CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



EXAM QUESTION PACK

17 CARBONYL COMPOUNDS

SCORE	PERCENTAGE
/	%

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Chapter 17

Carbonyl compounds

17.1 Aldehydes and ketones

1021. 9701_m22_qp_12 Q: 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

1022. 9701_m21_qp_12 Q: 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

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1023. 9701_m21_qp_12 Q: 27

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

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

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 ^{3}H 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 ^{3}H atoms.

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

C Neither ethanal nor water contain ^{3}H atoms.

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

1024. 9701_s21_qp_11 Q: 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.

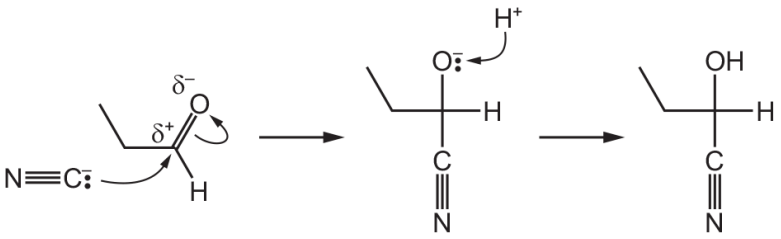
C The reaction is a condensation reaction.

D The reaction is nucleophilic substitution.

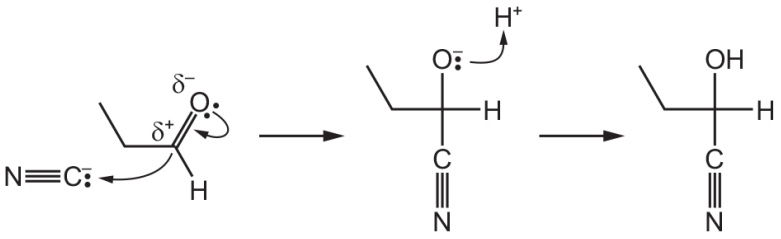
1025. 9701_s21_qp_12 Q: 28

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

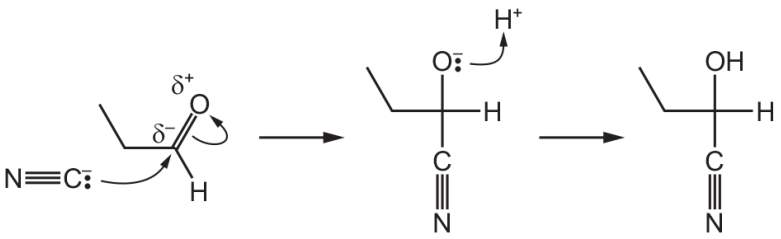
A



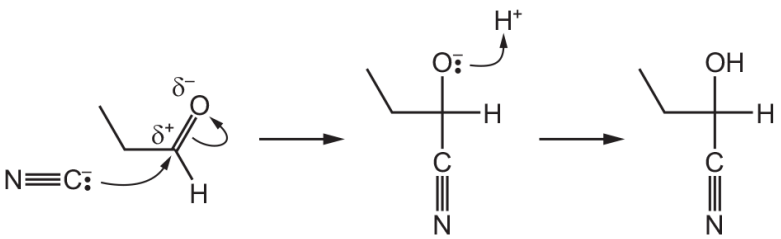
B



C



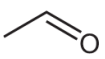
D



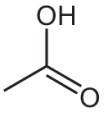
1026. 9701_s21_qp_13 Q: 26

The skeletal formulae of three compounds are shown.

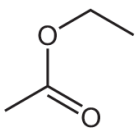
R



S



T

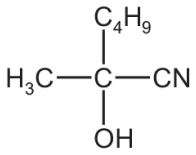


Which compounds will give a positive test with 2,4-dinitrophenylhydrazine reagent?

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

1027. 9701_s21_qp_13 Q: 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

1028. 9701_w21_qp_11 Q: 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.

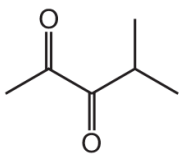
D The formation of the cyanohydrin product requires the use of cyanide ions as a catalyst.

1029. 9701_w21_qp_11 Q: 27

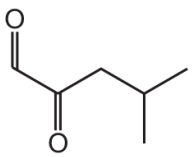
Reduction of compound R with $LiAlH_4$ gives the compound 4-methylpentane-2,3-diol.

What could be the identity of compound R?

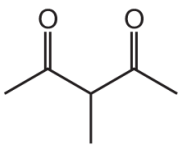
A



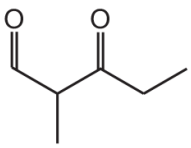
B



C



D



1030. 9701_w21_qp_12 Q: 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

1031. 9701_w21_qp_13 Q: 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.

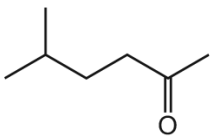
B The cyanohydrin product is formed by electrophilic addition.

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.

1032. 9701_s20_qp_11 Q: 20

The skeletal formula of compound X is shown.



Which row is correct?

	molecular formula of X	observation on addition of X to Fehling's reagent
A	$C_7H_{14}O$	no change
B	$C_7H_{14}O$	red precipitate forms
C	$C_7H_{16}O$	no change
D	$C_7H_{16}O$	red precipitate forms

1033. 9701_s20_qp_12 Q: 22

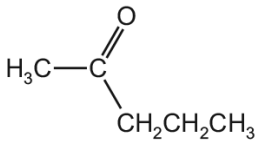
Which row correctly shows the type of mechanism of each of the two reactions?

	C_2H_5Br + KCN	CH_3COCH_3 + HCN
A	electrophilic substitution	electrophilic addition
B	electrophilic substitution	nucleophilic addition
C	nucleophilic substitution	electrophilic addition
D	nucleophilic substitution	nucleophilic addition

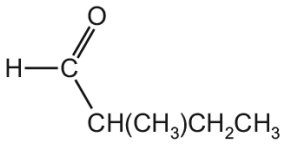
1034. 9701_s20_qp_13 Q: 24

Which statement about compound T and compound U is correct?

compound T



compound U



A T and U are stereoisomers.

B T can be distinguished from U by the use of alkaline aqueous iodine.

C T can be reduced by $LiAlH_4$ but not by $NaBH_4$.

D U can be formed by the oxidation of 3-methylbutan-1-ol.

1035. 9701_w20_qp_11 Q: 27

Which pair of test results would prove that a substance, X, is a ketone?

A X has no reaction with Tollens' reagent. X reacts with alkaline aqueous iodine.

B X is reduced by lithium aluminium hydride. X is oxidised by acidified dichromate(VI).

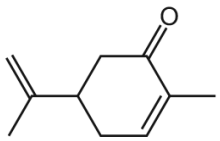
C X reacts with 2,4-DNPH reagent. X has no reaction with Fehling's reagent.

D X reacts with hydrogen cyanide. X is reduced by lithium aluminium hydride.

1036. 9701_w20_qp_11 Q: 28

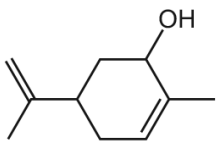
Carvone is found in spearmint oil.

carvone

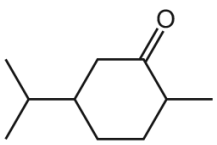


Which product is formed when carvone is reacted with $NaBH_4$?

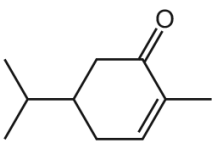
A



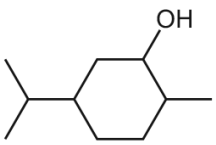
B



C



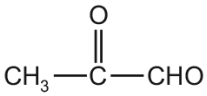
D



1037. 9701_w20_qp_12 Q: 23

Compound X contains two functional groups.

compound X



Which reagent will react with **only one** of the functional groups?

A acidified potassium dichromate(VI)

B 2,4-DNPH reagent

C hydrogen cyanide

D $NaBH_4$

1038. 9701_w20_qp_12 Q: 25

Diols in which both hydroxy groups are bonded to the same carbon atom can spontaneously eliminate a molecule of water to produce a carbonyl compound.

Which compound, after complete hydrolysis, gives a silver mirror with Tollens' reagent?

A 1,1-dibromobutane

B 1,2-dibromobutane

C 1,3-dibromobutane

D 2,2-dibromobutane

1039. 9701_s19_qp_11 Q: 29

Which reagent may be used to distinguish between propanone and ethanol?

A 2,4-dinitrophenylhydrazine

B bromine water

C Fehling's reagent

D Tollens' reagent

1040. 9701_s19_qp_12 Q: 27

Which reagent could be used to distinguish between ethanal and propanal?

A 2,4-dinitrophenylhydrazine

B I_2 / NaOH(aq)

C $K_2Cr_2O_7$ / H_2SO_4(aq)

D Tollens' reagent

1041. 9701_s19_qp_13 Q: 28

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

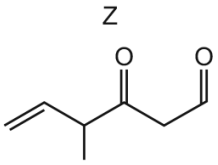
A set of isomeric compounds, with molecular formula $C_5H_{10}O$, all react in a 1 : 1 ratio with an excess of HCN by nucleophilic addition.

How many isomeric compounds are in the set?

A 5 **B** 6 **C** 7 **D** 8

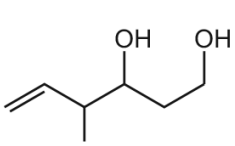
1042. 9701_w19_qp_11 Q: 26

The diagram shows the structure of compound Z.

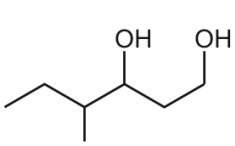


What is the product of the reaction between compound Z and an excess of $NaBH_4$?

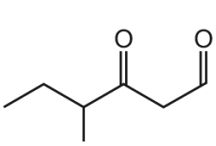
A



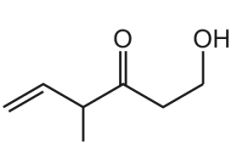
B



C



D



1043. 9701_w19_qp_11 Q: 27

Compound Q shows the following reactions.

- It gives an orange precipitate with 2,4-dinitrophenylhydrazine.
- It gives a red-brown precipitate with Fehling's reagent.
- It gives a pale yellow precipitate with alkaline aqueous iodine.

What could be the identity of Q?

A ethanal

B propan-2-ol

C propanal

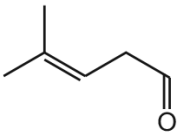
D propanone

1044. 9701_w19_qp_12 Q: 26

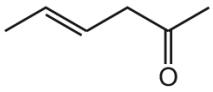
Compound X has stereoisomers and forms a precipitate when warmed with Fehling's reagent.

What could be the structure of compound X?

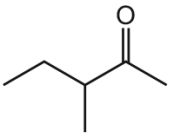
A



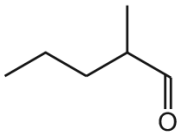
B



C

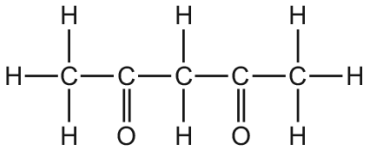


D



1045. 9701_w19_qp_12 Q: 27

The diagram shows the structure of Y.



Two suggestions are made about Y.

1 Y can be oxidised by hot, acidified dichromate(VI) ions.

2 One mole of Y gives one mole of tri-iodomethane when it reacts with an excess of alkaline aqueous iodine.

Which suggestions are correct?

A both 1 and 2

B 1 only

C 2 only

D neither 1 nor 2

1046. 9701_m18_qp_12 Q: 26

Compound X produces a carboxylic acid when heated under reflux with acidified potassium dichromate(VI). Compound X does not react with sodium metal.

What could be the identity of compound X?

A propanal

B propanone

C propan-1-ol

D propan-2-ol

1047. 9701_s18_qp_11 Q: 25

Compound Q

- contains a chiral centre,
- gives a positive result with Fehling's reagent,
- gives a positive result with alkaline aqueous iodine.

What could compound Q be?

A 1-hydroxybutanone

B 2-hydroxybutanal

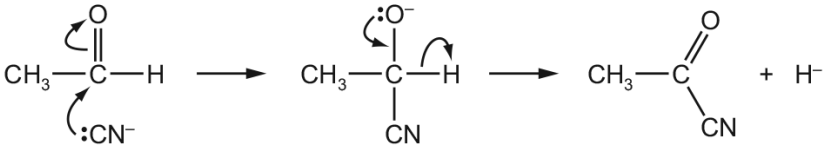
C 3-hydroxybutanal

D 3-hydroxybutanone

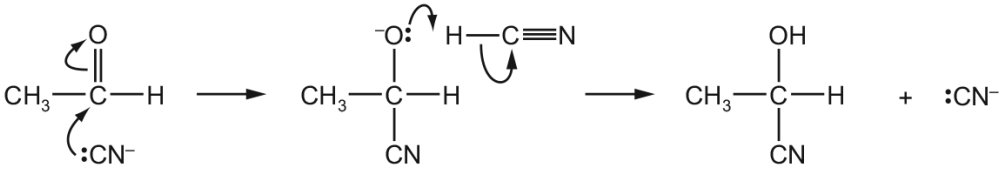
1048. 9701_s18_qp_11 Q: 26

What is the mechanism for the reaction of ethanal, CH_3CHO, with hydrogen cyanide, HCN, in the presence of NaCN?

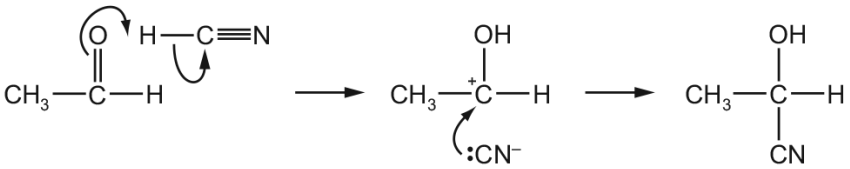
A



B



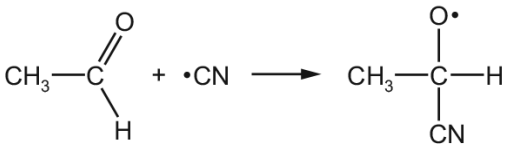
C

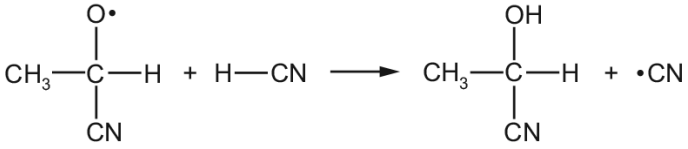


D

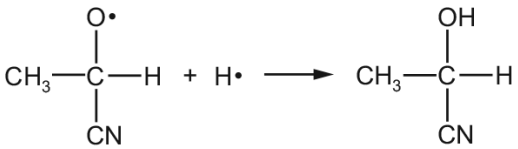
initiation $HCN \longrightarrow H\bullet + \bullet CN$

propagation





termination



1049. 9701_s18_qp_12 Q: 27

Which statement about butanone is correct?

A Butanone can be dehydrated by concentrated sulfuric acid to give CH_2=CHCH=CH_2.

B Butanone gives a positive result with Tollens' reagent.

C Butanone reacts with HCN by an electrophilic addition mechanism.

D Butanone reacts with $NaBH_4$ to give a chiral product.

1050. 9701_w18_qp_11 Q: 27

Which compound shows optical isomerism and gives a positive test with alkaline aqueous iodine?

A $CH_3COCH(OH)CH_3$

B $CH_3COCH_2CH_2OH$

C $HOCH_2CH(CH_3)CHO$

D $(CH_3)_2C(OH)CHO$

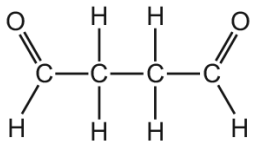
1051. 9701_w18_qp_12 Q: 27

Compound X has the empirical formula C_2H_3O.

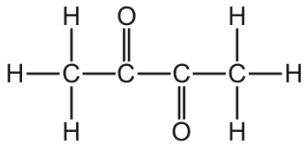
Compound X reacts with 2,4-dinitrophenylhydrazine reagent to give an orange precipitate and also decolourises warmed acidified potassium manganate(VII) solution.

What could be the identity of X?

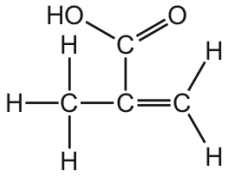
A



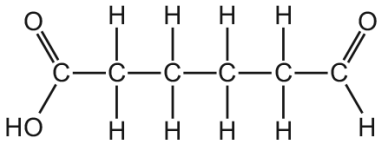
B



C



D



1052. 9701_m17_qp_12 Q: 25

Diols in which both hydroxy groups are bonded to the same carbon can spontaneously eliminate a molecule of water to produce a carbonyl compound.

Which compound, after complete hydrolysis, gives a positive reaction with Tollens' reagent?

A 1,1-dibromobutane

B 1,2-dibromobutane

C 1,3-dibromobutane

D 2,2-dibromobutane

1053. 9701_m17_qp_12 Q: 28

$CH_3CH_2COCH_2CH_3$ 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.

1054. 9701_m17_qp_12 Q: 29

Compound X, $CH_3CH(OH)CH(CHO)CH_3$, is heated under reflux with an excess of acidified $K_2Cr_2O_7$ to form compound Y.

Both X and Y are separately warmed with Fehling's solution and the observations noted.

What are the observations?

A Both X and Y give a red precipitate.

B Only X gives a red precipitate.

C Only Y gives a red precipitate.

D Neither X nor Y gives a red precipitate.

1055. 9701_s17_qp_11 Q: 20

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

Each of the following carbonyl compounds is reacted with $NaBH_4$. The product of each reaction is heated with Al_2O_3 at 600 °C, generating one product or a mixture of isomers.

Which carbonyl compound will produce the most isomers?

A butanal

B butanone

C pentan-3-one

D propanone

1056. 9701_s17_qp_11 Q: 25

Diols in which both hydroxy groups are bonded to the same carbon atom spontaneously eliminate a molecule of water to produce a carbonyl compound.

Which compound is hydrolysed to form a product that gives a positive reaction with 2,4-dinitrophenylhydrazine but **not** with Fehling's reagent?

A 1,1-dibromopropane

B 1,2-dibromopropane

C 1,3-dibromopropane

D 2,2-dibromopropane

1057. 9701_s17_qp_11 Q: 29

Which compound gives a positive test with alkaline aqueous iodine and does **not** show optical isomerism?

A $CH_3COCH_2CH_2OH$

B $CH_3CH_2CH(OH)CHO$

C $CH_3COCH(OH)CH_3$

D $(CH_3)_2C(OH)CHO$

1058. 9701_s17_qp_12 Q: 20

A carbonyl compound **X** will react 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 **X**?

A butanal

B butanone

C propanal

D propanone

1059. 9701_s17_qp_12 Q: 27

$H_2NNHC_6H_3(NO_2)_2$ is the structural formula of 2,4-DNPH.

Many, but not all, organic reactions need to be heated before reaction occurs.

Which reaction occurs at a good rate at room temperature (20 °C)?

