AS Level
Organic Chemistry Topical Work Book

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9701/22/F/M/22
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9701/21/M/J/21
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9701/12/O/N/21
9701/21/O/N/21 (other variants are same)

9701/12/F/M/20

(d) A reaction of another unsaturated carboxylic acid, **T**, is shown.

(i) **T** is one of a pair of geometrical (*cis-trans*) isomers.

Draw the other geometrical isomer of **T** and explain why the molecules exhibit this form of isomerism.

.....

.....

.....

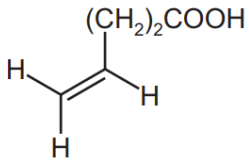
[3]

9701/22/F/M/20

(c) Fats are compounds made from glycerol and unsaturated carboxylic acids.

4-pentenoic acid is an example of an unsaturated carboxylic acid.

4-pentenoic acid



(i) Give the molecular formula of 4-pentenoic acid.

..... [1]

9701/22/F/M/20

(iii) The fastest reaction shown by Lucas's reagent is with a tertiary alcohol.

Draw the structure of the tertiary alcohol that is an isomer of pentan-3-ol.

[1]

9701/22/F/M/20

25 Structural isomerism and stereoisomerism should be considered when answering this question.

How many non-cyclic isomers have the molecular formula C_5H_{10}?

A 3 **B** 4 **C** 5 **D** 6

9701/12/F/M/20

20 Which pair of compounds are functional group isomers of each other?

A butan-1-ol and butanal

B ethylpropanoate and pentanoic acid

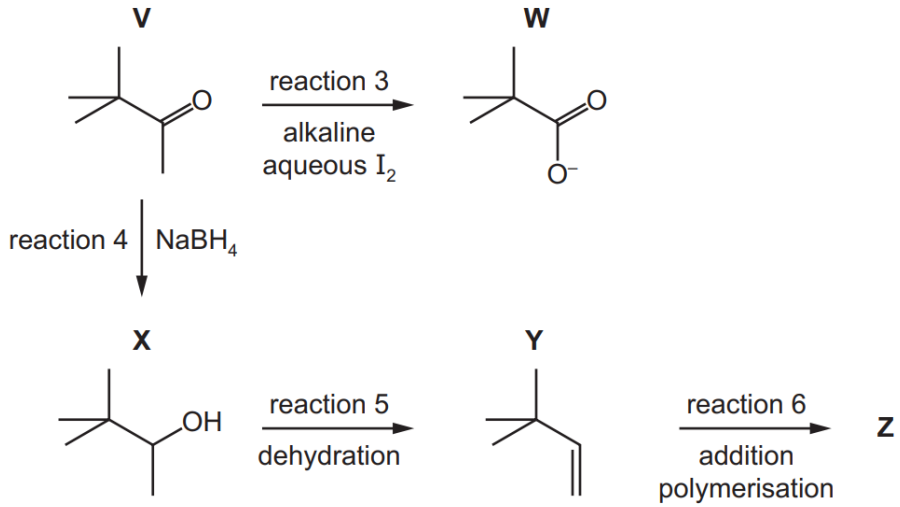
C hex-1-ene and hex-2-ene

D propylamine and propanenitrile

9701/12/F/M/20

(e) **V** is used in a wide range of organic reactions.

Some reactions of **V** are shown.



(iv) **X** is a mixture of two optical isomers.

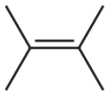
Draw the two optical isomers in the boxes provided.

[2]

9701/22/O/N/21

3 Compound **T** is an isomer of C_6H_{12}.

T



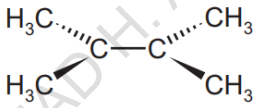
(a) Name **T**.

..... [1]

(b) Draw the skeletal formula of a structural isomer of **T** that shows *cis-trans* (geometrical) isomerism.

[1]

(c) Each carbon atom in **T** forms a sigma (σ) bond to at least one other carbon atom, as shown.



(i) On the diagram, draw the orbitals that represent the pi (π) bond that is also present in **T**.
[1]

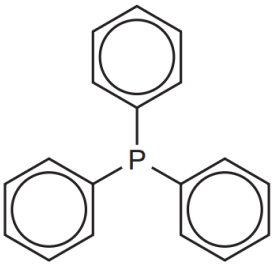
(ii) State the hybridisation of the two carbon atoms between which the pi (π) bond forms.

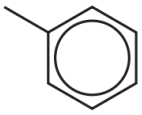
..... [1]

9701/22/O/N/21

(c) Triphenylphosphine is used in a type of reaction known as a *Wittig reaction*.

triphenylphosphine



where  = $-C_6H_5$

(i) Give the empirical formula of triphenylphosphine.

..... [1]

9701/21/O/N/21

22 Structural and stereoisomerism should be taken into account when answering this question.

Y is a gaseous hydrocarbon which decolourises aqueous bromine. It contains no rings.

10.0 g of Y occupies a volume of 3.43 dm^3 under room conditions.

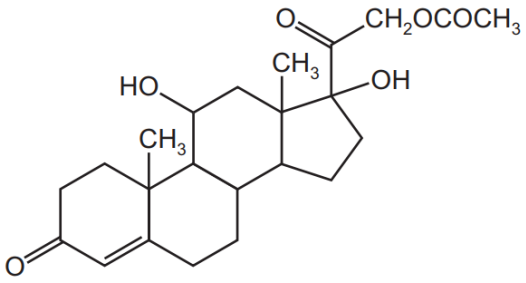
How many isomeric structures are possible for Y?

A 4 **B** 5 **C** 6 **D** 7

9701/12/O/N/21

20 The formula of hydrocortisone acetate is shown.

hydrocortisone acetate



Which row is correct?

	number of C atoms in one molecule	number of chiral atoms in one molecule
A	22	7
B	22	8
C	23	7
D	23	8

9701/12/O/N/21

38 One molecule of dodecane, $C_{12}H_{26}$, is cracked, producing three product molecules, X, Y and Z.

X is a straight chain alkane. Y and Z are straight chain alkenes with different M_r values.

Which statements about X, Y and Z are correct?

1 If Y and Z are but-1-ene and ethene respectively, X will be hexane.

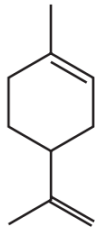
2 If X is butane, then Y and Z could both show *cis-trans* isomerism.

3 X could be octane.

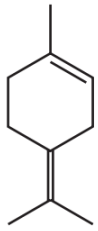
9701/11/O/N/21

37 A diketo acid is a compound with two ketone groups and one carboxylic acid group.

limonene



terpinolene



Which statements about the reactions of limonene and terpinolene are correct?

1 When reacted with an excess of hydrogen and a nickel catalyst, limonene and terpinolene produce the same compound.

2 An excess of hot concentrated acidified $KMnO_4$ reacts with limonene and with terpinolene to form different diketo acids.

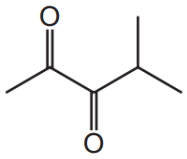
3 The reactions of limonene and terpinolene with an excess of Br_2 produce positional isomers with the same number of chiral carbon atoms.

9701/11/O/N/21

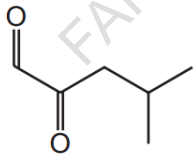
27 Reduction of compound R with $LiAlH_4$ gives the compound 4-methylpentane-2,3-diol.

What could be the identity of compound R?

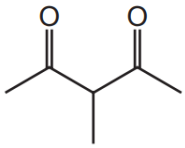
A



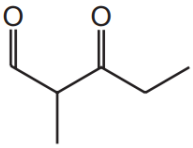
B



C



D



9701/11/O/N/21

22 Structural isomerism **and** stereoisomerism should be considered when answering this question.

A colourless liquid, $C_5H_{11}Cl$, exists as a mixture of two optical isomers.

When heated with sodium hydroxide in ethanol, a mixture of **only two** alkenes is formed.

What could the colourless liquid be?

A $(CH_3CH_2)_2CHCl$

B $CH_3CH_2CH_2CHClCH_3$

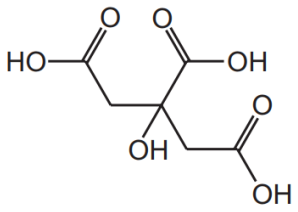
C $CH_3CH_2CCl(CH_3)_2$

D $(CH_3)_2CHCHClCH_3$

9701/11/O/N/21

5 Compound **X** contains the same functional groups as citric acid.

citric acid



(b) (i) Use the information in the table to deduce the skeletal formula of **X**, $C_3H_6O_3$. Draw the skeletal formula of **X** in the box. Label the chiral centre of compound **X** with an asterisk (*).

[2]

(c) Compound **X** is one of a pair of stereoisomers.

Stereoisomerism occurs when a molecule has at least one of two key features.

State the two key features that give rise to stereoisomerism.

1 .....

.....

2 .....

.....

[2]

(d) A structural isomer of compound **X** does not fizz when added to sodium.

Explain what is meant by *structural isomer*.

.....

..... [1]

4 **(a)** 1,3-dichloropropan-2-ol can be made by reacting **M**.

M → 1,3-dichloropropan-2-ol

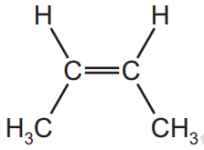
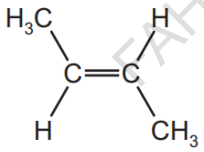
(i) Give the systematic name of **M**.

..... [1]

9701/23/M/J/21

4 **(a)** The table shows the structural formulae of four compounds, **A**, **B**, **C** and **D**, with molecular formula C_4H_8.

(i) Complete the table by giving the systematic name of **A**, **B**, **C** and **D**.

	structural formula	name
A	$CH_3CH_2CH{=}CH_2$	
B		
C		
D	$CH_2{=}C(CH_3)_2$	

[4]

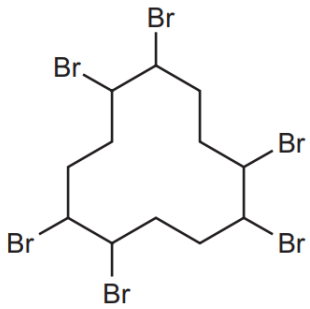
(ii) Explain what is meant by *stereoisomerism*.

.....

..... [1]

9701/22/M/J/21

37 The diagram shows a molecule of a compound used as a flame retardant.



Which statements about this structure are correct?

1 Each brominated C atom is chiral.

2 The molecular formula is $C_{12}H_{20}Br_6$.

3 The C–C–C bond angles are all 120°.

9701/13/M/J/21

20 Which compound shows stereoisomerism?

A 2-methylbut-2-ene

B 2-chloropropan-1-ol

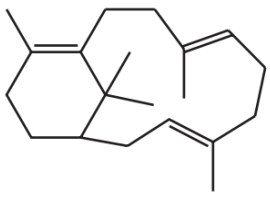
C difluorochlorobromomethane

D pent-1-ene

9701/13/M/J/21

20 Compound P is treated with an excess of hydrogen gas in the presence of a nickel catalyst. The product Q is fully saturated.

compound P



What is the number of chiral carbon atoms in the product Q?

A 4 **B** 5 **C** 6 **D** 7

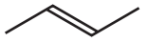
9701/12/M/J/21

33 A gaseous hydrocarbon has a density of 2.42 g dm^{-3} under room conditions.

What could be the skeletal formula of this hydrocarbon?

1 

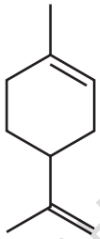
2 

3 

9701/11/M/J/21

23 Limonene is a hydrocarbon found in the rind of citrus fruits.

limonene



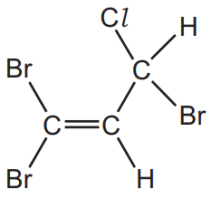
What is the molecular formula of limonene?

A $C_{10}H_{12}$ **B** $C_{10}H_{14}$ **C** $C_{10}H_{16}$ **D** $C_{10}H_{18}$

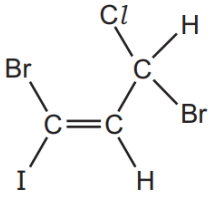
9701/11/M/J/21

22 Which compound could show **both** *cis-trans* isomerism and optical isomerism?

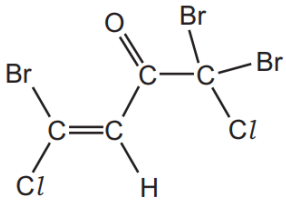
A



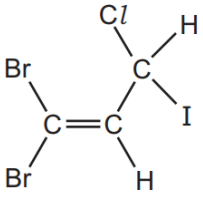
B



C

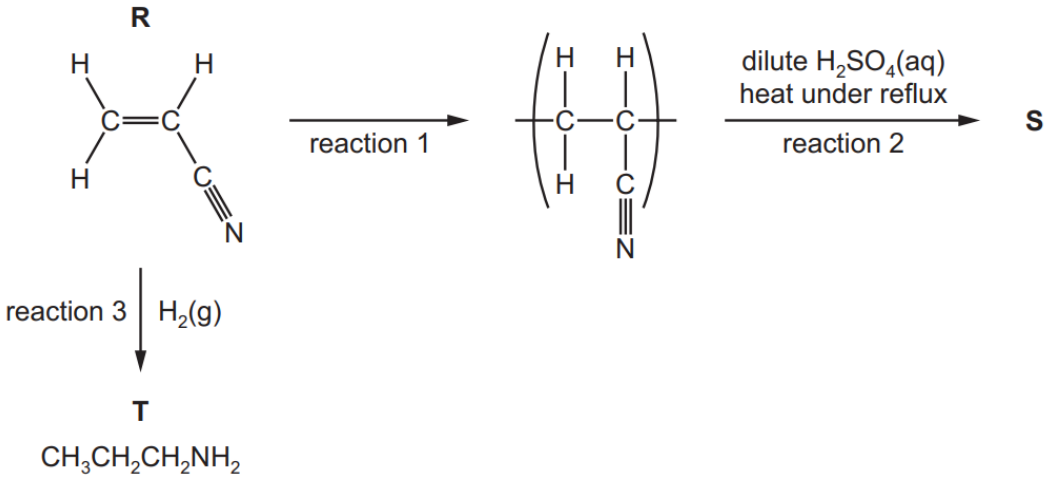


D



9701/11/M/J/21

(d) The flow chart shows some reactions of **R**.



(iii) Name **T**.

..... [1]

9701/22/F/M/21

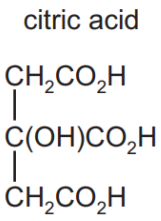
21 How many tertiary alcohols have the molecular formula $C_6H_{14}O$?

A 1 **B** 2 **C** 3 **D** 4

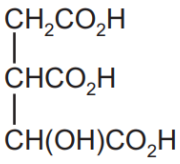
9701/12/F/M/21

20 The structures of citric acid and isocitric acid are shown.

citric acid



isocitric acid



How many chiral centres does each acid possess?

	citric acid	isocitric acid
A	1	1
B	1	2
C	0	1
D	0	2

9701/12/F/M/21

3 Liquids that contain molecules of **T** smell like lemons.

T

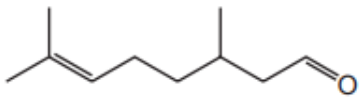


Fig. 3.1

(a) Molecules of **T** exist as a pair of stereoisomers.

Name the type of stereoisomerism shown by molecules of **T**. Explain your answer.

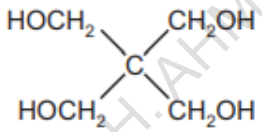
.....

..... [2]

9701/21/M/J/22

34 Pentaerythritol is used as an intermediate in the manufacture of paint.

pentaerythritol



Which statement is correct?

A Pentaerythritol can be dehydrated by concentrated sulfuric acid to form an alkene.

B The empirical formula and molecular formula of pentaerythritol are different.

C Pentaerythritol does not react with acidified potassium manganate(VII).

D One mole of pentaerythritol gives two moles of hydrogen gas on reaction with an excess of sodium.

9701/13/M/J/22

33 Structural isomerism only should be considered when answering this question.

Several compounds with molecular formula $C_4H_8O_2$ have **one** carbonyl group and **one** OH group.

How many of these compounds produce yellow crystals with alkaline I_2(aq) at room temperature?

A 2 **B** 3 **C** 4 **D** 5

9701/13/M/J/22

29 Structural isomerism and stereoisomerism should be considered when answering this question.

Y is a gaseous hydrocarbon which decolourises aqueous bromine.

10.0 g of Y occupies a volume of 3.43 dm^3 under room conditions.

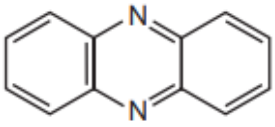
How many isomeric structures are possible for Y?

A 4 **B** 5 **C** 6 **D** 7

9701/13/M/J/22

27 The diagram shows the skeletal formula of phenazine.

phenazine



What is the empirical formula of phenazine?

A C_6H_4N **B** C_6H_6N **C** $C_{12}H_8N_2$ **D** $C_{12}H_{12}N_2$

9701/13/M/J/22

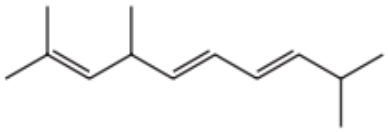
27 The molecular formula CH_3 can represent an anion, a cation or a free radical. Species with the molecular formula CH_3 can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons on the central carbon atom.

How many outer shell electrons on the central carbon atom must be present for CH_3 to act in these different ways?

	CH_3 as an electrophile	CH_3 as a free radical	CH_3 as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

9701/12/M/J/22

26 A skeletal formula is shown.



What is the total number of stereoisomers including the one shown?

A 4 **B** 6 **C** 8 **D** 16

9701/12/M/J/22

31 Structural isomerism and stereoisomerism should be taken into account when answering this question.

How many isomeric alkenes with formula C_5H_8 are present in the mixture produced when 1,4-dibromopentane is reacted with NaOH in ethanol?

A 1 **B** 2 **C** 3 **D** 4

9701/11/M/J/22

28 How many esters have the molecular formula $C_4H_8O_2$?

A 2 **B** 3 **C** 4 **D** 5

9701/11/M/J/22

27 Which compound will react with $LiAlH_4$ to form two optical isomers?

A $CH_3CH_2COCH_3$

B $CH_3CH_2CH_2CHO$

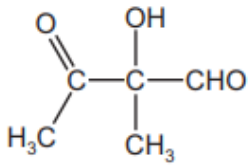
C $CH_3CH_2COCH_2CH_3$

D $CH_3CH(CH_3)CH_2CO_2H$

9701/11/M/J/22

Compounds **J** and **K** are found in plant oils.

J



K

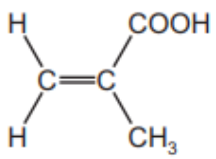


Fig. 4.1

(ii) **J** has **two** optical isomers.

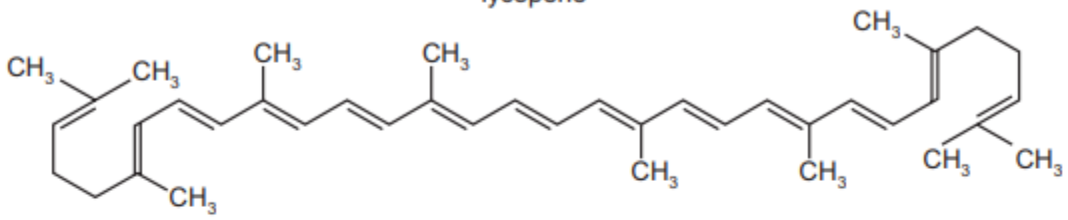
Draw the three-dimensional structures of the **two** optical isomers of **J**.

[2]

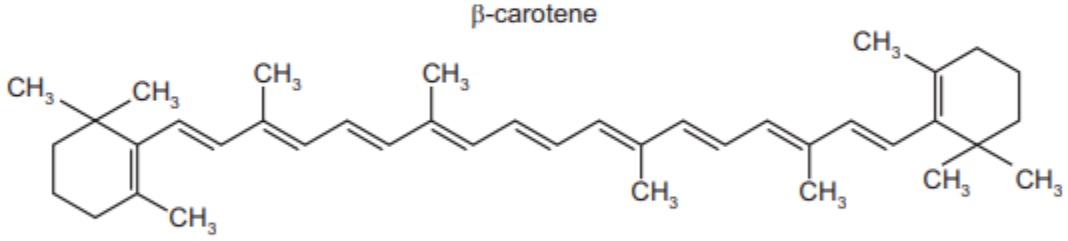
9701/22/F/M/22 (Q4)

39 The diagrams show the structures of lycopene and β-carotene.

lycopene



β-carotene



When lycopene is converted into β-carotene, what is the gain or loss of hydrogen atoms per molecule?

