

Week 25

A-Level Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

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A-Level Chemistry

Name: _____ Score: _____

1. Alkanes are:

- ☐ saturated hydrocarbons with general formula C_nH_{2n+2}
- ☐ unsaturated hydrocarbons with a $C=C$ bond
- ☐ compounds containing oxygen
- ☐ ionic compounds

2. Alkanes react with chlorine by free-radical substitution in the presence of:

- ☐ ultraviolet light
- ☐ a nucleophile
- ☐ water
- ☐ an acid catalyst

3. Alkenes are reactive because they have:

- ☐ a $C=C$ double bond (their functional group)
- ☐ only single bonds
- ☐ an $-OH$ group
- ☐ no functional group

4. In addition polymerisation:

- ☐ many alkene molecules join into one long chain, with no other product
- ☐ a small molecule like water is lost
- ☐ a polymer is split apart
- ☐ two different monomers alternate

5. Cracking is used to:

- ☐ break long-chain alkanes into shorter, more useful molecules
- ☐ join short alkanes into long ones
- ☐ add hydrogen to alkenes
- ☐ burn alkanes

6. Alkanes are saturated hydrocarbons containing only single bonds.

- ☐ True ☐ False

7. Alkanes react with halogens in UV light by free-radical _____.

8. Many ethene molecules join to form the polymer poly(_____).

9. An alkene decolourises bromine water, while an alkane leaves it orange — that is the standard test for a C=C double bond.

☐ True ☐ False

10. The initiation step is:

☐ UV light splitting the halogen into two radicals

☐ two radicals joining

☐ a radical reacting with the alkane

☐ the product forming

A-Level Chemistry

1. saturated hydrocarbons with general formula C_nH_{2n+2}

Alkanes have only single C–C bonds (saturated) and follow C_nH_{2n+2} .

2. ultraviolet light

UV light starts the reaction by splitting the halogen into radicals.

3. a C=C double bond (their functional group)

The electron-rich C=C double bond is the reactive functional group of alkenes (C_nH_{2n}).

4. many alkene molecules join into one long chain, with no other product

Alkenes open their double bonds and join into a polymer such as poly(ethene); nothing else is formed.

5. break long-chain alkanes into shorter, more useful molecules

Cracking turns heavy crude-oil fractions into smaller, more useful alkanes and alkenes.

6. True

General formula C_nH_{2n+2} .

7. substitution

Initiation, propagation and termination steps.

8. ethene

Addition polymerisation of the alkene.

9. True

The π electrons of the C=C attack the bromine; alkanes have no double bond, so nothing happens.

10. UV light splitting the halogen into two radicals

Initiation: $Cl_2 \rightarrow 2Cl \cdot$, the homolytic split that starts the chain.

14.1 Alkanes

Name: _____ Class: _____ Date: _____

Total: 12 marks

KEY WORDS propagation 增长 • initiation 引发 • termination 终止 • carbon monoxide 一氧化碳
• free-radical substitution 自由基取代

Objective

Build the skills to answer exam questions on **alkanes** 烷烃 — making them, **combustion** 燃烧, **free-radical substitution** 自由基取代, and their unreactivity.

You must be able to:

- recall how alkanes are made (hydrogenation, cracking) and describe combustion
- describe the free-radical substitution mechanism (initiation, propagation, termination)
- explain the unreactivity of alkanes and the environmental effects of combustion

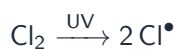
1 Worked examples

■ Making alkanes and combustion

- **hydrogenation:** add H_2 to an alkene (Pt/Ni catalyst, heat).
- **cracking:** break a long alkane into shorter ones (heat, Al_2O_3).
- **complete combustion** $\rightarrow \text{CO}_2 + \text{H}_2\text{O}$; **incomplete** (little O_2) $\rightarrow$ toxic **CO** + soot.

