CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



EXAM QUESTION PACK

15 HALOGEN COMPOUNDS

SCORE	PERCENTAGE
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Chapter 15

Halogen compounds

15.1 Halogenoalkanes

877. 9701_m22_qp_12 Q: 28

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

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

A ethene, propene, 2-methylpropene

B 2-methylpropene, ethene, propene

C propene, ethene, 2-methylpropene

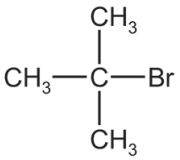
D propene, 2-methylpropene, ethene

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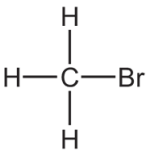
878. 9701_m22_qp_12 Q: 30

The diagram shows the structures of three halogenoalkanes.

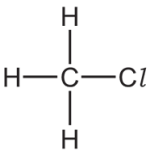
P



Q



R



P, Q and R can all be hydrolysed.

Which row is correct?

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

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879. 9701_m21_qp_12 Q: 25

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

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

Which isomer produces only one hydrocarbon product?

A 1,5-dibromopentane

B 1,4-dibromopentane

C 2,3-dibromopentane

D 2,4-dibromopentane

---

880. 9701_s21_qp_12 Q: 24

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

The experiment was repeated with 2-iodopropane.

Which row is correct?

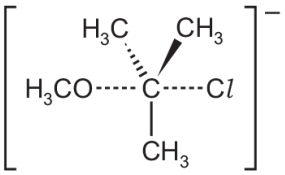
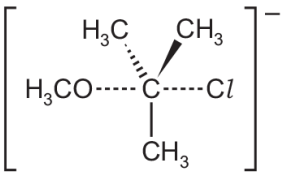
	colour of precipitate from **2-bromopropane** + $AgNO_3(aq)$	faster rate of reaction
A	cream	2-bromopropane + $AgNO_3(aq)$
B	yellow	2-bromopropane + $AgNO_3(aq)$
C	cream	2-iodopropane + $AgNO_3(aq)$
D	yellow	2-iodopropane + $AgNO_3(aq)$

---

881. 9701_s21_qp_12 Q: 25

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

Which row is correct?

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

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882. 9701_s21_qp_13 Q: 23

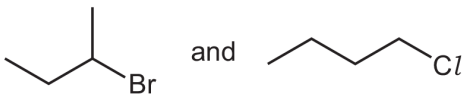
Halogenoalkanes react with nucleophiles such as OH^-.

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

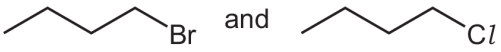
A



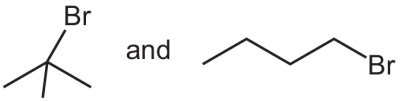
B



C



D



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883. 9701_w21_qp_12 Q: 25

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

What could be the halogenoalkane?

A 1-bromo-2-methylbutane

B 2-bromo-2-methylbutane

C 3-bromopentane

D 1-bromo-2,2-dimethylpropane

---

884. 9701_m20_qp_12 Q: 21

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

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

---

885. 9701_s20_qp_11 Q: 23

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

---

886. 9701_s20_qp_13 Q: 27

1,2-dibromopropane can be made from 1-bromopropane in two steps.

Which row is correct?

	step 1	step 2
A	addition	substitution
B	elimination	addition
C	hydrolysis	elimination
D	substitution	hydrolysis

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887. 9701_w20_qp_11 Q: 23

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

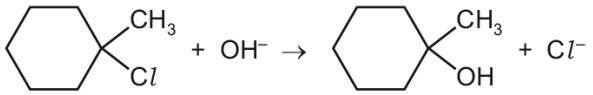
Which row of the table is correct about this reaction?

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

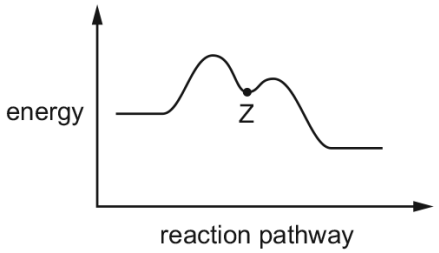
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888. 9701_w20_qp_11 Q: 25

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+

---

889. 9701_m19_qp_12 Q: 23

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

2-bromopentane is heated with an excess of ethanolic sodium hydroxide.

How many different hydrocarbons are produced?

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

---

890. 9701_m19_qp_12 Q: 24

Bromopropane reacts with water as shown.

$$CH_3CH_2CH_2Br + H_2O \rightarrow CH_3CH_2CH_2OH + HBr$$

Which statement is correct?

A This is an elimination reaction.

B This is a hydrolysis reaction.

C This is a redox reaction.

D This reaction tends to proceed via the S_N1 mechanism.

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891. 9701_s19_qp_11 Q: 23

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)

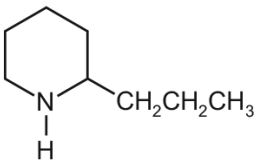
D 2-bromo-2-methylbutane and warm dilute NaOH(aq)

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892. 9701_s19_qp_11 Q: 25

The structure of coniine is shown.

coniine



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

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

What is the name of compound X?

A 1,1-dibromo-2-propylcyclopentane

B 1,2-dibromo-2-propylcyclopentane

C 1,4-dibromooctane

D 1,5-dibromooctane

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893. 9701_s19_qp_12 Q: 25

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

A ethanol

B ethene

C ethylamine

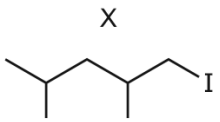
D propanenitrile

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894. 9701_s19_qp_13 Q: 20

The Finkelstein reaction occurs when NaI in propanone reacts with a chloroalkane or bromoalkane. The halogen is directly replaced by I. The reaction only works for primary halogenoalkanes.

Which halogenoalkane produces compound X?



A $(CH_3)_2CHCH(CH_3)CH_2CH_2Br$

B $(CH_3)_2CHCH(CH_3)CH_2Br$

C $(CH_3)_2CHCH_2CH_2CH(CH_3)Cl$

D $(CH_3)_2CHCH_2CH(CH_3)CH_2Cl$

---

895. 9701_s19_qp_13 Q: 24

Water is added to a sample of 2,3-dibromohexane.

Some of the 2,3-dibromohexane undergoes complete hydrolysis and some of it undergoes partial hydrolysis.

What is **not** present in the mixture of products?

A $CH_3CH(OH)CHBrCH_2CH_2CH_3$

B $CH_3CH(OH)CH(OH)CH_2CH_2CH_3$

C $CH_3CH_2CH(OH)CH(OH)CH_2CH_3$

D $CH_3CH_2CH_2CH(OH)CHBrCH_3$

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896. 9701_s19_qp_13 Q: 25

Which statement about the mechanism of an S_N1 reaction of a halogenoalkane is correct?

A A nucleophile is substituted by an electrophile.

B One intermediate is formed from two reacting molecules.

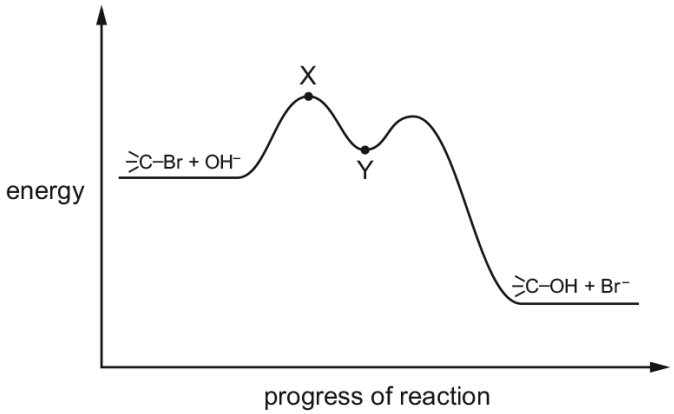
C The intermediate is stabilised by adjacent alkyl groups.

D The intermediate is uncharged.

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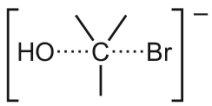
897. 9701_w19_qp_11 Q: 23

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

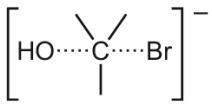


Which point in the diagram is correctly identified?

A X is $\geq$C+

B X is 

C Y is $\geq$C+

D Y is 

---

898. 9701_w19_qp_11 Q: 24

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

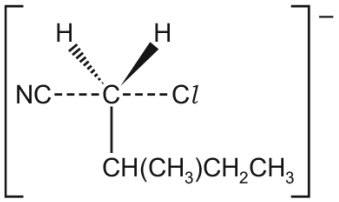
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899. 9701_w19_qp_12 Q: 23

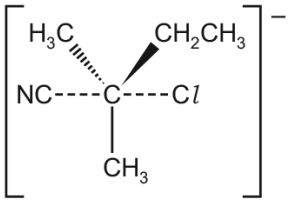
1-chloro-2-methylbutane reacts with sodium cyanide in ethanol in a nucleophilic substitution reaction.

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

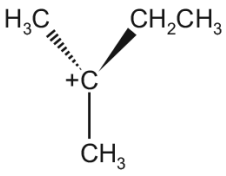
A



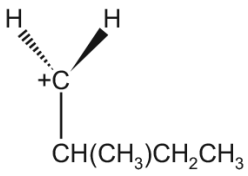
B



C



D



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900. 9701_m18_qp_12 Q: 28

Ethanedioic acid has the formula HO_2CCO_2H.

What is the formula of aluminium ethanedioate?

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

---

901. 9701_s18_qp_11 Q: 22

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	$[H_3CO\text{- - -}C(CH_3)_3\text{- - -}Cl]^-$	$H_3COC(CH_3)_3$

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902. 9701_s18_qp_12 Q: 23

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)

---

903. 9701_s18_qp_12 Q: 24

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

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

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

What could the colourless liquid be?

A $(CH_3CH_2)_2CHCl$

B $CH_3CH_2CH_2CHClCH_3$

C $(CH_3)_2CHCHClCH_3$

D $CH_3CH_2CCl(CH_3)_2$

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904. 9701_s18_qp_12 Q: 25

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

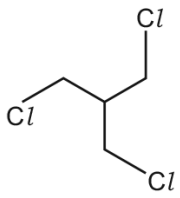
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905. 9701_s18_qp_13 Q: 23

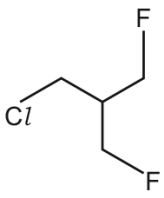
The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would be the quickest to produce a precipitate?

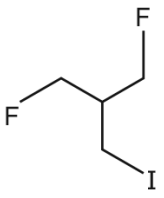
A



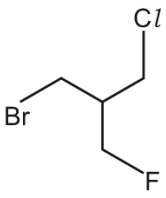
B



C



D



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906. 9701_s18_qp_13 Q: 24

Halogenoalkanes react with NaOH(aq) either by an S_N1 mechanism or by an S_N2 mechanism. The mechanism followed by the reaction depends on the structure of the halogenoalkane.

This question is about the reaction of 3-bromo-3-ethylpentane, $(C_2H_5)_3CBr$.

Which statement is correct?

A The mechanism is S_N1, due to the stabilisation of an intermediate anion by three alkyl groups.

B The mechanism is S_N1, due to the stabilisation of an intermediate cation by three alkyl groups.

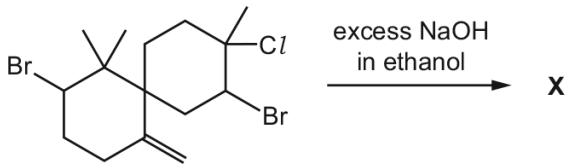
C The mechanism is S_N2, due to the stabilisation of an intermediate anion by three alkyl groups.

D The mechanism is S_N2, due to the stabilisation of an intermediate cation by three alkyl groups.

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907. 9701_w18_qp_11 Q: 25

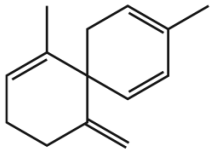
Compound J, $C_{15}H_{23}Br_2Cl$, is reacted with an excess of a hot concentrated solution of sodium hydroxide in ethanol. One of the products is **X**.



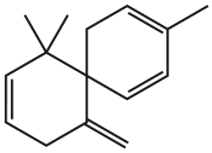
compound J

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

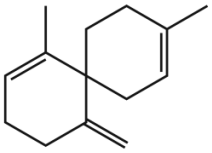
A



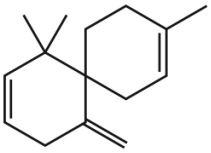
B



C



D



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908. 9701_w18_qp_12 Q: 23

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

---

909. 9701_w18_qp_12 Q: 25

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

What could be the halogenoalkane?

A 1-bromo-2-methylbutane

B 2-bromo-2-methylbutane

C 3-bromopentane

D bromodimethylpropane

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910. 9701_m17_qp_12 Q: 22

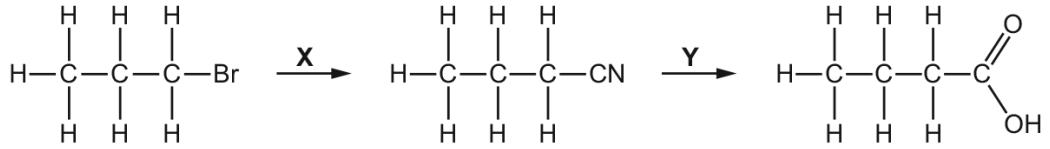
Which radical is most likely to form by the homolytic fission of one covalent bond in bromochloromethane, CH_2BrCl?

