HL Paper 1

Which reagents are needed to convert nitrobenzene to phenylamine in 2 steps?

	Step 1	Step 2
A.	tin and sodium hydroxide	concentrated hydrochloric acid
B.	sodium hydroxide	tin and concentrated hydrochloric acid
C.	concentrated hydrochloric acid	tin and sodium hydroxide
D.	tin and concentrated hydrochloric acid	sodium hydroxide

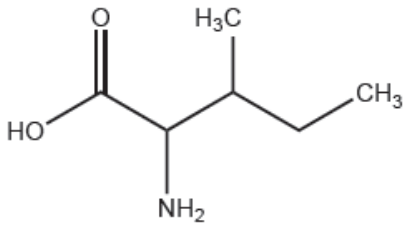
Markscheme

D

Examiners report

[N/A]

What is the number of optical isomers of isoleucine?



A. 0

B. 2

C. 4

D. 8

Markscheme

C

Examiners report

[N/A]

Which statement is correct for a pair of enantiomers under the same conditions?

A. A racemic mixture of the enantiomers is optically active.

B. They have the same chemical properties in all their reactions.

C. They have the same melting and boiling points.

D. They rotate the plane of plane-polarized light by different angles.

Markscheme

C

Examiners report

[N/A]

Which molecule is chiral?

A. 2-chlorobutane

B. 2,2-dichloropentane

C. Propan-2-amine

D. 4-hydroxybutanoic acid

Markscheme

A

Examiners report

[N/A]

Which molecule can be both reduced by sodium borohydride, $NaBH_4$, and oxidized by warm acidified potassium dichromate(VI)?

A. $CH_3CHOHCH_2CH_3$
B. $(CH_3)_3CCHO$
C. $(CH_3)_3COH$
D. $(CH_3)_3CCOC(CH_3)_3$

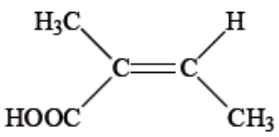
Markscheme

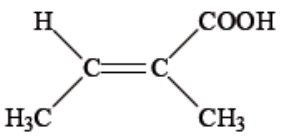
B

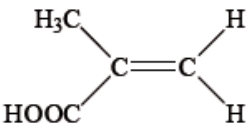
Examiners report

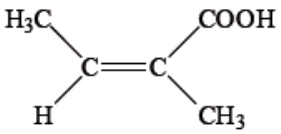
[N/A]

Which two molecules are cis-trans isomers of each other?

W 

X 

Y 

Z 

A. X and Z

B. X and Y

C. W and Y

D. W and Z

Markscheme

A

Examiners report

One respondent stated that this question was difficult. However, the question was in the midrange of difficulty and in fact was the 14^{th} easiest question on the paper with 77.42% of candidates getting the correct answer, A. The question had a linked discrimination index of 0.40.

Which halogenoalkane reacts the fastest with hydroxide ions in a nucleophilic substitution reaction?

A. 1-chlorobutane

B. 2-chloro-2-methylpropane

C. 1-iodobutane

D. 2-iodo-2-methylpropane

Markscheme

D

Examiners report

[N/A]

Which molecule exhibits optical isomerism?

A. 3-iodopentane

B. 2-iodo-2-methylpropane

C. 1,3-diiodopropane

D. 2-iodobutane

Markscheme

D

Examiners report

[N/A]

Propene is reacted first with hydrogen chloride to produce X which is then reacted with aqueous sodium hydroxide to give Y. Finally, Y is reacted with excess acidified potassium dichromate solution.

$$CH_3CHCH_2 \xrightarrow{HCL} X \xrightarrow{NaOH(aq)} Y \xrightarrow{H^+/Cr_2O_7{}^{2-}(aq)} Z$$

What is the major product, Z?

A. $CH_3CH(OH)CH_3$

B. CH_3COCH_3

C. CH_3CH_2CHO

D. $CH_3(CH_2)_2COOH$

Markscheme

B

Examiners report

[N/A]

Which molecule has a chiral centre?

