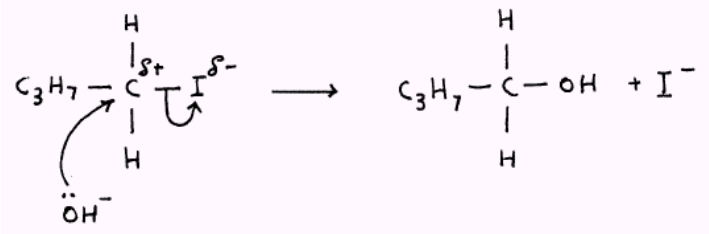
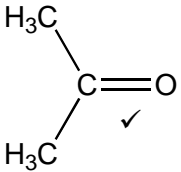
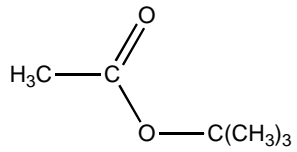
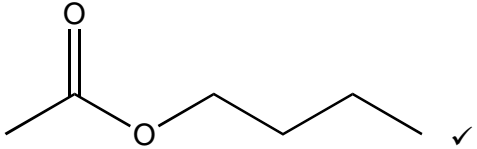


Question		Expected Answers	Marks	Additional Guidance
1	a	<p>Answers clockwise from top left</p> <p>$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ ✓</p> <p>$\text{CH}_3\text{CH}_2\text{CHCH}_2$ ✓</p> <p>$\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ ✓</p> <p>$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$ ✓</p>	4	<p>ALLOW skeletal formula</p> <p>ALLOW butanoic acid</p> <p>ALLOW but-1-ene</p> <p>ALLOW butyl ethanoate</p> <p>ALLOW butanal</p> <p>If name and structure given both must be correct</p> <p>If C_3H_7 used instead of $\text{CH}_3\text{CH}_2\text{CH}_2$ penalise once and then apply ECF</p> <p>If wrong carbon skeleton used then penalise once then apply ECF</p> <p>If a hydrogen is missing then penalise once</p>

Question		Expected Answers	Marks	Additional Guidance
b	i	<p>Nucleophilic substitution ✓</p> <p>Heterolytic ✓</p> <p>Dipole shown on C–I bond, C^{δ+} and I^{δ-} ✓</p> <p>Curly arrow from OH⁻ to carbon atom of C–I bond ✓</p> <p>Curly arrow from C–I bond to the iodine atom ✓</p>	5	<p>ANNOTATE WITH TICKS AND CROSSES</p> <p>DO NOT ALLOW fish hooks</p> <p>No need to show lone pair on OH⁻ or I⁻</p> <p>Curly arrow must come from the negative sign or lone pair on the oxygen of the hydroxide ion</p>  <p>ALLOW S_N1 mechanism</p> <p>dipole shown on C–I bond, C^{δ+} and I^{δ-} ✓</p> <p>curly arrow from C–I bond to the iodine atom ✓</p> <p>curly arrow from OH⁻ to correct carbonium ion ✓</p>
	ii	<p>Use reflux OR heat for more than 20 minutes ✓</p> <p>C–Cl stronger bond (than C–I bond) OR C–Cl shorter bond (than C–I bond) OR C–Cl bond is harder to break OR needs more energy to break C–Cl bond OR ora ✓</p>	2	<p>ALLOW heat stronger OR heat for longer OR heat at a higher temperature OR more heat</p> <p>Answer must refer to the C–Cl bond or C–I bonds</p>
Total			11	

Question	Expected Answers	Marks	Additional Guidance
2 (a)	<p>method 1: fermentation of sugars or carbohydrates OR reaction with yeast with sugar or carbohydrates ✓ $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ ✓</p> <p>method 2: hydration of ethene OR reaction of ethene with water OR reaction of steam with ethene ✓ $C_2H_4 + H_2O \rightarrow C_2H_5OH$ ✓</p>	4	<p>ALLOW sugar from equation</p> <p>ALLOW C_2H_6O in equation ALLOW correct multiples IGNORE state symbols</p> <p>ALLOW ethene from the equation IGNORE mention of any catalyst ALLOW C_2H_6O in equation OR H_2O over the arrow ALLOW correct multiples IGNORE state symbols</p>
(b) (i)	<p>$(CH_3)_2CO$ OR</p>  <p>$(CH_3)_2CHOH + [O] \rightarrow (CH_3)_2CO + H_2O$ ✓</p>	2	<p>If name and formula given both need to be correct ALLOW propanone OR acetone IGNORE propone NOT incorrect named compound</p> <p>ALLOW $C_3H_8O + [O] \rightarrow C_3H_6O + H_2O$ ALLOW O instead of [O] ALLOW correct multiples IGNORE state symbols</p>
(b) (ii)	<p>CH_3CH_2COOH OR propanoic acid ✓</p> <p>Any number or range of numbers between 1750–1640 (cm^{-1}) for C=O ✓</p> <p>Any number or range of numbers between 2500–3300 (cm^{-1}) for O–H ✓</p>	3	<p>ALLOW C=O and O—H marks independent of compound identified i.e. stand alone marks ALLOW correct bonds shown by the appropriate absorption on the IR spectrum IGNORE reference to C—O bond</p>
(c) (i)	2-methylpropan-2-ol ✓	1	ALLOW methylpropan-2-ol OR tertiarybutanol