A $\bullet CH_2Cl$ **B** $\bullet CH_2Br$ **C** $\bullet CHBrCl$ **D** $\bullet CH_2BrCl$

---

911. 9701_s17_qp_11 Q: 26

X and **Y** are the reagents required to convert 1-bromopropane into butanoic acid.



What are the correct identities of **X** and **Y**?

	X	Y
A	NH_3	HCl(aq)
B	KCN in C_2H_5OH	NaOH(aq)
C	KCN in C_2H_5OH	HCl(aq)
D	HCN	NaOH(aq)

---

912. 9701_s17_qp_12 Q: 23

Aqueous sodium hydroxide 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

---

913. 9701_s17_qp_12 Q: 26

2-bromo-2-methylpropane undergoes nucleophilic substitution when heated under reflux with an aqueous solution of sodium hydroxide.

Which row is correct?

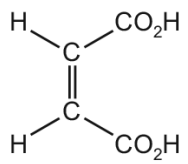
	mechanism for this reaction	reason
A	S_N1	the hydroxide ion is helped in its approach to the central carbon atom by the methyl groups
B	S_N1	the intermediate carbocation is stabilised by the inductive effect of the methyl groups
C	S_N2	the hydroxide ion is hindered in its approach to the central carbon atom by the methyl groups
D	S_N2	the intermediate carbocation is destabilised by the inductive effect of the methyl groups

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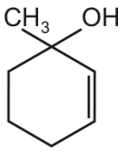
914. 9701_s17_qp_12 Q: 29

Which compound is chiral and reacts with Na_2CO_3 to give CO_2?

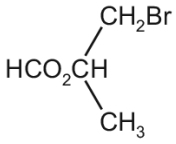
A



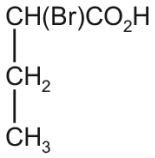
B



C



D



---

915. 9701_w17_qp_12 Q: 25

Equal volumes of aqueous silver nitrate were added to separate small volumes of bromoethane and iodoethane in two test-tubes. The test-tubes were shaken.

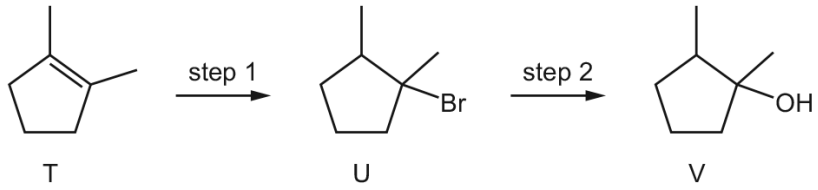
Which row about the observations made for **bromoethane** is correct?

	colour of precipitate	rate of reaction
A	cream	faster than for iodoethane
B	cream	slower than for iodoethane
C	yellow	faster than for iodoethane
D	yellow	slower than for iodoethane

---

916. 9701_m16_qp_12 Q: 24

Hydrogen bromide can be added to T to give compound U. Compound U can be hydrolysed to compound V.



Four students, W, X, Y and Z, made the following statements.

W All the atoms in a molecule of compound T lie in the same plane.

X Compound V contains only one chiral centre.

Y Step 1 is an electrophilic addition reaction.

Z Step 2 is a nucleophilic substitution reaction.

Which two students are correct?

A W and Y **B** W and Z **C** X and Y **D** Y and Z

---

917. 9701_m16_qp_12 Q: 25

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

Compound J is reacted with KOH dissolved in ethanol. Three isomeric alkenes with molecular formula C_4H_8 are formed.

What is J?

A $CH_3—CH_2—CH_2—CH_2—Br$

B $CH_3—\underset{\displaystyle Br}{\underset{|}{CH}}—CH_2—CH_3$

C $CH_3—\underset{\displaystyle CH_3}{\underset{|}{CH}}—CH_2—Br$

D $CH_3—\overset{\displaystyle CH_3}{\overset{|}{\underset{\displaystyle CH_3}{\underset{|}{C}}}}—Br$

---

918. 9701_s16_qp_11 Q: 25

A student prepares pentan-1-ol by the alkaline hydrolysis of 1-iodopentane. She gently warms the reaction mixture for 20 minutes.

$$CH_3CH_2CH_2CH_2CH_2I + OH^- \rightarrow CH_3CH_2CH_2CH_2CH_2OH + I^-$$

When the student uses 1-chloropentane to prepare the same alcohol she has to change the condition of the reaction.

Which change in condition should she use and what is the correct reason for its use?

	change in condition	reason
A	heat under reflux	C–C*l* bond is more polar than the C–I bond
B	heat under reflux	C–C*l* bond is stronger than the C–I bond
C	room temperature	C–C*l* bond is more polar than the C–I bond
D	room temperature	C–C*l* bond is shorter than the C–I bond

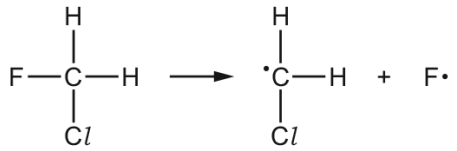
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919. 9701_s16_qp_12 Q: 20

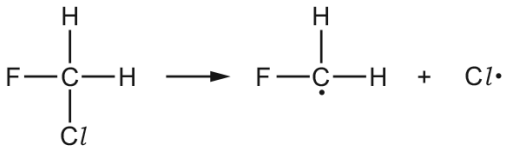
Chlorofluorocarbons damage the ozone layer by undergoing reactions with a free radical mechanism. The first stage of this is initiation.

Which equation is most likely to be the initiation stage when chlorofluoromethane is involved in such a reaction?

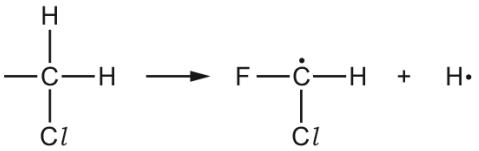
A



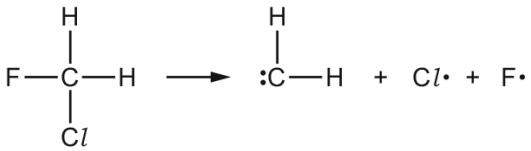
B



C



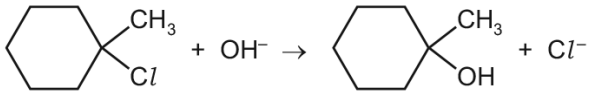
D



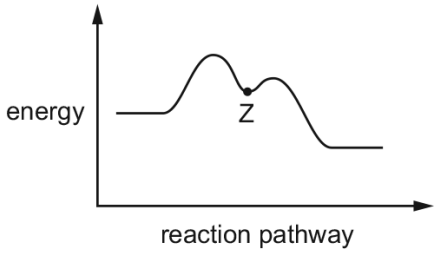
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920. 9701_s16_qp_12 Q: 24

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.

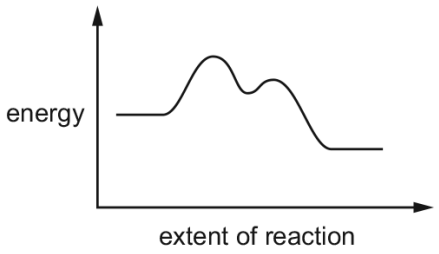
What is the charge on this carbon atom at point Z?

A δ+ **B** + **C** δ− **D** −

---

921. 9701_s16_qp_13 Q: 25

A reaction pathway diagram is shown.

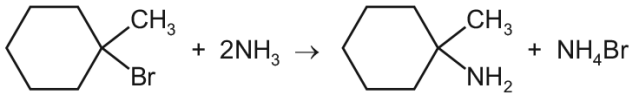


The four reactions that follow are all exothermic.

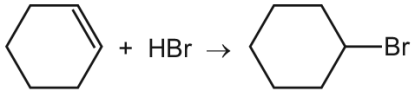
Which reaction would **not** have such a pathway?

A $CH_3I + NaCN \rightarrow CH_3CN + NaI$

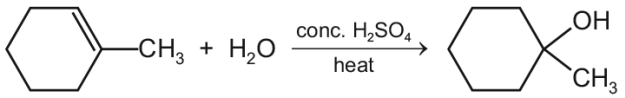
B



C



D



---

922. 9701_w16_qp_11 Q: 24

Chloroethane can be used to make sodium propanoate.

chloroethane → Q → sodium propanoate

The intermediate, Q, is hydrolysed with boiling aqueous sodium hydroxide to give sodium propanoate.

Which reagent would produce the intermediate, Q, from chloroethane?

A concentrated ammonia solution

B dilute sulfuric acid

C hydrogen cyanide in water

D potassium cyanide in ethanol

---

923. 9701_w16_qp_12 Q: 22

The reaction $CH_3CH_2CH_2CH_2Br + OH^- \rightarrow CH_3CH_2CH_2CH_2OH + Br^-$ proceeds via an S_N2 mechanism.

The reaction $(CH_3)_3CBr + OH^- \rightarrow (CH_3)_3COH + Br^-$ proceeds via an S_N1 mechanism.

Which statement about these two reactions is correct?

A Both reactions involve homolytic bond fission.

B Both reactions involve hydroxide ions acting as electron pair donors.

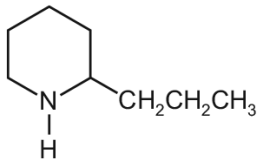
C Both reactions involve the formation of a positively-charged intermediate.

D Both reactions occur in a single step.

---

924. 9701_s15_qp_11 Q: 24

Coniine is the major constituent of the poison ‘oil of hemlock’.



coniine

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

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

X

What is the name of compound **X**?

A 1,1-dibromo-2-propylcyclopentane

B 1,2-dibromo-2-propylcyclopentane

C 1,4-dibromooctane

D 1,5-dibromooctane

---

925. 9701_s15_qp_11 Q: 25

2-bromopropane reacts with a hot concentrated solution of sodium hydroxide in ethanol.

Which substance is the major product of this reaction?

A propan-1-ol

B propan-2-ol

C 2-hydroxypropene

D propene

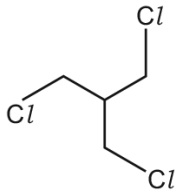
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926. 9701_s15_qp_11 Q: 26

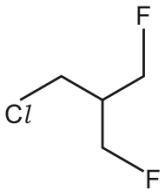
The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would be the quickest to produce a precipitate?

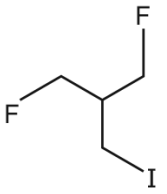
A



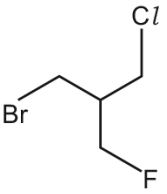
B



C



D

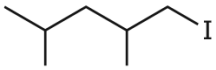


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927. 9701_s15_qp_13 Q: 22

The Finkelstein reaction occurs when NaI in propanone reacts with a chloroalkane or bromoalkane. The halogen is directly replaced by I and the reaction only works for primary halogenoalkanes.

Which halogenoalkane would produce compound X?



compound X

A $(CH_3)_2CHCH(CH_3)CH_2CH_2Br$

B $(CH_3)_2CHCH(CH_3)CH_2Br$

C $(CH_3)_2CHCH_2CH_2CH(CH_3)Cl$

D $(CH_3)_2CHCH_2CH(CH_3)CH_2Cl$

---

928. 9701_s15_qp_13 Q: 26

Alkane X has molecular formula C_4H_{10}.

X reacts with Cl_2(g) in the presence of sunlight to produce only two different monochloroalkanes, C_4H_9Cl. Both of these monochloroalkanes produce the same alkene Y, and no other organic products, when they are treated with hot ethanolic KOH.

What is produced when Y is treated with hot concentrated acidified $KMnO_4$?

A CO_2 and $CH_3CH_2CO_2H$

B CO_2 and CH_3COCH_3

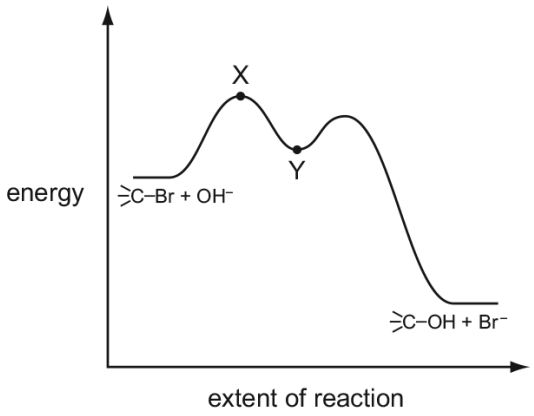
C HCO_2H and CH_3COCH_3

D CH_3CO_2H only

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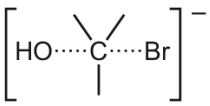
929. 9701_s15_qp_13 Q: 28

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

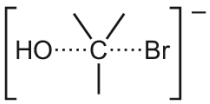


Which point in the diagram is correctly identified?

A X is $\geq$C+

B X is 

C Y is $\geq$C+

D Y is 

---

930. 9701_s15_qp_13 Q: 29

Four drops of 1-chlorobutane, 1-bromobutane and 1-iodobutane were put separately into three test-tubes containing 1.0 cm^3 of aqueous silver nitrate at 60 °C.

In each case, a hydrolysis reaction occurred. R represents the butane chain C_4H_9 and X the halogen atom.

$$H_2O(l) + R–X(l) + Ag^+(aq) \rightarrow R–OH(aq) + AgX(s) + H^+(aq)$$

The rate of formation of cloudiness in the test-tubes was in the order RC*l* < RBr < RI.

Why is this?

A The bond energy of R–X decreases from RC*l* to RI.

B The first ionisation energy of the halogen decreases from C*l* to I.

