

Section A (multiple choice)

Question 1: N/A

Question Number	Correct Answer	Mark
2	C	1

Question Number	Correct Answer	Mark
3	B	1

Question Number	Correct Answer	Mark
4	C	1

Question Number	Correct Answer	Mark
5	B	1

Question Number	Correct Answer	Mark
6	A	1

Question Number	Correct Answer	Mark
7	D	1

Question 8: N/A

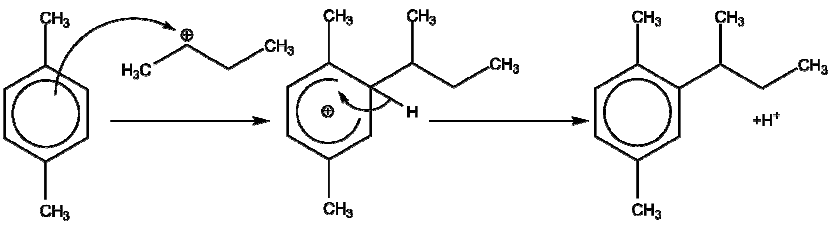
Question Number	Correct Answer	Mark
9 (a)	C	1

Question Number	Correct Answer	Mark
9 (b)	A	1

Question Number	Correct Answer	Mark
10	D	1

Section B

Question Number	Acceptable Answers	Reject	Mark
11 (a) (i)	Electrophilic substitution (any order)		1

Question Number	Acceptable Answers	Reject	Mark
(a) (ii)	<p> $\text{AlCl}_3 + \text{CH}_3\text{CH}(\text{Br})\text{CH}_2\text{CH}_3 \rightarrow \text{AlCl}_3\text{Br}^- + \text{CH}_3\text{C}^+\text{HCH}_2\text{CH}_3$ ALLOW $\text{CH}_3\text{CH}(\text{Br})\text{CH}_2\text{CH}_3 \rightarrow \text{Br}^- + \text{CH}_3\text{C}^+\text{HCH}_2\text{CH}_3$ Ignore position of the + for this mark Ignore curly arrows in this equation (1) </p>  <p>Electron pair (curly arrow) from ring to positively charged second carbon of carbocation (1)</p> <p>Structure of intermediate must include positive sign (1)</p> <p>Electron pair from C-H bond reforms delocalized ring (1)</p>	AlCl_4^-	4

Question Number	Acceptable Answers	Reject	Mark
(b)	<p>Advantage Graphite catalyst easier to remove / separate / can be filtered off (from reaction mixture) / graphite can be re-used (1)</p> <p>Justification AlCl_3 is soluble or graphite is insoluble / different state / different phase</p> <p>OR</p> <p>Graphite can be re-used (1)</p> <p>Mark independently</p>	Just graphite is a heterogeneous catalyst	2

Question Number	Acceptable Answers	Reject	Mark
(c) (i)	<p>(Conc) nitric acid (1)</p> <p>(Conc) sulfuric acid (1)</p> <p>penalise dilute once only</p>		2

Question Number	Acceptable Answers	Reject	Mark
(c) (ii)	<p>Greater electron density in ring / ring is activated / more susceptible to electrophilic attack (1)</p> <p>Due to electron releasing / donating methyl groups (1)</p>	Just more susceptible to attack	2

Question Number	Acceptable Answers	Reject	Mark
(c) (iii)	Reduction ALLOW redox	Hydrogenation	1

