

## Mark schemes

1

(a) **M1**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$   
*not  $\text{C}_3\text{H}_7\text{COOH}$*

1

**M2**  $\text{CH}_3\text{CH}_2\text{OH}$  or  $\text{C}_2\text{H}_5\text{OH}$

1

**M3**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_3 + \text{H}_2\text{O}$   
*allow  $\text{C}_3\text{H}_7\text{COOC}_2\text{H}_5$*   
*penalise M3 for wrong products and unbalanced equation*

1

**M4**  $\text{H}_2\text{SO}_4$  or  $\text{HCl}$  or  $\text{H}_3\text{PO}_4$  conc or dil or neither  
*not  $\text{HNO}_3$*

1

(b) **M1**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$   
*not  $\text{C}_4\text{H}_9\text{OH}$*

1

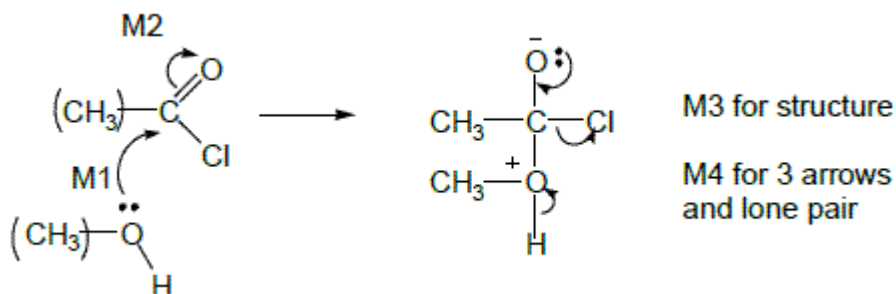
**M2**  $(\text{CH}_3\text{CO})_2\text{O}$

1

**M3**  $\rightarrow \text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_3 + \text{CH}_3\text{COOH}$   
*allow  $\text{CH}_3\text{COOC}_4\text{H}_9$*   
*penalise M3 for wrong products and unbalanced equation*

1

(c) (nucleophilic) addition-elimination



*not acylation alone*

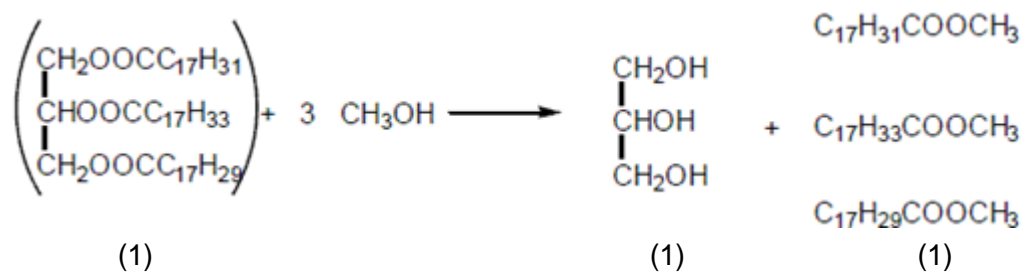
*M2 not allowed indep of M1 but allow M1 for correct attack on C+  
 +C=O loses M2*

*only allow M4 after correct or v close M3*

*ignore  $\text{Cl}^-$  removing  $\text{H}^+$*

5

(d)



