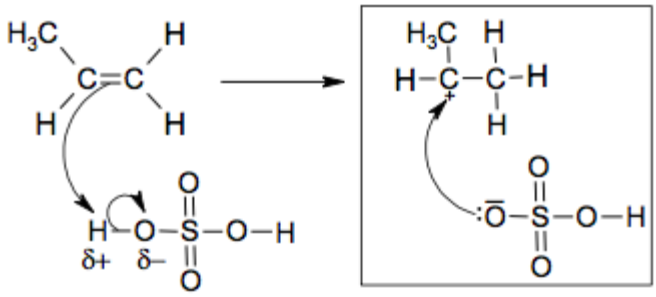
Mark schemes

1 (a) Electrophilic addition **1**



M2 = curly arrow from C=C towards H of H−O on 'their' sulfuric acid **1**

M3 = curly arrow to break H−O **1**

Penalise incorrect dipole/full charges

M4 = intermediate **1**

M5 = correct anion, lone pair on correct O and curly arrow from that lone pair to C+ on their carbocation **1**

***IGNORE** position of minus sign unless displayed structure*

***IGNORE** product*

Major product/propan-2-ol formed via most stable carbocation/carbonium ion

secondary carbocation/carbonium ion more stable (than primary) or reverse argument **1**

M6 for idea of carbocation stability

This statement gets M6 and M7

***NOT** stability of alcohols* **1**

(b) Hot/High T (and High P)

ALLOW *200-450 C/473-723 K (Quoted)*

1

(SiO_2 coated in) <u>phosphoric</u> acid (catalyst)

NOT *(aq)*

1

advantages of fermentation

- Low(er) T and P / lower energy use
- Less use of non-renewable fossil fuels/renewable /sustainable (resources)
- Low(er) equipment/plant/capital costs

IGNORE *carbon neutral*

max 2

1
1

Disadvantages of fermentation

- Slow(er) reaction
- Low atom economy
- Impure product/extra purification/distillation required
- Batch process/labour intensive/difficult to automate
- Land used for sugar crops (so not available for food crops)

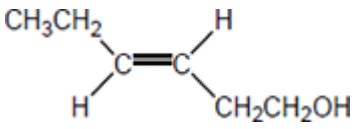
IGNORE *low yield*

Max 2

1
1

[13]

2 (a)



1

(b)

1

(c) **Stage 1**: consider the groups joined to right hand carbon of the C=C bond

Extended response

Maximum of 5 marks for answers which do not show a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.

Consider the atomic number of the atoms attached

M1 can be scored in stage 1 or stage 2

1

C has a higher atomic number than H, so CH_2OH takes priority

1

Stage 2: consider the groups joined to LH carbon of the C=C bond

Both groups contain C atoms, so consider atoms one bond further away

1

C, (H and H) from ethyl group has higher atomic number than H, (H and H) from methyl group, so ethyl takes priority

1

Stage 3: conclusion

The highest priority groups, ethyl and CH_2OH are on same side of the C=C bond so the isomer is Z

Allow M5 for correct ECF conclusion using either or both wrong priorities deduced in stages 1 and 2

1

The rest of the IUPAC name is 3-methylpent-2-en-1-ol

1

(d) Moles of maleic acid = 10.0 / 116.0 = 8.62×10^{-2}

AND mass of organic product expected = $(8.62 \times 10^{-2}) \times 98.0 = 8.45$ g

Or moles of organic product formed = $6.53 / 98.0 = 6.66 \times 10^{-2}$

1

% yield = $100 \times 6.53 / 8.45$

OR = $100 \times (6.66 \times 10^{-2}) / (8.62 \times 10^{-2})$

= 77.294 = 77.3%

AND statement that the student was NOT correct

1

[10]

3 (a) (Compounds with the) same molecular formula but different structural / displayed / skeletal formula

1

(b) (basic) elimination

1

Mechanism points:

