Question Number	Acceptable Answers	Reject	Mark
1 (a)	Alcohol; (2)-methylpropan-2-ol **(1)** Catalyst: sulfuric acid OR any named strong acid Ignore concentration of acid **(1)** Accept formula for acid	Formula of alcohol Just acid/H^+ for catalyst	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(i)	Tap funnel / separating funnel	Buchner funnel Filter funnel	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(ii)	To neutralize / remove/ react with (excess) acid Allow To neutralize / remove / react with (excess) H^+ To remove acidic impurities To remove ethanoic acid To remove the acid (used as a) catalyst Ignore additional comments on quenching or reaction stopping	To purify it To remove excess acid **and** alcohol Just "to quench acid catalyst/stop reaction"	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(iii)	Add (anhydrous) calcium chloride/ sodium sulfate/ magnesium sulfate/ Allow silica gel Allow formulae of drying agents	Conc. sulfuric acid Anhydrous copper sulphate Just "silica"	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(iv)	Round bottomed or pear-shaped flask + still head with stopper or thermometer + heat source **(1)** This mark cannot be given if apparatus is completely sealed /large gaps between components Downwards sloping condenser (with correct water flow) **+** collection vessel **(1)** Thermometer in correct position with bulb opposite condenser opening **(1)** Ignore fractionating column if included between flask and condenser	Conical flask Flat bottomed flask	**3**

Question Number	Acceptable Answers	Reject	Mark
***1 (c)**	**First mark** (Two signals so) two hydrogen environments **(1)** This mark may be gained by a description of the only two environments, but reference to hydrogen must be made. **Second mark** (Numbers of hydrogen in each environment are/ are predicted to be) in ratio 3:9 or 1:3 OR Peak due to $(CH_3)_3$ is 3x higher than peak due to CH_3 **(1)** **Third mark** Environments are CH_3COO and $(CH_3)_3$ (H may have been specified in first marking point) These may be shown on a diagram of the formula of the molecule OR H-C-C=O (peak at 2.1) and H-C-C (peak at 1.3) (**1**) **Fourth mark** Singlets/ no splitting as no H on adjacent C OR Singlets as the hydrogen environments are not adjacent to other H environments Allow "only one peak" for no splitting **(1)**	Just "the peaks are due to $(CH_3)_3$ and CH_3	**4**

Question Number	Acceptable Answers	Reject	Mark
1 (d)(i)	$CH_3COOCH_2CH(CH_3)_2$ Or correctly displayed Allow $CH_3COOCH_2CH(CH_3)$ CH_3		**1**

Question Number	Acceptable Answers	Reject	Mark
1 (d)(ii)	The H on the CH_3COO Accept circle round all of first methyl group Accept a hydrogen in this environment if rest of molecule is incorrect	Circle round C of first methyl group	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (e)(i)	Any acid with 6C (5C + COOH) which is chiral, so will have a branched chain $C_3H_7CH(CH_3)COOH$ OR $C_2H_5CH(CH_3)CH_2COOH$ OR $(CH_3)_2CHCH(CH_3)COOH$ **(1)** Infrared indicates (O-H present in a) carboxylic acid **(1)** High boiling temperature due to hydrogen bonding (between atoms in OH groups so not an ester.) Hydrogen bonds must be possible for structure shown Allow acids can form dimers. Allow TE from formula of straight chain molecule with explanation that London forces are higher in a linear molecule **(1)** (Optically active so) contains chiral C/ C bonded to four different groups The formula suggested must contain a chiral carbon to score this mark This may be shown by a chiral carbon being labelled in the formula **(1)** Carbonyl compound/ Carbonyl group/ Aldehyde **and** ketone absent (as no reaction with 2,4-dinitrophenylhydrazine)/ Allow carboxylic acids do not react with 2,4-dinitrophenylhydrazine/ **(1)**	Infrared indicates O- Infrared indicates alkyl group Just "does not contain C=O (group)"	**5**

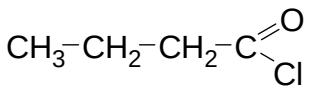
Question Number	Acceptable Answers	Reject	Mark
1 (e)(ii)	No because the isomers (which are carboxylic acids) contain same bonds / groups (C=O, C-O, C-H etc) **(1)** OR Yes because could be distinguished by infrared fingerprint **(1)**	Yes because spectrum is unique	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(i)	(Acid) hydrolysis	substitution	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(ii)	$K_2Cr_2O_7$ / $Na_2Cr_2O_7$ / $Cr_2O_7^{2-}$ Potassium dichromate((VI)) / sodium dichromate((VI)) / dichromate((VI)) ions *ALLOW* manganate((VII)) ions, etc	Just "dichromate" chromates Correct formula with wrong name and vice versa Incorrect oxidation number	**1**