C The solubility of AgX(s) decreases from AgC*l* to AgI.

D The R–X bond polarity decreases from RC*l* to RI.

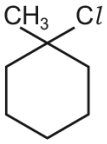
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931. 9701_w15_qp_11 Q: 24

Which compound undergoes an S_N1 substitution reaction with NaOH(aq)?

A $CH_3CH_2CH_2Br$

B $(CH_3)_3CCH_2I$

C 

D CH_2=CHCl

---

932. 9701_w15_qp_12 Q: 24

The depletion of the ozone layer in the upper atmosphere reduces the Earth's natural protection from harmful ultraviolet radiation.

Which compound would cause the most depletion of the ozone layer?

A CCl_3F **B** CF_4 **C** CO_2 **D** SO_2

Chapter 15

Halogen derivatives

STEMUP.CO.UK

15.1 Halogenoalkanes

119. 9701_s21_qp_21 Q: 6

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

(a) Name this type of reaction.

..... [1]

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

catalyst .....

conditions .....
[2]

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

	σ	π
C_3H_6		
C_3H_8O		

[2]

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

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

more stable carbocation	**less** stable carbocation

explanation .....

.....

.....

.....

.....
[3]

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

..... [1]

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

(i) Name this type of reaction.

..... [1]

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

reagents .....

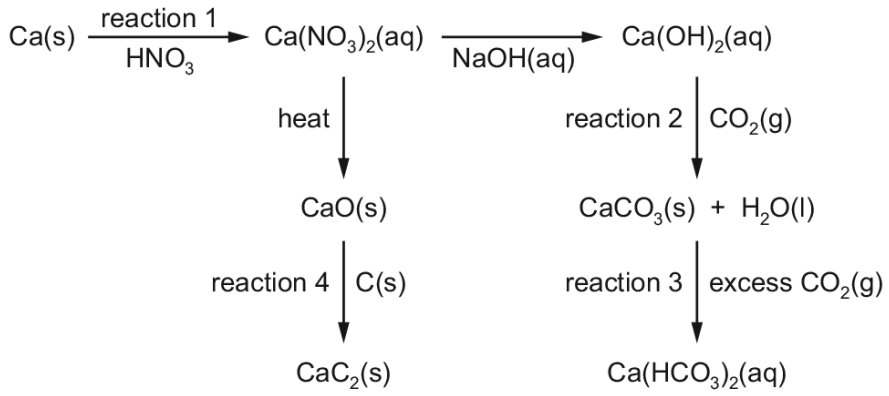
conditions .....
[2]

[Total: 12]

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120. 9701_w21_qp_21 Q: 2

The reaction scheme shows some reactions of calcium.



(a) (i) Reaction 1 produces $Ca(NO_3)_2$ and one other product.

Identify the other product.

..... [1]

(ii) Construct an equation for the thermal decomposition of $Ca(NO_3)_2$(s).

..... [1]

(iii) State the trend in the thermal stability of the Group 2 nitrates down the group.

..... [1]

(iv) In reaction 3, excess CO_2 is bubbled through water containing $CaCO_3$. A solution of $Ca(HCO_3)_2$(aq) forms.

Construct an equation for reaction 3.

..... [1]

(b) Describe how $Ca(OH)_2$ is used in agriculture.

.....

..... [1]

(c) In reaction 4, calcium carbide, CaC_2, is formed from CaO.

CaC_2 contains the C_2^{2-} anion. Each carbon in C_2^{2-} is sp hybridised.

(i) Describe how sp hybridised orbitals are formed.

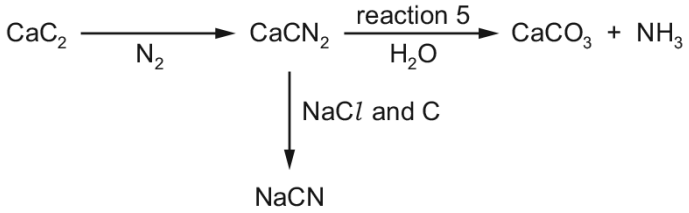
.....

..... [1]

(ii) Sketch a diagram to show how two sp hybrid orbitals can form a sigma (σ) bond.

[2]

(d) The flowchart shows some reactions of CaC_2.



(i) Reaction 5 can be used to prepare NH_3.

$$CaCN_2 + 3H_2O \rightarrow CaCO_3 + 2NH_3$$

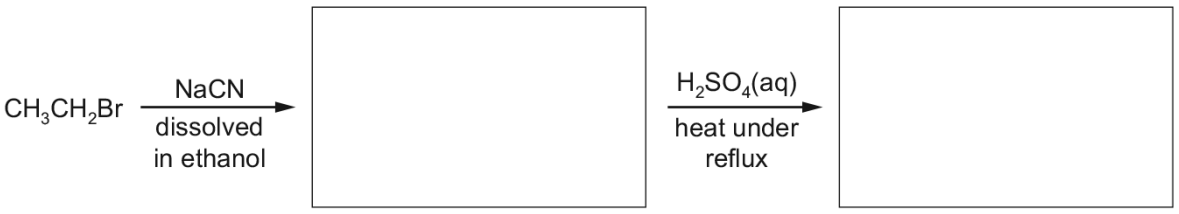
Calculate the minimum mass, in tonnes, of calcium cyanamide, $CaCN_2$, that is required to produce 1.50×10^6 tonnes of NH_3.

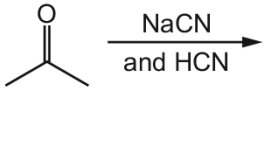
Show your working.

1 tonne = 1.00×10^6 g

minimum mass of $CaCN_2$ = ... tonnes
[2]

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





[3]

[Total: 13]

121. 9701_s20_qp_22 Q: 4

(a) An unlabelled bottle contains a straight-chain halogenoalkane, **Q**. The molecular formula of **Q** is C_5H_{11}**X**, where **X** is a halogen; bromine, chlorine or iodine.

A test is carried out to identify the halogen present in **Q**.
A sample of **Q** is added to NaOH(aq) and warmed. Dilute nitric acid is then added followed by a few drops of aqueous silver nitrate. A cream precipitate is observed.

(i) Suggest the identity of **X**.

..... [1]

(ii) Write an ionic equation to describe the formation of the cream precipitate. Include state symbols.

..... [1]

(iii) Describe a further test which would confirm the identity of **X**.

test .....

expected result .....
[2]

(b) The reaction of **Q** with NaOH(aq) tends to proceed via an S_N2 mechanism.

(i) Suggest the structural formula of the straight-chain halogenoalkane **Q**.

[1]

(ii) Explain why the reaction tends to proceed via an S_N2 mechanism rather than an S_N1 mechanism.

.....

.....

..... [2]

(c) Two different halogenoalkanes, **P** and **R**, both with the molecular formula C_4H_9Cl, are separately dissolved in ethanol and heated under reflux with sodium hydroxide.

The major organic product of each of these reactions is methylpropene.

(i) Name the type of reaction occurring.

..... [1]

(ii) Write an equation, using molecular formulae, to represent the reaction occurring.

..... [1]

(iii) Draw the skeletal formula of methylpropene.

[1]

(iv) Give the names of **P** and **R**.

..... [2]

[Total: 12]

---

122. 9701_s19_qp_23 Q: 5

Halogenoalkanes react with a number of different reagents in nucleophilic substitution reactions.

(a) A sample of potassium cyanide dissolved in ethanol is added to a sample of 1-bromobutane, $CH_3(CH_2)_3Br$, and heated under reflux. A nucleophilic substitution reaction occurs and compound **A** is formed.

(i) Name compound **A**.

..... [1]

(ii) What is meant by the term *nucleophile*?

.....

..... [1]

(iii) Identify the nucleophile in this reaction.

..... [1]

(iv) Explain why this reaction is described as a substitution reaction.

.....

..... [1]

(b) State the reagent(s) and conditions needed for $CH_3(CH_2)_3Br$ to react to form $CH_3(CH_2)_3NH_2$.

reagent(s) .....

conditions .....

[2]

(c) Equal amounts of three different halogenoalkanes are added to three separate test-tubes. An equal amount of aqueous silver nitrate and ethanol is added to each test-tube. The time taken for a precipitate to form is recorded for each halogenoalkane.

halogenoalkane	time taken for precipitate to form / s
$(CH_3)_3CCl$	460
$(CH_3)_3CBr$	190
$(CH_3)_3CI$	40

(i) Describe and explain the trend in reactivity of the different halogenoalkanes shown in this experiment.

.....

.....

..... [2]

(ii) All three halogenoalkanes tend to react via the S_N1 mechanism.

Explain why the S_N1 mechanism is favoured.

.....

.....

.....

..... [3]

(iii) Identify a halogenoalkane which tends to react with an aqueous solution of silver nitrate and ethanol via the S_N2 mechanism.

..... [1]

[Total: 12]

123. 9701_s19_qp_23 Q: 6

(a) Three alkenes, **X**, **Y** and **Z**, have the same molecular formula.

(i) Describe what is seen when aqueous bromine is added to **X**.

..... [1]

X, **Y** and **Z** are reacted separately with hot, concentrated, acidified manganate(VII) ions until no further reaction occurs. The carbon-containing products are shown in the table.

alkene	carbon-containing products
X	CO_2 + $(CH_3)_2CO$
Y	CO_2 + $CH_3CH_2CO_2H$
Z	CH_3CO_2H

(ii) Draw the structures of **X**, **Y** and **Z**.

X **Y** **Z**

[3]

(iii) Deduce the molecular formula of **X**, **Y** and **Z**.

..... [1]

(b) The structures of **V** and **W** are shown.

$CH_3(CH_2)_2CH_2OH$ $(CH_3)_3COH$

V **W**

(i) Name the class of compound that **V** and **W** each belong to.

V .....

W .....

[2]

(ii) **V** and **W** both react with sodium metal.

Write an equation for the reaction of **V** with sodium metal.

..... [1]

(iii) Name a reagent used to distinguish **V** from **W**. Describe any observations.

reagent .....

observations with **V** .....

observations with **W** .....

[3]

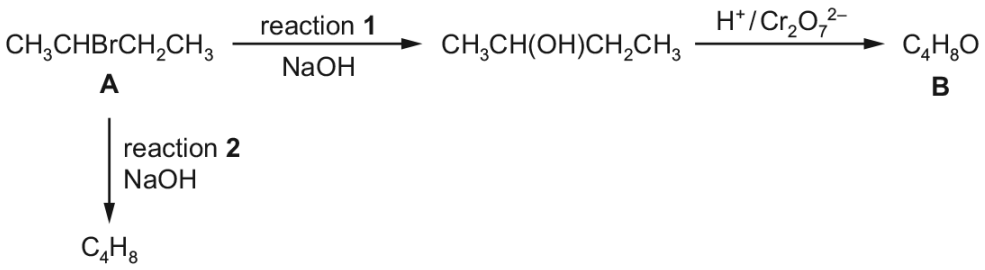
[Total: 11]

---

124. 9701_s18_qp_23 Q: 4

A is $CH_3CHBrCH_2CH_3$.

(a) Some reactions of **A** are shown.



(i) Name **A**.

..... [1]

(ii) Name the class of compound to which **B** belongs.

..... [1]

(b) There are three structural isomers of **A**.

Draw the structures of these three isomers of **A**.

[2]

(c) Reaction **1** occurs by two different mechanisms at the same time.

These mechanisms are referred to as S_N1 and S_N2.

(i) State what the letters 'S' and 'N' represent in the abbreviation S_N1.

S .....

N .....
[1]

(ii) Complete the S_N1 mechanism for reaction **1**.

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



[3]

(d) The S_N1 mechanism for reaction **1** is repeated using $CH_3CHClCH_2CH_3$ or $CH_3CHICH_2CH_3$ in place of the $CH_3CHBrCH_2CH_3$.

State and explain how the rates of these two reactions will compare with the rate of the original reaction using $CH_3CHBrCH_2CH_3$.

.....

.....

.....

.....

..... [3]

(e) Reaction **2** uses the same reagent as reaction **1**, but under different conditions.

State **two** differences in the conditions needed to ensure that reaction **2** is more likely to take place than reaction **1** when this reagent is added.

.....

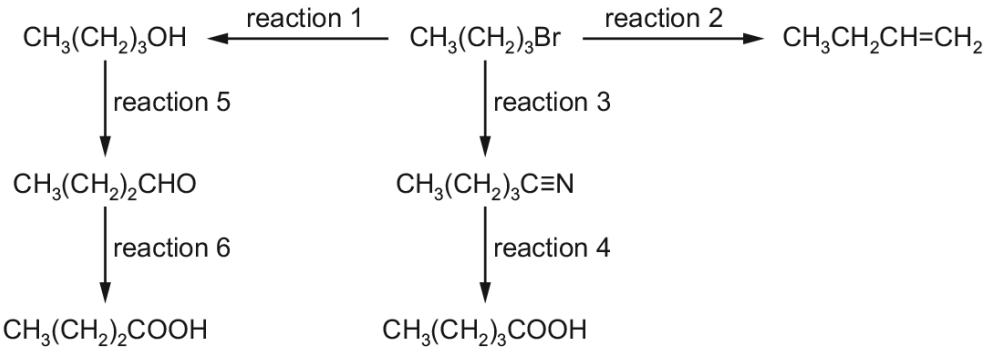
.....

..... [2]

[Total: 13]

125. 9701_w17_qp_21 Q: 3

Some reactions based on 1-bromobutane, $CH_3(CH_2)_3Br$, are shown.



(a) For each of the reactions state the reagent(s), the particular conditions required, if any, and the type of reaction.