Correct arrow from lone pair on :OH^- to H on C adjacent to C–Br

1

Correct arrow from C–H bond to C–C

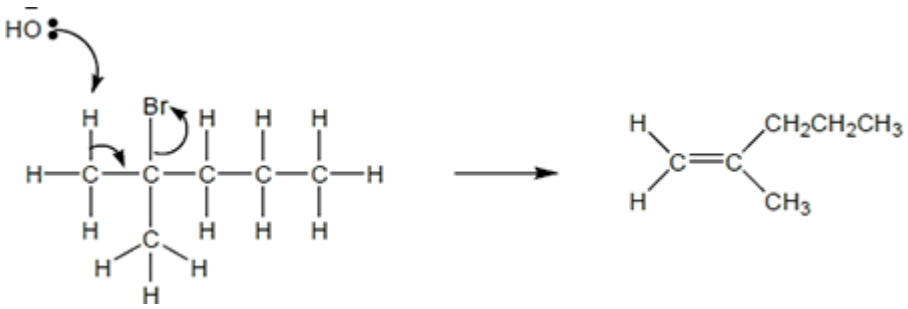
1

Correct arrow from C–Br bond to Br

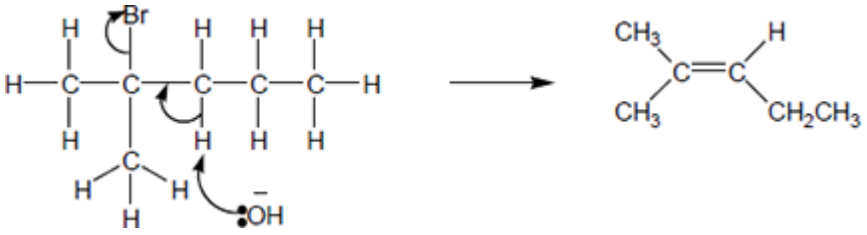
1

Structure of chosen product

1



OR



[6]

4 (a) Percentage of oxygen by mass = 100 – 40.9 – 4.5 = 54.6

1

	C	H	O
%			
Divide by A_r	$\frac{40.9}{12}$	$\frac{4.5}{1}$	$\frac{54.6}{16}$
	= 3.41	= 4.5	= 3.41

1

Divide by smallest =	$\frac{3.41}{3.41} = 1$	$\frac{4.5}{3.41} = 1.32$	$\frac{3.41}{3.41} = 1$
Nearest whole number ratio =	1 × 3	1.32 × 3	1 × 3

= 3 : 3.96 : 3

Nearest integer ratio = 3 : 4 : 3

1

Empirical formula $C_3H_4O_3$

Empirical formula mass = 88 = molecular formula mass

Therefore, molecular formula is same as the empirical formula - $C_3H_4O_3$

1

(b) $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$

1

(c) Advantage – ethanol is produced at a faster rate

1

Disadvantage – more energy is used / required in the reaction

1

(d) Air gets in / oxidation occurs

1

(e) Alcohol OH absorption in different place (3230–3550 cm^{-1}) from acid OH absorption (2500–3000 cm^{-1})

1

The C=O in acids has an absorption at 1680–1750 cm^{-1}

1

[10]

5

(a) UV light

1

$CCl_4 \longrightarrow CCl_3\bullet + \bullet Cl$

1

(b) $Cl\bullet + O_3 \longrightarrow ClO\bullet + O_2$

1

$ClO\bullet + O_3 \longrightarrow Cl\bullet + 2O_2$

1

(c) M_r of CF_3Cl = 104.5

Moles freon = $1.78 \times 10^{-4} \times 10^3 / 104.5 = 1.70 \times 10^{-3}$

1

Number of molecules = $1.70 \times 10^{-3} \times 6.02 \times 10^{23} = 1.02 \times 10^{21}$

1

Molecules in 500 cm^3 = $(1.02 \times 10^{21} \times 500 \times 10^{-6}) / 100$
$= 5.10 \times 10^{15}$