■ Free-radical substitution

1. initiation



UV light splits $\text{Cl}-\text{Cl}$ into two radicals

2. propagation



each radical makes a new radical, so the chain continues

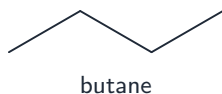
3. termination



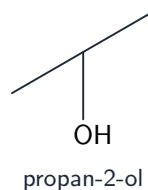
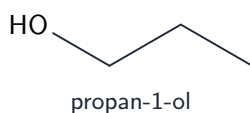
two radicals join, ending the chain

Free-radical substitution (needs UV light): initiation $\rightarrow$ propagation $\rightarrow$ termination

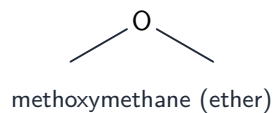
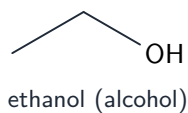
chain



positional



functional



Alkanes show chain and position isomerism

- **initiation:** $\text{Cl}_2 \xrightarrow{\text{UV}} 2\text{Cl}\cdot$
- **propagation:** $\text{Cl}\cdot + \text{C}_2\text{H}_6 \rightarrow \text{C}_2\text{H}_5\cdot + \text{HCl}$; $\text{C}_2\text{H}_5\cdot + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}\cdot$
- **termination:** two radicals join, e.g. $\text{Cl}\cdot + \text{C}_2\text{H}_5\cdot \rightarrow \text{C}_2\text{H}_5\text{Cl}$

Alkanes are unreactive: the C–H and C–C bonds are strong and have little polarity, so nothing attracts a polar reagent.

2 Practice

2.1 State the reagent and condition for making an alkane from an alkene. [2]

2.2 Give the products of the **incomplete** combustion of an alkane. [2]

3 Exam-style questions

3.1 What condition is needed for the free-radical substitution of an alkane by chlorine?[1]

- **A** a nickel catalyst
 - **B** ultraviolet light
 - **C** concentrated sulfuric acid
 - **D** aqueous sodium hydroxide
-

3.2 Why are alkanes generally unreactive towards polar reagents? [1]

- **A** they are ionic
 - **B** the C–H and C–C bonds are strong and non-polar
 - **C** they contain a double bond
 - **D** they are very volatile
-

3.3 Ethane reacts with chlorine in UV light.

(a) Write equations for the initiation step and **one** propagation step. [3]

(b) Write an equation for a termination step that forms chloroethane. [1]

3.4 Explain why incomplete combustion of a fuel is dangerous. [2]

Solutions

2.1 hydrogen (H_2) with a Pt or Ni catalyst; and heat.

2.2 carbon monoxide (and/or carbon/soot); water.

3.1 B. Free-radical substitution needs ultraviolet light.

3.2 B. Strong, non-polar C–H and C–C bonds offer no site for a polar reagent.

3.3 (a) initiation: $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$; propagation: $\text{Cl}\cdot + \text{C}_2\text{H}_6 \rightarrow \text{C}_2\text{H}_5\cdot + \text{HCl}$ and $\text{C}_2\text{H}_5\cdot + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}\cdot$.

(b) $\text{C}_2\text{H}_5\cdot + \text{Cl}\cdot \rightarrow \text{C}_2\text{H}_5\text{Cl}$.

3.4 it produces carbon monoxide, a toxic gas that binds to haemoglobin and prevents oxygen transport.

- 28** Two hydrocarbons, $R-CH_3$ and $R'-CH_3$, react separately with bromine in the presence of ultraviolet light. One of these hydrocarbons is unsaturated.

In each case, free radical substitution reactions occur.

R is $CH_3CHC(CH_3)$.

R' is $CH_3CH(CH_3)CH_2$.

Which row is correct?

	a propagation stage for the saturated hydrocarbon	a termination stage for the unsaturated hydrocarbon
A	$R-CH_2\cdot + Br\cdot \rightarrow R-CH_2Br$	$R'-CH_2\cdot + Br\cdot \rightarrow R'-CH_2Br$
B	$R-CH_2\cdot + Br_2 \rightarrow R-CH_2Br + Br\cdot$	$R'-CH_2\cdot + Br_2 \rightarrow R'-CH_2Br + Br\cdot$
C	$R'-CH_3 + Br\cdot \rightarrow R'-CH_2\cdot + HBr$	$2R-CH_2\cdot \rightarrow R-CH_2CH_2-R$
D	$2R'-CH_2\cdot \rightarrow R'-CH_2CH_2-R'$	$R-CH_3 + Br\cdot \rightarrow R-CH_2\cdot + HBr$

- 29** The fumes from the exhausts of petrol-burning cars contain the following pollutants.

