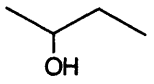
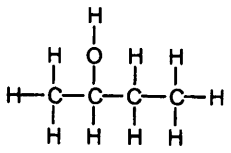
Abbreviations, annotations and conventions used in the mark scheme

/ = 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. CH_3, C_2H_5, OH, COOH, $COOCH_3$) to unambiguously define the arrangement of the atoms. (E.g. C_3H_7 would not be sufficient).

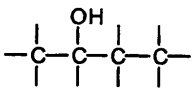
If not specified by the question, this may be given as either:

- a **structural formula** – e.g. $CH_3CH(OH)C_2H_5$,
- 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.*

Qu.	Expected answers:	Marks:

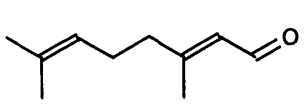
1 **(a) (i)** alkene / C=C double bond
(primary) alcohol / hydroxy(l) ✓ **[1]**

(b) (i) molecules with the same structure / order of bonds ... but different arrangements in space / 3-D arrangment ✓ **[1]**

(ii) cis-trans / geometric ✓ **[1]**

(iii) the double bond does not rotate ✓ **[1]**

(iv) same groups at one end / need different groups at both ends of the C=C ✓ **AW** **[1]**

(c) (i) 

a correct skeletal aldehyde is shown on C_1 ✓

rest of the skeletal structure (C_2-C_{10})correct ✓ **[2]**

(ii) $C_9H_{15}CH_2OH + [O] \longrightarrow C_9H_{15}CHO$ ✓ $+ H_2O$ ✓

NOT COH, allow $C_{10}H_{16}O$ **[2]**

(d) (i) flavouring / fruity smell etc

NOT perfume or sweetener **[1]**

(ii) conc H_2SO_4 ✓
reflux/ distil ✓ **[2]**

(iii) $CH_3COOH + C_9H_{15}CH_2OH \longrightarrow CH_3COOCH_2C_9H_{15} + H_2O$
✓ ✓ ✓

allow $C_2H_4O_2$ and $C_{12}H_{20}O_2$ but **NOT** wrong structures
allow ecf on the wrong acid **[3]**

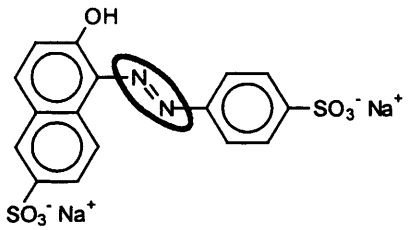
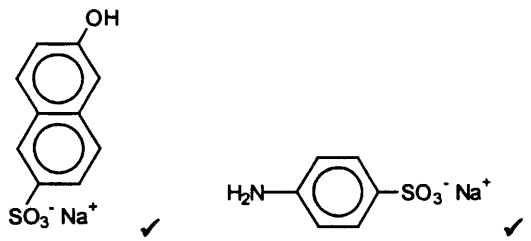
(e)

wavenumber range (cm^{-1})	3230-3550 (for OH)	1680-1750 (for C=O)	1000-1300 (for C-O)
geraniol	present ✓	(absent)	present ✓
aldehyde Y	(absent)	present ✓	(absent)
ester Z	(absent)	present ✓	present ✓

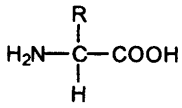
[5]

[Total: 20]

