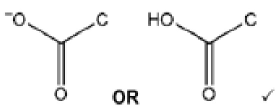
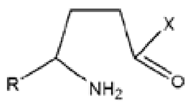
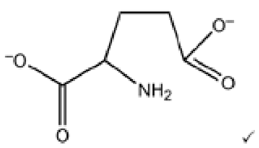
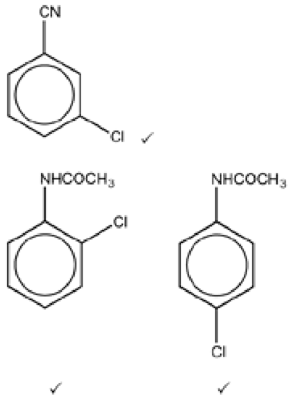
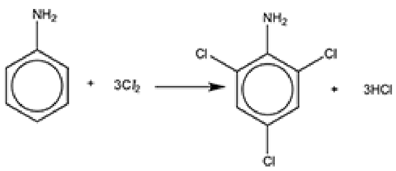
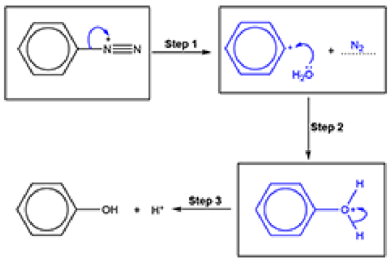
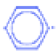
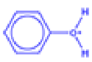
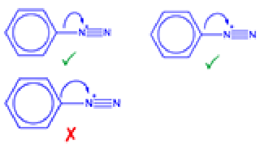
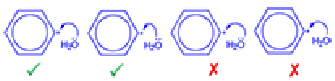
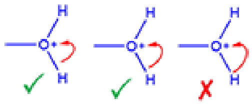
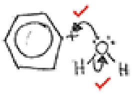
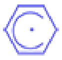
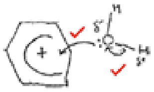
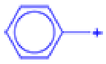
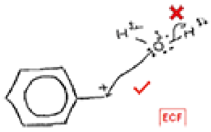
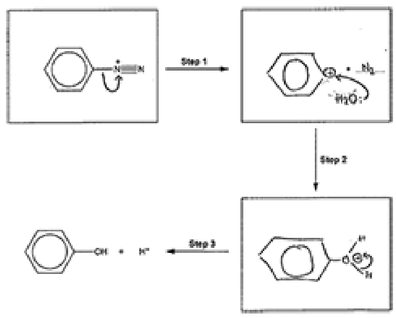
Mark scheme

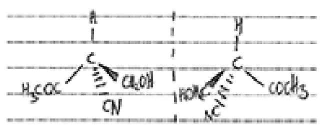
Question			Answer/Indicative content	Marks	Guidance
1			**Hydrolysis of ester:** Methanol / CH_3-OH ✓ **Formation of carboxylate / carboxylic acid from hydrolysis of ester or amide:**  *C=O of Carboxylate or carboxylic acid group must be attached to a C But ignore rest of molecule* **Hydrolysis of amide:** Breaks amide bond in ring to give: ✓  *Where R can be H or any other structure For X, ignore group attached to C=O* **Correct hydrolysis product:**  	4	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **DO NOT ALLOW** incorrect connectivity on OH **…BUT ALLOW ECF** on subsequent structures **DO NOT ALLOW** CH_3O^- (Na^+) **OR** sodium methoxide **ALLOW** $-COO^-Na^+$ **OR** −COONa **DO NOT ALLOW** esters or amides **ALLOW** NH_3^+**IGNORE** missing Hs on carbon chain Must be completely correct structure **ALLOW** $-COO^-Na^+$ **OR** −COONa **<u>Examiner's Comments</u>** Just over a quarter of candidates were able to gain all 4 marks. The successful candidates clearly identified where theester and amide would be hydrolysed on the structure provided, helping them draw out the correct products. This question differentiated well. Most were able to gain some credit for hydrolysing the ester to give methanol and a carboxylate or carboxylic acid, leaving the amide bond and ring intact. However, some lost the first mark for giving the methoxide ion, assuming that the alkaline conditions are capable of deprotonating the alcohol group. Lower attaining candidates often broke other C-C bonds in the ring forming a range of products. A few displayed the structure as $C=O^-Na^+$ and some also protonated the amine group either with the ring intact or broken.
			Total	**4**	
2		i		3	**IGNORE** additional copies of the same structures **IGNORE** connectivity to CN and $NHCOCH_3$ in products.

