M1. (a) (i)

Reagent	Tollens	Fehlings or Benedicts	$K_2Cr_2O_7/H^+$ or acidified	$KMnO_4/H^+$	I_2/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. $K_2Cr_2O_7$ or $Cr_2O_7^{2-}/H^+$ then mark on)

3

(ii) propanal 3 peaks

ignore splitting even if wrong

1

propanone 1 peak

1

(b) **X** is CH_3CH_2COOH or propanoic acid if both name and formula given, both must be correct, but

1

Y is $CH_3CH(OH)CH_3$ 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

$K_2Cr_2O_7/H^+$ or other oxidation methods as above
allow $Cr_2O_7^{2-}H^+$ 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
$NaBH_4$	$LiAlH_4$	H_2
in (m)ethanol or water or ether	ether or dry	Ni / Pt etc

1 **1** **1**

or dry		

Step 3 esterification or (nucleophilic) addition-elimination or condensation **1**

(conc) H_2SO_4 or HCl **1**

warm (allow without acid reagent if **X** and **Y** given as reagents) **1**

or reflux or heat **1**

[15]

M2. B

[1]

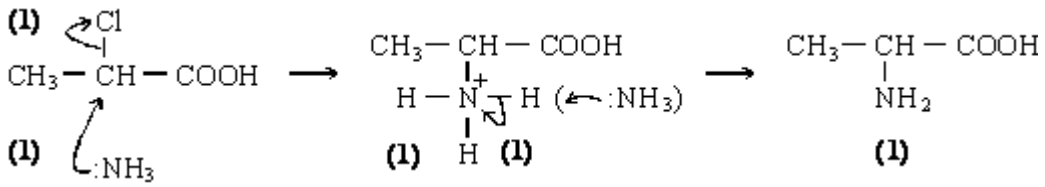
M3. (a) 2-chloropropanoic acid **(1)** **1**

(b) δ 1.72 Doublet ∴ next to CH **(1)**

δ 4.44 Quartet ∴ next to CH_3 **(1)** **2**

(c) Two triplets **(1)** **1**

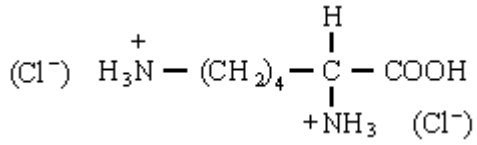
(d)



Allow S_N1

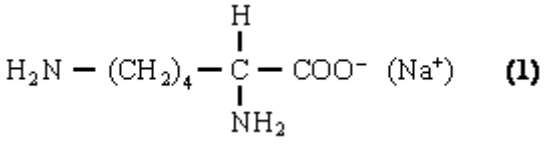
5

(e) (i)



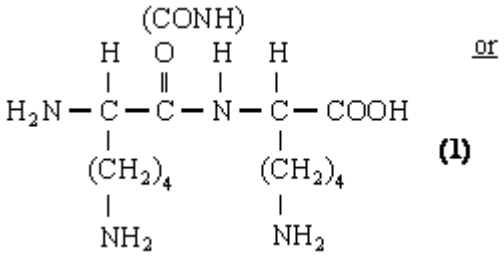
(1)

(ii)



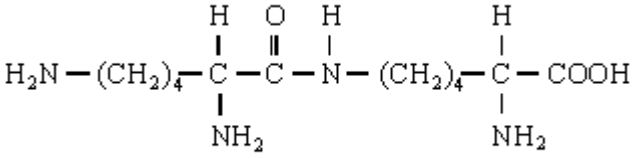
(1)

(iii)



(1)

<u>or</u>



<u>Or</u> anhydride

3

[12]

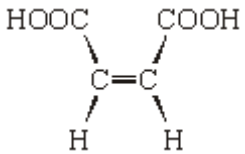
M4.B

[1]

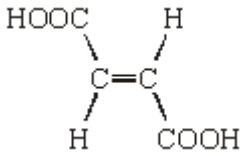
M5.D

[1]

M6. (a)



1



1

NB The bonds shown in the structure must be correct

Isomerism: E-Z isomerism

If written answer is correct, ignore incorrect labelling of structures.
If no written answer, allow correctly labelled structures.