A. $CH_3CH=CHCHO$

B. $(CH_3)_2C=CHCH_2OH$

C. $CH_3OCH_2CH_3$

D. $CH_3CHOHCH_2CH_3$

Markscheme

D

Examiners report

In this question, candidates had to identify which molecule had a chiral centre. One respondent stated that ethers are off-syllabus. It is true that as a functional group, ethers are not required based on Topic 10. However, it should be noted that candidates are expected to know that oxygen is divalent and hence can occur with two single bonds. This is also referred to in the Teacher's notes corresponding to AS 4.3.2, where a comparison between the intermolecular forces present in CH_3OCH_3 and CH_3CH_2OH is referred to. Hence, candidates are expected to be able to write a full structural formula from the condensed structural formula of $CH_3OCH_2CH_3$ to determine that it does not have a chiral centre.

Which molecule contains a chiral carbon?

A. $CH_3CHOHCH_2CH_3$
B. $(CH_3)_3CCHO$
C. $(CH_3)_3COH$
D. $(CH_3)_3COC(CH_3)_3$

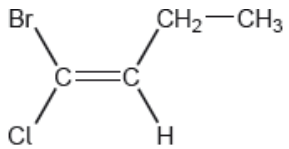
Markscheme

A

Examiners report

[N/A]

What is name of this compound applying IUPAC rules?



A. E 1-bromo-1-chlorobut-1-ene

B. Z 1-bromo-1-chlorobut-1-ene

C. E 1-bromo-1-chloro-2-ethylethene

D. Z 1-bromo-1-chloro-2-ethylethene

Markscheme

B

Examiners report

[N/A]

Which statements about substitution reactions are correct?

I. The reaction between sodium hydroxide and 1-chloropentane predominantly follows an S_N2 mechanism.

II. The reaction between sodium hydroxide and 2-chloro-2-methylbutane predominantly follows an S_N2 mechanism.

III. The reaction of sodium hydroxide with 1-chloropentane occurs at a slower rate than with 1-bromopentane.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

B

Examiners report

[N/A]

Which compound can exist as stereoisomers?

A. CH_3CH_2CHO

B. $CH_3CH_2COCH_3$

C. $CH_3CH(CH_3)_2$

D. $CH_3CH_2CHOHCH_3$

Markscheme

D

Examiners report

[N/A]

Which isomers exist as non-superimposable mirror images?

A. cis-trans isomers

B. diastereomers

C. enantiomers

D. structural isomers

Markscheme

C

Examiners report

[N/A]

Which molecule exhibits optical isomerism?

A. 3-chloropentane

B. 2-chlorobutane

C. 1,3-dichloropropane

D. 2-chloro-2-methylpropane

Markscheme

B

Examiners report

[N/A]

Which type(s) of stereoisomerism, if any, is/are present in the molecule CH_2=CHCHBrCH_3?

A. Optical only

B. Geometric only

C. Optical and geometric

D. Neither optical nor geometric

Markscheme

A

Examiners report

Nearly a quarter of the candidates were persuaded, presumably by the C=C, to chose option C.

Which factors affect the rate of nucleophilic substitution in halogenoalkanes?

I. The nature of the attacking nucleophile

II. The identity of the halogen

III. The structure of the halogenoalkane

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

D

Examiners report

[N/A]

What does a polarimeter measure?

A. Colour of reaction mixture

B. Polarity of a molecule

C. Configuration of a molecule as R or S

D. Rotation of plane-polarized light

Markscheme

D

Examiners report

The examiners regret the inclusion of R and S in the distractors. In the event, this question was the fifth easiest with over 84% giving the correct answer.

Which reaction occurs via a free-radical mechanism?

A. $\mathrm{C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr}$

B. $\mathrm{C_2H_4 + Br_2 \rightarrow C_2H_4Br_2}$

C. $\mathrm{C_4H_9I + OH^- \rightarrow C_4H_9OH + I^-}$

D. $\mathrm{(CH_3)_3CI + H_2O \rightarrow (CH_3)_3COH + HI}$

Markscheme

A

Examiners report

[N/A]

Halogenoalkanes can undergo $\mathrm{S_N1}$ and $\mathrm{S_N2}$ reactions with aqueous sodium hydroxide. Which halogenoalkane will react fastest with a $0.1\ \mathrm{mol\,dm^{-3}}$ solution of aqueous sodium hydroxide?

