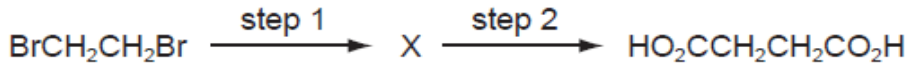
Section A

Q1 Butanedioic acid occurs in amber, algae, lichens, sugar cane and beets. It may be synthesised in two steps from 1,2-dibromoethane.



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)	$K_2Cr_2O_7 / H_2SO_4(aq)$

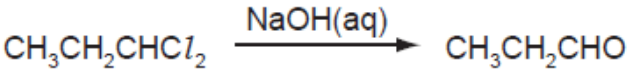
Q2 Which halogenoalkane will undergo an S_N1 reaction and produce a yellow precipitate when $AgNO_3(aq)$ is added to it?

A 1-chlorobutane
B 1-iodobutane
C 2-chloro-2-methylpropane
D 2-iodo-2-methylpropane

Q3 Which reaction will give 2-chloropropane in the best yield?

A propane gas with chlorine gas in the presence of ultraviolet light
B propan-2-ol with dilute NaCl (aq)
C propan-2-ol with $SOCl_2$
D propene with dilute HCl (aq)

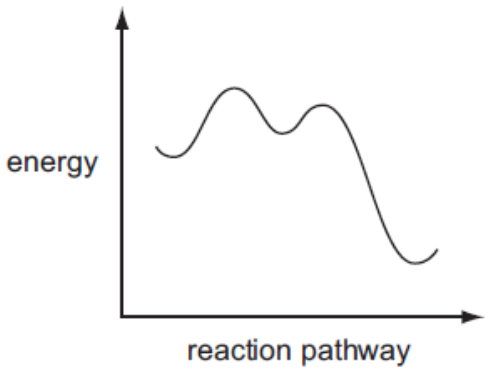
Q4 1,1-dichloropropane reacts with aqueous sodium hydroxide in a series of steps to give propanal.



Which term describes the first step of this reaction?

A electrophilic addition
B elimination
C nucleophilic substitution
D oxidation

Q5 A reaction pathway diagram is shown.



Which reaction does not have such a profile?

A $CH_3CHO + HCN \xrightarrow{NaCN} CH_3CH(OH)CN$

B $C_2H_5Br + NaOH \rightarrow C_2H_5OH + NaBr$

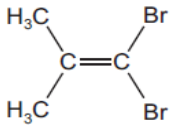
C $(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$

D 

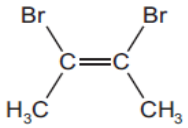
Q6 When 1-bromopropane is treated in succession with two reagents, X and Y, it produces propanoic acid. What are reagents X and Y?

	X	Y
A	NaOH(aq)	$H^+/Cr_2O_7^{2-}(aq)$
B	NaOH(aq)	CO_2
C	KCN in ethanol	$HCl(aq)$
D	KCN in ethanol	NaOH(aq)

Q7 Isomers X and Y both react with HBr.



X



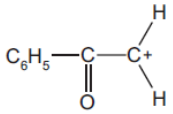
Y

A mixture of X and Y is reacted with HBr.
Which three structures represent three different possible products of this reaction?

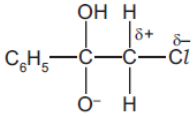
A	$(CH_3)_2CHCBr_3$	$(CH_3)_2CBrCHBr_2$	$CH_3CHBrCHBrCH_3$
B	$(CH_3)_2CHCBr_3$	$(CH_3)_2CBrCHBr_2$	$CH_3CBr_2CHBrCH_3$
C	$(CH_3)_2CBrCBr_3$	$(CH_3)_2CHCBr_3$	$CH_3CBr_2CHBrCH_3$
D	$(CH_3)_2CBrCHBr_2$	$CHBr_2CBr(CH_3)CH_3$	$CH_3CHBrCBr_2CH_3$

Q8 When phenacyl chloride, $C_6H_5COCH_2Cl$, is reacted with aqueous NaOH, the substitution reaction follows an S_N2 mechanism.
Which structure represents a species formed during the reaction?

A



B



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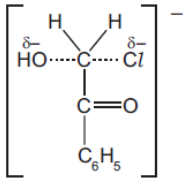
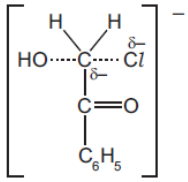
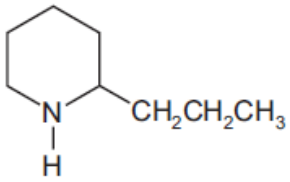


D



Q9 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

Q10 Bromine reacts with ethene to form 1,2-dibromoethane.
What is the correct description of the organic intermediate in this reaction?

