AQA A-LEVEL CHEMISTRY · 7405

CHEMISTRY



MARK SCHEME

3.3.7 OPTICAL ISOMERISM

SCORE	PERCENTAGE
/160	%

STEMUP

These questions belong to AQA, not to us.

The examination questions, mark schemes and examiner reports in this pack were written and published by AQA. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with AQA and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. AQA has not endorsed, approved or been involved in the production of it. AQA and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

AQA publishes its past papers, mark schemes and examiner reports free of charge. Always check the current specification at aqa.org.uk before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

D

[1]

Q2.

D

[1]

Q3.

D

[1]

Q4.

(a) 2-hydroxyhexanenitrile

1

(b) (Plane) polarised light

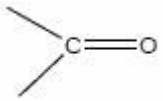
1

Enantiomers would <u>rotate</u> light in opposite directions

not different alone

1

(c) <u>planar</u> carbonyl group or

<u>planar</u> 

Not planar molecule,
not planar bond, not planar C=O

1

Attack from either side

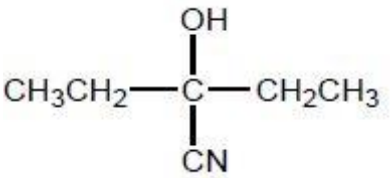
1

With <u>equal</u> probability

OR produces <u>equal</u> amounts (of the two isomers/enantiomers)

1

(d)



Does not contain a chiral centre

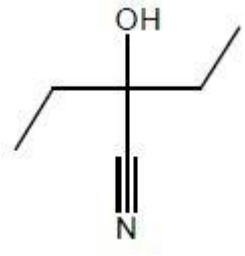
STEMUP.CO.UK

OR does not contain C attached to 4 different groups

OR contains two identical/ethyl groups

OR symmetrical (product)

Allow C_2H_5 or skeletal



M2 dependent on correct M1 (No structure = 0)

If pentan-3-one drawn then allow symmetrical ketone for M2

[8]

Q5.

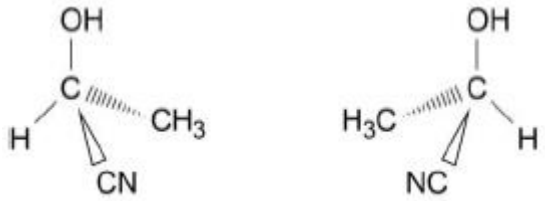
(a) 3

1

(b) Chain.

1

(c)



One 3D enantiomer.

1

Second enantiomer correctly drawn as 3D mirror image of first.

1

(d) Plane-polarised light.

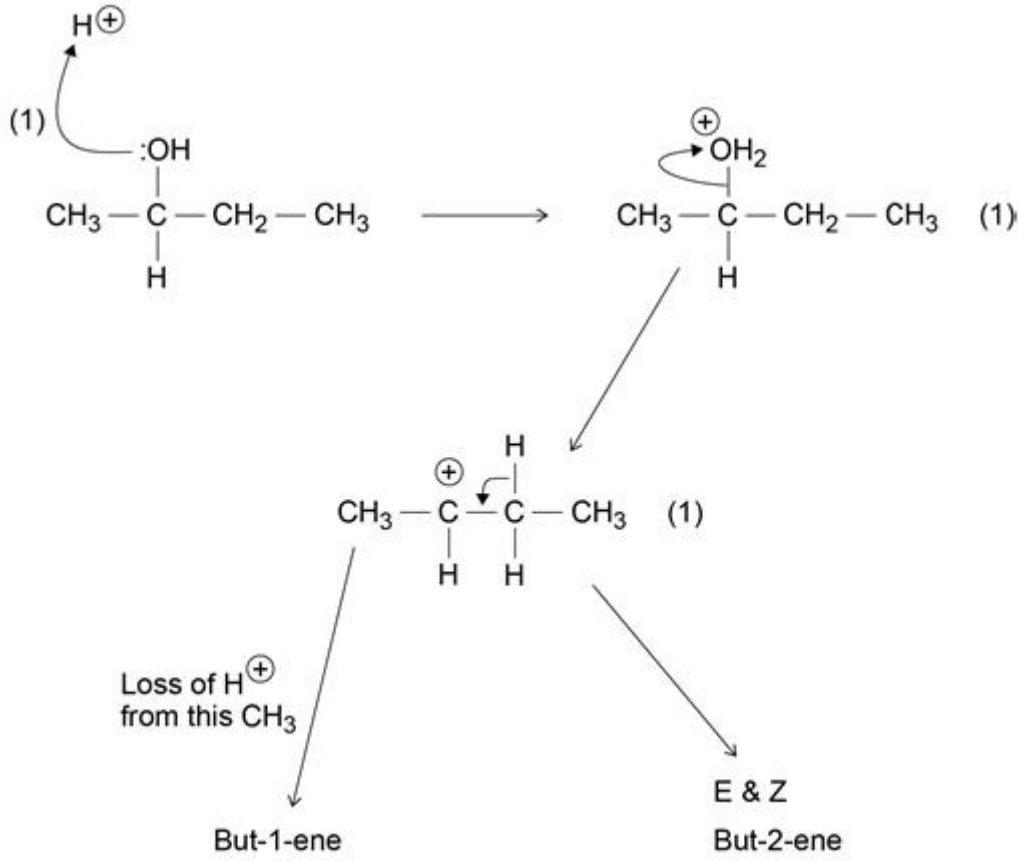
1

Rotated in opposite directions.

