

Abbreviations, annotations and conventions used in the mark scheme

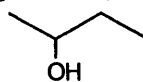
/ = alternative and acceptable answers for the same marking point
 ; = separates marking points
 NOT = answers not worthy of credit
 () = words which are not essential to gain credit
 (underlining) = key words which must be used
 ecf = allow error carried forward in consequential marking
 AW = alternative wording
 ora = or reverse argument

Marking structures in organic chemistry

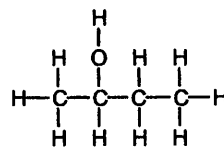
When a structure is asked for, there must be sufficient detail using conventional carbon skeleton and functional group formulae (e.g. CH₃, C₂H₅, OH, COOH, COOCH₃) to unambiguously define the arrangement of the atoms. (E.g. C₃H₇ would not be sufficient).

If not specified by the question, this may be given as either:

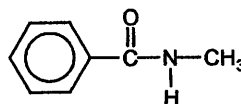
- a structural formula – e.g. CH₃CH(OH)C₂H₅,



- a skeletal formula – e.g.



- a displayed formula – e.g.

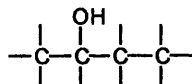


or as a hybrid of these – e.g.

The following errors should be penalised – although each one only loses a maximum of one mark on the paper:

- clearly connecting a functional group by the wrong atom
- showing only 'sticks' instead of hydrogen atoms

e.g.



Benzene rings may be represented as



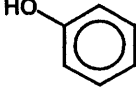
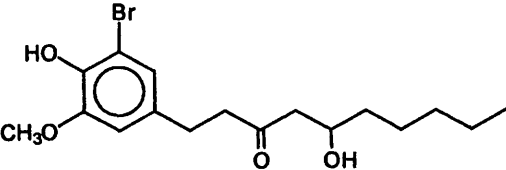
as well as



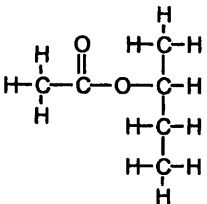
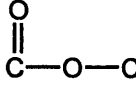
in any

of the types of formula above.

1 (a) (i) carboxylic acid ✓	NOT 'carboxyl'	[1]
(ii) $\text{CH}_3\text{CH}(\text{NH}_2)\text{COO}^- \text{Na}^+$ or a displayed structure where... $\text{COO}^- / \text{COONa}$ ✓ rest of the structure including Na also correct ✓	Allow 1 overall for covalent O – Na or missing charge on COO but otherwise correct	[2]
(iii) water / H_2O ✓		[1]
(b) H_3N^+ becomes H_2N ✓ rest of the molecule unchanged ✓		[2]
(c) condensation / water molecule removed / created (or shown) ✓		
NH_2 (from one molecule) reacts with the COOH (from the other molecule) (or shown by drawing around the groups) ✓ AW	allow any correct displayed isomer of C_3H_7	
$\begin{array}{c} \text{H} \\ \\ \text{---C---N---} \\ \\ \text{O} \end{array}$ displayed at least once ✓	allow ALA-ALA and VAL-VAL	
one correct dipeptide structure - eg $\begin{array}{ccccccc} & & \text{CH}_3 & & \text{H} & & \text{C}_3\text{H}_7 \\ & & & & & & \\ \text{H}_2\text{N} & \text{---} & \text{C} & \text{---} & \text{C} & \text{---} & \text{N} & \text{---} & \text{C} & \text{---} & \text{COOH} \\ & & & & & & & & \\ & & \text{H} & & \text{O} & & \text{H} & & \text{H} \end{array}$ ✓	allow -CO-NH- on the dipeptides	
second correct dipeptide structure – eg		
$\begin{array}{ccccccc} & & \text{C}_3\text{H}_7 & & \text{H} & & \text{CH}_3 \\ & & & & & & \\ \text{H}_2\text{N} & \text{---} & \text{C} & \text{---} & \text{C} & \text{---} & \text{N} & \text{---} & \text{C} & \text{---} & \text{COOH} \\ & & & & & & & & \\ & & \text{H} & & \text{O} & & \text{H} & & \text{H} \end{array}$		
/ or ecf which clearly shows the idea of amino acids swapping ✓		[5]
[Total: 11]		

- 2 (a) A phenol ✓ B ketone / Carbonyl ✓ NOT 'hydroxyl' for A or C
C (secondary) alcohol ✓ [3]
- (b) (i) B / ketone / carbonyl ✓ [1]
(ii) yellow/orange/red ✓
precipitate/crystals/solid ✓ [2]
(iii) (gingerol would not react because) ...
it does not contain an aldehyde group /
only aldehydes can react with Tollens' Reagent / only aldehydes can be easily oxidised /
ketones cannot be oxidised further ✓ NOT just "ketones don't react" etc [1]
- (c)  / phenol / A do not penalise the CH₃O- if included [1]
- (d) (i) bromination of the benzene ring ✓
eg  other functional groups unaffected ✓ [2]
(ii) HBr / hydrogen bromide [1]
- (e) Peak at 3400cm⁻¹ labelled O-H ✓
Peak at 1700cm⁻¹ labelled C=O ✓ if more than two peaks labelled, mark incorrect peaks first [2]
- (f) (i) same structural / displayed formula /
same order of bonds ✓
different spatial /3-d arrangement ✓ [2]
(ii) optical isomerism ✓ [1]