A 4 gained

B 2 gained

C no change

D 2 lost

9701/12/F/M/22

36 What is the least number of carbon atoms in a non-cyclic alkane molecule that has a chiral centre?

A 7 **B** 8 **C** 9 **D** 10

9701/12/F/M/22

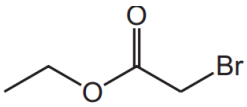
26 In this question, alkenes and cyclic alkanes should be considered.

How many **structural** isomers of C_4H_8 are there?

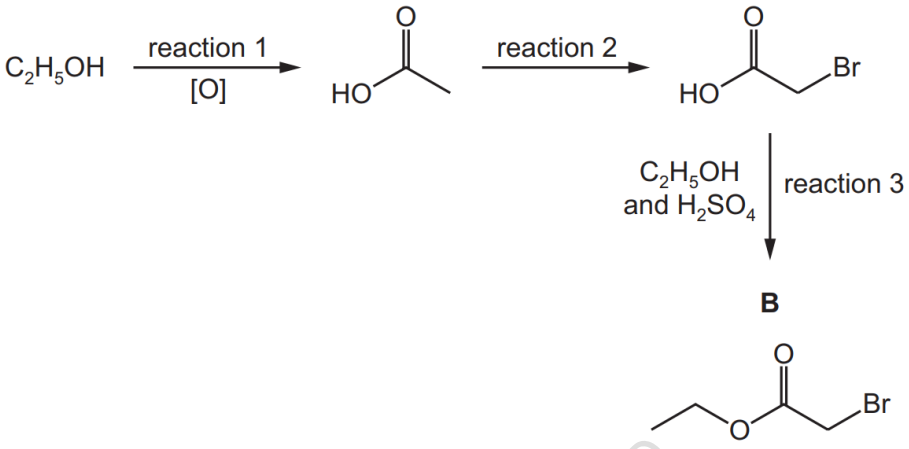
A 3 **B** 4 **C** 5 **D** 6

9701/12/F/M/22

Chapter 2 - Alkanes



The reaction scheme shows how **B** can be made from ethanol, C_2H_5OH.



(iii) Suggest the type of reaction that occurs in reaction 2.

..... [1]

(iv) H_2SO_4 acts as a homogeneous catalyst in reaction 3.

Explain why H_2SO_4 is described as *homogeneous*.

.....

..... [1]

9701/21/O/N/21

23 Which equation represents a valid propagation step in the chlorination of ethane?

A $C_2H_5Cl + Cl\bullet \rightarrow C_2H_4Cl\bullet + HCl$

B $C_2H_6 + Cl\bullet \rightarrow C_2H_5Cl + H\bullet$

C $C_2H_5Cl + H\bullet \rightarrow C_2H_5\bullet + HCl$

D $C_2H_5\bullet + Cl\bullet \rightarrow C_2H_5Cl$

9701/12/O/N/21

21 Bromomethane, CH_3Br, decomposes in the stratosphere forming methyl free radicals and bromine free radicals.

Which row correctly describes this decomposition?

	type of bond fission	number of electrons in a bromine free radical
A	homolytic	35
B	heterolytic	35
C	homolytic	36
D	heterolytic	36

9701/12/O/N/21

5 **(a)** Naphtha is a mixture which contains only hydrocarbon molecules.

(i) What is meant by the term *hydrocarbon*?

.....

..... [1]

(ii) Name the raw material that is used to produce a sample of naphtha.

..... [1]

(b) Compound **V** is found in naphtha. It has a molecular formula $C_{10}H_{22}$.

When **V** is heated at high pressure in the absence of air, an equal number of moles of ethene, propene and **W** are made. **W** is a compound made of straight chain, saturated molecules.

(i) Name the process that describes this reaction.

..... [1]

(ii) Deduce the structure of **W**. Draw its structure below.

[1]

9701/21/M/J/21

23 Methane and bromine react by free radical substitution.

P and Q are involved in the reaction mechanism.

P and Q:

- are **both** involved in propagation steps as reactants
- are **both** involved in termination steps as reactants.

What could be P and Q?

A Br and H **B** Br and CH_3 **C** Br and C_2H_6 **D** CH_3 and CH_3Br

9701/12/M/J/21

(g) Dichloromethane, CH_2Cl_2, is widely used as an organic solvent.

CH_2Cl_2 can be prepared by reacting CH_3Cl and Cl_2 at room temperature.

The reaction proceeds via several steps, as shown.

$$Cl_2 \xrightarrow{\text{initiation}} 2Cl^{\bullet}$$

$$Cl^{\bullet} + CH_3Cl \xrightarrow{\text{propagation 1}} HCl + {}^{\bullet}CH_2Cl$$

$$Cl_2 + {}^{\bullet}CH_2Cl \xrightarrow{\text{propagation 2}} \text{products}$$

$$Cl^{\bullet} + {}^{\bullet}CH_2Cl \xrightarrow{\text{final step}} CH_2Cl_2$$

(i) Give the name of the mechanism of this reaction.

..... [1]

(ii) State the essential condition required for the initiation step to take place.

..... [1]

(iii) Give the electronic configuration of $Cl^{\bullet}$.

$1s^2$ ..... [1]

(iv) Identify the products of the step labelled propagation 2.

..... [1]

(v) Name the type of reaction shown in the final step.

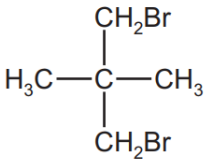
..... [1]

(vi) Suggest the identity of another organic molecule that is a product of the reaction of CH_3Cl and Cl_2 under the same conditions.

..... [1]

9701/22/F/M/21

22 The diagram shows the structure of a bromo compound that may be formed by the reaction of bromine with a hydrocarbon.



Which row is correct?

	type of reaction	mechanism
A	addition	electrophilic
B	addition	nucleophilic
C	substitution	nucleophilic
D	substitution	free-radical

9701/12/F/M/21

29 The free-radical substitution reaction between methane and chlorine involves initiation, propagation and termination stages.

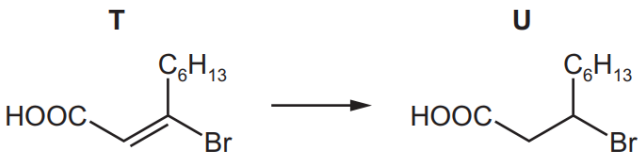
Which row is correct?

	involved in initiation stage	radical produced in a propagation stage
A	homolytic fission	H•
B	homolytic fission	CH_3•
C	heterolytic fission	H•
D	heterolytic fission	CH_3•

9701/12/M/J/22

Chapter 3 - Alkenes

(d) A reaction of another unsaturated carboxylic acid, **T**, is shown.



(i) **T** is one of a pair of geometrical (*cis-trans*) isomers.

Draw the other geometrical isomer of **T** and explain why the molecules exhibit this form of isomerism.

.....

.....

.....

[3]

(ii) Identify the reagent used to convert **T** to **U**.

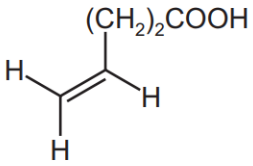
..... [1]

9701/22/F/M/20

(c) Fats are compounds made from glycerol and unsaturated carboxylic acids.

4-pentenoic acid is an example of an unsaturated carboxylic acid.

4-pentenoic acid



(i) Give the molecular formula of 4-pentenoic acid.

..... [1]

(ii) Draw the repeat unit of the addition polymer that can be formed from 4-pentenoic acid.

[1]

(iii) Unsaturated acids are often brominated before being added to soft drinks.

Complete the mechanism for the addition of Br_2 to 4-pentenoic acid.

- Include the structures of the intermediate and the product of the reaction.
- Include all charges, partial charges, lone pairs and curly arrows.

In the mechanism, R has been used to represent $(CH_2)_2COOH$.

[4]

40 Which statements comparing ethene and ethane are correct?

1 The bond angles in ethene are larger than the bond angles in ethane.

2 Ethene reacts much more quickly with bromine in the dark than ethane does.

3 Complete combustion of 0.01 mol of ethene or ethane produces the same volume of gas measured at room temperature and pressure.

9701/12/F/M/20

27 Which reaction would produce propanoic acid as one of its products?

A heating $(CH_3)_2C{=}CHCH_2CH_3$ with concentrated, acidified $KMnO_4$

B heating $CH_3CH_2CO_2CH_2CH_2CH_3$ with NaOH(aq)

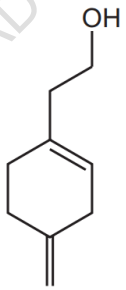
C heating CH_3CH_2OH with acidified $K_2Cr_2O_7$ under reflux

D reacting CH_3CHO with HCN then heating the organic product with H_2SO_4(aq)

9701/12/F/M/20

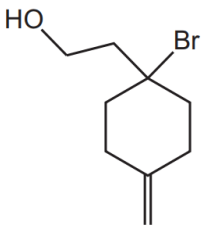
26 An excess of dry HBr is warmed with compound Y.

Y

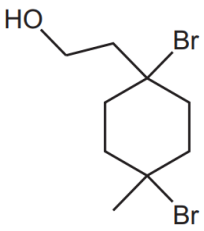


What is the major product of the reaction?

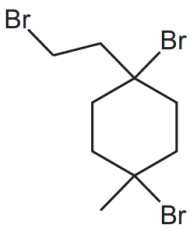
A



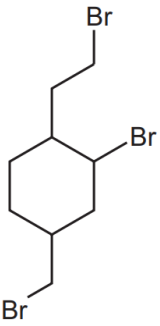
B



C

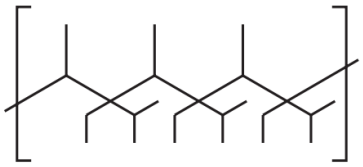


D



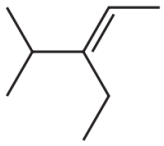
9701/12/F/M/20

24 A section of a polymer chain is shown.

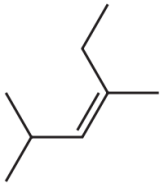


What is the correct monomer?

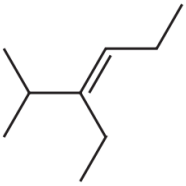
A



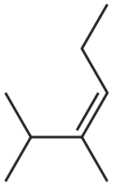
B



C



D



9701/12/F/M/20

(g) HI(g) reacts with propene, $CH_3CH{=}CH_2(g)$ to form a mixture of 1-iodopropane and 2-iodopropane.

(i) Identify which of 1-iodopropane and 2-iodopropane is the major product of this reaction.

Explain your answer.

.....

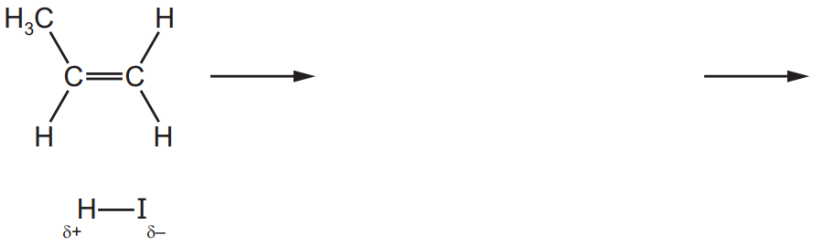
.....

.....

..... [2]

(ii) Complete the diagram to show the mechanism of the reaction between HI and $CH_3CH{=}CH_2$ that forms the major product identified in **(g)(i)**.

Include curly arrows, lone pairs of electrons and charges as necessary.

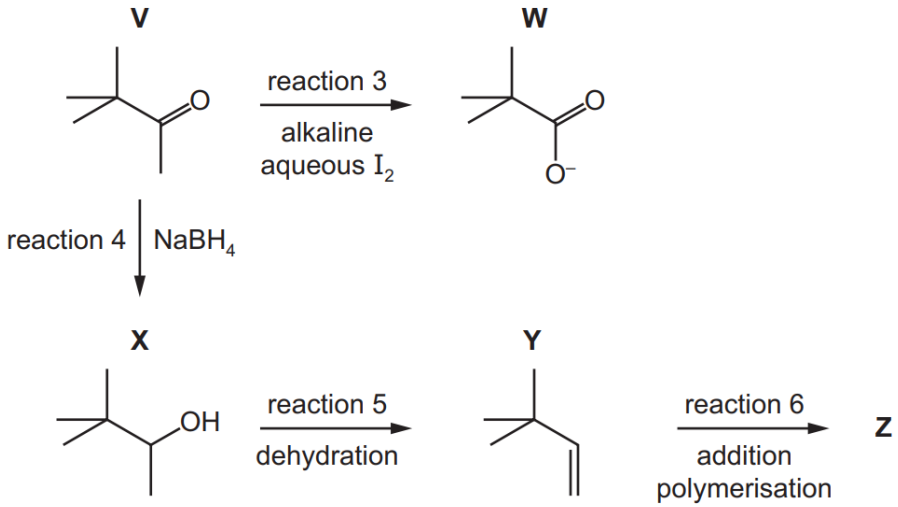


[3]

9701/22/O/N/21

(e) **V** is used in a wide range of organic reactions.

Some reactions of **V** are shown.



(vi) **Y** can form an addition polymer **Z**.

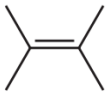
Draw one repeat unit of **Z**.

[1]

9701/22/O/N/21

3 Compound **T** is an isomer of C_6H_{12}.

T



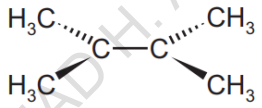
(a) Name **T**.

..... [1]

(b) Draw the skeletal formula of a structural isomer of **T** that shows *cis-trans* (geometrical) isomerism.

[1]

(c) Each carbon atom in **T** forms a sigma (σ) bond to at least one other carbon atom, as shown.

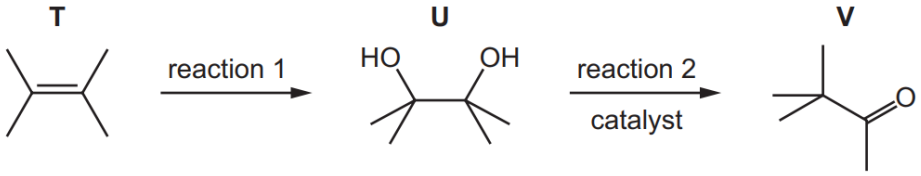


(i) On the diagram, draw the orbitals that represent the pi (π) bond that is also present in **T**. [1]

(ii) State the hybridisation of the two carbon atoms between which the pi (π) bond forms.

..... [1]

(d) A reaction scheme starting with **T** is shown. Reaction 2 occurs in the presence of a catalyst; knowledge of the mechanism for this reaction is not required.

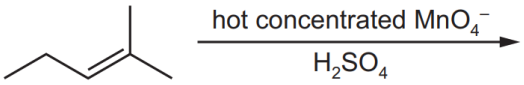


(i) Give the reagent(s) and conditions for reaction 1.

..... [1]

(d) Identify the organic products formed when compound **J**, shown below, is heated with hot concentrated acidified manganate(VII) ions.

J



[2]

9701/21/O/N/21

38 Which of the molecular formulae represent at least one compound that can undergo addition polymerisation?

1 C_4H_8

2 C_2H_3Cl

3 C_3H_6O

9701/12/O/N/21

38 One molecule of dodecane, $C_{12}H_{26}$, is cracked, producing three product molecules, X, Y and Z.

X is a straight chain alkane. Y and Z are straight chain alkenes with different M_r values.

Which statements about X, Y and Z are correct?

1 If Y and Z are but-1-ene and ethene respectively, X will be hexane.

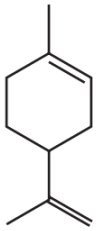
2 If X is butane, then Y and Z could both show *cis-trans* isomerism.

3 X could be octane.

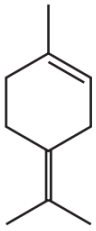
9701/11/O/N/21

37 A diketo acid is a compound with two ketone groups and one carboxylic acid group.

limonene



terpinolene



Which statements about the reactions of limonene and terpinolene are correct?

1 When reacted with an excess of hydrogen and a nickel catalyst, limonene and terpinolene produce the same compound.

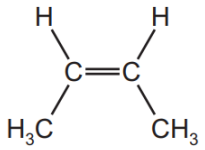
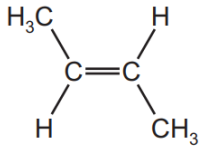
2 An excess of hot concentrated acidified $KMnO_4$ reacts with limonene and with terpinolene to form different diketo acids.

3 The reactions of limonene and terpinolene with an excess of Br_2 produce positional isomers with the same number of chiral carbon atoms.

9701/11/O/N/21

4 **(a)** The table shows the structural formulae of four compounds, **A**, **B**, **C** and **D**, with molecular formula C_4H_8.

(i) Complete the table by giving the systematic name of **A**, **B**, **C** and **D**.

	structural formula	name
A	$CH_3CH_2CH{=}CH_2$	
B		
C		
D	$CH_2{=}C(CH_3)_2$	

[4]

(ii) Explain what is meant by *stereoisomerism*.

.....

..... [1]

(b) **W** is an alkene with formula C_4H_8. It reacts with HBr to form two possible carbocations, $CH_3C^+(H)(CH_2CH_3)$ and $H_2C^+CH_2CH_2CH_3$.

(i) Identify **W** as compound **A**, **B**, **C** or **D**.

..... [1]

(ii) Draw the skeletal formula of the major organic product formed when HBr reacts with **W**. Explain why this is the major organic product.

.....

.....

.....

[3]

9701/22/M/J/21

6 Propene, C_3H_6, reacts with H_2O in the presence of an acid catalyst to form an alcohol with molecular formula C_3H_8O.

(a) Name this type of reaction.

..... [1]

(b) Name the catalyst used and state the conditions needed for this reaction to occur.

catalyst .....

conditions .....

[2]

(c) Complete the table to show the numbers of sigma (σ) bonds and pi (π) bonds present in propene, C_3H_6, and C_3H_8O.

	σ	π
C_3H_6		
C_3H_8O		

[2]

(d) The reaction of propene, C_3H_6, with H_2O occurs in a two-step mechanism. In step 1 C_3H_6 reacts with the catalyst, H^+, to form a carbocation.

(i) Draw structures to identify the more stable and less stable carbocations which can form in step 1. Explain your answer.

more stable carbocation	**less** stable carbocation

explanation .....

.....

.....

.....

.....

[3]

(ii) Name the major organic product formed from the reaction of propene, C_3H_6, with H_2O.

..... [1]

9701/21/M/J/21

(c) Propene is separated from the mixture and heated in air in the presence of a catalyst. Propene is oxidised to **X**, which contains two functional groups.

(i) Effervescence is seen when $Na_2CO_3(aq)$ is added to **X**.

Identify the functional group present in **X** which is responsible for this observation.

..... [1]

(ii) Identify a reagent which could be used to show that **X** contains a C=C. Include relevant observations.

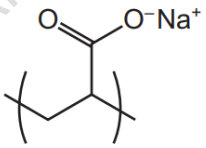
.....

..... [2]

(d) **X** reacts with another reagent to form **Y**.

Molecules of **Y** react together to form addition polymer **Z**. The diagram shows the repeat unit of polymer **Z**.

repeat unit of polymer **Z**



Draw the structural formula of monomer **Y**.

[1]

(e) Polymer **Z** is useful because it absorbs large amounts of water. However, there are problems associated with the disposal of products containing polymer **Z**.

Combustion is not an appropriate method to dispose of pure **Z** because the process releases harmful gases. Some of these gases contribute to the enhanced greenhouse effect.

(i) Identify a gas released during the combustion of **Z** which contributes to the enhanced greenhouse effect.

..... [1]

(ii) Identify another gas which could be produced during the combustion of pure **Z**. Describe a consequence, other than the enhanced greenhouse effect, of its release into the atmosphere.

