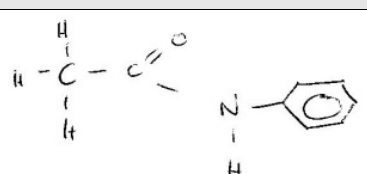


Question Number	Acceptable Answers	Reject	Mark
<b>1(a)(i)</b>	Concentrated nitric acid AND concentrated sulfuric acid ALLOW 'concentrated nitric and sulfuric acids' Concentrated HNO <sub>3</sub> and concentrated H <sub>2</sub> SO <sub>4</sub>	Extra reagents	1

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

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

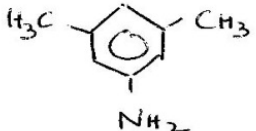
Question Number	Acceptable Answers	Reject	Mark
<b>1(b)(i)</b>	C <sub>6</sub> H <sub>5</sub> NH <sub>3</sub> <sup>+</sup> Cl <sup>-</sup>  ALLOW C <sub>6</sub> H <sub>5</sub> NH <sub>3</sub> Cl		1

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

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

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

Question Number	Acceptable Answers	Reject	Mark
<b>1b(v)</b>	<p>HCl + NaNO<sub>2</sub>  OR  Hydrochloric acid + Sodium nitrite / nitrate(III)  OR  alternative cation to Na<sup>+</sup></p> <p>IGNORE  HNO<sub>2</sub>  Concentration of HCl</p>	HCl + HNO <sub>2</sub>	1

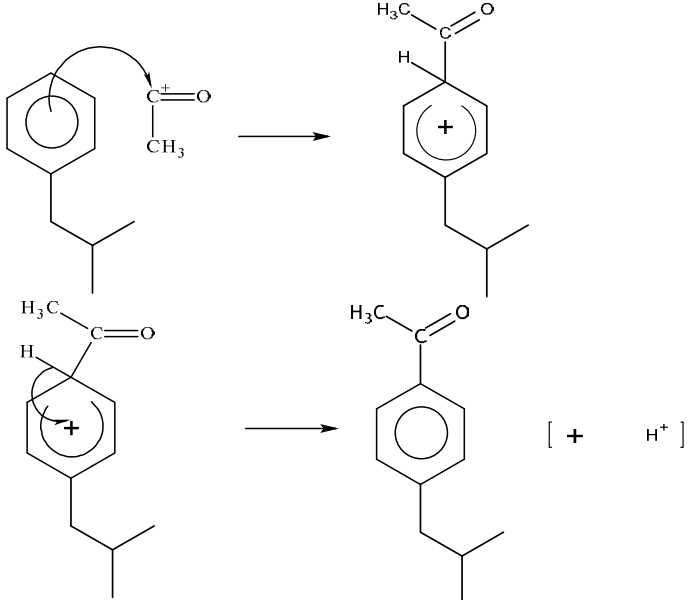
Question Number	Acceptable Answers	Reject	Mark
<b>1b(vi)</b>	 <p>ALLOW any substitution positions C<sub>6</sub>H<sub>3</sub>(CH<sub>3</sub>)<sub>2</sub>NH<sub>2</sub> H-<sub>6</sub>H<sub>2</sub>(CH<sub>3</sub>)<sub>2</sub>NH<sub>2</sub> Kekule structure</p>	C <sub>6</sub> H <sub>2</sub> (CH <sub>3</sub> ) <sub>2</sub> NH <sub>2</sub>	1

**Total for Question = 10 marks**

Question Number	Acceptable Answers	Reject	Mark
<b>2 (a)(i)</b>	<p>Overall <b>yield</b> 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<sub>2</sub> References to atom economy More efficient conversion Fewer side products</p>		<b>1</b>

