

## Mark schemes

1

(a) mol CH<sub>3</sub>OH = 0.07(0)

1

mol H<sub>2</sub> = 0.24(0)

1

(b) (i)  $\frac{[\text{CH}_3\text{OH}]}{[\text{CO}][\text{H}_2]^2}$  or  $\frac{(0.082/1.5)}{(0.210/1.5)(0.275/1.5)^2}$

*allow ( ) but expression using formulae must have brackets  
alternative expression using numbers must include volumes*

1

(ii) **M1** divides by vol

*Mark independently from (b)(i)*

*any AE is -1*

*if volume missed, can score only M3 and M4*

1

**M2**  $\frac{(0.082/1.5)}{(0.210/1.5)(0.275/1.5)^2}$   $\left( = \frac{(0.05467)}{(0.14)(0.1833)^2} \right)$

*mark is for correct insertion of correct numbers in correct Kc  
expression in b(ii)*

*If Kc expression wrong, can only score M1 & M4*

*If numbers rounded, allow M2 but check range for M3*

1

**M3** 11.6 or 11.7

*mark for answer*

*above 11.7 up to 12.2 scores 2 for M1 and M2*

*if vol missed, can score M3 for 5.16 (allow range 4.88 to 5.21)*

1

**M4** mol<sup>-2</sup> dm<sup>6</sup>

*Units conseq to their Kc in (b)(ii)*

1

(iii) no effect or no change or none

1

- (c) **M1**  $T_1$   
*if wrong - no further marks* 1
- M2** (forward) reaction is exothermic **OR** gives out heat  
backward reaction is endothermic  
*only award M3 if M2 is correct* 1
- M3** shifts to RHS to replace lost heat  
**OR** to increase the temperature  
**OR** to oppose fall in temp  
 backward reaction takes in heat  
**OR** to lower the temperature  
*not just to oppose the change* 1
- (d) fossil fuels used  
**OR**  
 $\text{CO}_2$   $\text{H}_2\text{O}$  produced/given off/formed which are greenhouse gases  
**OR**  
 $\text{SO}_2$  produced/given off/formed which causes acid rain  
**OR**  
 Carbon produced/given off/formed causes global dimming  
*not allow electricity is expensive*  
*ignore just global warming*  
*ignore energy or hazard discussion* 1
- (e)  $\text{C}_{17}\text{H}_{35}\text{COOCH}_3$  **or**  $\text{C}_{17}\text{H}_{31}\text{COOCH}_3$  **or**  $\text{C}_{17}\text{H}_{29}\text{COOCH}_3$   
**OR**  
 $\text{CH}_3\text{OCC}_{17}\text{H}_{35}$  **or**  $\text{CH}_3\text{OCC}_{17}\text{H}_{31}$  **or**  $\text{CH}_3\text{OCC}_{17}\text{H}_{29}$  1

[13]

2

(a) **M1** CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>COOH  
not C<sub>3</sub>H<sub>7</sub>COOH 1

**M2** CH<sub>3</sub>CH<sub>2</sub>OH or C<sub>2</sub>H<sub>5</sub>OH 1

**M3** CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>COOCH<sub>2</sub>CH<sub>3</sub> + H<sub>2</sub>O  
allow C<sub>3</sub>H<sub>7</sub>COOC<sub>2</sub>H<sub>5</sub>  
penalise M3 for wrong products and unbalanced equation 1

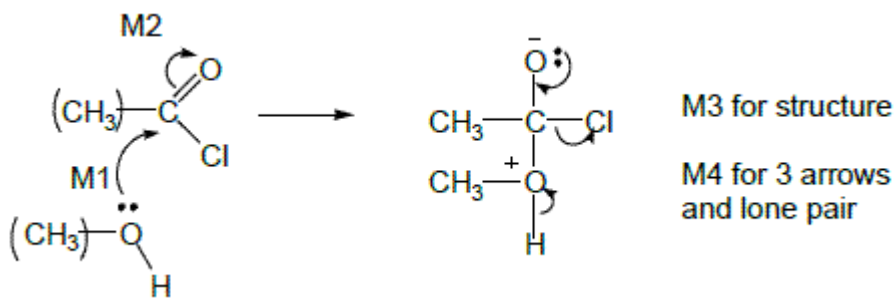
**M4** H<sub>2</sub>SO<sub>4</sub> or HCl or H<sub>3</sub>PO<sub>4</sub> conc or dil or neither  
not HNO<sub>3</sub> 1