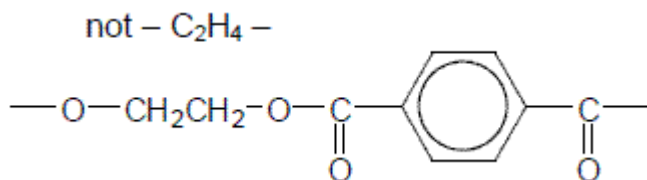
*ignore errors in initial triester*

*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*

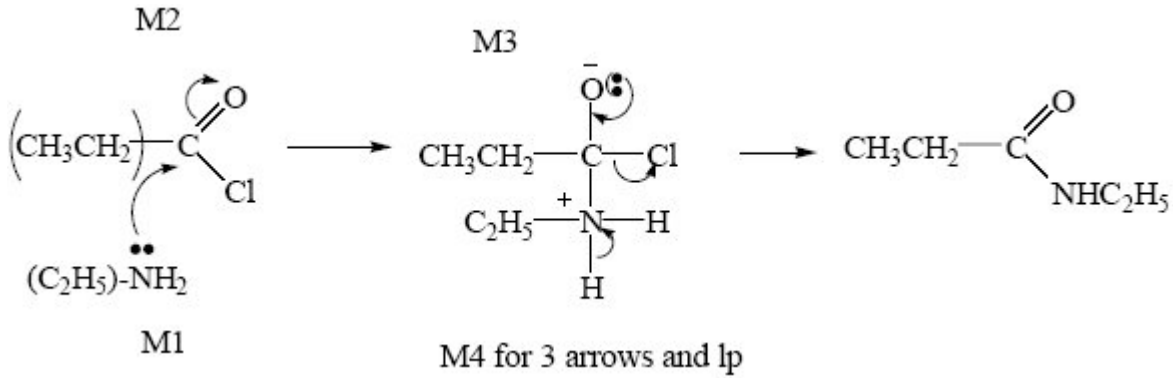
1

[19]

2

(a) (nucleophilic) addition-elimination

1



4

N-ethylpropanamide

- minus on NH<sub>2</sub> loses M1*
- M2 not allowed independent of M1, but allow M1 for correct attack on C+*
- +C=O loses M2*
- only allow M4 after correct or very close M3*
- lose M4 for Cl<sup>-</sup> removing H<sup>+</sup> in mechanism, but ignore HCl as a product*
- Not N-ethylpropaneamide*

1

(b)  $\text{CH}_3\text{CN}$  or ethan(e)nitrile or ethanonitrile

*not ethanitrile*

*but allow correct formula with ethanitrile*

1

for each step wrong or no reagent loses condition mark

*contradiction loses mark*

1

Step 1  $\text{Cl}_2$

uv or above  $300\text{ }^\circ\text{C}$

*wrong or no reagent loses condition mark*

1

Step 2 KCN

1

aq and alcoholic (both needed)

*allow uv light/(sun)light/uv radiation*

1

Step 3  $\text{H}_2/\text{Ni}$  or  $\text{LiAlH}_4$  or  $\text{Na}/\text{C}_2\text{H}_5\text{OH}$

*not  $\text{CN}^-$  but mark on*

*NOT  $\text{HCN}$  or  $\text{KCN} + \text{acid}$ , and this loses condition mark*

*NOT  $\text{NaBH}_4$*

*$\text{Sn}/\text{HCl}$  (forms aldehyde!)*

*ignore conditions*

1

[12]

<b>Mark Range</b>	<p>The marking scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC). There are no discrete marks for the assessment of QWC but the candidates' QWC in this answer will be one of the criteria used to assign a level and award the marks for this part of the question</p> <p style="text-align: center;"><b>Descriptor</b></p> <p style="text-align: center;">an answer will be expected to meet most of the criteria in the level descriptor</p>
4-5	<ul style="list-style-type: none"> <li>– claims supported by an appropriate range of evidence</li> <li>– good use of information or ideas about chemistry, going beyond those given in the question</li> <li>– argument well structured with minimal repetition or irrelevant points</li> <li>– accurate and clear expression of ideas with only minor errors of grammar, punctuation and spelling</li> </ul>
2-3	<ul style="list-style-type: none"> <li>– claims partially supported by evidence</li> <li>– good use of information or ideas about chemistry given in the question but limited beyond this</li> <li>– the argument shows some attempt at structure</li> <li>– the ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling</li> </ul>
0-1	<ul style="list-style-type: none"> <li>– valid points but not clearly linked to an argument structure</li> <li>– limited use of information or ideas about chemistry</li> <li>– unstructured</li> <li>– errors in spelling, punctuation and grammar or lack of fluency</li> </ul>

- (a) (i)  $M_r$  of  $C_6H_5NH_2 = 93$     $M_r$  of  $CH_3COCl = 78.5$   
total  $M_r$  of reagents = 264.5

1

$$\% \text{ atom economy} = \frac{M_r \text{ of wanted product}}{\text{total } M_r \text{ of all reagents}} \times 100 \text{ QWC}$$