Qu.	Expected answers:		Marks:
2 (a)	any two of ... fibres / dyes / explosives / pharmaceuticals etc ✓✓	allow any specific examples as long as they do involve aromatic nitro or amine groups – eg **NOT** nylon, fertiliser etc	[2]
(b)	temp 50-60° ✓ concentrated (acids) ✓	allow abbreviations for concentrated	[2]
(c)	$C_6H_6 + HNO_3 \longrightarrow C_6H_5NO_2 + H_2O$ reactants ✓ products ✓	allow a balanced equation for multiple nitration at any positions	[2]
(d) (i)	a pair of electrons ... ✓ ... (electrons) move / transferred / a (covalent) bond breaks/forms ✓		[2]
(ii)	it accepts a pair of electrons (from the benzene) ✓	**NOT** a 'lone' pair	[1]
(iii)	H(+) (on the ring) is replaced by NO_2(+) ✓	allow 'substitutes' ignore + charges	[1]
(iv)	it is not used up / reformed at the end **AW** ✓		[1]
(e)	π-bonding electrons are <u>delocalised</u> ✓ **six** π-electrons in benzene ✓ **four** π-electrons in the intermediate ✓		
	π-electrons are not over one carbon atom / over **five** carbon atoms / p-orbitals in the intermediate ✓ π-electrons are over the **complete** ring / **all around** the ring **all six** carbon atoms/ p-orbitals overlapping ✓	this must be stated in words to compare benzene and the intermediate	
	Quality of written communication for at least two sentences/statements with legible text and correct spelling, punctuation and grammar ✓		[6]
			[Total: 17]

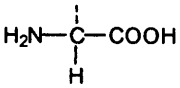
Qu.	Expected answers:	Marks:
3 (a)	**1st stage** aromatic amine / named aromatic amine / structure ✓ sodium nitrite / nitrous acid ✓ HCl/H_2SO_4 (but not conc) $/H^+$ ✓ at <10°C ✓ which forms a diazonium salt / ion ✓ **2nd stage** the product from the first stage mixed with the phenol **AW** ✓ (in excess) hydroxide / alkali ✓ if more than four are given, mark any wrong reagents, conditions first allow correct formulae for the reagents	[7]
(b) (i)	 ✓ allow any benzene rings as well as N=N circled, as long as no other groups are	[1]
(ii)	...16... carbon and .....10..... hydrogen atoms ✓ ✓	[2]
(c)	Na / NaOH / OH^- etc ✓	[1]
(d)	 ✓ ✓ allow 1 mark if they are both correct, but in the wrong boxes only penalise a slip with SO_3^- Na^+ once	[2]
		[Total: 13]

Qu.	Expected answers:	Marks:

4 (a) (i) $H_2NCHRCOOH$ /  ✓

allow R CH NH_2 and COOH in any order

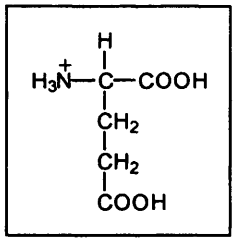
[1]

(ii) they both have the  group / or in words ✓

NOT just "they both have NH_2 and COOH"

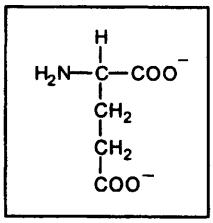
R group is H in glycine and CH_2CH_2COOH in glutamic acid ✓

[2]

(b) 

$-NH_3^+$ ✓

-COOH and side chain unaffected ✓



one $-COO^-$ ✓

both $-COO^-$ ✓

H_2N- and rest of molecule ✓

[5]

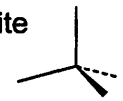
(c) glutamic acid/molecule with optical isomers ...

... is <u>chiral</u> ✓

... has four different / distinguishable groups attached to a carbon ✓

... the mirror images/isomers cannot be superimposed **AW** ✓

NOT just "different atoms"

one diagram showing **two** 3-D bonds not opposite each other, and not with angles looking like 90°  ✓

3-D diagram of the other isomer (allow ecf on one 3-D error) ✓

all groups correctly connected for glutamic acid in both diagrams ✓

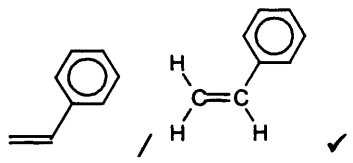
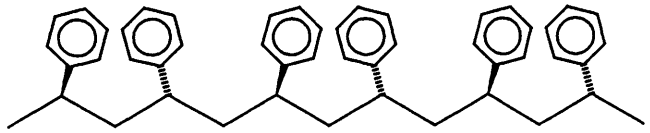
glycine
only has three different groups / two groups are the same / 3-D diagram used to show symmetry ✓