For the type of reaction choose from the list.
Each type may be used once, more than once or not at all.
Each reaction may be described by more than one type.

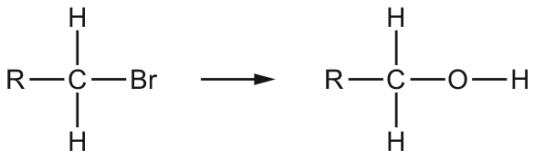
elimination hydrolysis substitution

oxidation addition condensation

reaction	reagent(s) and conditions	type(s) of reaction
1		
2		
3		
4		
5		
6		

[6]

(b) Complete the diagram to show the S_N2 mechanism of reaction 1. R represents the $CH_3(CH_2)_2$ group.
Include all necessary charges, dipoles, lone pairs and curly arrows.



[2]

(c) 2-bromo-2-methylpropane is a tertiary halogenoalkane that is a structural isomer of 1-bromobutane.

(i) Define the term *structural isomer* and name the three different types of structural isomerism.

definition .....

.....

.....

.....

types of structural isomerism

1 .....

2 .....

3 .....

[4]

(ii) 2-bromo-2-methylpropane is treated with the same reagents as in reaction 1.
Methylpropan-2-ol is formed.

Identify the mechanism for this reaction.
Explain why this reaction proceeds via a different mechanism from that of reaction 1.

mechanism .....

explanation .....

.....

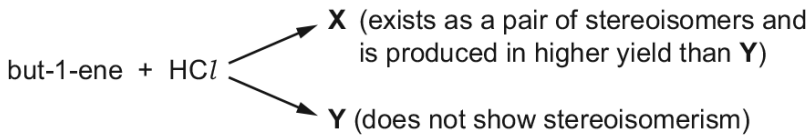
.....

.....

.....

[3]

(d) The product of reaction 2, but-1-ene, does **not** show stereoisomerism. However, but-1-ene reacts with HCl to form a mixture of structural isomers **X** and **Y**.



(i) Explain the meaning of the term *stereoisomers*.

.....

.....

..... [2]

(ii) Give **two** reasons why but-1-ene does **not** show stereoisomerism.

.....

.....

..... [2]

(iii) Name **X** and **Y**.

X .....

Y .....

[2]

(iv) Name the type of stereoisomerism shown by **X**.

..... [1]

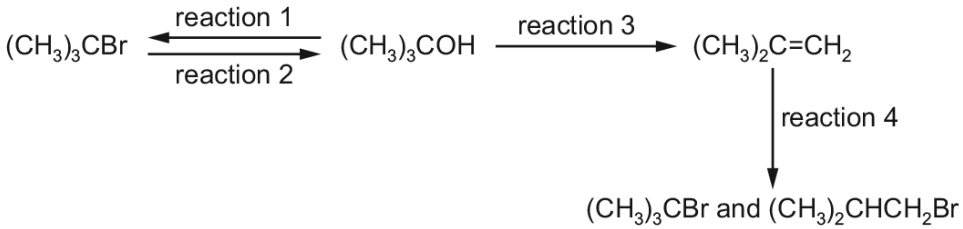
(v) Use the conventional representation to draw the two stereoisomers of **X**.

[2]

[Total: 24]

126. 9701_w17_qp_22 Q: 4

Some reactions are shown, based on methylpropan-2-ol, $(CH_3)_3COH$.



(a) For each of the reactions state the reagent(s), the particular conditions required, if any, and the type of reaction.

For the type of reaction choose from the list.
Each type may be used once, more than once or not at all.
Each reaction may be described by one or more than one type.

hydrolysis dehydration substitution

oxidation addition condensation

reaction	reagent(s) and conditions	type(s) of reaction
1		
2		
3		
4		

[5]

(b) Draw a diagram to show the S_N1 mechanism of reaction 2.
Include all necessary charges, dipoles, lone pairs and curly arrows.

[3]

(c) 1-bromobutane is a structural isomer of the product of reaction 1.

(i) Define the term *structural isomer* and name the three different types of structural isomerism.

definition .....

.....

.....

.....

types of structural isomerism

1 .....

2 .....

3 .....

[4]

(ii) 1-bromobutane is treated with the same reagents as in reaction 2. Butan-1-ol is formed.

Identify the mechanism of this reaction.
Explain why this reaction proceeds via a different mechanism from that of reaction 2.

mechanism .....

explanation .....

.....

.....

.....

.....

[3]

(d) The product of reaction 3, methylpropene, does **not** show stereoisomerism.

(i) Give **two** reasons why methylpropene does **not** show stereoisomerism.

.....

.....

..... [2]

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(ii) Methylpropene can be polymerised to form a poly(alkene).

State the type of polymerisation and draw the repeat unit of the polymer formed from methylpropene.

type of polymerisation .....

repeat unit

[3]

(iii) State the difficulty associated with the disposal of poly(alkenes).

.....

..... [1]

(e) Name the two products of reaction 4.

name of $(CH_3)_3CBr$ .....

name of $(CH_3)_2CHCH_2Br$ .....

[2]

[Total: 23]

---

127. 9701_w16_qp_22 Q: 4

In each section of this question the structural formula of an organic compound is shown. For each compound answer the questions about it.

(a) $CH_3CH_2CHBrCH_3$

(i) Name this compound.

..... [1]

(ii) This compound shows stereoisomerism.

Draw the **two** stereoisomers in the conventional way.

[2]

(iii) Give the structures of **three** other structural isomers of C_4H_9Br.

[3]

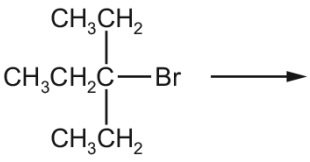
(b) $(C_2H_5)_3CBr$

(i) Name this compound.

..... [1]

(ii) $(C_2H_5)_3CBr$ reacts with aqueous OH^-.

Complete the mechanism for this reaction including all necessary curly arrows, charges, partial charges and lone pairs.



[3]

(iii) What *type of mechanism* occurs in **(ii)**?

..... [1]

(c) $CH_3CH_2CH_2CHBrCH_3$

(i) Give the reagents and conditions necessary for the conversion of this compound into a mixture of alkenes.

.....

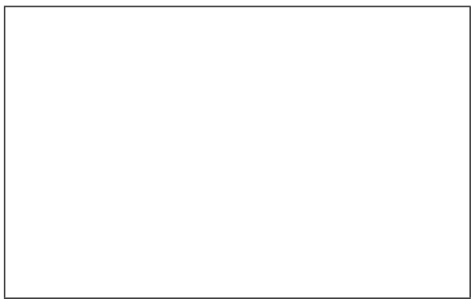
..... [2]

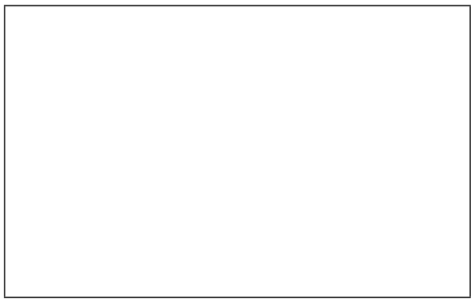
(ii) Give the name of the mechanism for the conversion in **(i)**.

..... [1]

(iii) Draw the skeletal formulae of the three alkenes produced by the conversion in **(i)**.







[3]

[Total: 17]

15.2 Relative strength of the C–Hal bond

128. 9701_s21_qp_22 Q: 3

A large excess of 2-bromo-2-methylpropane is added to 0.0010 mol of NaOH(aq), which contains a few drops of phenolphthalein indicator. A stopwatch is started as soon as the substances are mixed. The time taken for the pink colour to disappear is recorded.

The experiment is repeated at different temperatures, keeping all concentrations and volumes of reagents constant.

temperature /°C	time taken for pink colour to disappear / s
20	300
25	65
35	20

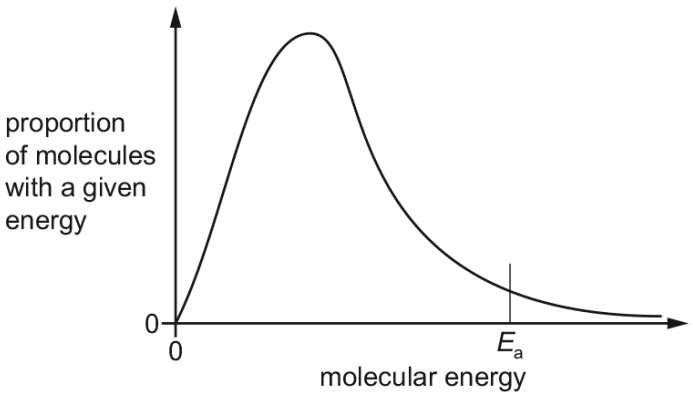
(a) Explain what is meant by the term *rate of reaction*.

.....

..... [1]

(b) The graph shows the energy distribution of molecules in a sample of 2-bromo-2-methylpropane at 25 °C.

E_a represents the activation energy for the reaction.



(i) Label the graph to show the proportion of 2-bromo-2-methylpropane molecules which have sufficient energy to react. [1]

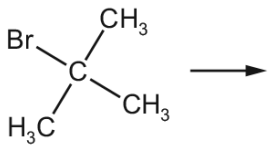
(ii) Use the same axes to sketch the distribution of energies of molecules in a sample of 2-bromo-2-methylpropane at 50 °C. [2]

(iii) State the effect of an increase in temperature on E_a for this reaction.

..... [1]

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

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



[3]

(ii) Name the mechanism for this reaction.

..... [1]

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

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

.....

.....

..... [2]

[Total: 11]

1.

The anaesthetic *halothane*, $CF_3CHBrCl$, is made industrially as shown below.

$$CCl_2{=}CHCl \xrightarrow[\text{stage 1}]{HF} CF_3CH_2Cl \xrightarrow[\text{stage 2}]{Br_2} CF_3CHBrCl$$

What type of reaction is occurring in stage 2?

A electrophilic addition

B electrophilic substitution

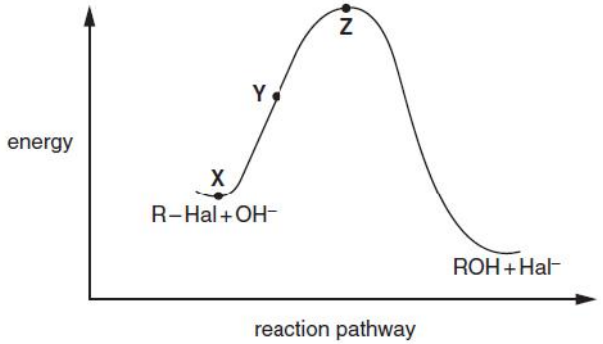
C free radical substitution

D nucleophilic addition

[2002 M/J (19)]

2.

Halogenoalkanes react with aqueous alkali. One mechanism of this reaction has the reaction pathway diagram shown below.



Which of the following statements are correct?

1 The reaction is an example of nucleophilic substitution.

2 Between **X** and **Y** the C-Hal bond will be lengthening.

3 The energy difference between **X** and **Z** represents the activation energy.

[2002 M/J (39)]

3.

Compound **X** undergoes the following reactions.

$$\underset{\mathbf{X}}{C_4H_9Br} \xrightarrow{NaOH(aq)\,/\,heat} C_4H_{10}O \xrightarrow{Cr_2O_7^{2-},\,H^+(aq)\,/\,heat} C_4H_8O \text{ only}$$

What is **X**?

A 1-bromobutane

B 2-bromobutane

C 1-bromo-2-methylpropane

D 2-bromo-2-methylpropane

[2002 O/N (24)]

4.

Chlorofluoroalkanes, commonly known as CFCs, undergo homolytic fission by ultraviolet irradiation in the stratosphere.

Which radical could result from this irradiation of $CHFClCF_2Cl$?

A $CHFCl\dot{C}FCl$

B $\dot{C}HClCF_2Cl$

C $\dot{C}HFCF_2Cl$

D $\dot{C}FClCF_2Cl$

[2003 M/J (27)]

5.

Chloroethane can be formed from bromoethane in two steps.

$$C_2H_5Br \xrightarrow{\text{step X}} C_2H_5OH \xrightarrow{\text{step Y}} C_2H_5Cl$$

Which statements about these steps are correct?

1 Step **X** involves a nucleophilic substitution.

2 Hot aqueous sodium hydroxide is the reagent in step **X**.

3 Hot aqueous sodium chloride is the reagent in step **Y**.

[2003 M/J (38)]

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6.

1,2-Dibromo-3-chloropropane (DBCP) has been used in the control of earthworms in agricultural land.

What would be the best synthesis of this compound?

A $CH_3CH_2CH_2Cl + 2Br_2 \rightarrow DBCP + 2HBr$

B $CH_3CHBrCH_2Br + Cl_2 \rightarrow DBCP + HCl$

C $CH_2{=}CHCH_2Cl + Br_2 \rightarrow DBCP$

D $ClCH_2CH{=}CH_2 + PBr_5 \rightarrow DBCP + PBr_3$

[2003 O/N (23)]

7.

Each of the following compounds is effective as a refrigerant.

The release of which one of these causes the greatest depletion of the ozone layer?

A CCl_2F_2 **B** CH_3OCH_3 **C** CH_3CHF_2 **D** $CH_3CH_2CH_3$

[2003 O/N (24)]

8.

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

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

What is the mechanism of the first step of this reaction?

