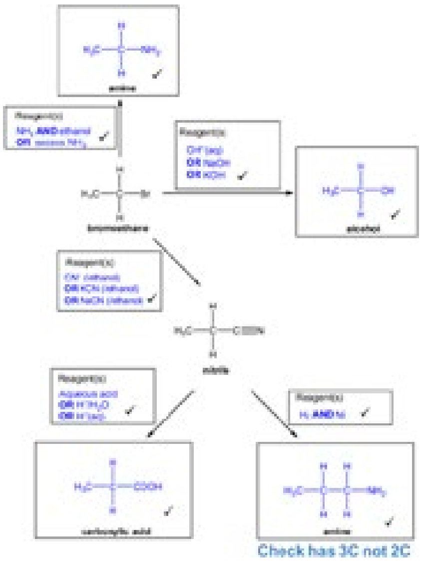
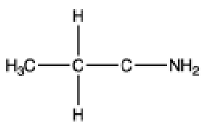
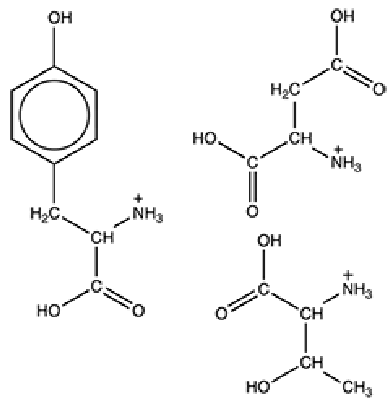
Mark scheme

Question	Answer/Indicative content	Marks	Guidance
1	 	9	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **DO NOT ALLOW** structure if H(s) are missing from **ONE** structural/displayed formula… **BUT ALLOW** any further omissions as **ECF** **ALLOW** any vertical bond to the OH **OR** NH_2  **DO NOT ALLOW** OH−, **OR** NH_{2-} but **ALLOW ECF** for subsequent use in this part **ALLOW** names of reagents e.g. ethanolic ammonia, if no formulae given **DO NOT ALLOW** other additional reagents **IGNORE** Conditions **For bromoethane to amine:** **IF** a secondary / tertiary amine is given **ALLOW** one mark for a correct structure **AND** one mark for an appropriate reagent to produce the amine shown. **For bromoethane to alcohol:** **ALLOW** H_2O **IGNORE** ethanol (as a solvent) **For bromoethane to nitrile:** **DO NOT ALLOW** HCN **OR** CN^- / H^+ **DO NOT ALLOW** H_2O / (aq) **For nitrile to carboxylic acid:** **ALLOW** any mineral acid **IGNORE** dilute/concentrated **For nitrile to amine:** **ALLOW** suitable non-specification alternative e.g. $LiAlH_4$, H_2 with Pd or Pt **<u>Examiner's Comments</u>** This question was well-answered with around a half of candidates scoring 8 or 9 marks. The full range of marks was seen across the whole cohort. The most common reasons for losing marks were for the addition of extra, contradictory reagents or for