					**IGNORE** HCl / H^+ **IGNORE** multisubstituted products **ALLOW** protonation of $NHCOCH_3$ group i.e. $NH_2^+COCH_3$ **ALLOW ECF** small slips on $NHCOCH_3$ e.g. extra O or missing 3 on CH_3 **Examiner's Comments** Most candidates were able to correctly recognise the correct direction for substitution, with over half gaining all 3 marks. Marks were most often lost for giving multiple substitution products despite being asked for the monosubstituted products. Many unnecessarily drew the same structures but with differentorientations i.e. substituting on carbon-3 of a ring is the same as substituting on carbon-5. **Misconception** Ensure students understand the term 'monosubstituted' and practise naming compounds to give the lowest possible numbering. This will also help them to recognise the equivalent structures.
		ii	 Correct organic product ✓ Correct balanced equation ✓	2	**ALLOW** any trichlorophenyl amine structure **ALLOW** $C_6H_2Cl_3NH_2$ **OR** $C_6H_4Cl_3N$ (allow elements in any order) for correct organic product **IGNORE** incorrect structural or molecular formula **IF** correct structure is drawn **ALLOW** ammonium salt of trichloro product $C_6H_2NH_3Cl_4$ **ALLOW** multiples for balanced equation **ALLOW** 1 mark for use of Br_2 with a correctly balanced equation **Examiner's Comments** The majority of candidates were able to give a suitable tri-substituted product, with many showing the structure although not asked for in the

					question. Many were also able to give a correct balancedequation too. Some were unsure how phenylamine would react showing the reaction with the aminegroup or only giving a monosubstituted product. Some didn't form HC*l* as another product, reacting phenyl amine with 1.5 Cl_2 instead. Others gave hydrogen as the product.
		iii	(In phenylamine) a (lone) pair of electrons on N is (partially) delocalised / donated into the π-system / ring ✓ Electron density increases/is higher (than benzene) ✓ **ORA** (phenylamine is) **more** susceptible to electrophilic attack **OR** (phenylamine) attracts/accepts electrophile/Cl_2 **more** **OR** (phenylamine) polarises electrophile/Cl_2 **more** ✓ **ORA**	3	Must be clear that electrons come from N not just NH_2 **ALLOW** the electron pair (in the p-orbitals) on N atom becomes part of the π-system / ring **ALLOW** diagram to show movement of lone pair into ring from N **ALLOW** lone pair of electrons on N is (partially) drawn / attracted / pulled into π-system / ring **ALLOW** lone pair on N (i.e. no reference to electrons) **ALLOW** π-bond instead of π-system / ring **DO NOT ALLOW** (two) lone pair**s** are delocalised/donated into the π-system / ring **Responses must be comparative for 2nd and 3rd marking point.** **IGNORE** activating **IGNORE** charge density **IGNORE** electronegativity **IGNORE** phenylamines react more readily with electrophiles/Cl_2 (*given in question*) **ALLOW** Cl^+ for electrophile **IGNORE** Cl for electrophile **ALLOW** Benzene can't polarise electrophile/Cl_2 but phenylamine can (polarise electrophile/Cl_2) **Examiner's Comments** Similar questions have been seen previously and many candidates were able to give clear and concise responses. The first marking point was the most frequently lost as although many described $-NH_2$ aselectron donating, they were not able to fully explain its role. Some understood that a lone pair wasdonated into the π-ring but did not specify that the lone pair was on the nitrogen. Other marks were lostby not making comparison to benzene, e.g. high electron density, polarises Cl_2. Some repeated theinformation from the question regarding phenylamine being more

					reactive with electrophiles but notexplaining why. Lower attaining candidates often described the structure of the benzene ring or referredto phenylamine being more electronegative.
			Total	**8**	
3			**C**	1	**Examiner's Comments** More than three quarters of candidates were able to identify C as being the secondary amide, with many annotating each structure with the correct functional group. Some gave B, i.e. a secondary amine not amide, and a few gave A, i.e. tertiary amide not secondary.
			Total	**1**	
4			**Mechanism**:  **M1**: Curly arrow from C−N bond to N^+ ✓ **M2**:  **AND** N_2 ✓ **M3**: Curly arrow from lone pair of O of H_2O to C^+ ✓ **M4**  **AND** Curly arrow from O–H bond to O+ ✓ **For all marks, treat additional curly arrows as CON** **ALLOW M3** shown in bottom box **IGNORE partial charges** **ALLOW M3 AND M4 combined e.g.**	4 (AO 3.2 ×4)	**ANNOTATE ANSWER TICKS AND CROSSES** -- **NOTE**: Curly arrows can be straight, snake-like, etc. but **NOT** half arrows **1st curly arrow** must start from, **OR** be traced back to, **any part of** C–N^+ bond and go to N **OR** + of N^+  **2nd curly arrow** must • start from, **OR** be traced back to **any point across width** of lone pair on O of H_2O • go to the C or + of C^+ of $C_6H_5^+$  **3rd curly arrow** must • start from '–' **of O–H** of $–OH_2^+$ • go to O or + of O^+ 