Question		Expected Answers	Marks	Additional Guidance
	(ii)	ester ✓	1	
	(iii)	$\text{CH}_3\text{CO}_2\text{C}(\text{CH}_3)_3$ OR $\text{CH}_3\text{COOC}(\text{CH}_3)_3$ OR  ester group shown ✓ rest of molecule ✓	2	ALLOW skeletal formula OR displayed formula ALLOW ester linkage even if rest of structure is wrong
		Total	13	

Question	Answer	Mark	Guidance
3 (a)		1	IGNORE any structural or displayed formula shown even if wrong (ie treat as rough working)
(b)	<p>(M_r of all reactants or M_r of all products) is 134.0 OR 134 OR (M_r of desired product) is 116.0 OR 116 ✓</p> <p>Atom economy = $100 \times \frac{116.0}{134.0}$ ✓</p>	2	<p>Remember the marks are for the working out and not for the answer IGNORE lack of decimal place in answer</p> <p>ALLOW correct expressions to calculate the M_r or the atom economy eg</p> $\text{Atom economy} = 100 \times \frac{(6 \times 12) + (12 \times 1) + (2 \times 16)}{116 + 18}$ <p>Award 2 marks for this expression: $100 \times \frac{116.0}{134.0}$ or similar expressions such as that above (subsumes 1st marking point)</p>
(c)	(i) acid (catalyst) ✓ heat OR reflux ✓	2	<p>ALLOW any acid, concentrated or dilute</p> <p>ALLOW 'high temperature' OR any temperature from 70 °C to 120 °C Warm is not sufficient but ALLOW warm to 80 °C</p> <p>IGNORE pressure</p>

Question			Answer	Mark	Guidance
3	(c)	(ii)	<p>maximum mass of ester than can be made is 9.7972973 (g) ✓</p> <p>$\% \text{ yield} = \frac{6.57}{9.80} \times 100 \checkmark$</p> <p>ALLOW 2 or more sig figs up to calculated value but rounded up correctly, ie ALLOW $\frac{6.57}{9.797} \times 100$ OR $\frac{6.57}{9.8} \times 100$</p>	2	<p>ALLOW moles of butan-1-ol = 0.08445946 AND moles of ester = 0.05663791</p> <p>OR moles of butan-1-ol = $\frac{6.25}{74}$ AND moles of ester = $\frac{6.57}{116}$</p> <p>for one mark</p> <p>ALLOW $\% \text{ yield} = \frac{0.05664}{0.08446} \times 100$ for one mark</p> <p>ALLOW 2 or more sig figs up to calculated value but rounded up correctly, ie $\frac{0.057}{0.084} \times 100$ OR $\frac{0.0566}{0.0845} \times 100$</p> <p>Remember the marks are for the working out</p>
	(d)		<p>Link between yield AND explanation required:</p> <p>(high percentage) yield shows a high % conversion (of reactants into products) ✓</p> <p>Link between atom economy AND explanation required:</p> <p>(low) atom economy shows a lot of waste (product) OR (low) atom economy shows not much desired product ✓</p>	2	<p>ALLOW percentage yield takes into account the practical difficulties of the process</p> <p>OR high % yield very little experimental loss of product</p> <p>OR high % yield because the process is not reversible</p> <p>OR most of reactants react to form products</p> <p>DO NOT ALLOW 'a lot of product made'</p> <p>There are waste products is NOT sufficient</p> <p>Reaction forms many products is NOT sufficient</p> <p>ALLOW undesired product(s) as alternative for waste</p> <p>IGNORE a lot of by-products but</p> <p>..... ALLOW a lot of waste by-products</p> <p>ALLOW (low) atom economy shows a lot of HCl</p> <p>OR a lot of SO₂ is made</p> <p>ALLOW (low) atom economy shows not much ester / butyl ethanoate made</p>

Question	Answer	Mark	Guidance
(e)	<p>NOTE: Comparison essential throughout, ie higher, less, etc.</p> <p>ANY TWO FROM Less waste (products) OR higher atom economy ✓</p> <p>Less toxic reactants OR less toxic (waste) products OR less corrosive reactants OR less corrosive (waste) products OR less harmful reactants OR less harmful (waste) products OR less hazardous reactants OR less hazardous (waste) products ✓</p> <p>Cheaper starting materials OR more readily available starting materials ✓</p> <p>Fewer steps OR one step rather than two steps ✓</p>	2	<p>ALLOW more sustainable</p> <p>ALLOW poisonous for toxic</p> <p>IGNORE 'dangerous'</p> <p>'Water is produced' is not sufficient</p> <p>Cheaper is not sufficient on its own</p> <p>IGNORE less energy OR easier to carry out OR reversible</p>
Total		11	