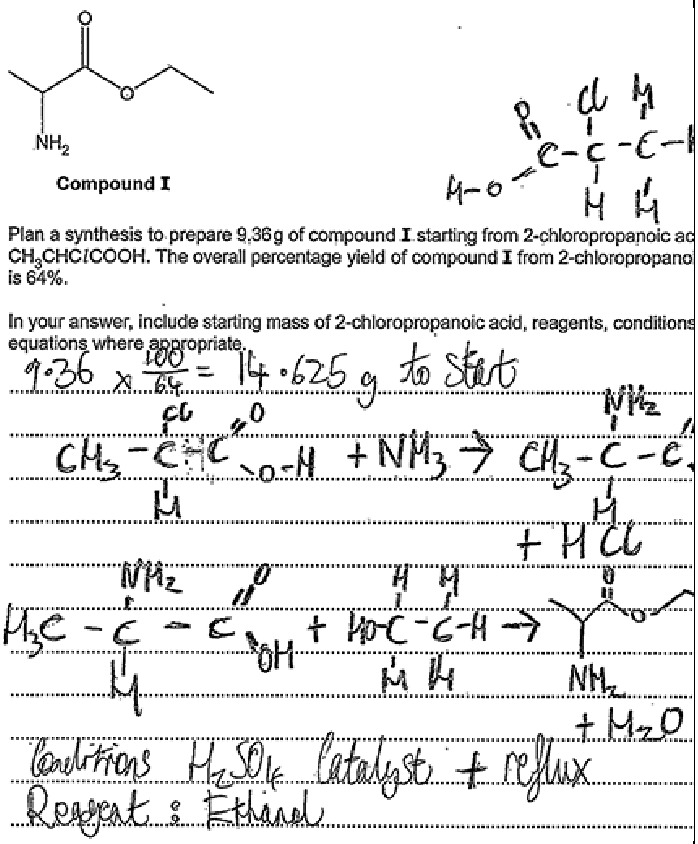
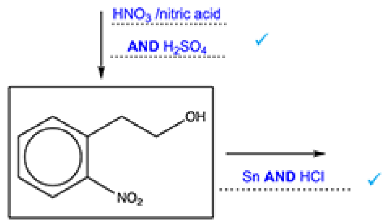
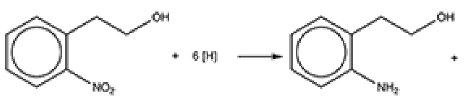
					missing hydrogens from structures. **Bromoethane to amine:** The amine structure was mostly correct with a few adding an extra hydrogen to the amine i.e. $CH_3CH_2NH_3$. Most gave the correct reagent as NH_3 but some omitted either ethanol or excess, so did not score here. **Bromoethane to alcohol:** The alcohol structure was usually correct. However, many lost the reagent mark here for the addition of acid/ H^+/H_2SO_4 alongside the hydroxide. **Bromoethane to nitrile:** A suitable cyanide was often used, but again many included an acid catalyst or aqueous conditions (aq) so lost the mark here. Ideally candidates would react in ethanol to prevent hydrolysis of the haloalkane. **Nitrile to carboxylic acid:** Most gave the correct carboxylic acid structure, while occasionally ethanoic acid was given instead of propanoic acid. Most identified the need for acid as a reagent but some omitted water or (aq). **Nitrile to amine:** H_2 was often seen as the reagent but sometimes without a catalyst. Many gave an incorrect structure here either with a missing C (i.e. ethylamine) or missing hydrogens on the first carbon i.e.  **OCR support** A useful resource for teaching about organic synthetic routes including functional groups, reagents and two-step processes can be found in the [Topic Exploration pack] on Teach Cambridge.
			Total	**9**	
2			**C**	1	**ALLOW** 1.5(0) **Examiner's Comments** Around two thirds of candidates gave the correct answer C, 1.50 mol dm^{-3} . Those that showed

					working were more likely to have the correct answer. Some only found the moles of ethylamine from the mass and M_r give so gave 0.03, A. Some candidates struggled to figure out that HC*l* was in excess, so used 0.04 moles of HC*l* to give a concentration of 2.0 mol dm^{-3}, D.
			Total	**1**	
3		i	16 ✓	1 (AO2.6)	**Examiner's Comments** This question was challenging for even the most able candidates with very few obtaining the correct answer of 16. Many identified the four chiral centres in compound E, often labelling these with an asterisk. However, only a small proportion were able to predict that there would be 16 possible optical isomers. Most provided an answer of four corresponding to the number of chiral centres or eight considering that each chiral centre would result in two optical isomers. They struggled to see that they needed 2^n in this case where n represents the number of chiral centres. Candidates have probably seen very few, if any, examples of chiral compounds with more than two chiral centres.
		ii	 **1 mark** for each **correct** structure with • **Either** NH_3^+ **OR** NH_2 ✓✓✓ **1 mark** for • **all 3 correct** structures with NH_3^+ ✓	4 (AO2.5 ×4)	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **IGNORE** connectivity **ALLOW** + charge on H of NH_3 group, i.e. NH_3^+ If structures are shown with NH_3 groups (without the + charge) **OR** as NH_2^+ groups allow **ECF** for subsequent use. **ALLOW** structures shown as correctly balanced salts, e.g NH_3Cl **OR** $NH_3^+Cl^-$ all marks can be awarded. **Examiner's Comments** A significant number of candidates did not attempt this question despite similar questions appearing in previous exam series. However, approximately a quarter of candidates scored all 4 marks. Some lost the final mark for not protonating the amine groups as required as under acidic conditions. A very

					common error was to hydrolyse the amides to give acyl chlorides or even aldehydes rather than carboxylic acids. Lower scoring candidates often had incomplete hydrolysis or no hydrolysis at all with just changes to acid/amine/phenol functional groups, e.g. protonation of amine to form salts or swapping or OH groups for Cl. Candidates need to check their answers carefully for missing or extra Hs as this lost marks. It was much easier to mark candidates' work presented with structures with a similar arrangement to compound E.
			Total	**5**	
4			**Level 3 (5-6 marks)** Correct calculation of mass of $CH_3CHClCOOH$. **AND** Planned synthesis includes substitution of –Cl and formation of compound **I** (or its corresponding ammonium salt) with the correct reagents and some conditions identified and equations are mostly correct. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3-4 marks)** Calculation of mass of $CH_3CHClCOOH$ is correct **AND** Planned synthesis includes one step of the synthesis with the correct reagent and some conditions identified and equation is mostly correct **OR** Calculation of mass of $CH_3CHClCOOH$ is partly correct **AND** Planned synthesis includes substitution of –Cl and formation of compound **I** (or its corresponding ammonium salt) with the correct reagents **OR**	6 (AO3.3× 6)	**Indicative scientific points may include:** **<u>Calculation of mass of $CH_3CHClCOOCH_3$</u>** **Using moles** • $n(\mathbf{I}) = \frac{9.36}{117.0}$ = 0.08(00) (mol) • $n(CH_3CHClCOOC_2H_5) = 0.0800 \times \frac{100}{64}$ = 0.125 (mol) • Mass of $CH_3CHClCOOH$ = 108.5 × 0.125 = 13.5625 g **Using mass** • Theoretical mass of $\mathbf{I} = 9.36 \times \frac{100}{64}$ = 14.625 (g) • Theoretical $n(CH_3CHClCOOH) = \frac{14.625}{117.0}$

