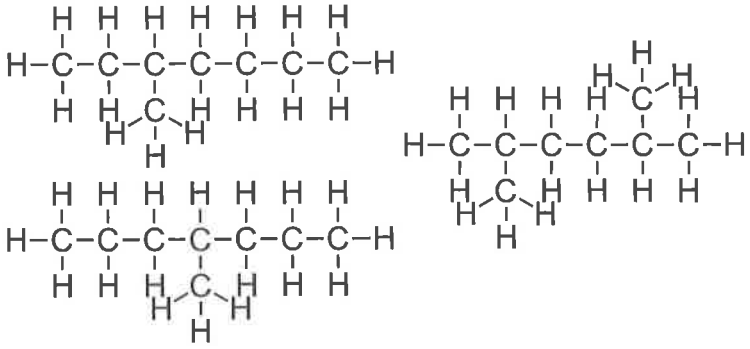
Section A

1	C	9	C
2	A	10	C
3	C	11	B
4	D	12	A
5	B	13	B
6	D	14	A
7	B	15	D
8	D		

Section B

16 a) Any three structural isomers ✓✓✓

e.g.



b) Bonds are not polar AND due to similiar electronegativity of C and H ✓
High bond enthalpy ✓

c) Octane has the strongest London forces (ACCEPT alternative names) ✓
These require the most energy (and hence highest temperature) to overcome ✓

Reason:
Heptane has fewer electrons AND therefore smaller temporary dipoles ✓
2-methylheptane stacks less well / there are fewer points of contact between 2-methylheptane molecules ✓

d) i) Moles (octane) = $\frac{3000}{114}$ = 26.32
One mole of octane reacts with 12.5 moles of O_2 ✓ (Can gain this mark with correctly balanced equation)
Moles O_2 = 12.5 × 26.32 = 328.9 ✓
Volume O_2 = 328.9 × 24 = 7895 dm^3 ✓ (ALLOW ECF – mark is for multiplication by 24)

ii) $C_8H_{18} + 8.5\ O_2 \rightarrow 8CO + 9H_2O$ (ALLOW multiples) ✓

iii) Binds to haemoglobin ✓
Reduces its ability to carry oxygen ✓

e)

LEVEL OF RESPONSE QUESTION	
Level 3: (5–6 marks)	Answer is structured in an entirely ordered manner. The names of the stages and equations are all correct, including at least one termination step, and at least one reason for not being synthetically useful is given.
Level 2: (3–4 marks)	Answer is mostly structured in an ordered manner. The naming of the stages and equations for them are both partly correct (or one is done correctly, but the other poorly). A vague reason for not being synthetically useful may be given.
Level 1: (1–2 marks)	Answer has limited structure. Answer includes a correct equation and one or two names of stages.
0 marks	No creditworthy response.

Indicative Content

Initiation

Homolytic fission of Cl_2

$Cl_2 \rightarrow 2Cl\bullet$

Caused by UV light

Propagation

$Cl\bullet + C_8H_{18} \rightarrow C_8H_{17}\bullet + HCl$

$C_8H_{17}\bullet + Cl_2 \rightarrow C_8H_{17}Cl + Cl\bullet$

$Cl\bullet$ can react many times over

Termination

$2Cl\bullet \rightarrow Cl_2$

$Cl\bullet + C_8H_{17}\bullet \rightarrow C_8H_{17}Cl$

$2C_8H_{17}\bullet \rightarrow C_{16}H_{34}$

Usefulness

Multiple organic products form

Substitution an occur at different positions

Product can react further / become multiply substituted

17 a) i) The carboxyl group and the amine group are attached to the same carbon ✓

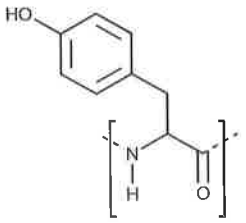
ii)

✓

iii) React with methanol ✓

In the presence of an acid catalyst / concentrated H_2SO_4 ✓

iv)