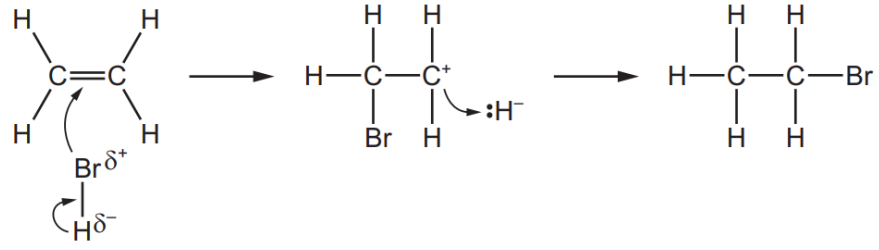
gas .....

consequence .....
[1]

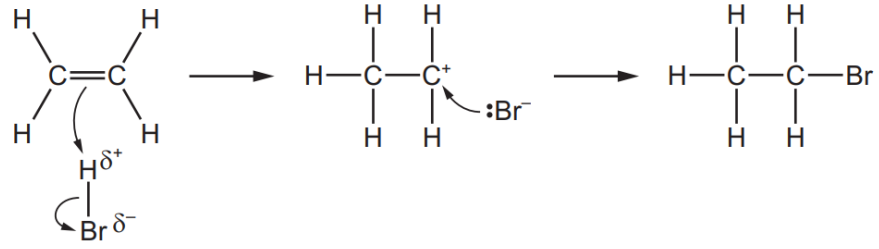
9701/21/M/J/21

22 What is the correct mechanism for the addition of hydrogen bromide to ethene?

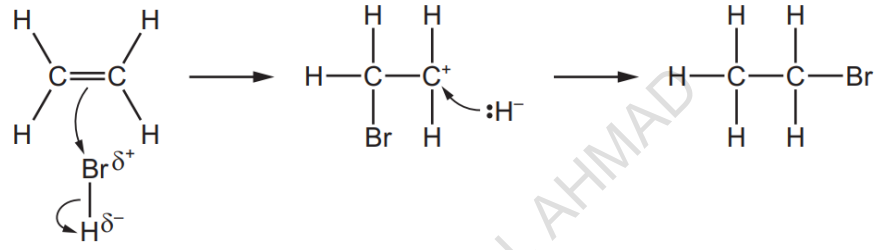
A



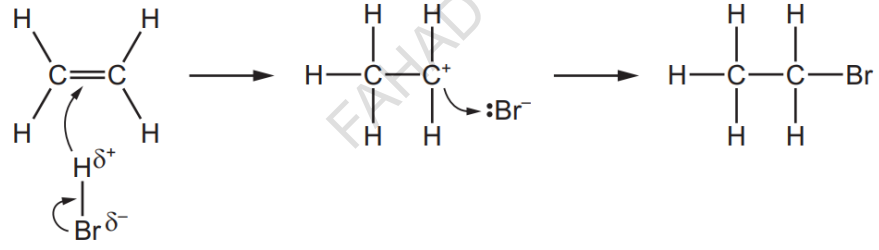
B



C



D



9701/13/M/J/21

21 Two carbon-containing products result from the reaction of alkene Z with a hot, concentrated, acidified solution of potassium manganate(VII).

One product forms an orange precipitate with 2,4-dinitrophenylhydrazine reagent. The other product is a gas which gives a white precipitate with aqueous calcium hydroxide.

Which alkene could be alkene Z?

A but-2-ene

B 2-methylpropene

C 2-methylbut-2-ene

D propene

9701/13/M/J/21

38 Which changes are commonly involved in the formation of an addition polymer?

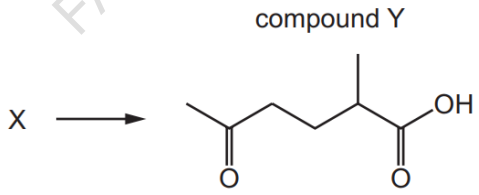
1 the formation of a σ-bond

2 the breaking of a π-bond

3 the change in hybridisation of the orbitals of a carbon atom from sp^2 to sp^3

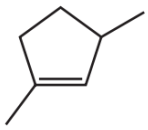
9701/12/M/J/21

22 Compound X can be converted into compound Y in a single step.



What could be the identity of X?

A



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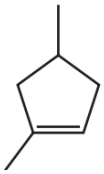

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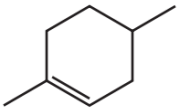

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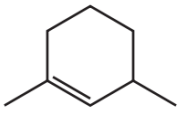
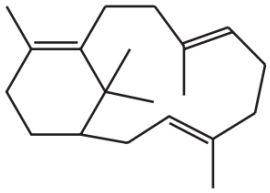


9701/12/M/J/21

20 Compound P is treated with an excess of hydrogen gas in the presence of a nickel catalyst. The product Q is fully saturated.

compound P



What is the number of chiral carbon atoms in the product Q?

A 4 **B** 5 **C** 6 **D** 7

9701/12/M/J/21

29 The table describes four reactions of propene.

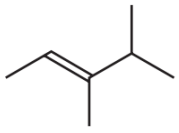
Which row is correct?

	reagent used	name of main organic product
A	aqueous bromine	2-bromopropane
B	cold acidified aqueous potassium manganate(VII)	propane-1,3-diol
C	hydrogen chloride	2-chloropropane
D	steam	propan-1-ol

9701/11/M/J/21

21 Which compound would produce two different carboxylic acids when treated with hot, concentrated, acidified manganate(VII) ions?

A



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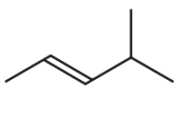
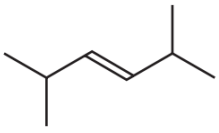


C

D



9701/11/M/J/21

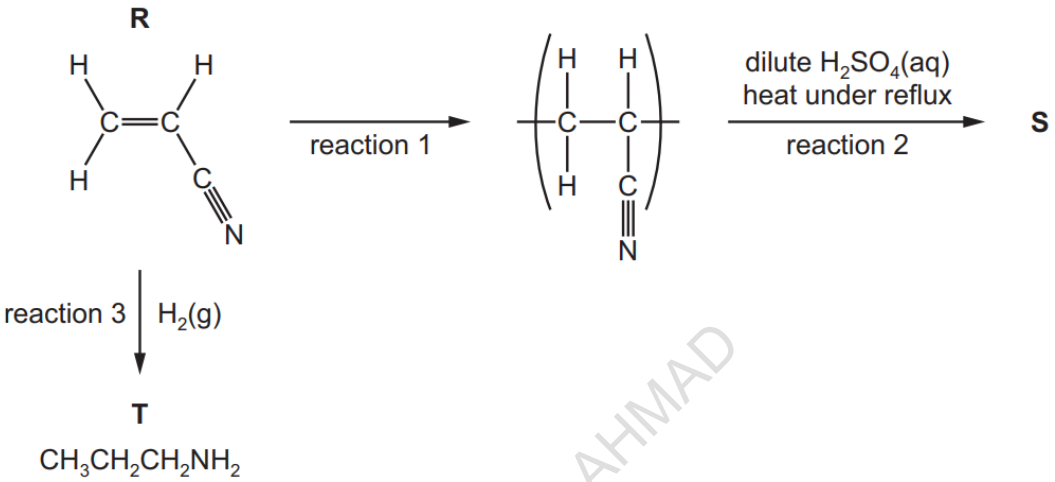
(iii) $(CH_2OH)_2$ also forms when an alkene **A** reacts with cold, dilute, acidified manganate(VII) ions.

Name **A**.

..... [1]

9701/22/F/M/21

(d) The flow chart shows some reactions of **R**.



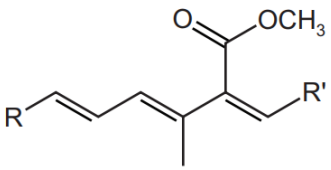
(i) Name the type of reaction shown in reaction 1.

..... [1]

9701/22/F/M/21

23 Part of the structure of strobilurin is shown. R and R' are inert groups.

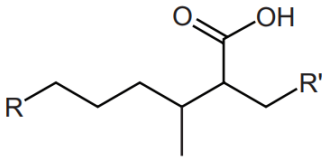
strobilurin



Strobilurin is warmed with aqueous sulfuric acid producing compound X. Compound X is then treated with hydrogen in the presence of a nickel catalyst producing compound Y.

What could be the structure of compound Y?

A



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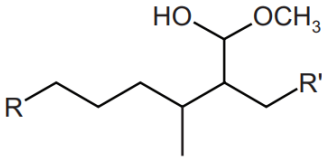

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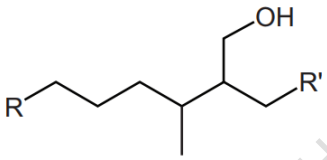

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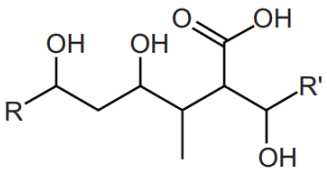


9701/12/F/M/21

3 Liquids that contain molecules of **T** smell like lemons.

T

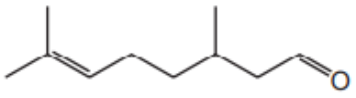


Fig. 3.1

(b) Two organic products are produced when a sample of **T** is heated under reflux with excess acidified concentrated $KMnO_4$.

Draw the structure of the two organic products, from this reaction, in the boxes.

organic product 1

organic product 2

[2]

(c) Fig. 3.2 shows two reactions of **T**.

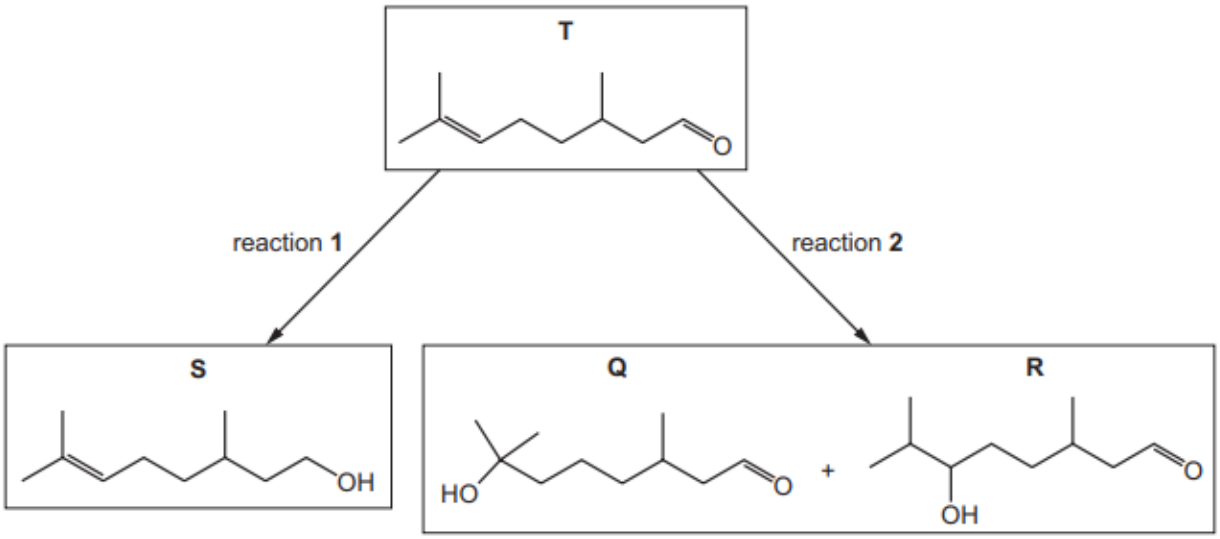


Fig. 3.2

(i) Identify a suitable reagent for reaction **1**.

..... [1]

(ii) Identify the reagent and conditions needed for reaction **2**.

.....

..... [2]

(iii) Suggest which product formed in reaction **2** has a higher yield. Explain your answer.

.....

.....

..... [3]

9701/21/M/J/22

40 One molecule of an addition polymer containing 2000 repeat units has an M_r of 112 000.

The polymer molecule contains chiral centres.

What is a possible monomer for this polymer?

A $CH_2=CHCH_3$

B $CH_2=C(CH_3)_2$

C $CH_2=CHCH_2CH_3$

D $CH_2=CHCH_2CH_2CH_3$

9701/13/M/J/22

38 Which compound can be used to make propanoic acid by treatment with a single reagent?

A $CH_2=CHCH_2CH_3$

B $CH_3CH_2CH_2CN$

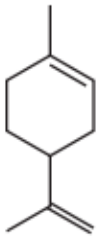
C $CH_3CH(OH)CN$

D $CH_3CH(OH)CH_3$

9701/13/M/J/22

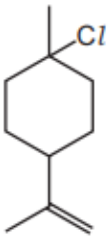
30 Limonene is found in lemon and orange oils.

limonene



What is the major product when limonene reacts with an excess of dry hydrogen chloride?

A



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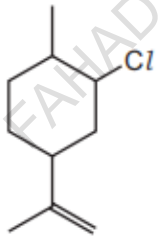

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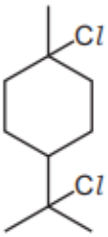

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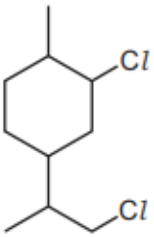


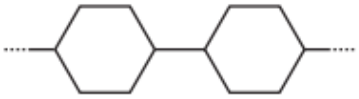
9701/13/M/J/22

39 Cyclohexene, as shown in the diagram, can form an addition polymer.

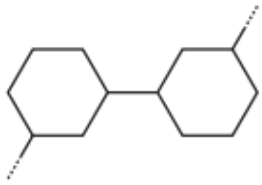
cyclohexene

Which structure represents a section of the polymer?

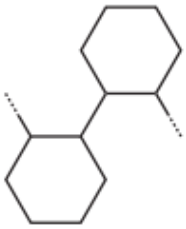
A



B



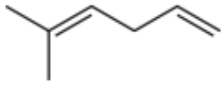
C



D

9701/12/M/J/22

30 The alkene shown reacts with an excess of HBr via an electrophilic addition reaction.



What is the **major** product formed?

A 3,5-dibromo-2-methylhexane

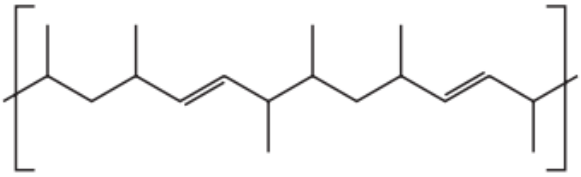
B 2,5-dibromo-2-methylhexane

C 2,6-dibromo-2-methylhexane

D 3,6-dibromo-2-methylhexane

9701/12/M/J/22

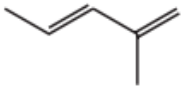
39 The diagram shows a section of an addition polymer formed from two different monomers.



One of the monomers is propene.

What is the other monomer?

A



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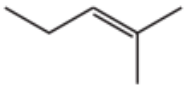

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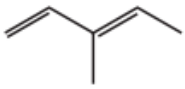


D

9701/11/M/J/22

30 Oct-1-ene, $CH_3(CH_2)_5CH{=}CH_2$, can be thermally cracked.

Which of the compounds W, X, Y and Z can be obtained by thermally cracking oct-1-ene?

W	X	Y	Z
$CH_2{=}CH_2$	$CH_3CH{=}CH_2$	$CH_3CH_2CH_3$	$CH_2{=}CHCH{=}CH_2$

A W, X, Y and Z

B W, X and Y only

C W, X and Z only

D W and X only

9701/11/M/J/22

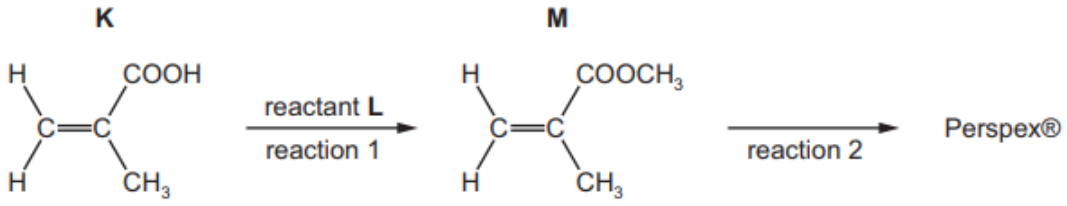


Fig. 4.2

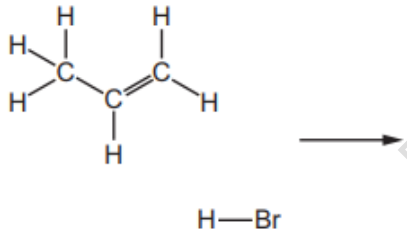
(ii) Draw **one** repeat unit of the addition polymer Perspex®.

[2]

9701/22/F/M/22 (Q4)

(e) HBr reacts with propene to form two bromoalkanes, $CH_3CH_2CH_2Br$ and $(CH_3)_2CHBr$.

(i) Complete the diagram to show the mechanism of the reaction of HBr and propene to form the major organic product.
Include charges, dipoles, lone pairs of electrons and curly arrows, as appropriate.
Draw the structures of the intermediate and the major organic product.



[4]

(ii) Explain why the two bromoalkanes are **not** produced in equal amounts by this reaction.

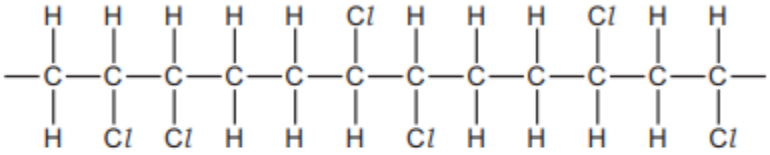
.....

.....

..... [2]

9701/22/F/M/22

37 A molecule of a polymer contains the sequence shown.



Which monomer could produce this polymer by addition polymerisation?

A $CHCl{=}CHCl$

B $CH_2{=}CHCl$

C $CH_3CCl{=}CHCl$

D $CH_3CCl{=}CH_2$

9701/12/F/M/22

27 Which compound will decolourise $Br_2(aq)$?

A $CH_3CH_2CH_2CH_2CH_2CO_2H$

B $CH_3CH_2CH_2CH_2CH_2CHO$

C $CH_3CHCHCH_2CH_2CH_2OH$

D $CH_3CH_2CH_2CO_2CH_2CH_3$

9701/12/F/M/22

28 Alkenes react with aqueous hydrogen bromide. The reaction proceeds via an intermediate carbocation. The more stable the intermediate, the faster the reaction.

Which sequence correctly shows an **increase** in the speed of reaction of the alkenes with hydrogen bromide?

A ethene, propene, 2-methylpropene

B 2-methylpropene, ethene, propene

C propene, ethene, 2-methylpropene

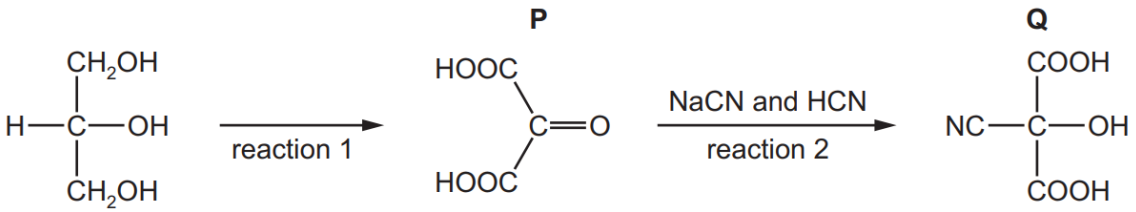
D propene, 2-methylpropene, ethene

9701/12/F/M/22

Chapter 4 - Alcohols

Glycerol, $CH_2(OH)CH(OH)CH_2OH$, is widely used in the food industry and in pharmaceuticals.

(a) A series of reactions starting from glycerol is shown.



(i) Suggest the reagent(s) and conditions for reaction 1.

.....

..... [2]

9701/22/F/M/20

(ii) Pentan-3-ol, $C_2H_5CH(OH)C_2H_5$, reacts slowly with HC*l* to form a secondary halogenoalkane.

Complete the equation for this reaction using structural formulae.

$C_2H_5CH(OH)C_2H_5$ + ... [1]

(iii) The fastest reaction shown by Lucas's reagent is with a tertiary alcohol.

Draw the structure of the tertiary alcohol that is an isomer of pentan-3-ol.

[1]

(iv) Tertiary alcohols tend to react with Lucas's reagent using the same mechanism as in their reaction with HC*l*.

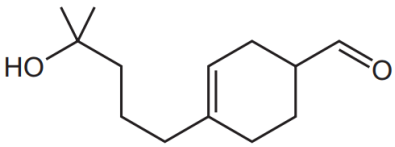
Suggest the type of reaction shown by tertiary alcohols with Lucas's reagent.

..... [1]

9701/22/F/M/20

38 Which compounds will produce a yellow precipitate with alkaline aqueous iodine?

1



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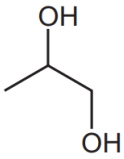

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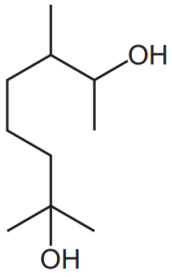
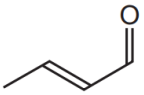


9701/12/F/M/20

29 What is the skeletal formula of the compound formed when $CH_3CH{=}CHCH_2OH$ is heated, under reflux, with $K_2Cr_2O_7 / H^+$?