A $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$

B $CH_3CH_2CH_2Br + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HBr$

C $CH_3CH_2OH + KBr \rightarrow CH_3CH_2Br + KOH$

D $(CH_3)_2CO + H_2NNHC_6H_3(NO_2)_2 \rightarrow (CH_3)_2C{=}NNHC_6H_3(NO_2)_2 + H_2O$

1060. 9701_s17_qp_13 Q: 22

The formulae of three compounds are shown.

C_3H_7CHO $C_2H_5COCH_3$ $CH_2CHCH_2CH_2OH$

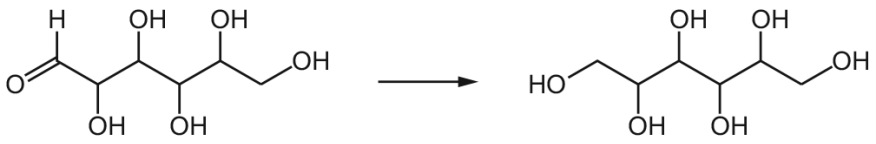
Only one of these compounds will decolourise bromine water. Only one of these compounds will produce a silver mirror with Tollens' reagent.

Which row shows the correct results?

	decolourises bromine water	forms a silver mirror with Tollens' reagent
A	C_3H_7CHO	$C_2H_5COCH_3$
B	$C_2H_5COCH_3$	C_3H_7CHO
C	$CH_2CHCH_2CH_2OH$	$C_2H_5COCH_3$
D	$CH_2CHCH_2CH_2OH$	C_3H_7CHO

1061. 9701_w17_qp_11 Q: 26

Glucose can be used to prepare sorbitol, a compound used as a sugar substitute.



glucose sorbitol

Which reagent may be used for this conversion?

A acidified potassium dichromate(VI)

B sodium borohydride

C sodium hydroxide

D Tollens' reagent

1062. 9701_w17_qp_12 Q: 24

2,3-dimethylpent-2-ene, $(CH_3)_2C=C(CH_3)CH_2CH_3$, is treated with cold, dilute $KMnO_4$. The product of this reaction is treated with an excess of concentrated H_2SO_4 at 180 °C, giving a mixture of isomeric hydrocarbons with molecular formula C_7H_{12}.

What is the name of one of the isomeric hydrocarbons?

A 2,3-dimethylpenta-1,2-diene

B cis-2,3-dimethylpenta-1,3-diene

C 2,3-dimethylpenta-1,4-diene

D 3,4-dimethylpenta-1,3-diene

1063. 9701_w17_qp_12 Q: 29

Compound G

- has a chiral centre,
- gives a positive result with alkaline aqueous iodine,
- does not give a silver mirror with Tollens' reagent.

What could compound G be?

A 1-hydroxybutan-2-one

B 2-hydroxybutanal

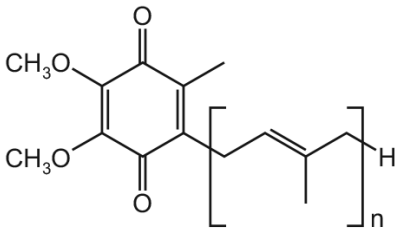
C 3-hydroxybutanal

D 3-hydroxybutan-2-one

1064. 9701_m16_qp_12 Q: 20

People who take statin drugs to control their blood cholesterol may also take 'coenzyme Q_{10}'.

The diagram shows a simplified structure of one form of this coenzyme.



coenzyme Q_{10}

Which row describes this structure correctly?

	the coenzyme is	number of π bonds in one molecule
A	an aldehyde	*n* + 2
B	an aldehyde	*n* + 4
C	a ketone	*n* + 2
D	a ketone	*n* + 4

1065. 9701_s16_qp_11 Q: 24

Alcohol Y gives product Z after mild oxidation. Z gives a positive result with Tollens' reagent and with 2,4-dinitrophenylhydrazine reagent.

What could be the identity of alcohol Y?

A butan-1-ol

B butan-2-ol

C butan-2,3-diol

D 2-methylbutan-2-ol

1066. 9701_s16_qp_11 Q: 28

Which reagent **cannot** be used to distinguish between ethanal and propanone?

A acidified sodium dichromate(VI) solution

B alkaline aqueous iodine

C cold acidified potassium manganate(VII) solution

D Fehling's reagent

1067. 9701_s16_qp_12 Q: 26

Which organic compound would **not** give **either** a yellow precipitate when treated with alkaline aqueous iodine **or** an orange precipitate when treated with 2,4-dinitrophenylhydrazine reagent?

A propanal

B propan-1-ol

C propan-2-ol

D propanone

1068. 9701_s16_qp_12 Q: 27

In which reaction is the organic compound oxidised?

A $CH_3CH_2CH_2CHO$ + Tollens' reagent

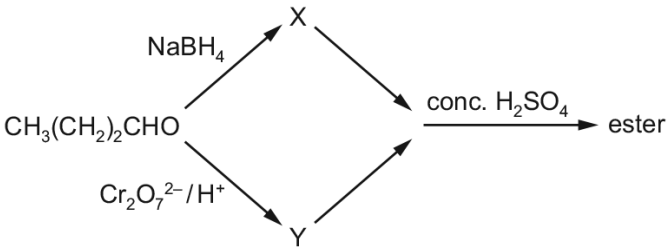
B $CH_3CH_2CH_2CHO$ + $LiAlH_4$

C $CH_3CH_2CH_2OH$ + concentrated H_3PO_4

D $CH_3CO_2C_2H_5$ + dilute H_2SO_4

1069. 9701_s16_qp_13 Q: 22

An ester with an aroma of pineapples can be synthesised in the laboratory from butanal using this reaction scheme.



What is the structural formula of the **ester**?

A $CH_3(CH_2)_2CO_2(CH_2)_2CH_3$

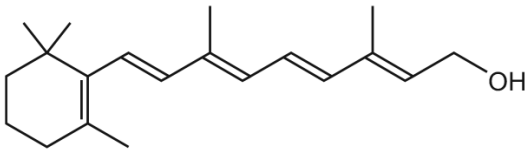
B $CH_3(CH_2)_2CO_2(CH_2)_3CH_3$

C $CH_3(CH_2)_3CO_2(CH_2)_2CH_3$

D $CH_3(CH_2)_3CO_2(CH_2)_3CH_3$

1070. 9701_s16_qp_13 Q: 24

Vitamin A contains retinol.



retinol

Under appropriate conditions, acidified $KMnO_4(aq)$ can be used to break apart C=C bonds.

After these bonds have been broken, further oxidation of the fragments may occur.

Under which conditions is the acidified $KMnO_4(aq)$ used and what do the final oxidation products include?

	conditions	final oxidation products
A	cold, dilute	aldehydes and carboxylic acids
B	cold, dilute	ketones and carboxylic acids
C	hot, concentrated	aldehydes and carboxylic acids
D	hot, concentrated	ketones and carboxylic acids

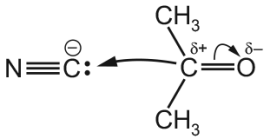
1071. 9701_w16_qp_11 Q: 26

Propanone reacts with an aqueous mixture of HCN and NaCN by a nucleophilic addition mechanism.

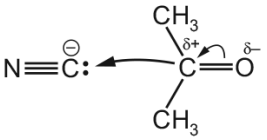
The first stage of the mechanism involves attack by cyanide ions.

Which diagram correctly represents this?

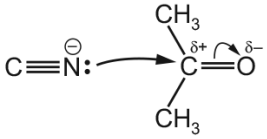
A



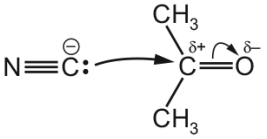
B



C

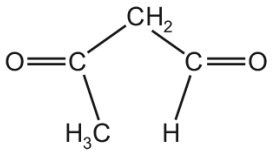


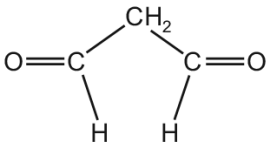
D

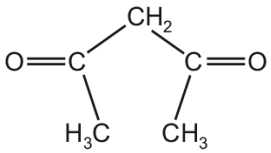


1072. 9701_w16_qp_11 Q: 27

P, Q and R are carbonyl compounds.


P


Q


R

Fehling's solution can be used to help identify these compounds.

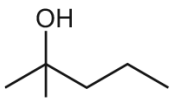
Which compounds form a red-brown precipitate on warming with Fehling's solution?

A P, Q and R **B** P and Q only **C** P only **D** Q only

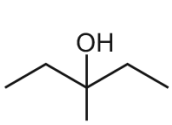
1073. 9701_w16_qp_12 Q: 25

Which compound can be oxidised by acidified potassium manganate(VII) to give 3-methylpentan-2-one?

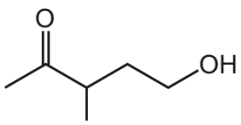
A



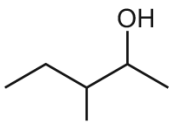
B



C



D



1074. 9701_w16_qp_12 Q: 28

Which row correctly describes the reactivity of aldehydes and ketones?

	with $NaBH_4$	with $H^+/Cr_2O_7^{2-}(aq)$
A	both react	both react
B	both react	only aldehydes react
C	only ketones react	both react
D	only ketones react	only aldehydes react

1075. 9701_s15_qp_11 Q: 20

Which reagent will give a different observation with compounds P and Q?

$HOCH_2CH(OH)CHO$ P $\qquad$ $HOCH_2COCH_2OH$ Q

A $Br_2(aq)$

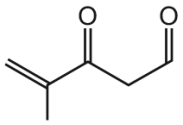
B hot acidified $KMnO_4$

C silver nitrate in ammonia solution

D warm acidified $K_2Cr_2O_7$

1076. 9701_s15_qp_12 Q: 27

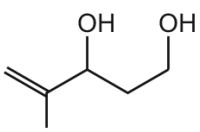
The diagram shows the structure of compound X.



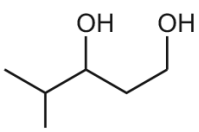
X

What is the product of the reaction between compound X and an excess of $NaBH_4$?

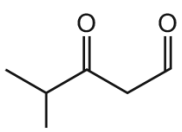
A



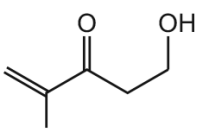
B



C

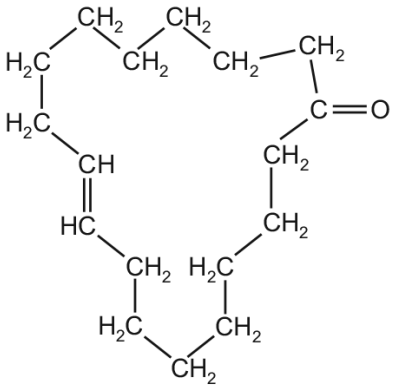


D



1077. 9701_s15_qp_13 Q: 24

The naturally-occurring molecule civetone is found in a gland of the African civet cat and has been used in perfumery.



civetone

Which reagent will **not** react with civetone?

A 2,4-dinitrophenylhydrazine reagent

B Fehling's reagent

C hydrogen bromide

D sodium tetrahydridoborate(III), $NaBH_4$

1078. 9701_w15_qp_11 Q: 26

Which compound **cannot** be oxidised by acidified potassium dichromate(VI) solution but **does** react with sodium metal?

A $(CH_3)_3COH$

B $CH_3COCH_2CH_3$

C $CH_3CH_2CH_2CH_2OH$

D $CH_3CH_2CH(OH)CH_3$

1079. 9701_w15_qp_11 Q: 27

Butan-2-ol can be made by reducing X with H_2/Ni.

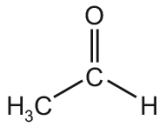
Butan-2-ol can be dehydrated to form Y and Z which are structural isomers of each other.

Which row is correct?

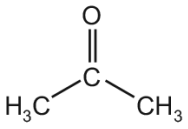
	X is	*cis-trans* isomerism is shown by
A	an aldehyde	both Y and Z
B	an aldehyde	only one of Y and Z
C	a ketone	both Y and Z
D	a ketone	only one of Y and Z

1080. 9701_w15_qp_11 Q: 28

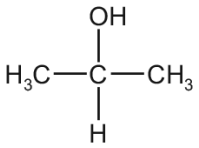
Tollens' reagent can be used to help identify compounds P, Q and R.



P



Q



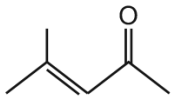
R

Which compound(s) form a silver precipitate on warming with Tollens' reagent?

A P and Q **B** P only **C** Q only **D** R only

1081. 9701_w15_qp_12 Q: 23

Compound Q can be made from propanone.



Q

Which types of reaction will Q undergo?

A nucleophilic addition and electrophilic addition

B nucleophilic addition and nucleophilic substitution

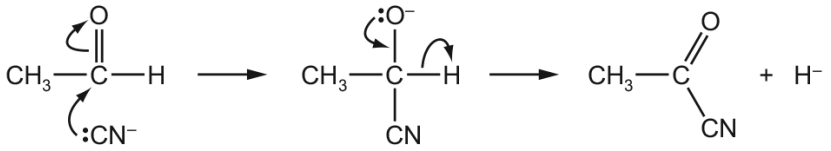
C nucleophilic addition only

D nucleophilic substitution and electrophilic addition

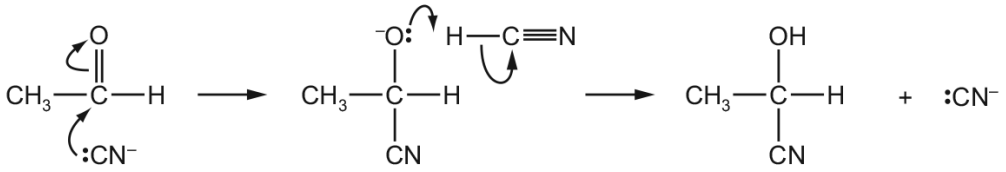
1082. 9701_w15_qp_12 Q: 27

What is the mechanism for the reaction of ethanal, CH_3CHO, with hydrogen cyanide, HCN, in the presence of a base?

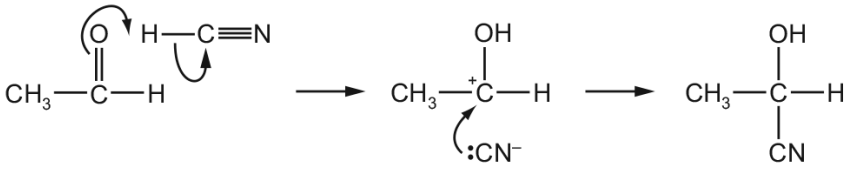
A



B



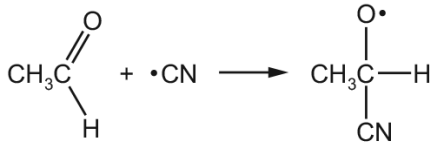
C

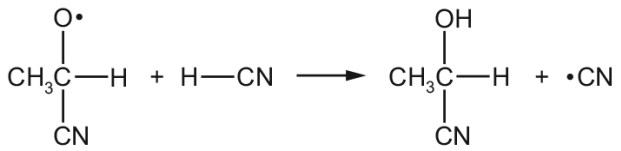


D

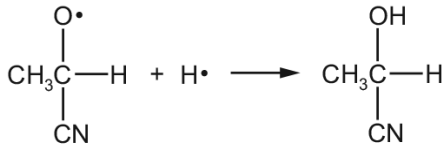
initiation $HCN \longrightarrow H\bullet + \bullet CN$

propagation



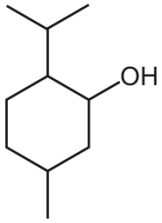


termination

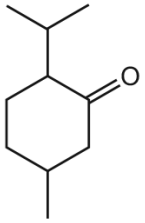


1083. 9701_w15_qp_12 Q: 28

Menthol and menthone are both found in peppermint oil.



menthol



menthone

Which statement about these compounds is correct?

A Both compounds can undergo mild oxidation.

B Both compounds will give an orange precipitate with 2,4-dinitrophenylhydrazine reagent.

C Menthol can be formed from menthone by reaction with $NaBH_4$.

D Menthone gives a positive test when warmed with Tollens' reagent.

Chapter 17

Carbonyl compounds

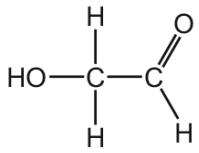
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17.1 Aldehydes and ketones

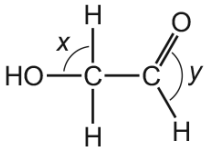
134. 9701_m21_qp_22 Q: 4

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.

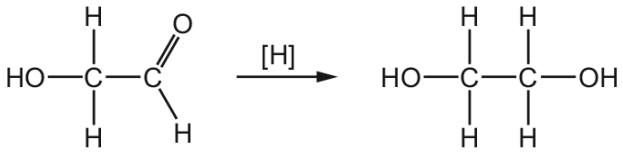
.....

.....

..... [2]

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

hydroxyethanal ethane-1,2-diol



(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]

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

Name **A**.

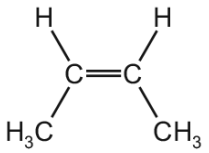
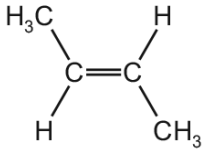
..... [1]

[Total: 10]

135. 9701_s21_qp_22 Q: 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]

(c) A sample of propan-1-ol reacts with concentrated sulfuric acid to form propene.

Identify the role of concentrated sulfuric acid in this reaction.

..... [1]

(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]

[Total: 12]

136. 9701_w21_qp_21 Q: 3

Phosphorus is a reactive Period 3 element.

(a) Phosphorus has several allotropes. Details of two allotropes are given.

allotrope of phosphorus	formula	melting point / °C
white	P_4	44
red	P	590

(i) White phosphorus and red phosphorus both have covalent bonding.

Suggest the types of structure shown by white phosphorus (P_4) and red phosphorus (P).

Explain why red phosphorus (P) has a higher melting point than white phosphorus (P_4).

structure of P_4 .....

structure of P .....

explanation .....

.....

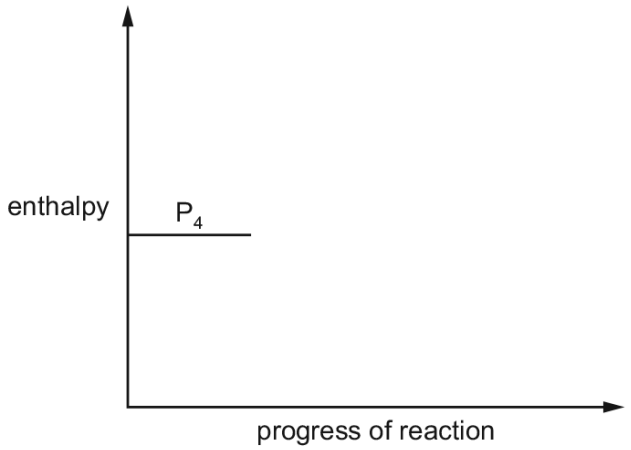
.....

[3]

(ii) Red phosphorus (P) forms when white phosphorus (P_4) is exposed to sunlight.

