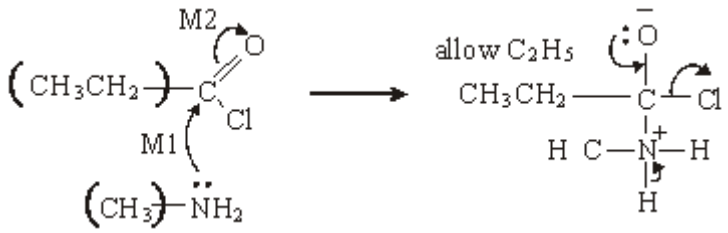
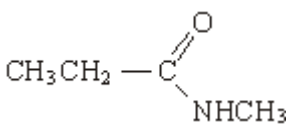
**M1.** (a) (nucleophilic) addition-elimination;




*(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 $\delta$+ if correct)*
*($Cl^-$ removing Ft loses M4)*

**1**



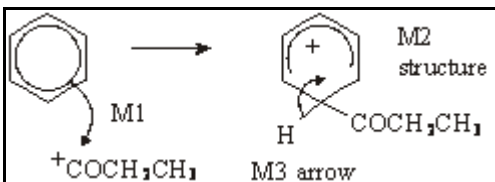
*(If MS lost above for wrong C chain, do not penalise same error again here)*

**5**

(b) $CH_3CH_2COCl + AlCl_3 \rightarrow [CH_3CH_2CO]^+ + AlCl_4^-$;

*(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 $AlCl_3$)*

**1**

| | |
|---|---|
|  *(M1 arrow from within hexagon to C or to + on C)* | *(horseshoe must not extend beyond C2 to C6 but can be smaller)*<br>*(+ not too close to C1)*<br>*(penalise M2 if $CH_3$ chain wrong again but allow M1 and M3)*<br>*(M3 arrow into hexagon unless Kekule)*<br>*(allow M3 arrow independent of* |

| | |
|---|---|
| *(don't penalise position of + on C of RCO+)* | *M2 structure)* |

**3**

$AlCl_4^- + H^+ \rightarrow AlCl_3 + HCl$;

*(or can be gained in mechanism);*

**1**

(c) M1 $CH_3CH_2COCl + H_2O \rightarrow CH_3CH_2COOH + HCl$ 1
*(penalise wrong alkyl group once at first error)*

**1**

M2 $M_r$ of $CH_3CH_2COCl$ = 92.5 1
*(if Mr wrong, penalise M2 only)*

**1**

M3 moles of $CH_3CH_2COCl$ = 1.48/92.5 = 0.016 1

**1**

M4 moles NaOH = 2 × 0.016 = 0.032 1
(allow for × 2 conseq to wrong no of moles)

**1**

M5 volume of NaOH = 0.032/0.42 = 0.0762 $dm^3$ or 76.2 $cm^3$ 1
*(with correct units)*
*(if ×2 missed in M4 lose M5 also)*

**1**

**[16]**

**M2.** (a) (i) An appropriate alkene; $CH_3CH_2CHCH_2$ or $(CH_3)_2CCH_2$

**1**

Isomer 1

**1**

Isomer 2

**1**

Position isomerism

**1**

Mechanism

electrophilic attack and electron shift to Br (Unless $H^+$ used)

1

carbocation

1

reaction with carbocation

*[Allow mechanism marks for the alkene $CH_3CHCHCH_3$]*
*[Allow one mark if mechanism for minor product given]*

1

(ii) An appropriate carbonyl; $CH_3CH_2CHO$

1

Mechanism nucleophilic attack and electron shift to O

1

anion intermediate

1

reaction with anion

*[Allow mechanism marks for the carbonyl $(CH_3)_2CO$]*

1

Isomer 1

1

Isomer 2

1

Optical isomerism

*NB Isomer structures must be tetrahedral*
*NB Penalise "stick" structures once in part (a)*

1

(b) QoL
Large charge on carbonyl carbon atom due to bonding to O and Cl

1

Nucleophiles have electron pairs which can be donated

1

Equation Species

1

Balanced

1

**[18]**

**M3.** (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**

□□□□□□□□ $\Delta S = (259 + 187) - (201 + 161)$

**1**

□□□□□□□□ $\Delta S$ = 84 ($JK^{-1}$ $mol^{-1}$) *(Ignore units)*

*Allow – 84 to score **(1)** mark*

**1**

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

**1**

$= -21.6 - 298 \times 84/1000$

$= -46.6$ 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]**