A



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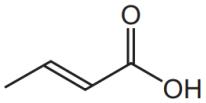

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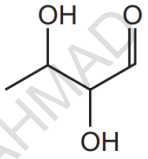
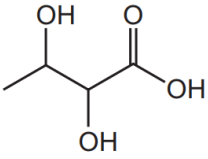


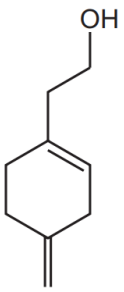
D



9701/12/F/M/20

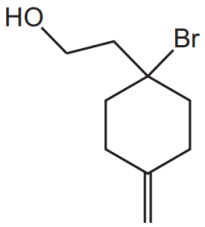
26 An excess of dry HBr is warmed with compound Y.

Y

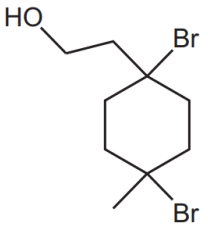


What is the major product of the reaction?

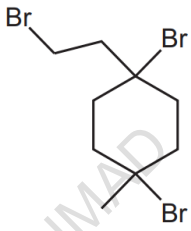
A



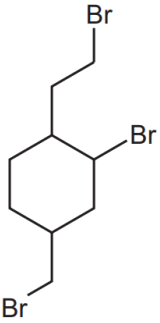
B



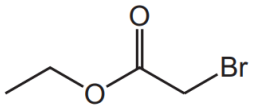
C



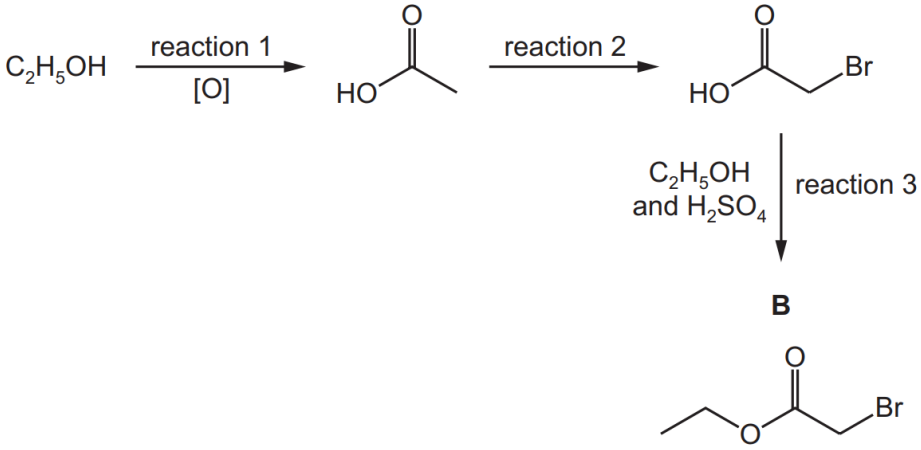
D



9701/12/F/M/20



The reaction scheme shows how **B** can be made from ethanol, C_2H_5OH.



(a) (i) Reaction 1 is an oxidation reaction.

Give the reagent(s) and conditions required for reaction 1.

reagent(s) .....

conditions .....

.....

[2]

(ii) Construct an equation to represent reaction 1.

Use [O] to represent an oxygen atom from the oxidising agent in this reaction.

..... [1]

9701/21/O/N/21

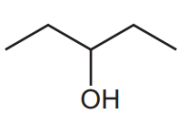
27 Structural and stereoisomerism should be taken into account when answering this question.

An organic compound, X, is dehydrated by heating with concentrated phosphoric(V) acid.

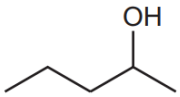
Only **two** organic products are formed.

What could be X?

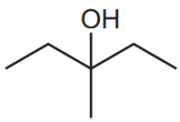
A



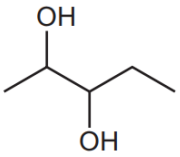
B



C



D



9701/12/O/N/21

26 Compound P is heated under reflux with an excess of acidified potassium dichromate(VI) to form compound Q.

Compound Q has a **lower** boiling point than compound P.

What could be compound P?

A 2-methylbutan-1-ol

B 2-methylbutan-2-ol

C pentan-1-ol

D pentan-2-ol

9701/12/O/N/21

40 Which reactions of propan-1-ol have water as one of the products?

1 passing propan-1-ol vapour over hot Al_2O_3

2 mixing propan-1-ol with warm ethanoic acid and a few drops of concentrated sulfuric acid

3 warming propan-1-ol with HBr

9701/11/O/N/21

33 Ethylene glycol, $HOCH_2CH_2OH$, is used as a de-icer. It allows ice to melt at temperatures below 0 °C.

Which statements are correct?

1 Ethylene glycol disrupts the extensive network of hydrogen bonds in ice.

2 Ethylene glycol molecules form hydrogen bonds with other ethylene glycol molecules.

3 Ethylene glycol molecules will dissolve in the water formed from the ice.

9701/11/O/N/21

25 Alcohol Y gives a yellow precipitate with alkaline aqueous iodine. It can be oxidised to give a mixture of products including substance Z. Substance Z gives a red-brown precipitate with Fehling's solution.

Which alcohol could be Y?

A $CH_3CH(OH)CH(CH_3)CH_2OH$

B $CH_3C(OH)(CH_3)CH_2CH_2OH$

C $CH_3CH(OH)CH_2CH(OH)CH_3$

D $CH_2(OH)CH_2CH(OH)CH_2CH_3$

9701/11/O/N/21

24 When an organic compound, Q, is treated with phosphorus pentachloride, fumes of hydrogen chloride are evolved. When Q is warmed with acidified aqueous potassium dichromate(VI), the solution turns green.

What is Q?

A CH_3CH_2CHO

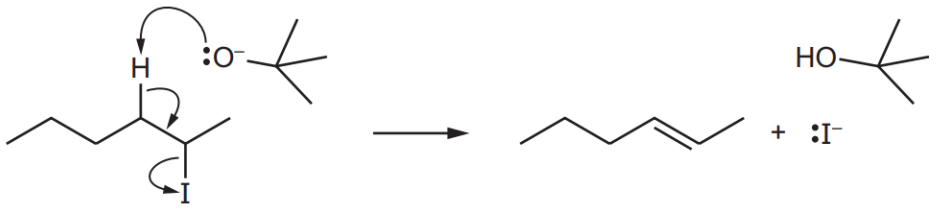
B $CH_3CH_2CO_2H$

C $CH_3CH(OH)CH_3$

D $(CH_3)_3COH$

9701/11/O/N/21

20 Hex-2-ene can be made by the reaction shown.



Which statement about this reaction is correct?

A $(CH_3)_3CO^-$ is behaving as a Brønsted-Lowry base.

B $(CH_3)_3CO^-$ is behaving as an oxidising agent.

C The C–I bond breaks via homolytic fission.

D This is a hydrolysis reaction.

9701/11/O/N/21

(d) Alcohol **Y** reacts completely when warmed with acidified $Cr_2O_7^{2-}$ to form **Z**.

Z is distilled from the reaction mixture as soon as it is made.

Tollens' reagent is added to a sample of **Z** and warmed. A silver mirror forms.

(i) Name the type of reaction that occurs when **Y** reacts to form **Z**.

..... [1]

(ii) Identify with a tick (✓) the functional group(s) present in **Z**.

functional group	present in **Z**
aldehyde	
ketone	
carboxylic acid	

[1]

9701/22/M/J/21

25 Two reactions are shown. Only one product is identified in each reaction.

ethanol + acidified $Cr_2O_7^{2-}$ → ethanal

ethanol + sodium → sodium ethoxide

Which statement about these reactions is correct?

A The formations of both ethanal and sodium ethoxide are redox reactions.

B The formations of both ethanal and sodium ethoxide result in colour changes.

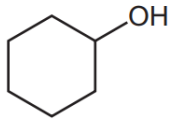
C The formation of ethanal is catalysed by potassium dichromate.

D The formation of sodium ethoxide is a dehydration reaction.

9701/13/M/J/21

39 Which alcohols can be oxidised to form an organic compound which will give coloured precipitates with both 2,4-dinitrophenylhydrazine reagent and alkaline aqueous iodine?

1



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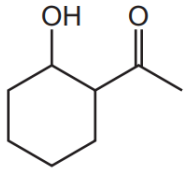

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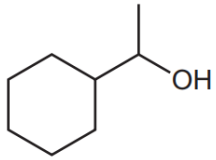
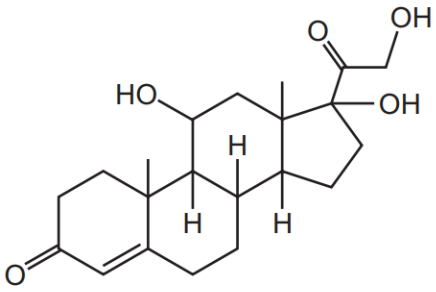


9701/12/M/J/21

37 Cortisone is a synthetic hormone.

cortisone



Which classes of alcohol does this molecule contain?

1 primary alcohol

2 secondary alcohol

3 tertiary alcohol

9701/12/M/J/21

27 Which reaction will form a strong organic base?

A ethanol and acidified sodium dichromate

B ethanol and hot aluminium oxide

C ethanol and sodium

D ethanol and hydrogen chloride

9701/12/M/J/21

26 Alcohol X reacts with concentrated sulfuric acid to produce a mixture of products.

Two of the products are structural isomers of each other.

What could be X?

A hexan-2-ol

B pentan-1-ol

C pentan-3-ol

D propan-2-ol

9701/12/M/J/21

38 Which pairs of compounds may be distinguished by testing with alkaline aqueous iodine?

1 butanal and butanone

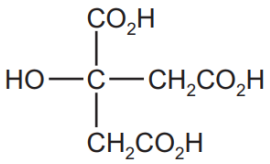
2 pentan-2-one and pentan-3-ol

3 propanone and propan-2-ol

9701/11/M/J/21

27 How many moles of hydrogen, H_2, are evolved when an excess of sodium metal is added to one mole of citric acid?

citric acid



A 0.5 **B** 1.5 **C** 2 **D** 4

9701/11/M/J/21

25 When an organic compound is oxidised, any oxygen atom gained by the organic molecule is considered to be from a water molecule also producing $2H^+ + 2e^-$. Any hydrogen atom lost may be considered to be lost as $H^+ + e^-$.

These changes can be represented by the following two equations.

$$H_2O \rightarrow [O] + 2H^+ + 2e^-$$

$$[H] \rightarrow H^+ + e^-$$

Compound X is oxidised by heating under reflux with hot, acidified potassium dichromate(VI) for one hour. The half-equation for the reduction reaction is shown.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

Under these conditions, one mole of potassium dichromate(VI) oxidises three moles of X.

What could X be?

A propanal

B propan-1-ol

C propan-1,2-diol

D propan-1,3-diol

9701/11/M/J/21

(c) Hydroxyethanal is converted to ethanedioic acid, $(CO_2H)_2$, when it reacts with excess acidified dichromate(VI) ions, $Cr_2O_7^{2-}$.

(i) State the role of acidified $Cr_2O_7^{2-}$ in this reaction.

..... [1]

(ii) State and explain any other necessary conditions for this reaction to be successful.

.....

.....

..... [2]

9701/22/F/M/21

24 Which compound produces a ketone when refluxed with an acidified solution of potassium dichromate(VI)?

A pentan-1-ol

B 2-methylbutan-1-ol

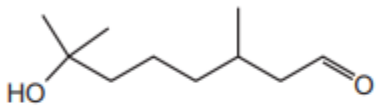
C 2-methylbutan-2-ol

D 3-methylbutan-2-ol

9701/12/F/M/21

(d) Separate samples of **Q** and **R** are added to separate test-tubes containing acidified $K_2Cr_2O_7$(aq) and heated.

Q



R

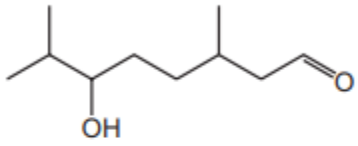


Fig. 3.3

(i) Predict the observations for each test-tube. Explain your answer in terms of the functional groups present in **Q** and **R**.

.....

.....

.....

..... [3]

(ii) When PCl_5(s) is added to separate samples of **Q** and **R** at room temperature, both react vigorously.

Complete the equation shown in Fig. 3.4 to describe the reaction that occurs when **R** reacts with PCl_5(s).

R

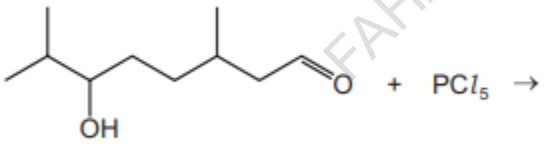


Fig. 3.4

[2]

(iii) Suggest why samples of **Q** and **R** must be dried before PCl_5 is added. Include a relevant equation to support your answer.

.....

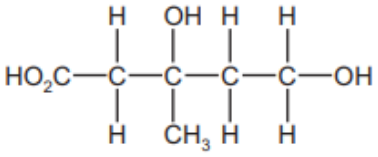
.....

..... [2]

9701/21/M/J/22(Q3)

28 The diagram shows the structural formula of mevalonic acid.

mevalonic acid



Which reagent and conditions will react with mevalonic acid to produce an organic compound **without** a chiral carbon atom?

A heat under reflux with CH_3OH/H^+

B heat under reflux with $Cr_2O_7^{2-}/H^+$

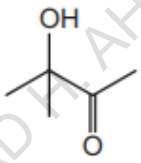
C Na at room temperature

D PCl_5 at room temperature

9701/13/M/J/22

26 Compound X contains an alcohol group and a carbonyl group.

compound X



Which row is correct?

	type of alcohol group	type of carbonyl group
A	primary	aldehyde
B	primary	ketone
C	tertiary	aldehyde
D	tertiary	ketone

9701/13/M/J/22

34 Which reaction has a product that gives a yellow precipitate when treated with alkaline $I_2(aq)$?

A 2-chloropropane is warmed with a dilute aqueous solution of sodium hydroxide.

B Ethanal is heated under reflux with acidified potassium dichromate(VI).

C Methyl ethanoate is heated under reflux with dilute sulfuric acid.

D Propanal is reacted with $NaBH_4$, followed by dilute sulfuric acid.

9701/12/M/J/22

33 Primary alcohols can be oxidised to aldehydes using either acidified potassium dichromate(VI) or acidified potassium manganate(VII). The reaction mixtures change colour as the oxidising agent is reduced.

What are the colour changes seen?

	acidified potassium dichromate(VI)		acidified potassium manganate(VII)	
	before	after	before	after
A	green	orange	purple	colourless
B	orange	green	colourless	purple
C	orange	green	purple	colourless
D	purple	colourless	orange	green

9701/12/M/J/22

38 Two 1 g samples of Y are reacted separately and completely with sodium and with sodium carbonate. The volumes of the gases produced are collected and measured.

	relative volumes of gases	
	with Na	with Na_2CO_3
Y	2	1

What could Y be?

A $CH_3CH(OH)CH_2OH$

B $CH_3CH(OH)CO_2H$

C CH_3COCH_2OH

D CH_3COCO_2H

9701/11/M/J/22

34 Crotyl alcohol, $CH_3CH{=}CHCH_2OH$, is a colourless liquid which is used as a solvent.

Crotyl alcohol will react separately with Br_2, $K_2Cr_2O_7/H^+$, conc. $KMnO_4/H^+$ and PCl_5 under suitable conditions.

Which row is correct?

	reactant	conditions	main product
A	Br_2	room temperature	$CH_3CH{=}CHCH_2Br$
B	$K_2Cr_2O_7/H^+$	heat under reflux	$CH_3CH{=}CHCHO$
C	conc. $KMnO_4/H^+$	heat under reflux	$CH_3CH{=}CHCO_2H$
D	PCl_5	room temperature	$CH_3CH{=}CHCH_2Cl$

9701/11/M/J/22

33 17.6 g of pentan-1-ol is completely combusted.

Which volume of gaseous products is formed when measured at s.t.p.?

A 22.4 dm^3 **B** 24.0 dm^3 **C** 49.3 dm^3 **D** 52.8 dm^3

(iv) **K** can be made from propanone in the three-step synthesis shown in Fig. 4.3.

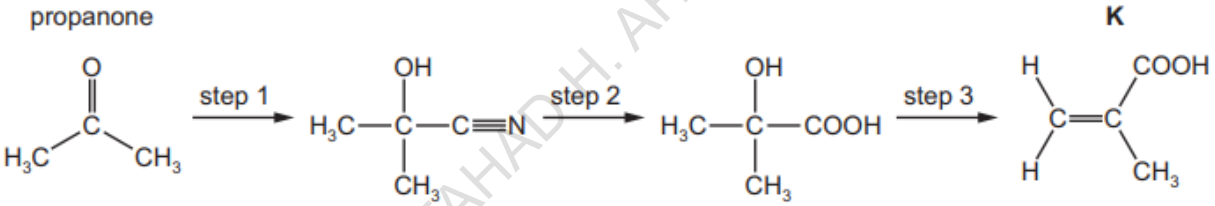


Fig. 4.3

Complete Table 4.3 to identify the reagent(s) used and the type of reaction in each step.

Table 4.3

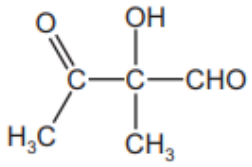
step	reagent(s)	type of reaction
1		
2		
3	Al_2O_3	

[5]

9701/22/F/M/22 (Q4)

Compounds **J** and **K** are found in plant oils.

J



K

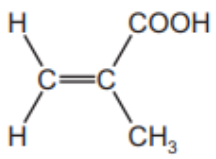


Fig. 4.1

(a) (i) Complete Table 4.1 to state what you would **observe** when **J** reacts with the reagents listed.

Table 4.1

reagent	observation with **J**
2,4-dinitrophenylhydrazine (2,4-DNPH)	
Tollens' reagent	
sodium metal	

[3]

9701/22/F/M/22

38 Compound Y is heated with a mild oxidising agent. One of the products of the reaction reacts with hydrogen cyanide forming 2-hydroxybutanenitrile.

What is compound Y?

A butan-1-ol

B butan-2-ol

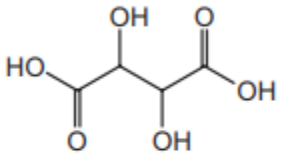
C propan-1-ol

D propan-2-ol

9701/12/F/M/22

32 The structure of tartaric acid is shown.

tartaric acid



Four moles of substance X react with one mole of tartaric acid.

What could be substance X?

A sodium

B sodium carbonate

C sodium hydrogencarbonate

D sodium hydroxide

9701/12/F/M/22

31 A sample of 2.30 g of ethanol is mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture is boiled under reflux for one hour. The required organic product is then collected by distillation. The yield of product is 60.0%.

Which mass of product is collected?

A 1.32 g **B** 1.38 g **C** 1.80 g **D** 3.00 g

9701/12/F/M/22

Chapter 5 - Halogenoalkanes

39 Which statements apply to tetrafluoromethane?

1 It is rapidly decomposed by ultraviolet radiation.

2 It is less harmful to the ozone layer than dichlorodifluoromethane.

3 It is a non-polar molecule.

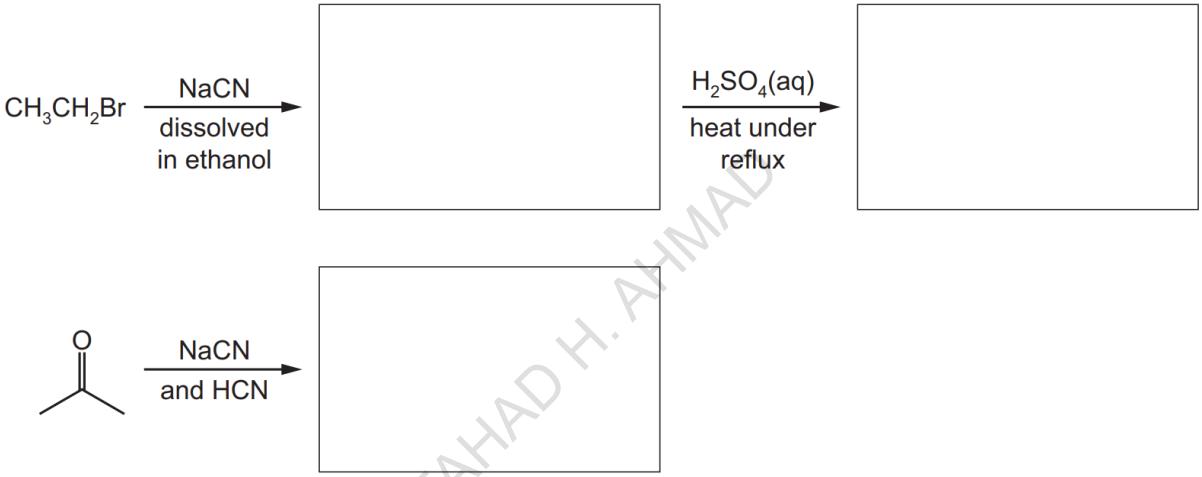
9701/12/F/M/20

21 Which row identifies a suitable starting material and reagent that can be used to produce butanenitrile?

	starting material	reagent
A	$CH_3CH_2CH_2Br$	HCN
B	$CH_3CH_2CH_2Br$	NaCN
C	$CH_3CH_2CH_2CH_2Br$	HCN
D	$CH_3CH_2CH_2CH_2Br$	NaCN

9701/12/F/M/20

(ii) Draw the structure of the organic products formed in the following reactions.