- 1 unburnt hydrocarbons
- 2 nitrogen dioxide
- 3 carbon monoxide

Which pollutants are removed by oxidation in a catalytic converter?

- A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

- 25** Two hydrocarbons, $CH_3CHC(CH_3)CH_3$ and $CH_3CH(CH_3)CH_2CH_3$, react separately with chlorine in the presence of ultraviolet light.

In each reaction, free-radical substitution occurs.

Which row is correct?

	identity of the hydrocarbon that can also undergo electrophilic addition	a termination stage of the free-radical substitution of the saturated hydrocarbon
A	$CH_3CHC(CH_3)CH_3$	$CH_3CH(CH_3)CH_2CH_2\cdot + Cl\cdot \rightarrow CH_3CH(CH_3)CH_2CH_2Cl$
B	$CH_3CHC(CH_3)CH_3$	$CH_3CHC(CH_3)CH_2\cdot + Cl\cdot \rightarrow CH_3CHC(CH_3)CH_2Cl$
C	$CH_3CH(CH_3)CH_2CH_3$	$CH_3CH(CH_3)CH_2CH_2\cdot + Cl\cdot \rightarrow CH_3CH(CH_3)CH_2CH_2Cl$
D	$CH_3CH(CH_3)CH_2CH_3$	$CH_3CHC(CH_3)CH_2\cdot + Cl\cdot \rightarrow CH_2CHC(CH_3)CH_2Cl$

- 3 The alkanes are a homologous series of organic molecules. Alkanes are generally unreactive and are commonly used as fuels.

(a) Define homologous series.

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

(b) Give two reasons to explain the general unreactivity of alkanes.

1
2 [2]

(c) Alkanes with low relative molecular mass, M_r , are more useful than those found in heavier crude oil fractions.

Name the process that is used to obtain alkanes with low M_r from heavier crude oil fractions.

..... [1]

(d) Hexane, C_6H_{14} , has four structural isomers.

Fig. 3.1 shows hexane and two of its structural isomers.

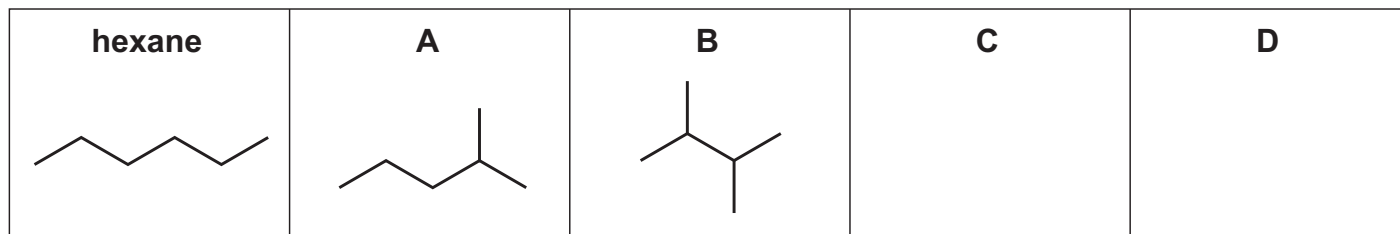


Fig. 3.1

(i) Complete Fig. 3.1 by drawing structures for **C** and **D**, the other two structural isomers of hexane. [2]

(ii) **A**, **B** and hexane have different boiling points.

Arrange **A**, **B** and hexane in order of increasing boiling point.

Explain your answer.

lowest < < highest

.....
.....
.....

[3]

- (e) Hexane can be converted into compounds **E** and **F** at high temperature and pressure. Fig. 3.2 shows the reaction scheme involving hexane, **E** and **F**.