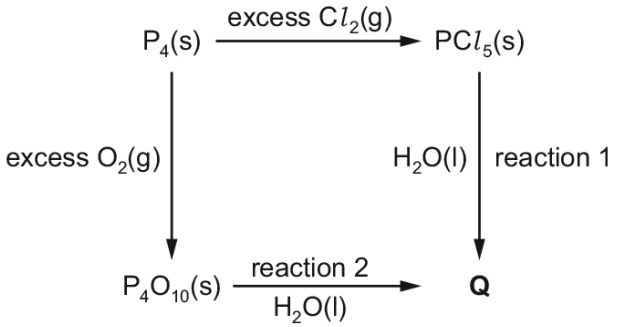
$$\underset{\text{white}}{\tfrac{1}{4}P_4(s)} \rightarrow \underset{\text{red}}{P(s)} \qquad \Delta H = -17.6\,\text{kJ mol}^{-1}$$

Use this information to draw a reaction pathway diagram to show the formation of red phosphorus (P) from white phosphorus (P_4).



[1]

(b) Some reactions of $P_4(s)$ are shown in the reaction scheme.



(i) State the oxidation number of phosphorus in P_4O_{10}.

..... [1]

(ii) Deduce the identity of **Q** and hence construct chemical equations for reactions 1 and 2.

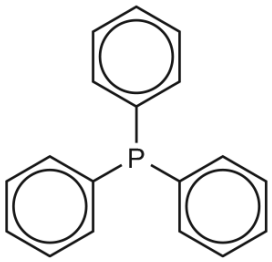
reaction 1 PCl_5 + ...H_2O → .....

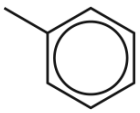
reaction 2 P_4O_{10} + ...H_2O → .....

[2]

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

triphenylphosphine

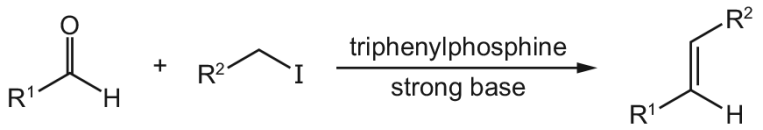


where  = $-C_6H_5$

(i) Give the empirical formula of triphenylphosphine.

..... [1]

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 $C_2H_5CHO \xrightarrow{NaBH_4}$ **G**

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

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

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

stage 1 .....

stage 2 .....

[2]

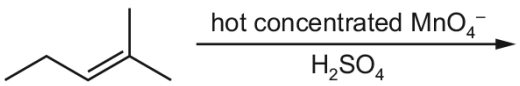
(iii) Draw the structures of **G** and **H** in the boxes provided.

G	**H**

[2]

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

J



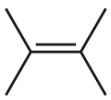
[2]

[Total: 14]

137. 9701_w21_qp_22 Q: 3

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

T



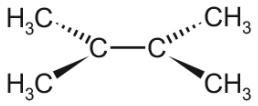
(a) Name **T**.

..... [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.

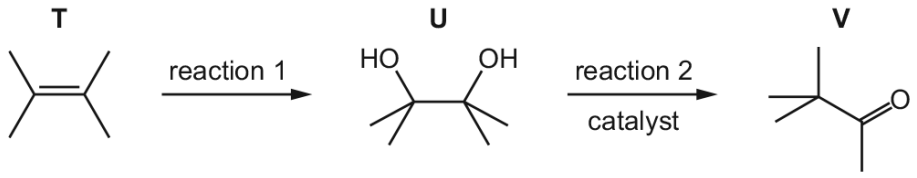


(i) On the diagram, draw the orbitals that represent the pi (π) bond that is also present in **T**. [1]

(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]

(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]

(iii) The progress of reaction 2 can be monitored by infrared spectroscopy.

The absorption caused by O–H bonds is always present because water is used as a solvent.

Identify two absorptions, and the bonds responsible for these absorptions, whose appearance will change significantly during the reaction.

1 .....

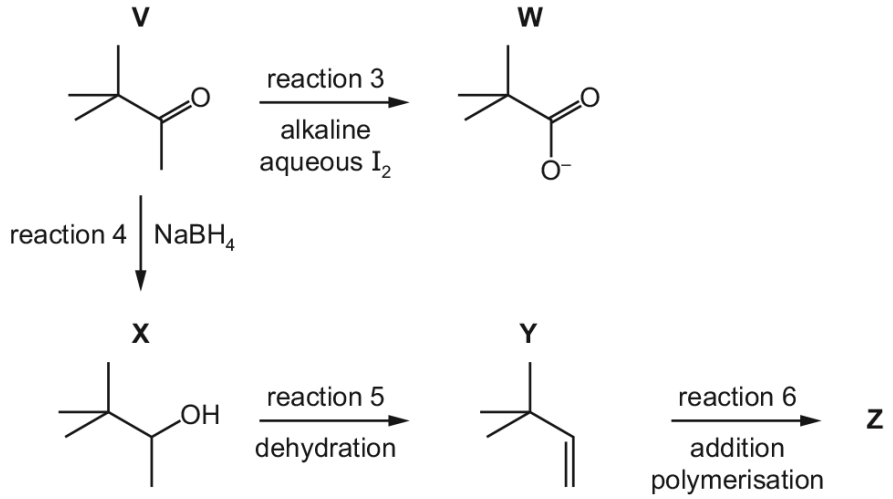
.....

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]

(v) Both optical isomers of **X** can be dehydrated to form a single product, **Y**.
Give the reagent(s) and conditions required for reaction 5.

..... [1]

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

Draw one repeat unit of **Z**.

[1]

vii) Reaction 6 does not proceed quickly at room temperature.

Suggest why this is the case.

.....

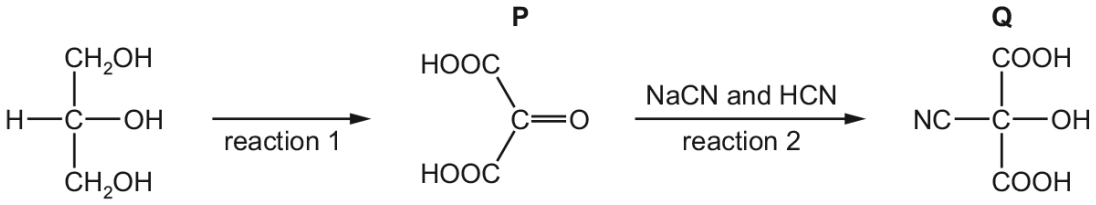
..... [1]

[Total: 17]

138. 9701_m20_qp_22 Q: 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.

.....

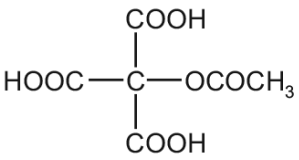
.....

.....

..... [1]

(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]

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(b) Glycerol can be used as a starting material in the manufacture of nitroglycerine, $C_3H_5N_3O_9$.

Nitroglycerine decomposes rapidly on heating to form a mixture of gases.

$$4C_3H_5N_3O_9(l) \rightarrow 12CO_2(g) + 10H_2O(g) + 6N_2(g) + O_2(g)$$

A sample of nitroglycerine decomposes, releasing 1.06 dm^3 of $O_2(g)$ at 850 K and 1.00×10^5 Pa.

(i) Calculate the mass of nitroglycerine that decomposes.

mass of nitroglycerine = ... g [3]

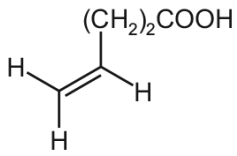
(ii) Calculate the total volume of gas released by this decomposition at 850 K and 1.00×10^5 Pa.

total volume of gas = ... dm^3 [1]

(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.

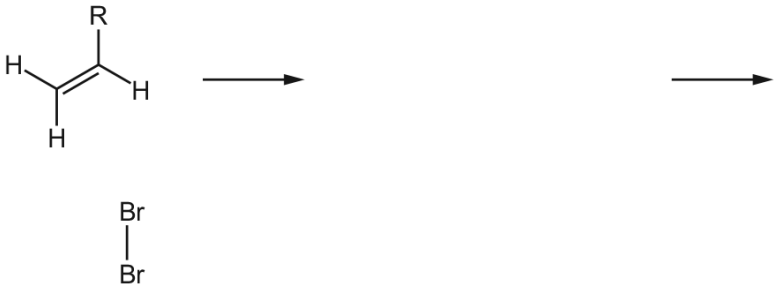
[1]

(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]

(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]

(iii) The C–Br bond has an absorption between 500 cm^{-1} and 600 cm^{-1} in an infrared spectrum.

The infrared spectra for both **T** and **U** have absorptions between 2850 cm^{-1} and 2950 cm^{-1}. These correspond to C–H bonds.

Identify:

- two other absorptions that would be seen in the infrared spectra of both **T** and **U**
- one other absorption that would **only** be seen in the infrared spectrum of **T**.

For each absorption, give the range of the absorption and the bonds that correspond to these absorptions.

absorption 1 present in both spectra .....

.....

.....

absorption 2 present in both spectra .....

.....

.....

absorption **only** present in spectrum of **T** .....

.....

.....

[3]

[Total: 24]

---

139. 9701_s20_qp_21 Q: 5

(a) Below is a list of species which can react with organic compounds.

CN^- HCl Cl H_2O CO_3^{2-}

(i) From the list, identify a species which can react with ethane.

..... [1]

(ii) From the list, identify **two** species which can attack the π bond in ethene.

..... [1]

(iii) From the list, identify a species which can be used to distinguish between solutions of propanoic acid and propan-1-ol. Describe any relevant observations.

.....

.....

..... [2]

(b) Cl(g) can be made from Cl_2(g).

(i) Describe the conditions required for this process.

..... [1]

(ii) Name this process.

..... [1]

(c) **(i)** Name an organic functional group which reacts with a nucleophile in an addition reaction.

..... [1]

(ii) Name an organic functional group which tends to react with a nucleophile in an S_N1 substitution mechanism.

..... [1]

(d) But-1-ene reacts with steam in the presence of concentrated phosphoric acid to form two isomers of molecular formula $C_4H_{10}O$.

Each reaction occurs via a different intermediate ion.

(i) Draw the structure of both intermediate ions.

[2]

(ii) Circle the more stable intermediate ion drawn in **(d)(i)**. Explain your answer.

.....

.....

..... [2]

[Total: 12]

---

140. 9701_w20_qp_22 Q: 3

PCl_5, PCl_3 and NCl_3 are halides of Group 15 elements.

(a) PCl_5 can be formed from the reaction of phosphorus with chlorine. PCl_5 has a melting point of 161 °C.

(i) Write an equation for the formation of PCl_5 from the reaction of phosphorus and chlorine.

..... [1]

(ii) State the type of structure and bonding shown by liquid PCl_5.

..... [1]

(b) A small amount of PCl_5 is added to excess water. The PCl_5 reacts vigorously to form a colourless solution.

(i) Give **one** other observation you would make when PCl_5 reacts with excess water.

..... [1]

(ii) Write the equation for the reaction of PCl_5 with excess water.

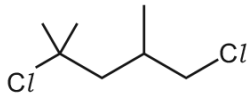
..... [1]

(iii) Estimate the pH of the resulting solution.

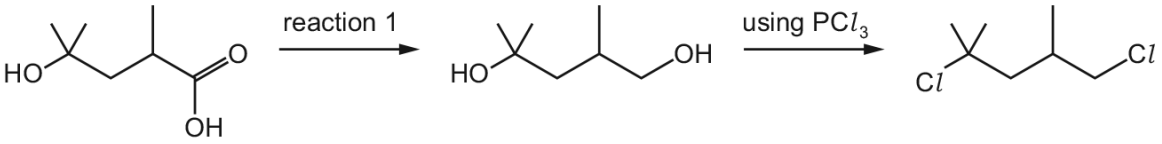
..... [1]

(c) PCl_3 is used to convert alcohols to chloroalkanes, such as compound **T**.

T



A possible synthesis of **T** is shown.



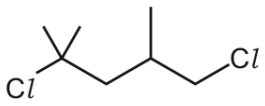
(i) Identify a reagent that could be used in reaction 1.

..... [1]

(ii) **T** exhibits optical isomerism.

Explain what is meant by the term *optical isomer* and circle any atom(s) in **T** that give rise to optical isomerism.

T



.....

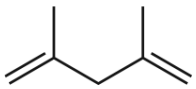
.....

.....

[2]

(iii) **T** is a **minor** product in the reaction of compound **S** with excess HCl.

S



Draw the structure of the **major** product of the reaction of **S** with excess HCl.

[1]

(d) NCl_3 is a yellow liquid that can be used to bleach flour.

(i) Predict the shape of the NCl_3 molecule and the Cl–N–Cl bond angle.

shape .....

bond angle .....
[2]

(ii) NCl_3 reacts with water to form HOCl, a weak Brønsted-Lowry acid.

Explain fully what is meant by the term *weak Brønsted-Lowry acid*.

.....

.....

..... [2]

(iii) NCl_3(l) decomposes according to the equation shown.

$$2NCl_3(l) \rightarrow N_2(g) + 3Cl_2(g)$$

A sealed container of volume 250 cm^3 contains an unreactive gas at a pressure of 1.00×10^5 Pa.

0.241 g of NCl_3(l) was injected into the sealed container.

The sealed container was heated to make the NCl_3(l) decompose fully and then cooled to 20 °C.

Calculate the final **total** pressure inside the sealed container at 20 °C after the NCl_3(l) has fully decomposed.

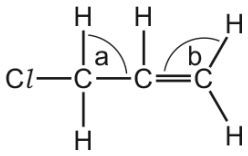
final **total** pressure = ... Pa
[4]

[Total: 17]

141. 9701_s19_qp_21 Q: 4

The structure of compound **Y** is shown.

Y



(a) Give the systematic name for **Y**.

..... [1]

(b) Predict the values for the bond angles a and b shown in the diagram.

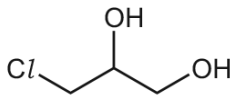
a .....

b .....

[2]

(c) When **Y** reacts with cold, dilute, acidified manganate(VII) ions, compound **Z** is produced.

Z



(i) State the molecular formula of **Z**.

..... [1]

(ii) Name the type of reaction occurring when **Y** is converted into **Z**.

..... [1]

(iii) Alcohols can be classified as primary, secondary or tertiary.

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

	alcohol group present in **Z**
primary	
secondary	
tertiary	

[1]

(d) Samples of organic compounds, **A**, **B**, **C** and **D**, are placed in unlabelled bottles.

A	**B**	**C**	**D**
$CH_3CH_2COCH_3$	$CH_3(CH_2)_2CHO$	CH_3CH_2OH	CH_3CO_2H

(i) Identify all of the compound(s), **A–D**, that contain a carbonyl group.

..... [1]

(ii) **A–D** are reacted separately with the reagents given in the table.

Complete the table to:
- identify which of the compounds, **A–D**, reacts with the reagents
- give an appropriate observation when a reaction occurs.

reagent	compounds identified	observation when a reaction occurs
Tollens' reagent		
alkaline solution of iodine		
sodium metal		

[8]

[Total: 15]

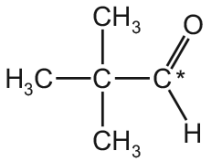
142. 9701_w19_qp_21 Q: 4

$(CH_3)_3CCHO$ is used in the synthesis of some antibiotics.

(a) (i) Give the name of $(CH_3)_3CCHO$.

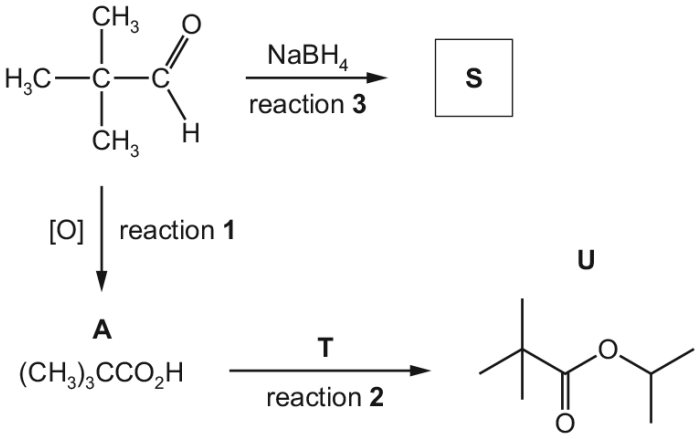
..... [1]

(ii) State the hybridisation of the carbon atom labelled with an asterisk, *.



..... [1]

(b) Two reaction sequences are shown.



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

Identify the reagent(s) and conditions for reaction **1**.

..... [1]

(ii) **A**, $(CH_3)_3CCO_2H$, is a solid at room temperature.

B, $CH_3CO_2(CH_2)_2CH_3$, is an isomer of **A**. **B** is a liquid at room temperature.

Explain the difference in the physical states of **A** and **B**, with reference to any intermolecular forces that may exist.

.....

.....

.....

..... [3]

(iii) Give the balanced equation for the reaction of $(CH_3)_3CCHO$ with $NaBH_4$ to form **S**.

Use [H] to represent an atom of hydrogen provided by $NaBH_4$.

..... [1]

(iv) Draw the structure of the organic molecule **T** that reacts with **A**, $(CH_3)_3CCO_2H$, in reaction **2**, to form **U**.

Suggest a catalyst for reaction **2**.

T

catalyst .....

[2]

(c) **X**, **Y** and **Z** are all isomers of $(CH_3)_3CCHO$.

A summary of some of the reactions and properties of **X**, **Y** and **Z** is shown in the table.

compound	observations with 2,4-DNPH	observations with Fehling's solution	principal absorptions in infra-red spectrum
X		no reaction	1715 cm^{-1}
Y		red precipitate	1730 cm^{-1}
Z	no reaction	no reaction	3200–3600 cm^{-1} 1630 cm^{-1} 1050 cm^{-1}

(i) **X** and **Y** each contains a carbonyl group.

Complete the table with the expected observations for the reactions of **X** and **Y** with 2,4-DNPH. [1]

(ii) Identify the functional group present in **Y** that causes the recorded observation with Fehling's solution.

..... [1]

(iii) **Y** has a chiral centre and exists as a pair of optical isomers.

State what is meant by the term *chiral centre*.

.....

..... [1]

(iv) Draw the optical isomers of **Y** using the conventional three-dimensional representation.

[2]

Z, $C_5H_{10}O$, has a branched carbon chain. It shows geometrical isomerism.

(v) Complete the table with the bond responsible for each of the principal absorptions seen in the infra-red spectrum of **Z**.

principal absorptions in infra-red spectrum	bond responsible
3200–3600 cm^{-1}	
1630 cm^{-1}	
1050 cm^{-1}	

[1]

(vi) Draw the skeletal formula of **Z**.

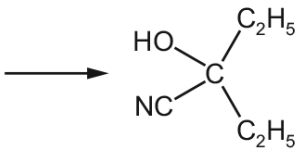
[3]

(vii) **X** contains a carbonyl group. **X** reacts with HCN, in the presence of a small amount of NaCN, to form $(C_2H_5)_2C(OH)CN$ as shown.

$$\mathbf{X} + HCN \rightarrow (C_2H_5)_2C(OH)CN$$

Draw the mechanism of the reaction of **X** with HCN.