1

(e) Elimination

STEMUP.CO.UK



Extended response question

M1

Mechanism (3 marks)

M2 arrow from lone pair on O to H^+

M3 1st intermediate **and** arrow from C–O^+H_2 bond to O (with loss of H_2O)

M4 2nd intermediate (carbocation) **and** arrow from C–H bond to C–C (with loss of H^+) to form C=C

M3 and M4 can be scored in one step (see alternative mechanism below).

If carbocation incorrect then answer cannot score maximum marks.

Explanation of formation of 3 alkenes

M5 loss of H^+ from C (in carbocation) adjacent to $^+$C (to which −OH was attached)

M6 From **^{1}C**–^{2}C+–^{3}C–^{4}C leads to but-1-ene

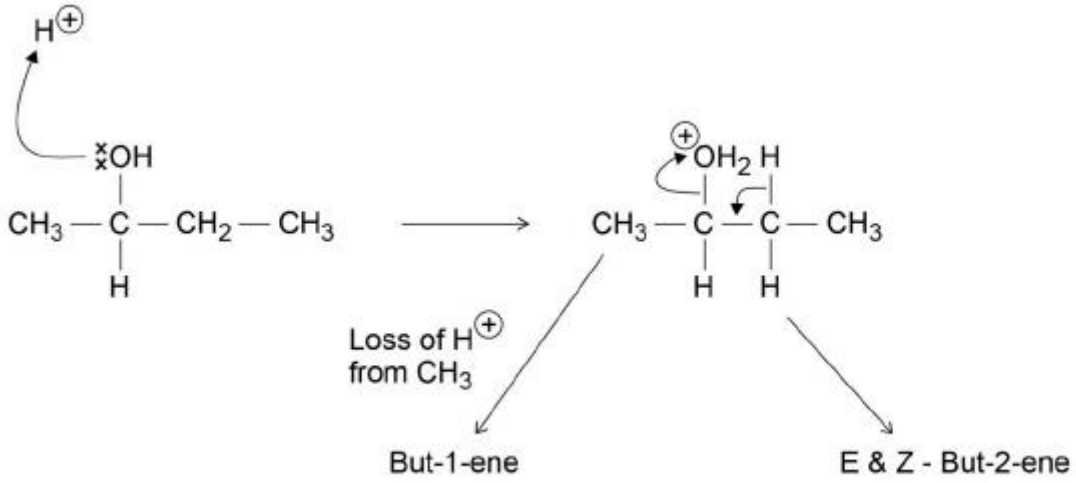
M7 From ^{1}C–^{2}C$^+$–**^{3}C**–^{4}C leads to but-2-ene

M8 But-2-ene formed as mixture of *E*-*Z* isomers

8

STEMUP.CO.UK

Alternative mechanism



[14]

Q6.

(a) $CH_3CH_2COCH_3 + 2[H] \longrightarrow CH_3CH_2CH(OH)CH_3$

1

(b) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

All stages are covered and the explanation of each stage is generally correct and virtually complete.

Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 then stage 3.

Level 3
5 – 6 marks

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows progression from stage 1 to stage 3.

Level 2
3 – 4 marks

Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes isolated statements but these are not presented in a logical order or show confused reasoning.

Level 1
1 – 2 marks

Insufficient correct chemistry to gain a mark.

Level 0
0 marks

STEMUP.CO.UK

Indicative Chemistry content

Stage 1: Formation of product
- Nucleophilic attack
- Planar carbonyl group
- H^- attacks from either side (stated or drawn)

Stage 2: Nature of product
- Product of step 1 shown
- This exists in two chiral forms (stated or drawn)
- Equal amounts of each enantiomer / racemic mixture formed

Stage 3: Optical activity
- Optical isomers / enantiomers rotate the plane of polarised light equally in
- With a racemic / equal mixture the effects cancel

6

[7]

Q7.

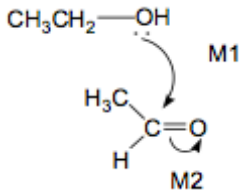
(a) (i) Nucleophilic addition

Any extra loses the mark

Allow minor spelling errors e.g. nucleophyllic

1

(ii)



M1 for arrow from lone pair on oxygen in ethanol to C of C=O (or to space half way between O and C)

M2 for arrow from C=O bond to oxygen in ethanal

Do not allow M2 as first step without nucleophilic attack, but can allow M1 for attack on C+ produced

+ rather than δ+ on C=O loses M2

Ignore any further steps

Mark independently

1
1

(b) (i) Equal mixture of enantiomers/optical isomers OWTTE

1

(ii) (Non-superimposable) mirror images

Ignore rotates light in opposite directions

Ignore stereoisomers

1

(c) (i) Ethan**al** 0.33

1

Ethan**ol** 4.16

Allow 4.2 for ethanol

STEMUP.CO.UK

1

(ii) $K_c = \dfrac{[acetal][H_2O]}{[CH_3CHO][CH_3CH_2OH]^2}$ or with names

$\dfrac{(0.37/0.31)(0.65/0.31)}{(0.58/0.31)(3.76/0.31)^2}$ **OR** $\dfrac{(0.37)(0.65)}{(0.58)(3.76)^2} \times 0.31$

