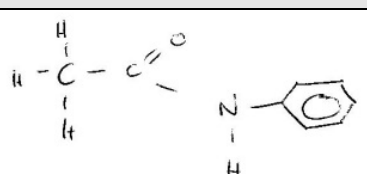


Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	Concentrated nitric acid AND concentrated sulfuric acid ALLOW 'concentrated nitric and sulfuric acids' Concentrated HNO ₃ and concentrated H ₂ SO ₄	Extra reagents	1

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	To prevent multiple substitutions/ to stop di- or trinitrobenzene forming ALLOW To stop further substitution (of NO ₂)/ further nitration IGNORE further reaction	Further addition of nitro groups	1

Question Number	Acceptable Answers	Reject	Mark
1(a)(iii)	Tin/ Sn AND concentrated HCl/ concentrated hydrochloric acid ALLOW Iron/Fe or Zn/Zinc for tin Conc for concentrated	Dilute HCl	1

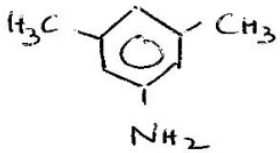
Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	C ₆ H ₅ NH ₃ ⁺ Cl ⁻ ALLOW C ₆ H ₅ NH ₃ Cl		1

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	 ALLOW C ₆ H ₅ for benzene Undisplayed CH ₃	Skeletal formula Structural formula	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(iii)i	(transition metal) complex ion ALLOW Transition metal complex / copper complex IGNORE Formulae of ions (1) F (azo) dye / azo compound / diazo compound ALLOW diazonium compound molecule for compound (1)		2

Question Number	Acceptable Answers	Reject	Mark
1b(iv)	Benzenediazonium chloride ALLOW Phenyldiazonium chloride	Benzadiazonium chloride Diazonium salt	1

Question Number	Acceptable Answers	Reject	Mark
1b(v)	$\text{HCl} + \text{NaNO}_2$ OR Hydrochloric acid + Sodium nitrite / nitrate(III) OR alternative cation to Na^+ IGNORE HNO_2 Concentration of HCl	$\text{HCl} + \text{HNO}_2$	1

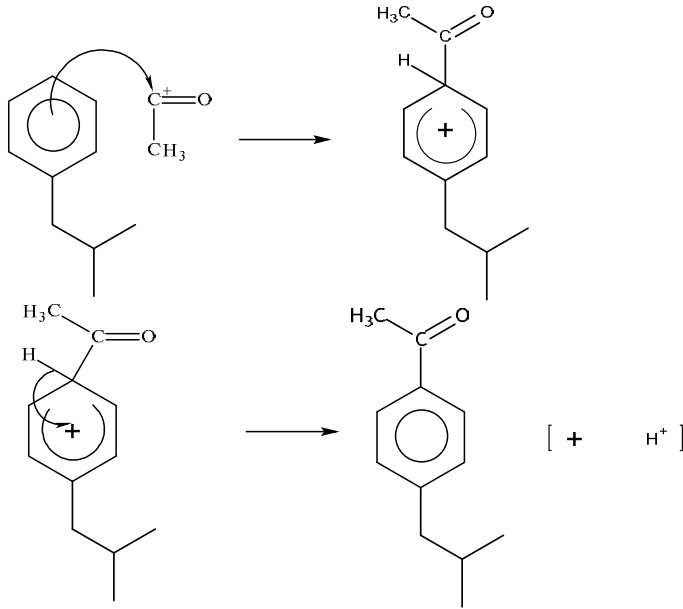
Question Number	Acceptable Answers	Reject	Mark
1b(vi)	 <p>ALLOW any substitution positions $C_6H_3(CH_3)_2NH_2$ $H-C_6H_2(CH_3)_2NH_2$ Kekule structure</p>	$C_6H_2(CH_3)_2NH_2$	1

Total for Question = 10 marks

Question Number	Acceptable Answers	Reject	Mark
2 (a) (i)	<p>Overall yield higher OR Reduces use of solvents (ALLOW chemicals / reactants) OR Less loss of chemicals OR Less waste products</p> <p>IGNORE References to Energy / fuel / CO_2 References to atom economy More efficient conversion Fewer side products</p>		1

Question Number	Acceptable Answers	Reject	Mark
2 (a) (ii)	<p>Lowers (operating) temperature / energy (requirements) OR Less fuel needed</p> <p>IGNORE References to catalyst properties such as 'lowers E_a', 'can be re-used' Atom economy</p>		1

Question Number	Acceptable Answers	Reject	Mark
2 (b) (i)	<p>$CH_3COCl + AlCl_3 \rightarrow CH_3CO^+ + AlCl_4^-$</p> <p>Structural formulae not required Positive charge may be anywhere on the electrophile. IGNORE Curly arrows even if incorrect</p>		1

