1

(a) (i) $CDCl_3$ or CD_2Cl_2 or C_6D_6 or CCl_4

Not D_2O Allow CD_3Cl

1

(ii) 4 **or four**

1

(iii) Triplet or 3 or three

1

(iv) 1,4-dichloro-2,2-dimethylbutane

Do not penalise different or missing punctuation or extra spaces.

Spelling must be exact and order of letters and numbers as here.

1

(b) (i) 3 or three

1

(ii) 190-220 (cm^{-1})

Allow a single number within the range.

***OR** a smaller range entirely within this range.*

1

(iii) hexan**e**-2,5-dione

Do not penalise different or missing punctuation or extra spaces.

Spelling must be exact and order of letters and numbers as here.

NB so must have middle e

1

[7]

2

(a) (i) Single / one (intense) peak / signal ***OR*** all H or all C in same environment ***OR*** 12 equiv H or 4 equiv C

Do not allow non-toxic or inert (both given in Q)

Any 2 from three

Ignore peak at zero

OR

Upfield / to the right of (all) other peaks ***OR*** well away from others ***OR*** doesn't interfere with other peaks

Ignore cheap

Ignore non-polar

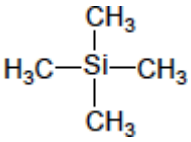
OR

Low bp ***OR*** volatile ***OR*** can easily be removed

Ignore mention of solubility

2

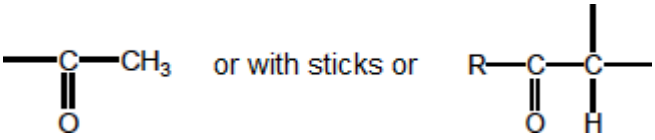
(ii)



Allow $Si(CH_3)_4$

1

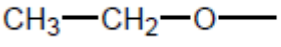
(b) (i)



Ignore any group joined on other side of CO
Ignore missing trailing bond
Ignore charges

1

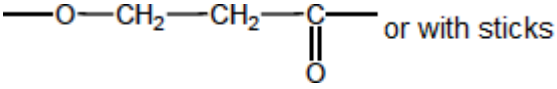
(ii)



Ignore any group joined on other side of −O−
Ignore missing trailing bond
Ignore charges as if MS fragment

1

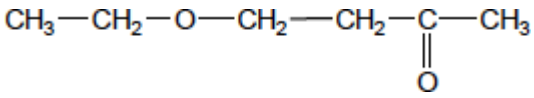
(iii)



Ignore missing trailing bonds
Ignore charges as if MS fragment

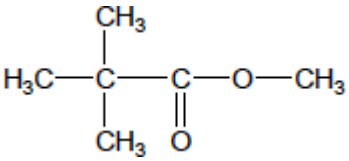
1

(iv)