A. 2-chloro-2-methylpropane

B. 2-iodo-2-methylpropane

C. 1-chlorobutane

D. 1-iodobutane

Markscheme

B

Examiners report

[N/A]

What is the product of the reaction between pentan-2-one and sodium borohydride, $NaBH_4$?

A. Pentan-1-ol

B. Pentan-2-ol

C. Pentanoic acid

D. Pentanal

Markscheme

B

Examiners report

[N/A]

Which compound could rotate the plane of polarization of polarized light?

A. $(CH_3)_2CHCH_2Cl$

B. $CH_3CH_2CH_2CH_2Cl$

C. $CH_3CH_2CHClCH_3$

D. $(CH_3)_3CCl$

Markscheme

C

Examiners report

[N/A]

What is the major organic product formed from the reaction of $(CH_3)_3CBr$ with a concentrated, ethanolic solution of KOH?

A. $(CH_3)_3COH$

B. $(CH_3)_2CCH_2$

C. $(CH_3)_2CO$

D. $(CH_3)_2CHO$

Markscheme

B

Examiners report

[N/A]

Which halogenoalkane reacts fastest with sodium hydroxide?

A. 1-iodobutane

B. 1-chlorobutane

C. 2-chloro-2-methylpropane

D. 2-iodo-2-methylpropane

Markscheme

D

Examiners report

[N/A]

1-bromobutane, $CH_3CH_2CH_2CH_2Br$, can be converted to 1-aminopentane, $CH_3CH_2CH_2CH_2CH_2NH_2$, in a two-step process.

$$CH_3CH_2CH_2CH_2Br \xrightarrow{I} CH_3CH_2CH_2CH_2CN$$
$$CH_3CH_2CH_2CH_2CN \xrightarrow{II} CH_3CH_2CH_2CH_2CH_2NH_2$$

What are the reagents **I** and **II**?

	I	II
A.	ammonia	hydrogen with nickel
B.	ammonia	hydrochloric acid
C.	potassium cyanide	ammonia
D.	potassium cyanide	hydrogen with nickel

Markscheme

D

Examiners report

[N/A]

Which molecule contains a chiral carbon?

A. $CH_3CH_2CHBrCH_2CH_3$

B. $CH_3CH_2CHBrCH_3$

C. $CH_2BrCH(CH_3)CH_2Br$

D. $CH_3CH_2CH_2CH_2CH_2Br$

Markscheme

B

Examiners report

[N/A]

How many four-membered ring isomers are there of dichlorocyclobutane, $C_4H_6Cl_2$?

A. 3

B. 4

C. 5

D. 6

Markscheme

C

Examiners report

This question tested assessment statement 20.6.3. The question was poorly answered with 30% choosing A and 41% B. It was the most difficult question in the paper answered correctly by only 17%.

What should be changed to alter the rate of nucleophilic substitution of tertiary halogenoalkanes?

A. The nucleophile

B. The concentration of the nucleophile

C. The concentration of the tertiary halogenoalkane

D. The size of the reaction flask

Markscheme

C

Examiners report

Students found this question one of the more difficult ones with 32.32% correct answers. Tertiary halogenoalkanes undergo SN1 reaction mechanism in which the rate of reaction is only first order with to the concentration of the halogenoalkane; thus choice C was the correct answer.

Which pair of isomers always shows optical activity?

A. Cis-trans

B. Enantiomers

C. Conformational

D. E/Z

Markscheme

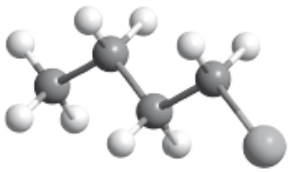
B

Examiners report

[N/A]

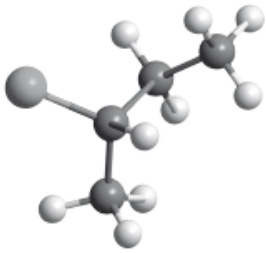
Which compound is optically active?

A.