A electrophilic substitution

B elimination

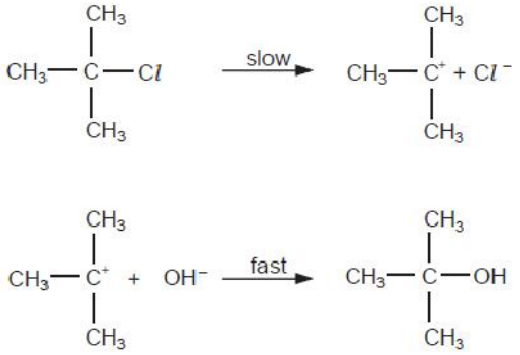
C nucleophilic substitution

D oxidation

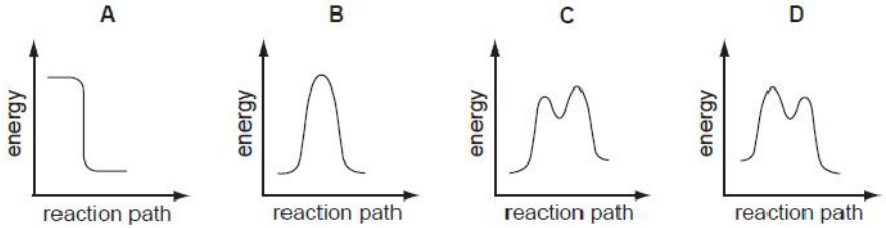
[2003 O/N (25)]

9.

A possible mechanism of the hydrolysis of 2-chloro-2-methylpropane is shown.



Which diagram represents the reaction profile for this mechanism?

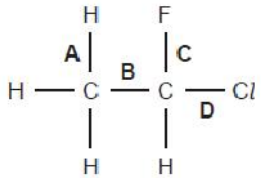


[2004 M/J (26)]

10.

Use of the Data Booklet is relevant to this question.

Which of the bonds in the structure below has the lowest bond energy?



[2004 O/N (27)]

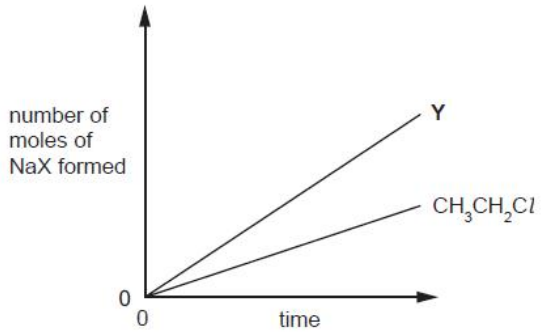
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11.

When halogenoalkanes, RX, are hydrolysed with NaOH, the corresponding sodium halide, NaX, is produced.

$$RX + NaOH \rightarrow ROH + NaX$$

A student investigated the amount of NaX produced by hydrolysing CH_3CH_2Cl and another halogenoalkane, **Y**. In a given time the amount of sodium halide formed was greater with **Y** than with CH_3CH_2Cl.



Which compound could be **Y**?

1 $ClCH_2CH_2Cl$

2 CH_3CH_2Br

3 CH_3CH_2I

[2004 O/N (38)]

12.

Bromomethane, CH_3Br, is used as a fumigant to destroy insect pests in grain that is to be stored. It can be made by reacting methanol with hydrogen bromide.

$$CH_3OH + HBr \rightarrow CH_3Br + H_2O$$

What type of reaction is this?

A condensation

B electrophilic substitution

C free radical substitution

D nucleophilic substitution

[2005 M/J (19)]

13.

Under the Montreal Protocol the use of chlorofluorocarbons is to be phased out. Fluorocarbons are often used to replace them. One chlorofluorocarbon which was widely used as a solvent is CCl_2FCClF_2 and large stocks of it remain. One process to use up these stocks is to convert it into the fluorocarbon CH_2FCF_3 by the following route.

$$CCl_2FCClF_2 \xrightarrow{\text{step 1}} CCl_3CF_3 \xrightarrow{\text{step 2}} CCl_2FCF_3 \xrightarrow{\text{step 3}} CH_2FCF_3$$

What type of reaction is step 1?

A elimination

B free radical substitution

C isomerisation

D nucleophilic substitution

[2005 M/J (21)]

14.

Dichlorodifluoromethane, CCl_2F_2, has been used in aerosol propellants and as a refrigerant.

Which statement helps to explain why dichlorodifluoromethane is chemically inert?

A The carbon-fluorine bond energy is large.

B The carbon-fluorine bond has a low polarity.

C Fluorine is highly electronegative.

D Fluorine compounds are non-flammable.

[2005 M/J (23)]

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15.

Under identical conditions, even though it proceeds by the same mechanism, reaction 1 is faster than reaction 2.

reaction 1 $CH_3CHBrCH_3 + NaCN \rightarrow CH_3CH(CN)CH_3 + NaBr$

reaction 2 $CH_3CHBrCH_3 + NaI \rightarrow CH_3CHICH_3 + NaBr$

What factor will explain this result?

A The C — I bond is a stronger bond than the C — Br bond.

B The C — N bond is a stronger bond than the C — I bond.

C The cyanide ion is a stronger nucleophile than the iodide ion.

D The cyanide ion is a weaker nucleophile than the iodide ion.

[2005 M/J (24)]

16.

In the upper atmosphere chlorofluoroalkanes (CFCs) are broken down to give chlorine radicals but not fluorine radicals.

What is the best explanation for this?

A Fluorine is more electronegative than chlorine.

B Fluorine radicals are less stable than chlorine radicals.

C The C–F bond is stronger than the C–Cl bond.

D The chlorine atom is larger than the fluorine atom.

[2005 O/N (22)]

17.

An amine is produced in the following reaction.

$$C_2H_5I + 2NH_3 \rightarrow C_2H_5NH_2 + NH_4I$$

What is the mechanism?

A electrophilic addition

B electrophilic substitution

C nucleophilic addition

D nucleophilic substitution

[2005 O/N (23)]

18.

High-energy irradiation in the stratosphere produces radicals from chlorofluoroalkanes, commonly known as CFCs.

Which radical could result from this irradiation of $CHFClCF_2Cl$?

A $CHFCl\dot{C}FCl$

B $\dot{C}HClCF_2Cl$

C $\dot{C}HFCF_2Cl$

D $\dot{C}FClCF_2Cl$

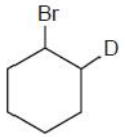
[2006 M/J (25)]

19.

Deuterium, D, is the ^2_1H isotope of hydrogen. DBr has the same chemical properties as HBr.

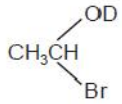
Which compounds could be made by the reaction of DBr with another compound in a single reaction?

1



2 $CHBr_2CHDBr$

3



[2006 M/J (38)]

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20.

When (chloromethyl)benzene, $C_6H_5CH_2Cl$, is treated in succession with two reagents **X** and **Y**, it gives phenylethanoic acid, $C_6H_5CH_2CO_2H$.

What are reagents **X** and **Y**?

	X	Y
A	NaOH(aq)	$K_2Cr_2O_7$(aq)
B	Cl_2(aq)	NaOH(aq)
C	NaCN (in aqueous ethanol)	dilute H_2SO_4
D	NaOH(aq)	CO_2

[2006 O/N (26)]

21.

The chlorine oxide free radical, $ClO^{\bullet}$, is formed during the depletion of the ozone layer by chlorofluoroalkanes (CFCs).

$$Cl^{\bullet} + O_3 \rightarrow ClO^{\bullet} + O_2$$

Which features are present in the chlorine oxide free radical?

1 an odd number of electrons

2 a single covalent bond

3 a dative covalent bond from oxygen to chlorine

[2006 O/N (31)]

22.

Which are properties of fluoroalkanes?

1 They are less reactive than the corresponding chloroalkanes.

2 They are non-flammable.

3 The C-F bond is stronger than a C-Cl bond.

[2006 O/N (38)]

23.

Under the Montreal Protocol, the manufacture of chlorofluorocarbons has been phased out, and they are being replaced by fluorocarbons.

One chlorofluorocarbon which was widely used as a solvent is CCl_2FCClF_2. Large stocks of it remain. One process to use up these stocks is to convert it into the fluorocarbon CH_2FCF_3 by the following route.

$$CCl_2FCClF_2 \xrightarrow{\text{step 1}} CCl_3CF_3 \xrightarrow{\text{step 2}} CCl_2FCF_3 \xrightarrow{\text{step 3}} CH_2FCF_3$$

What type of reaction is step 2?

A electrophilic substitution

B free radical reduction

C isomerisation

D nucleophilic substitution

[2007 M/J (20)]

24.

The compound 1,2-dichloroethene, $C_2H_2Cl_2$, has been used as an industrial solvent for a number of compounds including fats, camphor and caffeine.

Which statement about this compound is **incorrect**?

A The compound can be catalytically hydrogenated.

B The compound is a planar molecule.

C The compound shows *cis-trans* isomerism.

D The compound shows optical isomerism.

[2007 M/J (23)]

25.

Which term describes the action of NaOH(aq) on a bromoalkane?

A acid-base reaction

B electrophilic substitution

C elimination of HBr

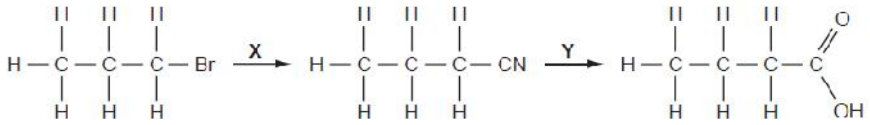
D nucleophilic substitution

[2007 M/J (24)]

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26.

X and **Y** are the reagents required to convert 1-bromopropane into butanoic acid.



What are the correct identities of **X** and **Y**?

	X	Y
A	NH_3	HCl(aq)
B	KCN in C_2H_5OH	NaOH(aq)
C	KCN in C_2H_5OH	HCl(aq)
D	HCN	NaOH(aq)

[2007 M/J (25)]

27.

What types of reaction are undergone by 2-bromopropane?

1 elimination

2 free radical substitution

3 nucleophilic substitution

[2007 M/J (38)]

28.

The anaesthetic *halothane*, $CF_3CHBrCl$, is made industrially as shown below.

$$CCl_2{=}CHCl \xrightarrow[\text{stage 1}]{HF} CF_3CH_2Cl \xrightarrow[\text{stage 2}]{Br_2} CF_3CHBrCl$$

Which type of reaction is occurring in stage 2?

A electrophilic addition

B electrophilic substitution

C free radical substitution

D nucleophilic addition

[2007 O/N (24)]

29.

Chlorofluoroalkanes, CFCs, can be used as refrigerants, aerosol propellants and fire extinguishers.

CFCs such as CCl_3F and CCl_2F_2 are more stable than chloroalkanes such as CCl_4.

What is the reason for their greater stability?

A Fluorine has a higher first ionisation energy than chlorine.

B Fluorine radicals are more stable than chlorine radicals.

C The C–F bond energy is larger than the C–Cl bond energy.

D The C–F bond is more polar than the C–Cl bond.

[2007 O/N (25)]

30.

Butanedioic acid occurs in amber, algae, lichens, sugar cane and beets. It may be synthesised in two steps from 1,2-dibromoethane.

$$BrCH_2CH_2Br \xrightarrow{\text{step 1}} X \xrightarrow{\text{step 2}} HO_2CCH_2CH_2CO_2H$$

Which reagents could be used for this synthesis?

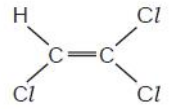
	step 1	step 2
A	HCN(g)	HCl(aq)
B	HCO_2Na(aq)	HCl(aq)
C	KCN(aq/alcoholic)	H_2SO_4(aq)
D	NaOH(aq)	$K_2Cr_2O_7/H_2SO_4$(aq)

[2007 O/N (26)]

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31.

Trichloroethene is widely used as a dry-cleaning agent.



With which of the following does trichloroethene react to give a chiral product?

A Br_2 **B** HCl **C** NaCN(aq) **D** NaOH(aq)

[2008 M/J (21)]

32.

Halogenoalkanes are important molecules in organic synthetic reactions. In particular they undergo a range of nucleophilic reactions.

Which reaction proceeds **only** by an S_N1 mechanism?

A $CH_3CH_2Br + NH_3$

B $CH_3CH_2CH_2I + OH^-$

C $CH_3CHBrCH_3 + NH_3$

D $(CH_3)_3CI + OH^-$

[2008 M/J (25)]

33.

Four drops of 1-chlorobutane, 1-bromobutane and 1-iodobutane were put separately into three test-tubes containing $1.0\,cm^3$ of aqueous silver nitrate at 60 °C.

A hydrolysis reaction occurred. (R represents the butane chain C_4H_9– and *X* the halogen atom.)

$$H_2O(l) + R–X(l) + Ag^+(aq) \rightarrow R–OH(aq) + AgX(s) + H^+(aq)$$

The rate of formation of cloudiness in the tubes was in the order RC*l* < RBr < RI.

Why is this?

A The R–*X* bond polarity decreases from RC*l* to RI.

B The solubility of Ag*X*(s) decreases from AgC*l* to AgI.

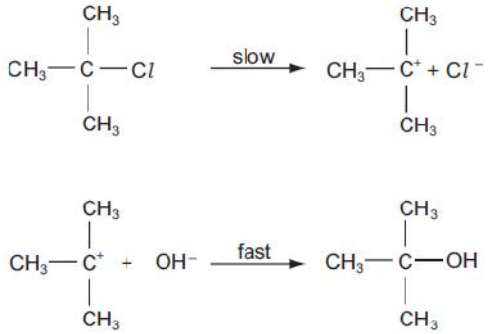
C The ionisation energy of the halogen decreases from C*l* to I.

