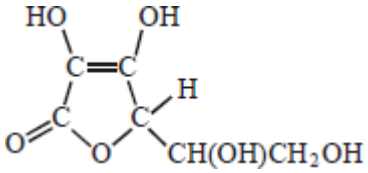
Q1.

Which one of the following is **not** a correct statement about vitamin C, shown below?



A It is a cyclic ester.

B It can form a carboxylic acid on oxidation.

C It decolourises a solution of bromine in water.

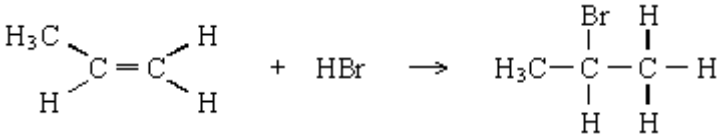
D It is a planar molecule.

(Total 1 mark)

Q2.

(a) Propene reacts with hydrogen bromide by an electrophilic addition mechanism forming 2-bromopropane as the major product.

The equation for this reaction is shown below.



(i) Outline the mechanism for this reaction, showing the structure of the intermediate carbocation formed.

(ii) Give the structure of the alternative carbocation which could be formed in the reaction between propene and hydrogen bromide.

(5)

(b) A substitution reaction occurs when 2-bromopropane reacts with aqueous sodium hydroxide.

(i) Draw the structure of the organic product of this reaction and give its name.

Structure

Name _____

(ii) Name and outline the mechanism for this reaction.

Name of mechanism _____

Mechanism

(5)

(c) Under different conditions, 2-bromopropane reacts with NaOH to produce propene.

(i) Name the mechanism for this reaction.

_____

(ii) State the role of sodium hydroxide in this reaction.

_____

(2)

(Total 12 marks)

Q3.

Which one of the following reactions involves nucleophilic addition?

A $CH_3CH = CH_2 + HBr \rightarrow CH_3CHBrCH_3$

B $CH_3CH_2CH_3 + Cl_2 \rightarrow CH_3CHClCH_3 + HCl$

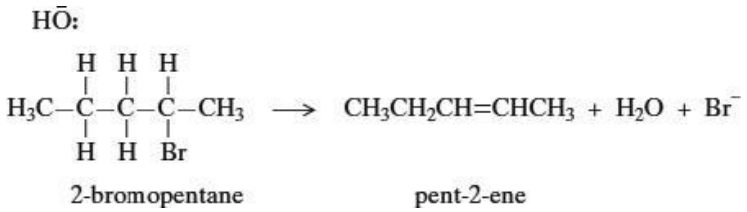
C $CH_3CH_2CH_2Br + NaOH \rightarrow CH_3CH_2CH_2OH + NaBr$

D $CH_3CH_2CHO + HCN \rightarrow CH_3CH_2CH(OH)CN$

(Total 1 mark)

Q4.

(a) Complete the mechanism below by drawing appropriate curly arrows.



(3)

(b) Draw and name the geometrical E-Z isomers of pent-2-ene.

Isomer 1 *Isomer 2*

Name _____ *Name* _____

(2)

(c) Pent-1-ene reacts with hydrogen bromide to produce 2-bromopentane as the major product.

(i) Outline the mechanism for this reaction.

(ii) Identify the minor product formed in this reaction.

_____

(iii) Explain why 2-bromopentane is the major product of this reaction.

_____

_____

_____

(7)

(Total 12 marks)

Q5.

This question is about 2-methylbut-1-ene.

(a) Name the mechanism for the reaction of 2-methylbut-1-ene with concentrated sulfuric acid.

Outline the mechanism for this reaction to form the major product.

Name of mechanism _____

Outline of mechanism to form major product

(5)

(b) Draw the structure of the minor product formed in the reaction in part (a)

Explain why this is the minor product.

Structure of minor product

Explanation _____

_____

_____

_____

(3)

(c) Draw the skeletal formula of a functional group isomer of 2-methylbut-1-ene.

(1)

(d) 2-methylbut-1-ene can form a polymer.

State the type of polymerisation.

Draw the repeating unit for the polymer formed.