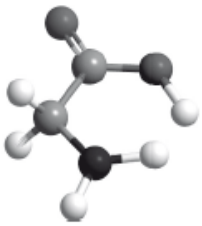
1-chlorobutane

B.



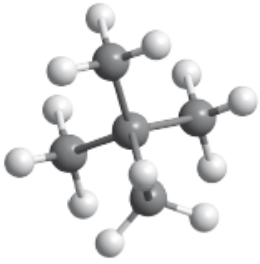
2-chlorobutane

C.



2-aminoethanoic acid

D.



2,2-dimethylpropane

Markscheme

B

Examiners report

Several respondents suggested that it would have been better if atomic labels were given in the 3D diagrams in this question which is a fair comment.

Which compound can exist as stereoisomers?

A. 1,2-dichloroethane

B. 1,1-dichloroethene

C. Butan-2-ol

D. Propan-2-ol

Markscheme

C

Examiners report

One can only apologise for the error in distractor B; it will be corrected in the published version.

Which statement is correct about the enantiomers of a chiral compound?

A. Their physical properties are different.

B. All their chemical reactions are identical.

C. A racemic mixture will rotate the plane of polarized light.

D. They will rotate the plane of polarized light in opposite directions.

Markscheme

D

Examiners report

One respondent stated that there were two answers to this question (A and D). The only correct answer is D, namely that, the enantiomers of a chiral compound rotate the plane of polarized light in opposite directions. Enantiomers have the same physical properties. However, diastereomers which are stereoisomers that are not enantiomers can have different physical properties.

Which compound has a chiral carbon?

A. Propan-2-ol

B. 1-bromo-2-methylbutane

C. 3-bromopentane

D. Ethane-1,2-diol

Markscheme

B

Examiners report

[N/A]

What is the correct order for the **increasing** rate of hydrolysis of halogenoalkanes by dilute aqueous sodium hydroxide?

A. $CH_3CH(CH_3)CH_2Cl < CH_3CHClCH_2CH_3 < (CH_3)_3CCl < (CH_3)_3CBr$

B. $(CH_3)_3CBr < (CH_3)_3CCl < CH_3CHClCH_2CH_3 < CH_3CH(CH_3)CH_2Cl$

C. $(CH_3)_3CCl < (CH_3)_3CBr < CH_3CHClCH_2CH_3 < CH_3CH(CH_3)CH_2Cl$

D. $CH_3CHClCH_2CH_3 < CH_3CH(CH_3)CH_2Cl < (CH_3)_3CBr < (CH_3)_3CCl$

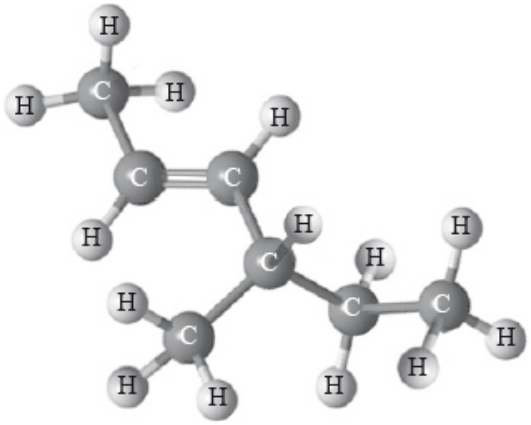
Markscheme

A

Examiners report

[N/A]

What is the name of the following compound applying IUPAC rules?



A. *cis*-4-methylhex-2-ene

B. *cis*-4-ethylpent-2-ene

C. *trans*-4-methylhex-2-ene

D. *trans*-4-ethylpent-2-ene

Markscheme

C

Examiners report

[N/A]

The hydrolysis of tertiary bromoalkanes with a warm dilute aqueous sodium hydroxide solution proceeds by a two-step S_N1 mechanism.

Step I: $R - Br \rightarrow R^+Br^-$

Step II: $R^+ + OH^- \rightarrow R - OH$

Which description of this reaction is consistent with the above information?

	Step I	Step II	Rate expression
A.	fast	slow	rate = k[R–Br]
B.	slow	fast	rate = k[R–Br]
C.	fast	slow	rate = k[R–Br][OH^-]
D.	slow	fast	rate = k[R–Br][OH^-]

Markscheme

B

Examiners report

[N/A]

What is the product of the reduction of 2-methylbutanal?

