A-Level Chemistry

Optical Isomerism

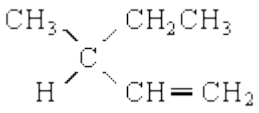
Mark Scheme

Time available: 54 minutes
Marks available: 50 marks

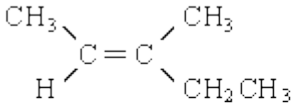
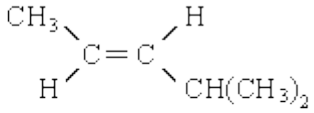
Mark schemes

1.

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


(1)

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


and


NOT C_3H_7

(1) **(1)**

Q and R in any order

3

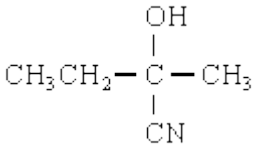
(b) (i) *Racemic mixture*: <u>equal</u> mixture of optical isomers / enantiomers

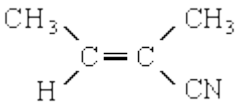
OR in explanation

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)**

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

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

6

[9]

2.

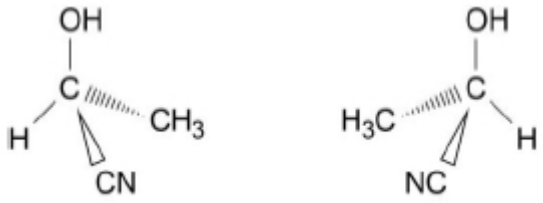
(a) 3

1

(b) Chain.

1

(c)



One 3D enantiomer.

1

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

1

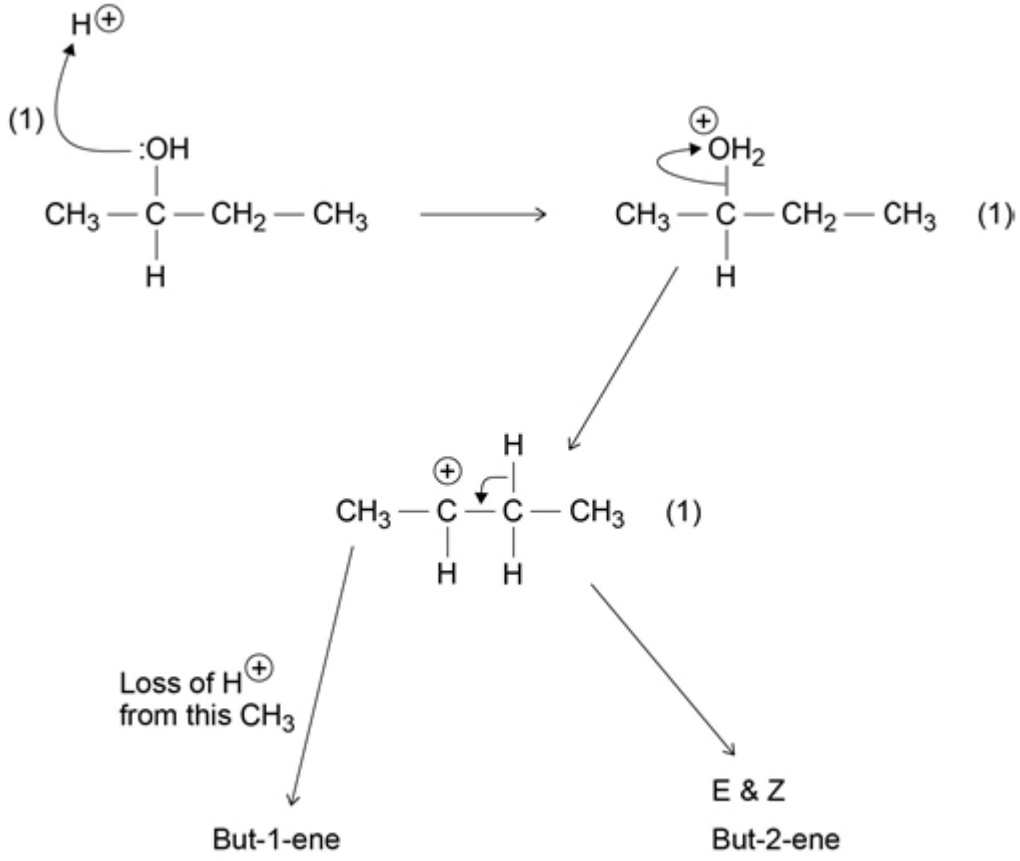
(d) Plane-polarised light.