			 -- **For**  **DO NOT ALLOW M2** for carbocation **BUT** ALLOW for M3 and/or M4 by ECF, e.g. 		**For**  **DO NOT ALLOW M2** for carbocation **BUT** **ALLOW for M3 and/or M4 by ECF, e.g.**  **<u>Examiner's Comments</u>** This question required candidates to apply their understanding of organic mechanisms to an unfamiliar reaction. The stem to the question includes important information and clues that should have guided candidates towards this unfamiliar mechanism, with the prompts for the three steps being critical. Many responses fell back to the familiar mechanism for electrophilic substitution, an approach that could not be credited. This question discriminated very well but many candidates scored few marks. Exemplar 1  This response has been included to show a candidate with an excellent understanding of the meaning of curly arrows and the importance of charges and dipoles. The prompts in the question are followed and the candidate has been given all four marks. Notice how the curly arrows start either from a bond or from a lone pair. The candidate has also realised that the addition of H_2O produces a positively charged oxonium ion. Many candidates

					omitted the '+' charge or showed the curly arrow for loss of a proton going to a H atom rather than the O atom of water. **Assessment for learning** In organic chemistry mechanisms, a curly arrow shows the movement of an electron pair and demonstrates the direction of electron flow in organic reactions. A curly arrow must start from: • A lone pair or negative charge and go to an atom to show where a bond **forms** • A bond to show where a bond **breaks**. In Question 2 (c), curly arrows: • start from a C–N bond to form the intermediate carbocation by elimination of N_2 • go from a lone pair on the water O atom to the + charge of the carbocation • go from an O–H bond to the + charge on the oxonium ion, losing a proton H^+ in the process.
			Total	**4**	
5			**Level 3 (5–6 marks)** Suggests **ALL** of the following • Reagents and conditions for **3** functional groups • Products for **3** functional groups • Optical isomerism with description and 3D optical isomers shown *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)** Suggests **two** of the following	6 (AO 3.1 ×3) (AO 3.2 ×3)	**CHECK TOP OF QUESTION FOR RESPONSES** --- *Indicative scientific points may include:* **<u>Stereoisomerism</u>** • Optical isomerism identified with description: e.g. chiral centre /non-superimposable mirror images • 3D Optical isomers drawn, e.g.  *Description is subsumed in 3D diagrams* **<u>Reactions of ketone/carbonyl e.g.</u>** $NaBH_4$

- Reagents and conditions for **2** functional groups
- Products for **2** functional groups
- Optical isomerism with description
  OR an attempt to show 3D optical isomers

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)
Suggests **two** of the following

- Reagents and conditions for **1** functional group
- Products for **1** functional group
- Identifies optical isomerism with description
  OR an attempt to show 3D optical isomers

There is an attempt at a logical structure with a line of reasoning.
The information is in the most part relevant.

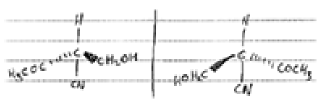
0 mark *No response or no response worthy of credit.*

<u>Key points to check</u>

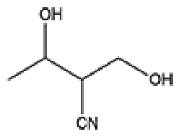
CHECK TOP OF QUESTION for responses
IGNORE CONNECTIVITY

in 3D isomer structures

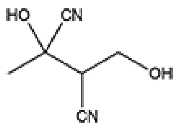
- *IGNORE bond angles*
- *Wedges needed*
- *ALLOW*



Some responses will not fit into this

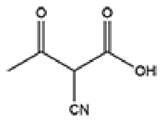


HCN **OR** CN^-/H^+ (e.g. $NaCN/H^+$)

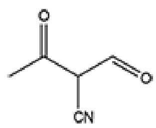


<u>Reactions of –OH, e.g.</u>

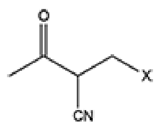
$H^+/Cr_2O_7^{2-}$ **OR** $H_2SO_4/K_2Cr_2O_7$ reflux



$H^+/Cr_2O_7^{2-}$ **OR** $H_2SO_4/K_2Cr_2O_7$ distil

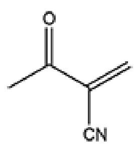


NaBr/KBr/Br^- **AND** acid/H^+ **OR** HBr

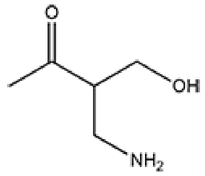
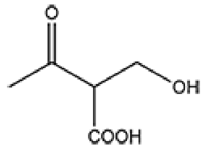


X = halogen

Acid/H^+ (catalyst) (e.g. H_2SO_4)