Ignore slips in acetal structure or formula $C_6H_{14}O_2$

If K_c wrong, allow M4 only for units conseq to their K_c

If volume omitted (gives 2.93×10^{-2}) may only score M1 and M4

If volume used = 310 cm^3 allow M2 then award M3 for 9.08 – 9.23 only and M4 for mol^{-1} cm^3 only

Treat error in converting 310 cm^3 to dm^3 as AE

M1

M2

9.1×10^{-3}

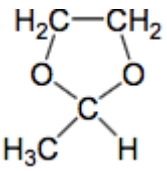
Allow range 9.08×10^{-3} – 9.23×10^{-3}

M3

$mol^{-1}dm^3$

Not $moles^{-1}dm^3$

M4

(d) 

1

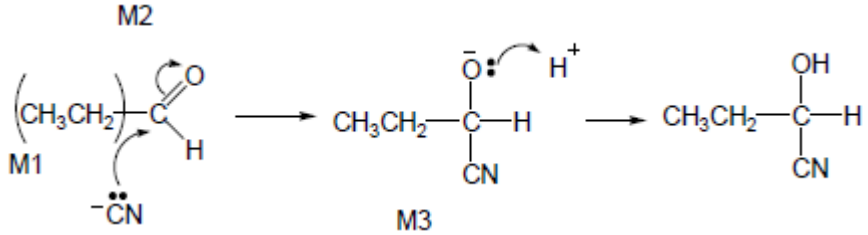
[12]

Q8.

(a) Nucleophilic addition

1

M4 for lp, arrow and H+



Allow C_2H_5- for CH_3CH_2-

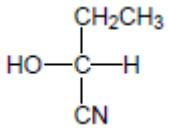
- *M1 and M4 include lone pair and curly arrow.*
- *Allow: CN^- but arrow must start at lone pair on C.*
- *M2 not allowed independent of M1, but allow M1 for correct attack on C+.*
- *+ rather than δ+ on C=O loses M2.*

STEMUP.CO.UK

- *Penalise incorrect partial charges.*
- *M3 is for correct structure including minus sign but lone pair is part of M4.*
- *Penalise extra curly arrows in M4.*

4

(b) (i) M1



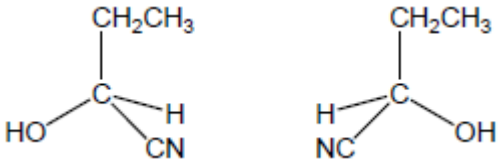
M1 for correct structure of product of part (a).

Allow C_2H_{5-} for CH_3CH_{2-}.

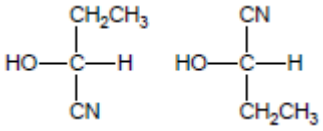
Penalise wrongly bonded, OH or CN or CH_2CH_3 once only in clip.

1

M2

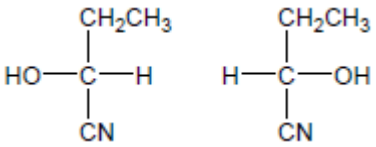


M2 cannot be gained by simply swapping two or more groups with no attempt to show a mirror image., e.g. do not allow M2 for



because these do not show the enantiomers as mirror images.

Students must show an attempt at mirror images, eg allow



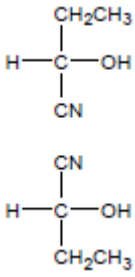
ie vertical groups same and horizontal swapped as if there was a mirror between them

No mirror need be shown

Do not penalize wedge bond when wedge comes into contact with both C & N

However these two could score M2 if placed as below as if with a "mirror" horizontally between them.

STEMUP.CO.UK



1

(ii) M1 (Plane) polarized light

M2 only scores following correct M1

1

M2 Rotated in opposite directions (equally) (only allow if M1 correct
or close)

Not just in different directions but allow one rotates light to the left and one to the right.

Not molecules rotate.

1

(c) 2-hydroxybutane(-1-)nitrile

1

(d) Weak acid / (acid) only slightly / partially dissociated / ionised

Ignore rate of dissociation.

1

$[CN^-]$ very low

Allow (very) few cyanide ions.

Mark independently.

1

(e) (i) $H_2C{=}CH{-}CH_3 + NH_3 + \frac{3}{2}O_2 \longrightarrow H_2C{=}CH{-}CN + 3H_2O$

OR

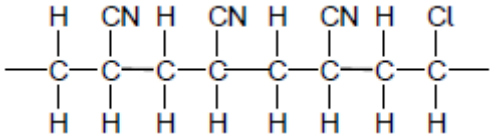
$H_2C{=}CH{-}CH_3 + NH_3 + 3O_2 \longrightarrow H_2C{=}CH{-}CN + 3H_2O_2$

OR doubled.

Allow C_3H_6 and CH_2CHCN or C_3H_3N on this occasion only.

1

(ii)



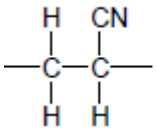
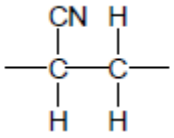
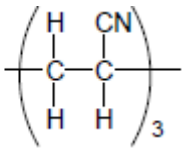
Ignore n.

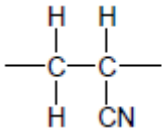
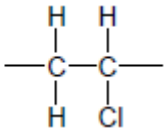
Must show trailing bonds.

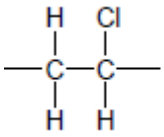
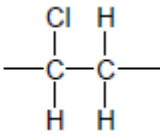
Do not penalise C–NC bond here on this occasion.