- Draw the structure of **X** and the intermediate.
- Include all charges, partial charges, lone pairs and curly arrows.



[3]

(viii) State the role of NaCN in the reaction in **(c)(vii)**.

..... [1]

[Total: 22]

143. 9701_m18_qp_22 Q: 3

Calcium and its compounds have a large variety of applications.

(a) Calcium metal reacts readily with most acids.

(i) Write an equation for the reaction of calcium with dilute nitric acid. State symbols are **not** required.

..... [1]

(ii) When calcium metal is placed in dilute sulfuric acid, it reacts vigorously at first.

After a short time, a crust of calcium sulfate forms on the calcium metal and the reaction stops. Some of the calcium metal and dilute sulfuric acid remain unreacted.

Suggest an explanation for these observations.

.....

.....

.....

..... [2]

(b) Calcium ethanedioate is formed when calcium reacts with ethanedioic acid, $(CO_2H)_2$. The compound contains one cation and one anion.

(i) Draw the 'dot-and-cross' diagram of the cation present in calcium ethanedioate. Show **all** electrons.

[1]

(ii) Draw the displayed formula of the anion present in calcium ethanedioate.

[2]

(c) Calcium chlorate(I), $Ca(ClO)_2$, is used as an alternative to sodium chlorate(I), $NaClO$, in some household products.

(i) Suggest a use for calcium chlorate(I).

..... [1]

(ii) The chlorate(I) ion is formed when cold aqueous sodium hydroxide reacts with chlorine.

Write an **ionic** equation for this reaction. State symbols are **not** required.

..... [1]

(iii) The chlorate(I) ion is unstable and decomposes when heated as shown.

Deduce the oxidation number of chlorine in each species. Complete the boxes.

$$3ClO^- \rightarrow 2Cl^- + ClO_3^-$$

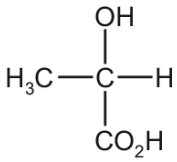
oxidation number of chlorine:	+1		

[1]

(iv) In terms of electron transfer, state what happens to the chlorine in the reaction in **(iii)**.

..... [1]

(d) Calcium lactate is used in some medicines. It forms when lactic acid (2-hydroxypropanoic acid) reacts with calcium carbonate.

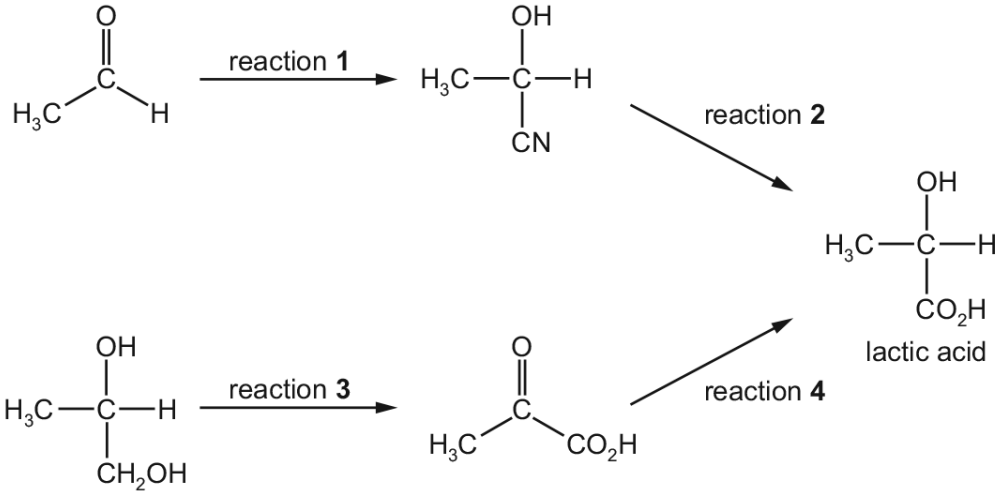


lactic acid

(i) Identify the **two** other products of the reaction of lactic acid with calcium carbonate.

..... [1]

Two possible methods of making lactic acid are shown.



(ii) State suitable reagents and conditions for reactions **1** and **3**.

reaction	reagents and conditions
1	
3	

[4]

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

..... [1]

(iv) Reaction **4** uses $NaBH_4$.

Identify the role of $NaBH_4$ in this reaction.

..... [1]

(v) Lactic acid has a chiral centre.

State what is meant by the term *chiral centre*.

.....

.....

..... [1]

[Total: 18]

144. 9701_s18_qp_22 Q: 4

W is $CH_3COCH_2CH_3$.

(a) The reaction between **W** and alkaline aqueous iodine produces a yellow precipitate.

(i) Give the name of the compound formed as a yellow precipitate in this reaction.

..... [1]

(ii) Give the name of **W**.

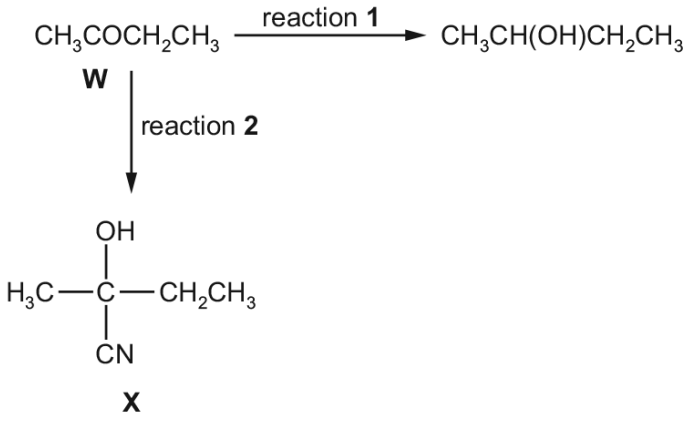
..... [1]

(b) There are two structural isomers of **W** that are also carbonyl compounds.

Draw the structures of these two isomers of **W**.

[2]

Two reactions of **W** are shown.



(c) **(i)** Identify the type of reaction occurring in reaction **1**.

..... [1]

(ii) Identify the reagent for reaction **1**.

..... [1]

(d) Reaction **2** is carried out by adding a mixture of HCN and NaCN to **W**.
The product, **X**, is formed as a mixture of two isomers.

(i) Complete the mechanism for this reaction.

Include the structure of the intermediate formed and all necessary charges, dipoles, lone pairs and curly arrows.

W



CN^- **X**

[4]

(ii) State the name of the type of isomerism shown by **X**.

..... [1]

(iii) Explain fully why **X** shows this type of isomerism.

.....

.....

.....

..... [2]

(e) If **X** is treated with ammonia and the product hydrolysed, a compound, **Y**, is obtained that contains 51.3% C, 9.40% H, 12.0% N and 27.3% O by mass.

(i) Show that the empirical formula of **Y** is $C_5H_{11}NO_2$.

[2]

(ii) The empirical formula of **Y** is $C_5H_{11}NO_2$ and the M_r of **Y** is 117.

Deduce the molecular formula of **Y**. You **must** explain your reasoning.

molecular formula = ...

.....

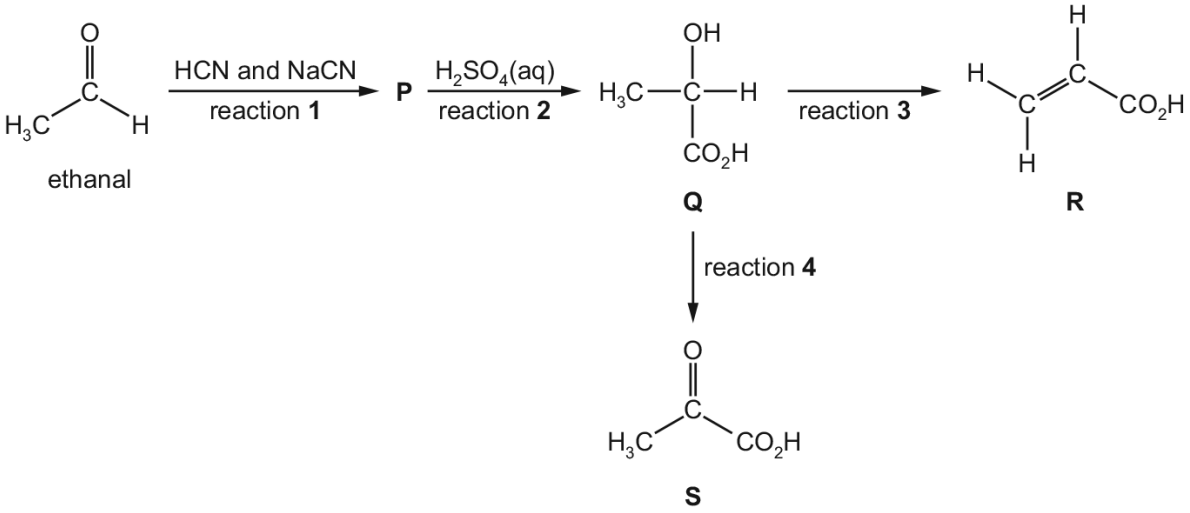
.....

[1]

[Total: 16]

145. 9701_w18_qp_22 Q: 4

The diagram shows a reaction sequence starting from ethanal.



(a) (i) Draw the **displayed** formula of **P**.

[1]

(ii) Name the type of chemical reaction that occurs in reaction **3**.

..... [1]

(iii) Write an equation to represent reaction **4**.

Use [O] to represent the oxidising agent.

..... [1]

(iv) State the reagents and conditions for reaction **4**.

..... [1]

STEMUP.CO.UK

(b) Compound **Q** is formed as a mixture of two optical isomers.

(i) Explain what is meant by the term *optical isomers*.

.....

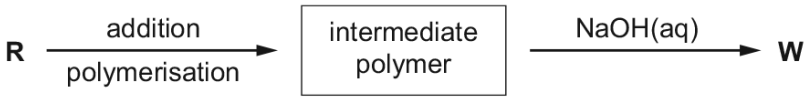
.....

..... [1]

(ii) Draw the **two** optical isomers of **Q**, showing clearly their three-dimensional structures.

[2]

(c) **R** can be used to make a polymer, **W**, in two steps.



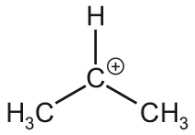
Draw one repeat unit of **W**.

[3]

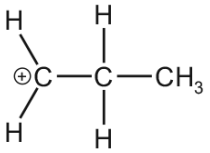
(d) Compound **Z**, $H_2C{=}CHCH_3$, is produced from **R**.

Z can be used in a two-step process to produce 2-aminopropane.

(i) In the first step, **Z** reacts with HBr to form two products. The structure of the product depends on which intermediate is formed, intermediate **I** or intermediate **II**.



intermediate **I**



intermediate **II**

Explain why intermediate **I** is more likely to form than intermediate **II**.

.....

.....

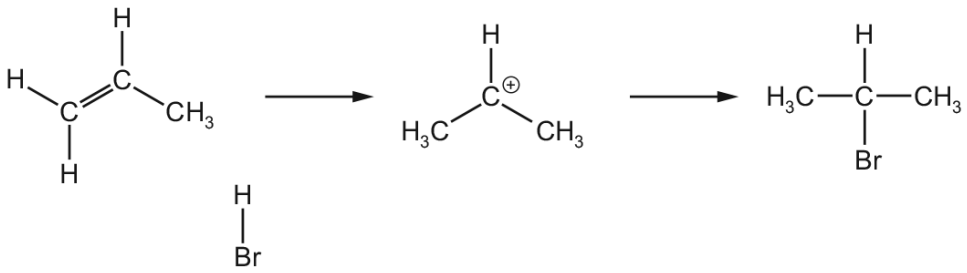
.....

..... [2]

(ii) When intermediate **I** forms, the product of the first step is **T**.

Complete the diagram to show the mechanism for the conversion of **Z** to **T**.
Include all relevant charges, partial charges, curly arrows and lone pairs.

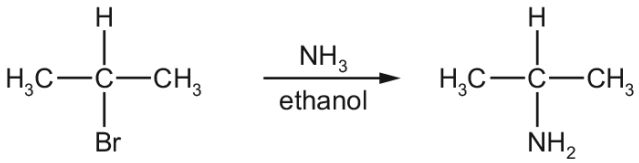
Z **T**



[3]

(iii) **T** can then be converted to 2-aminopropane.

T



2-aminopropane

Name the mechanism for this conversion.

..... [1]

(e) (i) Compound **S**, CH_3COCO_2H, can be reduced by $LiAlH_4$.

Complete the equation using structural formulae to represent this reaction.
Use [H] to represent the reducing agent.

CH_3COCO_2H + ... [2]

Other reducing agents containing Group 1 metal cations include $LiBH_4$, $NaBH_4$ and KBH_4.
The strength of the reducing agent depends on the size of its cation.

(ii) Give the electronic configuration of the Na^+ cation.

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

(iii) Suggest why ionic radius increases down Group 1.

.....

.....

..... [1]

[Total: 20]

146. 9701_s17_qp_21 Q: 4

P, **Q** and **R** all have the molecular formula C_3H_6O. They are all structural isomers of each other.

P and **Q** each contain an oxygen atom bonded directly to a carbon atom that is sp^2 hybridised.
R contains an oxygen atom bonded directly to a carbon atom that is sp^3 hybridised.

(a) (i) Explain the meaning of the term *structural isomers*.

.....

.....

.....

..... [2]

(ii) Explain how sp^2 and sp^3 hybridisation can occur in carbon atoms.

sp^2 hybridisation .....

.....

sp^3 hybridisation .....

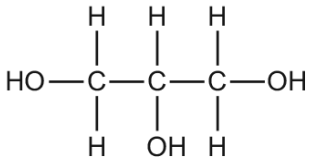
.....
[2]

(iii) State the bond angles normally associated with each type of hybridisation in carbon atoms.

sp^2 .....

sp^3 .....
[2]

(b) **R** contains two different functional groups, one of which is an alkene group.
R reacts with cold, dilute, acidified manganate(VII) ions to form propane-1,2,3-triol.



propane-1,2,3-triol

(i) Give the displayed formula of **R**.

[1]

(ii) State the type of reaction and what you would observe when **R** reacts with bromine water.

.....

..... [2]

(iii) Draw the structure of the product formed when **R** reacts with bromine water.

[1]

(iv) Identify the gaseous product formed when **R** reacts with hot, concentrated, acidified manganate(VII) ions.

..... [1]

(c) **P** and **Q** (C_3H_6O) both form an orange precipitate when reacted with 2,4-DNPH. Only **Q** produces a yellow precipitate when reacted with alkaline aqueous iodine.

(i) Name **P** and **Q**.

P .....

Q .....
[2]

(ii) Identify the yellow precipitate formed by the reaction of **Q** with alkaline aqueous iodine.

..... [1]

(d) **P** and **Q** each react with hydrogen cyanide to form a single product.
The product formed from **P** exists as a pair of optical isomers.
The product formed from **Q** does not exhibit optical isomerism.

(i) Explain the meaning of the term *optical isomers*.

.....

.....

.....

..... [2]

(ii) Ethanal, CH_3CHO, also reacts with hydrogen cyanide. The product of this reaction is $CH_3CH(OH)CN$.

Draw the mechanism of this reaction.
Include all necessary charges, dipoles, lone pairs and curly arrows.

[3]

[Total: 19]

147. 9701_m16_qp_22 Q: 3

Over one million tonnes of hydrogen cyanide, HCN, are produced each year using the Andrussow process. The overall equation for the reaction is shown.

$$CH_4(g) + NH_3(g) + 1\tfrac{1}{2}O_2(g) \rightleftharpoons HCN(g) + 3H_2O(g)$$

(a) (i) Draw a dot-and-cross diagram to represent the bonding in a molecule of ammonia, NH_3, and state the shape of the molecule.

shape of molecule .....

[3]

(ii) A molecule of hydrogen cyanide, HCN, is shown.

$$H—C\equiv N$$

The bonding between the carbon and nitrogen atoms consists of one sigma (σ) bond and two pi (π) bonds.

Sketch the shape of the sigma bond and one of the pi bonds in the space below.
Show clearly the position of the atomic nuclei in each diagram.

sigma (σ)

pi (π)

[2]

(b) The reaction exists as a dynamic equilibrium.

(i) Explain what is meant by the term *dynamic equilibrium*.

.....

..... [1]

(ii) State and explain how the amounts of the chemicals present in the equilibrium mixture will change when the pressure is increased.

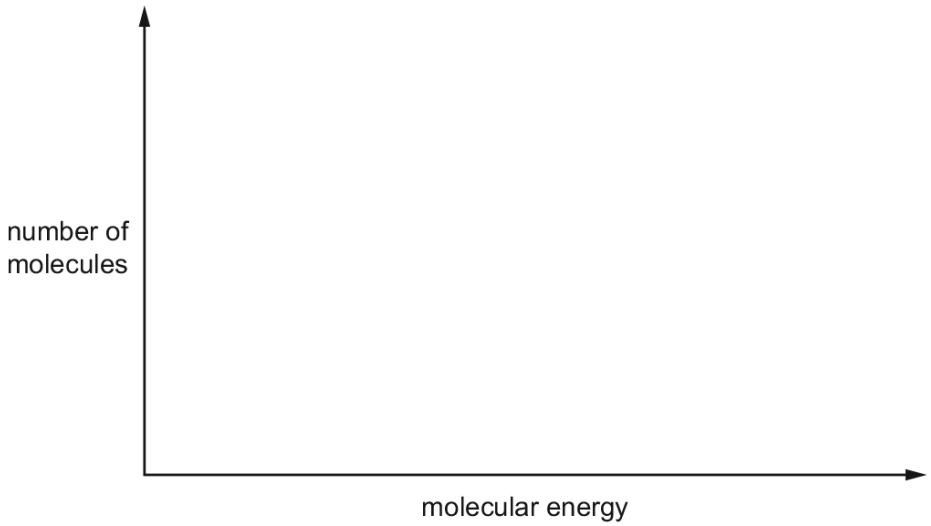
.....

.....

..... [2]

(c) The process uses a platinum catalyst, which increases the rate of reaction.

Sketch a Boltzmann distribution on the axes given below and use your diagram to explain how the platinum catalyst increases the rate of the reaction.



.....

.....

.....

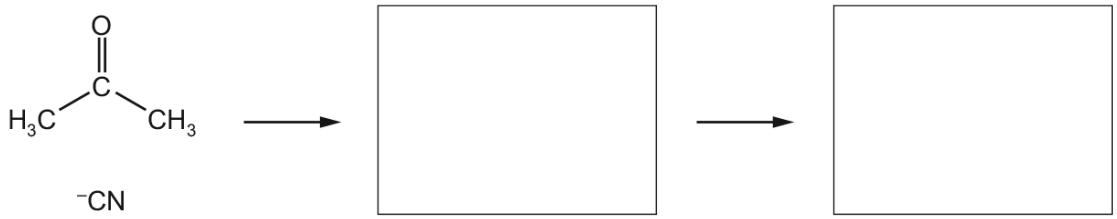
..... [3]

(d) The reaction of hydrogen cyanide with propanone is an important first step in many organic syntheses.