Allow answer in the range 5.10–5.13 × 10^{15}

Answer must be given to this precision

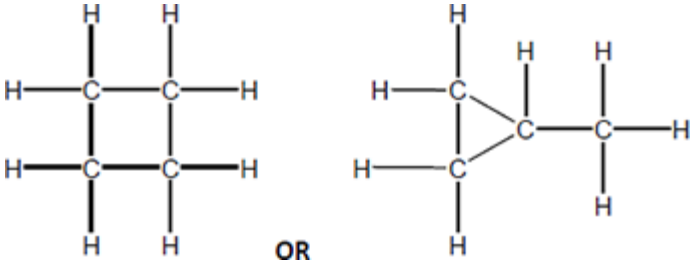
1

[7]

6

(a) Alkenes

1



OR

Correctly drawn molecule of cyclobutane or methyl cyclopropane, need not be displayed formula

1

(b) C_6H_{14} (or correct alkane structure with 6 carbons)

Allow hexane or any other correctly named alkane with 6 carbons

1

(c) Poly(but-2-ene)

1

(d) High pressure

Allow pressure ≥ MPa

Mention of catalyst loses the mark

1

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

Level 3

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

Answer communicates the whole process coherently and shows a logical progression from stage 1 and stage 2 (in either order) to stage 3.

5–6 marks

Level 2

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. Some steps in each stage may be out of order and incomplete.

3–4 marks

Level 1

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.

1–2 marks

Level 0

Insufficient correct chemistry to gain a mark.

0 marks

Indicative chemistry content

***Stage 1**: consider effect of higher temperature on yield*

(Or vice versa for lower temperature)

- *Le Chatelier's principle predicts that equilibrium shifts to oppose any increase in temperature*
- *Exothermic reaction, so equilibrium shifts in endothermic direction / to the left*
- *So a Higher T will reduce yield*

***Stage 2**: consider effect of higher temperature on rate*

(Or vice versa for lower temperature)

- *At higher temperature, more high energy molecules*
- *more collisions have E>Ea*
- *So rate of reaction increases / time to reach equilibrium decreases*

***Stage 3**: conclusion*

Industrial conditions chosen to achieve (cost-effective) balance of suitable yield at reasonable rate

[11]

7 (a) Measured volume would be greater

1

Level in burette falls as tap is filled before any liquid is delivered

1

(b) Drop sizes vary

Allow percentage error for amount of oil will be large as the amount used is so small

1

(c) Use a larger single volume of oil

1

Dissolve this oil in the organic solvent

1

Transfer to a conical flask and make up to 250 cm^3 with more solvent

1

Titrate (25 cm^3) samples from the flask

1

(d) Stage 1

Mass of oil = $0.92 \times (5.0 \times 10^{-2} \times 5) = 0.23$ (g)

1

Mol of oil = 0.23 / 885 = 2.6×10^{-4}

1

Extended response calculation

To gain 4 or 5 marks, students must show a logical progression from stage 1 and stage 2 (in either order) to stage 3

Stage 2

Mol bromine = $2.0 \times 10^{-2} \times 39.4 / 1000 = 7.9 \times 10^{-4}$

1

Stage 3

Ratio oil : bromine

2.6×10^{-4} : 7.9×10^{-4}

Simplest ratio = $2.6 \times 10^{-4} / 2.6 \times 10^{-4} : 7.9 \times 10^{-4} / 2.6 \times 10^{-4}$

= 1 : 3

1

Hence, 3 C=C bonds

M5 cannot be awarded unless working for M4 is shown

1

[12]

8 C

[1]

9 B

[1]

10 C

[1]

11 A

[1]

12 D

[1]

13 D

[1]

14 C

[1]