Question Number	Acceptable Answers	Reject	Mark
<p>2 (b) (ii)</p>	 <p>TE on incorrect electrophile in (b)(i)</p> <p>If benzene used instead of substituted benzene OR If final product is not 1,4 only MP 1 and 2 can be scored</p> <p>Curly arrow from on or within the circle to positively charged carbon</p> <p>ALLOW Curly arrow from anywhere within the hexagon</p> <p>Arrow to any part of the electrophile including to the + charge (which can be anywhere on the electrophile) (1)</p> <p>Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, and facing the tetrahedral carbon and with some part of the positive charge within the horseshoe ALLOW dotted horseshoe (1)</p> <p>Curly arrow from C–H bond to anywhere in the benzene ring reforming delocalized structure of a stable molecule (1)</p> <p>Correct Kekulé structures score full marks Ignore any involvement of AlCl_4^- in the final step</p>		<p>3</p>

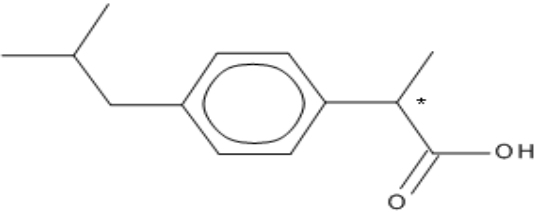
Question Number	Acceptable Answers	Reject	Mark
2 (b) (iii)	No HCl formed (as a by-product) OR Ethanoic acid easier to recover ALLOW Reverse arguments IGNORE Chlorine containing product References to ozone layer, acid rain, global warming Atom economy	Chlorine	1

Question Number	Acceptable Answers	Reject	Mark
2 (c) (i)	Catalyst (more) easily recovered / separated OR can be filtered OR Facilitates the use of flow (rather than batch) systems IGNORE references to properties of catalysts		1

Question Number	Acceptable Answers	Reject	Mark
2 (c) (ii)	<p>Reaction 1</p> <p>(red) phosphorus / P / P₄ and iodine / I₂ ALLOW PI₃ / HI (1)</p> <p>Reaction 3</p> <p>Hydrochloric acid / HCl(aq) or sulfuric acid / H₂SO₄ (aq) (1)</p> <p>and reflux / heat (1)</p> <p>Award second mark for Acid / H⁺ / H₃O⁺ and reflux</p> <p>OR</p> <p>NaOH(aq) / KOH(aq) (1)</p> <p>(reflux) then acidify with HCl(aq) or H₂SO₄ (aq) (1)</p> <p>IGNORE Omission of states throughout</p>	<p>NaI + H₂SO₄</p> <p>PI₅</p> <p>Just H⁺ / H₃O⁺</p> <p>reflux / heat without acid or with warm or <50°C</p>	

Question Number	Acceptable Answers	Reject	Mark
2 (c) (iii)	<p>C=O / carbonyl group (only) in carboxylic acid / ibuprofen (1)</p> <p>Absorption / peak at 1725 - 1700 (cm⁻¹) (1)</p> <p>If no other mark has been awarded, then ALLOW (for 1 mark)</p> <p>OH in both but in alcohol 3750 - 3200 (cm⁻¹) but in carboxylic acids 3300 to 2500 (cm⁻¹)</p>	<p>ketone</p> <p>1700 - 1680 (cm⁻¹)</p> <p>Single values rather than ranges</p>	2

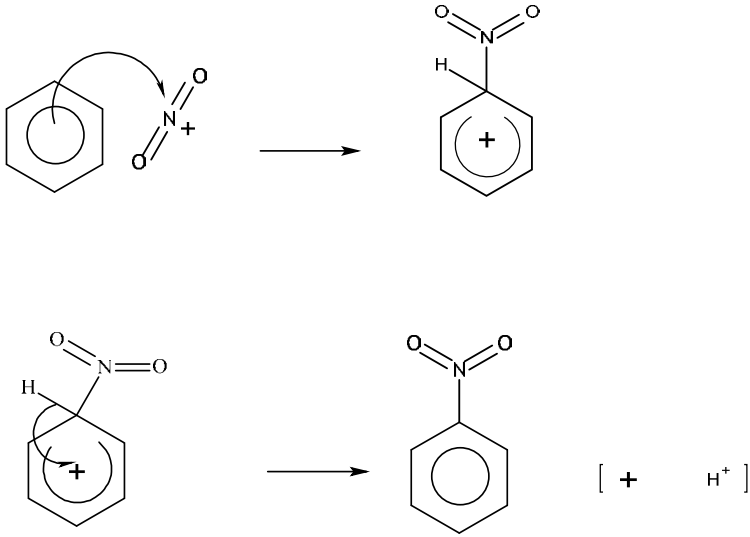
Question Number	Acceptable Answers	Reject	Mark
2 (d) (i)	<p>(A chiral molecule is) non-superimposable on its mirror image.</p> <p>ALLOW Asymmetric (tetrahedral) carbon atom / has a carbon atom bonded to four different groups / atoms</p> <p>IGNORE Has two enantiomers Functional (as in functional groups) Reference to rotation of plane polarized light</p>	molecules / species (for groups)	1