✓ Correct polymer

✓ H_2O is side product

✓ (IGNORE the fact the side chain comes out of brackets. IGNORE 'n's)

b)

LEVEL OF RESPONSE QUESTION	
Level 3: (5–6 marks)	Answer is structured in an entirely ordered manner. A full description of both removal of water and redistillation is given.
Level 2: (3–4 marks)	Answer is mostly structured in an ordered manner. One of the stages is fully described, or both are described with parts missing.
Level 1: (1–2 marks)	Answer has limited structure. Vague details of practical stages only.
0 marks	No creditworthy response.

Indicative Content

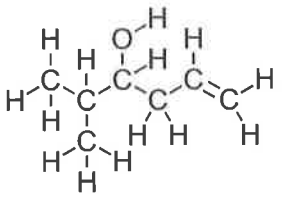
Removal of water

- Add a drying agent (ACCEPT named compound, e.g. $MgSO_4$ or $CaCl_2$)
- Stir and continue adding drying agent until it stops clumping together / swirls easily in flask
- Filter using a filter funnel and flask / Buchner apparatus

Redistillation

- Add to a (round-bottomed) flask, and add anti-bumping granules
- Connect to a Liebig condenser
- Seal/bung/thermometer at top to prevent vapours escaping / to ensure they pass into Liebig condenser
- Connect tube from lower end of Liebig condenser to water supply (and other to sink), and turn on water
- Use a water bath / oil bath to heat the aniline to its boiling point
- Collect the distillate that comes off

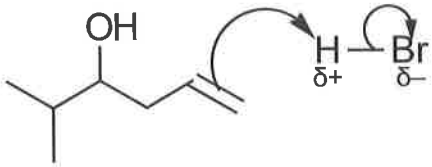
18 a)



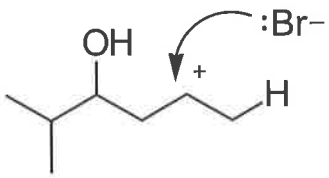
✓ (ALLOW any unambiguous structure showing all atoms and bonds)

b) 4-hydroxy-5-methylhex-1-ene (ALLOW unambiguous alternatives) ✓

c) i)



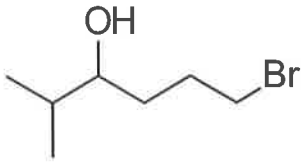
Correct arrow from double bond to H AND arrow from H–Br bond to Br ✓



Correct intermediate ✓ Correct arrow from Br^- to positive C ✓
Mechanism is electrophilic addition ✓

ii) Breaking of a covalent bond AND both electrons go to the same atom ✓

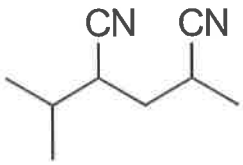
iii) Molecule C ✓



More of Molecule B forms ✓
Because mechanism proceeds through a more stable intermediate OR Because mechanism proceeds through a secondary carbocation, whereas mechanism to produce molecule C proceeds through a primary carbocation ✓

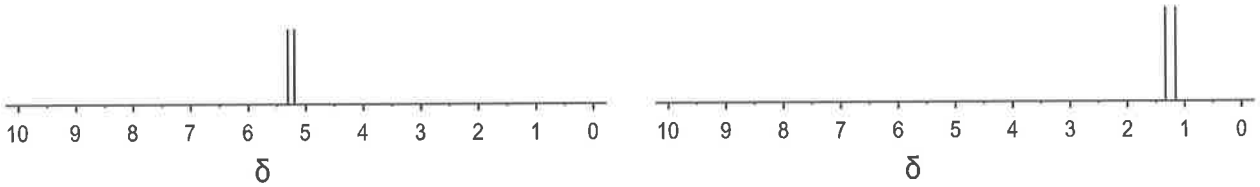
d) NaBr AND H_2SO_4 ✓ (DO NOT ALLOW HBr)

e) Nucleophilic substitution ✓



✓ (DO NOT ALLOW one substitution only, conditions specify excess CN^-)

f)