A It has a negative charge.
B It is a free radical.
C It is a nucleophile.
D It is an electrophile.

Q11 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
D potassium cyanide

Q12 Aqueous sodium hydroxide reacts with 1-bromopropane to give propan-1-ol.
How should the first step in the mechanism be described?

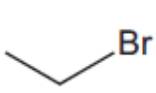
A by a curly arrow from a lone pair on the OH^- ion to the $C^{\delta+}$ atom of 1-bromopropane
B by a curly arrow from the $C^{\delta+}$ atom of 1-bromopropane to the OH^- ion
C by a curly arrow from the C–Br bond to the C atom
D by the homolytic fission of the C–Br bond

Q13 Aqueous sodium hydroxide reacts with 2-bromo-2-methylpropane to give 2-methylpropan-2-ol. The reaction proceeds by an S_N1 mechanism.
How should the first step in the mechanism be described?

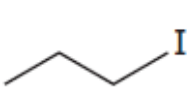
A by a curly arrow from a lone pair on the OH^- ion to the $C^{\delta+}$ atom of 2-bromopropane
B by a curly arrow from the C–Br bond to the Br atom
C by a curly arrow from the C–Br bond to the C atom
D by the homolytic fission of the C–Br bond

Q14 Compound Y can be hydrolysed by warm aqueous silver nitrate to form a precipitate that is soluble in dilute aqueous ammonia. Compound Y can undergo an elimination reaction to form an alkene
What could be the skeletal formula of compound Y?

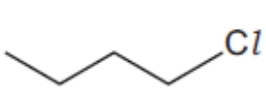
A



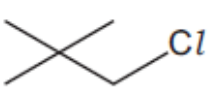
B



C



D



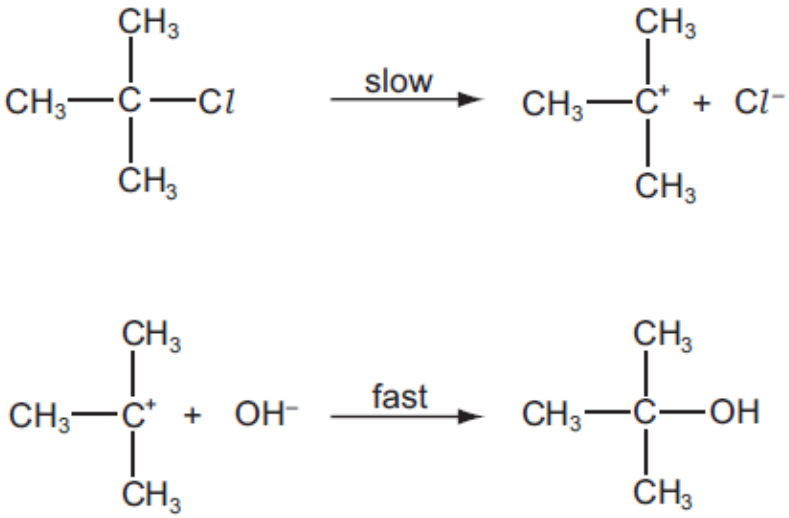
Q15 Which sequence of reagents may be used in the laboratory to convert propan-1-ol into 2-bromopropane?
A concentrated sulfuric acid, followed by bromine
B concentrated sulfuric acid, followed by hydrogen bromide
C ethanolic sodium hydroxide, followed by bromine
D ethanolic sodium hydroxide, followed by hydrogen bromide

Q16 A carbanion is an organic ion in which a carbon atom has a negative charge. A carbocation is an organic ion in which a carbon atom has a positive charge.
What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 2-bromo-2-methylbutane?
A heterolytic bond fission followed by an attack by an electrophile on a carbanion
B heterolytic bond fission followed by an attack by a nucleophile on a carbocation
C homolytic bond fission followed by an attack by an electrophile on a carbanion
D homolytic bond fission followed by an attack by a nucleophile on a carbocation