[3]

9701/21/O/N/21

25 A halogenoalkane has the molecular formula $C_5H_{11}Br$. The halogenoalkane does **not** form an alkene when treated with ethanolic sodium hydroxide.

What could be the halogenoalkane?

A 1-bromo-2-methylbutane

B 2-bromo-2-methylbutane

C 3-bromopentane

D 1-bromo-2,2-dimethylpropane

9701/12/O/N/21

24 Butanoic acid can be made from 1-bromopropane in two stages.

stage 1 $CH_3CH_2CH_2Br \rightarrow CH_3CH_2CH_2CN$

stage 2 $CH_3CH_2CH_2CN \rightarrow CH_3CH_2CH_2CO_2H$

Which types of reaction are stage 1 and stage 2?

	stage 1	stage 2
A	electrophilic addition	hydrolysis
B	electrophilic addition	oxidation
C	nucleophilic substitution	hydrolysis
D	nucleophilic substitution	oxidation

9701/12/O/N/21

39 Which statements about chlorofluoroalkanes are correct?

1 Both the C–C*l* and C–F bonds are readily dissociated by ultra-violet light.

2 They have caused ozone depletion.

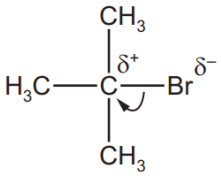
3 They are relatively chemically inert.

9701/11/O/N/21

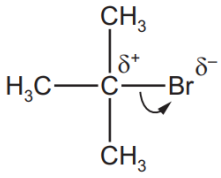
23 When 2-bromo-2-methylpropane reacts with aqueous sodium hydroxide, an alcohol is formed.

Which diagram describes the first step in the reaction mechanism?

A



B



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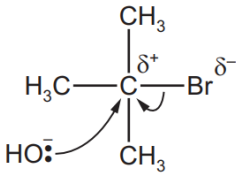

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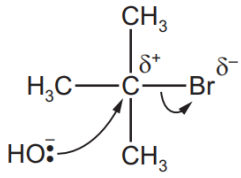


9701/11/O/N/21

22 Structural isomerism **and** stereoisomerism should be considered when answering this question.

A colourless liquid, $C_5H_{11}Cl$, exists as a mixture of two optical isomers.

When heated with sodium hydroxide in ethanol, a mixture of **only two** alkenes is formed.

What could the colourless liquid be?

A $(CH_3CH_2)_2CHCl$

B $CH_3CH_2CH_2CHClCH_3$

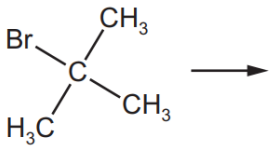
C $CH_3CH_2CCl(CH_3)_2$

D $(CH_3)_2CHCHClCH_3$

9701/11/O/N/21

(c) (i) Draw the mechanism to show the reaction of 2-bromo-2-methylpropane with $OH^-(aq)$. Show the intermediate formed in this reaction.

Include all charges, partial charges, lone pairs and curly arrows as appropriate.



[3]

(ii) Name the mechanism for this reaction.

..... [1]

(d) The original experiment is repeated at 25 °C with 2-chloro-2-methylpropane instead of 2-bromo-2-methylpropane. All other variables remain constant.

Predict the effect of using 2-chloro-2-methylpropane compared to 2-bromo-2-methylpropane on the time taken for the pink colour to disappear. Explain your answer.

.....

.....

..... [2]

9701/22/M/J/21

(e) 2-bromopropane reacts to form propene, hydrogen bromide and water under certain conditions.

(i) Name this type of reaction.

..... [1]

(ii) Describe the reagents and conditions needed to favour this reaction.

reagents .....

conditions .....
[2]

9701/21/M/J/21

38 Bromoethane reacts with NaOH in different ways depending on the solvent used.

Which rows about these reactions are correct?

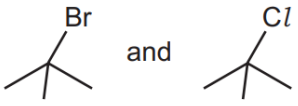
	solvent used	organic product
1	water	ethan-1,2-diol
2	ethanol	ethene
3	water	ethanol

9701/13/M/J/21

23 Halogenoalkanes react with nucleophiles such as OH^-.

Which pair of halogenoalkanes **both** react via an S_N1 mechanism?

A



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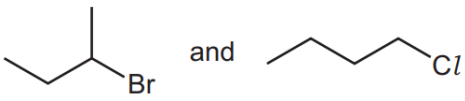

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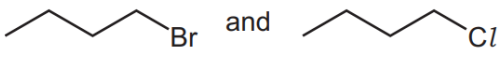

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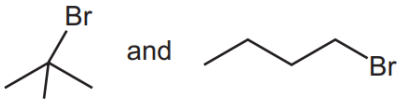
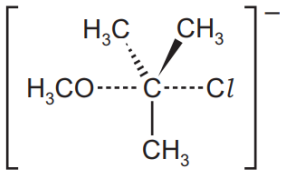
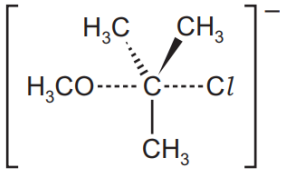


9701/13/M/J/21

25 Sodium methoxide, $Na^+CH_3O^-$, reacts with 2-chloro-2-methylpropane in a nucleophilic substitution reaction. The nucleophile is the CH_3O^- ion.

Which row is correct?

	intermediate or transition state	product
A	$(CH_3)_3C^+$	$(CH_3)_3COCH_3$
B	$(CH_3)_3C^+$	$(CH_3)_3CCH_2OH$
C		$HOCH_2C(CH_3)_3$
D		$H_3COC(CH_3)_3$

9701/12/M/J/21

24 A few drops of 2-bromopropane were placed in a test-tube. An equal volume of aqueous silver nitrate was added. A precipitate was formed.

The experiment was repeated with 2-iodopropane.

Which row is correct?

	colour of precipitate from **2-bromopropane** + $AgNO_3(aq)$	faster rate of reaction
A	cream	2-bromopropane + $AgNO_3(aq)$
B	yellow	2-bromopropane + $AgNO_3(aq)$
C	cream	2-iodopropane + $AgNO_3(aq)$
D	yellow	2-iodopropane + $AgNO_3(aq)$

9701/12/M/J/21

37 Which statements are correct?

1 1,1-difluoroethane is less reactive than 1,1-dichloroethane.

2 1,1-difluoroethane is polar.

3 The C–F bond is stronger than the C–C*l* bond.

9701/11/M/J/21

30 Butanoic acid is prepared from 1-bromopropane.

This synthesis requires a sequence of two reactions.

Which compound is prepared in the first stage of the synthesis?

A 1-aminopropane

B propan-1-ol

C butanal

D butanenitrile

9701/11/M/J/21

20 Bromoethane reacts with cyanide ions, producing propanenitrile.

Which statement about the S_N2 mechanism of this reaction is correct?

A The lone pair of electrons on C of CN^- attacks the carbon atom of the C–Br bond.

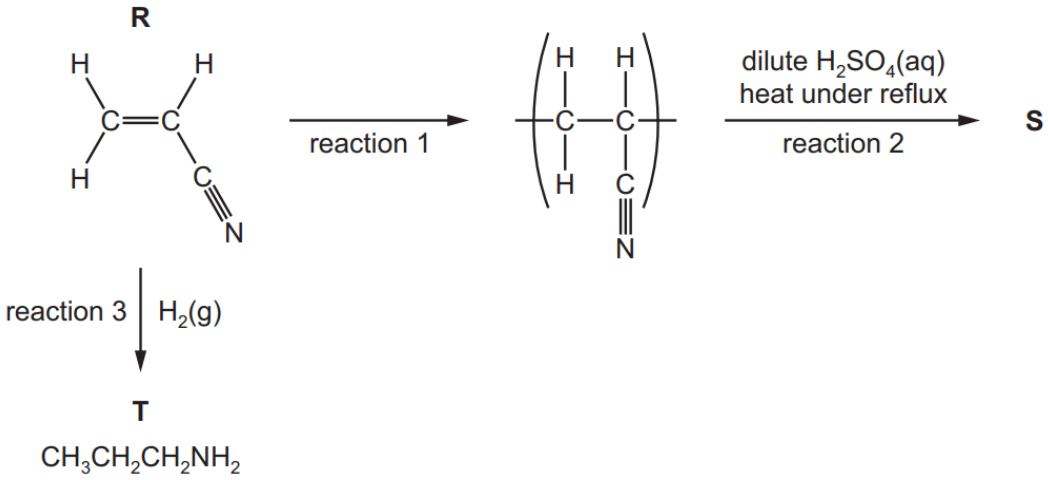
B The lone pair of electrons on C of CN^- attacks the carbocation formed when the C–Br bond breaks.

C The lone pair of electrons on N of CN^- attacks the carbon atom of the C–Br bond.

D The lone pair of electrons on N of CN^- attacks the carbocation formed when the C–Br bond breaks.

9701/11/M/J/21

(d) The flow chart shows some reactions of **R**.



(iv) **T** can also be formed by the reaction of $CH_3CH_2CH_2Br$ with ammonia.

State the necessary conditions of this reaction.

..... [1]

9701/22/F/M/21

37 In which reactions is the major product formed by a nucleophilic substitution reaction?

1 bromoethane + potassium cyanide in ethanol

2 bromoethane + ammonia in ethanol under pressure

3 bromoethane + hot concentrated sodium hydroxide in ethanol

9701/12/F/M/21

25 Dibromopentanes can undergo 'double elimination' reactions to produce hydrocarbons.

$$2NaOH + C_5H_{10}Br_2 \rightarrow C_5H_8 + 2NaBr + 2H_2O$$

Which isomer produces only one hydrocarbon product?

A 1,5-dibromopentane

B 1,4-dibromopentane

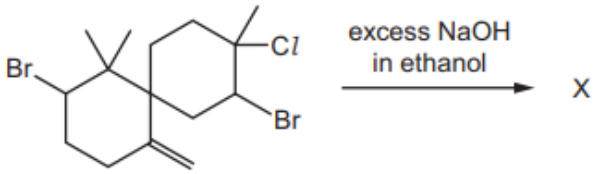
C 2,3-dibromopentane

D 2,4-dibromopentane

9701/12/F/M/21

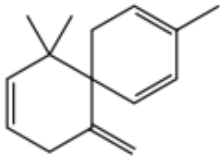
32 Compound J, $C_{15}H_{23}Br_2Cl$, is reacted with an excess of a hot concentrated solution of sodium hydroxide in ethanol. One of the products is X.

compound J



What could be the skeletal formula of X?

A



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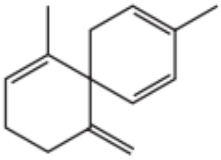

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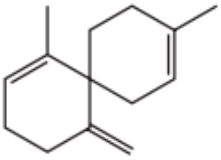

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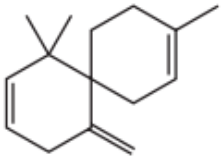


9701/13/M/J/22

31 Which statement concerning the hydrolysis of 1-bromopropane with water is correct?

A The hydrolysis reaction between water and 1-iodopropane is faster because the C–Br bond is less polar than the C–I bond.

B The hydrolysis reaction with water is very slow because water is a weak electrophile.

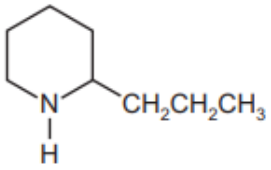
C The mechanism of the reaction involves the formation of a stable carbocation.

D The reaction is slower with 1-chloropropane because the C–Cl bond is stronger than the C–Br bond.

9701/13/M/J/22

32 The structure of coniine is shown.

coniine



Coniine can be synthesised by reacting ammonia with a dibromo compound, X.

X

$$NH_3 + C_8H_{16}Br_2 \rightarrow \text{coniine} + 2HBr$$

What is compound X?

A 1,1-dibromo-2-propylcyclopentane

B 1,2-dibromo-2-propylcyclopentane

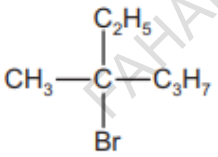
C $Br(CH_2)_3CHBr(CH_2)_3CH_3$

D $Br(CH_2)_4CHBr(CH_2)_2CH_3$

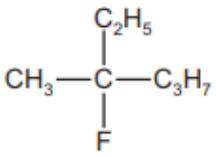
9701/12/M/J/22

31 The diagram shows the structures of two halogenoalkanes, P and Q.

P



Q



Both compounds can be hydrolysed.

Which row is correct?

	compound more readily hydrolysed	reaction mechanism
A	P	S_N1
B	P	S_N2
C	Q	S_N1
D	Q	S_N2

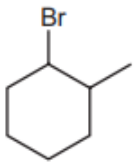
9701/12/M/J/22

28 Compound Z, $C_7H_{13}Br$, has two chiral centres. A sample of Z contains all four possible optical isomers.

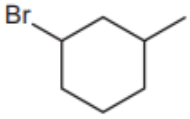
This sample of Z reacts with hot ethanolic NaOH to produce a mixture of **only** three isomers. Two of these isomers are optical isomers of each other.

What could be the formula of Z?

A

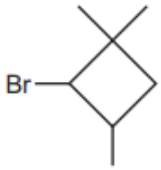


B



C

D

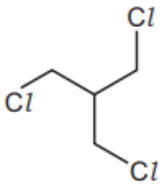


9701/12/M/J/22

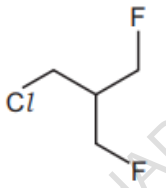
32 The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would be the quickest to produce a precipitate?

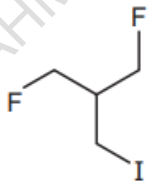
A



B



C



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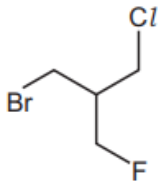


9701/11/M/J/22

31 Structural isomerism and stereoisomerism should be taken into account when answering this question.

How many isomeric alkenes with formula C_5H_8 are present in the mixture produced when 1,4-dibromopentane is reacted with NaOH in ethanol?

A 1 **B** 2 **C** 3 **D** 4

9701/11/M/J/22

26 Ethanol can be used to make propanenitrile in two steps.

$$CH_3CH_2OH \xrightarrow{X} CH_3CH_2Br \xrightarrow{Y} CH_3CH_2CN$$

What types of reaction are X and Y?

	X	Y
A	free-radical substitution	electrophilic substitution
B	free-radical substitution	nucleophilic substitution
C	nucleophilic substitution	nucleophilic substitution
D	nucleophilic substitution	electrophilic substitution

9701/11/M/J/22

(iii) The reaction of $CH_3CH_2CH_2Br$ and NaOH is different depending on whether water or ethanol is used as a solvent.

Complete Table 3.2 to identify the organic and inorganic products of the reaction of $CH_3CH_2CH_2Br$ and NaOH in each solvent.

Table 3.2

solvent	organic product(s)	inorganic product(s)
water		
ethanol		

[2]

9701/22/F/M/22

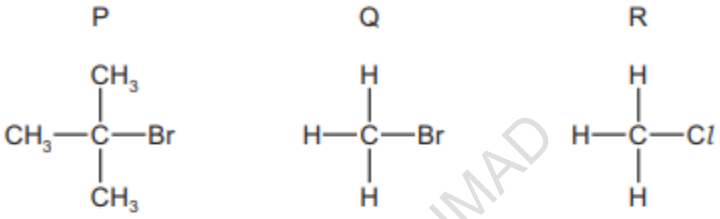
29 A reaction occurs when a sample of 1-chloropropane is heated under reflux with sodium hydroxide dissolved in ethanol.

Which row is correct?

	type of reaction	name of product
A	elimination	propan-1-ol
B	elimination	propene
C	substitution	propan-1-ol
D	substitution	propene

9701/12/F/M/22

30 The diagram shows the structures of three halogenoalkanes.



P, Q and R can all be hydrolysed.

Which row is correct?

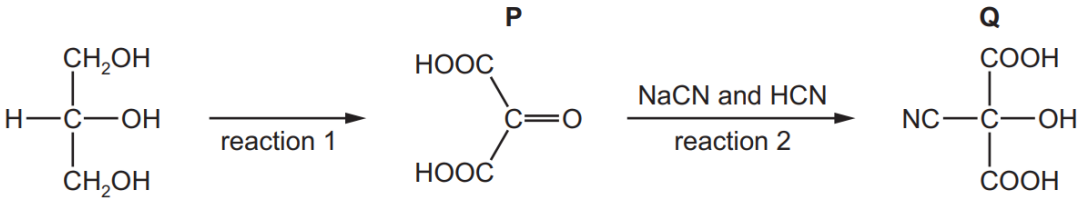
	relative speed of hydrolysis		mechanism of hydrolysis	
	Q	R	P	Q
A	fast	slow	S_N1	S_N2
B	fast	slow	S_N2	S_N1
C	slow	fast	S_N1	S_N2
D	slow	fast	S_N2	S_N1

9701/12/F/M/22

Chapter 6 - Carbonyl Compounds

3 Glycerol, $CH_2(OH)CH(OH)CH_2OH$, is widely used in the food industry and in pharmaceuticals.

(a) A series of reactions starting from glycerol is shown.



(i) Suggest the reagent(s) and conditions for reaction 1.

.....

..... [2]

(ii) Name the reaction mechanism for reaction 2.

..... [1]

(iii) Give the observation you would make when 2,4-dinitrophenylhydrazine is added to **P**.

..... [1]

(iv) **Q** does **not** show optical isomerism.

Explain why.

.....

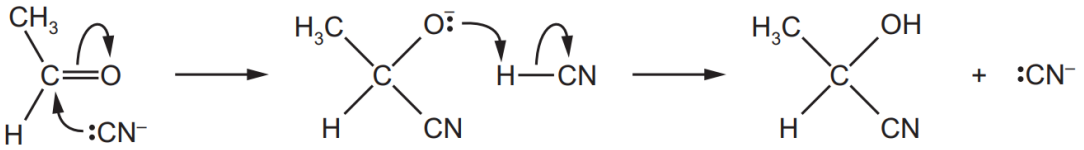
.....

.....

..... [1]

9701/22/F/M/20

37 Ethanal and hydrogen cyanide react together. The reaction mechanism involves cyanide ions.



Which statements about this mechanism are correct?

1 CN^- acts as a catalyst.

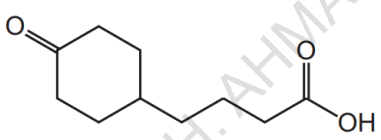
2 CN^- is a nucleophile.

3 It is an addition reaction.

9701/12/F/M/20

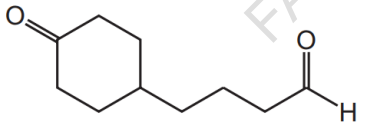
28 Compound X is treated with an excess of lithium aluminium hydride. The reaction is allowed to go to completion.

X



What is the structure of the organic product?

A



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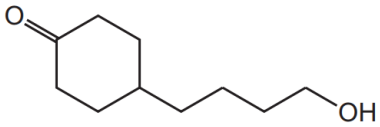

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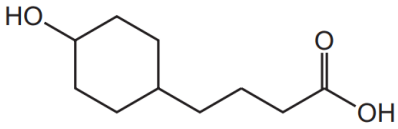

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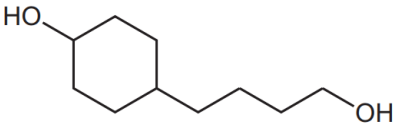
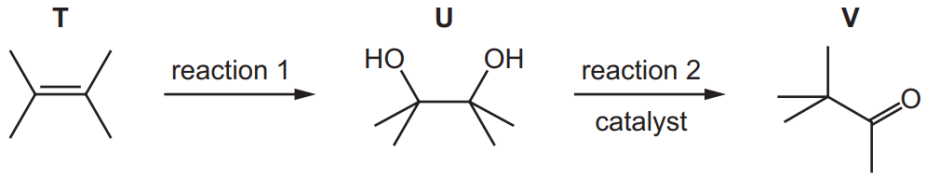


9701/12/F/M/20

(d) A reaction scheme starting with **T** is shown. Reaction 2 occurs in the presence of a catalyst; knowledge of the mechanism for this reaction is not required.



(i) Give the reagent(s) and conditions for reaction 1.

..... [1]

(ii) State and explain how 2,4-dinitrophenylhydrazine (2,4-DNPH) can be used to detect the presence of **V** as a product of reaction 2.