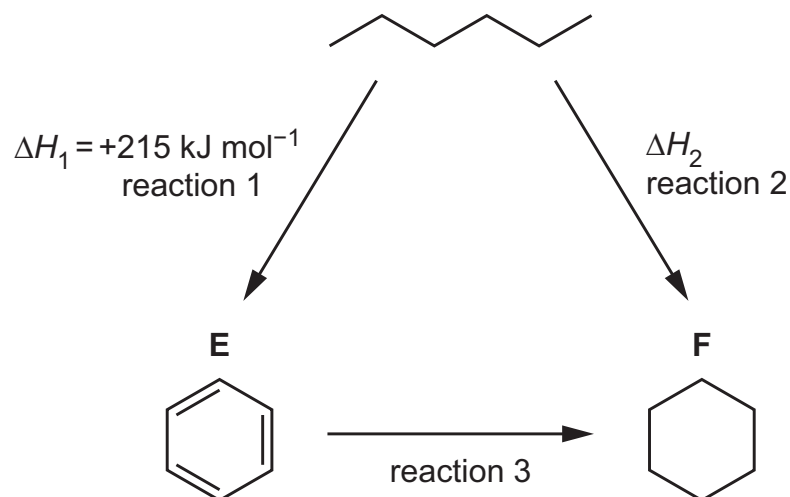


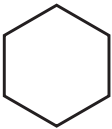
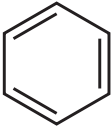
Fig. 3.2

- (i) Identify a suitable reagent for reaction 3.

..... [1]

- (ii) Use the data in Fig. 3.2 and in Table 3.1 to calculate the enthalpy change of reaction 2, ΔH_2 .

Table 3.1

compound	enthalpy change of formation, $\Delta H_f / \text{kJ mol}^{-1}$
	-156
	+48

$\Delta H_2 = \dots\dots\dots \text{ kJ mol}^{-1}$ [2]

- (iii) Write an equation for the complete combustion of hexane.

..... [1]

14.2 Alkenes

Name: _____ Class: _____ Date: _____

Total: 13 marks

KEY WORDS electrophilic addition 亲电加成 • addition polymerisation 加成聚合 • bromine 溴 • alkenes 烯烃
• polymer 聚合物

Objective

Build the skills to answer exam questions on **alkenes** 烯烃 — making them, **electrophilic addition** 亲电加成, the **bromine** 溴 test, **addition polymerisation** 加成聚合, and **Markovnikov's rule** 马氏规则.

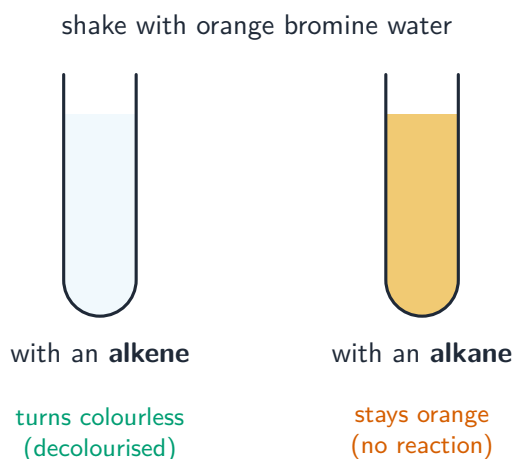
You must be able to:

- recall how alkenes are made and describe their addition reactions
- describe the electrophilic addition mechanism and use the bromine test
- explain carbocation stability and Markovnikov addition

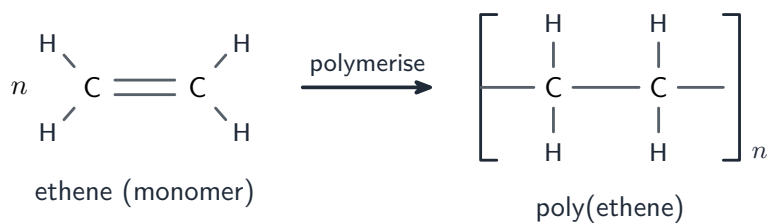
1 Worked examples

■ Reactions of alkenes

The C=C bond reacts by **electrophilic addition**: with H_2 (Pt/Ni) $\rightarrow$ alkane; steam (H_3PO_4) $\rightarrow$ alcohol; $\text{HX} \rightarrow$ halogenoalkane; $\text{X}_2 \rightarrow$ dihalide. Cold dilute $\text{KMnO}_4 \rightarrow$ diol; hot conc. KMnO_4 breaks the C=C.