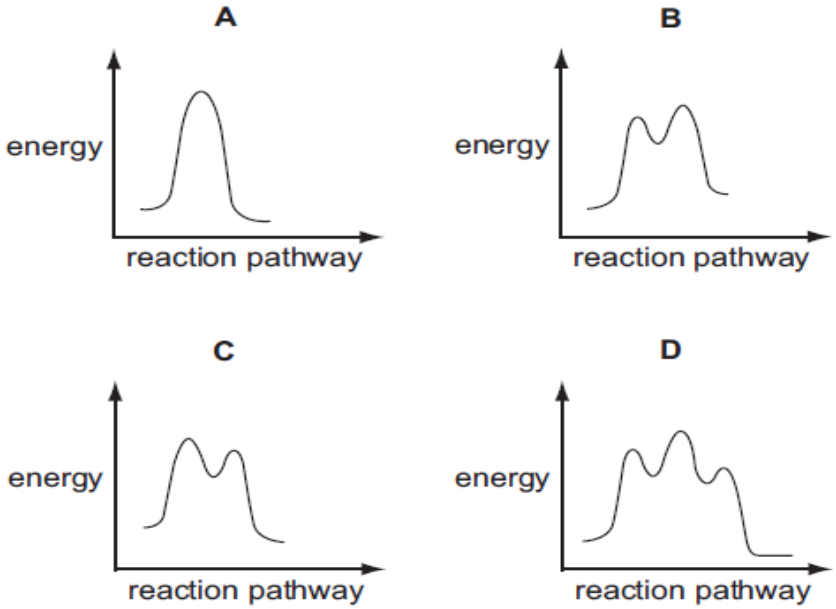
Q17 What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 1-bromobutane?
A attack by a nucleophile on a carbon atom with a partial positive charge
B heterolytic bond fission and attack by a nucleophile on a carbocation
C homolytic bond fission and attack by an electrophile on a carbanion
D homolytic bond fission and attack by a nucleophile on a carbocation

Q18 What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 2-bromo-2-methylbutane?
A heterolytic bond fission, attack by an electrophile on a carbanion
B heterolytic bond fission, attack by a nucleophile on a carbocation
C homolytic bond fission, attack by an electrophile on a carbanion
D homolytic bond fission, attack by a nucleophile on a carbocation

Q19 A possible mechanism for the exothermic hydrolysis of 2-chloro-2-methylpropane is shown.



Which diagram represents the reaction pathway diagram for this mechanism?



Section B

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

Q20 Bromoethane undergoes all of the conversions shown.
Which conversions are examples of nucleophilic substitution?
1 $C_2H_5Br \rightarrow C_2H_5CN$
2 $C_2H_5Br \rightarrow C_2H_5OH$
3 $C_2H_5Br \rightarrow C_2H_5NH_2$

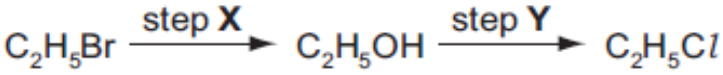
Q21 How can a good yield of ethylamine be made using bromoethane as starting material?
1 by heating bromoethane with an excess of ammonia gas in a sealed tube
2 by adding dilute aqueous ammonia to bromoethane at room temperature
3 by heating bromoethane under reflux with aqueous ammonium chloride

Q22 Fabrics for use in aircraft seating are treated with a coating containing a halogenoalkane. Why is this coating used?
1 The treated fabric burns less easily, improving safety.
2 The treated fabric forms hydrogen bonds to water more readily, so it is easier to wash.
3 The halogenoalkane undergoes addition polymerisation, stiffening the fabric.

Q23 X is an organic compound. X gives a precipitate with aqueous silver nitrate. Some or all of this precipitate remains undissolved when an excess of dilute aqueous ammonia is added. What could be the identity of X?
1 2-chlorobutane
2 2-bromobutane
3 iodomethane

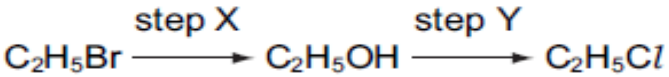
Q24 Y is an organic compound. Y gives a precipitate with aqueous silver nitrate. All of this precipitate dissolves when concentrated aqueous ammonia is added.
What is a possible identity for Y?
1 1-bromopropane
2 chloroethane
3 2-iodo-2-methylpropane

Q25 Chloroethane can be formed from bromoethane in two steps.



Which statements about these steps are correct?
1 Step X involves nucleophilic substitution.
2 Hot aqueous sodium hydroxide is the reagent in step X.
3 Hot aqueous sodium chloride is the reagent in step Y.