Type of polymerisation _____

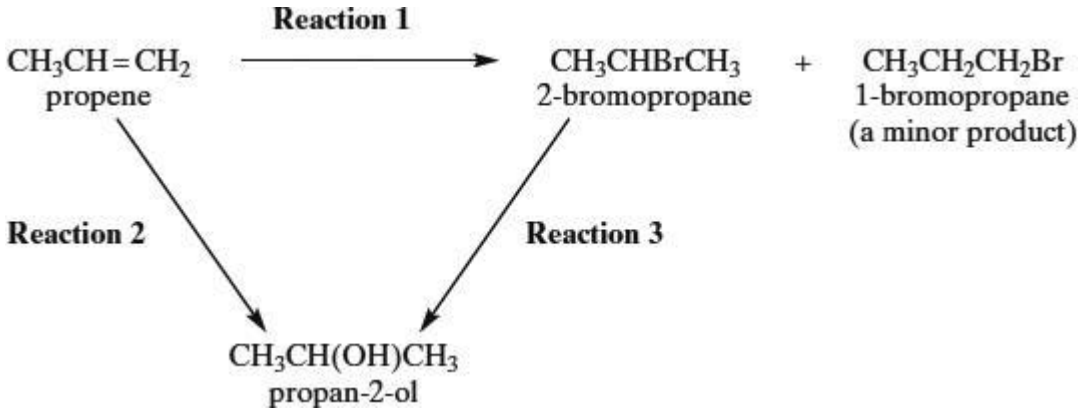
Repeating unit

(2)

(Total 11 marks)

Q6.

Consider the following reaction scheme.



(a) (i) Name the mechanism for **Reaction 1**.

_____

(ii) Explain why 1-bromopropane is only a minor product in **Reaction 1**.

_____

_____

_____

(3)

(b) Give a suitable reagent and state the essential conditions required for **Reaction 3**.

Reagent _____

Conditions _____

(2)

(c) The reagent used for **Reaction 3** can also be used to convert 2-bromopropane into propene. State the different conditions needed for this reaction.

_____

(1)

(d) **Reaction 2** proceeds in two stages.

Stage 1 $CH_3CH=CH_2 + H_2SO_4 \rightarrow CH_3CH(OSO_2OH)CH_3$

Stage 2 $CH_3CH(OSO_2OH)CH_3 + H_2O \rightarrow CH_3CH(OH)CH_3 + H_2SO_4$

(i) Name the class of alcohols to which propan-2-ol belongs.

_____

(ii) Outline a mechanism for Stage 1 of **Reaction 2**, using concentrated sulphuric acid.

(iii) State the overall role of the sulphuric acid in **Reaction 2**.

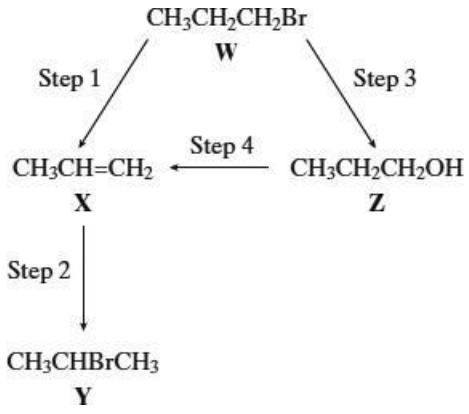
_____

(6)

(Total 12 marks)

Q7.

For this question refer to the reaction scheme below.



Which one of the following reagents would **not** bring about the reaction indicated?

A Step 1 : alcoholic KOH

B Step 2 : aqueous Br_2

C Step 3 : aqueous NaOH

D Step 4 : concentrated H_2SO_4

(Total 1 mark)

Q8.

Butenedioic acid, HOOCCH=CHCOOH, occurs as two stereoisomers. One of the isomers readily forms the acid anhydride $C_4H_2O_3$ when warmed.

(a) Draw the structures of the two isomers of butenedioic acid and name the type of isomerism shown.
Use the structures of the two isomeric acids to suggest why only one of them readily forms an acid anhydride when warmed. Draw the structure of the acid anhydride formed.

(6)

(b) Identify one electrophile which will react with butenedioic acid and outline a mechanism for this reaction.

(4)

(c) Write an equation for a reaction which occurs when butenedioic acid is treated with an excess of aqueous sodium hydroxide.

(2)

(d) Describe and explain the appearance of the proton n.m.r. spectrum of butenedioic acid.