1

$$= \frac{135}{264.5} \times 100 = 51.0 \%$$

1

(ii) expected yield =  $\frac{10}{93} \times 0.5 \times 135 = 7.26 \text{ kg}$

1

% yield =  $\frac{5.38}{7.26} \times 100 = 74.1 \%$

1

(iii) Although yield appears satisfactory (74%) % atom economy is only 51% QWC

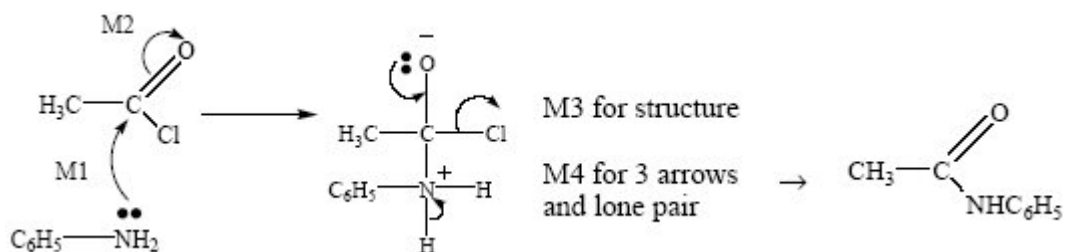
1

nearly half of the material produced is waste and must be disposed of QWC

1

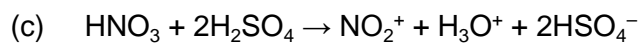
(b) (nucleophilic) addition-elimination

1

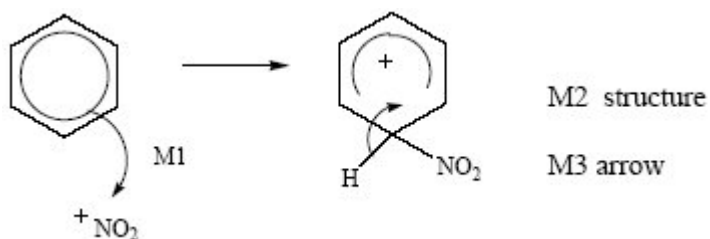


QWC (2)

4



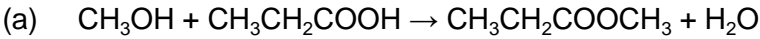
1



3

[16]

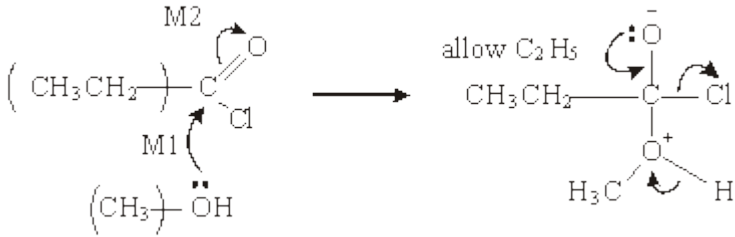
4



1

(b) (nucleophilic) addition-elimination NOT acylation

1



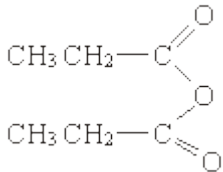
*ignore use of Cl- to remove H+*

*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

1

(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

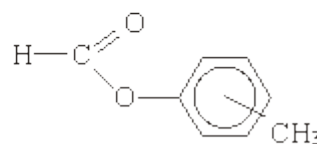
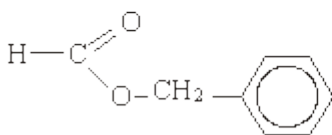
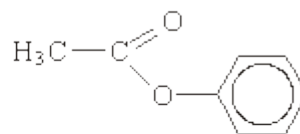
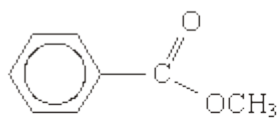
*any one*