Two doublets ✓ Shift on left of between 4.7 and 6.0 AND shift on right of between 0.9 and 2.0 ✓
Integration on left = 2 AND Integration on right = 3 ✓

g) (Broad) peak between 3200 and 3600 ✓
Would be present at start and not at end ✓

h) A (cream) precipitate would form ✓
Does not show the product has formed because:
It gives no indication of what is substituting the bromide group / what the end product is ✓
Does not show the progress of the reaction, only that some bromide has been substituted ✓

19 a) Different substances adsorb to the stationary phase OR dissolve in the mobile phase to different degrees ✓
The substances therefore take a different amount of time to pass through the column / have a different retention time ✓

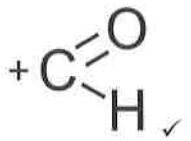
b) The chemist should carry out gas chromatography on a sample of known concentration of 2-naphtyl ethanoate ✓
The student should repeat this for a series of concentrations and draw a calibration curve ✓
The student should then compare the intensity / signal size for the 2-naphtyl ethanoate when the contaminated solvent is analysed to the calibration curve to determine the concentration ✓

c) This is incorrect as the compounds may have the same retention time ✓ AW

20 a) i) H_2 AND Ni ✓ (ACCEPT alternative viable metal catalyst)

ii) (Molecular ion) peak at 96 disappears AND peak at 100 appears ✓

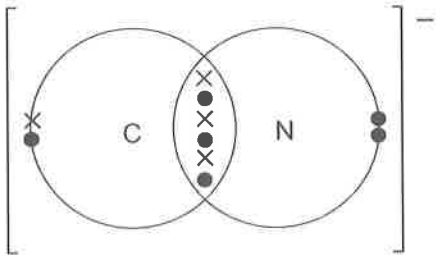
iii)



(DO NOT ALLOW structure without positive charge)

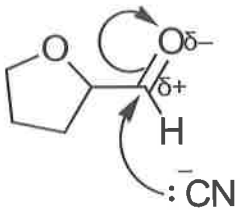
iv) Forms silver mirror/precipitate (on warming) ✓
RCHO + [O] → RCOOH ✓
$Ag^+ + e^- \rightarrow Ag$ ✓ (IGNORE state symbols)

b) i)

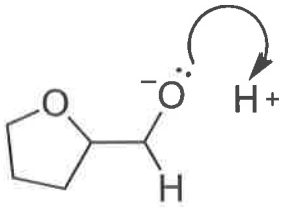


✓ (IGNORE inner shells)

ii)



✓ Both arrows correct



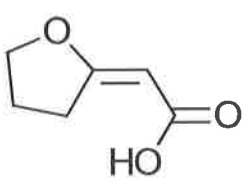
✓ (ALLOW H from solvent or HCN)

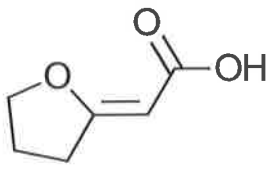
iii) Add acidified (potassium) dichromate ✓
Colour change from orange to green ✓ (MUST have starting colour)

c) i) $2RCOOH + Na_2CO_3 \rightarrow 2RCOONa + CO_2 + H_2O$ ✓
Fizzing/effervescence ✓

ii) Moles $NH_3 = 0.1 \times 0.05 = 5.00 \times 10^{-3}$
Moles RCOOH required = 5.00×10^{-3}
M_r of M = 146 ✓
Mass = $146 \times 5.00 \times 10^{-3} = 0.73(0)$ g ✓