A. 2-methylbutan-1-ol

B. 2-methylbutan-2-ol

C. 3-methylbutan-2-one

D. 2-methylbutanoic acid

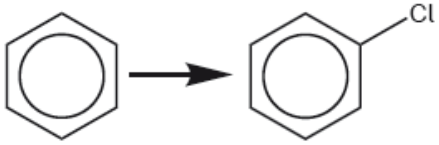
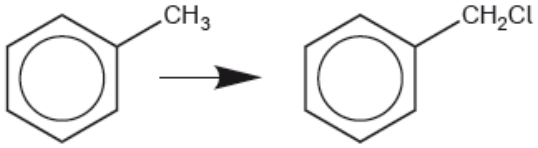
Markscheme

A

Examiners report

[N/A]

Which is the correct combination of substitution reaction mechanisms?

	 reaction mechanism	 reaction mechanism
A.	electrophilic	free radical
B.	nucleophilic	nucleophilic
C.	free radical	electrophilic
D.	free radical	nucleophilic

Markscheme

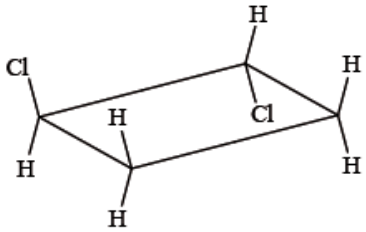
A

Examiners report

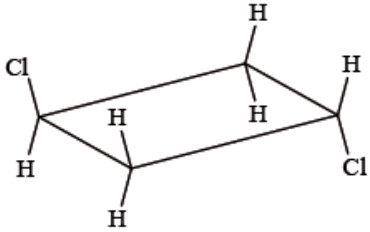
[N/A]

Which structure is a geometric isomer of *cis*-1,2-dichlorocyclobutane?

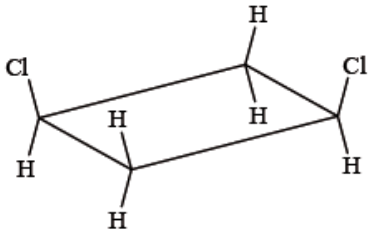
A.



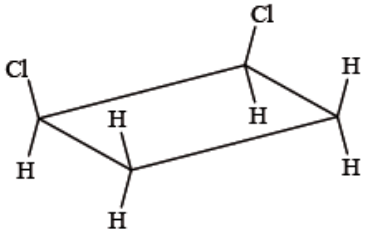
B.



C.



D.



Markscheme

A

Examiners report

This was the second most difficult question on the paper, the most popular answer being D. Candidates have clearly misread the question.

In which order should the reagents be used to convert benzene into phenylamine (aniline)?

	1st reagent	2nd reagent	3rd reagent
A.	NaOH	Sn / conc. HCl	conc. HNO_3 / conc. H_2SO_4
B.	Sn / conc. HCl	NaOH	conc. HNO_3 / conc. H_2SO_4
C.	conc. HNO_3 / conc. H_2SO_4	Sn / conc. HCl	NaOH
D.	NaOH	conc. HNO_3 / conc. H_2SO_4	Sn / conc. HCl

Markscheme

C

Examiners report

[N/A]

Which statement about isomerism is correct?

A. But-1-ene and but-2-ene are geometrical isomers.

B. But-1-ene has two geometrical isomers.

C. Butan-1-ol and butan-2-ol are optical isomers.

D. Butan-2-ol has two optical isomers.

Markscheme

D

Examiners report

[N/A]

What effect of optical isomers on plane-polarized light can be measured using a polarimeter?

A. Reflection

B. Emission

C. Rotation

D. Absorption

Markscheme

C

Examiners report

[N/A]

Propanitrile can be prepared by reacting bromoethane with potassium cyanide. Which statement is **not** correct about the reaction between bromoethane and potassium cyanide?

A. The reaction is bi-molecular.

B. The reaction follows the $\mathrm{S_N2}$ mechanism.

C. Homolytic fission occurs between the carbon-bromine bond in bromoethane.

D. The cyanide ion, $:\mathrm{CN^-}$, acts as a nucleophile.

Markscheme

C

Examiners report

One respondent stated that propanenitrile should have been written instead of propanitrile, which is correct.