1

(e) (i)  $C_8H_8O_2$

1

(ii) **any two from**



Allow  $-CO_2-$  allow  $C_6H_5$

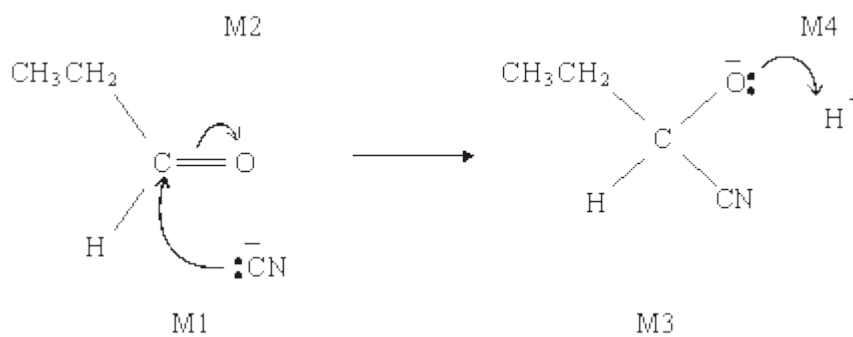
2

[12]

5

(a) nucleophilic addition

1

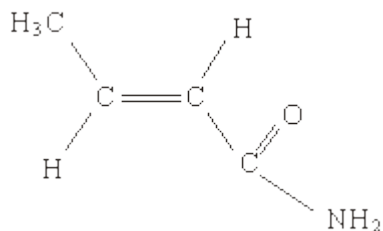


4

(b) (i) 2-hydroxybutanenitrile

1

(ii)



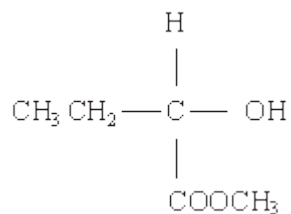
(allow 1 for amide even if not  $C_4H_7NO$ , i.e.  $RCONH_2$ )

(if not amide, allow one for any isomer of  $C_4H_7NO$  which shows geometric isomerism)

2

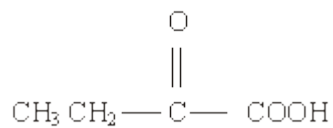


(c) (i)



1

(ii)



1

(iii)  $\text{CH}_3\text{CH}=\text{CHCOOH}$

1

[11]

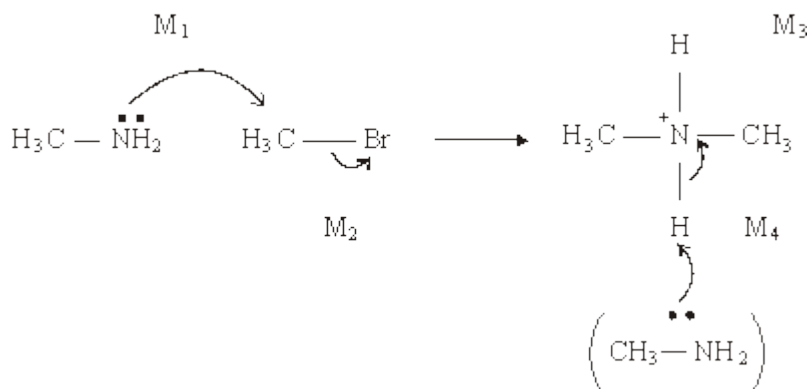
6

(a) dimethylamine

1

(b) nucleophilic substitution

1



4

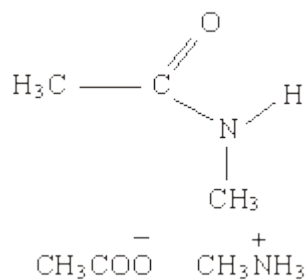
(c) quaternary ammonium salt

1

(cationic) surfactant / bactericide / detergent / fabric softener or conditioner/hair conditioner

1

(d)



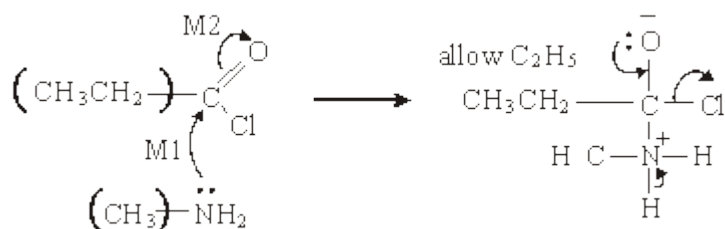
(allow CH<sub>3</sub>COOH or CH<sub>3</sub>COO<sup>-</sup> NH<sub>4</sub><sup>+</sup>)

