Question Number	Correct Answer	Mark
1 **(a)**	A	**1**

Question Number	Correct Answer	Mark
1 **(b)**	A	**1**

Question Number	Correct Answer	Mark
1 **(c)**	D	**1**

Question Number	Correct Answer	Mark
2	B	**1**

Question Number	Correct Answer	Mark
3	**D**	**1**

Question Number	Correct Answer	Mark
4	**C**	**1**

Question Number	Correct Answer	Mark
5	**D**	**1**

Question Number	Correct Answer	Mark
6	**D**	**1**

Question Number	Correct Answer	Mark
7	B	**1**

Question Number	Correct Answer	Mark
8	C	**1**

Question Number	Correct Answer	Mark
9	A	**1**

Question Number	Correct Answer	Mark
10	C	**1**

Question Number	Correct Answer	Mark
11	B	**1**

Question Number	Correct Answer	Mark
12	C	**1**

Question Number	Correct Answer	Mark
13	D	**1**

Question Number	Correct Answer	Mark
14	C	**1**

Question Number	Correct Answer	Mark
15	D	**1**

Question Number	Correct Answer	Mark
16	D	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)	Q: O-H ALLOW OH – O – H **(1)** R: C=O ALLOW – C = O | – C = O **(1)** IGNORE names ACCEPT answers written on spectrum	Just 'alcohol' — OH Just 'carbonyl' – C O | C-O	**2**

Question Number	Acceptable Answers	Reject	Mark
(b) (i)	Y = methanol / CH_3OH **(1)** Any two of the following: Molecular ion / M^+ / M_r / CH_3OH^+ / methanol = 32 CH_3^+ = 15 CH_3O^+ / CH_2OH^+ = 31 $CHOH^+$ / CH_2O^+ =30 COH^+ = 29 CO^+ = 28 **(1)** Charges not required TE in second mark for two correct possible peaks from an incorrect compound.		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b) (ii)	Two **(1)** This mark may be scored if two shifts are given. Any two shifts correctly identified: -O**H** at 2.0-4.0 / any value in this range **H**-C-O at 3.0- 4.2 / any value in this range **H** in C**H**$_3$ OH at 3.39 (ppm) **(1)** Allow TE for ethanol with three peaks **(1)** and three correct shift values: -O**H** at 2.0-4.0 / any value in this range **H**-C-O at 3.0- 4.2 / any value in this range CH in an alkane at 0.1-1.9 **(1)**	CH in an alkane at 0.1–1.9 Just CH_3 OH at 3.39	**2**

Question Number	Acceptable Answers	Reject	Mark
(c) (i)	Z contains two –OH/ one alcohol + one acid ALLOW two alcohol groups / is a diol		**1**

Question Number	Acceptable Answers	Reject	Mark
(c) (ii)	Z is an acid / contains –COOH / contains $-CO_2H$/ contains a carboxylic acid group / contains H^+		**1**

Question Number	Acceptable Answers	Reject	Mark
(c) (iii)	Z is a secondary alcohol/ a ketone is **formed** from **Z** / Z contains –C(H)(OH)– **(1)**	**Z** is a ketone	**1**

Question Number	Acceptable Answers	Reject	Mark
(c) (iv)	(Iodoform produced) so **Z** contains CH_3 CH(OH)- TE if **Z** is identified as a ketone in (iii): **Z** contains CH_3 C=O / **Z** is a methyl ketone		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (d)	Answers will be based on several pieces of information (molecular formula, products of ester hydrolysis, answers to (c)) which may be contradictory if errors have been made. ALLOW TE marks for formulae which are chemically possible (ie no 5 bonded carbons etc) and based on most of the deductions but **not necessarily all**. **Z** is $CH_3CH(OH)CH_2COOH$ **(1)** Stand alone mark ALLOW TE for an **acid** with OH in wrong position in **Z** if oxidation product identified as aldehyde TE for **Z** = CH_3COCH_2COOH if identified as ketone in (iii) **X** is $CH_3CH(OH)CH_2COOCH_3$ **(1)** Stand alone mark TE for a methyl ester of **Z**		**2**