Must contain, in any order,

STEMUP.CO.UK

3 of  or 3 of  or 

Allow  or 

and one of  or 

Allow –CH₂CH(CN)CH₂CHCl− etc.

1

(iii) Addition (polymerization)

Allow self-addition.

Do not allow additional.

1

[15]

Q9.

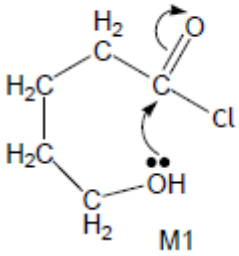
(a) (i) (nucleophilic) addition-elimination

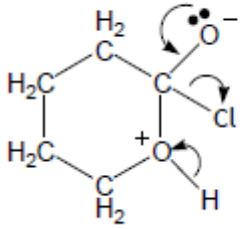
Not electrophilic addition-elimination

Ignore esterification

1

M2





M4 for 3 arrows and lp

M3 for structure

- *If wrong nucleophile used or O–H broken in first step, can only score M2.*
- *M2 not allowed independent of M1, but allow M1 for correct attack on C+*
- *+ rather than δ+ on C=O loses M2.*
- *If Cl lost with C=O breaking lose M2.*
- *M3 for correct structure <u>with charges</u> but lone pair on O is part of M4.*
- *Only allow M4 after correct / very close M3.*
- *Ignore HCl shown as a product.*

4

a 20-50 (ppm) or single value or range entirely within this range

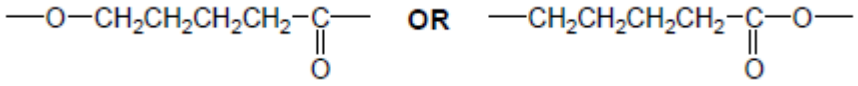
STEMUP.CO.UK

If values not specified as a or b then assume first is a.

1

b 50-90 (ppm) or single value or range entirely within this range

1

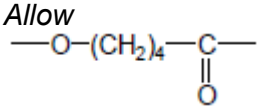
(ii)  **OR**

Must have trailing bonds, but ignore n.

1

OR –$OCH_2CH_2CH_2CH_2CO$– **OR** –$CH_2CH_2CH_2CH_2COO$–

Allow



but not - C_4H_{8-}

one unit only

Condensation

1

(b)

	Tollens'	Fehling's / Benedicts	Acidified potassium dichromate

Penalise wrong formula for Tollens or missing acid with potassium dichromate but mark on.

1

J	No reaction / no (visible) change / no silver mirror	No reaction / no (visible) change / stays blue / no red ppt	No reaction / no (visible) change / stays orange / does not turn green

Ignore 'clear', 'nothing'.

Penalise wrong starting colour for dichromate.

1

K	Silver <u>mirror</u> / grey <u>ppt</u>	Red <u>ppt</u> (allow brick red or red-orange)	(orange) turns green

1

J Two (peaks)

Allow trough, peak, spike.

1

STEMUP.CO.UK

K Four (peaks)

Ignore details of splitting.

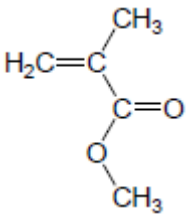
If values not specified as J or K then assume first is J.

1

(c) If all the structures are unlabelled, assume that the first drawn ester is L, the second ester is M; the first drawn acid is N, the second P. The cyclic compound should be obvious.

L

ester



OR $H_2C=C(CH_3)COOCH_3$

All $C_5H_8O_2$ L to P must have C=C.

Allow CH_3–.

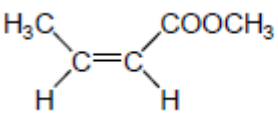
Allow $-CO_2CH_3$ etc.

Allow $CH_2C(CH_3)COOCH_3$.

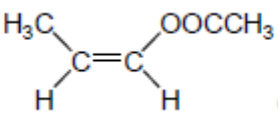
1

M

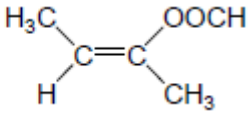
ester



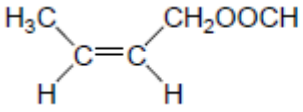
OR



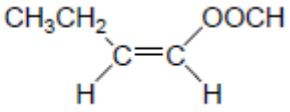
OR



$CH_3CH=CHCOOCH_3$ $CH_3CH=CHOOCCH_3$ $CH_3CH=C(CH_3)OOCH$



OR



OR

$CH_3CH=CHCH_2OOCH$ $CH_3CH_2CH=CHOOCH$

Allow either E–Z isomer.

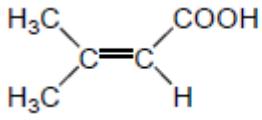
Allow CH_3– or C_2H_5– but not CH_2CH_3–.

Allow $CH_3CHCHCOOCH_3$ etc.

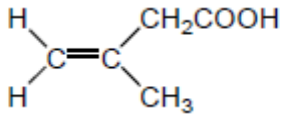
1

N

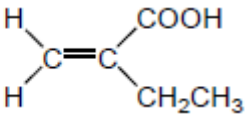
acid



OR



OR



$(CH_3)_2C=CHCOOH$ $H_2C=C(CH_3)CH_2COOH$ $H_2C=C(COOH)CH_2CH_3$

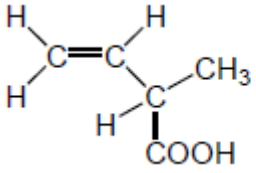
Allow CH_3– or C_2H_5– but not CH_2CH_3–.