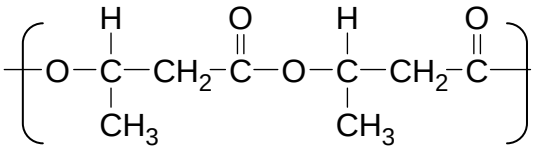
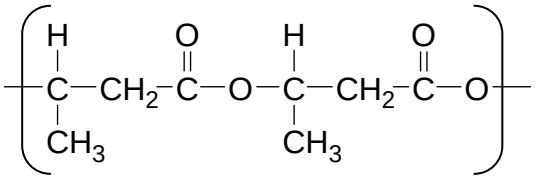
Question Number	Acceptable Answers	Reject	Mark
2 (a)(iii)	Lithium tetrahydridoaluminate/ lithium aluminium hydride/ $LiAlH_4$ (in dry ether)	Just $[H^-]$	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(iv)	Methyl butanoate **(1)** $CH_3CH_2CH_2COOH + CH_3OH \rightarrow$ $CH_3CH_2CH_2COOCH_3 + H_2O$ **(1)** *ALLOW* $\rightleftharpoons$ *IGNORE* state symbols even if wrong	Methyl butoate	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(v)	 Don't penalise undisplayed methyl groups as here. COCl must be displayed as above.	C_3H_7 for $CH_3CH_2CH_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(i)	Nitrogen inert / unreactive / less reactive (than oxygen) **OR** Oxygen might react with chemicals going through column / sample might oxidise		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(ii)	Solubility (in liquid / stationary phase) **OR** Interaction with liquid / stationary phase **OR** Interaction between mobile and stationary phase **OR** Attraction for liquid / stationary phase **OR** **Strength** of (named) intermolecular forces **OR** Adsorption on liquid / stationary phase **OR** Absorption on liquid / stationary phase	Size of molecule / molar mass Polarity, unless with explanation Boiling point / volatility Viscosity Attraction for carrier gas Just a named intermolecular force Just 'retention time' Density	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(i)	 OR  Ester link including C=O **(1)** Rest of polymer with oxygens at end correct **(1)** All H atoms must be shown. *PENALISE* lack of displayed C=O once only *ACCEPT* Without brackets around formula but bonds at end should be shown More than two correct units *IGNORE* n after brackets		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(ii)	Hydrolysis **OR** Splits / breaks ester link **OR** polymer breaks down to monomers **OR** equation showing hydrolysis	Just 'breaks polymer down'	**1**

Question Number	Acceptable Answers	Reject	Mark
3(a)(i)	Sodium/potassium dichromate((VI))/potassium manganate ((VII))/$Na_2Cr_2O_7$/$K_2Cr_2O_7$/$KMnO_4$ IGNORE references to acid	Just $Cr_2O_7^{2-}$ /MnO_4^-	**1**

Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	(Heat under) reflux **(1)** Use excess/sufficient oxidizing agent/reagent named in (a)(i), even if incorrect **(1)** IGNORE references to (excess) acid Stand alone marks		**2**

Question Number	Acceptable Answers	Reject	Mark
3(a)(iii)	CH_3CH_2CN/C_2H_5CN **(1)** ACCEPT displayed or skeletal formulae $CH_3CH_2CN + H^+ + 2H_2O \rightarrow CH_3CH_2COOH + NH_4^+$ OR $CH_3CH_2CN + HCl + 2H_2O \rightarrow CH_3CH_2COOH + NH_4Cl$ **(2)** If equation is incorrect then presence of H^+ or acid in equation/or above arrow **and** water on LHS scores (1) Mark cq on formula of nitrile ALLOW one mark for the following equation without H^+. $CH_3CH_2CN + 2H_2O \rightarrow CH_3CH_2COOH + NH_3$ ALLOW two marks for either of the following with H^+ above the arrow $CH_3CH_2CN + 2H_2O \rightarrow CH_3CH_2COOH + NH_3$ $CH_3CH_2CN + 2H_2O \rightarrow CH_3CH_2COOH + NH_4^+$ ALLOW answers for alkaline hydrolysis **followed by** acidification $CH_3CH_2CN + OH^- + H_2O \rightarrow CH_3CH_2COO^- + NH_3$ **(1)** Then $CH_3CH_2COO^- + H^+ \rightarrow CH_3CH_2COOH$ **(1)** If propanamide, $CH_3CH_2CONH_2$ is given initially then ALLOW the two equation marks for the hydrolysis $CH_3CH_2\ CONH_2 + H^+ + H_2O \rightarrow CH_3CH_2COOH + NH_4^+$ If no acid is used then only one mark $CH_3CH_2\ CONH_2 + H_2O \rightarrow CH_3CH_2COOH + NH_3$	Hydroxynitriles	**3**

Question Number	Acceptable Answers	Reject	Mark
3(b)	Reagent - Propanoyl chloride/CH_3CH_2COCl **(1)** **Any two from:** C-Cl bond is weaker (than C- 0) **(1)** Cl^-/chloride (ion) is a better leaving group **(1)** Carbonyl carbon is more positive/more δ+/more attractive to nucleophiles **(1)** OR Reagent - Propanoic anhydride/$(CH_3CH_2CO)_2O$ **(1)** CH_3COO^-/propanoate (ion) is a better leaving group **(1)** Carbonyl carbon is more positive/more δ+/more attractive to nucleophiles **(1)** IGNORE references to eversible/equilibrium/ catalysts IGNORE bond polarity	Propyl chloride Just Cl is more electronegative	**3**

Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	Radio waves/radio frequency	Just radio	**1**

Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	**Any two from:** Protons/nuclei/they have a property called spin/ have a magnetic moment/ have a magnetic field/ are aligned with the external magnetic field **(1)** **which** flips/changes **(1)** align against the external magnetic field (when radiation is absorbed) **(1)**	starts to spin just dipole moment polarity flips any reference to electrons or molecules scores zero	**2**

Question Number	Acceptable Answers	Reject	Mark
3(c)(iii)	Quartet **(1)** ALLOW quadruplet/indication of four (peaks) Value from 0.1 to 1.9 (ppm) inclusive **(1)** ACCEPT any range within the above range		**2**