Question Number	Acceptable Answers	Reject	Mark
18 (a) (i	Transesterification ~~Ethanol transesterification~~	~~Substituted esterification~~	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (a) (ii)	To prevent hydrolysis/ to stop fatty acids forming / to stop breakdown of esters / water reacts with esters/ water is a better nucleophile than ethanol	To dilute ethanol Ethanol would react with water A reaction would occur (unspecified)	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b)	(Vegetable) Fats/ oils are renewable (crude oil is not) / biodiesel comes from a renewable source / doesn't use up fossil fuel resources/ carbon footprint is less / (closer to) carbon neutral / growing vegetables absorb CO_2 If more than one answer is given, and one is incorrect, no mark Ignore comments on biodegradability	Just "made from plants" Just "crude oil is not sustainable" Less polluting produces less greenhouse gases / less CO_2 Burns more cleanly Requires less energy for production	**1**

Ouestion Number	Acceptable Answers	Reject	Mark
(c)	Substances to be separated have different (forces of) attraction to / affinity for / solubilities in / adsorption to one or both of the mobile and stationary phases OWTTE **(1)** ALLOW absorption GC: **mobile** phase a (inert / unreactive) **gas** OR GC: **mobile** phase nitrogen / helium / argon / other named inert gas **(1)** GC: **Stationary** phase a **liquid** (on an (inert) solid) / a solid **(1)** HPLC: **stationary** phase a **solid** / silica **(1)** HPLC: **mobile** phase a **liquid** **(1)**	Different retention times without a reason why Different volatilities Different masses Different reactivity Different reactions Different interactions	**5**

TOTAL FOR SECTION C = 20 MARKS

Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	C 60/12 = 5 H 8/1 = 8 O 32/16 = 2 ALLOW 1 mol = 100 g So 60 %C = C_5, etc		**1**

Question Number	Acceptable Answers	Reject	Mark
(a)(ii)	**C=C** **Test** : add bromine water/Br_2(aq) **(1)** **Result**: From yellow/brown/red-brown/orange to colourless/decolorises **(1)** OR **Test** : add (acidified) potassium manganate((VII)) (solution) **(1)** **Result**: goes from pink/purple to colourless/brown **(1)** **Test** : add alkaline potassium manganate((VII)) (solution) **(1)** **Result**: goes green **(1)** **COOH:** **Test** : add $NaHCO_3$ /Na_2CO_3/sodium carbpnate (solution) **(1)** **Result**: Fizzes/bubbles/large volume neutralized **(1)**	Bromine/Br_2/Br_2(l) clear for colourless clear for colourless PCl_5 /$LiAlH_4$ as test NaOH/NaOH(aq) colourless gas evolved	**4**

	ALLOW gas given off that turns limewater cloudy OR **Test** : with **blue** litmus **(1)** **Result**: turns red **(1)** The test can be with any other indicator, including universal indicator, with the correct initial and final colour ALLOW pH meter **(1)** pH 4-6 **(1)** OR **Test** : add ethanol with conc H_2SO_4 (and warm) **(1)** **Result**: gives pleasant/fruity smell of ester **(1)** OR **Test:** add magnesium **(1)** **Result:** fizzing/bubbles etc (of hydrogen) **(1)** ALLOW gas given off that burns with a squeaky pop	Add sodium colourless gas evolved	

Question Number		Reject	Mark
19 (b)(i)	Explanation of precedence/priority in terms of atomic numbers/masses of the attached groups OR Highest-precedent/priority groups on each carbon are on opposite sides of the molecule **(1)** *E*-/entgegen **(1)** Mark independently	Both CH_3/methyl groups on the same side so Z (0/2)	**2**