Allow $-CO_2H$.

STEMUP.CO.UK

Not cyclic isomers.

Not the optically active isomer.



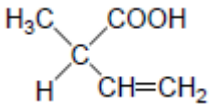
which is P anyway

Allow $(CH_3)_2CCHCOOH$ etc.

1

P

acid



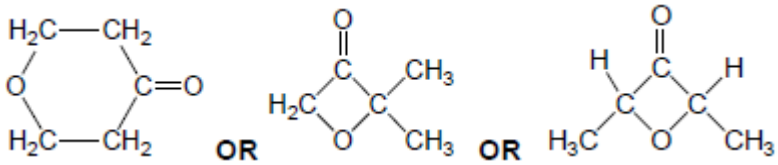
Allow $-CO_2H$.

$CH_3CH(COOH)CH=CH_2$

Allow $CH_3CH(CO_2H)CHCH_2$ or $CH_3CH(CO_2H)C_2H_3$.

1

Q



Not cyclic esters.

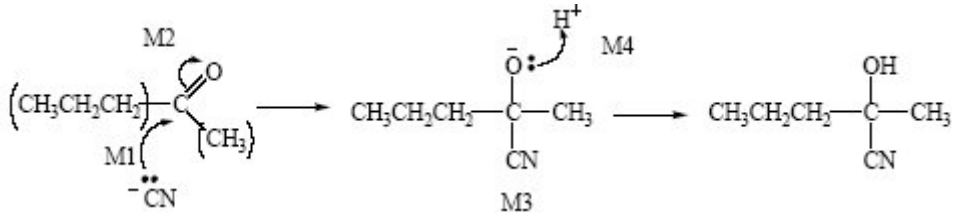
1

[19]

Q10.

(a) <u>nucleophilic addition</u>

1



Attack by HCN loses M1 and M2

M2 not allowed independent of M1, but allow M1 for correct attack on C+

+C=O loses M2

M2 only allowed if correct carbon attacked

allow minus charge on N i.e. $:CN^-$

4

M3 for completely correct structure not including lp

allow C_3H_7 in M3

STEMUP.CO.UK

M4 for lp and arrow

allow without –

1

2-hydroxy-2-methylpentan(e)nitrile

allow 2-hydroxy-2-methylpentanonitrile

(b) Product from **Q** is a racemic mixture/equal amounts of enantiomers

if no reference to products then no marks;

1

racemic mixture is inactive or inactive explained

*not **Q** is optically active or has a chiral centre etc*

1

Product from **R** is inactive (molecule) or has no chiral centre

1

[9]

Q11.

(a) **X** (O–H) (alcohols)

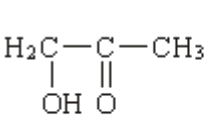
penalise acid or missing "alcohol"

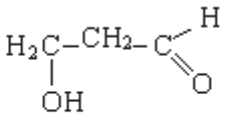
1

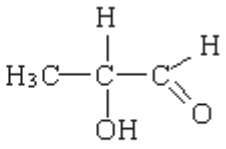
Y C=O

allow carbonyl

1





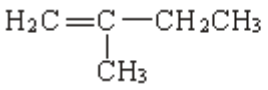


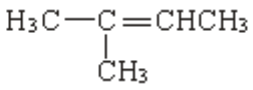
A

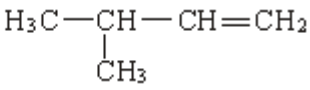
NOT acid

4

(b)





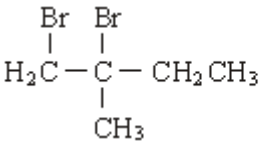


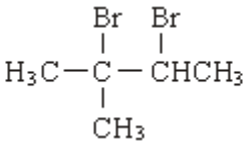
Allow conseq dibromocompounds following incorrect unbranched alkenes

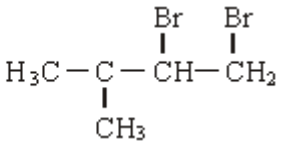
NOT allow dibromocompound consequent on a duplicate alkene

NOT allow monobromocompounds if HBr added

3







3

6:3:1 either next to correct structure or to none

1

STEMUP.CO.UK

Allow a mark for identifying correct dibromocompound with three peaks even if integration ratio is wrong

1

if 6:3:1 missing or wrong, no marks for splitting

Only award a mark for splitting if it is clear which integration number it refers to

6 singlet or drawn

1

3 doublet or drawn

1

1 quartet/quadruplet or drawn

1

(max 10 marks)

[16]

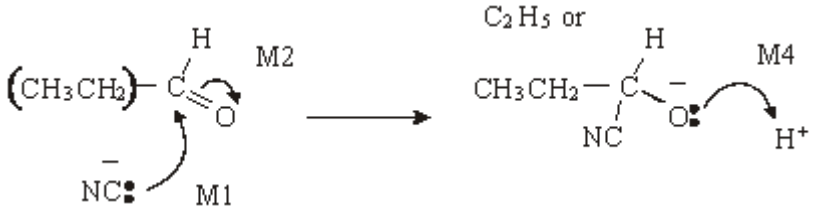
Q12.

B

[1]

Q13.