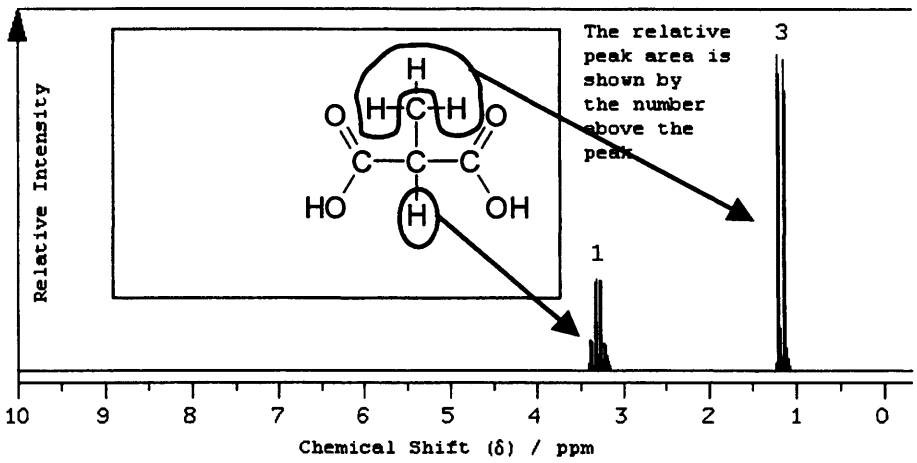
7 marks

quality of written communication
for correct use and organisation of at least **one** technical term:
*(in the correct place), non-superimposable, enantiomer, stereoisomer(ism), tetrahedral, assymetric ✓

[8]

[Total: 16]

Qu.	Expected answers:	Marks:
5 (a) (i)	addition (polymerisation) ✓ **NOT** additional	[1]
(ii)	 / ✓	[1]
(iii)	π-bond breaks ✓ **many** molecules join / a **long** chain forms / equation to show this using 'n' ✓	[2]
(b)	alternating ✓  all four side groups placed above the chain with an alternating arrangement clearly shown by use of 3-D bonds ✓✓ where 1 mark is for an incorrect diagram, but "(alternating) 3-D /spacial arrangement of side chains" stated in words	[3]
(c)	atactic has side chains irregular / random(ly arranged in space/3-D) ✓ **ora** atactic has weaker intermolecular / Van der Waals' forces between the chains ✓ **ora** **NOT** just "weaker bonds" chemically sensible suggestion why irregular side chains could give weaker forces – eg because chains can't get as close / less surface contact ✓ **AW ora**	[3]
		[Total: 10]

Qu.	Expected answers:	Marks:
6 (a) (i)	Find the m /e of .... ✓ ... the peak furthest to the right / with highest m /e or mass ✓	allow attempts to cater for the ^{13}C peak [2]
	$C_2H_3O_2$ /empirical formula has M_r = 59 ✓ so M_r of molecular formula is $^{118}/_{59}$= 2 /twice the empirical formula ✓	[2]
(b) (i)	OH peak disappears (with D_2O / on the second spectrum)	[1]
(ii)		
	peak at 3.3ppm identifed as due to the CH ✓	assignment must be for this structure (not just R-CH_3 etc)
	peak at 1.2ppm identified as due to the CH_3 ✓	
	protons (and not the carbon) on the groups are identified ✓	can be by Ha, Hb etc
	relative peak areas / numbers above the peaks show ... the number of (equivalent) protons in each group / three protons on one carbon and one on the other carbon ✓ **AW**	
	quadruplet / 1:3:3:1 splitting (of the peak at 3.3ppm) shows... three protons on the neighbouring/adjacent carbon ✓	
	doublet / 1:1 splitting (of the peak at 1.2ppm) shows ... one proton on the neighbouring /adjacent carbon ✓	[6]
(iii)	no of peaks: one ✓	if the wrong structure is chosen allow ecf for: two peaks ✓, splitting ✓✓ (as last 2 marks for part (ii)) [3]
	splitting: none ✓	
	all four protons equivalent / in the same environment ✓	
		[Total: 14]