Which statement is correct about the major reaction between 1-chloropropane, $CH_3CH_2CH_2Cl$, and dilute sodium hydroxide solution, NaOH (aq)?

A. The rate equation is second order.
B. The hydroxide ion acts as a Brønsted–Lowry base.
C. The reaction has two distinct steps.
D. Water is a product.

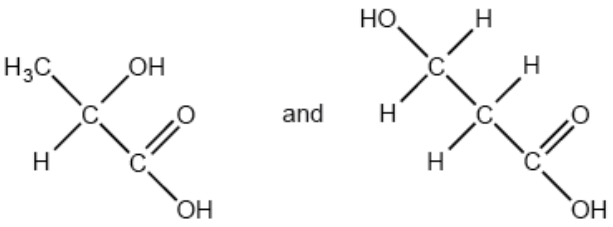
Markscheme

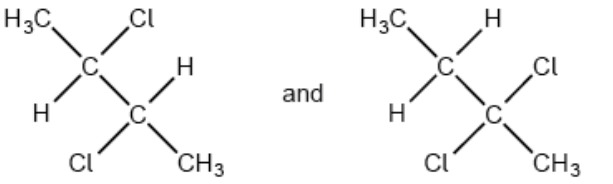
A

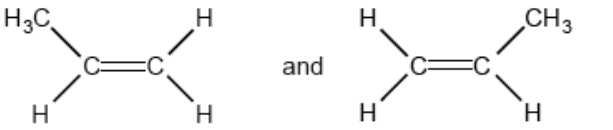
Examiners report

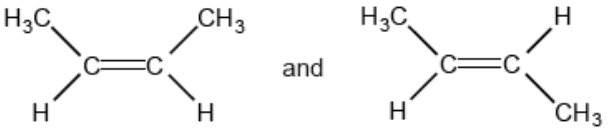
[N/A]

Which pair are geometric isomers?

A. 

B. 

C. 

D. 

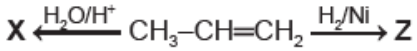
Markscheme

D

Examiners report

[N/A]

Propene reacts separately with H_2O/H^+ and H_2/Ni to give products **X** and **Z** respectively.



What are the major products of the reactions?

	X	Z
A.	$CH_3CH(OH)CH_3$	$CH_3CH_2CH_3$
B.	$CH_3CH_2CH_2OH$	$CH_3C{\equiv}CH$
C.	$CH_3C(O)CH_3$	$CH_3CH_2CH_3$
D.	$CH_3CH(OH)CH_3$	$CH_3C{\equiv}CH$

Markscheme

A

Examiners report

[N/A]

Which statement about stereoisomers is correct?

A. 1,2-dichloroethane has two geometrical isomers.

B. 1,2-dichloroethane has two optical isomers.

C. 1,2-dichloroethene has two geometrical isomers.

D. 1,2-dichloroethene has two optical isomers.

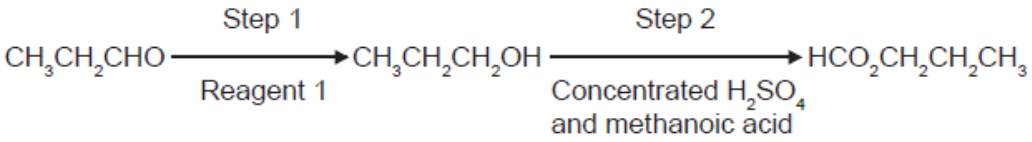
Markscheme

C

Examiners report

[N/A]

Which is correct for the conversion of propanal to propyl methanoate?



	Reagent for step 1	Reaction type in step 1	Reaction type in step 2
A.	H_2O	hydration	addition
B.	$K_2Cr_2O_7$, dilute H_2SO_4	oxidation	nucleophilic substitution (condensation)
C.	$NaBH_4$	reduction	oxidation
D.	$NaBH_4$	reduction	nucleophilic substitution (condensation)

Markscheme

D

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[N/A]