15. Halogen compounds

15.1 Halogenoalkanes

Paper 1

Question Paper

1 The reaction of chlorine with methane is carried out in the presence of light.

What is the function of the light?

A to break the C–H bonds in methane

B to break the chlorine molecules into atoms

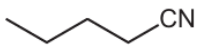
C to break the chlorine molecules into ions

D to heat the mixture

2 When X is added to NaOH(aq) and heated under reflux, pentan-2-ol is made.

Which organic product is made when X is heated with a solution of KCN dissolved in ethanol?

A



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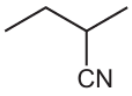

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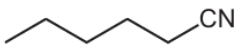

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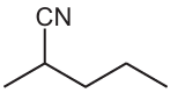


3 1-chlorobutane and 1-iodobutane both react with aqueous sodium hydroxide by a nucleophilic substitution mechanism.

Which reaction has the greatest rate under the same conditions and which mechanism is followed by this reaction?

	greatest rate	mechanism
A	1-chlorobutane	S_N1
B	1-chlorobutane	S_N2
C	1-iodobutane	S_N1
D	1-iodobutane	S_N2

4 Which reaction occurs when ethane and chlorine are mixed in diffused sunlight?

A a free-radical substitution with hydrogen given off

B a free-radical substitution with hydrogen chloride given off

C a free-radical substitution with no gas given off

D a nucleophilic substitution with hydrogen chloride given off

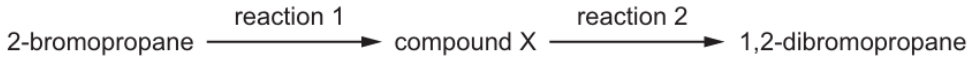
5 Q is either a primary or a tertiary halogenoalkane. Q undergoes hydrolysis with aqueous sodium hydroxide.

The first step in the mechanism of this reaction involves two species reacting together.

Which row is correct?

	Q	behaviour of hydroxide ion
A	primary halogenoalkane	electrophile
B	primary halogenoalkane	nucleophile
C	tertiary halogenoalkane	electrophile
D	tertiary halogenoalkane	nucleophile

6 2-bromopropane is converted to 1,2-dibromopropane in a pathway involving two reactions.



What are the reagents and conditions for the two reactions?

	reaction 1	reaction 2
A	heat under reflux with aqueous NaOH	HBr(g) at room temperature
B	heat under reflux with aqueous NaOH	Br_2(l) at room temperature
C	heat under reflux with ethanolic NaOH	HBr(g) at room temperature
D	heat under reflux with ethanolic NaOH	Br_2(l) at room temperature

7 Which reagents could be used to form 2-bromobutane from butan-1-ol?

A bromine and ultraviolet light

B concentrated sulfuric acid with potassium bromide, under reflux

C concentrated sulfuric acid followed by bromine

D concentrated sulfuric acid followed by hydrogen bromide

8 Aqueous NaOH reacts with 1-bromopropane to give propan-1-ol.

What should be included in a diagram of the first step in the mechanism?

A a curly arrow from a lone pair on the OH^- ion to the $C^{\delta+}$ atom of 1-bromopropane

B a curly arrow from the $C^{\delta+}$ atom of 1-bromopropane to the OH^- ion

C a curly arrow from the C–Br bond to the C atom

D the homolytic fission of the C–Br bond

9 1-bromopropane reacts with hot ethanolic NaOH.

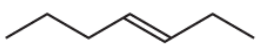
What is the molecular formula of the product in this reaction?

A C_3H_6 **B** C_3H_8 **C** C_3H_7O **D** C_3H_8O

10 Which compound has an M_r of 84 and will react with HBr to give a product with an M_r of 164.9?

A

B



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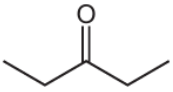


D

11 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

12 Which row describes the solvent used and type of reaction occurring when bromoethane reacts with NaOH to form ethene?

	solvent	type of reaction
A	ethanol	elimination
B	ethanol	substitution
C	water	elimination
D	water	substitution

13 Which statement describes what happens when 2-chloro-2-methylpropane is warmed with NaOH(aq)?

A This secondary halogenoalkane reacts by a mixture of an S_N1 and an S_N2 mechanism.