D The bond energy of R–*X* decreases from RC*l* to RI.

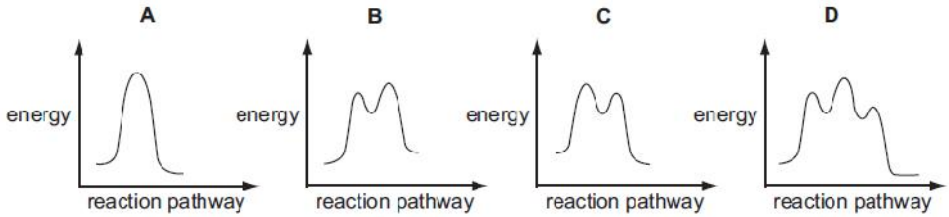
[2008 O/N (23)]

34.

24 A possible mechanism of the exothermic hydrolysis of 2-chloro-2-methylpropane is shown.



Which diagram represents the reaction profile for this mechanism?



[2008 O/N (24)]

35.

Which of the following would be suitable for use in a fire extinguisher?

1 $CBrF_3$

2 $CH_3(CH_2)_5CH_2Br$

3 HCl

[2008 O/N (38)]

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36.
In the hydrolysis of bromoethane by aqueous sodium hydroxide, what is the nature of the attacking group and of the leaving group?

	attacking group	leaving group
A	electrophile	electrophile
B	electrophile	nucleophile
C	nucleophile	electrophile
D	nucleophile	nucleophile

[2009 M/J (24)]

37.
Which reaction would **not** give propene as one product?

A adding an excess of concentrated sulfuric acid to propan-1-ol

B adding warm aqueous sodium hydroxide to 2-bromopropane

C adding warm ethanolic sodium hydroxide to 1-bromopropane

D passing propan-2-ol vapour over heated aluminium oxide

[2009 M/J (25)]

38.
Which statements are true for an S_N2 reaction?

1 One bond is broken as another bond is formed.

2 The formation of a transition state involves the collision of two molecules or ions.

3 A carbon atom in the transition state is bonded, either fully or partially, to five other atoms.

[2009 O/N-11 (37)]

39.
The chlorine free radical takes part in the destruction of the ozone layer.

Which statements about this free radical are correct?

1 It is formed by the heterolytic fission of the covalent bond in a chlorine-containing molecule.

2 It has a single unpaired electron.

3 It has the same electron arrangement as a chlorine atom.

[2009 O/N-11 (38)]

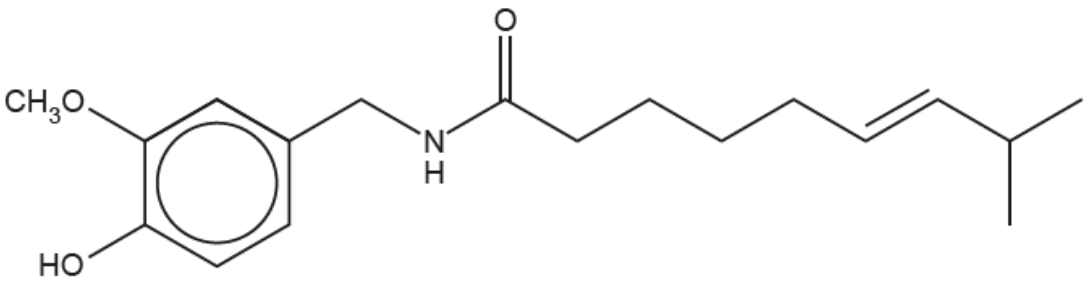
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Halogen – 2023 A2 Chemistry 9701

1. Nov/2023/Paper_9701/41/No.8(b)

Capsaicin is found in chilli peppers.

capsaicin

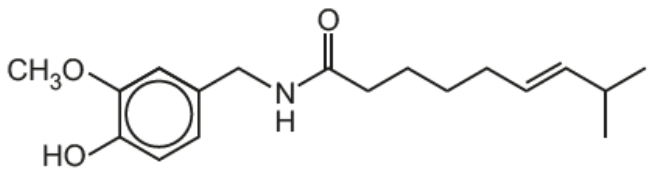


You should assume the CH_3O group is unreactive in the reactions involved in this question.

(b) Complete the equation for the reaction of capsaicin with an excess of $Br_2(aq)$ in the dark.

Draw the structure of the organic product in the labelled box.

capsaicin



+ .....Br_2 ⟶

organic product

+ .....

[3]

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2. June/2023/Paper_9701/42/No.8(a _ b)

(a) Describe the difference in reactivity between chloroethane and chlorobenzene with $OH^-(aq)$.

Explain your answer.

.....

.....

.....

..... [2]

(b) Compound **T**, $C_5H_9O_2Cl$, is a useful synthetic intermediate.

Fig. 8.1 shows some reactions of **T**.

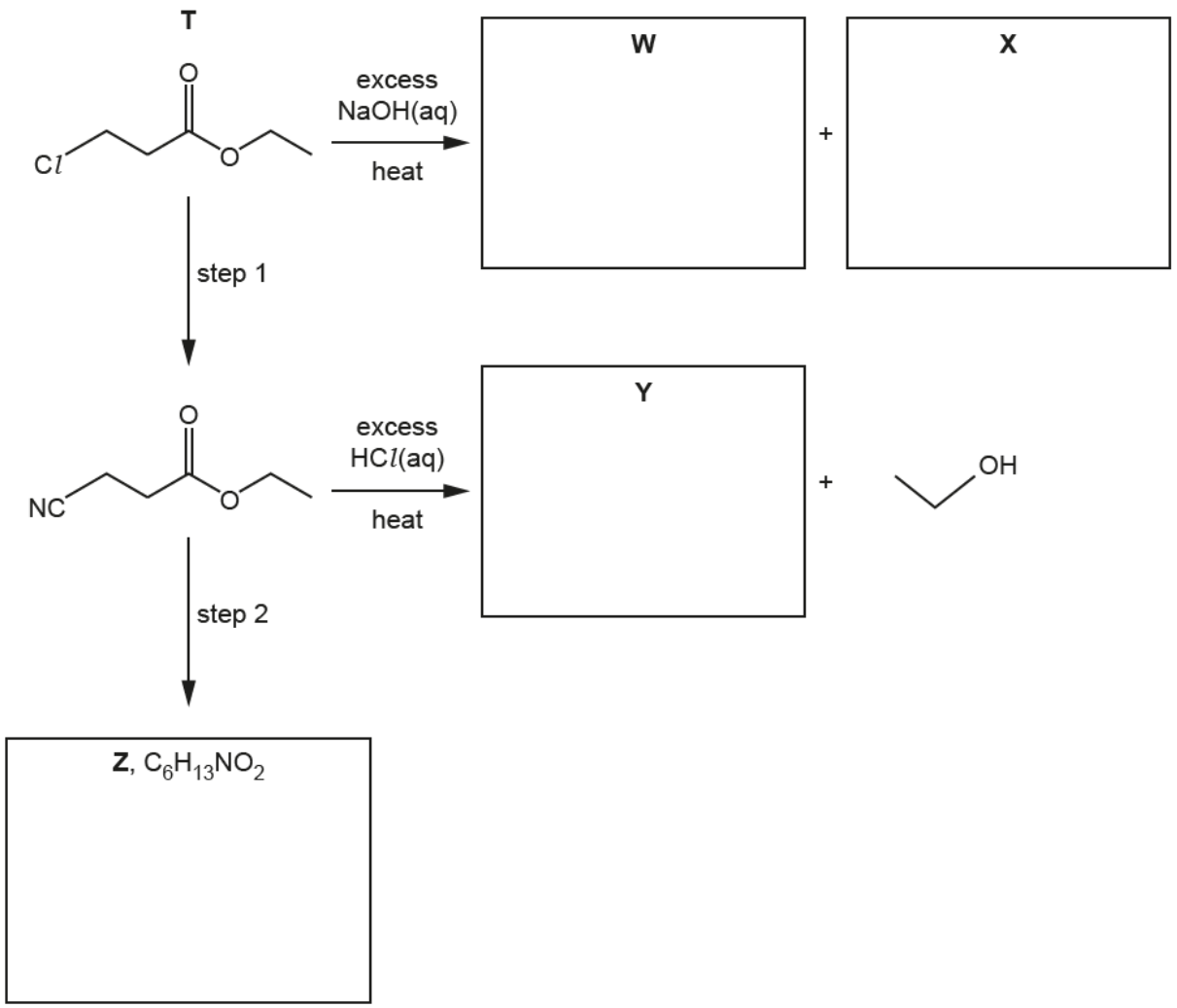


Fig. 8.1

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(i) Give the systematic name for **T**.

..... [1]

(ii) Draw the structures of **W**, **X**, **Y** and **Z** in Fig. 8.1. [4]

(iii) State the reagents and conditions for steps 1 and 2 in Fig. 8.1.

step 1 .....

step 2 .....
[2]

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Halogen derivatives – 2021 AS

1. Nov/2021/Paper_12/No.21

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

Which row correctly describes this decomposition?

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

2. Nov/2021/Paper_12/No.24

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

stage 1 $CH_3CH_2CH_2Br \rightarrow CH_3CH_2CH_2CN$

stage 2 $CH_3CH_2CH_2CN \rightarrow CH_3CH_2CH_2CO_2H$

Which types of reaction are stage 1 and stage 2?

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

3. Nov/2021/Paper_12/No.25

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

What could be the halogenoalkane?

A 1-bromo-2-methylbutane

B 2-bromo-2-methylbutane

C 3-bromopentane

D 1-bromo-2,2-dimethylpropane

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4. Nov/2021/Paper_12/No.39

Which statements about chlorofluoroalkanes are correct?

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

2 They have caused ozone depletion.

3 They are relatively chemically inert.

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5. Nov/2021/Paper_22/No.1

Hydrogen iodide, HI, is a colourless gas at room temperature.

(a) (i) Explain why HI has a higher boiling point than HC*l* and HBr.

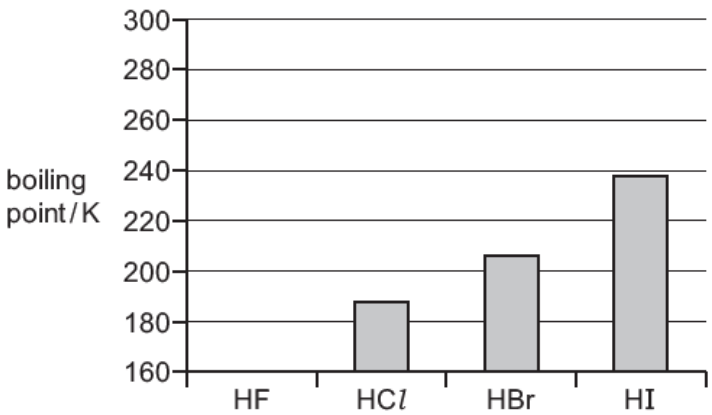
.....

.....

.....

..... [2]

(ii) The bar chart shows the boiling points of HC*l*, HBr and HI. The boiling point of HF is not shown.



Hydrogen bonds form between HF molecules.

Draw a bar on the bar chart to predict the boiling point of HF.

Explain your answer.

.....

..... [2]

(b) The standard enthalpy change of formation, $\Delta H_f^{\ominus}$, of HI(g) is +26.5 kJ mol^{-1}.

Define the term *standard enthalpy change of formation*.

.....

.....

..... [2]

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(c) HI(g) can be formed by reacting $H_2(g)$ with $I_2(g)$. The reaction is reversible, and an equilibrium forms quickly at high temperatures.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(i) Construct an expression for the equilibrium constant, K_p, for the reaction of $H_2(g)$ and $I_2(g)$ to form HI(g).

$K_p =$

[1]

(ii) The equilibrium partial pressures of the gases at 200 °C are as follows.

$$p_{H_2(g)} = 895\,Pa$$
$$p_{I_2(g)} = 895\,Pa$$
$$p_{HI(g)} = 4800\,Pa$$

Calculate K_p for this reaction.

K_p = ... [1]

(iii) State how the value of K_p would change, if at all, if the reaction were carried out at 100 °C rather than 200 °C.

Explain your answer.

.....

.....

.....

..... [2]

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(d) HI reacts with oxygen to form iodine and water.

(i) Construct an equation for the reaction of HI with oxygen.

..... [1]

(ii) Explain, with reference to oxidation numbers, why this reaction is a redox reaction.

.....

.....

.....

..... [2]

(e) HI(g) can also be formed by the reaction of $I_2(g)$ with hydrazine, $N_2H_4(g)$.

$$2I_2(g) + N_2H_4(g) \rightarrow 4HI(g) + N_2(g)$$

State the change in pressure that would occur when 2 mol $I_2(g)$ fully reacts with 1 mol $N_2H_4(g)$ in a sealed container at constant temperature. Explain your answer.

.....

.....

.....

..... [2]

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(f) In the laboratory, HI(aq) can be formed in a two-step process.

step 1 $3I_2(s) + 2P(s) \rightarrow 2PI_3(s)$

step 2 $PI_3(s) + 3H_2O(l) \rightarrow H_3PO_3(aq) + 3HI(aq)$

(i) Draw a 'dot-and-cross' diagram of a PI_3 molecule.

[2]

(ii) Name the type of reaction in **step 2**.

..... [1]

(iii) $H_3PO_3(aq)$ and HI(aq) are both strong Brønsted–Lowry acids.

Give the meaning of the term *strong Brønsted–Lowry acid*.

.....