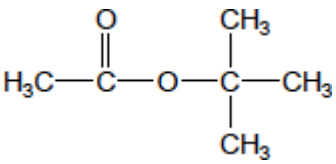
1

(c) (i) Check structure has 6 carbons



Allow $(CH_3)_3CCOOCH_3$ or $(CH_3)_3CCO_2CH_3$

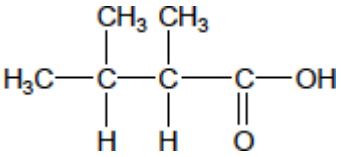
1



Allow $CH_3COOC(CH_3)_3$ or $CH_3CO_2C(CH_3)_3$

1

(ii) Check structure has 6 carbons

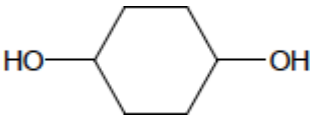


Allow $(CH_3)_2CHCH(CH_3)COOH$ or $(CH_3)_2CHCH(CH_3)CO_2H$

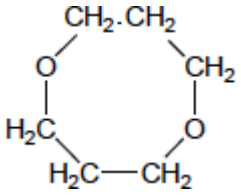
Penalise C_3H_7

1

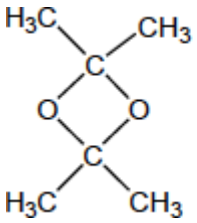
(iii) Check structure has 6 carbons



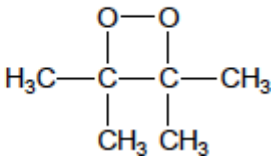
OR



Allow



OR

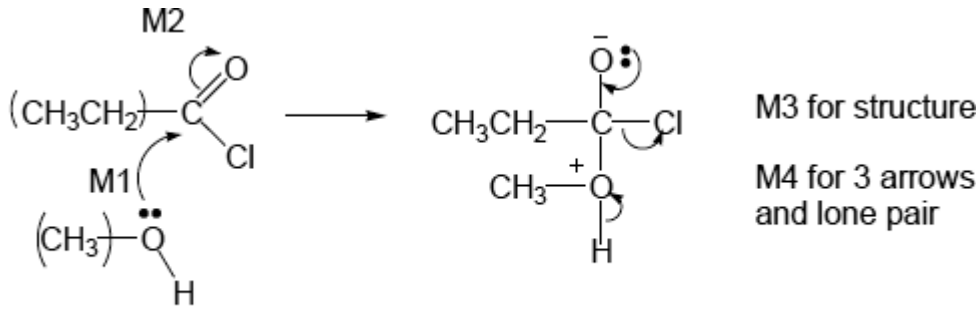


1

[11]

3

(a)



methyl propanoate (**NO** mark for name of mechanism)

- *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 with charges but lp on O is part of M4*
- *only allow M4 after correct/very close M3*
- *ignore Cl^- removing H^+*

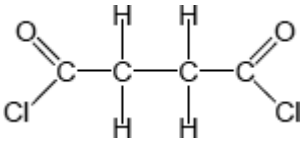
4

(b) (i) pentan<u>e</u>-<u>1,5</u>-diol

Second 'e' and numbers needed

Allow <u>1,5</u>-pentan<u>e</u>diol but this is not IUPAC name

(ii)



Must show ALL bonds

1

(iii) All three marks are independent

M1 (base or alkaline) Hydrolysis (allow close spelling)

1

Allow (nucleophilic) addition-elimination or saponification

M2 <u>δ+ C</u> in polyester

1

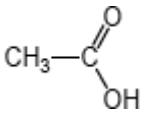
M3 reacts with OH^- or hydroxide ion

1

Not reacts with NaOH

1

(c) (i)



Allow CH_3COOH or CH_3CO_2H

1

(ii) (nucleophilic) addition-elimination

Both addition and elimination needed and in that order

OR

(nucleophilic) addition followed by elimination

*Do **not** allow electrophilic addition-elimination / esterification*

Ignore acylation

1

(iii) any **two** from: ethanoic anhydride is

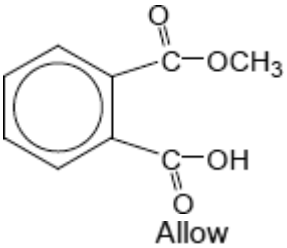
- less corrosive
- less vulnerable to hydrolysis
- less dangerous to use,
- less violent/exothermic/vigorous reaction OR more controllable rxn
- does not produce toxic/corrosive/harmful fumes (of HCl) OR does not produce HCl
- less volatile

***NOT** COST*

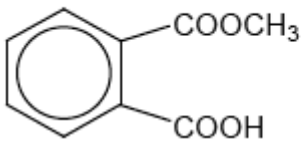
List principle beyond two answers

2

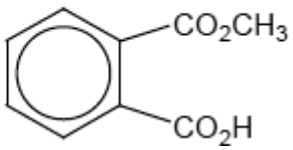
(d)



Allow



or



1

(e) (i) ester

*Do **not** allow ether*

Ignore functional group/linkage/bond

1

(ii) 12 or twelve (peaks)

1

(iii) 160 – 185

Allow a number or range within these limits

Penalize extra ranges given

Ignore units

1

(f) (i)

sulfuric acid	sodium hydroxide	✓
hydrochloric acid	ammonia	X or blank
ethanoic acid	potassium hydroxide	✓
nitric acid	methylamine	X or blank

4 correct scores 2

3 correct scores 1

2 or 1 correct scores 0

2

(ii) Pink to colourless

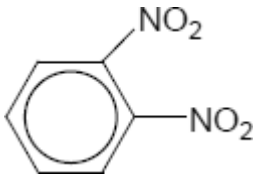
Allow 'red' OR 'purple' OR 'magenta' instead of 'pink'

*Do **not** allow 'clear' instead of 'colourless'*

1

[21]

4 (a)

F	G
	

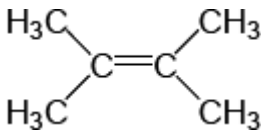
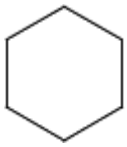
Penalize $-O_2N$ once

Penalise missing circle once

Don't penalise attempt at bonding in NO_2

1

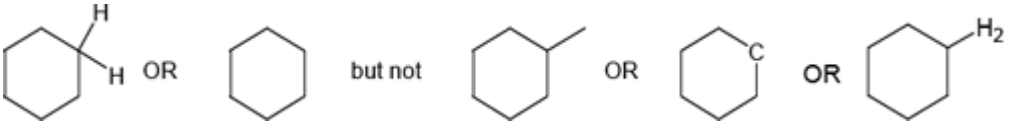
(b)