<u>Reactions of C–CN, e.g.</u>

			exact pattern and a best-fit match may be needed **<u>Clear communication</u>** Focus on • Clear diagrams of 3D optical isomers • Diagrams of unambiguour structures • Reagents and functional group formed are linked • Communication is more a general feel for the quality of theresponses. **<u>Slips and minor errors in structures</u>** • Do not penalise the odd slip or omission, e.g. An extra C in a chain; a C short in a chain, C shown instead of CH_2 or skeletal • You need to judge the extent of any slip based on the whole response. Remember that each candidate		H_2 **AND** metal catalyst e.g. Ni, Pt, Pd  H^+/H_2O e.g. HCl(aq) or H_2SO_4(aq)  **OTHER REAGENTS, CONDITIONS AND PRODUCTS** **e.g. $LiAlH_4$ as reagent** **Check with Team Leader** **<u>Examiner's Comments</u>** Overall, candidates performed well when answering this question. They were required to identify that compound **A** shows optical isomerism and to choose a reaction for each of the three functional groups. Candidates were also expected to use structures for the organic products. To achieve the highest level of response, a description of optical isomerism should be accompanied by 3D diagrams of the optical isomers. Optical isomerism was usually identified, with associated diagrams with almost all candidates identifying the chiral centre. Most attempted 3D diagrams but candidates do need to take care that the groups attached to the chiral C atom are those in compound A and that no parts of chains are omitted. Optical isomers do also require use bold and dashed wedges to be used. Most candidates showed good knowledge and understanding of reactions for the three functional groups. • For the primary alcohol, most chose $H^+/Cr_2O_7^{2-}$, with distil (→ aldehyde) or

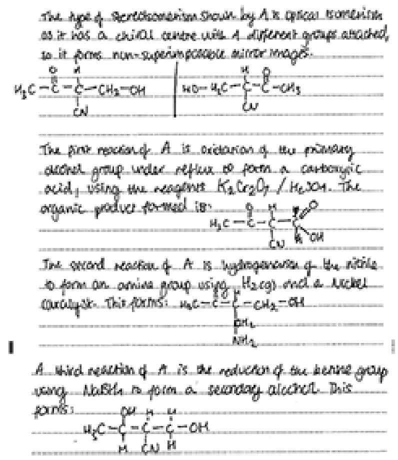
reflux (→ carboxylic acid); a significant number chose a concentrated acid (→ alkene) or Br−/H+ (→ haloalkane)

- For the ketone, most chose $NaBH_4$ (→ secondary alcohol)
- For the nitrile, most chose either H_2/Ni (→ amine) or $H^+(aq)$ (→ carboxylic acid).

Clear diagrams of the products were usually seen although many omitted a CH_2 from the amine branch for hydrolysis of the nitrile or an extra CH_2 in the aldehyde or carboxylic acid branch from oxidation of the primary alcohol.

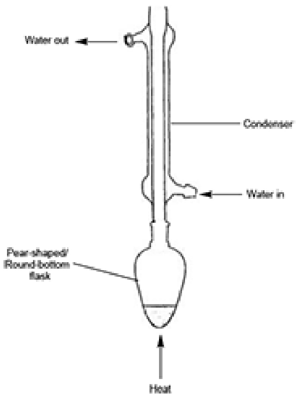
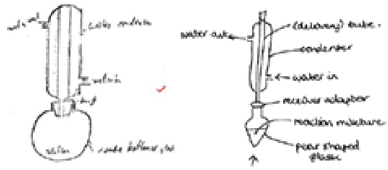
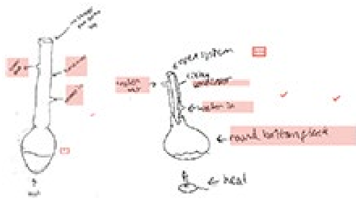
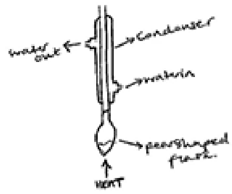
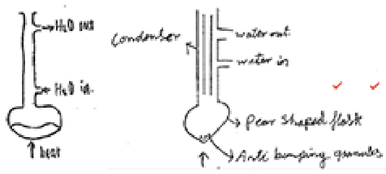
Some candidates chose 2,4-DNP for a reaction of the ketone and treated the question as one requiring tests, and then proving that the compound was a ketone from no reaction with Tollens' reagent. The question asked for the organic product and the 2,4- DNP product is beyond the demands of this specification (although this was seen very rarely). Candidates adopting this reaction were limiting the extent of their response and candidate should have considered this requirement before selecting 2.4-DNP.

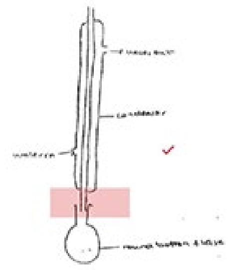
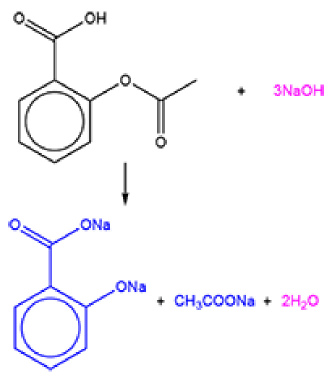
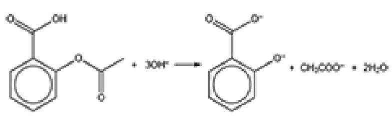
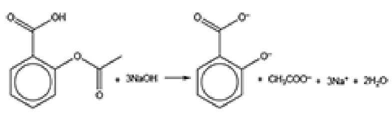
Exemplar 2