(a) necleophilic addition;



1

M3 structure;

(be lenient on position of charge on CN–)
(M2 not allowed independent of M1,
but allow M1 for correct attack on C+
if M2 show as independent first.)
(+on C of C=O loses M2 but ignore δ+ if correct)
(M4 for arrow and lone pair (only allow for correct M3 or close))

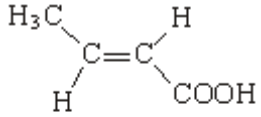
4

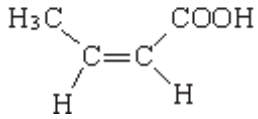
(b) (i) 2-hydroxybutanoic acid

1

(ii)

STEMUP.CO.UK



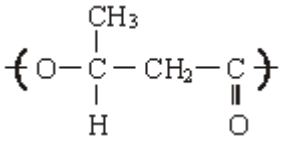


1

geometric(al) or cis-trans

1

(c) (i)



(one unit only) (ignore brackets or n) (trailing bonds are needed)

1

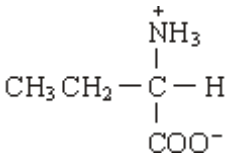
(ii) can be hydrolysed

OR

can be reacted with/attacked by acid/base/nucleophiles/H_2O/OH^-;

1

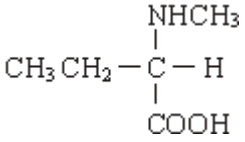
(d) (i)



(allow $-NH_3^+$)

1

(ii)



(or zwitterions product)

1

(iii) nucleophilic substitution;

1

[14]

Q14.

D

[1]

STEMUP.CO.UK

Q15.

(a) **A** any C_5 alkene

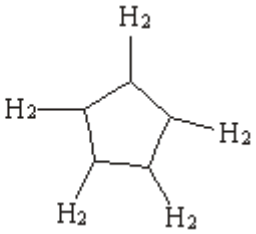
1

B



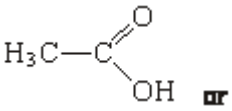
etc

penalise

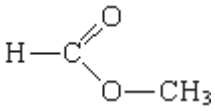


1

(b) **C**



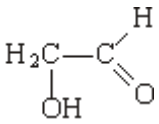
or



or CH_3COOH or $HCOOCH_3$

1

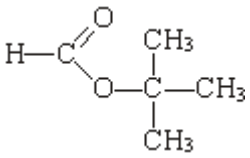
D



or $HOCH_2CHO$

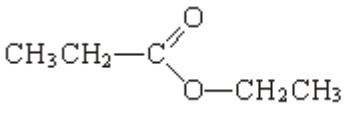
1

(c) **E**



1

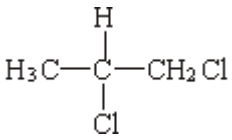
F



(allow C_2H_5)

1

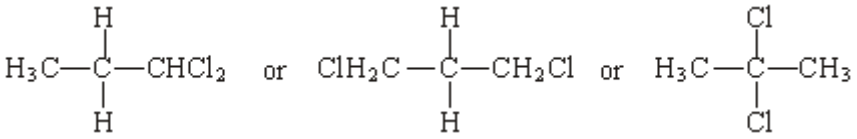
(d) **G**



1

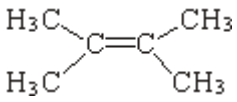
H

STEMUP.CO.UK



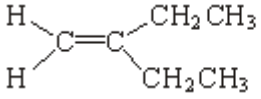
1

(e) **I**



1

J


(allow C_2H_5) **NOT** hex-3-ene

1

[10]

Q16.

D

[1]

Q17.

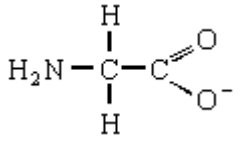
(a) 2-amino(e) propanoic acid **(1)**

1

(b) (i) molecules with same structure / structural formula **(1)**
but with bonds **(atoms or groups)** arranged differently in space (3D) **(1)**

(ii) Plane polarised light **(1)**
Rotated (equally) in opposite directions **(1)**

4

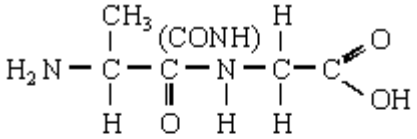
(c)  **(1)**

allow $H_2NCH_2COO^-$

Penalise NH_2- and OH- once per paper but CH_3– is allowed

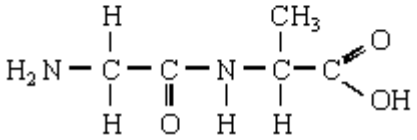
1

STEMUP.CO.UK



(1)

(d)

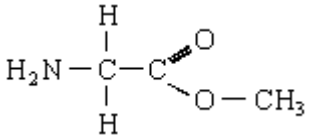


(1)

Not anhydrides; not repeating units

2

(e)



(1)

or $H_2NCH_2COOCH_3$

1

[9]

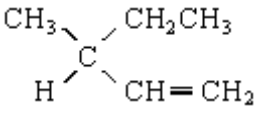
Q18.

D

[1]

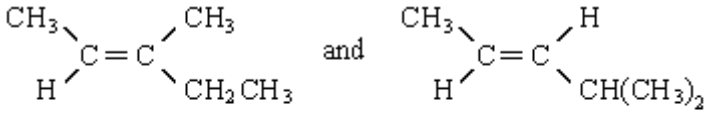
Q19.