(3)

(Total 15 marks)

Mark schemes

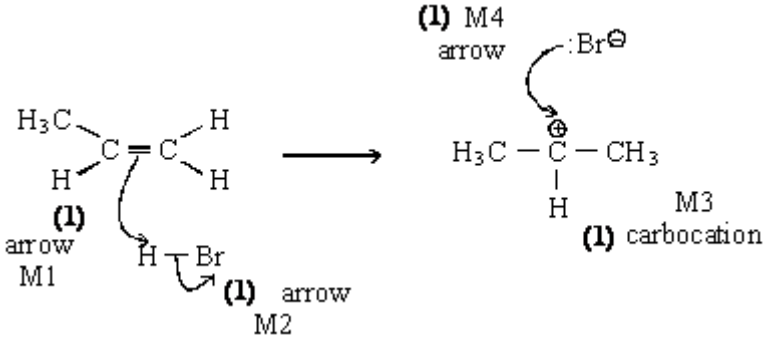
Q1.

D

[1]

Q2.

(a) (i)



If wrong carbocation, lose structure mark
If wrong alkene, lose structure mark
Can still score ¾ i.e. penalise M3
Penalise M2 if polarity included incorrectly
no bond between H and Br
bond is shown as ⟶ *or* ⟶

(ii) $CH_3CH_2\overset{\oplus}{C}H_2$ **(1)**

credit secondary carbocation here if primary carbocation has been used in (i)

Ignore attack on this carbocation by $\ddot{Br}^{\ominus}$

5

(b) (i) *Structure*:

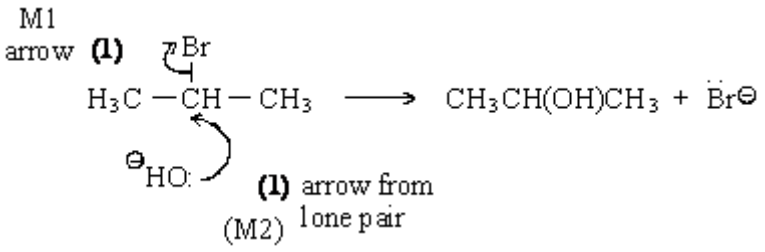
$H_3C-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_3$ **(1)** [insist on C — OH bond]

No credit for propan-1-ol even when named correctly
Credit propane-2-ol

Name: propan-2-ol **(1)**
Not 2-hydroxypropane

(ii) *Name of mechanism*: nucleophilic substitution **(1) (both words)**
(NOT S_N1 or S_N2)

Mechanism:



penalise incorrect polarity on C-Br (M1)
Credit the arrows even if incorrect haloalkane
If S_N1, both marks possible

i.e. M1 C–Br M2 $^{\ominus}HO$ correct carbocation

5

(c) (i) elimination **(1)**
Ignore nucleophylic elimination
Penalise electrophilic elimination

(ii) base **(1)**
OR proton acceptor
NOT nucleophile (base)

2

[12]

Q3.

D

[1]

Q4.

(a) M1 curly arrow from lone pair on oxygen of hydroxide ion to H atom on C-H adjacent to C-Br

1

M2 curly arrow from single bond of adjacent C-H to adjacent single bond C-C
(only credit M2 if M1 is being attempted to correct H atom)

1

M3 curly arrow from C-Br bond to side of Br atom
(credit M3 independently)

1

(b) Ml credit a correct structure for either geometrical E-Z isomer and its designation as either *cis* or *trans.*
OR credit two correct geometrical E-Z isomer structures (ignore the names)
OR credit two correct names for *cis* pent-2-ene and *trans* pent-2-ene (ignore the structures)

1

M2 credit a second mark if all four parts of the required structures and names are correct.

(credit "linear" structures)
(insist on the alkyl groups being attached clearly by C-C bonds)

1

(c) (i) Ml curly arrow from middle of C = C bond to H atom on H-Br

(penalise M1 if partial negative charge or formal positive charge on H)
(penalise Ml if pent-2-ene is used)

1

M2 curly arrow from H-Br bond to side of Br atom

1

M3 correct structure for correct secondary carbocation

1

M4 curly arrow from lone pair on bromide ion to the positive carbon of carbocation, ensuring that bromide ion has a negative charge.

(with the exception of pent-2-ene, if the wrong alkene is used, only penalise the structure M3)
(penalise the use of two dots in addition to a covalent bond, once only)

1

(ii) 1-bromopentane

1

(iii) Ml 2-bromopentane is formed *via* the secondary (or 2°) carbocation

1

OR 1-bromopentane is formed *via* the primary (or 1°) carbocation
M2 a secondary carbocation is more stable than a primary carbocation -
award this mark only if the quality of language justifies the award.