Question Number	Acceptable Answers	Reject	Mark
(c) (iv)	<p>NaNO_2 / sodium nitrite / sodium nitrate(III) & HCl (any strong acid) (1)</p> <p>Temp $0-10^\circ\text{C}$ / less than 10°C / any quoted temperature between $0-10^\circ\text{C}$ / in ice bath (1)</p> <p>$\text{C}_6\text{H}_3(\text{CH}_3)_2\text{NH}_2 + \text{HNO}_2 + \text{HCl} \rightarrow \text{C}_6\text{H}_3(\text{CH}_3)_2\text{N}_2^+\text{Cl}^- + 2\text{H}_2\text{O}$ (1)</p> <p>Add phenol dissolved in alkali (1)</p> <p>$(\text{C}_6\text{H}_3(\text{CH}_3)_2\text{N}_2^+\text{Cl}^- + \text{C}_6\text{H}_5\text{OH}) \rightarrow \text{C}_6\text{H}_3(\text{CH}_3)_2\text{N}_2\text{C}_6\text{H}_4\text{OH} + (\text{HCl})$ (1)</p> <p>Mark given for correct organic product Allow correct organic product shown as $-\text{O}^-$ instead of $-\text{OH}$</p> <p>Mark independently</p>	HNO_3	5

Question Number	Acceptable Answers	Reject	Mark
12 (b) (ii)	<p>Mix organic solvent and oil-water mixture in a separating funnel then separate (1)</p> <p>Distil / rotary evaporate (to separate clove oil from organic solvent) (1)</p> <p>Add (anhydrous) CaCl_2 / (anhydrous) MgSO_4 / (anhydrous) Na_2SO_4 / silica gel / calcium oxide to clove oil, (then filter / decant) (1)</p> <p>ALLOW name or formula of drying agent</p> <p>(Second and third marks in either order)</p> <p>OR</p> <p>Add (saturated solution) of NaCl / sodium salt (1)</p> <p>Separate in a separating funnel (1)</p> <p>Add named drying agent to clove oil, (then filter / decant) (1)</p>	(Anhydrous) CuSO_4 NaOH , sodium carbonate, sodium hydrogencarbonate, calcium carbonate	3

Question Number	Acceptable Answers	Reject	Mark
12 (c)	<p>Choice with justification (1)</p> <p>e.g. 'yes it's reasonable as clove oil may be in use at harmful /toxic levels so we need to identify what that level is'</p> <p>'no as clove oil has been in use for many years in many ways so tests on animals not necessary to confirm it's safe to use at current levels' / no, as humans would have to consume large amounts</p>	<p>Yes because it's toxic</p> <p>No, because of objections to animal testing in general</p>	1

Question Number	Acceptable Answers	Reject	Mark
12 (d)*	<p>4 clear justified comparisons - 1 mark each</p> <p>ScCO₂ oil obtained seems purier (as colour closely matches that of eugenol)</p> <p>requires no further purification, (others use solvent extraction)</p> <p>greater yield per hour</p> <p>yield 15.3g per 100g of buds</p> <p>no organic solvent (because it is chlorinated) and so environmental problems / harmful / damage ozone layer</p> <p>requires high pressure so likely to be expensive / requires specialist equipment</p> <p>Steam distillation steam distillation can be done using standard lab equipment / does not require high pressures</p> <p>yield only 6.1g / 6.2g per 100g of buds</p> <p>Steam gives the least yield per hour</p> <p>Soxhlet produces greater yield of oil but has a smaller percentage of eugenol / eugenol ethanoate</p> <p>yield 16.8g per 100g of buds</p> <p>(takes longer) but does not require high pressures</p> <p>uses organic solvent (because it is chlorinated) and so environmental problems / harmful / damage ozone layer</p> <p>Oil obtained seems least pure</p> <p style="text-align: right;">(4)</p> <p>Synthetic route has several steps, each with a low yield clove buds are renewable but materials in synthesis are not / materials in synthesis likely to be obtained from oil</p> <p style="text-align: right;">(1)</p>	<p>produces pale yellow oil</p> <p>Just no organic solvent</p> <p>Only two hours / shorter time than other methods Just higher percentage yield</p> <p>Just no organic solvent</p> <p>Higher yield than soxhlet</p> <p>Cost of chemicals Yield is 35 %</p>	5