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

..... [1]

(ii) Complete the diagram to show the mechanism of the reaction of hydrogen cyanide with propanone.
Draw the structure of the intermediate and the product of the reaction.
Include all relevant charges, partial charges, curly arrows and lone pairs.

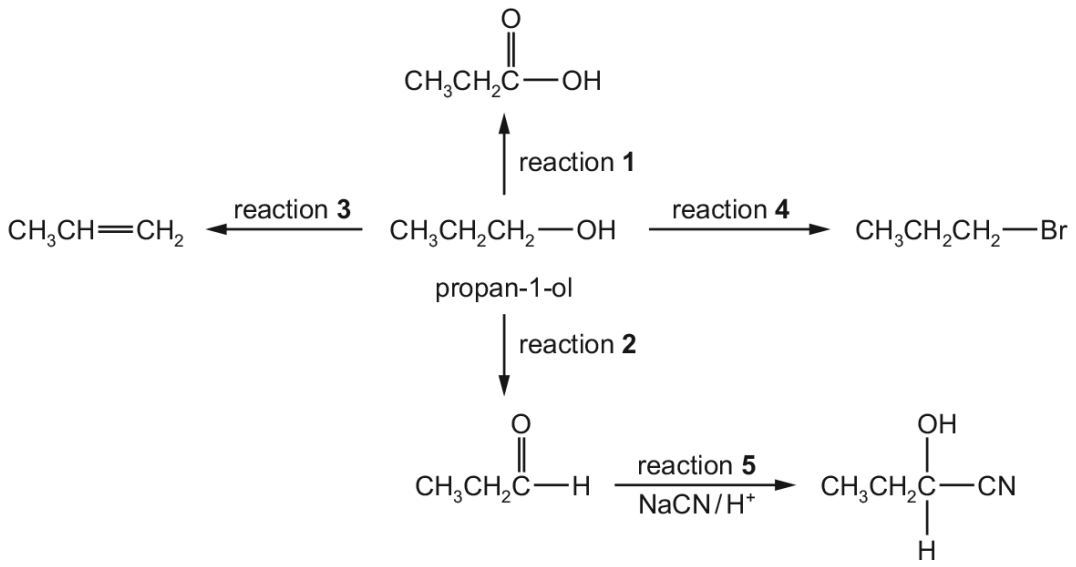


[5]

[Total: 17]

148. 9701_s16_qp_22 Q: 5

A reaction sequence based on propan-1-ol is shown.



(a) Reactions **1** and **2** can both be carried out using the same reagents.

(i) Identify suitable reagents for reactions **1** and **2**.

.....

..... [1]

(ii) State and explain how the reaction should be carried out to ensure that reaction **2** rather than reaction **1** occurs.

.....

.....

.....

..... [2]

(b) Identify the necessary reagents and conditions for each of reactions **3** and **4**.

reaction **3** .....

.....

reaction **4** .....

.....

[2]

(c) (i) Complete the reaction mechanism for reaction **5**. Include all relevant lone pairs, curly arrows, charges and partial charges.



[4]

The product of reaction **5** exhibits stereoisomerism.

(ii) Draw the two stereoisomers in the conventional way.

[2]

(iii) Suggest why a mixture of the two stereoisomers is formed by reaction **5**.

.....

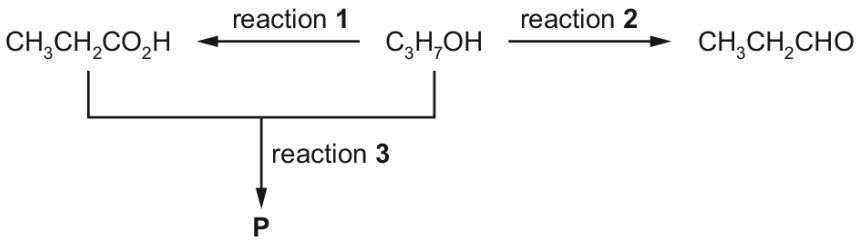
.....

..... [2]

[Total: 13]

149. 9701_w16_qp_21 Q: 5

A sequence of reactions is shown starting with an alcohol, C_3H_7OH.



(a) Draw the skeletal formula of the alcohol C_3H_7OH.

[1]

(b) State the reagents and conditions needed for reaction **1**.

.....

..... [2]

(c) State the reagents and conditions needed for reaction **2**.

.....

..... [2]

(d) Name **P**, the organic product of reaction **3**.

..... [1]

[Total: 6]

150. 9701_w16_qp_22 Q: 5

In each section of this question choose the answer or answers from the options listed.

(a) Six particles are listed.

H• H^+ Cl• Cl^- $\bullet CH_3$ $^+CH_3$

(i) Identify **two** particles produced during the reaction of methane and chlorine in the presence of UV light.

..... [1]

(ii) Identify the **two** particles produced by the heterolytic fission of a bond in chloromethane.

..... [1]

(b) Seven reaction types are listed.

addition substitution oxidation elimination

hydrolysis condensation reduction

(i) Name the type of reaction involved when Tollens' reagent is used to identify an aldehyde.

..... [1]

(ii) Name the type of reaction involved in the test for a carbonyl group using 2,4-DNPH.

..... [1]

(iii) Name the type of reaction involved in the reaction of a ketone with $NaBH_4$.

..... [1]

(iv) Name the type of reaction involved in the reaction of an aldehyde with HCN.

..... [1]

[Total: 6]

151. 9701_S15_qp_21 Q: 3

Ethanal reacts with hydrogen cyanide, in the presence of a small amount of NaCN, as shown.

$$CH_3CHO + HCN \rightarrow CH_3CH(OH)CN$$

(a) Use bond energies from the *Data Booklet* to calculate the enthalpy change for this reaction. Include a sign with your answer.

enthalpy change = ... $kJ\,mol^{-1}$ [3]

(b) The product of this reaction shows stereoisomerism as it contains a chiral centre. This reaction produces an equimolar mixture of two optical isomers.

(i) Explain the meanings of the terms *stereoisomerism* and *chiral centre*.

stereoisomerism .....

.....

.....

chiral centre .....

.....

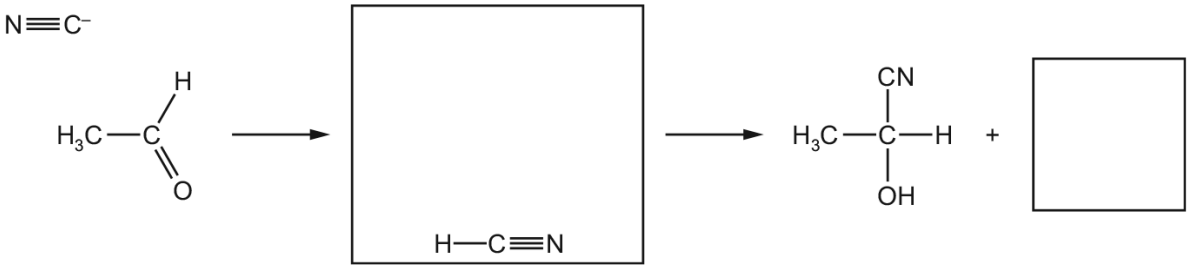
[2]

(ii) Suggest why the two optical isomers are produced in equal amounts by this reaction.

.....

..... [1]

(c) (i) Complete the diagram to show the mechanism of this reaction. Include all necessary charges, partial charges, lone pairs and curly arrows and show the structure of the intermediate.



[5]

(ii) With reference to your mechanism in **(i)**, explain the role of the NaCN in this reaction.

.....

..... [1]

[Total: 12]

152. 9701_S15_qp_22 Q: 4

There are seven structural isomers with the molecular formula $C_5H_{10}O$ that are carbonyl compounds. Four of these are aldehydes.

These four aldehydes, **A**, **B**, **C** and **D**, have the following properties.

- Aldehyde **A** has a straight chain while **B**, **C** and **D** are branched.
- Aldehyde **B** is the only one of the four isomers with a chiral centre and it exists as a pair of optical isomers.
- Aldehyde **C** has two methyl groups in its structure but **D** has three.

(a) (i) Give the structure of each of the four isomers.

A

B

C

D

[4]

(ii) Draw the three-dimensional structures of the two optical isomers of **B**.

[2]

(b) (i) Describe a chemical test that would allow you to distinguish between any of the four isomers **A** to **D** and any of the other three structural isomers of $C_5H_{10}O$, that are carbonyl compounds.

In your answer you should describe any necessary reagents and conditions as well as explaining what you would **see** in each case.

.....

.....

.....

.....

..... [3]

(ii) Describe a test that would give the same result with all seven carbonyl isomers of $C_5H_{10}O$.

.....

.....

..... [2]

[Total: 11]

153. 9701_S15_qp_23 Q: 3

A, **B**, **C**, **D**, **E** and **F** are all structural isomers with the molecular formula C_4H_8O.

(a) **A**, **B** and **C** all give an orange precipitate when treated with 2,4-DNPH but only **A** and **B** give a brick-red precipitate when warmed with Fehling's solution.

(i) Draw the **skeletal** formulae of **A**, **B** and **C**.

A	B	C

[3]

(ii) Name the type of structural isomerism shown by **A** and **B**.

..... [1]

(iii) State what you would **see** when a sample of **A** is warmed with Tollens' reagent.

..... [1]

(b) **D**, **E** and **F** all decolourise bromine and effervesce slowly with sodium metal.

E shows geometrical isomerism. Only **D** has a branched chain.

None of these isomers contains an oxygen atom bonded to a carbon atom involved in π bonding.

None of these isomers contains a chiral centre.

(i) Give the structures of **D**, **E** and **F**. Show the two stereoisomers of **E** and label the stereoisomerism shown.

D	
E	**E** .....
F	

[5]

(ii) Identify the gas produced during the reaction of each of these isomers with sodium metal.

..... [1]

(c) Another compound, **G**, C_3H_6O, contains the same functional group as **A**.

Give equations for the reactions of **G** with each of acidified potassium dichromate(VI) and sodium tetrahydridoborate, $NaBH_4$, using [O] or [H] as appropriate.

(i) reaction with acidified potassium dichromate(VI)

C_3H_6O + ... $\rightarrow$ ..... [1]

(ii) reaction with $NaBH_4$

C_3H_6O + ... $\rightarrow$ ..... [1]

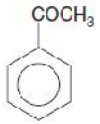
[Total: 13]

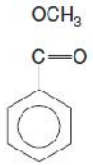
1.

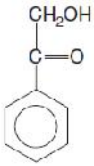
A compound **R** has all of the following properties:

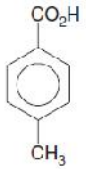
it is neutral;
it gives an orange precipitate with 2,4-dinitrophenylhydrazine;
it evolves hydrogen chloride when treated with PCl_5 in the cold.

What could **R** be?

A 

B 

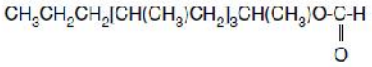
C 

D 

[2002 M/J (28)]

2.

30 The acarid mite releases *lardolure* to attract other mites to a host: this chemical can be destroyed by hydrolysis with acid.



A simplified formula for *lardolure* may be written as $RCH(CH_3)O\text{-}\overset{\overset{O}{\|}}{C}\text{-}H$.

What are the products of its hydrolysis?

A $RCH(CH_3)CO_2H + CH_3OH$

B $RCH(CH_3)CO_2H + HCO_2H$

C $RCH(CH_3)OH + CO_2$

D $RCH(CH_3)OH + HCO_2H$

[2002 M/J (30)]

3.

The Russian composer Borodin was also a research chemist who discovered a reaction in which two ethanal molecules combine to form a compound commonly known as alcol (reaction I). Aldol forms another compound on heating (reaction II).

I $2CH_3CHO \rightarrow CH_3CH(OH)CH_2CHO$

II $CH_3CH(OH)CH_2CHO \rightarrow CH_3CH{=}CHCHO + H_2O$

Which of the following best describes reactions I and II?

	I	II
A	addition	elimination
B	addition	reduction
C	elimination	reduction
D	substitution	elimination

[2002 O/N (20)]

4.

Oxidation of an alkene **Y** gives a diol; further oxidation gives a diketone.

What could be **Y**?

A $CH_3CH{=}C(CH_3)_2$

B $(CH_3)_2CHCH{=}CH_2$

C $C_6H_5CH{=}CHC_6H_5$

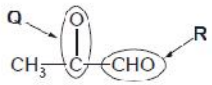
D $(C_6H_5)_2C{=}CHCH_3$

[2002 O/N (26)]

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5.

27 Burnt sugar has a characteristic smell caused partly by the following compound. It has two functional groups indicated by **Q** and **R**.



When this compound is tested in a laboratory with 2,4-dinitrophenylhydrazine and Fehling's reagent, which functional groups are responsible for positive tests?

	2,4-dinitrophenylhydazine	Fehling's reagent
A	**Q** and **R**	**Q** and **R**
B	**R** only	**Q** and **R**
C	**Q** and **R**	**R** only
D	**Q** only	**R** only

[2002 O/N (27)]

6.

Ethanal may be converted into a three-carbon acid in a two-step process.

Which compound is the intermediate?

A CH_3CO_2H **B** CH_3CN **C** CH_3CH_2CN **D** $CH_3CH(OH)CN$

[2002 O/N (28)]

7.

In the reaction between an aldehyde and HCN catalysed by NaCN, which statements about the reaction mechanism are true?

1 A new carbon-carbon bond is formed.

2 In the intermediate, the oxygen carried a negative charge.

3 The last stage involves the formation of a hydrogen-oxygen bond.

[2002 O/N (39)]

8.

The product of the reaction between propanone and hydrogen cyanide is hydrolysed under acidic conditions.

What is the formula of the final product?

A $CH_3CH(OH)CO_2H$

B $CH_3CH_2CH_2CO_2H$

C $(CH_3)_2CHCONH_2$

D $(CH_3)_2C(OH)CO_2H$

[2003 M/J (30)]

9.

$CH_3CH_2COCH_2CH_3$ reacts with hydrogen cyanide to form a cyanohydrin.

Which features apply to the product?

A It has one chiral centre.

B It is formed by electrophilic addition.

C It is formed via a C–OH intermediate.

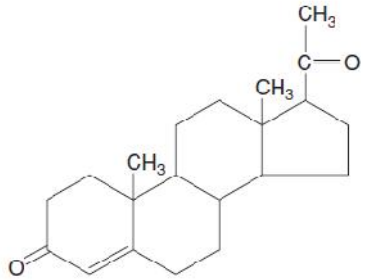
D Its formation requires the use of cyanide ions as a catalyst.

[2003 O/N (29)]

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10.

The compound shown is a hormone produced during pregnancy to suppress ovulation.



Which reagents would give positive results with this compound?

1 aqueous bromine

2 2,4-dinitrophenylhydrazine

3 Fehling's reagent

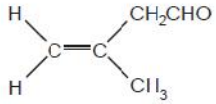
[2003 O/N (39)]

11.

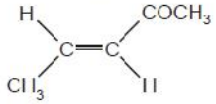
Compound **P** displays *cis-trans* isomerism and gives a red-brown precipitate with Fehling's solution.

What is **P**?

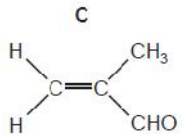
A



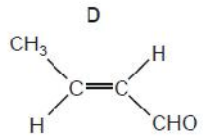
B



C



D



[2004 M/J (22)]

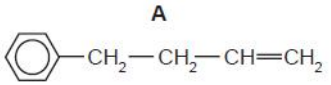
12.

Compound **X**

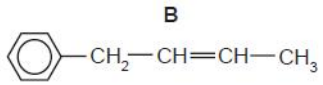
- has the molecular formula $C_{10}H_{14}O$;
- is unreactive towards mild oxidising agents.

What is the structure of the compound formed by dehydration of **X**?

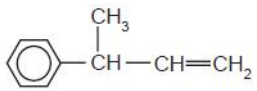
A



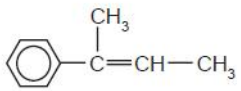
B



C



D



[2004 M/J (28)]

13.

For which pair of compounds can the members be distinguished by means of Tollens' test (the use of a solution containing $Ag(NH_3)_2^+$)?

A CH_3CHO and CH_3COCH_3

B CH_3COCH_3 and $C_2H_5COCH_3$

C CH_3COCH_3 and $CH_3CO_2CH_3$

D CH_3CO_2H and $CH_3CO_2CH_3$

[2004 M/J (29)]

14.

Compound **X** changes the colour of acidified sodium dichromate(VI) from orange to green. 1 mol of **X** reacts with 2 mol of HCN(g).

What could **X** be?

A $CH_3COCH_2COCH_3$

B $CH_3CH_2CH_2CHO$

C $H_2C{=}CHCH_2CHO$

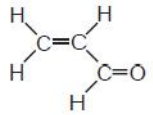
D $OHCCH_2CH_2CHO$

[2004 M/J (30)]

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15.

Acrolein is produced in photochemical smog. It has a strong smell, irritates eyes and mucous membranes and is carcinogenic.



acrolein

What can be deduced from this structure?

1 All bond angles are approximately 120°.

2 It will undergo electrophilic addition reactions.

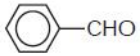
3 It will undergo nucleophilic addition reactions.

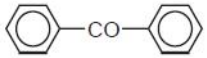
[2004 M/J (37)]

16.

Which carbonyl compounds could be easily oxidised to carboxylic acids that are readily soluble in cold water?

1 CH_3CH_2CHO

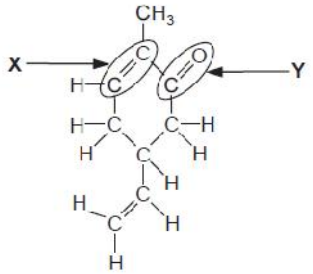
2 

3 

[2004 M/J (39)]

17.

This molecule is responsible for the flavour of spearmint chewing gum.



What is a true statement about the functional groups **X** or **Y**?

A **X** will undergo nucleophilic addition.

B **Y** will undergo nucleophilic addition.

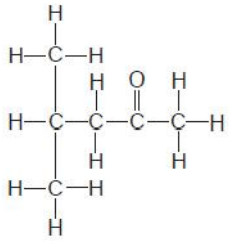
C **X** will undergo electrophilic substitution.

D **Y** will undergo electrophilic substitution.

[2004 O/N (24)]

18.

The solvent methylisobutylketone, MIBK, can be made from propanone.



Which reagent could distinguish this compound from an aldehyde?

A $Br_2(aq)$

B 2,4-dinitrophenylhydrazine

C $NaBH_4$

D Tollens' reagent

[2004 O/N (29)]

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19.

Lactic acid builds up in muscles when oxygen is in short supply. It can cause muscular pain. Part of the reaction sequence is shown.

$$CH_2OHCH(OH)CHO \rightarrow CH_3COCO_2H \rightarrow CH_3CH(OH)CO_2H$$

glyceraldehyde pyruvic acid lactic acid

Which statements about the reaction sequence are correct?

1 An aldehyde is oxidised to a carboxylic acid.

2 A ketone is reduced to a secondary alcohol.

3 A secondary alcohol is oxidised to a ketone.

[2004 O/N (40)]

20.