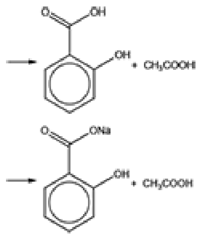
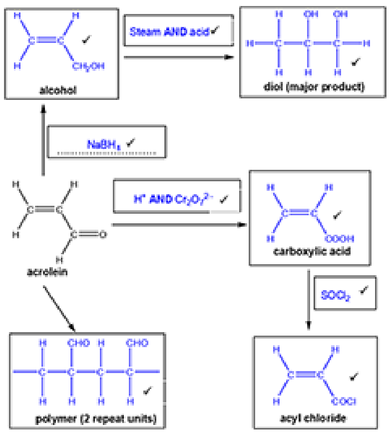
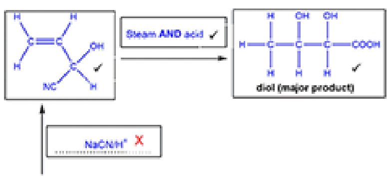


This exemplar shows a good response that lacks 3D diagrams for the optical isomers. The candidate has clearly given reagents and conditions and has shown the organic products. In the response, you can see that the candidate initially showed an extra CH_2 in the –COOH branch, and a mistake in the amine branch.

The absence of 3D structures limits the response to Level 2 and 4 marks have been awarded for

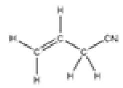
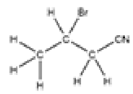
					choosing correct and relevant reagents and conditions, and for the clear communication of the structures.
			Total	**6**	
6		i	 **Reaction apparatus (Labels NOT required)** flask **AND** upright condenser **AND** open system at top ✓ *(Could be labelled)* **Labels AND direction of water flow** Pear-shaped/round-bottom flask **AND** condenser **AND** water in at bottom and out at top ✓ Heat **NOT** required **DO NOT ALLOW** flask, conical flask, volumetric flask **DO NOT ALLOW** thermometer **DO NOT ALLOW** condensing tube as label	2 (AO 3.3 ×2)	For open system, **DO NOT ALLOW**  **For open system, ALLOW** label. e.g. 'open at top'  **ALLOW** line across flask   **ALLOW small** gap between flask and condenser **BOD**, e.g.

					 **If in doubt, ask Team Leader** **<u>Examiner's Comments</u>** Most candidates drew a diagram that looked like a vertical condenser above a flask. The quality of the diagrams was not very good. Candidates then needed to label their diagram. Errors included a bung or thermometer inserted at the top of the condenser and water flowing the wrong way in the condenser. For labelling, candidates were expected to use scientific terminology. Responses such as 'condensation tube' and vague terms such as 'flask' were not credited. These labels were often omitted. A significant number drew a set up for distillation instead of reflux.
		ii	 Organic products ✓ ✓ ***2 marks*** 3NaOH AND $2H_2O$ ✓ ***1 mark*** NOTE: ALLOW O^-Na^+ for ONa throughout **SCROLL DOWN FOR PRODUCTS**	3 (AO 2.6 ×3)	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **IGNORE** annotations of provided structure of aspirin at top left **ALLOW** equation with 3OH– **OR** 3NaOH giving anions for organic products, i.e.  **OR**  **ALLOW** 1 of the 2 organic products mark for BOTH structures as COOH and OH (or mixture) e.g

					 **<u>Examiner's Comments</u>** This question was the hardest part of Question 5 and about half the candidates were not given any marks. Some drew the sodium carboxylate salt of aspirin structure, leaving the ester link intact. A large number of candidates realised that the ester would be hydrolysed. Sometimes the sodium salts were often not shown and, even they were shown, the phenol group was often shown intact. The hardest mark was the formation of $2H_2O$ and a large number of candidates showed the more intuitive but incorrect '$3H_2O$' instead.
			Total	**5**	
7			 **Only possible alternative that can gain credit:** Reaction with $NaCN/H^+$ 	9 (AO1.2 ×4) (AO2.5 ×5)	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** Correct names instead of formula for all reagents throughout e.g. For H^+ and $Cr_2O_7^{2-}$, **ALLOW** acidified dichromate For Steam and acid • For steam, **ALLOW** $H_2O(g)$ **OR** H_2O with T ≥ 100°C • For acid, **ALLOW** H^+ **OR** H_2SO_4 **OR** H_3PO_4 • Note both needed for 1 mark. **ALLOW** either way round. For $NaBH_4$ • **IGNORE** water / aqueous /acid • **ALLOW** $LiAlH_4$ For $SOCl_2$, **ALLOW** PCl_5 **OR** $COCl_2$ • **IGNORE** H^+ OR HCl For H^+ and $Cr_2O_7^{2-}$, **ALLOW** H_2SO_4 **AND** $K_2Cr_2O_7$ **OR** $Na_2Cr_2O_7$ **ALLOW** Tollens' reagent