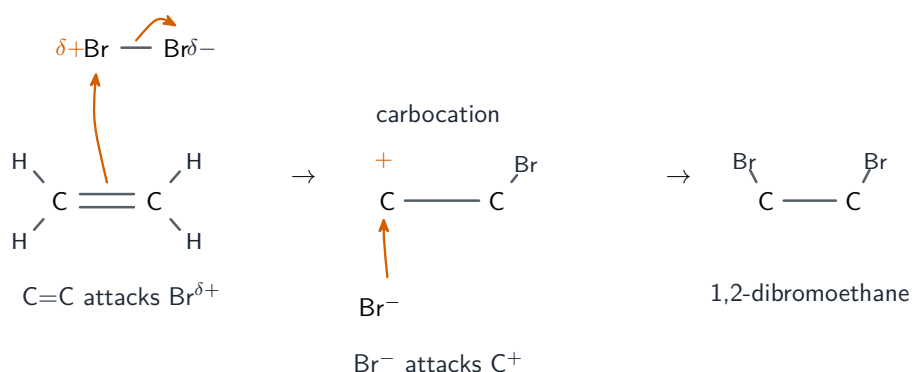


Test for C=C: an alkene decolourises orange bromine water; an alkane does not

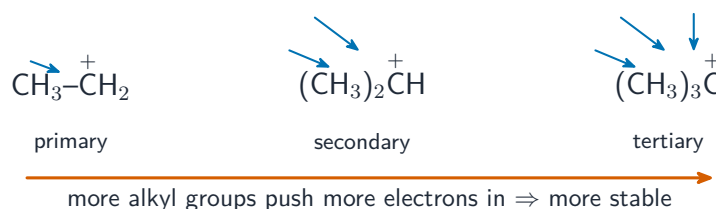


Addition polymerisation: many ethene molecules join into poly(ethene), with no other product

■ Mechanism and Markovnikov



Electrophilic addition: the electron-rich C=C attacks the electrophile, forming a carbocation, then the nucleophile attacks



Markovnikov: HBr adds so the *more stable* carbocation forms

Alkyl groups push electrons in (inductive effect), so tertiary > secondary > primary — the basis of Markovnikov's rule

2 Practice

2.1 State the reagent and condition for making an alcohol from an alkene. [2]

2.2 Describe the test for a C=C double bond and the positive result. [2]

3 Exam-style questions

3.1 Which reagent converts ethene into a halogenoalkane? [1]

- **A** H_2 / Ni
- **B** steam / H_3PO_4
- **C** HBr at room temperature
- **D** hot KMnO_4

3.2 During electrophilic addition, the positive intermediate formed is a: [1]

- **A** free radical
- **B** carbocation
- **C** nucleophile
- **D** diol

3.3 (a) Describe the mechanism of the electrophilic addition of bromine to ethene (use curly arrows or words). [3]

(b) Write the equation for the addition polymerisation of ethene to poly(ethene). [1]

3.4 When HBr adds to propene, 2-bromopropane is the major product. Explain why, using carbocation stability. [3]

Solutions

2.1 steam (H_2O gas) with a phosphoric acid (H_3PO_4) catalyst.

2.2 shake with (orange) bromine water; an alkene decolourises it / turns it colourless.

3.1 C. HBr at room temperature gives a halogenoalkane.

3.2 B. The intermediate is a carbocation.

3.3 (a) the $\text{C}=\text{C}$ double bond attacks the $\delta+$ bromine, with a curly arrow from the double bond; the $\text{Br}-\text{Br}$ bond breaks heterolytically, forming a carbocation and a Br^- ; the Br^- then attacks the carbocation to give 1,2-dibromoethane.

(b) $n \text{CH}_2=\text{CH}_2 \rightarrow -(\text{CH}_2\text{CH}_2)_n-$.

3.4 adding H^+ to propene can form a secondary or a primary carbocation; the secondary carbocation is more stable, because two alkyl groups push electrons towards the positive carbon; the more stable (secondary) carbocation forms preferentially, giving 2-bromopropane.

27 Which intermediate ion forms in the greatest amount during the addition of HBr to propene?

- A** $\text{CH}_3\text{CH}^+\text{CH}_3$
- B** $\text{CH}_3\text{CH}_2\text{CH}_2^+$
- C** $\text{CH}_3\text{CH}^-\text{CH}_2\text{Br}$
- D** $\text{CH}_3\text{CHBrCH}_2^-$

27 What is the major product when 2-methylpent-2-ene reacts with hydrogen bromide?

- A** 1-bromo-2-methylpentane
- B** 2-bromo-2-methylpentane
- C** 3-bromo-2-methylpentane
- D** 4-bromo-2-methylpentane

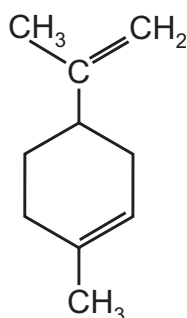
28 Pent-2-ene is reacted with cold, dilute, acidified manganate(VII) ions.