Which reagent could be used to distinguish between

$CH_3CH(OH)CH_2CHO$ and $CH_3COCH_2CH_2OH$?

A acidified potassium dichromate(VI)

B dilute sulphuric acid

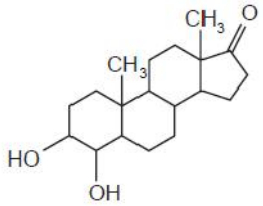
C 2,4–dinitrophenylhydrazine

D Fehling's reagent

[2005 M/J (28)]

21.

The steroid shown is an intermediate compound obtained during the synthesis of *Formestane* which is used in the treatment of breast cancer.



Which statements about this compound are correct?

1 It reacts with hydrogen cyanide in a nucleophilic addition reaction.

2 It can be oxidised by warm acidified potassium dichromate(VI) to a carboxylic acid.

3 It will react with Fehling's solution.

[2005 M/J (39)]

22.

Compounds *X*, *Y* and *Z* all react with PCl_5 to release hydrogen chloride, but only one of them reacts with 2,4-dinitrophenylhydrazine reagent.

Which one of the following combinations could be *X*, *Y* and *Z*?

	X	*Y*	*Z*
A	CH_2OH | CH_2OH	CHO | CHO	CO_2H | CO_2H
B	CH_2OH | CH_2OH	CH_2OH | CHO	CHO | CO_2H
C	CH_2OH | CHO	CH_2OH | CO_2H	CHO | CO_2H
D	CH_2OH | CO_2H	CHO | CO_2H	CO_2H | CO_2H

[2005 O/N (25)]

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23.

In 1903 Arthur Lapworth became the first chemist to investigate a reaction mechanism. The reaction he investigated was that of hydrogen cyanide with propanone.

What do we now call the mechanism of this reaction?

A electrophilic addition

B electrophilic substitution

C nucleophilic addition

D nucleophilic substitution

[2005 O/N (26)]

24.

What is formed when propanone is refluxed with an anhydrous solution of $NaBH_4$?

A propanal

B propan-1-ol

C propan-2-ol

D propane

[2005 O/N (27)]

25.

Which alcohol may be oxidised to a product which reacts with 2,4-dinitrophenylhydrazine reagent but not with Fehling's reagent?

A butan-1-ol

B butan-2-ol

C 2-methylpropan-1-ol

D 2-methylpropan-2-ol

[2006 M/J (27)]

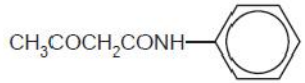
26.

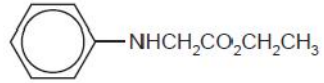
The first stage in the synthesis of antipyrine, a drug used in reducing fever, is the reaction between compound **P** and phenylhydrazine.

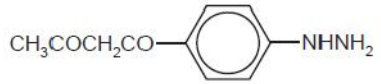


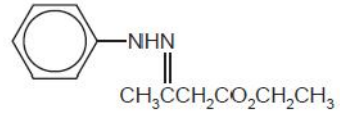
P phenylhydrazine

What is the product **Q** of this first stage?

A 

B 

C 

D 

[2006 M/J (28)]

27.

Aldehydes and ketones are carbonyl compounds.

Which of them react both with $NaBH_4$ and with Tollens' reagent?

A both aldehydes and ketones

B aldehydes only

C ketones only

D neither aldehydes nor ketones

[2006 M/J (29)]

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28.

How can the rate of reaction between ethanal and aqueous hydrogen cyanide be increased?

1 by irradiation with ultraviolet light

2 by a rise in temperature

3 by the addition of a small quantity of aqueous sodium cyanide

[2006 M/J (39)]

29.

Which compound

- is unaffected by hot alkaline potassium manganate(VII);
- gives hydrogen when treated with sodium?

A $(CH_3)_2CHCOCH_3$

B $(CH_3)_3COH$

C $CH_3CH_2CH(OH)CH_3$

D $CH_3CO_2CH(CH_3)_2$

[2006 O/N (27)]

30.

A common industrial solvent is a mixture of propanone, CH_3COCH_3, and pentyl ethanoate $CH_3CO_2(CH_2)_4CH_3$.

Which reagent would have no effect on this solvent?

A Na(s)

B $NaBH_4$

C NaOH(aq)

D 2,4-dinitrophenylhydrazine reagent

[2006 O/N (28)]

31.

Which reagent gives the same visible result with propanal and with propan-2-ol?

A 2,4-dinitrophenylhydrazine reagent

B acidified potassium dichromate(VI)

C sodium

D Tollens' reagent

[2007 M/J (27)]

32.

Compound **X** will decolourise a warm acidified solution of manganate(VII) ions and forms orange crystals on reaction with 2,4-dinitrophenylhydrazine.

What is **X**?

A $CH_3CH{=}CHCH_2OH$

B $CH_3COCH_2CH_3$

C $CH_3CH_2CH_2CHO$

D $CH_3CH(OH)CH_2CO_2H$

[2007 M/J (28)]

33.

Which compound would undergo nucleophilic addition?

A ethene, C_2H_4

B bromoethane, C_2H_5Br

C ethanal, CH_3CHO

D ethane, C_2H_6

[2007 M/J (29)]

34.

Hept-4-enal is present in cow's milk.

$CH_3CH_2CH{=}CHCH_2CH_2CHO$

hept-4-enal

What is formed when hept-4-enal is reduced with **either** hydrogen and a nickel catalyst **or** sodium borohydride?

A with H_2/Ni $CH_3(CH_2)_5CH_2OH$

B with H_2/Ni $CH_3(CH_2)_5CH_3$

C with $NaBH_4$ $CH_3(CH_2)_5CH_2OH$

D with $NaBH_4$ $CH_3(CH_2)_5CHO$

[2007 O/N (28)]

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35.
Which of these reactions is shown by butanone, $CH_3COCH_2CH_3$?

A On warming with acidified potassium dichromate(VI) the solution turns green.

B On heating with Fehling's reagent a red precipitate is formed.

C With 2,4-dinitrophenylhydrazine reagent an orange precipitate is formed.

D With hydrogen cyanide an aldehyde is formed.

[2007 O/N (29)]

36.
In the reaction between an aldehyde and HCN catalysed by NaCN, which statements about the reaction mechanism are true?

1 A new carbon-carbon bond is formed.

2 In the intermediate, the oxygen carries a negative charge.

3 The last stage involves the formation of a hydrogen-oxygen bond.

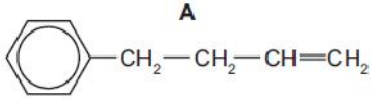
[2007 O/N (39)]

37.
Compound **X**

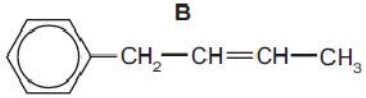
- has the molecular formula $C_{10}H_{14}O$;
- is unreactive towards mild oxidising agents.

What is the structure of the compound formed by dehydration of **X**?

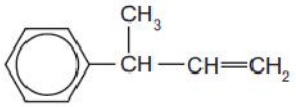
A



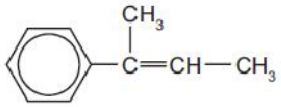
B



C



D



[2008 M/J (27)]

38.
Ethanal, CH_3CHO, can be reduced using an aqueous methanolic solution of $NaBH_4$ as the reducing agent.

This is a nucleophilic addition reaction.

What could be the first step of this mechanism?

A attack of an H^+ ion at the carbon atom of the carbonyl group

B attack of an H^+ ion at the oxygen atom of the carbonyl group

C attack of an H^- ion at the carbon atom of the carbonyl group

D attack of an H^- ion at the oxygen atom of the carbonyl group

[2008 M/J (28)]

39.
Compound **X**, $C_6H_{12}O$, is oxidised by acidified sodium dichromate(VI) to compound **Y**.

Compound **Y** reacts with ethanol in the presence of a little concentrated sulphuric acid to give liquid **Z**.

What is the formula of **Z**?

A $CH_3(CH_2)_2CH{=}CHCO_2H$

B $CH_3(CH_2)_4CH_2COCH_2CH_3$

C $CH_3(CH_2)_4CO_2CH_2CH_3$

D $CH_3CH_2CO_2(CH_2)_4CH_3$

[2008 M/J (30)]

40.
The product of the reaction between propanone and hydrogen cyanide is hydrolysed under acidic conditions.

What is the formula of the final product?

A $CH_3CH(OH)CO_2H$

B $CH_3CH_2CH_2CO_2H$

C $(CH_3)_2CHCONH_2$

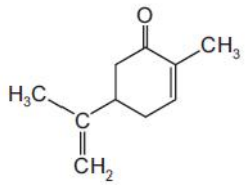
D $(CH_3)_2C(OH)CO_2H$

[2008 O/N (29)]

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41.

Carvone gives the characteristic flavour to caraway and spearmint.



carvone

Prolonged heating of carvone with hot concentrated acidified potassium manganate(VII) produces carbon dioxide and a compound **X**.

X contains nine carbon atoms and reacts with 2,4-dinitrophenylhydrazine reagent.

What is the maximum number of molecules of 2,4-dinitrophenylhydrazine that will react with one molecule of **X**?

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

[2009 M/J (28)]

42.

How can the rate of reaction between ethanal and aqueous hydrogen cyanide be increased?

1 by irradiation with ultraviolet light

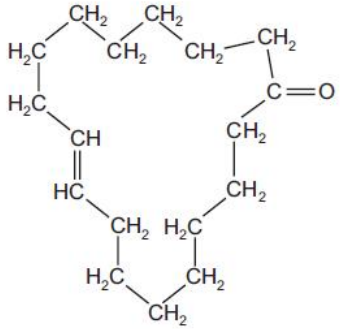
2 by a rise in temperature

3 by the addition of a small quantity of aqueous sodium cyanide

[2009 M/J (39)]

43.

The naturally-occurring molecule civetone is found in a gland of the African civet cat and has been used in perfumery.



civetone

With which reagent will civetone **not** react?

A 2,4-dinitrophenylhydrazine reagent

B Fehling's reagent

C hydrogen bromide

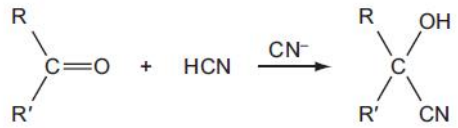
D sodium tetrahydridoborate(III) (sodium borohydride)

[2009 O/N-11 (27)]

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44.

Cyanohydrins can be made from carbonyl compounds by generating CN^- ions from HCN in the presence of a weak base.



In a similar reaction, $^-CH_2CO_2CH_3$ ions are generated from $CH_3CO_2CH_3$ by strong bases.

Which compound can be made from an aldehyde and $CH_3CO_2CH_3$ in the presence of a strong base?

A $CH_3CH(OH)CO_2CH_3$

B $CH_3CO_2CH_2CH(OH)CH_3$

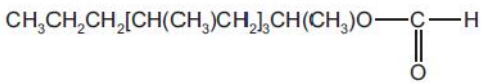
C $CH_3CH_2CH(OH)CH_2CO_2CH_3$

D $(CH_3)_2C(OH)CH_2CO_2CH_3$

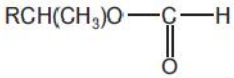
[2009 O/N-11 (28)]

45.

The acarid mite releases *lardolure* to attract other mites to a host. This chemical can be destroyed by hydrolysis with acid.



A simplified formula for *lardolure* may be written as follows.



What are the products of its hydrolysis?

A $RCH(CH_3)CO_2H + CH_3OH$

B $RCH(CH_3)CO_2H + HCO_2H$

C $RCH(CH_3)OH + CO_2$

D $RCH(CH_3)OH + HCO_2H$

[2009 O/N-11 (30)]

46.

A compound has a relative molecular mass of 88 and its molecule contains only four carbon atoms.

What could this compound be?

1 a saturated non-cyclic diol

2 a secondary alcohol containing an aldehyde group

3 a primary alcohol containing a ketone group

[2009 O/N-11 (40)]

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47.

Carbonyl compounds – 2021 AS

1. Nov/2021/Paper_11/No.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 $(CH_3)_3COH$

2. Nov/2021/Paper_11/No.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 $CH_2(OH)CH_2CH(OH)CH_2CH_3$

3. Nov/2021/Paper_11/No.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.

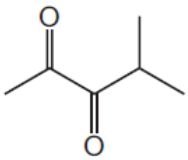
D The formation of the cyanohydrin product requires the use of cyanide ions as a catalyst.

4. Nov/2021/Paper_11/No.27

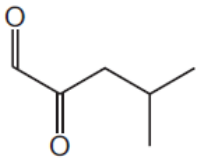
Reduction of compound R with $LiAlH_4$ gives the compound 4-methylpentane-2,3-diol.

What could be the identity of compound R?

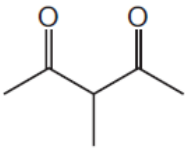
A



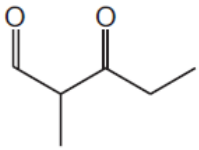
B



C



D



5. Nov/2021/Paper_11/No.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 solution 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

6. Nov/2021/Paper_11/No.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

7. Nov/2021/Paper_12/No.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

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8. Nov/2021/Paper_12/No.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

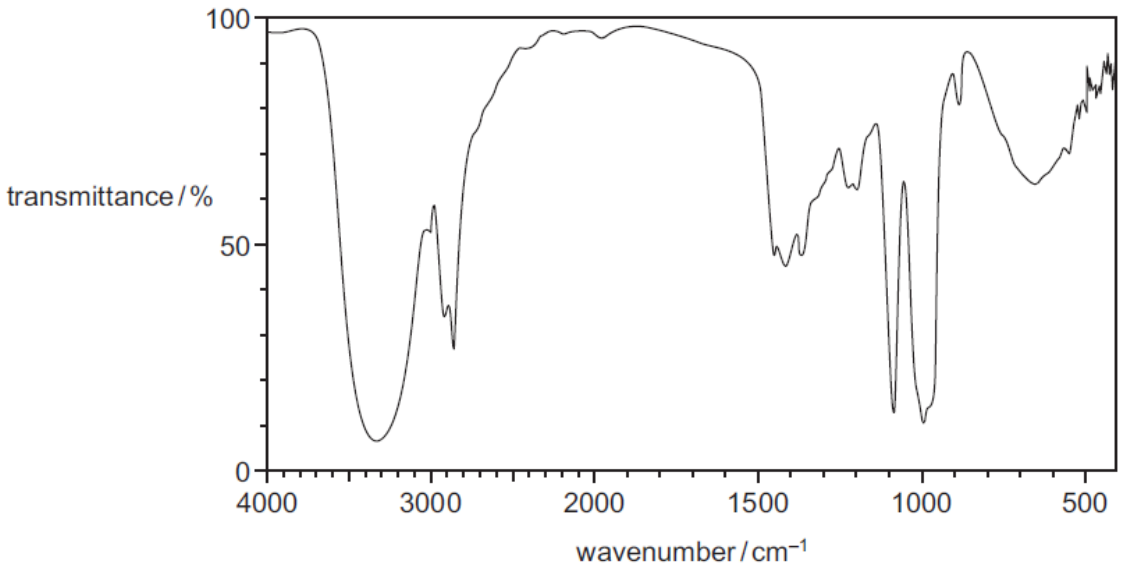
B 2-hydroxy-2-methylpropanoic acid

C 3-hydroxy-2-methylbutanoic acid

D 3-hydroxy-2-methylpropanoic acid

9. Nov/2021/Paper_12/No.30

The infra-red spectrum of Y is shown.



What could Y be?

A $CH_3CO_2C_2H_5$

B $CH_2(OH)CH{=}CHCH_2OH$

C $CH_3(CH_2)_2CO_2H$

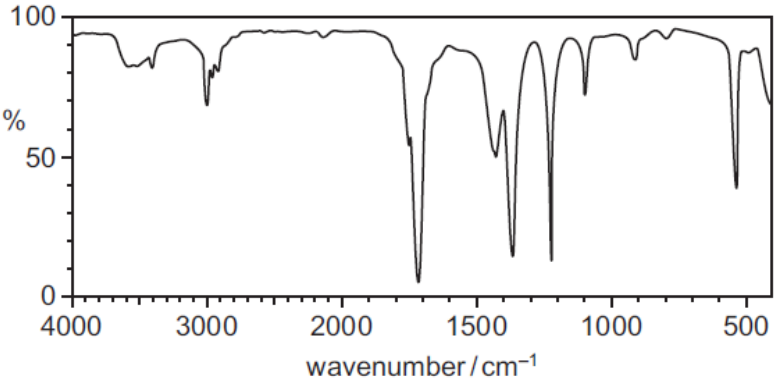
D $CH_2(OH)(CH_2)_2CHO$

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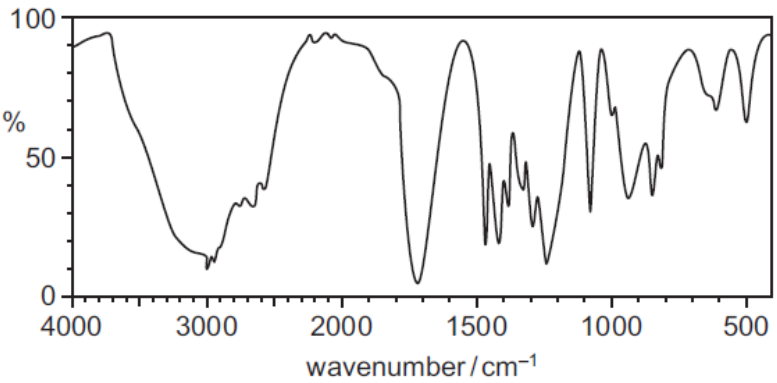
10. Nov/2021/Paper_13/No.30

The infra-red spectra of three organic compounds are shown.

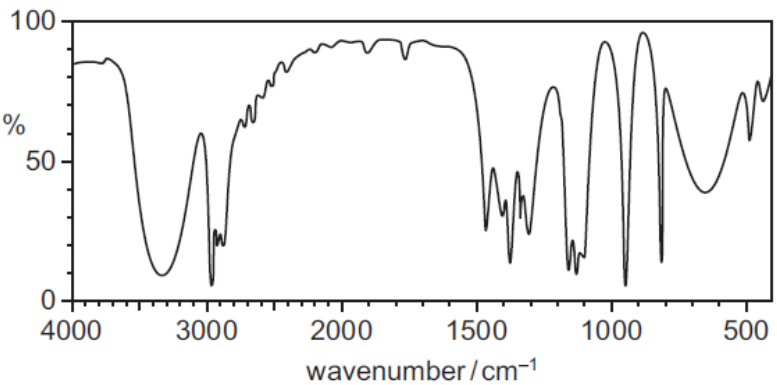
spectrum 1



spectrum 2



spectrum 3



What could the three compounds be?