.....

..... [2]

(iv) Give the formula of the conjugate base of H_3PO_3.

..... [1]

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

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

Explain your answer.

.....

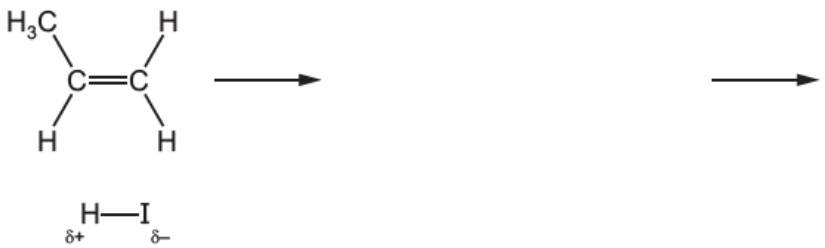
.....

.....

..... [2]

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

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



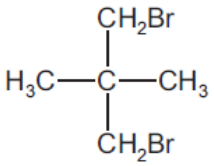
[3]

[Total: 26]

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6. March/2021/Paper_12/No.22

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



Which row is correct?

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

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7. June/2021/Paper_11/No.37

Which statements are correct?

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

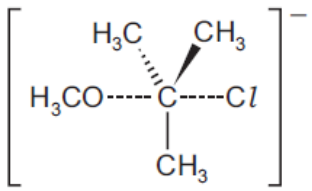
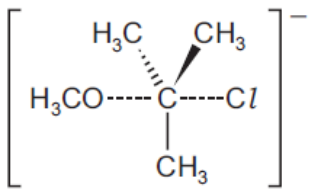
2 1,1-difluoroethane is polar.

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

8. June/2021/Paper_12/No.25

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

Which row is correct?

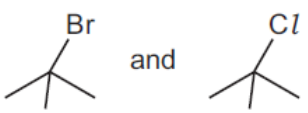
	intermediate or transition state	product
A	$(CH_3)_3C^+$	$(CH_3)_3COCH_3$
B	$(CH_3)_3C^+$	$(CH_3)_3CCH_2OH$
C		$HOCH_2C(CH_3)_3$
D		$H_3COC(CH_3)_3$

9. June/2021/Paper_13/No.23

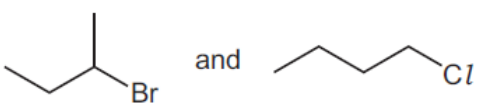
Halogenoalkanes react with nucleophiles such as OH^-.

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

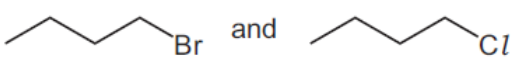
A



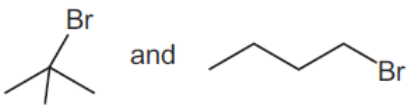
B



C



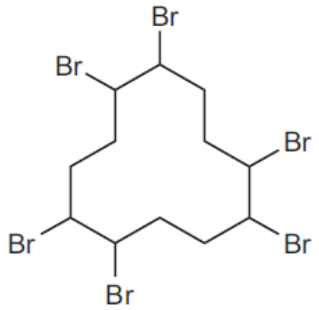
D



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10. June/2021/Paper_13/No.37

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



Which statements about this structure are correct?

1 Each brominated C atom is chiral.

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

3 The C–C–C bond angles are all 120°.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

11. June/2021/Paper_13/No.38

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

Which rows about these reactions are correct?

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

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Halogen compounds – 2022 June AS Chemistry 9701

1. June/2022/Paper_11/No.31

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

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

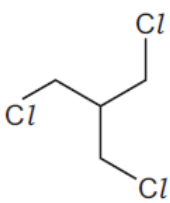
A 1 **B** 2 **C** 3 **D** 4

2. June/2022/Paper_11/No.32

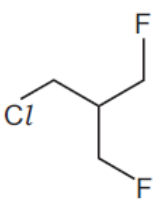
The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would be the quickest to produce a precipitate?

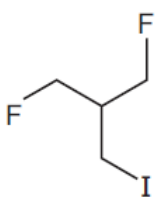
A



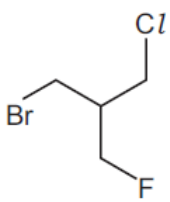
B



C

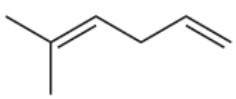


D



3. June/2022/Paper_12/No.30

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



What is the **major** product formed?

A 3,5-dibromo-2-methylhexane

B 2,5-dibromo-2-methylhexane

C 2,6-dibromo-2-methylhexane

D 3,6-dibromo-2-methylhexane

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4. June/2022/Paper_13/No.31

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

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

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

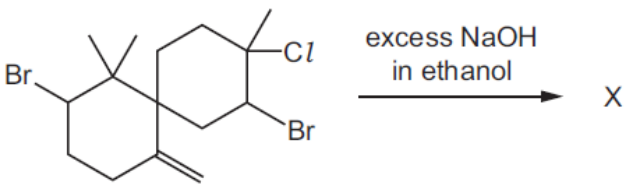
C The mechanism of the reaction involves the formation of a stable carbocation.

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

5. June/2022/Paper_13/No.32

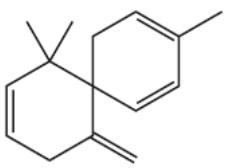
Compound J, $C_{15}H_{23}Br_2Cl$, is reacted with an excess of a hot concentrated solution of sodium hydroxide in ethanol. One of the products is X.

compound J

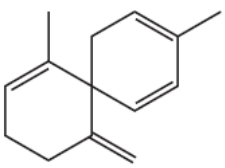


What could be the skeletal formula of X?

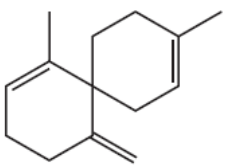
A



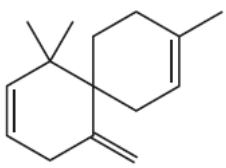
B



C



D



6. June/2022/Paper_13/No.35

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

A 1-bromopropane reacting with hot ethanolic sodium hydroxide

B 2-iodopropane reacting with hot aqueous sodium hydroxide

C propanal reacting with hydrogen cyanide under alkaline conditions

D propanal reacting with hydrogen cyanide under acidic conditions

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7. June/2022/Paper_22/No.4(b)

(b) Halothane is an anaesthetic.

halothane

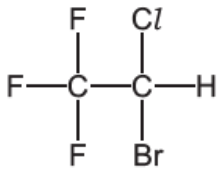


Fig. 4.1

(i) Identify the chiral centre in halothane and mark it with an asterisk (*). [1]

When halothane reacts in ultraviolet light, homolytic fission occurs and the C–Br bond is broken.

(ii) Construct an equation to show the homolytic fission of halothane, $CF_3CHBrCl$.

..... [1]

(iii) Complete Fig. 4.2 to show the arrangement of electrons in a bromine atom using the electrons in boxes notation.

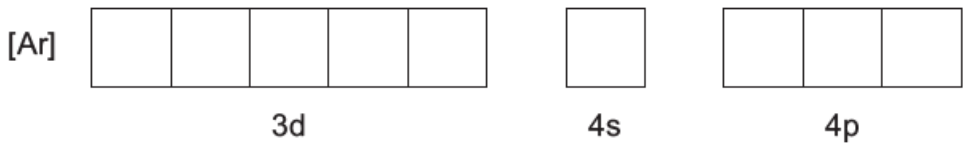


Fig. 4.2

[1]

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8. June/2022/Paper_22/No.5

Fig. 5.1 shows three reactions of 2-bromopropane, $CH_3CH(Br)CH_3$.

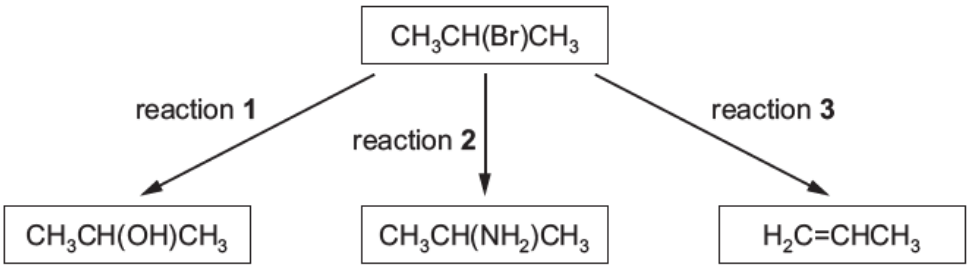


Fig. 5.1

(a) Complete Table 5.1 for each reaction, by:

- stating the reagent and conditions used
- identifying the type of reaction that occurs.

Table 5.1

reaction	reagent and conditions	type of reaction
1		
2		
3		

[6]

(b) A sample of 2-iodopropane, $CH_3CH(I)CH_3$, reacts under the same conditions as reaction **1** to produce $CH_3CH(OH)CH_3$.

Explain why 2-iodopropane reacts at a faster rate than 2-bromopropane.

.....

.....

..... [2]

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(c) Fig. 5.2 shows how butan-1-ol can be made from 1-bromopropane in three steps.

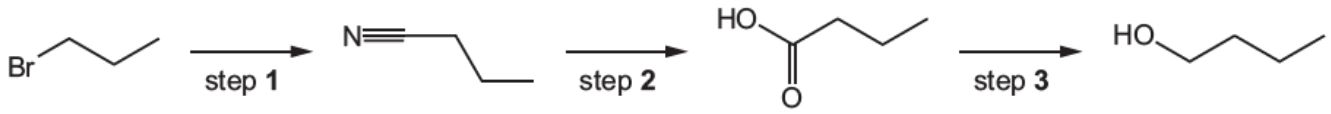


Fig. 5.2

(i) In step **1**, 1-bromopropane reacts with CN^- to form butanenitrile.

Complete Fig. 5.3 to show the mechanism for step **1**. Include charges, dipoles, lone pairs of electrons and curly arrows as appropriate.

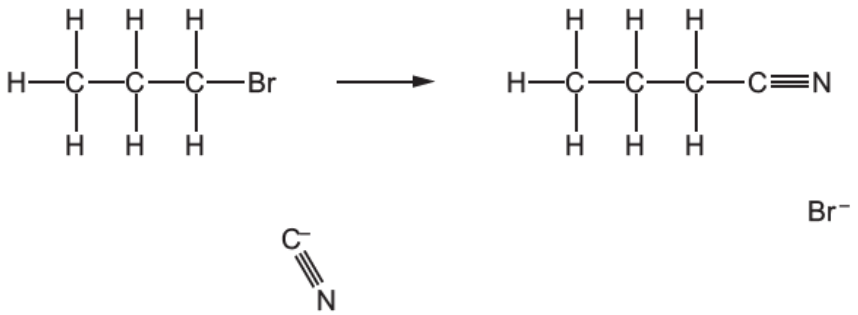


Fig. 5.3

[2]

(ii) In step **2**, butanenitrile is heated with HC*l*(aq). A hydrolysis reaction occurs.

Construct an equation for the reaction in step **2**.

..... [1]

(iii) Step **3** is a reduction reaction.

Construct an equation for the reduction reaction in step **3**. Use [H] to represent one atom of hydrogen from the reducing agent.

..... [1]

(iv) State the identity of a suitable reducing agent in step **3**.

..... [1]

[Total: 13]

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9. June/2022/Paper_23/No.4

(a) 2-methylpropene reacts with HCl(g) at room temperature. The major organic product is 2-chloro-2-methylpropane.

(i) Complete Fig. 4.1 to show the structure of the intermediate and mechanism for this reaction. Include charges, dipoles, lone pairs of electrons and curly arrows as appropriate.



Fig. 4.1

[3]

(ii) Explain why, in this reaction, 2-chloro-2-methylpropane is produced at a higher yield than 1-chloro-2-methylpropane.

.....

.....

..... [2]

(b) Two bottles labelled **Q** and **M** each contain a straight-chain halogenoalkane with molecular formula C_4H_9X, where **X** represents Cl, Br or I.
A sample from each bottle is added to separate samples of equal amounts of aqueous silver nitrate in ethanol. In each reaction, the same organic product, **T**, and a precipitate are made, as shown in Fig. 4.2.



Fig. 4.2

Table 4.1 describes the colour of each of the precipitates made.

Table 4.1

halogenoalkane added to $AgNO_3$(aq) in ethanol	colour of precipitate
Q	white
M	yellow

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(i) Identify the functional group present in **T** and name the type of reaction that occurs using the information in Fig. 4.2 and Table 4.1.

functional group in **T** .....

type of reaction .....

[2]

(ii) Construct an ionic equation to describe the formation of the yellow precipitate produced when **M** reacts with $AgNO_3(aq)$ in ethanol.

..... [1]

(iii) Describe which reagent, **Q** or **M**, will produce a precipitate more quickly when each is added to $AgNO_3(aq)$ in ethanol. Explain your answer.

reagent .....

.....

.....

[1]

(iv) When pure **T** is added to alkaline $I_2(aq)$, a yellow precipitate and an anion, **L**, are made.

Identify the anion **L**.

..... [1]

(v) Deduce the structure of the straight-chain halogenoalkane **M**.

[2]

[Total: 12]

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Halogen compounds – 2022 Nov AS Chemistry 9701

1. Nov/2022/Paper_12/No.31

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.

2. Nov/2022/Paper_12/No.32

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

3. Nov/2022/Paper_21/No.3(c)

(c) PCl_5 reacts with alcohols to form chloroalkanes.

(i) Identify this type of reaction.