					IGNORE connectivity except **DO NOT ALLOW** -COH for aldehyde For polymer **ALLOW** alternating side chains. **IGNORE** brackets and use of ‘n’ ‘End bonds’ **MUST** be shown (solid or dotted) **IF** NaCN/H^+ reacted with acrolein instead of $NaBH_4$ • No mark for NaCN/H+ **OR** HCN • Unsaturated alcohol award mark for product as shown • Final product must have CN hydrolysed as shown **<u>Examiner’s Comments</u>** This question discriminated well. Many candidates were able to demonstrate an excellent knowledge of organic reactions and it was not uncommon to see scores of at least 7 marks. This question identified which candidates had learned their synthetic routes including necessary reagents and conditions. Marks were often lost for small details such as missing Hs (check all Cs have four bonds) or not specifying that steam is required for hydration of alkenes or missing the acid needed for oxidation. Many suggested the use of NaOH or just a mixture of acids to product the diol. The minor 1,3-diol or 1,1-diol product was often seen. The sequence leading to an acyl chloride from acrolein was usually the most well answered. However, quite a few tried to use HCl to make the acyl chloride. Many lost marks for the polymer for incorrect connectivity on the aldehyde, e.g. -COH or attempting to make a polymer via connection of the aldehyde group. **OCR support** This <u>topic guide</u> provides a summary of synthetic routes. Copies of the summary posters without the conditions can be found on <u>Teach Cambridge</u>. This should be used in conjunction with the <u>organic synthesis topic exploration pack</u>.
			Total	**9**	

8			Dissolve in the minimum quantity of hot water/solvent ✓ Cool (to allow crystals form) **AND** Then filter (under reduced pressure) ✓ (Leave to) dry ✓	3 (AO3.3 ×3)	**ALLOW** any solvent **IGNORE** • Initial filtering • Filtration between dissolving and cooling (implies hot filtration) • Washing with cold solvent **DO NOT ALLOW** use of drying agent (e.g. $MgSO_4$) **Examiner's Comments** About a quarter of candidates gained all 3 marks. They were able to give clear, well-structured answers with all the steps as carried out in PAG 6 practical activities. The best answers were often in the form of bullet pointed steps and often included extra details such as a hot filtration step or promoting crystallisation by scratching the surface. Many candidates lost the first mark as their responses didn't give sufficient detail, e.g. hot solvent, not just warm and minimum volume required. Some missed the cooling step essential for formation of crystals before filtration. Some missed that the crystals need to be dried following filtration but often if only given 1 mark this was the mark given. Lots of confusion with purification with organic liquid was seen, such as references to use of a separating funnel, drying agents and distillation. Some also went on to explained how to check purity using melting point determination. **OCR support** A useful resource for revising the steps for purification of an organic solid is the Topic exploration pack: Experiments on organic synthesis in Learner Activity 2.
			Total	**3**	
9			**Level 3 (5–6 marks)** A **three** stage synthesis in the **correct** order **AND** Equations for each stage are mostly	6 (AO3.3 ×6)	**Mark second page as SEEN** **Indicative scientific points may include:** **IGNORE conditions**

			correct **AND** Most reagents 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)** Synthesis includes at least **two** stages in **any** order **OR** uses NH_3 and HBr in the **correct** order (without chain extension) **AND** some of the reagents and some equations 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)** Planned synthesis includes reagents for **any** two stages **OR** Describes one stage with reagents 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 mark** No response or no response worthy of credit.		***Stage 1: Reaction with CN^-*** • Reagents: CN^- (in ethanol) • Equation: $H_2C{=}CHCH_2Br + CN^- \rightarrow H_2C{=}CHCH_2CN + Br^-$ **Intermediate 1**  ***Stage 2: Addition of HBr to C=C*** • Reagents**:** HBr • Equation: $H_2C{=}CHCH_2CN + HBr \rightarrow CH_3CHBrCH_2CN$ **Intermediate 2**  ***Stage 3: Reduction of CN*** • Reagents: H_2 (with Ni) • Equation: $H_3CCHBrCH_2CN + 2H_2 \rightarrow CH_3CHBrCH_2CH_2NH_2$ ***Needs CN^- before HBr*** ***– CN^- would react with both Br atoms*** ***Needs HBr before H_2*** ***– H_2 would react with C=C*** **<u>Alternative three stage syntheses:</u>** ***Alternative using $LiAlH_4$*** ***Caution - Can be done as stage 2 or 3*** • Reagents: LiAlH4 • Equation: $H_2C{=}CHCH_2CN + 4[H] \rightarrow H_2C{=}CHCH_2CH_2NH_2$ **OR** $H_3CCHBrCH_2CN + 4[H] \rightarrow CH_3CHBrCH_2CH_2NH_2$ ***Needs CN^- before HBr and $LiAlH_4$*** ***Can have HBr and $LiAlH_4$ in any order***

