M1.(a) (i) $(CH_3)_2CHOH + (CH_3CO)_2O \rightarrow CH_3COOCH(CH_3)_2 + CH_3COOH$

Allow *$CH_3CO_2CH(CH_3)_2$ and CH_3CO_2H*

Ignore $(CH_3)_2-C$ in equation

1

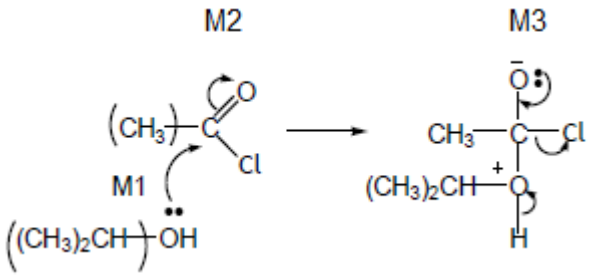
(1)-methylethyl ethanoate OR

Propan-2-yl ethanoate

Ignore extra or missing spaces, commas or hyphens

1

(ii)



M4 for 3 arrows and lp

NO Mark for name of mechanism

M1 for lone pair on O and arrow to C or to mid-point of space between O and C

M2 for arrow from C=O bond to O

- *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, max1 for M1*

M3 for correct structure <u>with charges</u> (penalise wrong alcohol here) but lone pair on O is part of M4

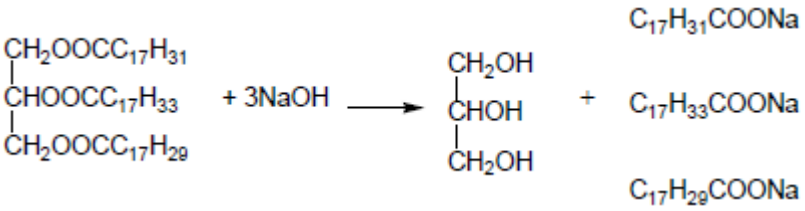
Penalise $(CH_3)_2-C$ in M3

M4 for lone pair on O and three arrows

- *Only allow M4 after correct / very close M3*
- *M4 can be gained over more than one structure*
- *Ignore Cl^- removing H^+*

4

(b) (i)



Penalise covalent Na e.g. -O-Na

LHS 1
RHS 1

(ii) $C_{17}H_{33}COOCH_3$

Allow $C_{19}H_{36}O_2$

1

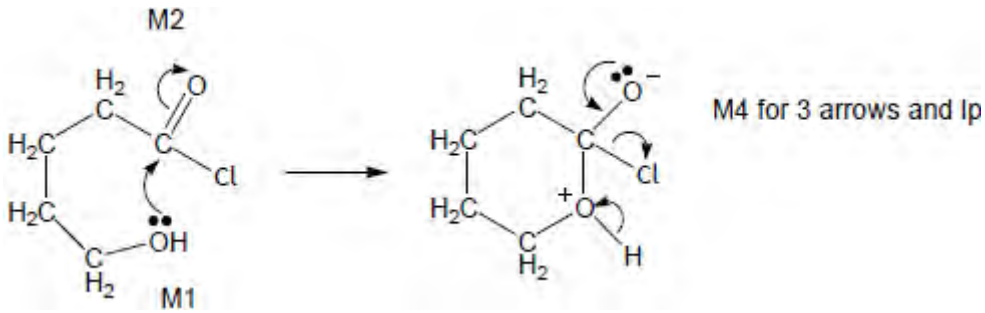
[9]

M2.(a) (i) (nucleophilic) addition-elimination

Not electrophilic addition-elimination

Ignore esterification

1



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

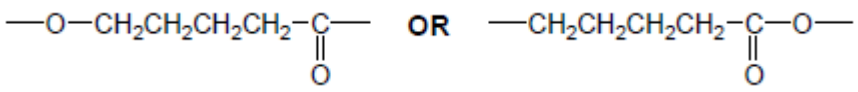
a 20-50 (ppm) or single value or range entirely within this range

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

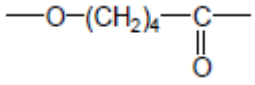
(ii)  **OR**

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

K *Four (peaks)*

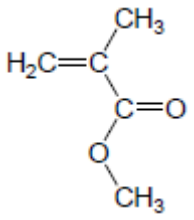
Ignore details of splitting.

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.

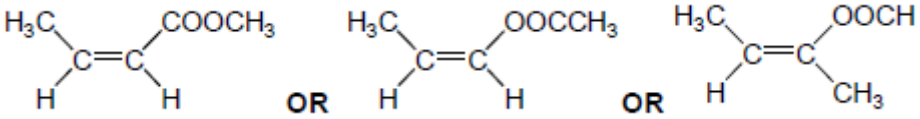
Allow CH_3–.

Allow $-CO_2CH_3$ etc.

Allow $CH_2C(CH_3)COOCH_3$.