Question Number	Acceptable Answers	Reject	Mark
2 (d) (ii)	 <p>ALLOW any clear indication of chiral carbon</p>		1

Question Number	Acceptable Answers	Reject	Mark
2 (d) (iii)	<p>(A racemic mixture is) an equimolar mixture of the two enantiomers / (optical) isomers</p> <p>ALLOW (for equimolar mixture) equal amounts / concentrations / volumes / proportions</p> <p>OR 50:50 mixture</p>	Just 'no effect on plane polarised light'	1

Question Number	Acceptable Answers	Reject	Mark
2 (d) (iv)	<p>Any two of</p> <ol style="list-style-type: none"> 1. All the ibuprofen is useful (rather than half) 2. No need for separation of isomers / enantiomers 3. No need for a more complex synthesis forming just one enantiomer 4. Sometimes one enantiomer has negative effects 5. Smaller dosage may be used <p>ALLOW (For point 4 above) Dose / inactive isomer is less likely to be harmful</p> <p>IGNORE Reference to cost / yield / atom economy / side effects</p>		2

Question Number	Acceptable Answers	Reject	Mark
3 (a) (i)	$\text{HNO}_3 + 2\text{H}_2\text{SO}_4 \rightarrow \text{H}_3\text{O}^+ + 2\text{HSO}_4^- + \text{NO}_2^+$ <p>OR</p> $\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{O} + \text{HSO}_4^- + \text{NO}_2^+$ <p>OR</p> <p>2-step version of these involving H_2NO_3^+</p> <p>Correct electrophile (1) correct equation(s) (1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
<p>3 (a) (ii)</p>	 <p>OR NO_2^+ as electrophile</p> <p>TE on incorrect electrophile in (a)(i)</p> <p>Curly arrow from on or within the circle to positively charged nitrogen</p> <p>ALLOW Curly arrow from anywhere within the hexagon</p> <p>Arrow to any part of the electrophile including to the + charge (1)</p> <p>Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, and facing the tetrahedral carbon and with some part of the positive charge within the horseshoe (1)</p> <p>Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure (1)</p> <p>Correct Kekulé structures score full marks</p> <p>Ignore any involvement of anion in the final step</p>		3

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iii)	Benzene ring in phenol has higher electron density ALLOW O / OH donates electron density to the (benzene) ring (1) Because lone pair of electrons on (phenol) oxygen is donated to / overlaps with / interacts with (π electrons of benzene) ring (1)		2

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iv)	Substitution may also occur at the 2 / 6 ring positions / ortho position ALLOW 'other' / 3 / 5 / meta ring positions / isomers ALLOW further substitution occurs IGNORE By-products formed		1

Question Number	Acceptable Answers	Reject	Mark
3 (a)(v)	Tin /Sn & (conc.) hydrochloric acid / HCl(aq) ALLOW Iron/ Fe for tin ALLOW HCl for HCl(aq)	LiAlH ₄ / NaBH ₄	1

Question Number	Acceptable Answers	Reject	Mark
3 (a)(vi)	Yield = $(100 \times 0.25 \times 0.74 \times 0.85) = 15.725 / 15.73 / 15.7 / 16$ (%)	16.0 and other rounding errors	1

Question Number	Acceptable Answers	Reject	Mark
3 (b) (i)	Insoluble impurities are removed by the hot filtration (1) Soluble impurities are removed by the cold filtration (1)		2

Question Number	Acceptable Answers	Reject	Mark
3 (b) (ii)	5°C and 95°C (1) Because the lowest proportion (ALLOW 'amount') of paracetamol remains in solution (at the end) (1) IGNORE Just 'greatest difference in temperature'		2

Question Number	Acceptable Answers	Reject	Mark
3 (b) (iii)	Measure melting temperature ALLOW TLC (with UV light) Ignore Must melt over range of 2°C Data = data book value	Boiling temperature HPLC	1

Question Number	Acceptable Answers	Reject	Mark
3 c(i)	Peak at m/e = 151 clearly labelled M ALLOW Alternative labels		1

Question Number	Acceptable Answers	Reject	Mark
3 c(ii)	43 = $\left[\text{CH}_3\text{-C} \begin{array}{l} \diagup \\ \text{O} \end{array} \right]^+$ OR CH ₃ CO ⁺ / C ₂ H ₃ O ⁺ ALLOW CONH ⁺ Ignore position of charges	C ₃ H ₇ ⁺ uncharged species	1

Question Number	Acceptable Answers	Reject	Mark
3 (d)	Limit number of tablets sold OR Give (oral) advice at the point of sale OR Use packs with tablets individually wrapped ALLOW Reduce the (tablet) dose	Only sell on prescription / doctor's advice Label packet	1