A-Level Chemistry

Carboxylic Acids and Esters

Mark Scheme

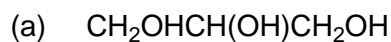**Time available: 61 minutes**
Marks available: 57 marks

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Mark schemes

1. (a) $CH_2OHCH(OH)CH_2OH$

1

(Potassium) Carboxylate salt

Allow fatty acid salt / salt
Salt of a carboxylic acid

1

Soap

Allow detergent / surfactant

1

(b) $638 = 173 + 3(15 + 14n)$
M_r ester fragment = 173

M1

Show subtract $638 - (M1 + 45)$

M2

Division of M2 by 42
n = 10

n must be an integer

M3

(c) Amount HCl = $0.100 \times 0.01565 = 1.565 \times 10^{-3}$ mol

M1

Initial amount KOH = $\frac{0.421}{56.1}$ = 7.50×10^{-3} mol

M2

Amount KOH used = M2 − M1 = 5.939×10^{-3} mol

M3

Amount ester = $\frac{5.935 \times 10^{-8}}{3}$ = 1.980×10^{-3} mol (M3 / 3)

M4

Mass ester = $(1.980 \times 10^{-3}) \times 638 = 1.263$ g (M4 x 638)

M5

%age by mass = $\frac{1.263}{1.45} \times 100$ = 87.1 % ((M5 / 1.45) x 100)

Allow 87.0 to 87.1
Allow 2 sf
Don't allow M6 for an answer >100%

M6

(d)   Allow to dissolve both oil and KOH

> *To act as a mutual solvent **OR** To ensure reactants are miscible*

M1

Precaution must be linked to heating
e.g. Use a water bath for heating mixture

> *Allow electrical heater / mantle*

> *Allow sand bath*

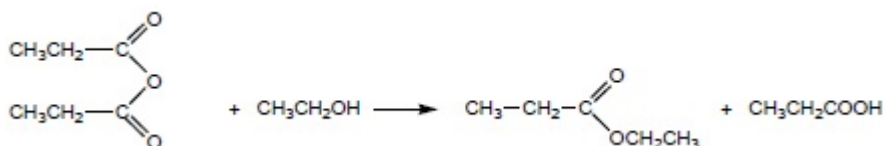**M2**

Prevents risk of fire / Ethanol is flammable

> *Allow KOH is corrosive/caustic/damages eyes if matches alternative precaution given*

M3

[15]

2.   (a)

Ethyl propanoate only

> **M1** *Structure of ester (allow $C_2H_5CO_2C_2H_5$)*

1

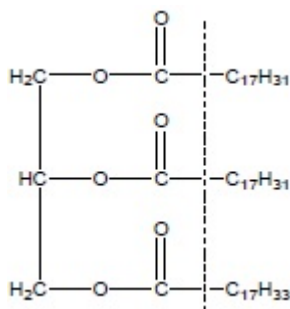> **M2** *propanoic acid formula (allow $C_2H_5CO_2H$) and correctly balanced equation*

1

> **M3** *Ethyl propanoate only*

1

(b)

M1 for all except $C_{17}H_{3x}$ (i.e. all to the left of the dotted line)

> *Allow $-O_2C-$, $-OOC-$, $-OCO-$*

> *Not $-CO_2-$, $-COO-$*

1

M2 for two $C_{17}H_{31}$ and one $C_{17}H_{33}$ in any order top to bottom

1

(c)

M1 for skeleton
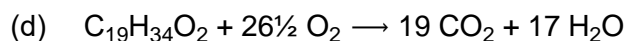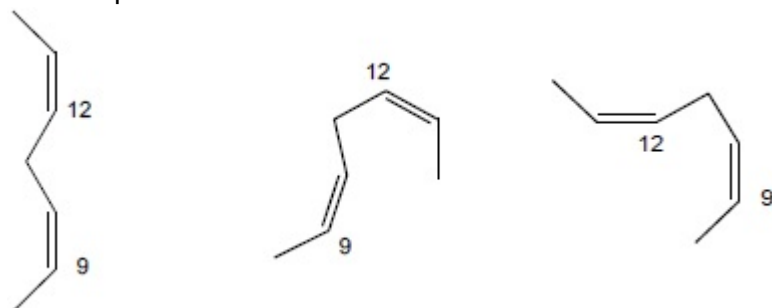
1

