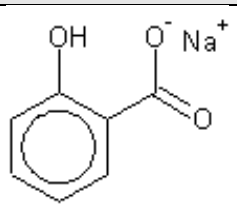
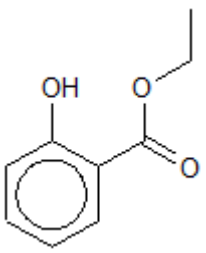
Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	 → + CH_3OH ALLOW COO^-Na^+ for carboxylate group Skeletal drawing —OH for methanol Ignore omission of charges	O—$Na^{(+)}$	**(1)**

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	No more precipitate formed / No more solid formed / solution turns universal indicator paper red / litmus red / pH meter reading below 7 IGNORE Tests involving gas formation with metals or carbonates "No further reaction" **Just** 'use indicator/pH meter'	Precipitate "**disappears**" effervescence fizzing bubbles	**(1)**

Question Number	Acceptable Answers	Reject	Mark
1(b)	(Sparingly soluble because of) the London forces between **the rings** / between **the molecules** ALLOW van der Waals' forces / induced dipole / instantaneous dipole-induced dipole / temporary dipoles for London forces Ignore references to **permanent** dipoles **(1)** Hydrogen bonds between salicylic acid **and water** (which increases solubility) **(1)** IGNORE Any mention of "hydrophobic"		**(2)**

Question Number	Acceptable Answers	Reject	Mark
1(c)	Any three from (Acid hydrolysis) The acid is a catalyst (not a reagent) OR The reaction is reversible / is an equilibrium reaction / does not go to completion / produces lower yield **IGNORE** References to number of steps (needed to produce product) OR Produces the (carboxylic) acid (not its salt) OR The H^+ is an electrophile (and the OH^- nucleophile) ALLOW reverse arguments		**(3)**

Question Number	Acceptable Answers	Reject	Mark
1(d)(i)	**A** PCl_5/$SOCl_2$/ PCl_3 **(1)** **B** $LiAlH_4$ **(1)** ALLOW names for A and/or B **C**  Allow $COOC_2H_5$ / $COOCH_2CH_3$ for ester group **(1)**	HCl $NaBH_4$	**(3)**

Question Number	Acceptable Answers	Reject	Mark
1(d)(ii)	Any two from four differences: Compound D produces hydrogen chloride **and** not water OR Compound D reacts irreversibly not reversibly / goes to completion / produces higher yield OR Compound D reacts faster / more vigorously / reacts with alcohols without the need for a catalyst or H^+ ALLOW Compound D reacts more exothermically OR Compound D produces only one liquid / produces only one solid product (and so no further separation is needed) **IGNORE** References to heating reagents	 HCl**(aq)**	**(2)**

Question Number	Acceptable Answers	Reject	Mark
1(e)	Three (proton / hydrogen) environments **NOTE**: This must be stated. **(1)** **M2** One singlet **and** one triplet **and** one quartet OR these shown on diagram **(1)** **M3** Splitting is due to (n+1) rule / number of adjacent hydrogen atoms **NOTE**: This must be clearly stated **at least once** in candidate's answer and not contradicted by a wrong splitting pattern **(1)** **M4** (Area ratios of peaks) 3:2:1 stated/or relative order **and** consistent with CH_3:CH_2:OH Can be shown on annotated (displayed) formula of ethanol ALLOW reference to height ratios **(1)** **M5** (Chemical shift values, δ, in ppm) Singlet = 2.0 - 4.0, Triplet = 0.1 - 1.9, Quartet = 3.0 - 4.2 OR shown on diagram Allow any single value, or range of values, within these ranges **(1)**	'adjacent **carbons**'	**(5)**

Question Number	Acceptable Answers	Reject	Mark
1(f)	Because it has **12** protons/ hydrogen atoms in the same environment/are equivalent		**(1)**

Question Number	Acceptable Answers	Reject	Mark
1(g)	Radio waves Ignore electromagnetic radiation	In combination with infrared/microwaves/uv	**(1)**