H	J
	

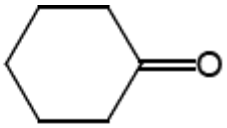
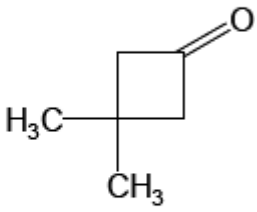
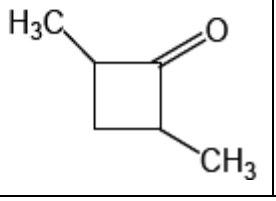
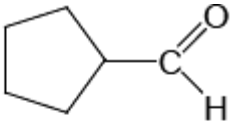
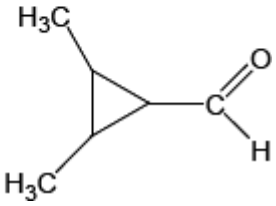
*If **both H** and **J** correct but reversed, award one mark*

1

A carbon in saturated ring structures should be shown as

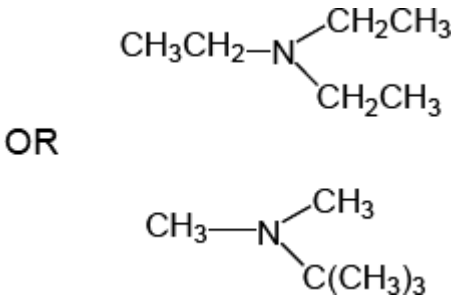
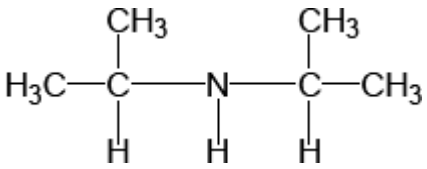


(c)

K	L
 OR  OR 	 OR 

1

(d)

M	N
 OR	

Allow C_2H_5 but

NOT allow C_4H_9 or C_3H_7

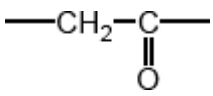
1
1

[8]

5 (a) OH alcohols

1

(b) (i) 2.6



Ignore any group on RHS

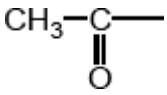
*Must clearly indicate relevant **two** H on a C next to C=O*

On LHS, penalise H or CH or CH_2 or CH_3

Ignore missing trailing bonds or attached R groups

1

(ii) 2.2



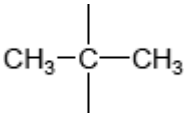
Ignore all groups on RHS

*Must clearly indicate relevant **three** H on C next to C=O*

Ignore missing trailing bonds or attached R group

1

(iii) 1.2



Or in words: two <u>equivalent</u> CH_3 groups

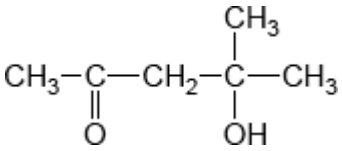
Must clearly indicate two <u>equivalent</u> methyl groups.

Penalise attached H

Ignore missing trailing bonds or attached R groups

1

(iv)



1

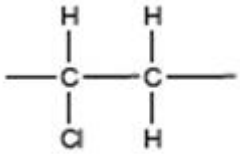
[5]

6 (a) <u>Benzene-1,2-dicarboxylic acid</u>

Allow 1,2-benzenedicarboxylic acid

1

(b)



Must show all bonds including trailing bonds

Ignore n

1

(c) (i) 2 C_2H_5OH

NB Two ethanols

1

H_2O

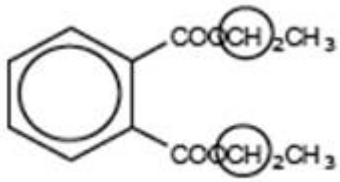
but only one water

1

(ii) 6 or six

1

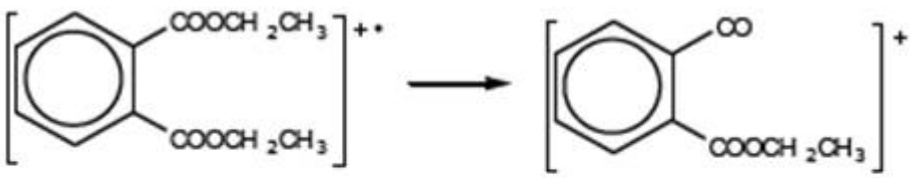
(iii)

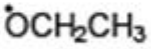


Ignore overlap with O to the left or H to the right, but must only include this one carbon. either or allow both (as they are identical)

1

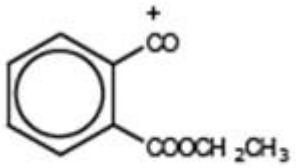
(d)