1

Rotated in opposite directions.

1

(e) Elimination



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)

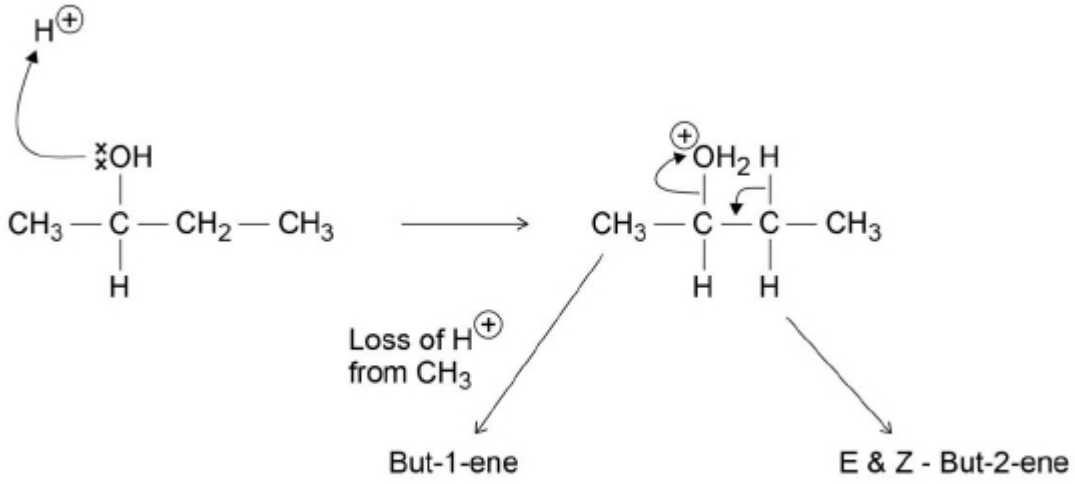
M6 From **^{1}C**–^{2}C+–^{3}C–^{4}C leads to but-1-ene

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

Alternative mechanism



[14]

3. (a) 2-hydroxyhexanenitrile

1

(b) (Plane) polarised light

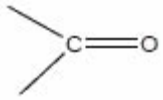
1

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

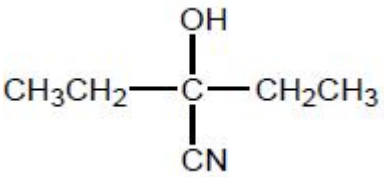
1

With <u>equal</u> probability

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

1

(d)



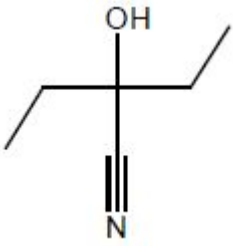
Does not contain a chiral centre

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]

4. (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

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]

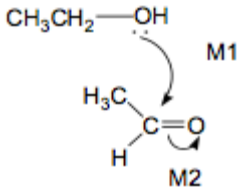
5. (a) (i) <u>Nucleophilic addition</u>

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

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}

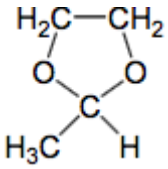
Allow range 9.08×10^{-3} – 9.23×10^{-3}

M3

$mol^{-1}dm^3$

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

M4

(d) 

1

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