Question Number	Acceptable Answers	Reject	Mark
1(h)	**Any two from three:** **Salicylic acid** (has O-H at) **3300-2500** (cm^{-1}) Ignore the phenolic OH between 3750-3200 (cm^{-1}) for salicylic acid OR Compound **D** (has C=O at) **1795** (cm^{-1}) **and** **1700-1680** (cm^{-1}) for **salicylic acid** **ALLOW** **1725-1700** (cm^{-1}) for **salicylic acid** OR Compound **D** (has C-Cl at) **800-600** (cm^{-1})	1740-1720 (cm^{-1})	**(2)**

Question Number	Acceptable Answers	Reject	Mark
2(a)(i)	Aldehydes often contain (carboxylic) **acid** formed by oxidation (by the oxygen in air)		**1**

Question Number	Acceptable Answers	Reject	Mark
2(a)(ii)	A larger volume of sodium carbonate solution is neutralized / a larger volume of carbon dioxide forms / faster reaction / more effervescence / more vigorous ALLOW reverse argument for impure aldehyde	(The old stock of) aldehyde does not react	**1**

Question Number	Acceptable Answers	Reject	Mark
2(a)(iii)	$Na_2CO_3(aq) + 2C_3H_7COOH(aq) \rightarrow$ $2C_3H_7COO^{(-)}Na^{(+)}(aq) + CO_2(g) + H_2O(l)$ Correct balanced equation **(1)** Correct state symbols on correct species **(1)** ALLOW $H_2O(aq)$ $C_3H_7COO^{(-)}Na^{(+)}(s)$ $C_3H_7COOH(l)$	$NaCO_3$	**2**

Question Number	Acceptable Answers	Reject	Mark
2(a)*(iv)	3300 -2500 (cm^{-1}) AND O-H (stretching) **(1)** 1725 – 1700 (cm^{-1}) AND C=O (stretching) **(1)** ALLOW single numbers or ranges within these ranges ALLOW 1300-1250 (cm^{-1}) AND C-O in COOH Very broad (O-H) due to hydrogen bonding **(1)**	COOH (group) COOH (group) Hydrogen Bonding in C=O	**3**

Question Number	Acceptable Answers	Reject	Mark
2(a)(v)	**First mark** (stand alone) 4 peaks OR 4 hydrogen environments ALLOW 4 chemical shifts **(1)** **Second and Third Marks** Splitting pattern: ($CH_3CH_2CH_2COO\underline{\mathbf{H}}$) singlet /1 line ($CH_3CH_2C\underline{\mathbf{H_2}}COOH$) triplet / three lines ($CH_3C\underline{\mathbf{H_2}}CH_2COOH$) sextuplet / sextet / six lines ($C\underline{\mathbf{H_3}}CH_2CH_2COOH$) triplet / three lines All four correct **(2)** any three **(1)** ALLOW No splits, 2 splits, five splits, 2 splits scores 2 1,3,6,3 'splits' scores 1 mark	 1 split 3 splits 6 splits 3 splits	**3**

Question Number	Acceptable Answers	Reject	Mark
2(b)	Start pH at 2.9 ALLOW 2—4 **(1)** Initial sharp rise to buffer region then vertical section at 25 cm^3 ALLOW Gradual rise to vertical section at 25 cm^3 **(1)** Vertical within pH range 6-11 **and** 2.5-4 units long **(1)** End pH value in range 12-13 **(1)**	 Horizontal from start deviation from vertical maximum before final pH Graph ending before 50cm^3	**4**

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	White / steamy / misty fumes ALLOW 'gas' for fumes IGNORE correct indicator test on product	White smoke Effervescence Just 'fumes' Just 'gas'	**1**

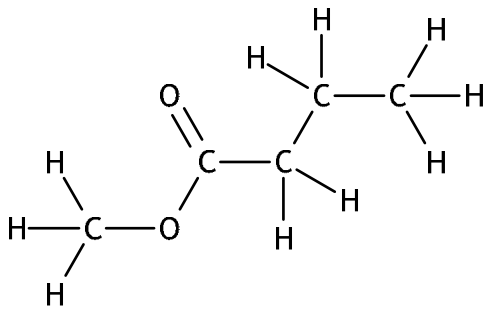
Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	$CH_3CH_2CH_2COCl$ **(1)** ALLOW displayed formula butanoyl chloride **(1)** ALLOW Butanyl chloride No TE on incorrect structure	C_3H_7COCL Butyl Chloride Buthyl Chloride	**2**