What is the major product?

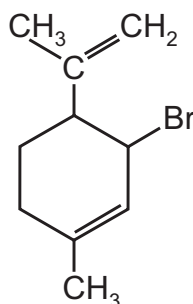
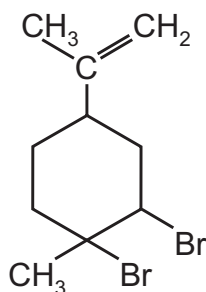
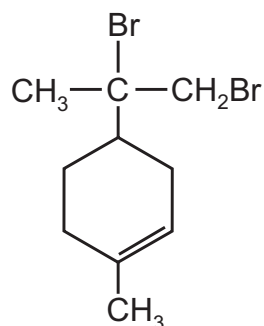
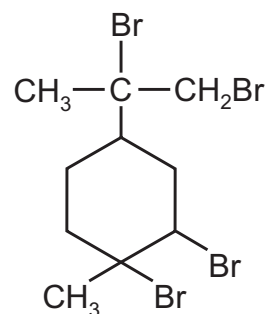
- A** $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}(\text{OH})\text{CH}_3$
- B** $\text{CH}_3\text{CH}_2\text{COCOCH}_3$
- C** a mixture of $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$
- D** $\text{CH}_3\text{CH}_2\text{COOH}$ and CH_3COOH

29 Limonene is an oil formed in the peel of citrus fruits.

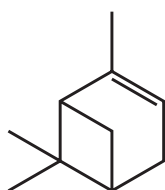
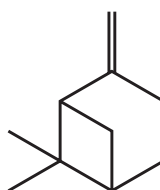
limonene



Which product is formed when an excess of bromine, $\text{Br}_2(\text{l})$, reacts with limonene at room temperature in the dark?

A**B****C****D**

29 Pinenes are unsaturated compounds. The structures of two pinenes are shown.

 α -pinene β -pinene

A mixture of these two pinenes reacts with hot concentrated acidified KMnO_4 .

What are the molecular formulae of the organic products?

- A** $\text{C}_9\text{H}_{14}\text{O}$ and $\text{C}_{10}\text{H}_{16}\text{O}_3$
B $\text{C}_9\text{H}_{14}\text{O}$ and $\text{C}_{10}\text{H}_{14}\text{O}_4$
C $\text{C}_9\text{H}_{16}\text{O}_2$ and $\text{C}_{10}\text{H}_{16}\text{O}_3$
D $\text{C}_9\text{H}_{16}\text{O}_2$ and $\text{C}_{10}\text{H}_{14}\text{O}_4$

4 Fig. 4.1 shows a possible synthesis of propene, C_3H_6 .

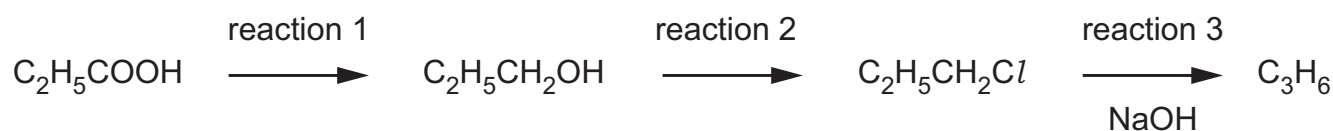


Fig. 4.1

(a) (i) Identify the type of reaction that occurs in reaction 1.

..... [1]

(ii) Suggest a suitable reagent for reaction 2.

..... [1]

(iii) Reaction 3 is an elimination reaction.

Write an equation for this reaction and identify the solvent and conditions used.

equation

solvent and conditions [2]

(iv) $C_2H_5CH_2OH$ can be directly converted to C_3H_6 .

Suggest the reagent and conditions for this conversion.

..... [1]

(b) Under suitable conditions, propene polymerises to form poly(propene).

Poly(propene) exhibits stereoisomerism.