(b) **M1** CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH  
not C<sub>4</sub>H<sub>9</sub>OH 1

**M2** (CH<sub>3</sub>CO)<sub>2</sub>O 1

**M3** → CH<sub>3</sub>COOCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub> + CH<sub>3</sub>COOH  
allow CH<sub>3</sub>COOC<sub>4</sub>H<sub>9</sub>  
penalise M3 for wrong products and unbalanced equation 1

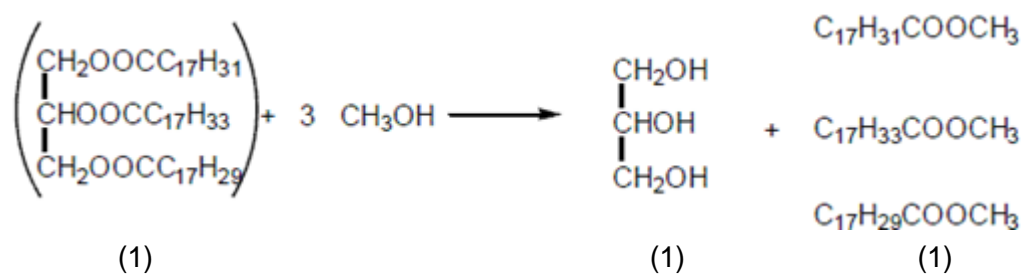
(c) (nucleophilic) addition-elimination



not acylation alone  
M2 not allowed indep of M1 but allow M1 for correct attack on C+  
+C=O loses M2  
only allow M4 after correct or v close M3  
ignore Cl<sup>-</sup> removing H<sup>+</sup>

5

(d)



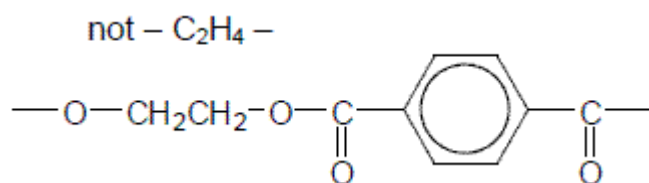
*ignore errors in initial triester*

*First mark for 3CH<sub>3</sub>OH*

*Third mark for all three esters*

3

(e)



*First mark for correct ester link second mark for the rest including trailing bonds*

*If ester link wrong, lose second mark also*

2

Adv reduces landfill  
saves raw materials  
lower cost for recycling than making from scratch  
reduces CO<sub>2</sub> emissions by not being incinerated  
*not allow cost without qualification*  
*ignore energy uses*

1

Disad difficulty/cost of collecting/sorting/processing  
product not suitable for original purpose, easily contaminated  
*not allow cost without qualification*  
*ignore energy uses*

1

[19]

3

(a) (i) propan(e)-1,2,3-triol or 1,2,3- propan(e)triol  
*not propyl*  
*ignore hyphen, commas*

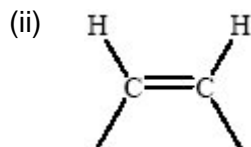
1

- (ii) soaps  
*allow anionic surfactant*  
*not cationic surfactant*  
*not detergents, not shampoos*

1

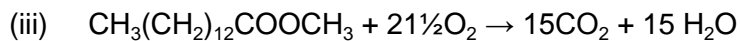
- (b) (i) (bio)diesel  
*Allow fuel for diesel engines*  
*not biofuel, not oils*