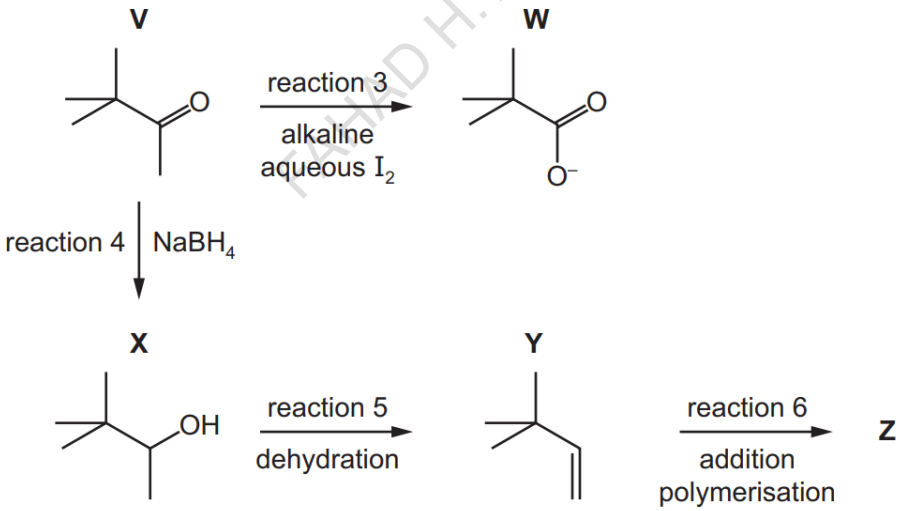
.....

.....

..... [2]

(e) **V** is used in a wide range of organic reactions.

Some reactions of **V** are shown.



(i) **V** and **W** are colourless and soluble in water.

State what you would observe in reaction 3.

..... [1]

(ii) Reaction 3 is a redox reaction.

Identify which of the **reactants** is reduced in this reaction.

..... [1]

(iii) Construct an equation for reaction 4.

Use [H] in the equation to represent an atom of hydrogen from $NaBH_4$.

$C_6H_{12}O$ + ... [1]

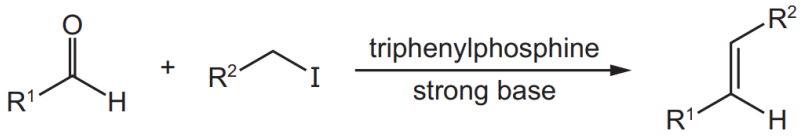
(iv) **X** is a mixture of two optical isomers.

Draw the two optical isomers in the boxes provided.

[2]

9701/22/O/N/21

In a Wittig reaction, an aldehyde reacts with a halogenoalkane to form an alkene. The conversion is shown in the following unbalanced equation.



Compound **H** can be made from propanal, C_2H_5CHO. Stage 3 in the reaction scheme is a Wittig reaction.

stage 1 $C_2H_5CHO \xrightarrow{NaBH_4} \mathbf{G}$

stage 2 $\mathbf{G} \xrightarrow{\text{red phosphorus and } I_2} C_2H_5CH_2I$

stage 3 (Wittig reaction) $C_2H_5CH_2I + C_2H_5CHO \xrightarrow[\text{strong base}]{\text{triphenylphosphine}} \mathbf{H}$

(ii) State the types of reaction that occur in stages 1 and 2.

stage 1 .....

stage 2 .....

[2]

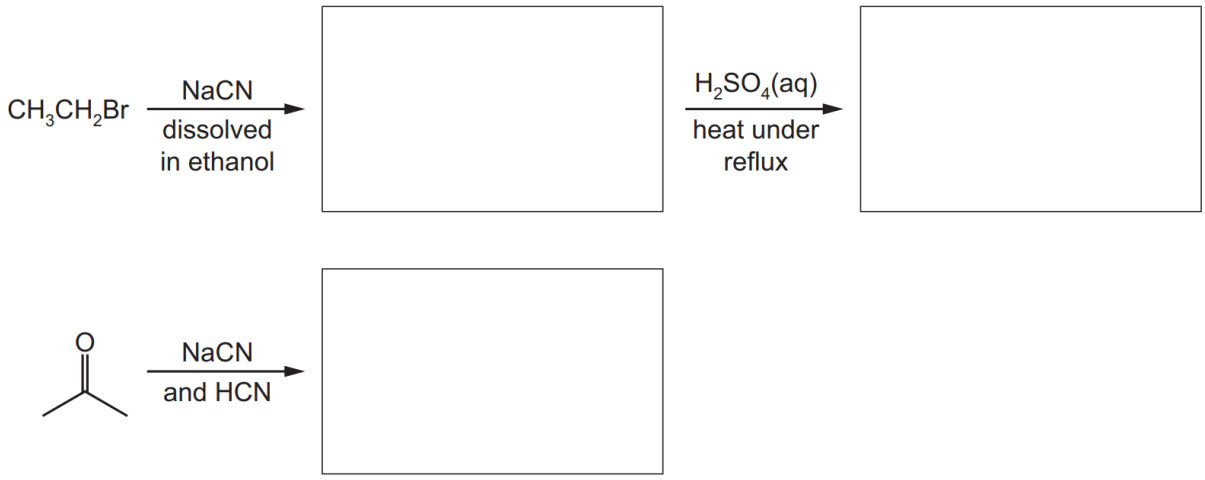
(iii) Draw the structures of **G** and **H** in the boxes provided.

G	**H**

[2]

9701/21/O/N/21

(ii) Draw the structure of the organic products formed in the following reactions.



[3]

9701/21/O/N/21

39 Which of the reactions give products containing a chiral centre?

1 $CH_2(OH)COCO_2H$ + an excess of HCN

2 $CH_2(OH)COCO_2H$ + an excess of $NaBH_4$

3 $CH_2(OH)COCO_2H$ + an excess of $LiAlH_4$

9701/12/O/N/21

28 Which compound produces a precipitate with 2,4-dinitrophenylhydrazine reagent **and** also with alkaline aqueous iodine?

A butan-2-ol

B butanal

C butanone

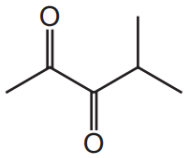
D pentan-3-one

9701/12/O/N/21

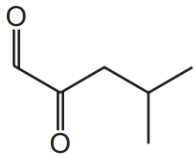
27 Reduction of compound R with $LiAlH_4$ gives the compound 4-methylpentane-2,3-diol.

What could be the identity of compound R?

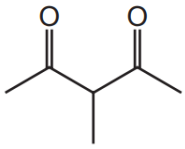
A



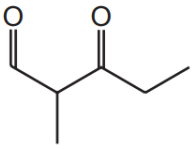
B



C



D



9701/11/O/N/21

26 $CH_3CH_2COCH_2CH_3$ reacts with hydrogen cyanide to form an organic product called a cyanohydrin.

Which statement is correct?

A The cyanohydrin product has one chiral centre.

B The cyanohydrin product is formed by electrophilic addition.

C The cyanohydrin product is formed via an intermediate which contains a C–OH group.

D The formation of the cyanohydrin product requires the use of cyanide ions as a catalyst.

9701/11/O/N/21

25 Alcohol Y gives a yellow precipitate with alkaline aqueous iodine. It can be oxidised to give a mixture of products including substance Z. Substance Z gives a red-brown precipitate with Fehling's solution.

Which alcohol could be Y?

A $CH_3CH(OH)CH(CH_3)CH_2OH$

B $CH_3C(OH)(CH_3)CH_2CH_2OH$

C $CH_3CH(OH)CH_2CH(OH)CH_3$

D $CH_2(OH)CH_2CH(OH)CH_2CH_3$

9701/11/O/N/21

4 **(a)** 1,3-dichloropropan-2-ol can be made by reacting **M**.

M → 1,3-dichloropropan-2-ol

(i) Give the systematic name of **M**.

..... [1]

(ii) Name the functional group present in **M** that changes during this reaction.

..... [1]

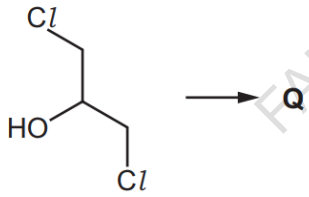
(iii) State a suitable reagent for this reaction.

..... [1]

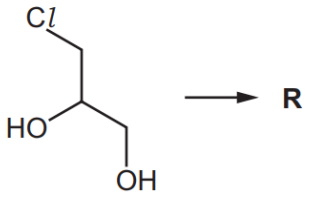
(b) Separate samples of 1,3-dichloropropan-2-ol and 3-chloropropane-1,2-diol are heated with excess acidified $Cr_2O_7^{2-}$ until there is no further reaction.

In each reaction, a different organic product, **Q** or **R**, is made.

1,3-dichloropropan-2-ol → **Q**



3-chloropropane-1,2-diol → **R**



Q and **R** are tested separately with 2,4-dinitrophenylhydrazine solution, 2,4-DNPH, and sodium carbonate solution, $Na_2CO_3(aq)$.

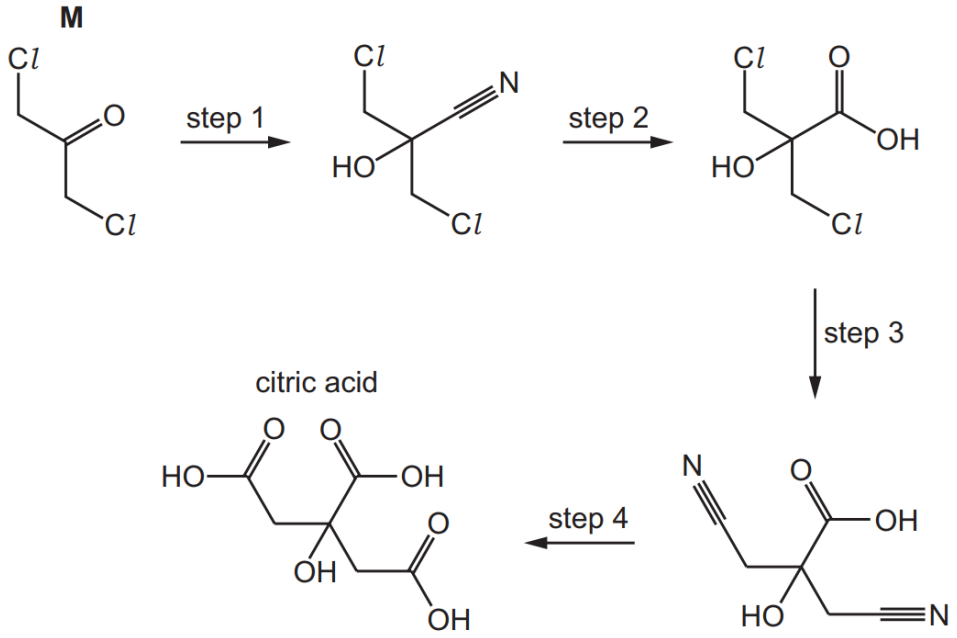
Complete the table to give any relevant observations.

If no reaction occurs, write 'no visible change'.

reagent	observation with **Q**	observation with **R**
2,4-DNPH		
$Na_2CO_3(aq)$		

[4]

(c) Citric acid can be made from **M** in a four-step reaction.



Complete the table for each step of the reaction sequence to identify:

- the reagents and conditions required
- the type of reaction.

step	reagent and conditions	type of reaction
1		
2	dilute sulfuric acid	
3		
4	dilute sulfuric acid	

[5]

9701/23/M/J/21

(d) Alcohol **Y** reacts completely when warmed with acidified $Cr_2O_7^{2-}$ to form **Z**.

Z is distilled from the reaction mixture as soon as it is made.

Tollens' reagent is added to a sample of **Z** and warmed. A silver mirror forms.

(i) Name the type of reaction that occurs when **Y** reacts to form **Z**.

..... [1]

(ii) Identify with a tick (✓) the functional group(s) present in **Z**.

functional group	present in **Z**
aldehyde	
ketone	
carboxylic acid	

[1]

9701/22/M/J/21

39 Three compounds, X, Y and Z, are shown.

X	Y	Z
$C_2H_5COCH_3$	C_2H_5CHO	CH_3CO_2H

Which statements about X, Y and Z are correct?

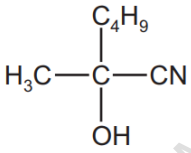
1 X reacts with alkaline aqueous iodine.

2 Y reacts with Tollens' reagent.

3 Z does **not** react with alkaline aqueous iodine.

9701/13/M/J/21

27 The diagram shows the structure of a compound formed by the reaction of HCN with a carbonyl compound, X.



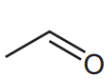
What is the mechanism of this reaction and what is the functional group in X?

	mechanism of reaction	functional group in X
A	electrophilic addition	aldehyde
B	electrophilic addition	ketone
C	nucleophilic addition	aldehyde
D	nucleophilic addition	ketone

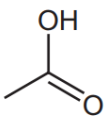
9701/13/M/J/21

26 The skeletal formulae of three compounds are shown.

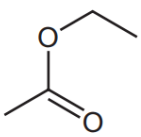
R



S



T



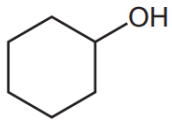
Which compounds will give a positive test with 2,4-dinitrophenylhydrazine reagent?

A R only **B** R and S only **C** S and T only **D** R, S and T

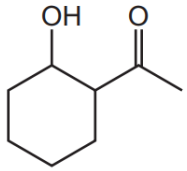
9701/13/M/J/21

39 Which alcohols can be oxidised to form an organic compound which will give coloured precipitates with both 2,4-dinitrophenylhydrazine reagent and alkaline aqueous iodine?

1



2



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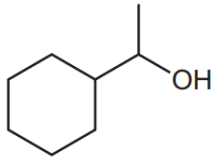
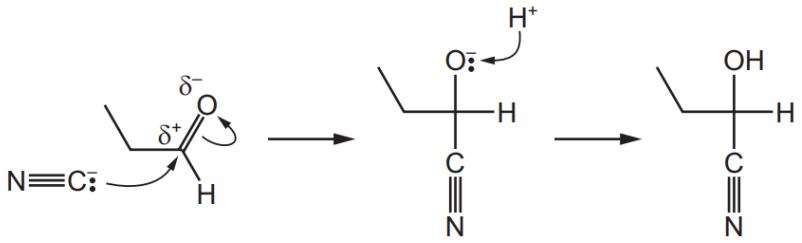


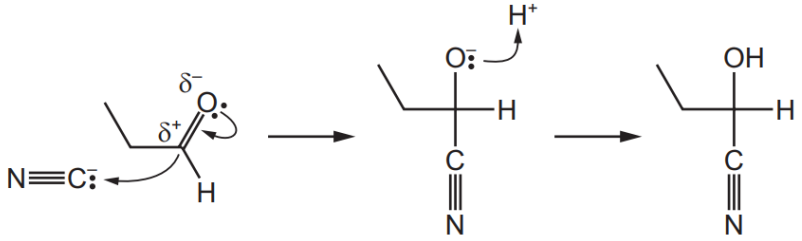
9701/12/M/J/21

28 Which reaction mechanism for the formation of $C_2H_5CH(OH)(CN)$ is correct?

A



B



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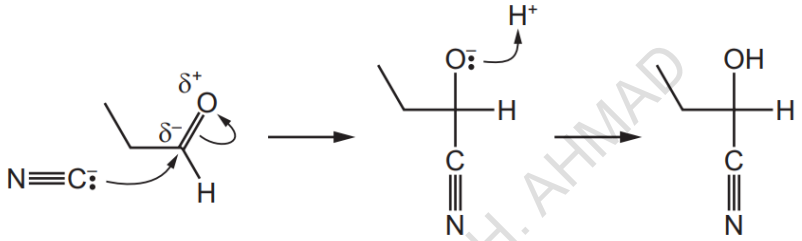
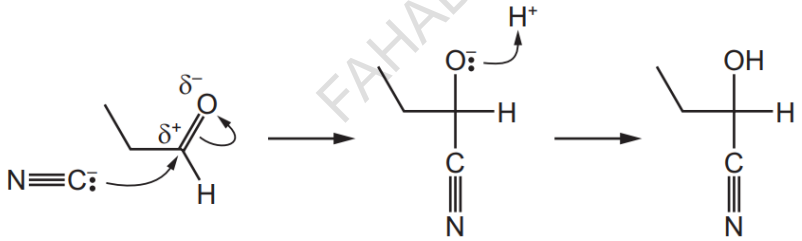


D



9701/12/M/J/21

39 Which reactions have a coloured organic product?

1 ethanal + 2,4-dinitrophenylhydrazine reagent

2 ethanol + acidified potassium dichromate(VI)

3 ethene + cold dilute acidified potassium manganate(VII)

9701/11/M/J/21

38 Which pairs of compounds may be distinguished by testing with alkaline aqueous iodine?

1 butanal and butanone

2 pentan-2-one and pentan-3-ol

3 propanone and propan-2-ol

9701/11/M/J/21

28 Which statement is correct for the reaction of carbonyl compounds with HCN?

A The reaction is catalysed by concentrated H_2SO_4.

B Pentan-2-one and HCN react to give a chiral product.

C The reaction is a condensation reaction.

D The reaction is nucleophilic substitution.

9701/11/M/J/21

25 When an organic compound is oxidised, any oxygen atom gained by the organic molecule is considered to be from a water molecule also producing $2H^+ + 2e^-$. Any hydrogen atom lost may be considered to be lost as $H^+ + e^-$.

These changes can be represented by the following two equations.

$$H_2O \rightarrow [O] + 2H^+ + 2e^-$$

$$[H] \rightarrow H^+ + e^-$$

Compound X is oxidised by heating under reflux with hot, acidified potassium dichromate(VI) for one hour. The half-equation for the reduction reaction is shown.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

Under these conditions, one mole of potassium dichromate(VI) oxidises three moles of X.

What could X be?

A propanal

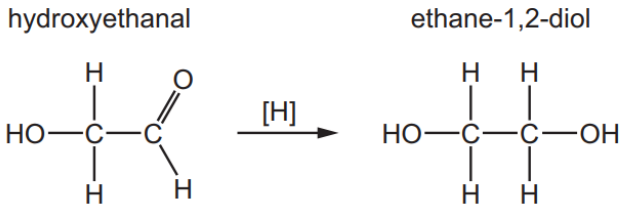
B propan-1-ol

C propan-1,2-diol

D propan-1,3-diol

9701/11/M/J/21

(d) Hydroxyethanal can be reduced to ethane-1,2-diol, $(CH_2OH)_2$, as shown.



(i) Write an equation for the reduction of hydroxyethanal to $(CH_2OH)_2$.

Use [H] to represent an atom of hydrogen from the reducing agent.

..... [1]

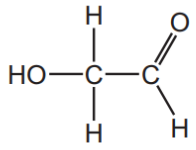
(ii) Identify a reagent for this reduction reaction.

..... [1]

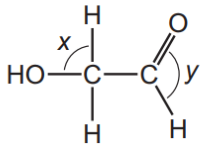
9701/22/F/M/21

4 Hydroxyethanal, $HOCH_2CHO$, has been observed in dust clouds near the centre of our galaxy.

hydroxyethanal



(a) Predict the bond angles labelled *x* and *y* in the diagram of hydroxyethanal.



x = ...°

y = ...°

[2]

(b) Hydroxyethanal reacts separately with 2,4-dinitrophenylhydrazine (2,4-DNPH) and with Tollens' reagent.

State what you would observe in each reaction.

reaction with 2,4-DNPH .....

reaction with Tollens' reagent .....

[2]

(c) Hydroxyethanal is converted to ethanedioic acid, $(CO_2H)_2$, when it reacts with excess acidified dichromate(VI) ions, $Cr_2O_7^{2-}$.

(i) State the role of acidified $Cr_2O_7^{2-}$ in this reaction.

..... [1]

(ii) State and explain any other necessary conditions for this reaction to be successful.

.....

.....

..... [2]

9701/22/F/M/21

40 An organic compound, T, does **not** fizz when aqueous sodium carbonate is added to it.

Compound T contains 27.6% by mass of oxygen.

What could be the identity of T?

1 propanal

2 ethyl butanoate

3 3-methylpentanoic acid

9701/12/F/M/21

39 Two carbonyl compounds have the molecular formula C_3H_6O.

Which reagents give **different** observations with these two compounds?

1 acidified aqueous potassium manganate(VII)

2 Fehling's reagent

3 alkaline aqueous iodine

9701/12/F/M/21

27 In this question you can assume that ^1H and ^3H have the same chemical properties.

A sample of ethanal contains only one isotope of hydrogen, ^1H.