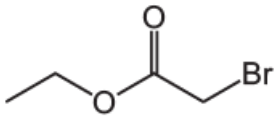
	spectrum 1	spectrum 2	spectrum 3
A	propanoic acid	propanone	propan-2-ol
B	propanone	propanoic acid	propan-2-ol
C	propanone	propan-2-ol	propanoic acid
D	propan-2-ol	propanoic acid	propanone

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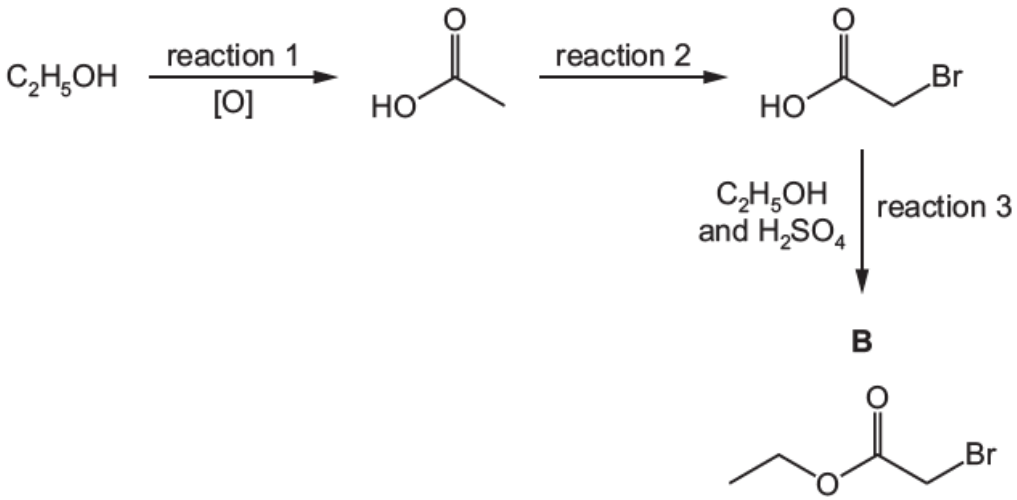
11. Nov/2021/Paper_23/No.4

Compound **B** is a liquid with a fruity smell.

B



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]

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

..... [1]

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

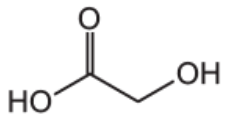
Explain why H_2SO_4 is described as *homogeneous*.

.....

..... [1]

(b) Reaction 2 needs to take place in the absence of water to prevent formation of compound **C**.

C



If **C** is present in the reaction mixture of reaction 3, a different compound, compound **D**, will also form. Compound **D** has two identical functional groups.

The infrared spectrum of **D** shows strong absorptions at 1100 cm^{-1} and 1720 cm^{-1}, but no absorption due to O–H bonds.

Use the *Data Booklet* to identify the functional group present in **D**.

Explain your answer as fully as you can.

.....

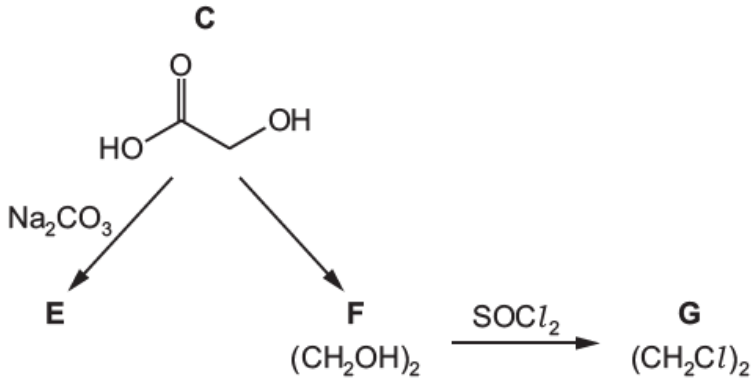
.....

.....

..... [3]

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(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]

[Total: 12]

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12. March/2021/Paper_12/No.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

13. March/2021/Paper_12/No.27

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

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

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 ^{3}H 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 ^{3}H atoms.

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

C Neither ethanal nor water contain ^{3}H atoms.

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

14. March/2021/Paper_12/No.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

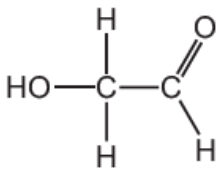
3 alkaline aqueous iodine

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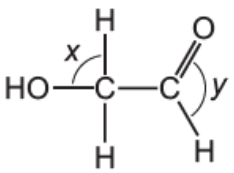
15. March/2021/Paper_22/No.4

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.

.....

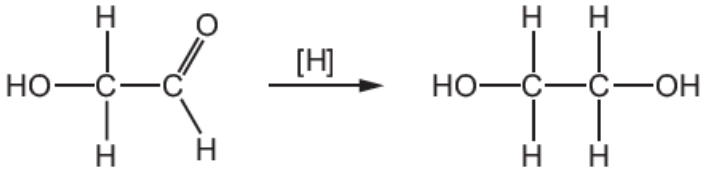
.....

..... [2]

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

hydroxyethanal ethane-1,2-diol



(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]

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

Name **A**.

..... [1]

[Total: 10]

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16. June/2021/Paper_11/No.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.

17. June/2021/Paper_11/No.31

Ethanol combines with ethanoic acid to form ethyl ethanoate according to the following reaction.

$$C_2H_5OH(l) + CH_3CO_2H(l) \rightleftharpoons CH_3CO_2C_2H_5(l) + H_2O(l) \qquad \Delta H^{\ominus} = -6\,kJ\,mol^{-1}$$

9.2 g ethanol, 12 g ethanoic acid and 8.8 g ethyl ethanoate are mixed and allowed to stand at 298 K, until equilibrium is reached.
(M_r: C_2H_5OH, 46; CH_3CO_2H, 60; $CH_3CO_2C_2H_5$, 88)

The resulting equilibrium mixture is found to contain 4.8 g ethanoic acid.

The experiment is repeated at 323 K.

Which statements are correct?

1 There are 0.22 moles of ethyl ethanoate in the mixture at equilibrium at 298 K.

2 The equilibrium mixture at 323 K will contain more than 4.8 g of ethanoic acid.

3 If a small amount of water is added at the start of either experiment the value of K_c would not be affected.

18. June/2021/Paper_11/No.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

19. June/2021/Paper_11/No.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)

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20. June/2021/Paper_11/No.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

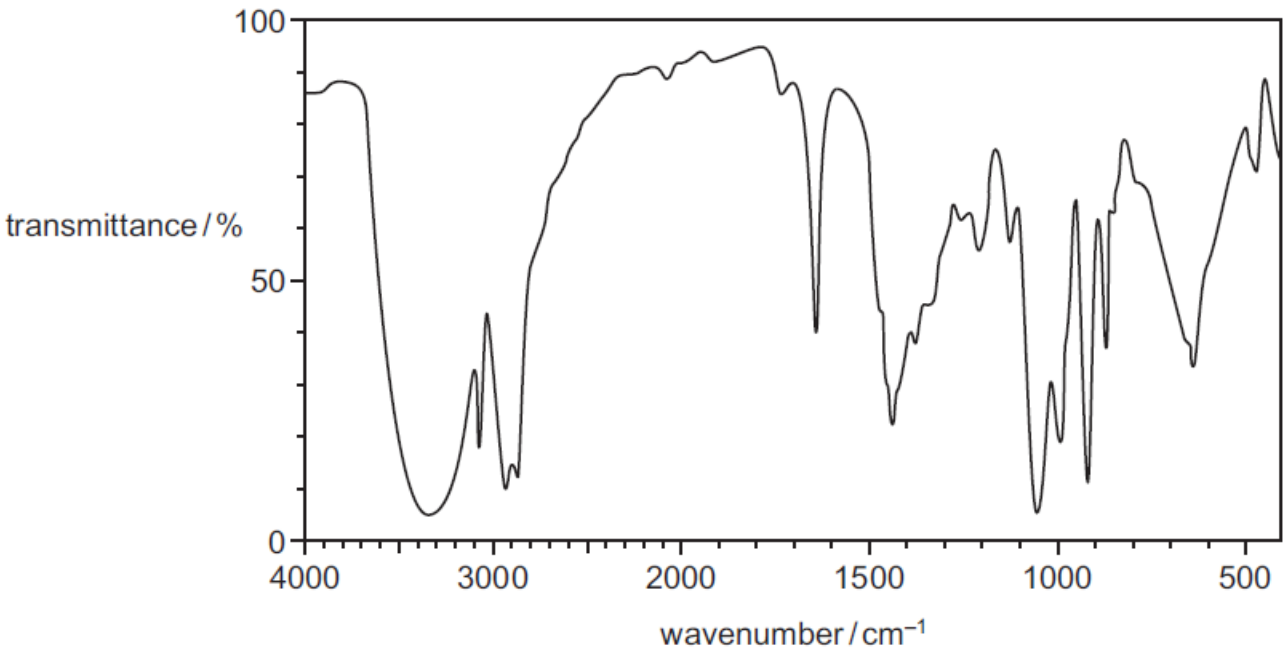
2 solvent

3 flavouring

21. June/2021/Paper_12/No.30

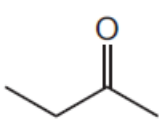
The molecular formula of Z is C_4H_8O.

The infra-red spectrum of Z is shown.

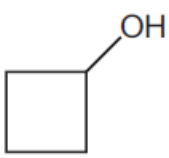


What could be Z?

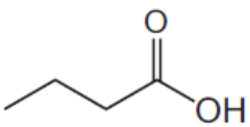
A



B



C



D

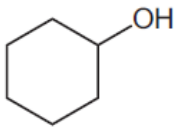


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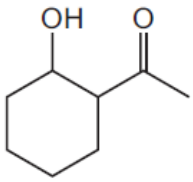
22. June/2021/Paper_12/No.39

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?

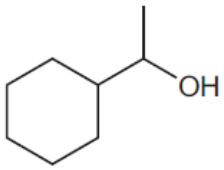
1



2



3



23. June/2021/Paper_13/No.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

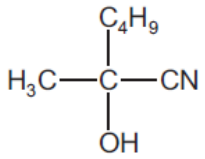
C 2-methylbut-2-ene

D propene

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24. June/2021/Paper_13/No.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

25. June/2021/Paper_13/No.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

26. June/2021/Paper_13/No.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

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27. June/2021/Paper_13/No.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.

28. June/2021/Paper_22/No.4(d)

(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]

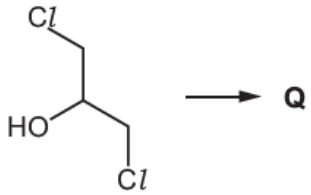
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29. June/2021/Paper_23/No.4(b)

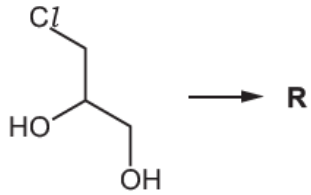
(b) Separate samples of 1,3-dichloropropan-2-ol and 3-chloropropane-1,2-diol are heated with excess acidified $Cr_2O_7^{2-}$ until there is no further reaction.

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

1,3-dichloropropan-2-ol



3-chloropropane-1,2-diol



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]

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Carbonyl compounds – 2022 June AS Chemistry 9701

1. June/2022/Paper_11/No.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 $CH_3CH(CH_3)CH_2CO_2H$

2. June/2022/Paper_11/No.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

3. June/2022/Paper_11/No.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

4. June/2022/Paper_12/No.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).

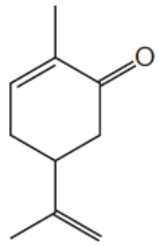
C Methyl ethanoate is heated under reflux with dilute sulfuric acid.

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

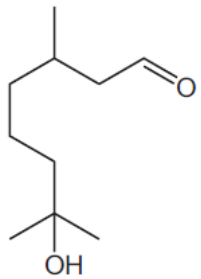
5. June/2022/Paper_12/No.36

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

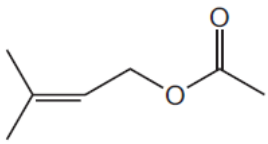
A



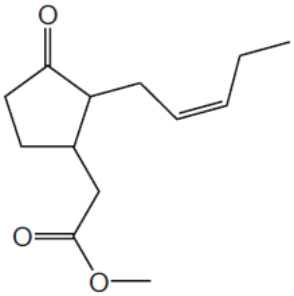
B



C



D



6. June/2022/Paper_12/No.37

Which reaction is a redox reaction?

A ethanenitrile heated under reflux with dilute hydrochloric acid

B ethanoic acid reacted with aqueous sodium hydroxide

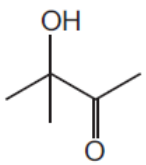
C ethanoic acid reacted with sodium

D ethyl ethanoate heated under reflux with dilute hydrochloric acid

7. June/2022/Paper_13/No.26

Compound X contains an alcohol group and a carbonyl group.

compound X



Which row is correct?

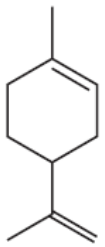
	type of alcohol group	type of carbonyl group
A	primary	aldehyde
B	primary	ketone
C	tertiary	aldehyde
D	tertiary	ketone

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8. June/2022/Paper_13/No.30

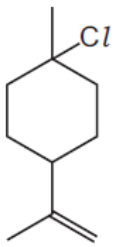
Limonene is found in lemon and orange oils.

limonene

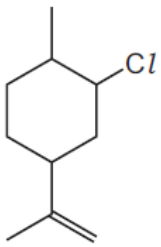


What is the major product when limonene reacts with an excess of dry hydrogen chloride?

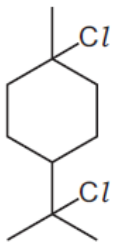
A



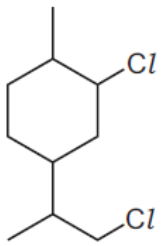
B



C



D



9. June/2022/Paper_13/No.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

10. June/2022/Paper_13/No.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

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11. June/2022/Paper_21/No.3(c, d)

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

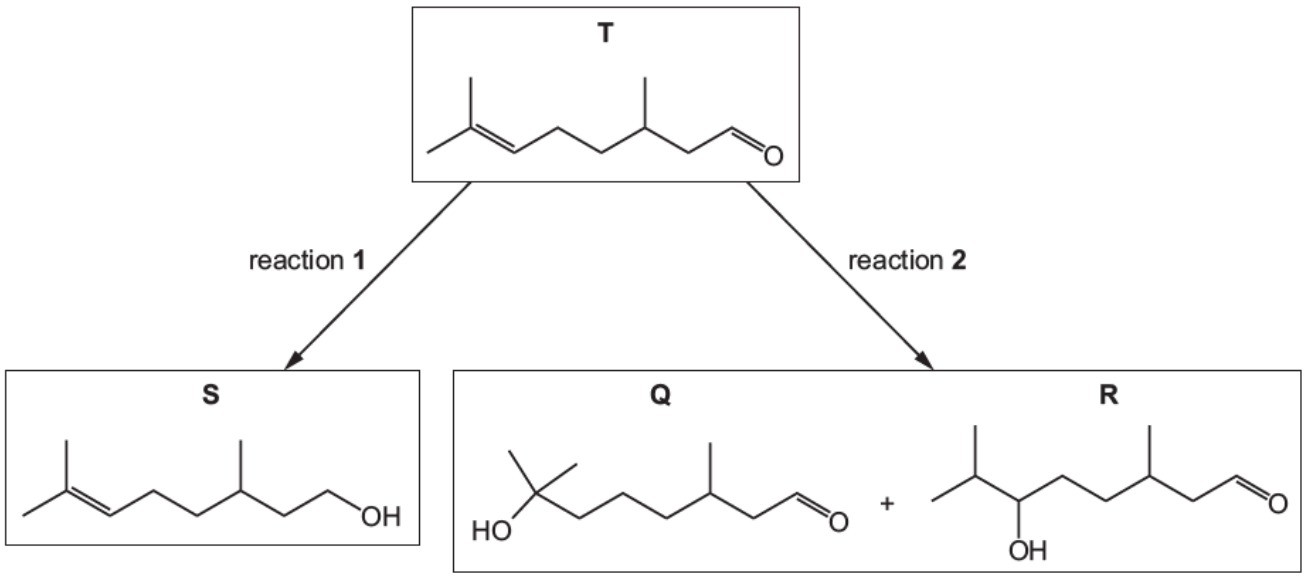


Fig. 3.2

(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.

.....

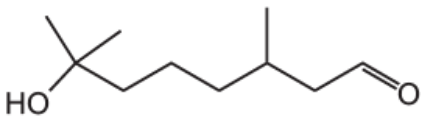
.....

..... [3]

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

Q



R

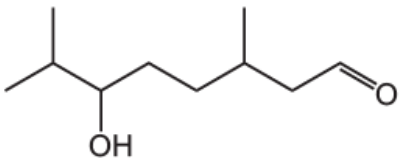


Fig. 3.3

(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

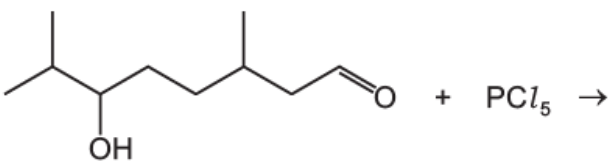


Fig. 3.4

[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]

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(c) **W**, **X** and **Y** have the same molecular formula, $C_5H_{10}O$.

W, **X** and **Y** are added separately to different reagents. Observations for these reactions are described in Table 4.1.

Table 4.1

	+ 2,4-dinitrophenylhydrazine	+ alkaline I_2(aq)	+ Fehling's reagent and warm
W	orange precipitate seen	no change	orange-red precipitate seen
X	orange precipitate seen	yellow precipitate seen	no change
Y	orange precipitate seen		

(i) **W**, **X** and **Y** each contain a common functional group.

Name the functional group that is present in all three compounds.

..... [1]

(ii) State the formula of the yellow precipitate produced when **X** is added to alkaline I_2(aq).

..... [1]

(iii) **W** could be one of four structural isomers.

- Draw the skeletal formulae for two possible structural isomers of **W**.
- Describe the type of structural isomerism shown.

isomer 1

isomer 2

type of structural isomerism

.....

[3]

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13. June/2022/Paper_23/No.3(b, c)

(c) **K** has molecular formula C_3H_6O.
When **K** is added to 2,4-dinitrophenylhydrazine, an orange precipitate forms.
When **K** is warmed with Tollens' reagent, a silver mirror forms.

Draw the displayed formula of **K**.

K

[2]

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Carbonyl compounds – 2022 Nov AS Chemistry 9701

1. Nov/2022/Paper_11/No.28

Which pair of reagents react together in a redox reaction?

A CH_3CHCH_2 + Br_2

B $CH_3CH_2CH_2OH$ + concentrated H_3PO_4

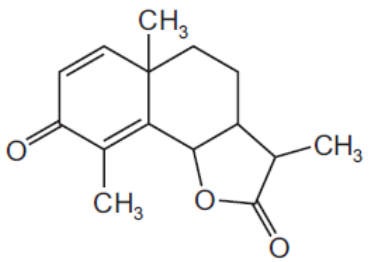
C CH_3COCH_3 + HCN

D $HCO_2C_2H_5$ + dilute H_2SO_4

2. Nov/2022/Paper_11/No.29

The structure of santonin is shown.

santonin



Santonin is first treated with warm dilute H_2SO_4. The product of this reaction is treated with cold dilute acidified $KMnO_4$. A final product, Q, is obtained.