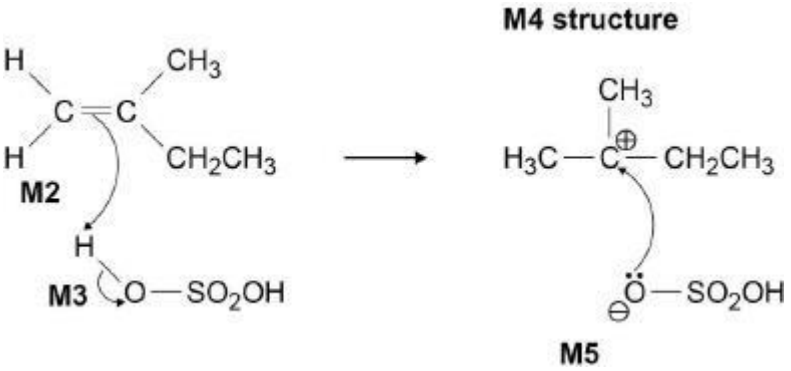
(the argument must involve clear statements about carbocations)

1

[12]

Q5.

(a) Electrophilic addition



NB Allow fully displayed or other structural formulae

if H_2O used as electrophile − max 4 ONLY

M2 must show an arrow from = of C=C towards the H atom of the H−O bond or HO that is part of H−O−S−… on a compound with molecular formula H_2SO_4

M2 could have arrow to H^+ in which case M3 would be for an independent H−O bond break on a compound with formula H_2SO_4

M3: must use an arrow to show the breaking of the H−O bond

M3 ignore partial charges unless wrong

M4: is for the correct carbocation structure

NOT M4 if primary carbocation shown.

M5: must show an arrow from a lone pair of electrons on the correct oxygen of the negatively charged ion towards the positively charged carbon atom

M5 NOT HSO_4

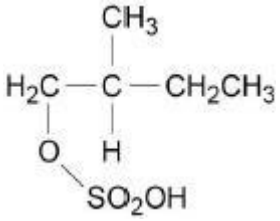
credit as shown or as: OSO_3H − in which case negative charge can be shown anywhere ECF from H_2SO_3 in M2

NB: The arrows are double-headed

IGNORE *subsequent use of water to hydrolyse hydrogensulfate*

M1M2M3M4M5

(b)



If tertiary shown here allow as ECF for M1 if primary shown in (a)

M1

(major) product formed via more stable carbocation OR tertiary carbocation more stable (than primary)

Must be clear refers to intermediate and not product

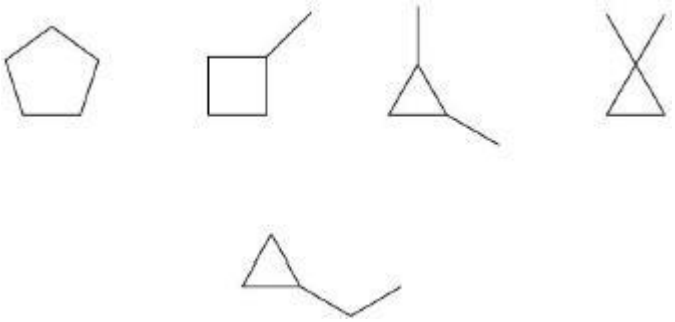
M2

Due to electron-releasing character / (positive) inductive effect of three alkyl groups (as opposed to one)

Primary has one e⁻ donating alkyl group

M3

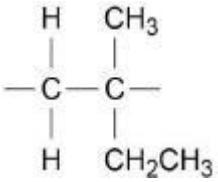
(c) Skeletal formula of cycloalkane



ignore structure of 2-methylbut-1-ene

1

(d) Addition (polymerisation)



Not additional

Penalise incorrect attachment of ethyl group

Must have trailing bonds

Ignore n and brackets

Ignore structure of 2-methylbut-1-ene

M1M2

[11]

Q6.

(a) (i) Electrophilic addition

(Both words required)

1

(ii) M1 the reaction <u>to form 1-bromopropane</u> goes *via* the <u>primary carbocation</u> OR 1° carbocation

OR *via* $CH_3CH_2\overset{+}{C}H_2$

M2 <u>primary carbocations are less stable than secondary carbocations</u>

(Credit converse arguments for M1 and M2 i.e. the reaction <u>to form 2-bromopropane</u> goes via the <u>secondary carbocation</u> , M1, and <u>secondary carbocations are more stable than primary carbocations, M2</u>)

(Accept the use of "carbonium ions" as an alternative to carbocation)