It is reduced to compound Z, C_2H_6O, in a nucleophilic addition reaction using $NaBH_4$. All the hydrogen atoms in the $NaBH_4$ are the ^3H isotope.

$$CH_3CHO \xrightarrow{NaBH_4} \underset{\text{compound Z}}{C_2H_6O}$$

Compound Z is then oxidised back to ethanal and water.

$$C_2H_6O + [O] \rightarrow CH_3CHO + H_2O$$

Which statement about the final mixture of products is correct?

A Both ethanal and water contain ^3H atoms.

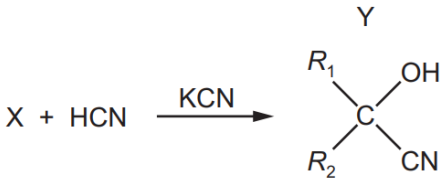
B Ethanal is the only product containing ^3H atoms.

C Neither ethanal nor water contain ^3H atoms.

D Water is the only product containing ^3H atoms.

9701/12/F/M/21

26 The diagram shows the formation of compound Y from compound X in a chemical reaction. R_1 and R_2 are alkyl groups.



Which row about this reaction is correct?

	mechanism	compound X
A	electrophilic addition	aldehyde
B	electrophilic addition	ketone
C	nucleophilic addition	ketone
D	nucleophilic addition	aldehyde

9701/12/F/M/21

24 Which compound produces a ketone when refluxed with an acidified solution of potassium dichromate(VI)?

A pentan-1-ol

B 2-methylbutan-1-ol

C 2-methylbutan-2-ol

D 3-methylbutan-2-ol

9701/12/F/M/21

(c) Fig. 3.2 shows two reactions of **T**.

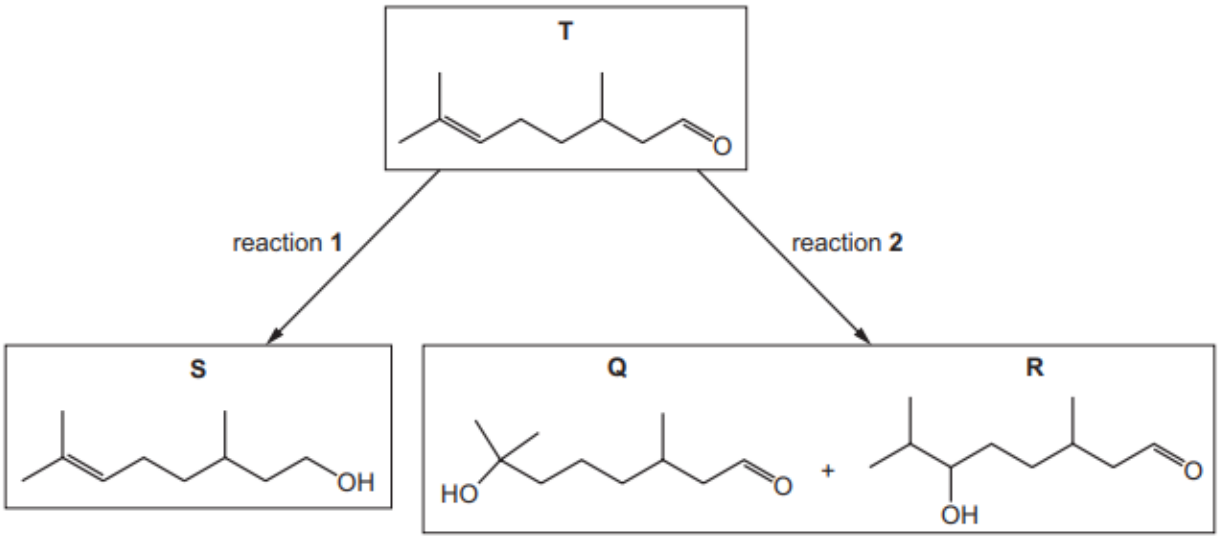


Fig. 3.2

(i) Identify a suitable reagent for reaction **1**.

..... [1]

(ii) Identify the reagent and conditions needed for reaction **2**.

.....

..... [2]

(iii) Suggest which product formed in reaction **2** has a higher yield. Explain your answer.

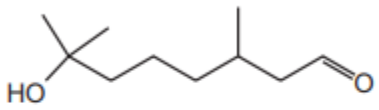
.....

.....

..... [3]

(d) Separate samples of **Q** and **R** are added to separate test-tubes containing acidified $K_2Cr_2O_7$(aq) and heated.

Q



R

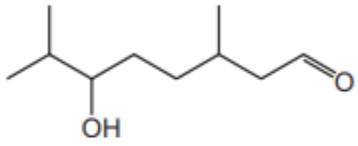


Fig. 3.3

(i) Predict the observations for each test-tube. Explain your answer in terms of the functional groups present in **Q** and **R**.

.....

.....

.....

..... [3]

9701/21/M/J/22 (Q3)

36 A carbonyl compound has the structural formula CH_3COCHO.

Which row is correct for the observations made when this compound is treated with the given reagents?

	2,4-DNPH reagent	Fehling's reagent
A	silver mirror	red precipitate
B	silver mirror	orange precipitate
C	orange precipitate	silver mirror
D	orange precipitate	red precipitate

9701/13/M/J/22

35 Which reaction has a nucleophilic addition mechanism and gives a good yield of product under the stated conditions?

A 1-bromopropane reacting with hot ethanolic sodium hydroxide

B 2-iodopropane reacting with hot aqueous sodium hydroxide

C propanal reacting with hydrogen cyanide under alkaline conditions

D propanal reacting with hydrogen cyanide under acidic conditions

9701/13/M/J/22

33 Structural isomerism only should be considered when answering this question.

Several compounds with molecular formula $C_4H_8O_2$ have **one** carbonyl group and **one** OH group.

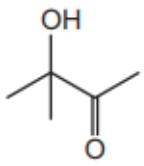
How many of these compounds produce yellow crystals with alkaline I_2(aq) at room temperature?

A 2 **B** 3 **C** 4 **D** 5

9701/13/M/J/22

26 Compound X contains an alcohol group and a carbonyl group.

compound X



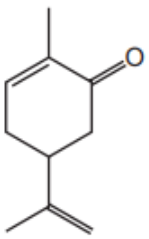
Which row is correct?

	type of alcohol group	type of carbonyl group
A	primary	aldehyde
B	primary	ketone
C	tertiary	aldehyde
D	tertiary	ketone

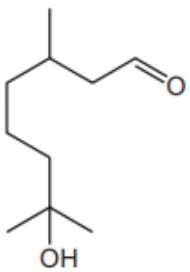
9701/13/M/J/22

36 Which compound forms a precipitate when mixed with 2,4-DNPH reagent and also forms a precipitate when mixed with Fehling's reagent?

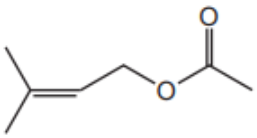
A



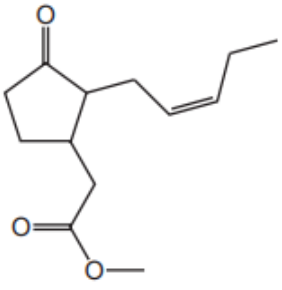
B



C

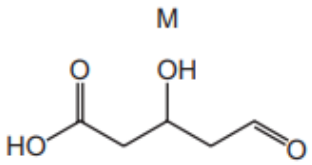


D



9701/12/M/J/22

35 The skeletal formula of M is shown.



M is reacted with an excess of $LiAlH_4$. Dilute acid is then added.

What is the molecular formula of the final organic product?

A $C_5H_6O_5$ **B** $C_5H_{10}O_4$ **C** $C_5H_{10}O_3$ **D** $C_5H_{12}O_3$

9701/12/M/J/22

34 Which reaction has a product that gives a yellow precipitate when treated with alkaline $I_2(aq)$?

A 2-chloropropane is warmed with a dilute aqueous solution of sodium hydroxide.

B Ethanal is heated under reflux with acidified potassium dichromate(VI).

C Methyl ethanoate is heated under reflux with dilute sulfuric acid.

D Propanal is reacted with $NaBH_4$, followed by dilute sulfuric acid.

9701/12/M/J/22

36 A carbonyl compound, X, reacts with HCN in the presence of NaCN to make a compound with M_r 85. Compound X does **not** react with Fehling's reagent.

What is compound X?

A butanal

B butanone

C propanal

D propanone

9701/11/M/J/22

35 The skeletal formulae of two organic compounds are shown.

Which reagents can be used to distinguish these two compounds?

1 alkaline $I_2(aq)$

2 acidified $K_2Cr_2O_7$

3 2,4-dinitrophenylhydrazine (2,4-DNPH reagent)

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

9701/11/M/J/22

27 Which compound will react with $LiAlH_4$ to form two optical isomers?

A $CH_3CH_2COCH_3$

B $CH_3CH_2CH_2CHO$

C $CH_3CH_2COCH_2CH_3$

D $CH_3CH(CH_3)CH_2CO_2H$

9701/11/M/J/22

(iv) **K** can be made from propanone in the three-step synthesis shown in Fig. 4.3.

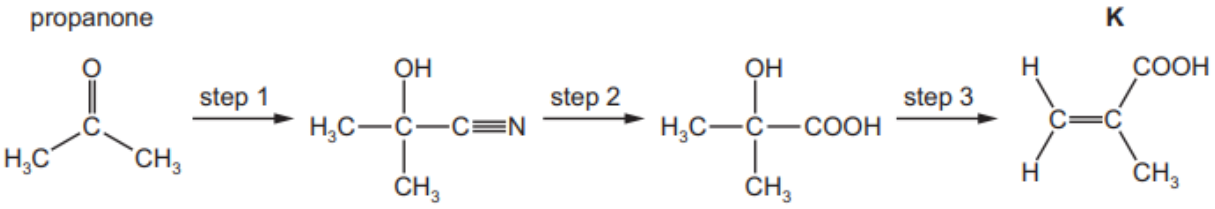


Fig. 4.3

Complete Table 4.3 to identify the reagent(s) used and the type of reaction in each step.

Table 4.3

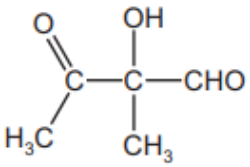
step	reagent(s)	type of reaction
1		
2		
3	Al_2O_3	

[5]

9701/22/F/M/22 (Q4)

Compounds **J** and **K** are found in plant oils.

J



K

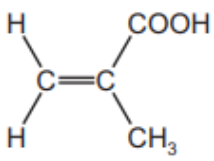


Fig. 4.1

(a) (i) Complete Table 4.1 to state what you would **observe** when **J** reacts with the reagents listed.

Table 4.1

reagent	observation with **J**
2,4-dinitrophenylhydrazine (2,4-DNPH)	
Tollens' reagent	
sodium metal	

[3]

9701/22/F/M/22 (Q4)

38 Compound Y is heated with a mild oxidising agent. One of the products of the reaction reacts with hydrogen cyanide forming 2-hydroxybutanenitrile.

What is compound Y?

A butan-1-ol

B butan-2-ol

C propan-1-ol

D propan-2-ol

9701/12/F/M/22

33 Which compound gives both:

- an orange precipitate with 2,4-DNPH reagent
- **and** a yellow precipitate with alkaline $I_2(aq)$?

A ethanol

B methanal

C propanal

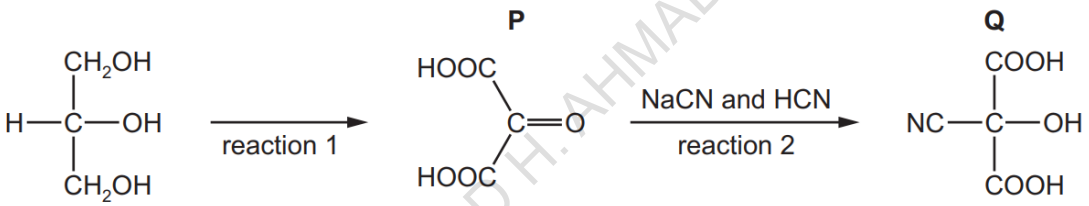
D propanone

9701/12/F/M/22

Chapter 7 - Carboxylic Acids/Esters

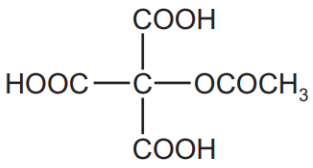
3 Glycerol, $CH_2(OH)CH(OH)CH_2OH$, is widely used in the food industry and in pharmaceuticals.

(a) A series of reactions starting from glycerol is shown.



(v) When **Q** is heated with excess aqueous ethanoic acid in the presence of a catalytic amount of sulfuric acid, two reactions take place to form compound **R**.

R



Identify the two types of reaction that occur.

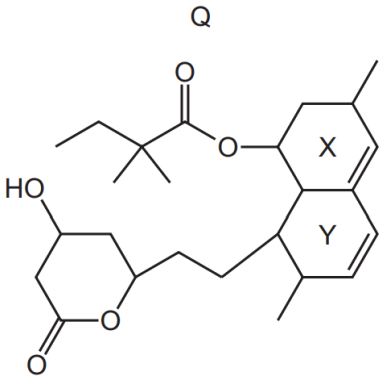
1 .....

2 .....

[2]

9701/22/F/M/20

30 The diagram shows the structure of compound Q.



Two of the rings, X and Y, contain a C=C bond.

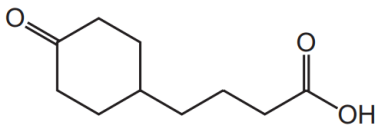
Which row is correct?

	number of ester groups in one molecule of Q	description of rings X and Y
A	1	both are planar
B	1	neither is planar
C	2	both are planar
D	2	neither is planar

9701/12/F/M/20

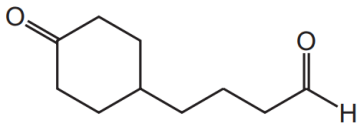
28 Compound X is treated with an excess of lithium aluminium hydride. The reaction is allowed to go to completion.

X

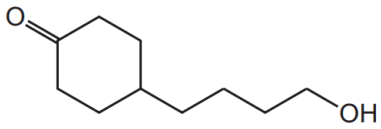


What is the structure of the organic product?

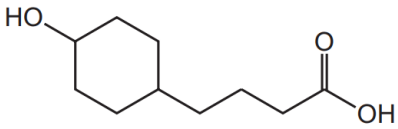
A



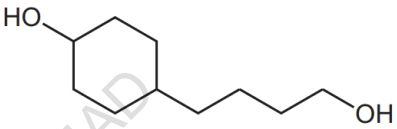
B



C



D



9701/12/F/M/20

27 Which reaction would produce propanoic acid as one of its products?

A heating $(CH_3)_2C{=}CHCH_2CH_3$ with concentrated, acidified $KMnO_4$

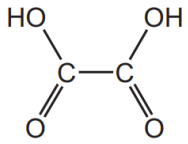
B heating $CH_3CH_2CO_2CH_2CH_2CH_3$ with NaOH(aq)

C heating CH_3CH_2OH with acidified $K_2Cr_2O_7$ under reflux

D reacting CH_3CHO with HCN then heating the organic product with H_2SO_4(aq)

9701/12/F/M/20

22 The diagram shows the structure of ethanedioic acid.



Ethanedioic acid reacts with ethanol in the presence of a few drops of concentrated sulfuric acid to form a diester. The molecular formula of the diester is $C_6H_{10}O_4$.

What is the structural formula of the diester?

A $CH_3CH_2CO_2CO_2CH_2CH_3$

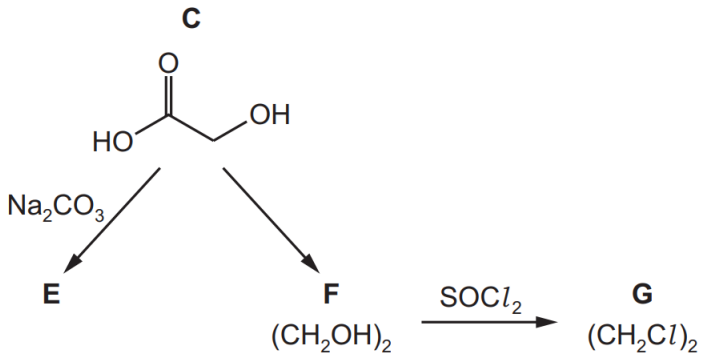
B $CH_3CH_2OCOCO_2CH_2CH_3$

C $CH_3CH_2O_2CO_2CCH_2CH_3$

D $CH_3CO_2CH_2CH_2OCOCH_3$

9701/12/F/M/20

(c) Some other reactions of **C** are shown.



(i) Draw the structure of **E**.

[1]

(ii) Suggest why $NaBH_4$ is not a suitable reagent to make **F**, $(CH_2OH)_2$, from **C**.
Explain your answer.

.....

..... [1]

(iii) Construct an equation for the reaction of $(CH_2OH)_2$ with $SOCl_2$ to form **G**, $(CH_2Cl)_2$.

..... [1]

(d) Explain why **C** is very soluble in water.

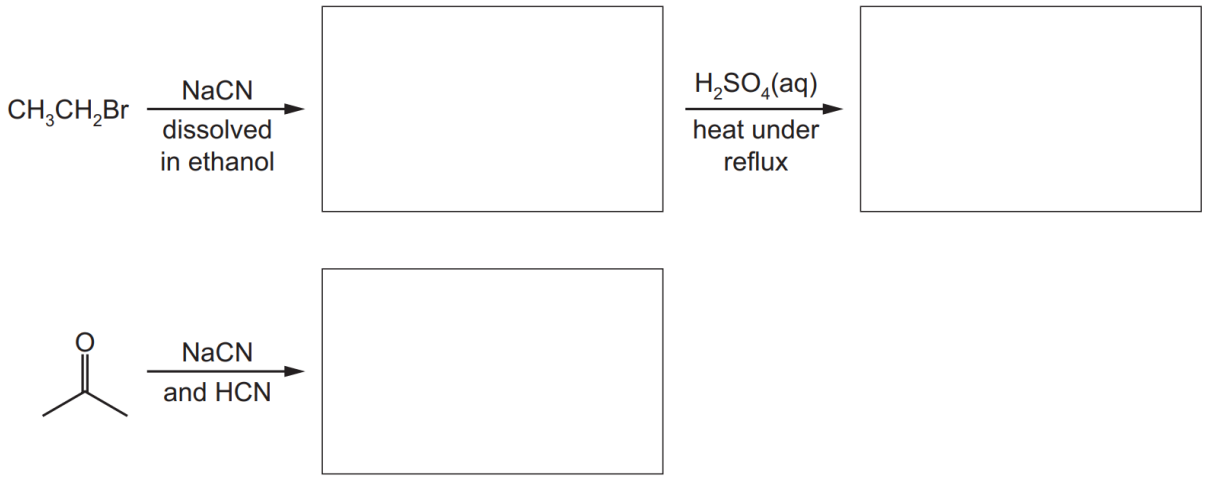
.....

.....

..... [1]

9701/21/O/N/21

(ii) Draw the structure of the organic products formed in the following reactions.



[3]

9701/21/O/N/21

40 Ethyl butanoate is heated with a dilute aqueous solution of sodium hydroxide.

Which substances are products of this reaction?

1 sodium butanoate

2 water

3 sodium ethanoate

9701/12/O/N/21

29 Organic compound Z has an alcohol group and a carboxylic acid group.

Compound Z reacts with magnesium carbonate to make a salt with a relative formula mass of 230.3.

Compound Z does **not** react with acidified potassium manganate(VII).

What could be the identity of compound Z?

A 2-hydroxy-2-methylbutanoic acid

B 2-hydroxy-2-methylpropanoic acid

C 3-hydroxy-2-methylbutanoic acid

D 3-hydroxy-2-methylpropanoic acid

9701/12/O/N/21

24 Butanoic acid can be made from 1-bromopropane in two stages.

stage 1 $CH_3CH_2CH_2Br \rightarrow CH_3CH_2CH_2CN$

stage 2 $CH_3CH_2CH_2CN \rightarrow CH_3CH_2CH_2CO_2H$

Which types of reaction are stage 1 and stage 2?

	stage 1	stage 2
A	electrophilic addition	hydrolysis
B	electrophilic addition	oxidation
C	nucleophilic substitution	hydrolysis
D	nucleophilic substitution	oxidation

9701/12/O/N/21

29 The structural formula of an ester is $(CH_3)_2CHOCO(CH_2)_2CH_3$.

This ester is boiled with aqueous hydrochloric acid.

Which two products are formed?

A propan-1-ol and butanoic acid

B propan-2-ol and butanoic acid

C propan-1-ol and propanoic acid

D propan-2-ol and propanoic acid

9701/11/O/N/21

28 Citric acid is found in lemon juice.

citric acid

$HO_2CCH_2C(OH)(CO_2H)CH_2CO_2H$

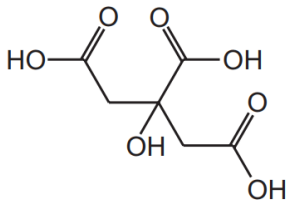
Which volume of 0.40 mol dm^{-3} sodium hydroxide solution is required to neutralise a soluti containing 0.0050 mol of citric acid?