Question Number	Acceptable Answers	Reject	Mark
(b)(ii)	45 $COOH^+$ /CO_2H^+ **(1)** 55 $C_4H_7^+$ OR $C_3OH_3^+$ **(1)** ALLOW Structural/displayed formulae of ions Absence of + charge (1 max)		**2**

Question Number	Acceptable Answers	Reject	Mark
(b)(iii)	If they say yes **(0)** (No) (Cleavage of the C—COOH bond in) both compounds gives fragment(s) of the same mass OR Both give the same peak(s)/fragment(s) Both give CO_2H^+/ $C_4H_7^+$ fragments The mark can be scored by referring to just one of the fragments/peaks/masses.	'No' on its own	**1**

Question Number	Acceptable Answers	Reject	Mark
***19(c)(i) QWC**	**C** is CH_3CHO (alone) **(2)** **D** is $CH_3COCOOH$ (alone) **(2)** so tiglic acid must be **B** **(1)** tiglic acid mark can only be awarded if correct structures of either **C** or **D** are given. **Any one of the following** **C** must be an aldehyde **(1)** **D** is a ketone **(1)** Mention that CH_3CO present in either/both compounds (because of formation of iodoform) **(1)** If one or both of the structures are incorrect any of the last 3 marks can be awarded max 5 If C and D are fully correct, but the wrong way round max 5	CH_3COH **1 max**	**6**

Question Number	Acceptable Answers	Reject	Mark
(c)(ii)	Doesn't distinguish *E*- isomer from *Z*-isomer/geometric isomers (so no) OR Doesn't distinguish which sides of C=C functional groups are on	Just isomers/ stereoisomers/ enatiomers	**1**

Question Number	Acceptable Answers	Reject	Mark
(d)(i)	CH_3CHO **(1)** ACCEPT displayed or skeletal **Step 1** (heat)using acidified potassium dichromate/or $H^+/Cr_2O_7^{2-}$ **(1)** distil (product as formed) conditional on dichromate **(1)** **Step 2** HCN with KCN OR KCN with H^+/acid OR KCN with (cold) NaOH(aq)/alkali **(1)** ALLOW HCN with NaOH/alkali For step 2 Ignore conditions e.g. any references to heat	CH_3COH Manganate VII/$KMnO_4$ Reflux HCN alone	**4**

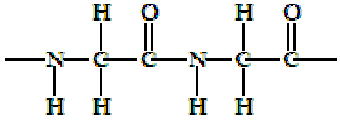
Question Number	Acceptable Answers	Reject	Mark
(d)(ii)	**Nucleo**philic addition Any recognisable spelling of 'philic' and addition, either order **Both** words needed	**Nutro**philic addition Any other or additional words	**1**

Question Number	Acceptable Answers	Reject	Mark
***19(d)(iii) QWC**	Ethanal is planar (at the reaction site) OR Ethanal is a planar molecule **(1)** Attack (from CN^- to give the cyanohydrin) is (equally likely) from either side/above or below/from both sides (of the molecule) (so a racemic mixture is formed) **(1)** Mark independently	Intermediate is planar Square planar Can attack carbocation from either side/any reference to SN1/SN2	**2**

Question Number	Acceptable Answers	Reject	Mark
(d)(iv)	Receptors for the compound in the body are often stereospecific so only one stereoisomer is pharmacologically active OR Body recognises one (stereo)isomer ALLOW Only one (stereo)isomer is active OR One/the other isomer may be toxic/dangerous/harmful OR One isomer destroys body cells OR (Different) isomers have different biological/pharmacological/biochemical properties		**1**

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	Formula showing $-NH_3^+$ and $—COO^-$ /$—CO_2^-$ Charges can be anywhere on functional group Rest of the molecule must be correct ALLOW displayed/part displayed formula		**1**