Alternative using radical substitution:
Stage 1: Reaction with CN^-

- Reagents: CN^- (in ethanol)
- Equation:

$H_2C{=}CHCH_2Br + CN^- \rightarrow H_2C{=}CHCH_2CN + Br^-$

Stage 2: Reduction of CN and C=C

- Reagents: H_2 (with Ni)
- Equation:

$H_2C{=}CHCH_2CN + 3H_2 \rightarrow CH_3CH_2CH_2CH_2NH_2$

Stage 3: Reaction with Br_2

- Reagents: Br_2 (with UV)
- Equation:

$CH_3CH_2CH_2CH_2NH_2 + Br_2 \rightarrow$
$CH_3CHBrCH_2CH_2NH_2 + HBr$

Needs CN^- before H_2
Needs H_2 before Br_2

Two stage synthesis using NH_3 and HBr forming product with no lengthening of carbon chain

Stage 1: Reaction of NH_3

- Reagents: NH_3 (in ethanol)
- Equation:

$H_2C{=}CHCH_2Br + NH_3 \rightarrow H_2C{=}CHCH_2NH_2 + HBr$
OR *$2\ NH_3 \rightarrow NH_4Br$*

Stage 2: Addition of HBr to C=C

- Reagents: HBr
- Equation:

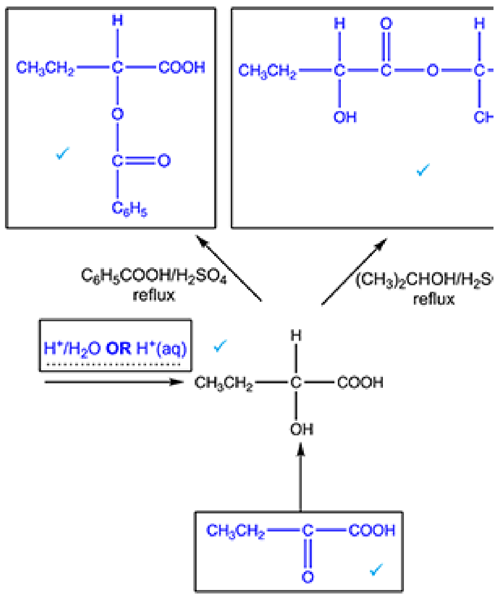
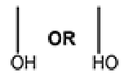
$H_2C{=}CHCH_2NH_2 + HBr \rightarrow CH_3CHBrCH_2NH_2$

Needs NH_3 before HBr
– HBr would react with C=C

<u>**Examiner's Comments**</u>

This challenging level of response question was generally well attempted. Many candidates recognised the reagents required in this synthesis but fewer candidates were able to deduce three

					correct reagents in the right order with equations to achieve Level 3. Most candidates achieved Level 2 4 marks. Many correctly identified suitable reagents but carried out the stages in the wrong order. A common error was to carry out electrophilic addition with HBr first then react with cyanide ion, not realising both Br groups would react and the reaction would not be selective. Alternatively, having introduced the nitrile group then carried out the reduction first, not realising that the C=C would also be reduced. The lowest scoring responses were often incomplete and despite identifying some reagents did not give equations. Candidates are encouraged to read the questions carefully so they can make sure their response covers all the detail required. Many candidates used molecular formula in their equations. It is usually preferrable in organic chemistry to give structures. Some gave surplus information such as the mechanisms and reaction conditions for each reaction. The key to answering this question well was knowing reagents for different functional group interconversions as well as planning each step to make sure of a logical synthesis. Some candidates were seemingly confused by the term 'intermediate' and gave an intermediate as in a mechanism, e.g. carbocation. **OCR support** A useful resource for teaching how to identify functional groups and practice at devising synthetic routes is the Topic exploration pack on Organic synthesis. This should be used in conjunction with the reaction pathways summaries.
			Total	**6**	
10			**C**	1 (AO1.2)	**<u>Examiner's Comments</u>** D was the most common incorrect response, separating the amide into a ketone and amine. This was followed by A, not recognising that a phenol OH is distinct from alcohol OH. A common strategy was to circle or label the functional groups on the structure of paracetamol.
			Total	**1**	

11	a			4 (AO2.5× 4)	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** any vertical bond to the OH group e.g. **ALLOW**  **IGNORE** connectivity of CH_3CH_2 group **IGNORE** inorganic by-products **ALLOW** HCl/H_2O, H_2SO_4/H_2O **IGNORE** dilute **<u>Examiner's Comments</u>** The majority of candidates were able to identify at least one of the structures. A significant number of candidates did not check the number of bonds of each atom in their structures and frequently had too many or too few hydrogen atoms attached. Most candidates identified that acidic conditions were required but some missed the aqueous condition that was also required for the mark.
	b		**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	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