Question Number	Correct Answer	Reject	Mark
13 (a)	B		1

Question Number	Correct Answer	Reject	Mark
13 (b)	B		1

Question Number	Correct Answer	Reject	Mark
14	D		1

Question Number	Correct Answer	Reject	Mark
15	D		1

Question Number	Correct Answer	Reject	Mark
16 (a)	C		1

Question Number	Correct Answer	Reject	Mark
16 (b)	D		1

Question Number	Correct Answer	Reject	Mark
17	B		1

Question Number	Correct Answer	Reject	Mark
18	D		1

Question Number	Correct Answer	Reject	Mark
19	C		1

Question Number	Acceptable Answers	Reject	Mark
20 (a)	Orange/yellow and precipitate/ppt or solid or crystals ALLOW orange-red or red-orange for colour	Any other colour alone or in combination, e.g.red	1

Question Number	Acceptable Answers	Reject	Mark
20(b)	<p>Heat with) Benedict's/Fehling's (solution) (1)</p> <p>Ketone/X would remain blue/no change/no reaction (1)</p> <p>Aldehyde/Y would form red/brown and ppt/Cu_2O (1)</p> <p>ALLOW combinations of red or brown with orange</p> <p>OR</p> <p>(Heat with) Tollens' Reagent/ammoniacal silver nitrate (1)</p> <p>Ketone/X remains colourless/no change/no reaction (1)</p> <p>Aldehyde/Y forms a silver mirror or black/grey precipitate/Ag/silver (1)</p> <p>OR</p> <p>(Heat with) acidified dichromate((VI)) (ions) (1)</p> <p>Ketone/X remains orange/no change/no reaction (1)</p> <p>Aldehyde/Y goes green/blue (1) ALLOW <i>answer with acidified or alkaline KMnO_4</i></p> <p>Ketone/X remains purple/pink/no change/no reaction (1)</p> <p>Aldehyde/Y goes colourless (with acid)/goes green (with alkali) (1)</p> <p>Near miss on reagent (e.g. silver nitrate not ammoniacal silver nitrate) observations can score 2</p> <p>ALLOW iodoform test with ketone identified (since X can only be butanone) (Aqueous) sodium hydroxide and iodine (1)</p> <p>Ketone/X forms yellow precipitate/solid/crystals (1)</p> <p>Aldehyde/Y no change/no reaction (1)</p>	<p>Just orange</p> <p>Ppt</p> <p>Just clear</p>	3

Question Number	Acceptable Answers	Reject	Mark
20(c)(i)	<p>Both $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$ And $(\text{CH}_3)_2\text{CHCHO}$</p> <p>ACCEPT displayed or skeletal formulae if structural formulae not given</p>	COH unless shown correctly in a displayed or skeletal formula	1

Question Number	Acceptable Answers	Reject	Mark
20(c)(ii)	<p>Recrystallization</p> <p>IGNORE solvent</p>	Just crystallization	1

Question Number	Acceptable Answers	Reject	Mark
20(c)(iii)	<p>Measure melting temperature / point (1)</p> <p>Compare with literature/database / known value (1)</p> <p>Second mark can only be awarded if first mark scored</p>	Just boiling temperature	2

Question Number	Acceptable Answers	Reject	Mark
21(a)	<p>Hazard – methanol/alcohol is flammable (1) IGNORE flammability of vegetable/diesel oils</p> <p>Precaution – use electrical heating source/water bath /avoid naked flames (1)</p> <p>OR</p> <p>Hazard – methanol/alcohol is toxic (1) Precaution – Use in well-ventilated area/fume cupboard/store away from children/wear gloves (1)</p> <p>OR</p> <p>Hazard – NaOH/reaction mixture is corrosive /burns (the skin)/damages the eyes (1) IGNORE references to (strong) alkali(ne) Precaution – wear gloves/goggles</p> <p>ALLOW any 2 hazards but the precaution must be associated with the appropriate hazard</p> <p>If the Hazard is not clearly identified but the precaution is appropriate then allow one mark, e.g. "Use of flammable substances so avoid naked flames" = (1) mark</p>	<p>Just volatile</p> <p>Just dangerous /harmful</p> <p>Just irritant</p>	4