Question Number	Acceptable Answers	Reject	Mark
(a)(ii)	**Any two from** High energy needed (to overcome) **(1)** strong ionic/electrostatic forces OR strong forces between oppositely charged ions/between positive and negative **(1)** between **different** (zwitter)ions OR between $-NH_3^+$ and $—COO^-$ OR between one molecule and another OR Chains of zwitterions/molecules **(1)**	any reference to intermolecular forces eg (strongly) polar/bond polarity if they state the ionic bond is within the same molecule	**2**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	 Correct peptide link **(1)** Minimum two residues and extension to the rest of the molecule **(1)** ALLOW $-NHCH_2CONHCH_2CO-$ **(2)** Drawn the other way round, i.e. starting with the carbonyl group Brackets around outside with 'n' ie $\lceil.....\rceil_n$ ~~Second mark depends on first~~		**2**

Question Number	Acceptable Answer	Reject	Mark
***20(b) QWC**	**Key Points** **KP1** Spot (of hydrolysate) on paper/tlc/thin layer chromatogram **(1)** **KP2** Marker spots of known amino-acids/measure R_f **(1)** **KP3** Run in (suitable) solvent/discussion of comparative solubilities in phases **(1)** **KP4** (Spray with) ninhydrin (and heat) [Stand alone mark] **(1)** **KP 5** Marker spots and the unknown spots correspond ALLOW Compare R_f values of marker spots with hydrolysate spots **(1)** OR If 2-d chromatography used (2 different solvents run in two directions at right angles): **KP1** Spot (of hydrolysate) on paper/tlc/thin layer chromatogram **(1)** **KP2** Run in (suitable) solvent in one direction **(1)** **KP3** Develop in suitable/different solvent at right angles OR discussion of comparative solubilities in phases **(1)** **KP4** Spray with ninhydrin (andheat) **(1)** **KP5** Compare hydrolysate spots with same experiment for known amino acids **(1)** OR	Spot one amino acid/protein Water alone as solvent Spot one amino acid	**5**

	if column/GLC/GC used **KP1** Put amino acid mixture **(**Hydrolysate) into column **(1)** **KP2** Separately known amino-acids into column **(1)** **KP3** Detect amino acids in effluent with Ninhydrin/mass spectrometry **(1)** **KP4** Measure retention times/ discussion of comparative solubilities in phases **(1)** **KP 5** Compare retention times **(1)**	Spot one amino acid	

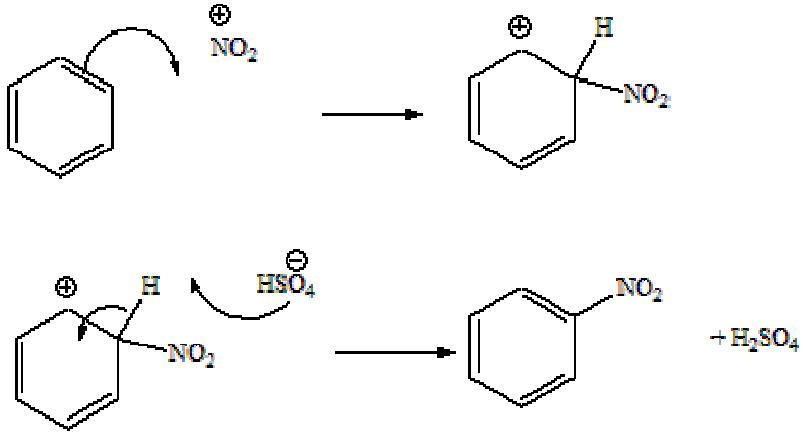
S

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	Not knowing the structure of the molecule (means that the reactions/reagents/reactants needed to make it are also unknown) ALLOW Structure not known		**1**