1

(b) M1 NaOH OR KOH OR correct name

1

M2 aqueous or solution in water *(ignore heat, reflux etc.)*

(Penalise M1 for hydroxide ion alone, but mark on and credit M2)
(Credit M2 ONLY for H_2O as reagent and heat / warm / T=50 to 100°C)
(NaOH(aq) scores M1 and M2 provided it is not contradicted)
(Penalise M2 if NaOH(aq) followed by concentrated or ethanol)
(Penalise M1 and M2 if followed by acid)

1

(c) Ethanolic OR alcoholic OR CH_3CH_2OH / CH_3OH solvent OR aqueous ethanol/alcohol
OR higher temperature *(must be comparative)*

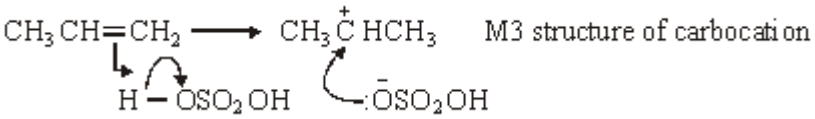
(Ignore heat or heat under reflux)
(Credit part (c) independently from part (b))
(Penalise "ethanoic")

1

(d) (i) Secondary OR 2°

1

(ii)



M1 arrow from double bond to H of H – O bond
M2 arrow from bond to oxygen atom to show H – O bond breakage
M4 arrow from lone pair of electrons to carbon atom of carbocation

(Penalise M1 if arrow goes to H_2SO_4 or to formal positive charge on H, but ignore partial charges on sulphuric acid unless wrong)
(Credit M2 for H^+ ion)
(For M4, accept negative charge anywhere on the ion)

4

(iii) Catalyst ONLY

(Ignore homogeneous, heterogeneous)

1

[12]

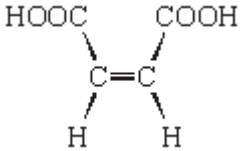
Q7.

B

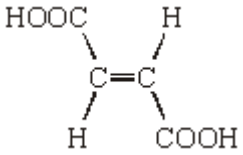
[1]

Q8.

(a)



1



1

NB The bonds shown in the structure must be correct

Isomerism: E-Z isomerism

If written answer is correct, ignore incorrect labelling of structures.
If no written answer, allow correctly labelled structures.

1

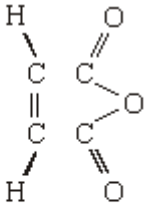
Both COOH groups must be on the same side/ close together/ cis

1

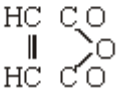
No rotation about C=C axis

1

Structure

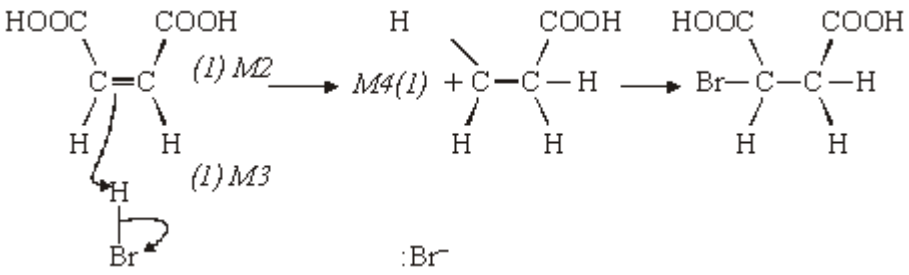


Allow



1

(b) Br_2 / HBr / H_2SO_4 / H^+ / Br^+ / NO_2^+ (*Mark M1*)



NB If electrophile H^+ / Br^+ / NO_2^+ allow M1, M2 and M4
If the acid is incorrect, M2 and M3 can still be scored
Allow M4 consequentially if repeat error from part (a)

4

(c) e.g. $2NaOH + HO_2CCHCHCO_2H \rightarrow NaO_2CCHCHCO_2Na + 2H_2O$

Both H replaced

1

Balanced for atoms and charges

1

NB Allow ionic equations and
$2NaOH + C_4H_4O_4 \rightarrow C_4H_2O_4Na_2 + 2H_2O$
Allow one if structure incorrect but molecular formula correct
Allow one for a correct equation showing one H replaced

(d) *M1* Two peaks

1

M2 No splitting or singlets

1

M3 (Two) non-equivalent protons or two proton environments

1

M4 No adjacent protons

1

M5 Same area under the two peaks or same relative intensity

1

NB Doublet could score M1 and M3 or M5 (Max 2)
More than two peaks CE = 0
Apply the "list principle" to incorrect answers if more than 3 given

Max 3

[15]