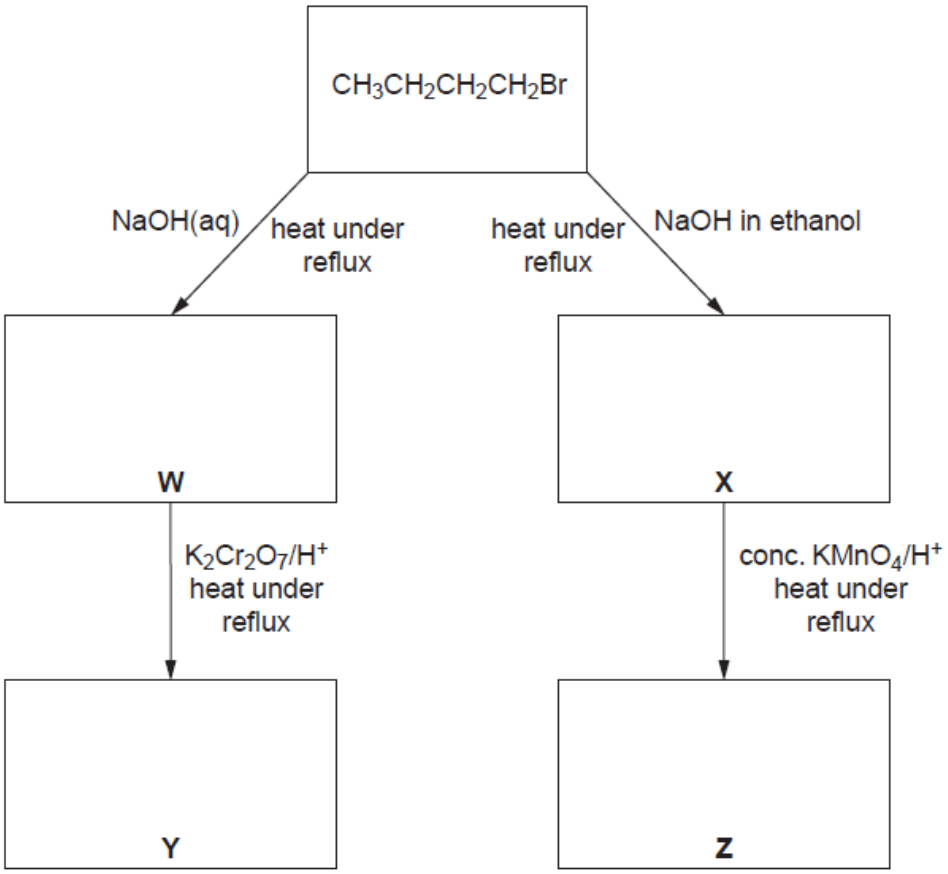
Q26 Chloroethane can be formed from bromoethane in two steps.



Which statements about these steps are correct?
1 Hot aqueous sodium hydroxide is the reagent in step X.
2 $SOCl_2$ is the reagent in step Y.
3 Step X is a substitution reaction.

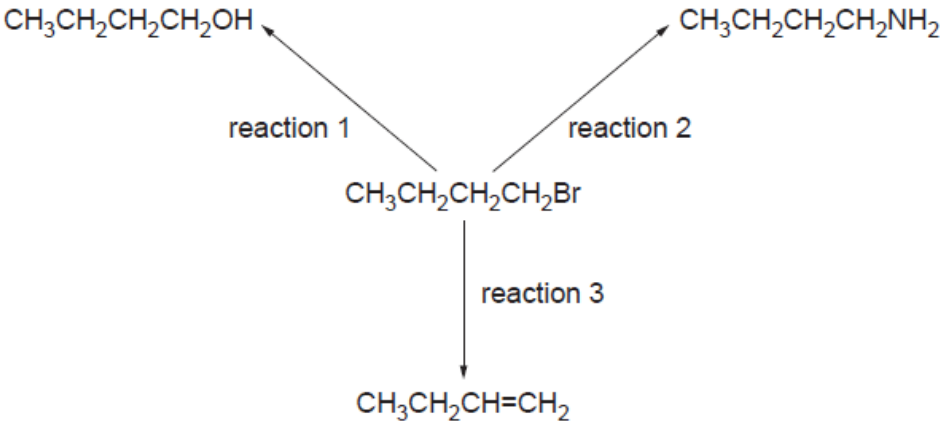
1. C
2. D
3. C
4. C
5. B
6. A
7. B
8. C
9. D
10. D
11. D
12. A
13. B
14. C
15. B
16. B
17. A
18. B
19. C
20. A
21. D
22. D
23. C
24. B
25. B
26. A

Q1 Complete the following reaction scheme which starts with 1-bromobutane.
In **each empty** box, write the **structural formula** of the organic compound that would be formed.