15 (a) 2,2,4-trimethylpentane

1

(b) 5

1

(c) $C_{20}H_{42} \longrightarrow C_8H_{18} + 2C_3H_6 + 3C_2H_4$

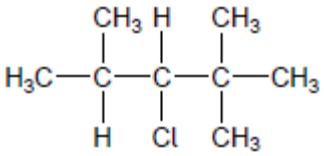
1

(d) Mainly alkenes formed

1

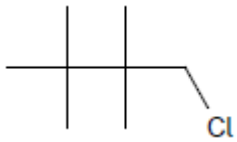
(e) 4 (monochloro isomers)

1



1

(f)



1

(g) $C_8H_{17}{}^{35}Cl = 96.0 + 17.0 + 35.0 = 148.0$
and $C_8H_{17}{}^{37}Cl = 96.0 + 17.0 + 37.0 = 150.0$

Both required

1

M_r of this $C_8H_{17}Cl$ $\frac{(1.5 \times 148.0)}{2.5} + \frac{(1.0 \times 150.0)}{2.5} = 148.8$

1

(h) $\frac{24.6}{12} \quad \frac{2.56}{1} \quad \frac{72.8}{35.5} = 2.05 : 2.56 : 2.05$

Simplest ratio = $\frac{2.05}{2.05} : \frac{2.56}{2.05} : \frac{2.05}{2.05}$

= 1 : 1.25 : 1

1

Whole number ratio (× 4) = 4 : 5 : 4

1

MF = $C_8H_{10}Cl_8$

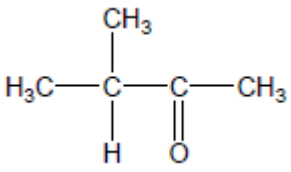
1

[12]

16 (a) 3-methylbutan-2-ol

1

(b)



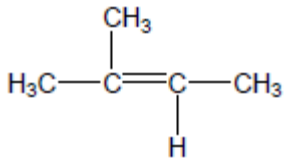
Allow $(CH_3)_2CHCOCH_3$

1

(c) Elimination

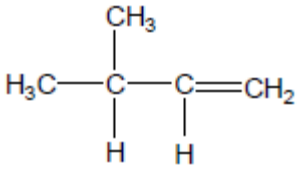
1

(d)



Allow $(CH_3)_2C=CHCH_3$

1



Allow $(CH_3)_2CHCH=CH_2$

1

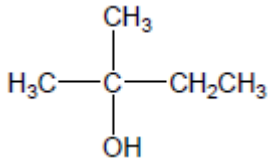
(e) Position

1

(f) C B A

1

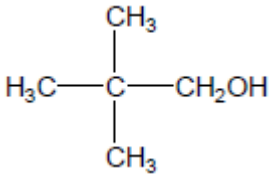
(g)



Allow $(CH_3)_2C(OH)CH_2CH_3$

1

(h)



Allow $(CH_3)_3CCH_2OH$

1

[9]

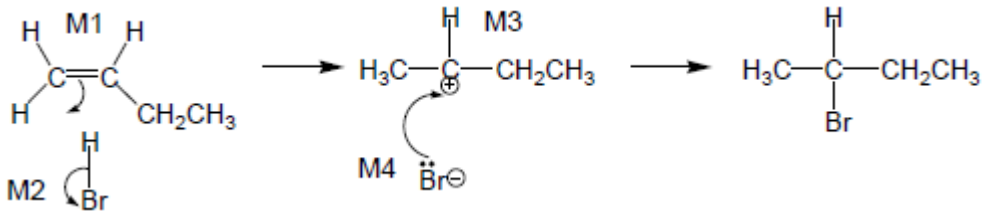
17 (a) HBr **OR** HCl **OR** H_2SO_4

Allow HI or HY

1

(b) Electrophilic addition

1



Allow consequential marking on acid in 12.1 and allow use of HY

4

(c) The major product exists as a pair of enantiomers

1

The third isomer is 1-bromobutane (minor product)

1

Because it is obtained via primary carbocation

1

[9]

18 B

[1]

19 C

[1]

20 C

[1]

21 C

[1]