Question Number	Acceptable Answers	Reject	Mark
21(b)	<p>Any two from:</p> <p>Reuses/reduces waste (vegetable) oil/ lessens need to dispose of (vegetable) oil (1)</p> <p>Could lessen use of (non-renewable/non-sustainable) crude oil/fossil fuels OR vegetable oil/biodiesel/reactants renewable/sustainable (1)</p> <p>Plants grown for vegetable oil could offset some CO₂ emissions (1)</p> <p>IGNORE references to transport/temperature/energy savings cost/profit/high yield/biodegradability/greenhouse gases</p>	<p>Just methanol is renewable</p> <p>Just carbon neutral/just reduces carbon footprint</p>	2

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	Sodium/potassium dichromate((VI))/potassium manganate ((VII))/Na ₂ Cr ₂ O ₇ /K ₂ Cr ₂ O ₇ /KMnO ₄ IGNORE references to acid	Just Cr ₂ O ₇ ²⁻ / MnO ₄ ⁻	1

Question Number	Acceptable Answers	Reject	Mark
22(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
22(a)(iii)	<p>CH₃CH₂CN/C₂H₅CN (1)</p> <p>ACCEPT displayed or skeletal formulae</p> <p>CH₃CH₂CN + H⁺ + 2H₂O → CH₃CH₂COOH + NH₄⁺</p> <p>OR</p> <p>CH₃CH₂CN + HCl + 2H₂O → CH₃CH₂COOH + NH₄Cl (2)</p> <p>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</p> <p>ALLOW one mark for the following equation without H⁺. CH₃CH₂CN + 2H₂O → CH₃CH₂COOH + NH₃</p> <p>ALLOW two marks for either of the following with H⁺ above the arrow CH₃CH₂CN + 2H₂O → CH₃CH₂COOH + NH₃ CH₃CH₂CN + 2H₂O → CH₃CH₂COOH + NH₄⁺</p> <p>ALLOW answers for alkaline hydrolysis followed by acidification CH₃CH₂CN + OH⁻ + H₂O → CH₃CH₂COO⁻ + NH₃ (1)</p> <p>Then CH₃CH₂COO⁻ + H⁺ → CH₃CH₂COOH (1)</p> <p>If propanamide, CH₃CH₂CONH₂ is given initially then ALLOW the two equation marks for the hydrolysis CH₃CH₂CONH₂ + H⁺ + H₂O → CH₃CH₂COOH + NH₄⁺</p> <p>If no acid is used then only one mark CH₃CH₂CONH₂ + H₂O → CH₃CH₂COOH + NH₃</p>	Hydroxynitriles	3

Question Number	Acceptable Answers	Reject	Mark
22(b)	<p>Reagent - Propanoyl chloride/$\text{CH}_3\text{CH}_2\text{COCl}$ (1)</p> <p>Any two from:</p> <p>C-Cl bond is weaker (than C- O) (1)</p> <p>Cl^-/chloride (ion) is a better leaving group (1)</p> <p>Carbonyl carbon is more positive/more δ^+/more attractive to nucleophiles (1)</p> <p>OR</p> <p>Reagent - Propanoic anhydride/$(\text{CH}_3\text{CH}_2\text{CO})_2\text{O}$ (1)</p> <p>CH_3COO^-/propanoate (ion) is a better leaving group (1)</p> <p>Carbonyl carbon is more positive/more δ^+/more attractive to nucleophiles (1)</p> <p>IGNORE references to reversible/equilibrium/catalysts</p> <p>IGNORE bond polarity</p>	<p>Propyl chloride</p> <p>Just Cl is more electronegative</p>	3

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

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

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