1

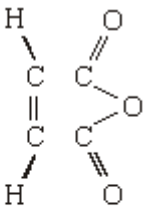
Both COOH groups must be on the same side/ close together/ cis

1

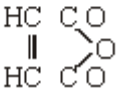
No rotation about C=C axis

1

Structure

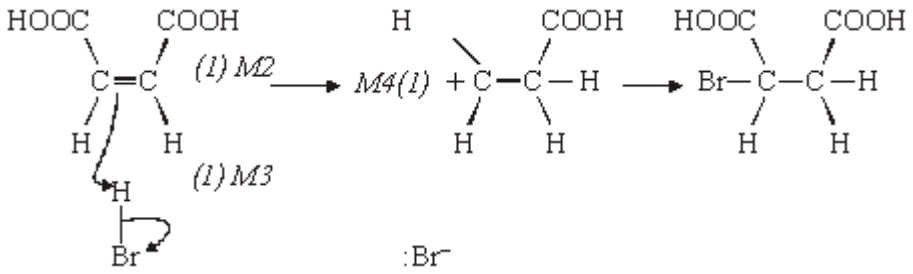


Allow



1

(b) Br_2 / HBr / H_2SO_4 / H^+ / Br^+ / NO_2^+ (*Mark M1*)



NB If electrophile H^+ / Br^- / NO_2^+ allow M1, M2 and M4
If the acid is incorrect, M2 and M3 can still be scored
Allow M4 consequentially if repeat error from part (a)

4

(c) e.g. $2NaOH + HO_2CCHCHCO_2H \rightarrow NaO_2CCHCHCO_2Na + 2H_2O$

Both H replaced

1

Balanced for atoms and charges

1

NB Allow ionic equations and *$2NaOH + C_4H_4O_4 \rightarrow C_4H_2O_4Na_2 + 2H_2O$*
Allow one if structure incorrect but molecular formula correct
Allow one for a correct equation showing one H replaced

(d) *M1* Two peaks

1

M2 No splitting or singlets

1

M3 (Two) non-equivalent protons or two proton environments

1

M4 No adjacent protons

1

M5 Same area under the two peaks or same relative intensity

1

NB Doublet could score M1 and M3 or M5 (Max 2)
More than two peaks CE = 0
Apply the "list principle" to incorrect answers if more than 3 given

Max 3

[15]

M7. (a) *M1* $K_p = ({}_pY)^3.({}_pZ)^2/({}_pW)^2.({}_pX)$ *NB [ ] wrong*

1

M2 temperature

1

M3 increase

1

M4 particles have more energy or greater velocity/speed

1

M5 more collisions with $E > E_a$ or more successful collisions

1

M6 Reaction exothermic or converse

1

M7 Equilibrium moves in the left

1

Marks for other answers

Increase in pressure or concentration	*allow M1, M5, M6*	*Max 3*
Addition of a catalyst;	*allow M1, M5, M6*	*Max 3*
Decrease in temperature;	*allow M1, M2, M6*	*Max 3*
Two or more changes made;	*allow M1, M6*	*Max 2*

(b) (i) Advantage; reaction goes to completion, not reversible or faster

1

Disadvantage; reaction vigorous/dangerous

(exothermic must be qualified)

or HCl(g) evolved/toxic
or CH_3COCl expensive

NB Allow converse answers
Do not allow reactions with other reagents e.g. water or ease of separation

1

(ii) $\Delta S = \Sigma S$ products $- \Sigma S$ reactants

1

□□□□□□□□ ΔS = (259 + 187) – (201 + 161)

1

□□□□□□□□ ΔS = 84 (JK^{-1} mol^{-1}) *(Ignore units)*

*Allow – 84 to score **(1)** mark*

1

□□□□□□□□ $\Delta G = \Delta H - T\Delta S$

1

= – 21.6 – 298 × 84/1000
= – 46.6 kJ mol^{-1} or – 46 600 J mol^{-1}

1

*Allow **(2)** for – 46.6 without units*
(Mark ΔG consequentially to incorrect ⊿S)
(e.g. ⊿S = –84 gives ⊿G = +3.4 kJ mol^{-1})

1

[15]