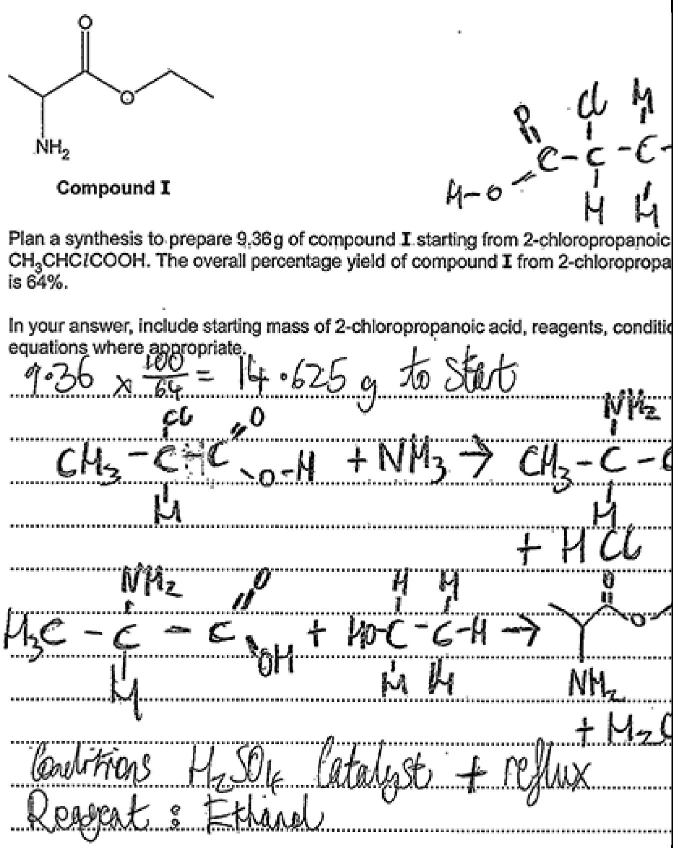
			$CH_3CHClCOOH$ is correct **AND** Planned synthesis includes one step of the synthesis with the correct reagent and some conditions identified and equation is mostly correct **OR** Calculation of mass of $CH_3CHClCOOH$ is partly correct **AND** Planned synthesis includes substitution of –Cl and formation of compound **I** (or its corresponding ammonium salt) with the correct reagents **OR** 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.*		**Using mass** • Theoretical mass of $\mathbf{I} = 9.36 \times \frac{100}{64}$ = 14.625 (g) • Theoretical $n(CH_3CHClCOOH) = \frac{14.625}{117.0}$ = 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: $CH_3CHClCOOH + 2NH_3 \rightarrow CH_3CHNH_2COOH + NH_4Cl$

			The information is in the most part relevant. **0 marks** No response or no response worthy of credit.		**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)*

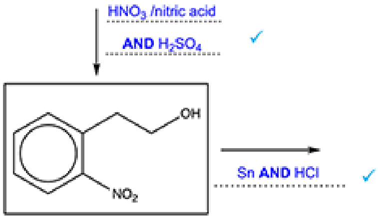
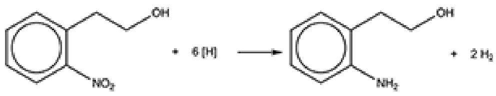
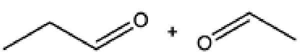
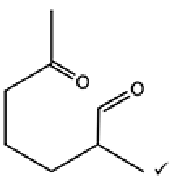
Examiner's Comments

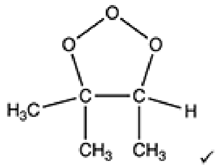
This question was marked using a level of response mark scheme. Most candidates gave an answer worth of at least Level 2 (3-4 marks) by providing the synthetic steps with reagents and equations for the synthesis of compound I. Exemplar 2, below, shows a frequent Level 2 response. The best performing 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	**10**	
12		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)	**Examiner's Comments** 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**	
13			A	1 (AO1.1)	**Examiner's Comments** Many candidates did not identify CH_3NH_2 as a nucleophile and selected option B.
			Total	**1**	
14		i	 **BOTH** structures required for ✓ 	2 (AO3.1×1) (AO3.2×1)	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous

		ii	 ✓	1 (AO3.2)	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **Examiner's Comments** Most candidates were able to score 1 mark for correctly drawing the structures of the two aldehyde products of the first reaction. The second reaction proved more challenging, with most candidates incorrectly drawing two products. Few candidates were given this mark. A common error was to produce multiple products (rather than a ring structure) or to put positive/negative charges on the oxygen atoms within the ring structure.
			Total	**3**	
15			A	1 (AO1.1)	**Examiner's Comments** Most candidates correctly selected A. The most common incorrect response was option D as candidates had misinterpreted the amide group as a ketone and an amine.
			Total	**1**	