How many atoms of hydrogen in each molecule of product Q will react with sodium metal?

A 2 **B** 4 **C** 5 **D** 6

3. Nov/2022/Paper_11/No.30

Compound R can be formed from 1-bromopropane using a nucleophilic substitution reaction followed by an oxidation reaction.

What is the identity of R?

A propanoic acid

B propanone

C propylamine

D propyl ethanoate

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4. Nov/2022/Paper_11/No.33

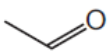
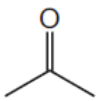
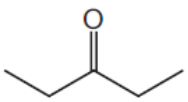
W reacts with alkaline $I_2(aq)$ to form a yellow precipitate and $CH_3CH_2CO_2^-$ ions.

Which row identifies W and the yellow precipitate?

	identity of W	identity of yellow precipitate
A	butanone	CHI_3
B	butanone	CH_3I
C	propanone	CHI_3
D	propanone	CH_3I

5. Nov/2022/Paper_12/No.35

The table shows a student's predictions for the reactions of three compounds.

	compound	alkaline $I_2(aq)$	Fehling's reagent	Tollens' reagent
1		✓	✓	✓
2		✓	✗	✗
3		✗	✗	✗

key

✓ = reaction occurs

✗ = no reaction

Which rows show the correct predictions?

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

6. Nov/2022/Paper_12/No.36

Which mechanism describes the reaction of aldehydes and ketones with HCN + NaCN?

A electrophilic addition

B electrophilic substitution

C nucleophilic addition

D nucleophilic substitution

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7. Nov/2022/Paper_12/No.38

The ester $CH_3CH_2CO_2CH_3$ is hydrolysed by boiling with aqueous sodium hydroxide.

Which compound is one of the products?

A ethanol

B propan-1-ol

C sodium methanoate

D sodium propanoate

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8. Nov/2022/Paper_21/No.5(a)

Lactones are cyclic esters. Under suitable conditions, lactones form from molecules that have both an alcohol and a carboxylic acid functional group.

Equation **1** shows an example of the formation of a lactone.

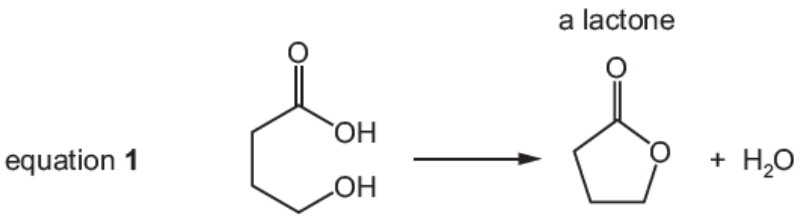


Fig. 5.1 shows the synthesis of lactone **P** from compound **M**.

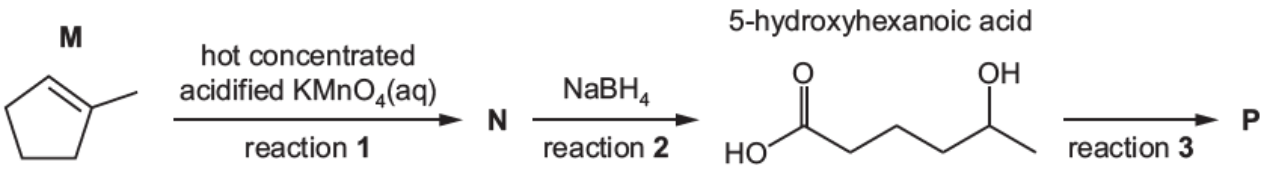


Fig. 5.1

(a) (i) **M** reacts with hot concentrated acidified $KMnO_4$(aq) to form **N**, $C_6H_{10}O_3$, in reaction **1**.

Draw the structure of **N**.

[1]

(ii) **N** is reduced by $NaBH_4$ to form 5-hydroxyhexanoic acid in reaction **2**.

Construct an equation for reaction **2** using molecular formulae.
In the equation, use [H] to represent one atom of hydrogen from the reducing agent.

..... [1]

(iii) Reaction **2** is a nucleophilic addition.

Suggest why reaction **2** creates a mixture of two organic compounds.

.....

..... [2]

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(iv) Draw lactone **P**, the product of reaction **3**.

[1]

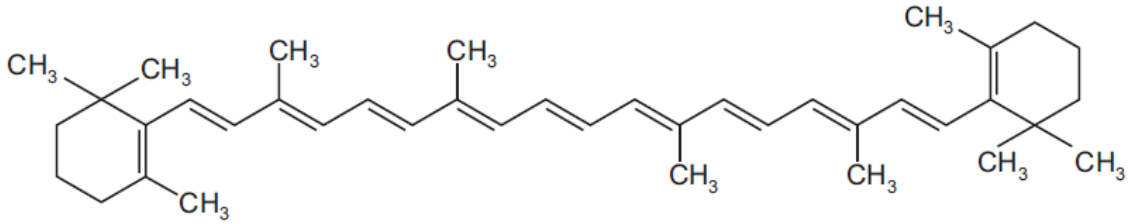
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Carbonyl compounds – 2023 AS Chemistry 9701

1. Nov/2023/Paper_ 9701/11/No.30

β-carotene is responsible for the orange colour of carrots.

β-carotene



β-carotene is oxidised by hot, concentrated, acidified $KMnO_4$.

When an individual molecule of β-carotene is oxidised in this way, many product molecules are formed.

How many of these product molecules contain a ketone functional group?

A 4 **B** 6 **C** 9 **D** 11

2. Nov/2023/Paper_ 9701/11/No.31

1,1-dichloropropane reacts with aqueous sodium hydroxide in a series of steps to give propanal.

$$CH_3CH_2CHCl_2 \xrightarrow{NaOH(aq)} CH_3CH_2CHO$$

Which term describes the first step of this reaction?

A addition

B elimination

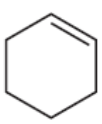
C oxidation

D substitution

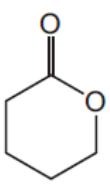
3. Nov/2023/Paper_ 9701/11/No.36

Which compound will produce a yellow-orange precipitate when added to 2,4-dinitrophenylhydrazine?

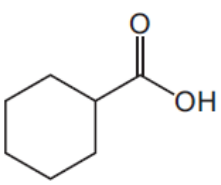
A



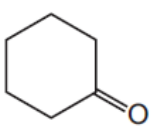
B



C



D



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4. Nov/2023/Paper_ 9701/11/No.37

Ethanal, CH_3CHO, undergoes an addition reaction with HCN in the presence of CN^- ions.

Which row identifies the type of reaction and the name of the product formed?

	type of reaction	name of product
A	electrophilic addition	2-hydroxypropanenitrile
B	electrophilic addition	2-hydroxyethanenitrile
C	nucleophilic addition	2-hydroxypropanenitrile
D	nucleophilic addition	2-hydroxyethanenitrile

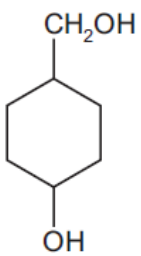
5. Nov/2023/Paper_ 9701/12/No.35

Heating compound X, $C_7H_{14}O_2$, under reflux with an excess of acidified potassium dichromate(VI) produces compound Y.

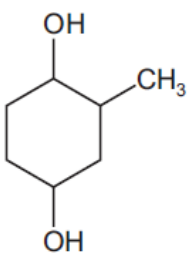
Compound Y produces hydrogen gas with sodium metal and forms orange crystals with 2,4-DNPH reagent.

What could X be?

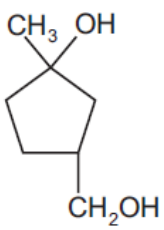
A



B



C



D

$(CH_3)_2C(OH)CH_2CH_2CH_2CHO$

6. Nov/2023/Paper_ 9701/12/No.36

Which reaction takes place by a nucleophilic addition mechanism?

A propene reacting with hydrogen bromide

B 2-bromopropane reacting with sodium hydroxide in ethanol

C propanone reacting with hydrogen cyanide

D methane reacting with chlorine

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7. June/2023/Paper_9701/11/No.33

Which reagent:

- can confirm the presence of a carbonyl group in an organic compound
- does **not** distinguish between aldehydes and ketones?

A acidified $K_2Cr_2O_7$

B 2,4-DNPH reagent

C Fehling's reagent

D $LiAlH_4$

8. June/2023/Paper_9701/11/No.34

Which compound gives a positive test with alkaline aqueous iodine and does **not** show optical isomerism?

A $CH_3COCH_2CH_2OH$

B $CH_3CH_2CH(OH)CHO$

C $CH_3COCH(OH)CH_3$

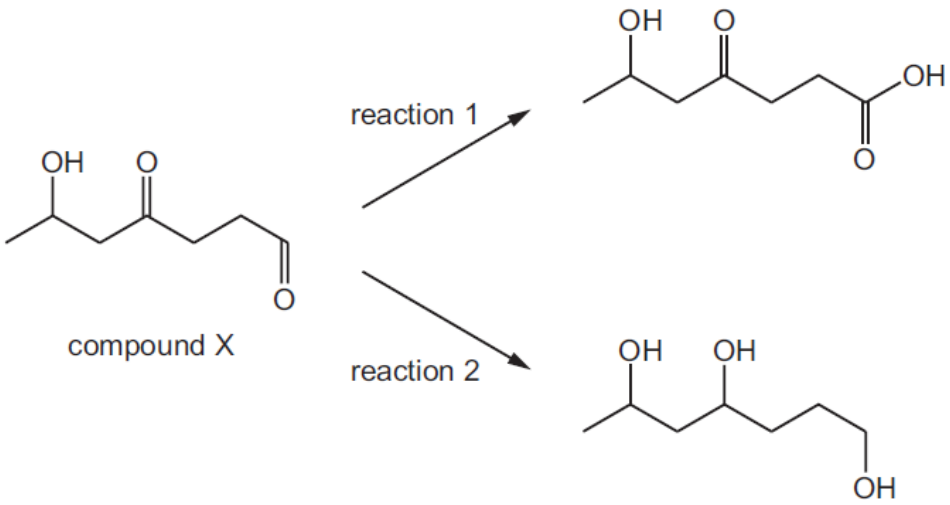
D $(CH_3)_2C(OH)CHO$

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9. June/2023/Paper_9701/11/No.35

Two samples of compound X were treated separately with different reagents which were added in excess.

The products of these two reactions are shown.



Which reagents could be used for reaction 1 and reaction 2?

	reaction 1	reaction 2
A	hot acidified sodium dichromate(VI)	Na
B	hot acidified sodium dichromate(VI)	$NaBH_4$
C	Tollens' reagent followed by $HCl(aq)$	Na
D	Tollens' reagent followed by $HCl(aq)$	$NaBH_4$

10. June/2023/Paper_9701/12/No.34

Compound G gives a pale yellow precipitate with alkaline $I_2(aq)$.

What could be compound G?

A pentan-1-ol

B pentan-2-ol

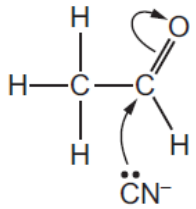
C pentan-3-ol

D 2-methylpentan-2-ol

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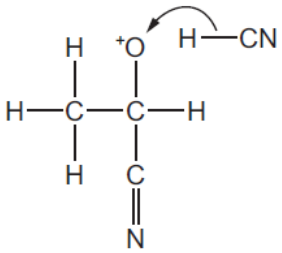
11. June/2023/Paper_9701/12/No.35

The mechanism for the reaction between ethanal and hydrogen cyanide starts with the step shown.

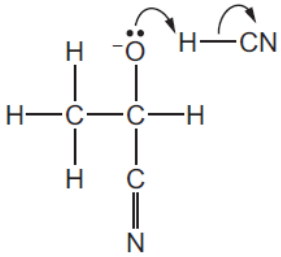


What is the correct structure of the intermediate ion formed, and what is the next step in this mechanism?

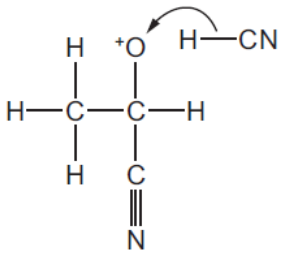
A



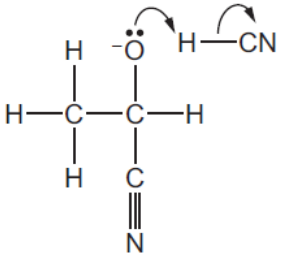
B



C



D



12. June/2023/Paper_9701/12/No.36

Which compound reacts with 2,4-dinitrophenylhydrazine reagent but does **not** react with Tollens' reagent?

A CH_3COCO_2H

B $CH_3CH(OH)CHO$

C CH_3COCHO

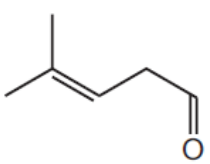
D $CH_3CH(OH)CH_3$

13. June/2023/Paper_9701/12/No.37

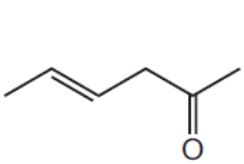
Compound X has stereoisomers and forms a precipitate when warmed with Fehling's reagent.

What could be the structure of compound X?

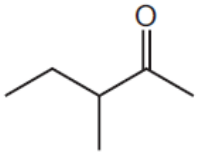
A



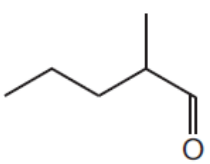
B



C



D



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14. June/2023/Paper_9701/13/No.33

T is an organic compound which contains 66.7% by mass of carbon. T also contains one atom of oxygen per molecule.

T reacts with alkaline $I_2(aq)$ to produce a yellow precipitate.

What is T?

A methylpropan-2-ol

B butan-2-ol

C butanal

D butanone

15. June/2023/Paper_9701/13/No.34

Which statement about butanone is correct?

A Butanone can be dehydrated by concentrated sulfuric acid to give $CH_2=CHCH=CH_2$.

B Butanone gives a positive result with Tollens' reagent.

C Butanone reacts with HCN by an electrophilic addition mechanism.

D Butanone reacts with $NaBH_4$ to give a chiral product.

(b) **A** and **B** are structural isomers with molecular formula $C_5H_{10}O$.

They are both straight-chained molecules with only one functional group.

Table 5.1 describes observations when separate samples of **A** and **B** are added to different reagents.

Table 5.1

reagent	**A**	**B**
2,4-dinitrophenylhydrazine (2,4-DNPH reagent)	orange precipitate appears	orange precipitate appears
Tollens' reagent	silver mirror appears	no reaction
alkaline $I_2(aq)$	no reaction	no reaction

(i) Name the functional group present in both **A** and **B**.

..... [1]

(ii) Draw the structures of **A** and **B** in the boxes.

A	**B**

[2]

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(c) **C** is a structural isomer of **A** and **B**.

C is straight chained and has two functional groups.

C shows only one type of stereoisomerism.

Table 5.2 describes observations when separate samples of **C** are added to different reagents.

Table 5.2

reagent	**C**
2,4-dinitrophenylhydrazine (2,4-DNPH reagent)	no reaction
$Br_2(aq)$	orange to colourless
alkaline $I_2(aq)$	yellow precipitate appears

(i) Draw the structure of **C** in the box.

C

[2]

(ii) Name the type of stereoisomerism shown by molecules of **C**.

..... [1]

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(b) CH_3CHO is used in a two-step synthetic route to form **W**, as shown in Fig. 6.1.
In step 1, CH_3CHO is heated with HCN in the presence of KCN.

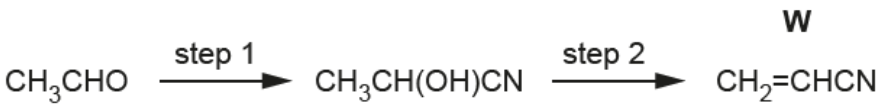


Fig. 6.1

(i) Name the mechanism for the reaction in step 1 in Fig. 6.1.

..... [1]

(ii) Complete Fig. 6.2 to show the mechanism for the reaction in step 1.
Include all products, charges, dipoles, lone pairs of electrons and curly arrows, as appropriate.

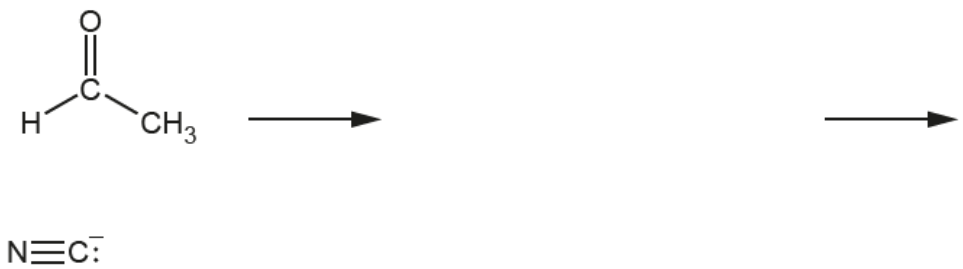


Fig. 6.2

[3]

(iii) Suggest a suitable reagent and conditions for step 2 in Fig. 6.1.

..... [1]

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18. March/2023/Paper_9701/12/No.26

Which reagents and conditions would result in the formation of butanenitrile, $CH_3CH_2CH_2CN$?

A 1-bromobutane heated under pressure with ammonia in ethanol

B 1-bromopropane heated with potassium cyanide in ethanol

C propanal heated with hydrogen cyanide in the presence of potassium cyanide

D propanone heated with hydrogen cyanide in the presence of potassium cyanide

19. March/2023/Paper_9701/12/No.34

Structural and stereoisomerism should be considered when answering this question.

P has molecular formula $C_5H_{10}O$.

P produces an orange precipitate with 2,4-dinitrophenylhydrazine (2,4-DNPH reagent).

How many isomeric structures does P have?

A 5 **B** 6 **C** 7 **D** 8

(b) **A** and **B** show reactions typical of aliphatic aldehydes.

(i) **A** undergoes a nucleophilic addition reaction with a mixture of HCN and KCN, forming compound **C**.

Complete the diagram to show the mechanism for this reaction.

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

Draw the structure of the organic intermediate.



[4]

(ii) Table 3.1 shows information about three experiments involving **B**.

Complete Table 3.1.

Table 3.1

experiment	reagents	observation with **B**
1		solution turns from orange to green
2		a silver mirror forms on the sides of the reaction vessel
3	$Br_2(aq)$	

[3]

(iii) **B**, C_4H_8O, is oxidised by acidified potassium manganate(VII).

Complete the equation for this reaction. Use [O] to represent one atom of oxygen from the oxidising agent.

C_4H_8O + ... [1]

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(iv) **C** is a chiral molecule.

Circle any chiral centres in the structure of **C** shown in Fig. 3.2.

C

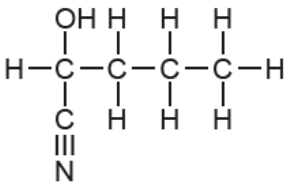


Fig. 3.2

[1]

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