(a) *Structure of* **P**:



(1)

Structures of **Q** and **R**:



NOT C_3H_7

(1) **(1)**

Q and R in any order

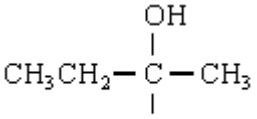
3

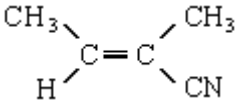
(b) (i) *Racemic mixture*: equal mixture of optical isomers / enantiomers
OR in explanation

Explanation: planar (>C=O) **(1)**
attack from either side is equally likely **(1)**

(ii) *Reagent* ***S***: HCN or (KCN / HCl **or** H_2SO_4) **(1)**

STEMUP.CO.UK

*Compound **T***:  **(1)**

*Compound **U***:  **(1)**

6

[9]

Q20.

(a) (i) 0.86 **(1)**

(ii) total moles = 0.86 + 0.43 +0.085 = 1.375 **(1)**

∴ **mole fraction of H_2** = $\frac{0.86}{1.375}$ = 0.625 **(1)**

(0.62 - 0.63)

Conseq on (i)

(iii) pp = mole fract^n × total P **(1)**
= 0.625 × 1.75 × 10^4
= 1.09 × 10^4 (kPa) **(1)**
or 1.1(0)
Ignore units
Conseq on (ii)

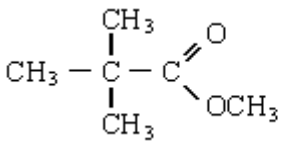
5

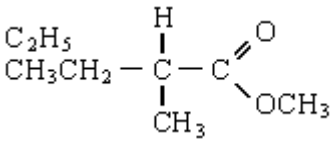
(b) (i) $K_p = \frac{P_{CH3OH}}{P^2_{H_2} \times P_{CO}}$ **(1)**
Penalise [ ]

(ii) $K_p = \frac{2710}{(12300)^2 \times (7550)}$ = 2.37 (2.4) × 10^{-9} **(1)**
OR 2.37 × 10^{-15}

Units: kPa^{-2} **(1)**
or Pa^{-2}
not conseq to wrong K_p expression

3

(c) *Isomer **E**:*  **(1)** allow $(CH_3)_3CCOOCH_3$ or $(CH_3)_3CCO_2CH_3$

*Isomer **F**:*  **(1)**

2

STEMUP.CO.UK

[10]

Q21.

B

[1]

Q22.

D

[1]

STEMUP.CO.UK

Q4.

(a) As usual, naming nitriles proved difficult for some, but 56% of students gave the correct answer.

(b) Although this question was answered well by most, an appreciable number of students were careless with language and appeared to say that the enantiomers themselves rotate, or that the plane polarised light is 'refracted' or 'bent' rather than 'rotated in opposite directions'.

(c) The first mark was less commonly scored than expected as many students wrote about a planar molecule or a planar bond rather than planar carbonyl group; the other two marks were frequently awarded.

(d) A significant number were not able to deduce the correct product and many incorrect products were seen. These included the cyanohydrin formed from pentanal. This showed a lack of care in reading the question.

Q7.

Both parts of question (a) were answered very well and it was good to see the correct use of curly arrows. Part (b)(i) was well done but in (b)(ii) many students simply stated what stereoisomers do to plane polarised light and so failed to answer the question. Part (c)(i) was answered extremely well and the K_c expression in part (c)(ii) was also answered well. The calculation was well done but a frequent error was to use amounts, in moles, rather than concentrations by not using the volume. Better students answered part (d) correctly while others showed only one hydroxyl group from the diol reacting and so produced an answer for the acetal which did not match the given molecular formula.

Q8.

In part (a), the nucleophilic addition mechanism was very well done; common errors included missing the charge on the nucleophile or on the intermediate structure and showing a bond between the carbonyl carbon and the N of CN in the intermediate. In part (b)(i), students were not used to drawing 3D structures, and credit was given where attempts showed a pair of mirror images. Again there were some problems with wrongly bonded OH, CN and CH_2CH_3 groups in these structures. The method needed to distinguish between two enantiomers was well known, although to gain M2 polarised light had to be 'rotated' not turned or reflected, and rotated in 'opposite' directions not just different directions. A few students suggested wrongly that the molecules polarised the light or that the molecules themselves were rotated. The name in part (c) was well answered but part (d) was answered poorly. There was confusion of K_a, the acid dissociation constant, with a rate constant, and many students missed the link to low concentrations of cyanide ions from the weak acid HCN and focused mainly on the rate of the dissociation of the acid. Parts (e)(i) and (e)(iii) were answered well but responses to part (e)(ii) sometimes included the C=C bond or the CN group as part of the polymer chain.

Q9.

The nucleophilic addition-elimination mechanism in part (a)(i) presented a real challenge to many students, who were confused by the cyclic nature of the product, failed to identify the correct nucleophile and suggested either separate nucleophiles such as H_2O, CH_3OH

STEMUP.CO.UK

and OH^- or alternatively loss of the proton from the OH group before nucleophilic attack. Most students gave the correct range for the carbon atom labelled **b**, but often the range for the carbon atom labelled **a** was given as 160–185 as for a carbonyl carbon. In part (a)(ii), the repeating unit for the polyester was answered well although some students gave twice the repeating unit.