[Total: 16]

3 (a) (i) (conc) H ₂ SO ₄	NOT just H ⁺ / acid or anything suggesting the acid is dilute [1]
(ii) to prevent loss (of reactants / products) by evaporation / vapours AW	[1]
(b) (i) 	
correct displayed ester group ✓ 	[2]
rest of the structure also correct ✓	
(ii) butan-2-ol ✓	: NOT just butanol [1]
(c) flavouring / perfume	: NOT any solvent type uses such as nail-varnish nor medicines etc [1]
[Total: 6]	

4 (a) % O = 45.1 ✓

$$\begin{array}{l} C = 50.7/12.0 = 4.2 \qquad 4.225 / 2.819 = 1.499 \approx 1.5 = 3 \\ H = 4.2 / 1.0 = 4.2 \qquad 4.2 / 2.819 = 1.490 \approx 1.5 = 3 \\ O = 45.1 / 16.0 = 2.8 \text{ (ecf)} \qquad 2.819 / 2.819 = 1.000 = 1.0 = 2 \\ \text{calculation of moles } \checkmark \end{array}$$

$C_3H_3O_2$ clearly deduced from the ratio of moles ✓

NOT any method
which works back from
the molecular formula [3]

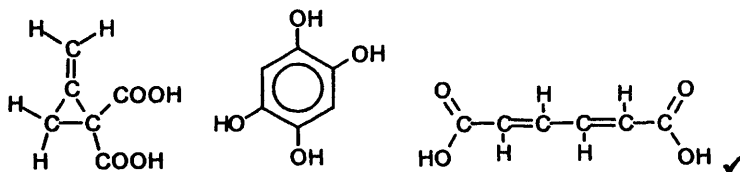
(b) (i) empirical formula has $M_r = 36 + 3 + 32 = 71$ (or ect) ✓

2 x empirical $M_r = 142$ / within range 138-144 ✓

Only allow ecf on 2nd
Mark if 2 x M_r is still
138 - 144 [2]

(ii) mass spectrometry ✓ [1]

(c) any valid structure eg

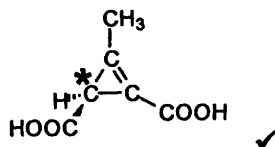


[1]

(d) (i) carbon with 4 different groups attached ✓

Allow "functional
groups" [1]

(ii)



[1]

(e) (i) carboxylic acid / COOH protons

NOT "OH protons" [1]

(ii) D replaces protons on OH groups/ OH protons are labile ✓
Peak for (CO) OH protons disappears ✓

[2]

(iii) (E is correct structure because ...)

peaks Y and Z are due to two (equivalent) protons ✓

ignore which they
assign to peaks Y and Z

EITHER COMPARING PEAK AREAS...

structure E has groups: = CH₂ / two CH ✓
structure F would give a peak with area 3 / area 1

ignore any reference
to shift values or (lack
of) splitting

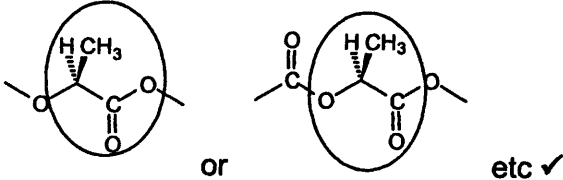
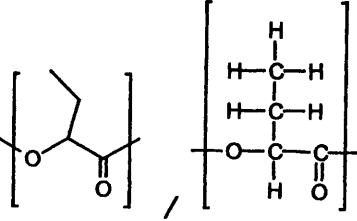
OR COMPARING THE NUMBER OF PEAKS...

structure E has three environments / H_{a1} H_{b1} H_c are labelled
on the structure ✓

structure F would give four peaks (incl. COOH)

[3]

[Total: 15]