1

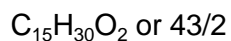


*ignore anything else attached except any more H atoms.*

1



**OR**

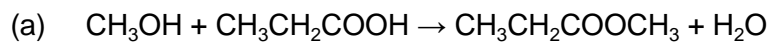


*not allow equation doubled*

1

**[5]**

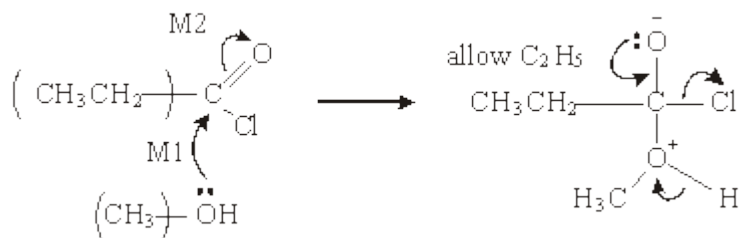
**4**



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- (b) (nucleophilic) addition-elimination NOT acylation

1



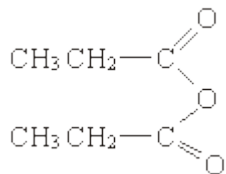
*ignore use of Cl<sup>-</sup> to remove H<sup>+</sup>*

*M3 for structure*

*M4 for 3 arrows and lone pair*

4

(c)



allow C<sub>2</sub>H<sub>5</sub> and —CO<sub>2</sub>—

allow CH<sub>3</sub>CH<sub>2</sub>COOCOCH<sub>2</sub>CH<sub>3</sub>

or (CH<sub>3</sub>CH<sub>2</sub>CO)<sub>2</sub>O

1

(d) (i) faster/not reversible/bigger yield/purer product/no(acid) (catalyst) required

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(ii) anhydride less easily hydrolysed or reaction less violent/exothermic  
no (corrosive) (HCl) fumes formed or safer or less toxic/dangerous  
expense of acid chloride or anhydride cheaper

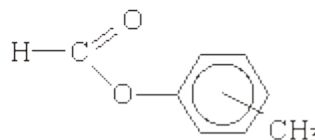
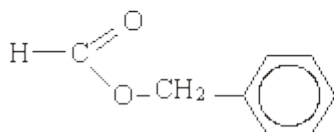
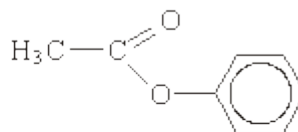
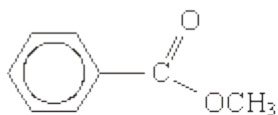
any one

1

(e) (i) C<sub>8</sub>H<sub>8</sub>O<sub>2</sub>

1

(ii) any two from



Allow —CO<sub>2</sub>— allow C<sub>6</sub>H<sub>5</sub>

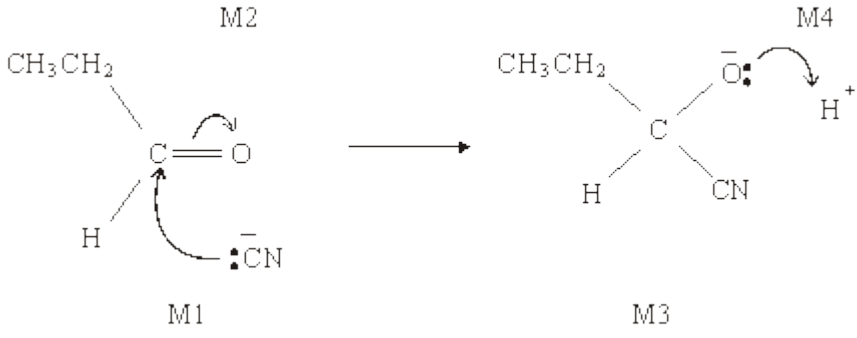
2

[12]

5

(a) nucleophilic addition

1

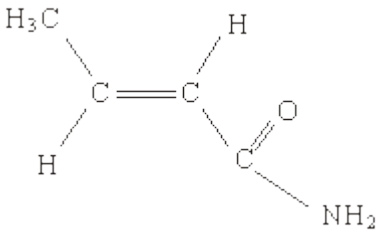


4

(b) (i) 2-hydroxybutanenitrile

1

(ii)

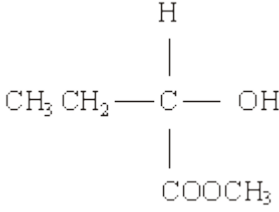


(allow 1 for amide even if not C<sub>4</sub>H<sub>7</sub>NO, i.e. RCONH<sub>2</sub>)

(if not amide, allow one for any isomer of C<sub>4</sub>H<sub>7</sub>NO which shows geometric isomerism)