			Attempts to calculate mass of $CH_3CHClCOOC_2H_5$ but makes little progress **AND** Planned synthesis includes substitution of –Cl and formation of compound **I** (or its corresponding ammonium salt) with the correct reagents and some conditions identified and equations are mostly correct *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1-2 marks)** Calculation of mass of $CH_3CHClCOOH$ is partly correct **OR** Planned synthesis includes both steps with some of the reagents and conditions identified **OR** Attempts equations for both steps but these may contain errors **OR** Describes one step of the synthesis with reagents, conditions and equation mostly correct *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.		= 0.125 (mol) • Mass of $CH_3CHClCOOH$ = 108.5 × 0.125 = 13.5625 g **ALLOW** slip/rounding errors such as errors in M_r, e.g. use of 107.5 instead of 108.5 for $CH_3CHClCOOH$ → 13.4375 --- ***Examples of partly correct calculations*** Mass = 5.5552 g from $0.0800 \times \frac{64}{100} \times 108.5$ (% *yield inverted*) Mass = 8.68 g from 0.0800 × 108.5 (% *yield omitted*) **<u>Synthesis: *Either order for 2 stages*</u>** **Substitution of –Cl → amine:** • Reagents: (excess) NH_3 • Condition: ethanol • Equation: $CH_3CHClCOOH + 2NH_3 \rightarrow CH_3CHNH_2COOH + NH_4Cl$ **OR** $CH_3CHClCOOH + NH_3 \rightarrow CH_3CHNH_2COOH + HCl$ **Esterification of amine → compound I** • Reagents: CH_3CH_2OH • Conditions: acid (catalyst), e.g. H_2SO_4 (reflux/heat) • Equation: $CH_3CHNH_2COOH + CH_3CH_2OH \rightarrow$

					$CH_3CHNH_2COOCH_2CH_3 + H_2O$ **OR --** **Esterification of carboxylic acid → ester** • Reagents: CH_3CH_2OH • Conditions: acid (catalyst), e.g. H_2SO_4 (reflux/heat) • Equation: $CH_3CHClCOOH + CH_3CH_2OH \rightarrow$ $CH_3CHClCOOCH_2CH_3 + H_2O$ **Substitution of –Cl → amine:** • Reagents: (excess) NH_3 • Condition: ethanol • Equation: e.g $CH_3CHClCOOCH_2CH_3 + 2NH_3 \rightarrow$ $CH_3CHNH_2COOCH_2CH_3 + NH_4Cl$ **OR** $CH_3CHClCOOCH_2CH_3 + NH_3 \rightarrow$ $CH_3CHNH_2COOCH_2CH_3 + HCl$ **OR** $CH_3CHClCOOCH_2CH_3 + NH_3 \rightarrow$ $CH_3CHNH_3ClCOOCH_2CH_3$ *(ammonium salt)* **Examiner's Comments** This question was marked using a level of response mark scheme. Most candidates gave an answer worth of at least Level 2 (3-4 marks) by providing the synthetic steps with reagents and equations for the synthesis of compound I. Exemplar 2, below, shows a frequent Level 2 response. The best performing candidates correctly determined the mass attempting to calculate the mass and showed the synthesis efficiently, using equations to communicate the preparation of compound I, with these responses being given Level 3 (5-6 marks). A number of responses omitted the mass calculation, such responses received Level 2 (1-2 marks). Exemplar 2

					 In this response the candidate has attempted to calculate the starting mass but has made little progress. Two stages of the synthesis have been covered with the reagents and most of the conditions identified. Both equations are complete. This is a Level 2 response and 4 marks have been given as the repones is logical and well communicated
			Total	**6**	
5		i		2 (AO1.2×2)	**IGNORE** references to concentration **IGNORE** 'dilute' for HCl **IGNORE** H_2 **IGNORE** NaOH if seen as a reagent to convert nitro group into amine e.g 'Sn/(concentrated) HCl then NaOH' scores the mark
		ii		1 (AO2.6)	**<u>Examiner's Comments</u>** Candidates were familiar with the reagents required in these two reactions.

					The most able candidates were able to identify the use of 6[H] as the reducing agent and the production of 2 water molecules. Incorrect responses commonly included the use of HCl and $NaBH_4$ as a reactant.
			Total	**3**	