B This secondary halogenoalkane reacts only by an S_N2 mechanism.

C This tertiary halogenoalkane reacts mostly by an S_N1 mechanism.

D This tertiary halogenoalkane does **not** react with hydroxide ions under these conditions.

14 When bromoethane reacts with hot ethanolic sodium hydroxide a colourless gas is formed. This gas decolourises aqueous bromine.

What is the colourless gas?

A 1,2-dibromoethane

B ethanol

C ethene

D hydrogen bromide

15 Halogenoalkanes react with hot ethanolic potassium cyanide.

The reaction mechanism is either S_N1 or S_N2.

Which statement is correct?

A All secondary halogenoalkanes react by the S_N2 mechanism only.

B Both the halogenoalkane and the cyanide ion are involved in the initial step of the S_N1 mechanism.

C Chloroethane reacts with cyanide ions by the S_N1 mechanism only.

D The S_N2 mechanism involves a short-lived negatively charged transition state.

16 2-bromopropane reacts with hot ethanolic sodium hydroxide.

Which substance is the major product of this reaction?

A propan-1-ol

B propan-2-ol

C 2-hydroxypropene

D propene

17 For which reaction will the major organic product have the lowest relative molecular mass?

A Bromoethane is heated under reflux with an aqueous solution of sodium hydroxide.

B Bromoethane is heated under reflux with a solution of sodium cyanide in ethanol.

C 2-bromopropane is heated under reflux with an aqueous solution of sodium hydroxide.

D 2-bromopropane is heated under reflux with concentrated ethanolic sodium hydroxide.

18 C_4H_9Cl reacts with warm dilute aqueous sodium hydroxide solution.

Which isomer of C_4H_9Cl will form the most stable cation intermediate?

A 1-chlorobutane

B 2-chlorobutane

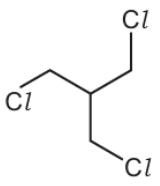
C 1-chloro-2-methylpropane

D 2-chloro-2-methylpropane

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

Which compound would be the quickest to produce a precipitate?

A



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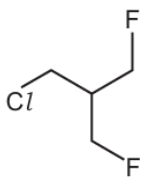

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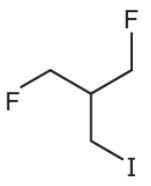

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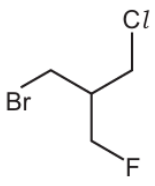
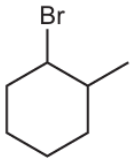


20 Compound Z, $C_7H_{13}Br$, has two chiral centres. A sample of Z contains all four possible optical isomers.

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

What could be the formula of Z?

A



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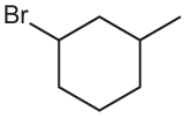

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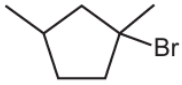
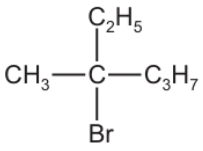


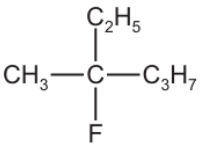
D

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

P



Q



Both compounds can be hydrolysed.

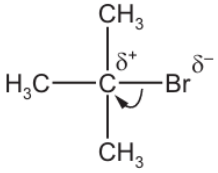
Which row is correct?

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

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

Which diagram describes the first step in the reaction mechanism?

A



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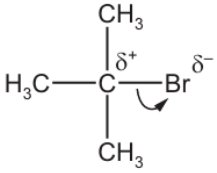

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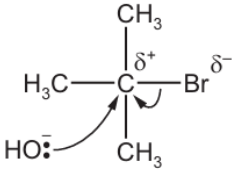

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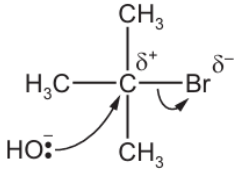


23 A halogenoalkane has the molecular formula $C_5H_{11}Br$. The halogenoalkane does **not** form an alkene when treated with ethanolic sodium hydroxide.

What could be the halogenoalkane?