5 (a)	stage 1 HCN and KCN ✓ nucleophilic addition ✓ $\text{CH}_3\text{CHO} + \text{HCN} \longrightarrow \text{CH}_3\text{CH}(\text{OH})\text{CN} \quad \checkmark$	allow KCN with HCl/H ₂ SO ₄ or HCN with NaOH for the first two marks, but acid / alkali does not score on its own.	[8]
	stage 2 (named) dilute acid /H ⁺ (aq) ✓ heat/reflux ✓ hydrolysis ✓ $\text{CH}_3\text{CH}(\text{OH})\text{CN} + 2\text{H}_2\text{O} \longrightarrow \text{CH}_3\text{CH}(\text{OH})\text{COOH} + \text{NH}_3$ Or including H ⁺ on the left to give NH ₄ ⁺ ✓	reagents and conditions can be on either line	
(b) (i)	condensation ✓		[1]
(ii)			[1]
(iii)	(fermentation because ...) natural processes (often) produce one (optical) isomer ✓ synthetically gives a mixture of (both optical) isomers ✓	Allow "racemic"	[2]
(c) (i)	poly(propene), poly(phenylethene) etc ✓	must be a hydrocarbon allow new or old names	[1]
(ii)	atactic ✓ syndiotactic ✓		[2]
(d)	a correct repeat of a polyester with 'sticks' / bracketed ... the ester bond displayed/skeletal ✓ side chain / hydrogens also correct and the repeat shows only one monomer ✓	Do NOT allow H or OH at either end if no brackets	
			[2]

[Total: 17]

<p>6 (a) ethylamine/bases react with/accept a proton/H^+ ✓ to give $C_2H_5NH_3^+$ ✓ (using the) lone pair of electrons on the N atom of the amine / lone pair shown on N of a correct structure of the amine ✓ a dative covalent bond forms between N and H / curly arrow shown from lone pair towards H^+ / dative bond shown from N to H ✓</p>	<p>must be stated somewhere</p> <div style="text-align: center;"> <p>$C_2H_5\ddot{N}H_2$ or $C_2H_5\overset{\cdot}{N}H_2$</p> </div> <p>could score the last two marks</p> <p style="text-align: right;">[4]</p>
<p>(b) (phenylamine is a weaker base because ...) the phenyl group pulls electrons away from the nitrogen ✓ the lone pair is delocalised / interacts with the π electrons over the ring / or shown in a suitable diagram – eg</p> <div style="text-align: center;"> </div> <p>the lone pair is not donated as easily / is less available / H^+ is not accepted as easily ✓</p>	<p>Must be clear which way electrons are going</p> <p style="text-align: right;">[3]</p> <p style="text-align: right;">[Total: 7]</p>

7 (a) (i) iron / iron(III)bromide / aluminium chloride etc ✓

accept any iron(III) or aluminium chloride/bromide but **NOT** just "iron bromide" [1]

(ii) halogen carrier ✓

accept Lewis but **NOT** "Friedel-Crafts catalyst" [1]

(iii) $C_6H_6 + Br_2 \longrightarrow C_6H_5Br + HBr$

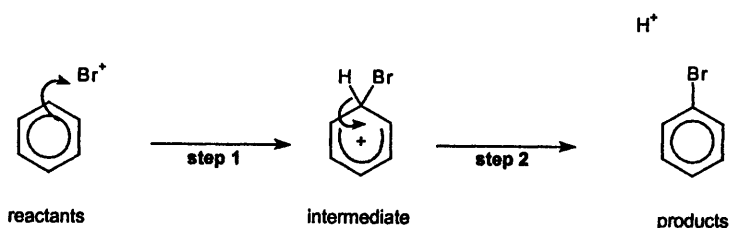
HBr as product ✓
rest of the equation also correct ✓

allow H^+ and Br^-
allow a balanced equation for di or tri but bromination [2]

(iv) bromobenzene

allow name from di or tribromination in (iii) as long as they are correct [1]

(b)



curly arrow from benzene π -bond to Br^+ ✓

correct intermediate ✓
curly arrow from C-H bond to gap in π -bond ✓

H^+ and bromobenzene as products ✓

check curly arrows clearly start and finish at the correct atom / bond
the 'smile' must reach round all 5 carbons with the + clearly not on the tetrahedral carbon

[4]

Question 7 continues overleaf

7 (c) (i) p-orbitals overlap above and below the ring / stated in words or shown in either diagram ✓

correct diagrams of π -bonds in cyclohexene and benzene:



π -bond(s)/electrons are labelled in either diagram or their position is described in words. ✓

π -bonding is drawn: in cyclohexene ✓
in benzene ✓

π -bond(s)/ electrons are labelled in either diagram or their position is described in words ✓

4 marks on π -bonding

[4]

(ii) the negative charge/ π electrons are more spread out / delocalised (in benzene ora) ✓

the bromine is less polarised / a catalyst is needed to polarise the bromine (in benzene ora) ✓

electrophiles / bromine are less attracted (to benzene ora) ✓

more energy is needed (to break the π -bond) due to the delocalisation (in benzene ora)

AW

ANY 3 out of 4 marks explaining the different reactivity

Quality of Written Communication

one mark for the correct use and organisation of the following terms: **p-orbitals, delocalised** ✓

one mark for correct spelling, punctuation and grammar in at least two sentences ✓

[2]

[Total: 18]

Do NOT give the diagram mark if a double bond is also shown

allow any reasonable attempt at the benzene π -bonding, but not a simple



these marks can be gained from the explanation of the relative reactivity of either benzene or cyclohexene but a comparison must be made for each mark

do NOT give the last mark for just saying that benzene is more stable than cyclohexene

max
[3]