M2 for both Z correct
Independent marks

1

C9 – C14 shown with double bonds in the correct place
Ignore structure beyond carbon 14
*If hydrogens shown or not skeletal can only score **M2***

Other representations include

(d) $C_{19}H_{34}O_2 + 26\frac{1}{2}\ O_2 \longrightarrow 19\ CO_2 + 17\ H_2O$
        Allow 53/2 or all doubled

1

(e) Absorption in spectrum at 2350 cm^{-1} does not correspond to data booklet value of
      1680 – 1750 cm^{-1} or for C=O bonds in organic compounds)
        Allow would expect a peak at 1680 – 1750 cm^{-1}

1

(f) C=O <u>Bonds</u> in CO_2 absorb infrared radiation (of 2350 cm^{-1})

1

IR radiation emitted by the earth does not escape (from the atmosphere)
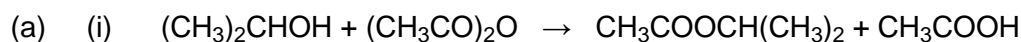OR
This energy is transferred to other molecules in the atmosphere by collisions (so all
atmosphere is warmed)
        Ignore IR reflected

1

[11]

3. (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*
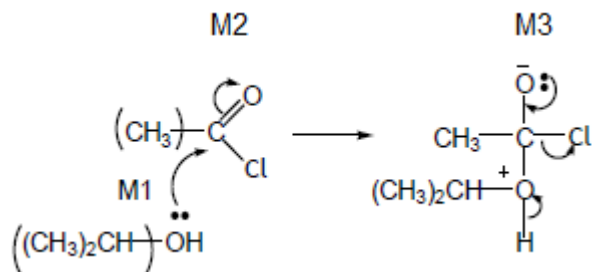   *Ignore $(CH_3)_2 -C$ in equation*

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
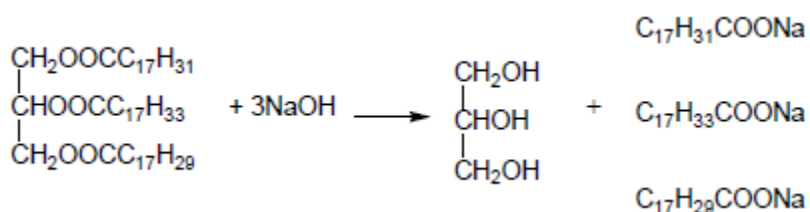
Penalise $(CH_3)_2 -C$ in M3

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)

CH₂OOCC₁₇H₃₁ ... etc. (reaction equation)

Penalise covalent Na e.g. -O-Na

<div align="right">

LHS 1
RHS 1

</div>

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

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

<div align="right">1</div>

<div align="right">**[9]**</div>

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

Not molecular formula

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$HOCH_2CH(OH)CH_2OH$
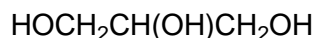
<div align="right">1</div>

(ii) $\rightarrow \ 19CO_2 \ + \ 19H_2O$

Or doubled

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$C_{17}H_{35}COOCH_3 + 27½$ or $55/2 \ O_2$
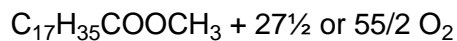
Consequential on correct right-hand side

<div align="right">1</div>

(b) (i) A   0.7

<div align="right">1</div>

Ethanol   6.4

<div align="right">1</div>

Water   3.6

<div align="right">1</div>

(ii) No effect

If wrong, CE = 0

<div align="right">1</div>

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

Ignore moles of gas

<div align="right">1</div>

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

Must have all brackets but allow ( )

1

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

If K_c wrong can only score M4 for units consequential to their K_c working in (b)(iv)
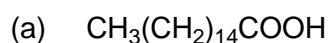
1

M3 0.55 (min 2dp)

1

M4 No units

1

[13]

5. (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]