2

[10]

7

(a) (nucleophilic) addition-elimination;



(M3 for structure)

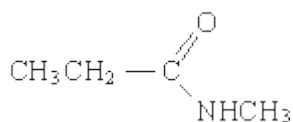
(M4 for 3 arrows and lone pair)

(M2 not allowed independent of M1, but allow M1 for correct attack on C+ if M2 show as independent first.)

(+on C of C=O loses M2 but ignore δ+ if correct)

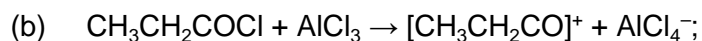
(Cl<sup>-</sup> removing Ft loses M4)

1



(If MS lost above for wrong C chain, do not penalise same error again here)

5

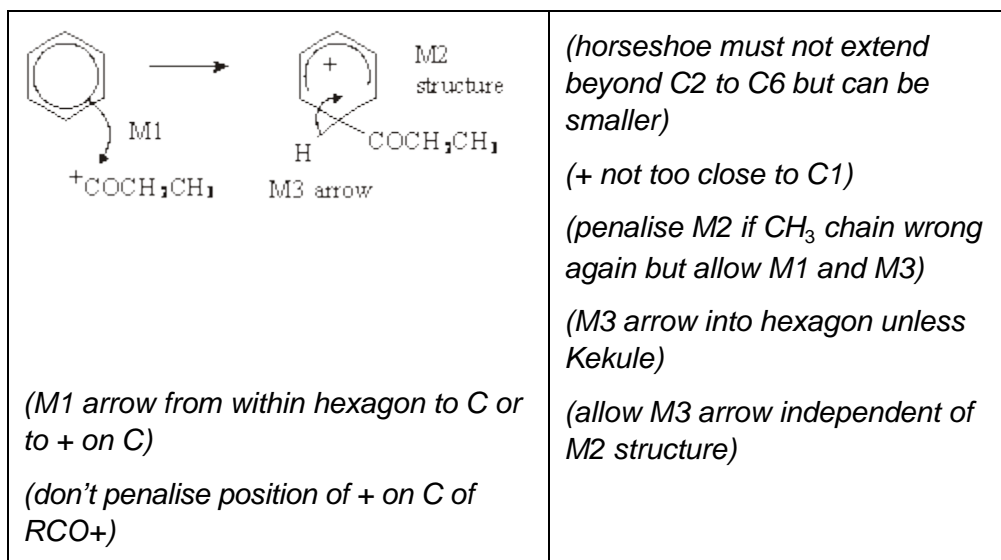


*(penalise wrong alkyl group once at first error)*

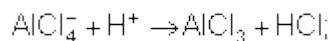
*(position of + on electrophile can be on O or C or outside [ ])*

*(penalise wrong curly arrow in the equation or lone pair on  $\text{AlCl}_3$ )*

1

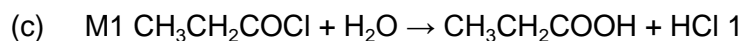


3



*(or can be gained in mechanism);*

1



*(penalise wrong alkyl group once at first error)*

1

M2  $M_r$  of  $\text{CH}_3\text{CH}_2\text{COCl} = 92.5$  1

*(if  $M_r$  wrong, penalise M2 only)*

1

M3 moles of  $\text{CH}_3\text{CH}_2\text{COCl} = 1.48/92.5 = 0.016$  1

1

M4 moles  $\text{NaOH} = 2 \times 0.016 = 0.032$  1

*(allow for  $\times 2$  consequ to wrong no of moles)*

1

M5 volume of  $\text{NaOH} = 0.032/0.42 = 0.0762 \text{ dm}^3$  or  $76.2 \text{ cm}^3$  1

*(with correct units)*

*(if  $\times 2$  missed in M4 lose M5 also)*

1

[16]