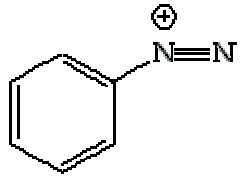
Question Number	Acceptable Answers	Reject	Mark
(a)(ii)	Credit any reasonable arguments for example: **First mark** No longer any demand for madder/indigo OR Cheaper alternatives available **(1)** **Second mark** So the growing industries collapsed OR no market for crops OR farmers had to grow alternative crops OR decreased employment OR economic damage OR decreased GDP OR Loss of export **(1)**		**2**

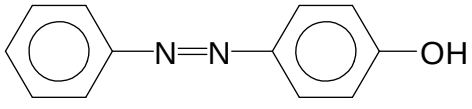
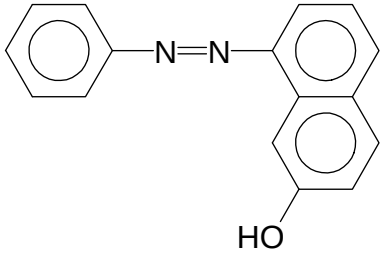
Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	**First mark** Double bonds expected to react with bromine water turning it colourless OR Bromine water remained yellow/orange/red/brown **(1)** **Second mark** So benzene does not contain double bonds OR Double bonds not normal/not simply double bonds/any indication that double bonds are different OR His representation incorrect **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
(b)(ii)	The p/pi-/π/6 electrons (of carbon) OR π system **(1)** Electrons are delocalised around the ring **(1)** Which gives the molecule greater stability/need more energy to break the bonds in benzene (and hence a less exothermic hydrogenation enthalpy) Allow it is more stable **(1)**	Harder to break/disrupt [alone]	**3**

Question Number	Acceptable Answers	Reject	Mark
21(c)	$2H_2SO_4 + HNO_3 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ **(1)** OR $H_2SO_4 + HNO_3 \rightarrow NO_2^+ + H_2O + HSO_4^-$ OR $H_2SO_4 + HNO_3 \rightarrow H_2NO_3^+ + HSO_4^-$ **and** $H_2NO_3^+ \rightarrow NO_2^+ + H_2O$ **Charges are needed for first mark**  Attack on nitronium ion arrow must start on or in the benzene **(1)** Wheland intermediate Can be a part, but not complete circle, in correct place inside ring BUT part circle must cover minimum of 3 carbon atoms AND must not include where nitro group is attached and must positive charge somewhere **(1)** **Either but only one of first two marks can be lost if bond is clearly to oxygen** Arrow from H bond into the ring to produce either H^+ or H_2SO_4 and return to aromaticity **(1)**		**4**

Question Number	Acceptable Answers	Reject	Mark
21(d)(i)	< 0^{o} C/temperature too low: reaction too slow/insufficient energy to overcome activation energy **(1)** > 10^{o} C/temperature too high: diazonium ion decomposes/produces phenol **(1)**	Will not take place	**2**

Question Number	Acceptable Answers	Reject	Mark
(d)(ii)	 Positive charge can be on either N Cl^- may be given as well ALLOW circle in benzene ring and hydrogens/carbons displayed OR ---N=N^+ Is acceptable providing charge is on the end N	 Positive charge on wrong N	**1**

Question Number	Acceptable Answers	Reject	Mark
(d)(iii)	Adds phenol in sodium hydroxide/OH^-/alkali ALLOW 2-naphthol in sodium hydroxide/OH^- /alkali **(1)** Correct structure for the -N=N- bond between 2 benzene rings **(1)** Remainder of molecule **(1)** which is either:  ALLOW anionic form of —OH OR if 2-naphthol is used it is:  	Ignore position of –OH group on the ring	**3**

Question Number	Acceptable Answers	Reject	Mark
21 (e)	**First mark** $—SO_3^-$ are solvated / hydrated Can be drawn with polar H of water OR Negative ion bonds with/attracted to water **(1)** **Second mark** **Nitrogen/oxygen** atoms **hydrogen-bonded** (to water) Can be drawn **(1)**	Just sodium ions attracted to water	**2**