A 12.5 cm^3 **B** 25.0 cm^3 **C** 37.5 cm^3 **D** 50.0 cm^3

9701/11/O/N/21

5 Compound **X** contains the same functional groups as citric acid.

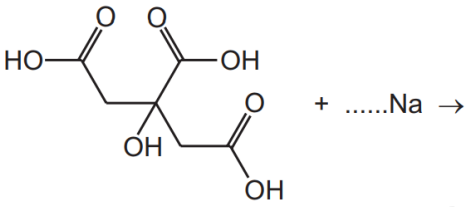
citric acid



The table describes some of the similarities and differences between citric acid and compound **X**.

	citric acid	**X**
chiral centre	no	yes
reaction with Na	fizzing	fizzing
reaction with $H^+/Cr_2O_7^{2-}$	remains orange	orange to green

(a) Complete the equation to show the reaction of excess sodium with citric acid. Show the skeletal structure of the product.



[3]

(b) (i) Use the information in the table to deduce the skeletal formula of **X**, $C_3H_6O_3$. Draw the skeletal formula of **X** in the box. Label the chiral centre of compound **X** with an asterisk (*).

[2]

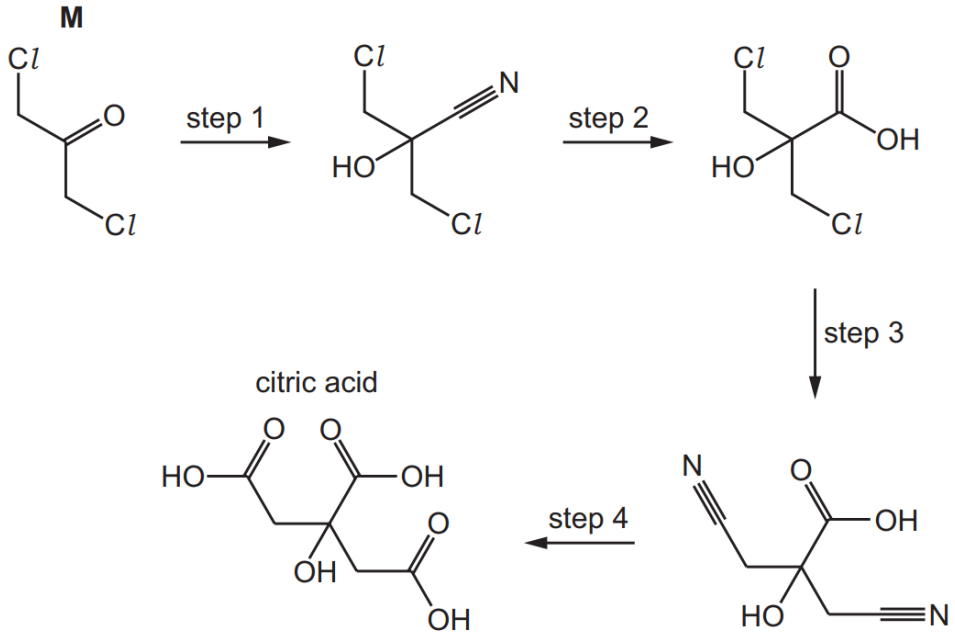
(ii) Explain why compound **X** reacts with acidified $Cr_2O_7^{2-}$ but citric acid does not.

.....

.....

..... [2]

(c) Citric acid can be made from **M** in a four-step reaction.



Complete the table for each step of the reaction sequence to identify:

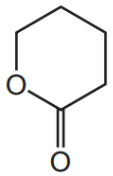
- the reagents and conditions required
- the type of reaction.

step	reagent and conditions	type of reaction
1		
2	dilute sulfuric acid	
3		
4	dilute sulfuric acid	

[5]

40 5-hydroxypentanoic acid is readily converted into the cyclic compound L.

L



Which statements about this reaction are correct?

1 Acidified sodium dichromate(VI) is used as a reagent.

2 A water molecule is produced in the reaction.

3 The reaction can be catalysed by concentrated H_2SO_4.

9701/13/M/J/21

29 Two reactions are shown.

$$(CH_3)_2CHCO_2H \xrightarrow{LiAlH_4} \text{alcohol P}$$

$$CH_3CO_2CH(CH_3)_2 \xrightarrow{\text{hydrolysis}} \text{alcohol Q + acid R}$$

To which classes of alcohol do P and Q belong?

	P	Q
A	primary	primary
B	primary	secondary
C	secondary	primary
D	secondary	secondary

9701/13/M/J/21

28 Compound Y is treated with a single reagent under suitable conditions. 2-methylbutanoic acid is produced.

What could compound Y be?

A pentan-2-one

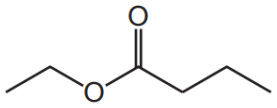
B 2-methylbutan-2-ol

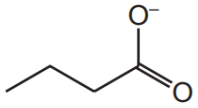
C 2-methylbutanenitrile

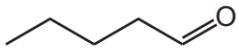
D methylpropanenitrile

9701/13/M/J/21

40 Which mixtures form a carboxylic acid as one of the products?

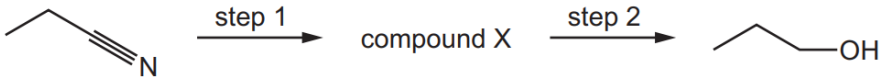
1  + $H_2SO_4(aq)$ →

2  + $H_2SO_4(aq)$ →

3  + $H_2SO_4(aq)$ →

9701/12/M/J/21

29 The synthesis shown may be used for the production of propan-1-ol.

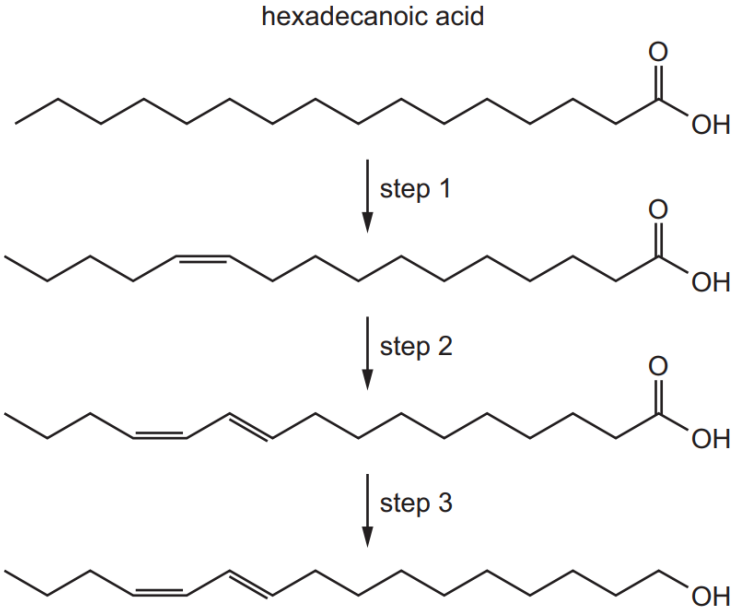


Which row gives the correct reagents for steps 1 and 2?

	step 1	step 2
A	HC*l*(aq)	H_2 + Ni
B	HC*l*(aq)	Li*Al*H_4
C	NaOH(aq)	H_2 + Ni
D	NaOH(aq)	$NaBH_4$

9701/12/M/J/21

21 Hexadeca-10,12-dien-1-ol is produced by silk moths from hexadecanoic acid in a three-step enzymic process.



Which row contains correct descriptions of the three steps?

	step 1	step 2	step 3
A	elimination	elimination	dehydration
B	elimination	reduction	reduction
C	oxidation	elimination	oxidation
D	oxidation	oxidation	reduction

9701/12/M/J/21

40 Propanoic acid is reacted with an excess of lithium aluminium hydride. The organic product of this reaction is reacted with ethanoic acid in the presence of concentrated sulfuric acid, forming product X.

What are major commercial uses of X?

1 fuel

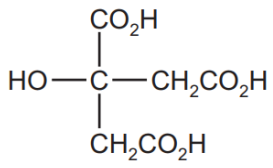
2 solvent

3 flavouring

9701/11/M/J/21

27 How many moles of hydrogen, H_2, are evolved when an excess of sodium metal is added to one mole of citric acid?

citric acid



A 0.5 **B** 1.5 **C** 2 **D** 4

9701/11/M/J/21

24 The compound cetyl palmitate, $C_{15}H_{31}CO_2C_{16}H_{33}$, is a waxy solid.

Cetyl palmitate is heated under reflux with an excess of aqueous sodium hydroxide.

Which products will be formed?

A $C_{15}H_{31}ONa$ and $C_{16}H_{33}CO_2Na$

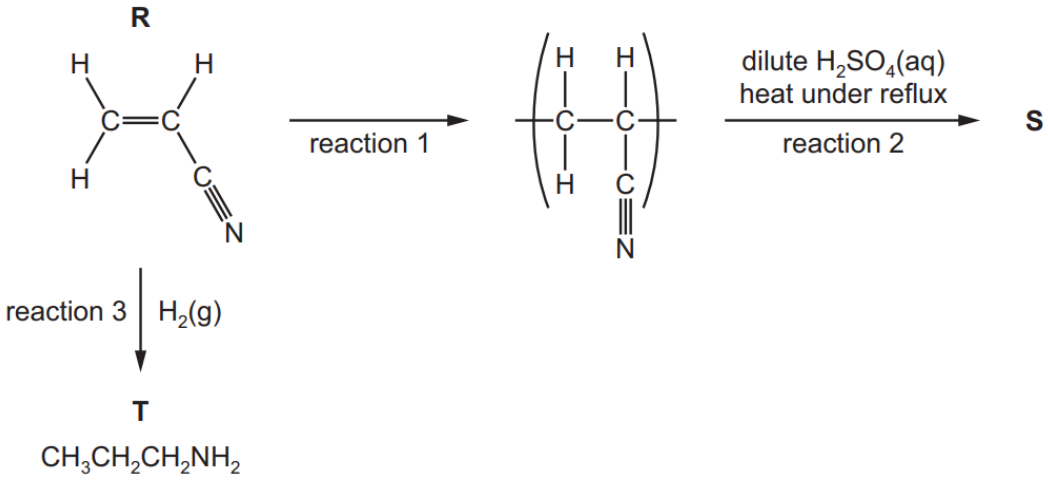
B $C_{15}H_{31}CO_2Na$ and $C_{16}H_{33}ONa$

C $C_{15}H_{31}OH$ and $C_{16}H_{33}CO_2Na$

D $C_{15}H_{31}CO_2Na$ and $C_{16}H_{33}OH$

9701/11/M/J/21

(d) The flow chart shows some reactions of **R**.



(ii) Draw the structure of **S**, the organic product of reaction 2.

[1]

9701/22/F/M/21

40 An organic compound, T, does **not** fizz when aqueous sodium carbonate is added to it.

Compound T contains 27.6% by mass of oxygen.

What could be the identity of T?

1 propanal

2 ethyl butanoate

3 3-methylpentanoic acid

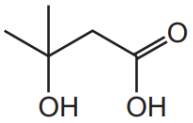
9701/12/F/M/21

38 An excess of P reacts with Q, in the presence of concentrated sulfuric acid, to form R.

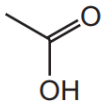
Effervescence is seen when a piece of sodium is added to pure R.

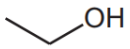
The structure of P is shown.

P



Which organic compounds could be compound Q?

1 

2 

3 

9701/12/F/M/21

29 Which reaction gives butanoic acid as one of its products?

A acid hydrolysis of butyl ethanoate

B alkaline hydrolysis of butyl ethanoate

C acid hydrolysis of ethyl butanoate

D alkaline hydrolysis of ethyl butanoate

9701/12/F/M/21

28 Ethanedioic acid has the formula HO_2CCO_2H.

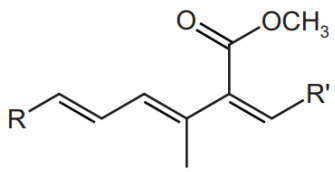
What is the formula of aluminium ethanedioate?

A AlC_2O_4 **B** $Al(C_2O_4)_3$ **C** $Al_2C_2O_4$ **D** $Al_2(C_2O_4)_3$

9701/12/F/M/21

23 Part of the structure of strobilurin is shown. R and R' are inert groups.

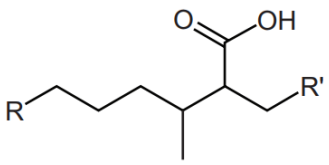
strobilurin



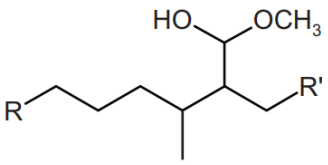
Strobilurin is warmed with aqueous sulfuric acid producing compound X. Compound X is then treated with hydrogen in the presence of a nickel catalyst producing compound Y.

What could be the structure of compound Y?

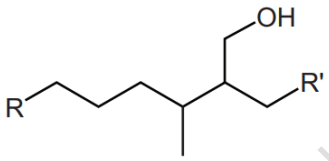
A



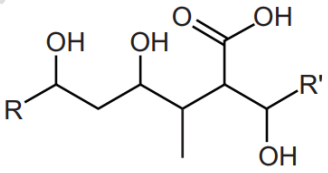
B



C

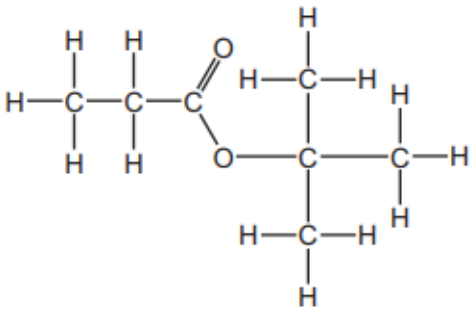


D



9701/12/F/M/21

37 An ester is shown.



Which two compounds react to form this ester?

A 2-methylpropan-1-ol and propanoic acid

B 2-methylpropan-2-ol and propanoic acid

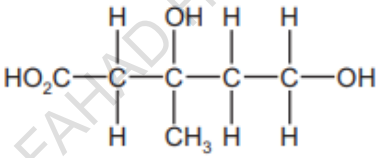
C propan-1-ol and 2-methylpropanoic acid

D 2-methylpropan-2-ol and ethanoic acid

9701/13/M/J/22

28 The diagram shows the structural formula of mevalonic acid.

mevalonic acid



Which reagent and conditions will react with mevalonic acid to produce an organic compound **without** a chiral carbon atom?

A heat under reflux with CH_3OH/H^+

B heat under reflux with $Cr_2O_7^{2-}/H^+$

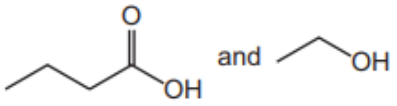
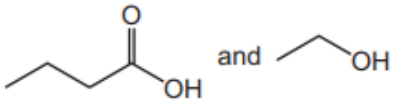
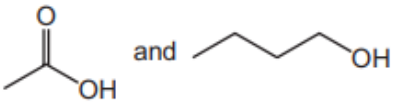
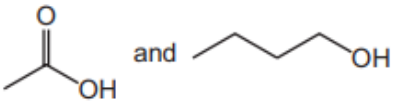
C Na at room temperature

D PCl_5 at room temperature

9701/13/M/J/22

38 Ethyl butanoate is a flavouring, with a fruity flavour.

Which row is correct?

	alcohol and acid that react to form ethyl butanoate	the mass of water formed when 2.32 g of ester is formed
A		0.36 g
B		0.40 g
C		0.36 g
D		0.40 g

9701/12/M/J/22

37 Which reaction is a redox reaction?

A ethanenitrile heated under reflux with dilute hydrochloric acid

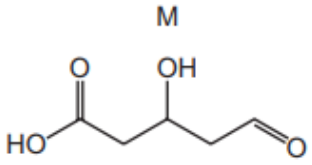
B ethanoic acid reacted with aqueous sodium hydroxide

C ethanoic acid reacted with sodium

D ethyl ethanoate heated under reflux with dilute hydrochloric acid

9701/12/M/J/22

35 The skeletal formula of M is shown.



M is reacted with an excess of $LiAlH_4$. Dilute acid is then added.

What is the molecular formula of the final organic product?

A $C_5H_6O_5$ **B** $C_5H_{10}O_4$ **C** $C_5H_{10}O_3$ **D** $C_5H_{12}O_3$

9701/12/M/J/22

38 Two 1 g samples of Y are reacted separately and completely with sodium and with sodium carbonate. The volumes of the gases produced are collected and measured.

	relative volumes of gases	
	with Na	with Na_2CO_3
Y	2	1

What could Y be?

A $CH_3CH(OH)CH_2OH$

B $CH_3CH(OH)CO_2H$

C CH_3COCH_2OH

D CH_3COCO_2H

9701/11/M/J/22

37 Which compound produces butan-2-ol and ethanoic acid on hydrolysis?

A $CH_3CO_2CH(CH_3)_2$

B $CH_3CO_2CH(CH_3)CH_2CH_3$

C $CH_3CH(CH_3)CO_2CH_2CH_3$

D $CH_3CH_2CO_2CH(CH_3)CH_2CH_3$

9701/11/M/J/22

(iv) **K** can be made from propanone in the three-step synthesis shown in Fig. 4.3.

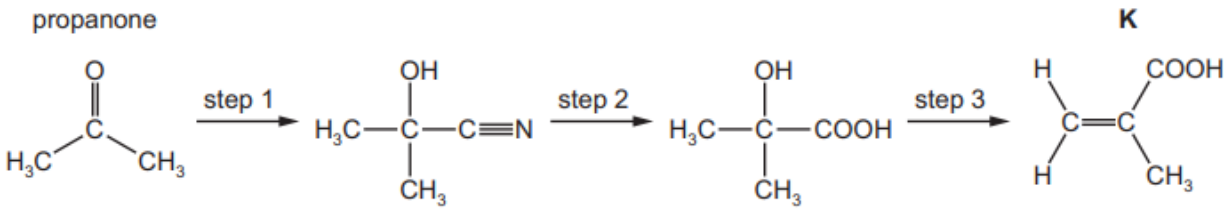


Fig. 4.3

Complete Table 4.3 to identify the reagent(s) used and the type of reaction in each step.

Table 4.3

step	reagent(s)	type of reaction
1		
2		
3	Al_2O_3	

[5]

9701/22/F/M/22 (Q4)

(b) **K** is used to make the addition polymer Perspex®. A synthesis of Perspex® is shown in Fig. 4.2.

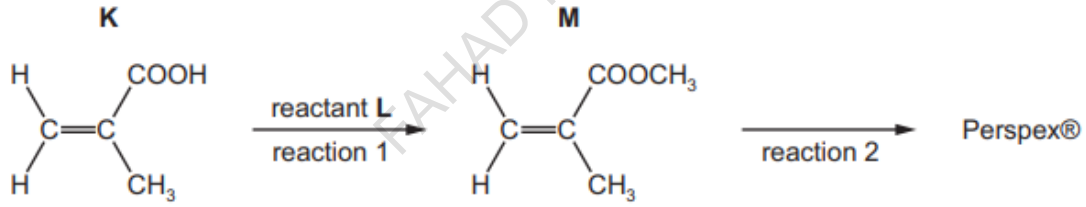


Fig. 4.2

(i) Identify **L**. State the conditions required for reaction 1.

L = ...

conditions = ...

[2]

9701/22/F/M/22 (Q4)

35 Compound X contains a single ester group.

X contains 27.6% by mass of oxygen.

Which pair of products could be produced by the hydrolysis of X?

A butan-1-ol and ethanoic acid

B ethanol and propanoic acid

C methanol and methanoic acid

D propan-2-ol and butanoic acid

9701/12/F/M/22

34 A student suggests two uses of $LiAlH_4$.

reaction 1 $CH_3—CH=CH_2 \xrightarrow{LiAlH_4} CH_3—CH_2—CH_3$

reaction 2 $CH_3CO_2H \xrightarrow{LiAlH_4} CH_3CH_2OH$

Which reactions would give the product shown?

A both reactions

B reaction 1 only

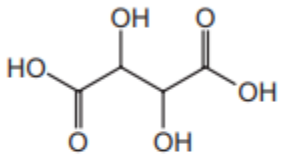
C reaction 2 only

D neither reaction

9701/12/F/M/22

32 The structure of tartaric acid is shown.

tartaric acid



Four moles of substance X react with one mole of tartaric acid.

What could be substance X?

A sodium

B sodium carbonate

C sodium hydrogencarbonate

D sodium hydroxide

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