(i) Identify the type of polymerisation that forms poly(propene) from propene.

..... [1]

(ii) Define stereoisomerism.

.....

..... [2]

(iii) Draw a section of poly(propene), showing **two** repeat units.

Use your diagram to identify the type of stereoisomerism shown by poly(propene). Explain your answer.

section of poly(propene)

[3]

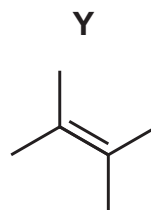
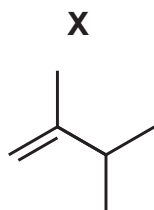
(iv) State **two** difficulties associated with the disposal of poly(propene).

1

2

[2]

(c) Under different conditions, two molecules of propene can combine to form compounds **X** and **Y**.



(i) Name **X**.

..... [1]

(ii) Fig. 4.2 shows the mass spectrum of either compound **X** or compound **Y**.

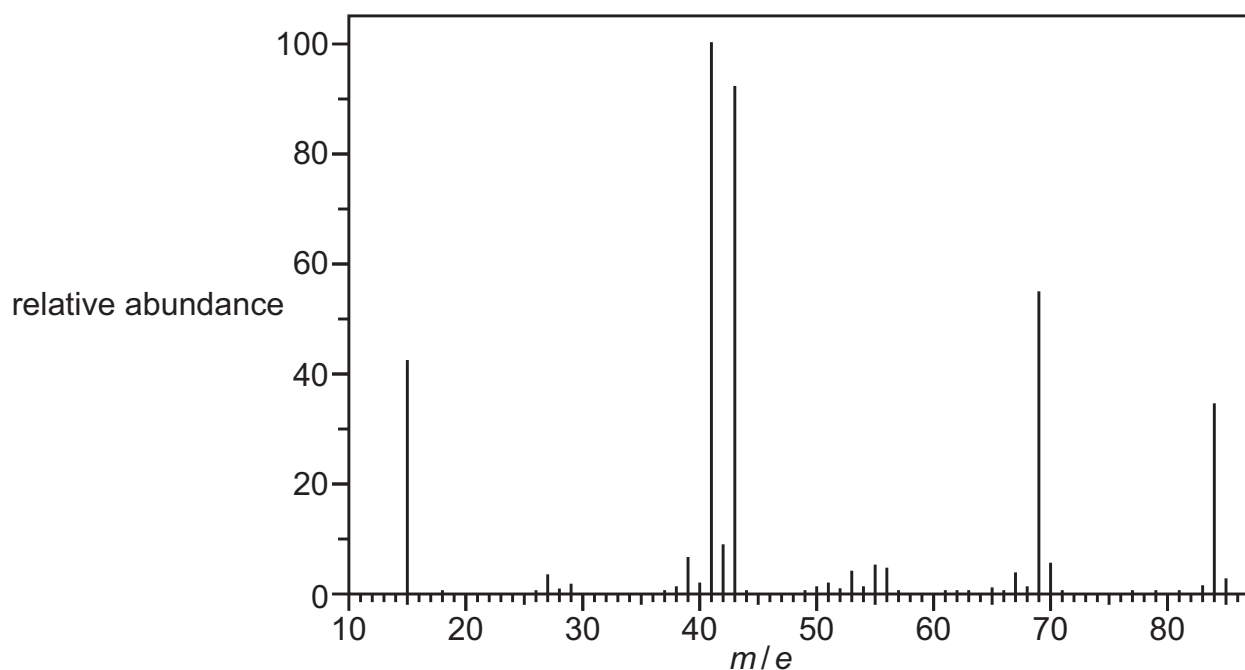


Fig. 4.2

Identify which of **X** and **Y** gives this mass spectrum.

Give **one** reason for your answer, referring to the fragmentation pattern.

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

(iii) The molecular ion peak in the spectrum in Fig. 4.2 has relative abundance 34.7.

Calculate the relative abundance of the $[M+1]^+$ peak in this spectrum.

relative abundance of $[M+1]^+$ peak = [1]

Important values, constants and standards

molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23} \text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ (4.18 J g ⁻¹ K ⁻¹)

The Periodic Table of Elements

Group																				
1	2													13	14	15	16	17	18	
																		2 He helium 4.0		