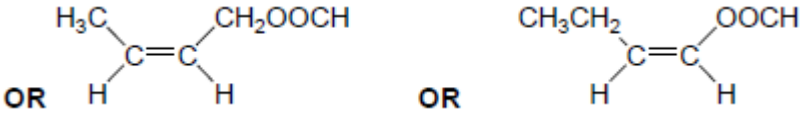
1

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.

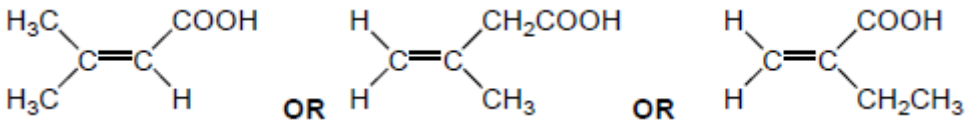
Allow CH_3– or C_2H_5– but not CH_2CH_3–.

Allow $CH_3CHCHCOOCH_3$ etc.

1

N

acid



OR OR

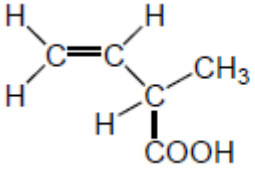
$(CH_3)_2C=CHCOOH$ *$H_2C=C(CH_3)CH_2COOH$* *$H_2C=C(COOH)CH_2CH_3$*

Allow CH_3– or C_2H_5– but not CH_2CH_3–.

Allow −CO_2H.

Not cyclic isomers.

Not the optically active isomer.



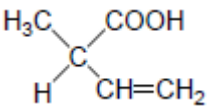
which is P anyway

Allow $(CH_3)_2CCHCOOH$ etc.

1

P

acid



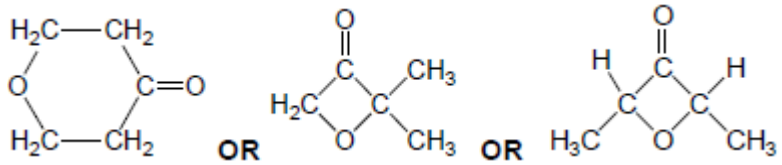
Allow −CO_2H.

$CH_3CH(COOH)CH=CH_2$

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

1

Q



Not cyclic esters.

1

[19]

M3.*(a)* $CH_3(CH_2)_{14}COOH$

Allow molecular formulae.

1

$CH_2OHCHOHCH_2OH$

Allow one mark only if formulae are swapped in position.

1

(b) *Keeping the foodstuff dry*

Allow an answer which refers to removal of water from the environment.

Do not allow dehydration / removal of water from the fat.

1

(c) *They (antioxidants) react with free radicals*

1

And they are used up in the reaction / do not remain behind after reaction

Lose one mark for any reference to 'catalysts can't slow down a reaction'.

1

(d) *Mol of fat = (2.78 / 806 =) 3.45 × 10^{-3}*

Mol of NaOH = 3.68 × 10^{-3} = mol of fatty acid

1

Mol of NaOH = 3.68 × 10^{-3}

Mol of fat hydrolysed = 1.23 × 10^{-3}

1

Mol of fat hydrolysed = (3.68 × 10^{-3} / 3 =) 1.23 × 10^{-3}

Mass of fat hydrolysed = 0.987 g

1

Percentage hydrolysed = 35.5 – 35.7

Percentage hydrolysed = 35.5 – 35.7

Do not penalise precision at any point.

Since there are a variety of approaches to this calculation, award four marks for a correct answer but it must be clear that there is some relevant working.

The answer alone gets M4 only.

Any incorrect use of the 3:1 ratio is CE – lose M3 and M4.

1

[9]

M4.*(a)* *Mg + $2C_6H_4(OH)COOH \rightarrow (C_6H_4(OH)COO)_2Mg + H_2$*

Accept multiples, including fractions.

1

(b) Gas syringe / inverted burette over water / measuring cylinder over water

Collection apparatus must show graduations or be clearly labelled (eg syringe, burette, measuring cylinder).

1

[2]

M5.*(a)* *(i)* *$\underline{3}CH_3OH$*

Not molecular formula

1

$HOCH_2CH(OH)CH_2OH$

1

(ii) → $19CO_2$ + $19H_2O$

Or doubled

1

$C_{17}H_{35}COOCH_3$ + 27½ or 55/2 O_2

Consequential on correct right-hand side

1

(b) (i) A0.7

1

Ethanol6.4

1

Water3.6

1

(ii) No effect

If wrong, CE= 0

1

*Equal moles on each side of equation **OR** V cancels*

Ignore moles of gas

1

(iii) M1 $K_c = \dfrac{[\text{DEM}][H_2O]^2}{[A][C_2H_5OH]^2}$

Must have all brackets but allow ( )

1

(iv) *M2* $\frac{2.1 \times (3.4)^2}{0.85 \times (7.2)^2}$

If K_c wrong can only score M4 for units consequential to their K_c working in (b)(iv)

1

M3 0.55 (min 2dp)

1

M4 No units

1

[13]