..... [1]

(ii) Draw the structure of the organic product formed in the reaction of an excess of PCl_5 with butane-1,3-diol.

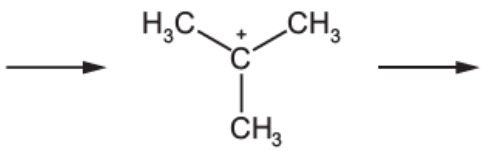
[1]

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4. Nov/2022/Paper_22/No.1(e)

(e) $OH^-(aq)$ reacts with 2-bromo-2-methylpropane in an S_N1 reaction.
The molecular ion $(CH_3)_3C^+$ forms as the intermediate in this reaction.

(i) Draw the mechanism for the S_N1 reaction of OH^- with 2-bromo-2-methylpropane.
Include charges, dipoles, lone pairs of electrons and curly arrows as appropriate.
Draw the structures of the organic reactant and organic product.



[3]

(ii) 2-bromo-2-methylpropane is a tertiary bromoalkane.

Define tertiary bromoalkane.

.....

..... [1]

(iii) Organic compound **M** forms when 2-bromo-2-methylpropane is heated with **ethanolic** OH^-.

Draw the structure of **M**.

[1]

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1. Nov/2023/Paper_ 9701/21/No.4(c, d)

(c) **C** and **D** both react with HBr.

(i) **C** reacts with HBr to form **E**.

Complete the diagram in Fig. 4.2 to show the mechanism for this reaction.

Draw the structure of the organic intermediate.

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



Fig. 4.2

[3]

(ii) **D** reacts with HBr to produce **F**, a chiral bromoalkane.

Draw the structure of **F**.

F

[1]

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(iii) Explain why the reaction of HBr with **C** and **D** produces different major products.



Fig. 4.3

.....

.....

.....

..... [2]

(d) **C** can be used to form **H**.

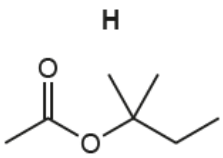


Fig. 4.4

One possible synthesis of **H** is shown in Fig. 4.5. Different portions of **C** are used in reactions 1 and 3. Some of the products are then combined to produce **H**.

Fig. 4.5 does not show any of the inorganic products of the reactions.

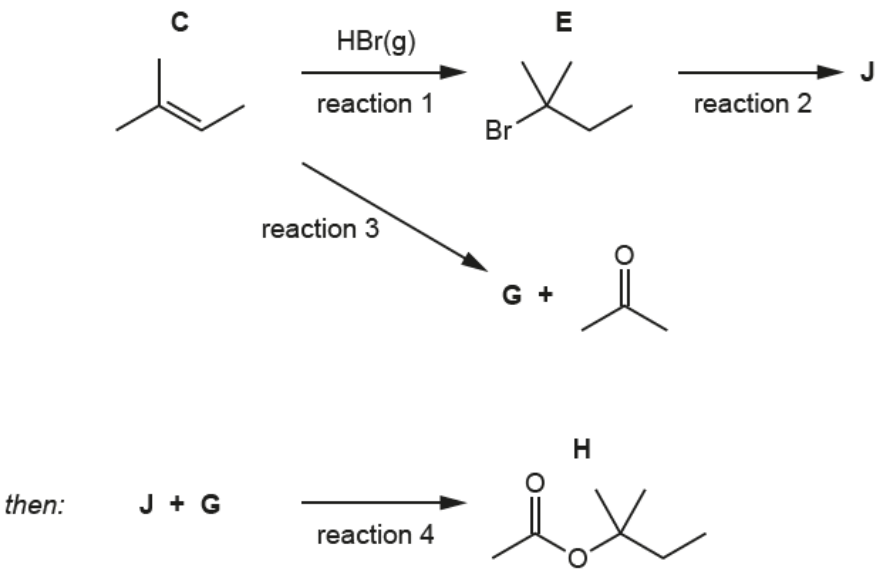


Fig. 4.5

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Complete Table 4.1 with the reagents and conditions required for each of the reactions shown in Fig. 4.5.

Table 4.1

	reagent and conditions
reaction 1 **C** → **E**	HBr(g)
reaction 2 **E** → **J**	
reaction 3 **C** → **G** + 	
reaction 4 **J** + **G** → **H**	

[3]

2. June/2023/Paper_9701/11/No.29

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

3. June/2023/Paper_9701/11/No.31

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.

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4. June/2023/Paper_9701/12/No.29

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

5. June/2023/Paper_9701/12/No.30

Alkynes are hydrocarbons that contain one triple C≡C bond.

Like alkenes, alkynes take part in addition reactions. A saturated compound can be formed.

For example, ethyne, H–C≡C–H, reacts with an excess of hydrogen to form ethane.

Propyne, C_3H_4, undergoes an addition reaction with an excess of hydrogen bromide in two stages. Markovnikov's rule applies to the addition of HBr at each stage.

What is the main product obtained when propyne reacts with an excess of hydrogen bromide?

A $CH_2BrCH_2CH_2Br$

B $CH_3CH_2CHBr_2$

C $CH_3CHBrCH_2Br$

D $CH_3CBr_2CH_3$

6. June/2023/Paper_9701/12/No.31

Bromine reacts with alkenes by an electrophilic addition mechanism in which a cation is formed as an intermediate.

Which mixture will produce the most stable intermediate cation?

A 3,3-dimethylpent-1-ene + bromine

B ethene + bromine

C methylpropene + bromine

D propene + bromine

7. June/2023/Paper_9701/12/No.32

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.

8. June/2023/Paper_9701/13/No.27

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

2-bromopentane is heated with an excess of ethanolic sodium hydroxide.

How many different hydrocarbons are produced?

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

9. June/2023/Paper_9701/13/No.30

Which type of reaction happens during the hydrolysis of 2-bromopropane?

A electrophilic addition

B free radical substitution

C nucleophilic addition

D nucleophilic substitution

10. June/2023/Paper_9701/21/No.3(d _ f)

Chlorine is a very reactive element.

(d) Chlorine reacts with methane in a series of reactions to produce chloroalkanes.

(i) State the conditions required for chlorine to react with methane.

..... [1]

(ii) One of the products of the reaction is CH_2Cl_2 which reacts further to produce $CHCl_3$.

Complete Table 3.2 to show details of the mechanism that forms $CHCl_3$ from CH_2Cl_2.

Table 3.2

name of step	equation
initiation	.....
propagation	$CH_2Cl_2 + Cl\bullet \rightarrow$ .....
termination	..... $\rightarrow CHCl_3$

[3]

(e) $CHCl_3$ and HF are used to form $CHClF_2$ in a substitution reaction.

Construct an equation for this reaction.

..... [1]

(f) **X** is a product of the substitution reaction that occurs when $CHClF_2$ reacts with Br_2.

There is only one naturally occurring isotope of fluorine, ^{19}F.

The mass spectrum of **X** shows molecular ion peaks at m/e = 164, 166 and 168.

Complete Table 3.3 to show **all** the molecular ions responsible for each peak.

Table 3.3

m/e	formulae of molecular ions
164	
166	
168	$(CF_2{}^{37}Cl{}^{81}Br)^+$

[2]

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11. June/2023/Paper_9701/22/No.3

Fig. 3.1 describes a sequence of reactions that can be used to produce a food additive, compound **Y**, from CH_3CH_2Cl.

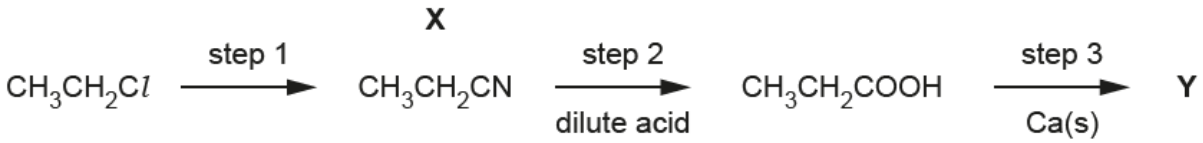


Fig. 3.1

(a) (i) State the reagent and conditions for step 1 in Fig. 3.1.

..... [1]

(ii) Give the systematic name of **X**.

..... [1]

(iii) Identify the type of reaction that occurs when dilute acid is added to **X** in step 2.

..... [1]

(iv) In step 3, **Y** and a gas are produced.
Construct an equation for step 3.

..... [2]

(b) CH_3CH_2COOH can also be formed from propan-1-ol and potassium dichromate(VI).
State the conditions required.

..... [1]

(c) Complete Table 3.1 to show the number of sigma bonds (σ) and pi bonds (π) present in a molecule of **X**.

Table 3.1

type of bond	number of bonds in **X**
sigma (σ)	
pi (π)	

[2]

[Total: 8]

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12. March/2023/Paper_9701/12/No.27

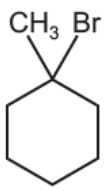
Compound X, $C_7H_{13}Br$, reacts with hot alcoholic NaOH to produce two compounds, Y and Z.

On reaction with Br_2, Y gives a product, $C_7H_{12}Br_2$, which exists as a mixture of four optical isomers.

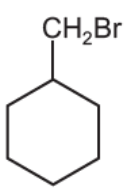
On reaction with Br_2, Z gives a product, $C_7H_{12}Br_2$, which is non-chiral.

What could X be?

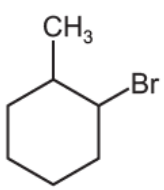
A



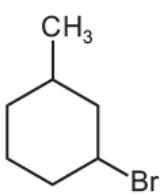
B



C



D



13. March/2023/Paper_9701/12/No.31

Which compound reacts most rapidly with aqueous silver nitrate by an S_N1 mechanism?

A 1-chloromethylpropane

B 2-chloromethylpropane

C 1-iodomethylpropane

D 2-iodomethylpropane

14. March/2023/Paper_9701/22/No.4(a _ c)

Fig. 4.1 shows some reactions of compound **D**, 2-bromobutane.

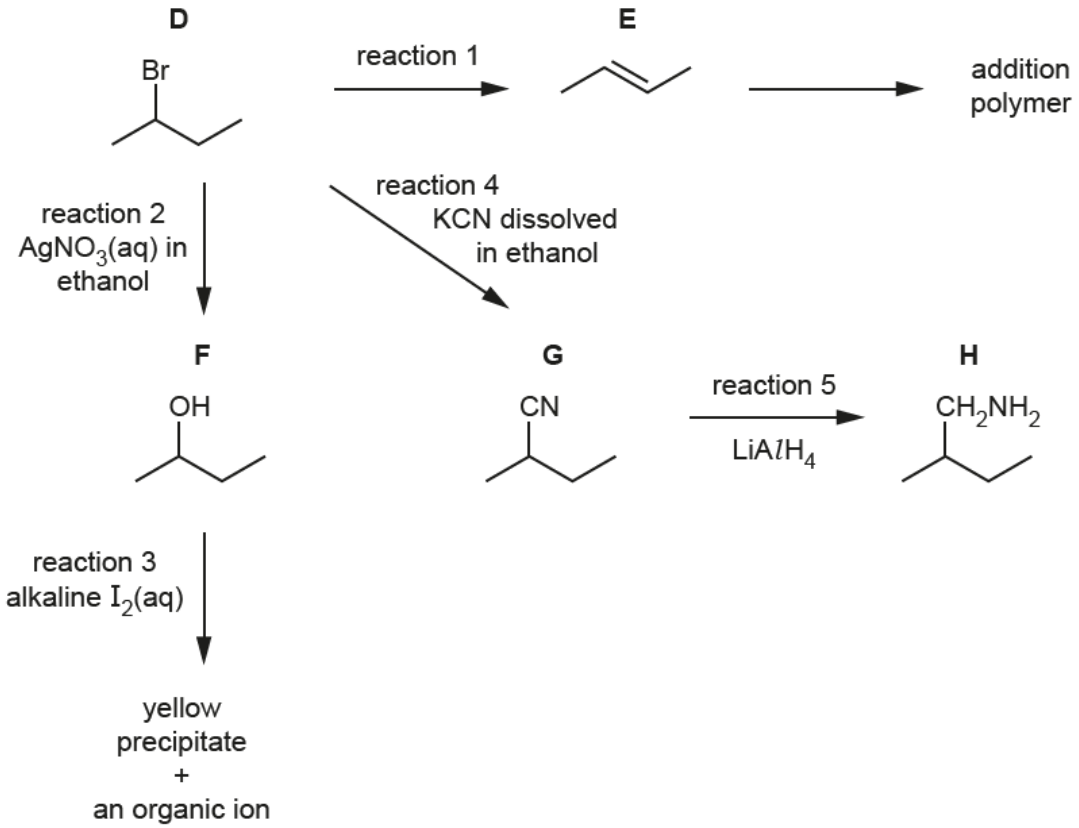


Fig. 4.1

(a) (i) State the reagent and conditions used to form **E** in reaction 1.

..... [1]

(ii) Draw the structure of **one** repeat unit of the addition polymer that forms from **E**.

[1]

(iii) **E** also forms when **F** is heated strongly in the presence of an Al_2O_3 catalyst.

Write an equation for this reaction.

..... [1]

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(b) (i) Predict what is observed in reaction 2.

..... [1]

(ii) Identify the yellow precipitate and the organic ion formed in reaction 3.

yellow precipitate .....

organic ion .....

[2]

(c) (i) State the type of reaction that occurs in reaction 4.

..... [1]

(ii) Reaction 5 is similar to the reaction of $LiAlH_4$ with carboxylic acids to form alcohols.

Suggest the role of $LiAlH_4$ in reaction 5.

..... [1]

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