$[DEP]^{+\cdot}$

OR $[C_{12}H_{14}O_4]^{+\cdot} \rightarrow [C_{10}H_9O_3]^{+} + [C_2H_5O]^{\cdot}$



Allow + on C or O in

1

Dot must be on O in radical

1

(e) (i) Rate = k[DEP]

Must have brackets but can be ( )

1

(ii) Any **two** of

- experiment repeated/continued over a long period
- repeated by independent body/other scientists/avoiding bias
- investigate breakdown products
- results made public

Not just repetition

Ignore animal testing

2 max

[11]

7 (a) (i) Single reagent

If wrong single reagent, CE = zero

Incomplete single reagent (e.g. carbonate) or wrong formula (e.g.$NaCO_3$) loses reagent mark, but mark on

For “no reaction” allow “nothing”

Different reagents

If different tests on E and F; both reagents and any follow on chemistry must be correct for first (reagent) mark.
Reagent must react: i.e. not allow Tollens on G (ketone) – no reaction.
Second and third marks are for correct observations.
i.e. for different tests on E and F, if one reagent is correct and one wrong, can score max 1 for correct observation with correct reagent.

PCl_5 PCl_3

$SOCl_2$

1

E ester

Na_2CO_3/$NaHCO_3$ named carbonate

metal e.g.Mg

no reaction

no reaction

named indicator

no effect

No reaction

1

F acid

Na_2CO_3/$NaHCO_3$ named carbonate

Effervescence or CO_2

metal e.g.Mg

Effervescence or H_2

named indicator

acid colour

fumes

1

(ii) Single reagent

If wrong single reagent, CE = zero
Incomplete single reagent (e.g. carbonate) or wrong formula (e.g.$NaCO_3$) loses reagent mark, but mark on
For "no reaction" allow "nothing"

Different reagents

If different tests on E and F; **both** reagents and any follow on chemistry must be correct for first (reagent) mark.
Reagent must react: i.e. not allow Tollens on G (ketone) – no reaction.
Second and third marks are for correct observations.

1

i.e. for different tests on E and F, if one reagent is correct and one wrong, can score max 1 for correct observation with correct reagent.

G ketone

$AgNO_3$

no reaction

Na_2CO_3/$NaHCO_3$ named carbonate

water

no reaction

named indicator

no effect

Named alcohol

no reaction

Named amine or ammonia

no reaction

1

H Acyl chloride

$AgNO_3$

(white) ppt

Na_2CO_3/$NaHCO_3$ named carbonate

Effervescence or CO_2 or fumes or exothermic

water

fumes

named indicator

acid colour

Named alcohol

Smell or fumes

Named amine or ammonia

fumes

1

Allow iodoform test or Brady's reagent (2,4,dnph) test (both positive for G)

(iii) Single reagent

If wrong single reagent, CE = zero
Incomplete single reagent (e.g. carbonate) or wrong formula (e.g.$NaCO_3$) loses reagent mark, but mark on

For "no reaction" allow "nothing"

Different reagents

If different tests on E and F; **both** reagents and any follow on chemistry must be correct for first (reagent) mark.

Reagent must react: i.e. not allow Tollens on G (ketone) – no reaction.

Second and third marks are for correct observations.

i.e. for different tests on E and F, if one reagent is correct and one wrong, can score max 1 for correct observation with correct reagent.

1

J Primary alcohol

$K_2Cr_2O_7$/ H^+

goes green

$KMnO_4$/ H^+

decolourised / goes brown

Lucas test ($ZnCl_2$/HCl)

Penalise missing H^+ but mark on

1

K Tertiary alcohol

$K_2Cr_2O_7$/ H^+

No reaction

$KMnO_4$/ H^+

no reaction

Lucas test ($ZnCl_2$/HCl)

Rapid cloudiness

1

If uses subsequent tests e.g. Tollens/Fehlings, test must be on product of oxidation

(b) (i) 3,3-dimethylbutan-1-ol

Allow 3,3-dimethyl-1-butanol

1

4

1

Triplet on three

1

(ii) 2-methylpentan-2-ol

Allow 2-methyl-2-pentanol

1

5

1

Singlet or one or no splitting

1

[15]

8 (a) chromatography (allow GLC TLC GC HPLC)

allow any qualification

1

(b) 5

1

Allow 320(.0) or 322(.0)

1

(c) Use of excess air/oxygen or high temperature (over 800 °C)
or remove chlorine-containing compounds before incineration

1

(d) (i) $Si(CH_3)_4$ allow SiC_4H_{12}

allow displayed formula and do not penalise sticks

Not TMS

1

(ii) 3

1

[6]