The distinguishing test in part (b) was well done, although a significant number of students thought that substance **K** was an acid and wrongly suggested $NaHCO_3$ or Na_2CO_3 to distinguish between the compounds. It was common for students to fail to see the symmetry of **J** and so to predict, incorrectly, three peaks in its proton n.m.r. spectrum. Five peaks was a common incorrect answer for **K**, suggesting that students had misread the question and given the ^{13}C n.m.r. result.

Part (c) of this question proved to be very challenging and fewer than 10% of students scored full marks. Isomer **Q** was found particularly difficult where many students omitted one of the O atoms from their suggested structure. Other common errors included missing the double bond in **L**, giving the structure of **P** as the structure of **N** (which suggests a failure to recognise that optical isomerism is a form of stereoisomerism) or writing an unbranched carbon chain for the acid **N**. Answers to part (c) were often very badly presented, with a great deal of crossing out, duplication of answers and poor labelling of structures.

Q10.

In part (a), large numbers of candidates were able to write a correct mechanism for the nucleophilic addition of HCN to ketone **Q**. By contrast, most found it difficult to name the product correctly and so only 15% scored full marks overall. In part (b) many answers discussed the optical activity of the original ketones **Q** and **R** rather than that of the products of their reactions with HCN. Many also thought that both ketones produced racemic mixtures.

Q11.

In part (a) most candidates were able to identify the absorption labelled X as due to the presence of the alcohol O–H bond and that labelled Y as due to the presence of the C=O bond. Yet many then drew a carboxylic acid or even an ester as a possible structure. An appreciable number failed to label one of their structures as A. Better candidates scored highly here.

Part (b) discriminated well. Better candidates were able to score (almost) full marks but weak candidates struggled to score more than a few marks. Many had difficulty with the structure of the three branched-chain C5 alkenes; unbranched alkenes were commonly given as were duplicates of a previous answer.

Only the better candidates were able to identify which dibromoalkane gave only three n.m.r. peaks and only the most able were able to deduce correctly the integration ratio and the splitting pattern of the three peaks.

Q13.

The name of the mechanism was well answered in part (a) but the actual mechanism itself was much more discriminating. Too many candidates are still careless in their drawing of curly arrows and fail to start every arrow either at a bond or a lone pair. Attack by the cyanide ion must show a lone pair on the carbon atom as the source of the curly arrow. The carbonyl group carbon has a δ+ charge not a full positive charge as suggested by several. Part (b) was less well done. Although many answered part (b)(i) correctly, several omitted the number 2 in the name or failed to count the number of carbons carefully. Part

STEMUP.CO.UK

(b)(ii) was misread by many, who simply drew the two optical isomers of **Q** rather than the two geometrical isomers of the dehydration product of **Q**. The repeating unit was usually correct in part (c) although some gave an extra oxygen in their structure and others gave more than the single repeating unit requested. The zwitterion in part (d)(i) was generally well known, but many drew incorrectly a quaternary ammonium salt in part (d)(ii).

Q15.

Parts (a) and (d) were the least discriminating, but only the most able were able to identify both **E** and **J** correctly.

In part (b), most were able to identify **C** correctly as either ethanoic acid or methyl methanoate, but many suggested that **D** was ethanoic acid, despite the wavenumber given for the O-H infra-red absorption being that for O-H in alcohols not that for O-H in acids.

Most found **F** easy to deduce, but several forgot that both compounds were esters and suggested dimethylpropanoic acid for **E.**

In part (d), **G** was better answered than H and in part (e), more were able to deduce the structure of I correctly than that of **J**.

Q17.

Part (a) was answered correctly by all except the weakest candidates. Part (b) was less well answered. Too many answers failed to say that stereoisomers have the same structure but that the bonds are arranged differently in space. The statement that they have the *same molecular formula* is insufficient, and another common error was to say that stereoisomers have *different structures*. In part (b)(ii), the use of plane polarised light was necessary with a statement that the isomers rotated the plane of polarised light equally in opposite directions.
Too many answers were not precise enough to gain the marks.

Parts (c), (d) and (e) were well answered by all except the weakest candidates and the structures required were drawn accurately. A few candidates muddled pH 14 in part (c) and gave the protonated form; others misread the question and used *alanine* when *glycine* should have been used in parts (c) and (e) or ethanol in part (e) instead of methanol.

Q19.

This question was found difficult by many candidates and some marks were lost by candidates who did not read the question carefully. The second line of the question stated that P, Q and R were all branched-chain molecules, but many answers included unbranched isomers. Part (b) was better answered, but again the question asked for the reason a racemic mixture was formed and many answers contained only a description of what a racemic mixture is. Part (c) was found to be difficult and only the most able candidates gained all three marks here.

Q20.

The equilibrium parts of this question were generally answered well. In part (a)(i), the correct value of 0.86 was the most common answer but this was the least well-answered section of part (a). Full marks were awarded in parts (ii) and (iii) if the number of moles of hydrogen given in part (i) was used correctly. Even if the numbers were not used correctly, a mark was given in part (iii) for the correct statement that partial pressure

STEMUP.CO.UK

equals mole fraction multiplied by the total pressure. In part (b) common errors were to include square brackets in the expression for K_p or to forget that the partial pressure of hydrogen should be squared. The units of K_p expected were kPa^{-2} but Pa^{-2} were accepted as long as the value given for K_p was 2.37×10^{-15}. Part (c) was poorly answered. Many structures were not esters at all and of those which were, few were methyl esters of C_5 acids. F was answered better than E but only the better candidates scored any marks here.

STEMUP.CO.UK