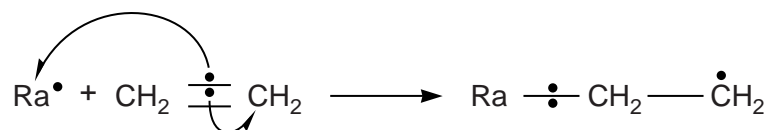
Bebbington remembers, 'after about 200 experiments, we discovered that the key to the successful polymerisation of ethylene [ethene] was an impurity in the ethylene – *ie* oxygen. Too much O_2 – ca. 500–1000 ppm (parts per million) – led to decomposition of the ethylene, 20–200 ppm of O_2 gave polyethylene, and no oxygen – no polyethylene'. 'Oxygen', explained Bebbington, 'was acting not as a catalyst but as an initiator because it was being used up during the polymerisation reaction'.

The role of oxygen in the polymerisation process

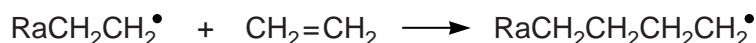
It has since been shown that oxygen reacts with some of the ethene to give an organic peroxide. Organic peroxides are very reactive molecules containing oxygen–oxygen single bonds that are quite weak and that break easily to give free radicals, represented here as Ra^\bullet .

The free radical, Ra^\bullet , uses one of the electrons in one of the $C=C$ bonds to form a new bond between itself and the left hand carbon atom. The other electron returns to the right hand carbon.

This can be shown using 'half curly arrow' notation:

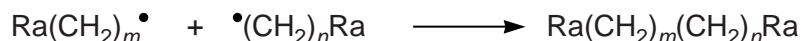


This produces a bigger free radical – lengthened by CH_2CH_2 – that can react with another ethene molecule in the same way:



So now the radical is even bigger. It can react with another ethene – and so on and so on. The polymer chain gets longer and longer.

The chain doesn't grow indefinitely. Sooner or later two free radicals will collide together.



That immediately stops the growth of two chains and produces one of the final molecules in the poly(ethene). It is important to realise that the poly(ethene) is going to be a mixture of molecules of different sizes, made in this sort of random way.

Moving on

By April 1936 the first pound of poly(ethene) had been made. It was sent to the Nobel Division of ICI in Ardeer, Scotland, where the only injection moulding machines existed, and a few small pill boxes were made. Back at Winnington, Perrin and his team made more poly(ethene) and started testing their new material. The PE that they had made was low density polyethene (see Figure 2). Its excellent insulating properties at high frequencies soon attracted the telephone industry, which was quick to spot it as a replacement for gutta-percha to insulate telephone cables. (Gutta-percha – latex from rubber trees in the Far East – was becoming increasingly difficult to obtain because of the imminent war.) On 1 September 1939 poly(ethene) became an official product of ICI.

During World War II all PE was made for the Government, specifically for high frequency experimental radar cable. The successful development of radar is said to have shortened the war by years. A poly(ethene) tube, called Pluto, was also laid across the Channel for transferring petrol from the UK to France.

Since its discovery over 70 years ago, there have been many improvements to the synthesis of poly(ethene). These have centred on the development of several types of catalyst – notably Ziegler–Natta catalysts in the 1950s and metallocene catalysts in the 1970s – so that the polymerisation can be done at lower pressures and temperatures, thus using less energy and making the process more environmentally acceptable.

Poly(ethene) – it's so useful

In its simplest form poly(ethene) consists of a long backbone of carbon atoms with two hydrogen atoms attached to each. This is called linear poly(ethene) or high density poly(ethene) (HDPE). Sometimes the hydrogen atoms are replaced by other PE molecules, which gives branched or low density poly(ethene) (LDPE) – the molecules don't pack together so well.

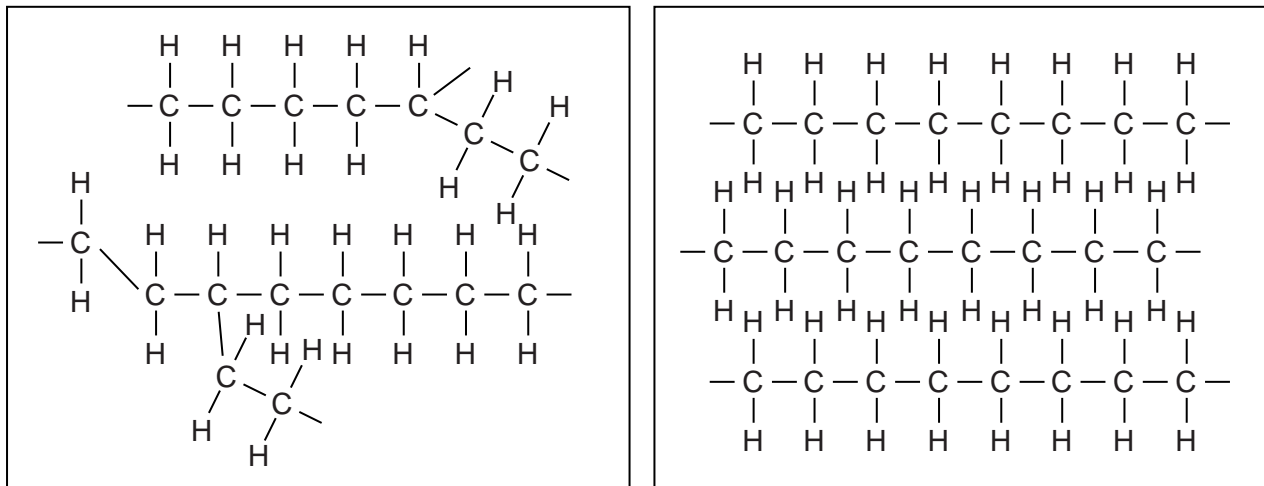


Figure 2: Part of the structure of the polymer chain in LDPE (left) and HDPE (right)

Approximately two thirds of all injection moulded PE items are made from HDPE – industrial containers, such as crates and pallets, gas and water pipes, canoes, car parts, and food containers, carbonated bottle bases and caps; LDPE is used mainly for food packaging films, waterproof films, and electrical cable insulation.

As well as poly(ethene), many other polymers can be made from alkene monomers. These include poly(propene), which is used to make drain pipes and crates and poly(chloroethene), or PVC, which is used to make the coating for electrical wires.

END OF ADVANCE NOTICE ARTICLE