(Nov 2009 P22)

Q2 Halogenoalkanes have many chemical uses, particularly as intermediates in organic reactions. Three reactions of 1-bromobutane, $CH_3CH_2CH_2CH_2Br$, are shown below.



(a) For **each** reaction, state the reagent and solvent used.

reaction 1 reagent .....solvent .....

reaction 2 reagent .....solvent .....

reaction 3 reagent .....solvent .....

(b) When 1-iodobutane, $CH_3CH_2CH_2CH_2I$, is reacted under the same conditions as those used in reaction 1, butan-1-ol is formed.
What difference, if any, would there be in the rate of this reaction compared to the reaction of 1-bromobutane?
Use appropriate data from the *Data Booklet* to explain your answer.
.....

.....

.....

.....
Dichlorodifluoromethane, CCl_2F_2, is an example of a chlorofluorocarbon (CFC) that was formerly used as an aerosol propellant. In September 2007, at the Montreal summit, approximately 200 countries agreed to phase out the use of CFCs by 2020.
(c) State two properties of CFCs that made them suitable as aerosol propellants.

1. ..... 2. .....
(d) When CFCs are present in the upper atmosphere, homolytic fission takes place in the presence of ultraviolet light.
(i) What is meant by the term *homolytic fission*?

.....

.....
(ii) Suggest an equation for the homolytic fission of CCl_2F_2.

.....
(e) The most common replacements for CFCs as aerosol propellants are hydrocarbons such as propane and butane.
Suggest **one** disadvantage of these compounds as aerosol propellants.

.....
(Nov 2010 P22)

Q3 Although few halogenoalkanes exist naturally, such compounds are important as intermediates in organic reactions and as solvents.
The bromoalkane **B** has the following composition by mass: C, 29.3%; H, 5.7%; Br, 65.0%.
The relative molecular mass of **B** is 123.
(a) Calculate the molecular formula of **B**.

Halogenoalkanes such as bromoethane, C_2H_5Br, have two different reactions with sodium hydroxide, NaOH, depending on the conditions used.
(b) (i) When hot aqueous NaOH is used, the C_2H_5Br is hydrolysed to ethanol, C_2H_5OH.
Describe the mechanism of this reaction. In your answer, show any relevant charges, dipoles, lone pairs of electrons and movement of electron pairs by curly arrows.

(ii) What will be formed when C_2H_5Br is reacted with NaOH under different conditions?

.....

(iii) What are the conditions used?

.....

(iv) What type of reaction is this?

.....

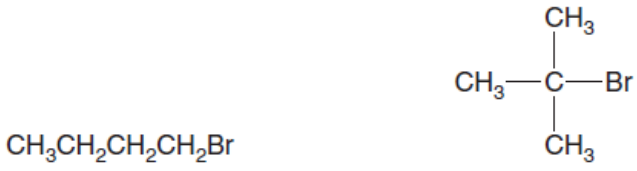
When 1,4-dichlorobutane, $ClCH_2CH_2CH_2CH_2Cl$, is reacted with NaOH, two different reactions can occur, depending on the conditions used.

(c) (i) Draw the **displayed** formula of the product formed when 1,4-dichlorobutane is reacted with hot aqueous NaOH as in **(b)(i)**.

(ii) Draw the **skeletal** formula of the product formed when 1,4-dichlorobutane is reacted with NaOH in the way you have described in **(b)(ii)** and **(b)(iii)**.

(Nov 2010 P23)

Q4



1-bromobutane 2-bromo-2-methylpropane

(a) 1-Bromobutane reacts with **aqueous** sodium hydroxide to form butan-1-ol.

(i) Give a balanced equation for this reaction.

.....

(ii) Name the type of reaction. .....

(iii) Describe the mechanism of this reaction.

(b) 1-Bromobutane and 2-bromo-2-methylpropane both react with an **ethanolic** (**alcoholic**) solution of sodium hydroxide to form alkenes.
(i) Name the type of reaction. .....
(ii) Identify, by means of the structural formula, the alkene formed from
I 1-bromobutane,

II 2-bromo-2-methylpropane.

(iii) Hot, concentrated manganate(VII) ions break the double bond in alkenes. Each of the two alkenes in **(b)(ii)** gives CO_2 and H_2O from the terminal group, but the rest of the molecule remains as an organic oxidation product. Suggest the formula of each of these products.

from I .....

from II .....
(c) Complete the reaction sequence giving the intermediate, the reagents and the conditions for the synthesis of 2,2-dimethylpropanoic acid.

Step I: reagent .....

conditions .....

Step II: reagent .....

conditions .....
(Nov 2003)