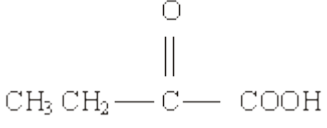
2

(c) (i)



1

(ii)



1

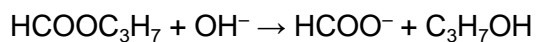
(iii) CH<sub>3</sub>CH=CHCOOH

1

[11]

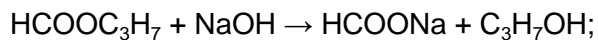
6

(a) propyl methanoate;



1

OR



1

(b) order wrt A = 1;

1

order wrt NaOH = 1;

1

Initial rate in Exp 4 =  $2.4 \times 10^{-3}$ ;

1

(c) (i)  $r(\text{ate}) = k[\text{A}]$

OR

$$r(\text{ate}) = k[\text{A}][\text{NaOH}]^0;$$

*(penalise missing [ ] but mark on)*

*(penalise missing [ ] once per paper)*

*(if wrong order, allow only units mark conseq on their rate eqs)*

*(penalise  $k_a$  or  $k_w$  etc)*

1

$$(ii) \quad k = \frac{9.0 \times 10^{-3}}{0.02};$$

1

$$= 0.45;$$

1

$$\text{s}^{-1};$$

1

(iii) (large) excess of  $\text{OH}^-$  or  $[\text{OH}^-]$  is large/high;

1

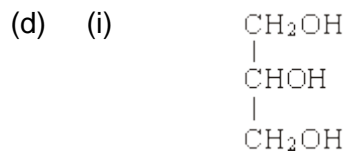
$[\text{OH}^-]$  is (effectively) constant

OR

$[\text{A}]$  is the limiting factor (Q of L mark)

1





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propan(e)-1,2,3-triol

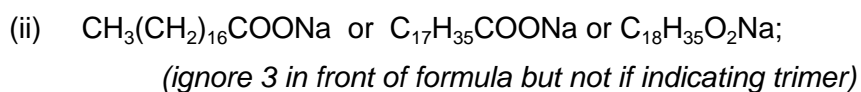
OR

1,2,3-propan(e)triol

OR

Glycerol;

1



1

(not just anion and penalise Na shown as covalently bonded) soap -  
allow with detergent but not detergent alone;

1

[15]

7

[1]

8

(a) (i)

Reagent	Tollens	Fehlings or Benedicts	$\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$ or acidified	$\text{KMnO}_4/\text{H}^+$	$\text{I}_2/\text{NaOH}$
Propanal	silver (mirror)	red ppt or goes red (not red solution)	goes green	goes colourless	No reaction
Propanone	no reaction	no reaction	no reaction	no reaction	Yellow (ppt)

(penalise incomplete reagent e.g.  $\text{K}_2\text{Cr}_2\text{O}_7$  or  $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$  then mark on)

3

(ii) propanal 3 peaks  
ignore splitting even if wrong

1

propanone 1 peak

1

(b) X is CH<sub>3</sub>CH<sub>2</sub>COOH or propanoic acid if both name and formula given,  
both must be correct, but

1

Y is CH<sub>3</sub>CH(OH)CH<sub>3</sub> or propan-2-ol allow propanol with correct formula

1

**Mark the type of reaction and reagent/condition independently.**  
**The reagent must be correct or close to score condition**

Step 1 Oxidation

K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>/H<sup>+</sup> or other oxidation methods as above

allow Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup>H<sup>+</sup> if penalised above (ecf)

reflux (not Tollens/Fehlings) or heat or warm

1

Step 2

reduction or nucleophilic addition	reduction or nucleophilic addition	reduction or hydrogenation
NaBH <sub>4</sub>	LiAlH <sub>4</sub>	H <sub>2</sub>
in (m)ethanol or water or ether or dry	ether or dry	Ni / Pt etc

1

1

1

Step 3 esterification or (nucleophilic) addition-elimination or condensation

1

(conc) H<sub>2</sub>SO<sub>4</sub> or HCl

1

warm (allow without acid reagent if X and Y given as reagents)

1

or reflux or heat

1

**[15]**

**9**

**[1]**