Question Number	Acceptable Answers	Reject	Mark
2(d)(i)	Butan-1-ol OR $CH_3CH_2CH_2CH_2OH$ If 2 answers are given both must be correct	Butanol Butanal C_4H_9OH	**1**

Question Number	Acceptable Answers	Reject	Mark
2(d)(ii)	(Dry) Ethoxyethane / diethylether / Ether OR $C_2H_5OC_2H_5$ / $CH_3CH_2OCH_2CH_3$ If 2 answers are given they must both be correct		**1**

Question Number	Acceptable Answers	Reject	Mark
2(d)(iii)	The responses are in pairs: a type (1) and an **associated** justification (1) Reduction (of butanoic acid) **(1)** By addition of hydrogen / loss of oxygen **(1)** **OR** Oxidation of lithium tetrahydroidaluminate / aluminium hydride / $LiAlH_4$ **(1)** By addition of oxygen **(1)** **OR** (Nucleophilic) addition **(1)** of hydride / H^- **(1)** **OR** Redox **(1)** Because butanoic acid has been reduced AND $LiAlH_4$ has been oxidised **(1)**	Any substitution Electrophilic addition	**2**

Question Number	Acceptable Answers	Reject	Mark
2(e)(i)	(Concentrated / dilute) sulfuric / hydrochloric acid ALLOW any **strong** acid ALLOW 'acid (catalyst)' **(1)** (heat or boil under) reflux ALLOW Heat / warm **(1)** Elevated temp$\leq 65^0$C	Just 'catalyst' Just H^+ Just 'boil' Just 'distil' High temperature Increased concentration	**2**

Question Number	Acceptable Answers	Reject	Mark
2(e)(ii)	 All bonds must be shown except ALLOW CH_3 at either end of molecule.	Omitted Hydrogen / sticks	**1**

Question Number	Acceptable Answers	Reject	Mark
2(e)(iii)	Butanoyl chloride / $CH_3CH_2CH_2COCl$ ALLOW Butanyl chloride OR Butanoic anhydride / $(CH_3CH_2CH_2CO)_2O$ OR Specified alkyl butanoate (not methyl butanoate) If name and structure are both given they must both be correct	Butyl Chloride Buthyl Chloride	**1**

Question Number	Acceptable Answers	Reject	Mark
2(e)(iv)	**Advantage** marks are dependent on correct reagent (or near miss e.g. propanoyl chloride) in (iii). No TE on random answer to (iii) eg H_2SO_4 Advantages – any **two** from: Higher yield / goes to completion/ not an equilibrium reaction / not reversible No heat / no refluxing / less energy needed No catalyst needed / faster By-product is a gas (so easier to separate) **(2)** Disadvantage (marked independently of (e)(iii)) any **one** of: (Acyl chloride is) more expensive / corrosive IGNORE Acyl chloride is toxic / hazardous / harmful / difficult to store OR toxic /corrosive **and** HCl /gas / fumes evolved IGNORE harmful/ hazardous/ dangerous OR has lower atom economy **(1)**	Good yield	**3**

Question Number	Correct Answer	Reject	Mark
3 (a)(i)	Methyl propanoate ALLOW methy or methly for methyl		**1**

Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	Toxic (steamy/misty) fumes/ toxic HCl(gas)/corrosive HCl(gas)/toxic propanoyl chloride/lachrymatory propanoyl chloride **(1)** So use in a fume cupboard **(1)** OR Corrosive Propanoyl chloride is **(1)** So wear gloves when handling **(1)**	HCl(aq)/ hydrochloric acid Just harmful/irritant Just harmful/irritant	**2**

Question Number	Acceptable Answers	Reject	Mark
3(b)	Table 0.31, 0.16, 1.41 all 3 scores 2, 2 out of 3 scores 1, 1 or 0 out of 3 scores 0 **(2)** $K_c = \frac{(0.21/V) \times (1.41/V)}{(0.16/V) \times (0.31/V)}$ $K_c = 5.969758$ $K_c = 5.97$ **(1)** IGNORE sf except 1 IGNORE any units ALLOW TE from incorrect values in table.		**3**