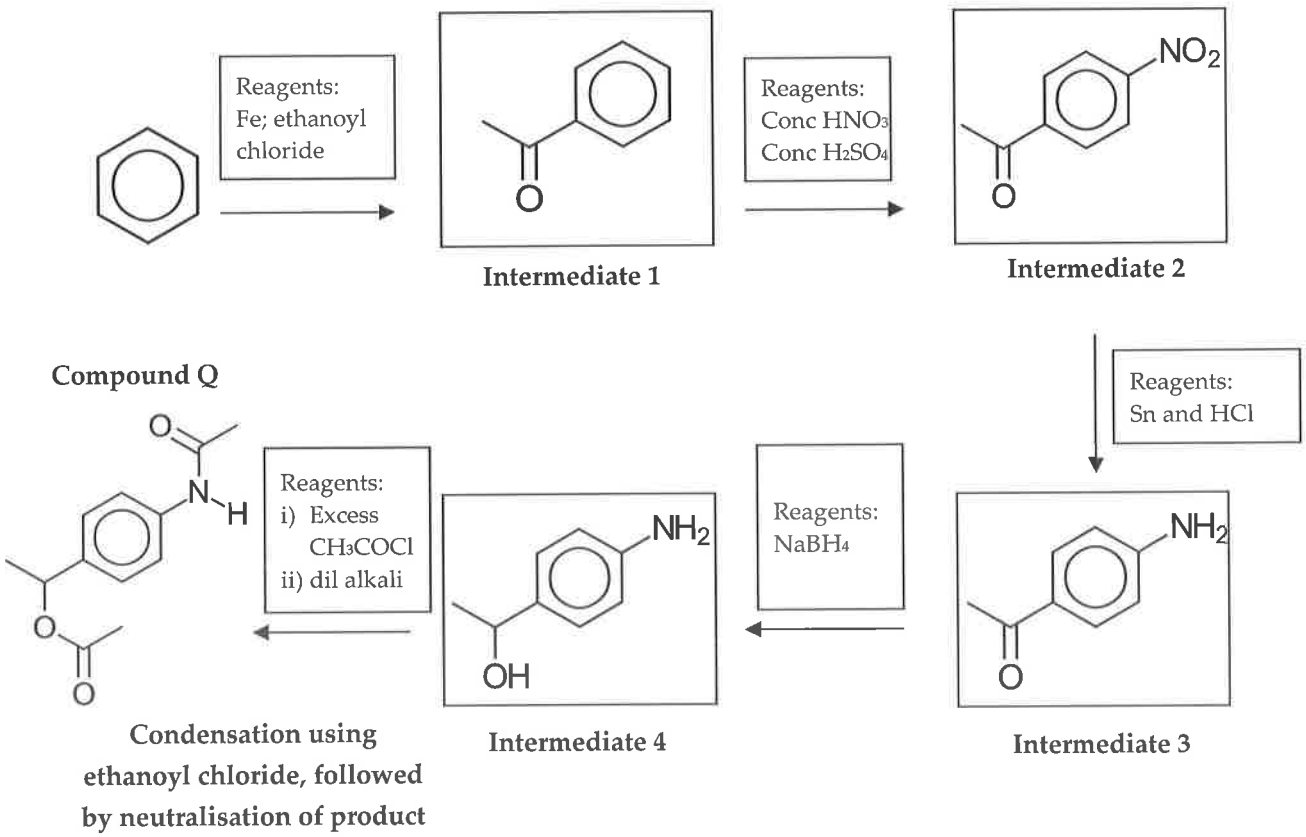
d)





✓ For formation of correct alkene ✓ For other isomer ✓
Bromine water ✓

21



Awarding of marks: ✓✓✓ for reagents used to achieve a correct transformation
✓✓✓✓ for intermediate with functional group introduced correctly
(IGNORE order – final marks)
✓✓ for viable order of steps (ALLOW reduction of -$COCH_3$ group before introduction and reduction of nitro group, but DO NOT ALLOW Friedel–Crafts acylation of nitro compound as this would substitute at wrong carbon.) AWARD one mark if two steps in viable order at any point