A 1-bromo-2-methylbutane

B 2-bromo-2-methylbutane

C 3-bromopentane

D 1-bromo-2,2-dimethylpropane

24 Bromoethane reacts with cyanide ions, producing propanenitrile.

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

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

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

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

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

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

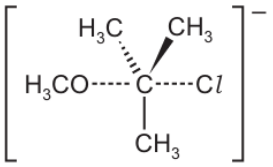
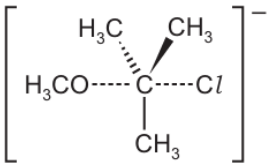
The experiment was repeated with 2-iodopropane.

Which row is correct?

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

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

Which row is correct?

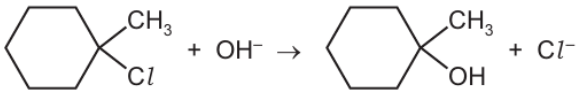
	intermediate or transition state	product
A	$(CH_3)_3C^+$	$(CH_3)_3COCH_3$
B	$(CH_3)_3C^+$	$(CH_3)_3CCH_2OH$
C		$HOCH_2C(CH_3)_3$
D		$H_3COC(CH_3)_3$

27 Iodoethane, CH_3CH_2I, reacts with aqueous silver nitrate at 50 °C. A precipitate forms during this reaction.

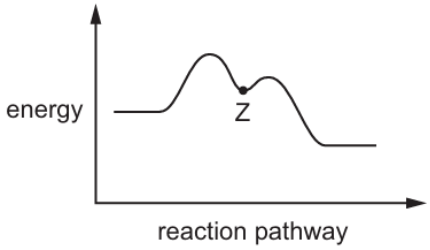
Which row of the table is correct about this reaction?

	type of organic reaction	colour of precipitate
A	electrophilic substitution	cream
B	electrophilic substitution	yellow
C	nucleophilic substitution	cream
D	nucleophilic substitution	yellow

28 1-chloro-1-methylcyclohexane is hydrolysed by heating with NaOH(aq).



The reaction pathway is shown.



One carbon atom in 1-chloro-1-methylcyclohexane is bonded to three other carbon atoms.

What is the charge on this carbon atom at point Z?

A 1– **B** δ– **C** δ+ **D** 1+

29 2-bromo-2-methylpentane is a tertiary halogenoalkane.

Which organic products are formed when 2-bromo-2-methylpentane reacts with a hot concentrated ethanolic solution of sodium hydroxide?

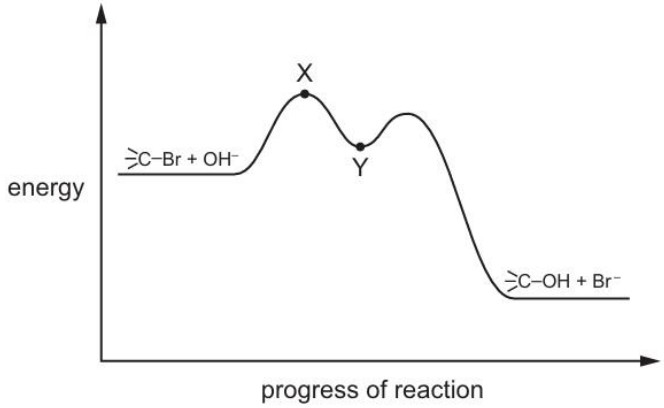
A 2-methylpent-1-ene only

B 2-methylpent-1-ene and 2-methylpent-2-ene

C 2-methylpent-2-ene only

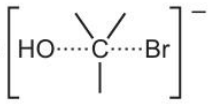
D 2-methylpent-2-ene and 4-methylpent-2-ene

30 A tertiary bromoalkane, indicated here by $\geq$C–Br, reacts with aqueous NaOH. The mechanism has the reaction pathway shown.

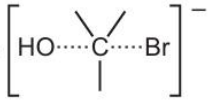


Which point in the diagram is correctly identified?

A X is $\geq$C+

B X is 

C Y is $\geq$C+

D Y is 

31 Bromoethane and chloroethane are added separately to water. Hydrolysis reactions occur.

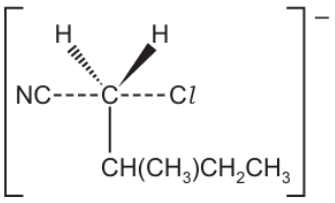
Which compound hydrolyses more rapidly and what is the mechanism?

	compound that hydrolyses more rapidly	mechanism
A	bromoethane	electrophilic substitution
B	bromoethane	nucleophilic substitution
C	chloroethane	electrophilic substitution
D	chloroethane	nucleophilic substitution

32 1-chloro-2-methylbutane reacts with sodium cyanide in ethanol in a nucleophilic substitution reaction.

What is the most likely intermediate or transition state in this reaction?

A



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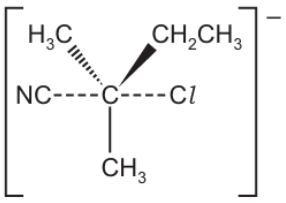

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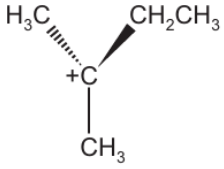

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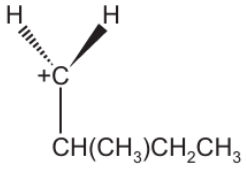


33 Which reaction is most likely to involve the formation of a positively charged intermediate?

A 1-bromopentane and warm dilute NaOH(aq)

B 1-bromo-2,2-dimethylpropane and warm dilute NaOH(aq)

C 1-bromo-3-methylbutane and warm dilute NaOH(aq)

D 2-bromo-2-methylbutane and warm dilute NaOH(aq)

34 Which product can be made from bromoethane by an elimination reaction?

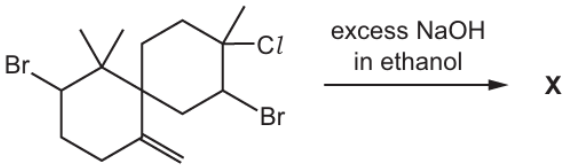
A ethanol

B ethene

C ethylamine

D propanenitrile

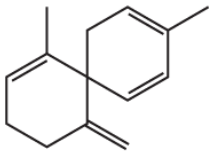
35 Compound J, $C_{15}H_{23}Br_2Cl$, is reacted with an excess of a hot concentrated solution of sodium hydroxide in ethanol. One of the products is **X**.



compound J

What could be the skeletal formula of **X**?

A



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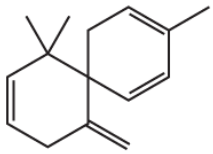

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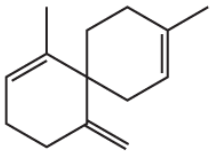

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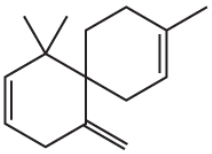

36 Compound P reacts separately with KOH(aq) and HBr.

$CH_2CHCH_2CH_2Cl$

compound P

What are the mechanisms of these two reactions?

	KOH (aq)	HBr
A	nucleophilic addition	electrophilic addition
B	nucleophilic addition	free radical substitution
C	nucleophilic substitution	electrophilic addition
D	nucleophilic substitution	free radical substitution

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

What could be the halogenoalkane?

A 1-bromo-2-methylbutane

B 2-bromo-2-methylbutane

C 3-bromopentane

D bromodimethylpropane

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

Which row is correct?

	intermediate or transition state	product
A	$(CH_3)_3C^+$	$(CH_3)_3COCH_3$
B	$(CH_3)_3C^+$	$(CH_3)_3CCH_2OH$
C	$[HOCH_2\text{- - -}C(CH_3)_3\text{- - -}Cl]^-$	$HOCH_2C(CH_3)_3$
D	$[H_3CO\text{- - -}C(CH_3)_3\text{- - -}Cl]^-$	$H_3COC(CH_3)_3$

39 Primary halogenoalkanes undergo hydrolysis reactions.

Which reaction would occur most rapidly if they are all warmed to the same temperature?

A C_2H_5Br with H_2O

B C_2H_5Br with NaOH(aq)

C C_2H_5Cl with H_2O

D C_2H_5Cl with NaOH(aq)

40 When warm water is added to halogenoalkane X, an S_N1 reaction occurs.

$AgNO_3$(aq) is then added; a yellow precipitate is formed.

What could be X?

A 1-chlorobutane

B 1-iodobutane

C 2-chloro-2-methylpropane

D 2-iodo-2-methylpropane