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

Question Number	Acceptable Answers	Reject	Mark
<b>2 (b)(i)</b>	<p>CH<sub>3</sub>COCl + AlCl<sub>3</sub> → CH<sub>3</sub>CO<sup>+</sup> + AlCl<sub>4</sub><sup>-</sup></p> <p>Structural formulae not required Positive charge may be anywhere on the electrophile. IGNORE Curly arrows even if incorrect</p>		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<p><b>2</b> <b>(b) (ii)</b></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 <b>any</b> part of the electrophile including to the + charge (which can be anywhere on the electrophile) <b>(1)</b></p> <p>Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, <b>and</b> facing the tetrahedral carbon <b>and</b> with some part of the positive charge within the horseshoe ALLOW dotted horseshoe <b>(1)</b></p> <p>Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure of a stable molecule <b>(1)</b></p> <p>Correct Kekulé structures score full marks Ignore any involvement of <math>\text{AlCl}_4^-</math> in the final step</p>		<p><b>3</b></p> <p>Curly arrow on or outside the hexagon</p> <p>Partial bonds to H and <math>\text{CH}_3</math> unless part of a 3D with a wedge bond</p>

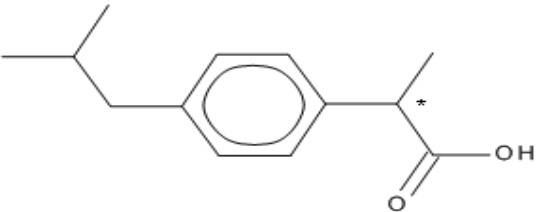
Question Number	Acceptable Answers	Reject	Mark
<b>2 (b) (iii)</b>	No HCl formed (as a by-product) OR Ethanoic acid easier to recover  ALLOW Reverse arguments  IGNORE Chlorine containing product References to ozone layer, acid rain, global warming Atom economy	Chlorine	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>2 (c) (i)</b>	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		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>2</b>  <b>(c)(ii)</b>	<p><b>Reaction 1</b></p> <p>(red) phosphorus / P / P<sub>4</sub> and iodine / I<sub>2</sub> ALLOW PI<sub>3</sub> / HI <b>(1)</b></p> <p><b>Reaction 3</b></p> <p>Hydrochloric acid / HCl(aq) or sulfuric acid / H<sub>2</sub>SO<sub>4</sub> (aq) <b>(1)</b></p> <p><b>and</b> reflux / heat <b>(1)</b></p> <p>Award second mark for Acid / H<sup>+</sup> / H<sub>3</sub>O<sup>+</sup> <b>and</b> reflux</p> <p>OR</p> <p>NaOH(aq) / KOH(aq) <b>(1)</b></p> <p>(reflux) <b>then</b> acidify with HCl(aq) or H<sub>2</sub>SO<sub>4</sub> (aq) <b>(1)</b></p> <p>IGNORE Omission of states throughout</p>	<p>NaI + H<sub>2</sub>SO<sub>4</sub></p> <p>PI<sub>5</sub></p> <p>Just H<sup>+</sup> / H<sub>3</sub>O<sup>+</sup></p> <p>reflux / heat without acid or with warm or &lt;50°C</p>	

Question Number	Acceptable Answers	Reject	Mark
<b>2</b>  <b>(c)(iii)</b>	<p>C=O / carbonyl group (only) in carboxylic acid / ibuprofen <b>(1)</b></p> <p>Absorption / peak at 1725 - 1700 (cm<sup>-1</sup>) <b>(1)</b></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<sup>-1</sup>) but in carboxylic acids 3300 to 2500 (cm<sup>-1</sup>)</p>	<p>ketone</p> <p>1700 - 1680 (cm<sup>-1</sup>)</p> <p>Single values rather than ranges</p>	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>2 (d)(i)</b>	<p>(A chiral molecule is) non-superimposable on its mirror image.</p> <p>ALLOW Asymmetric (tetrahedral) carbon atom / has a carbon atom bonded to <b>four</b> 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)	<b>1</b>

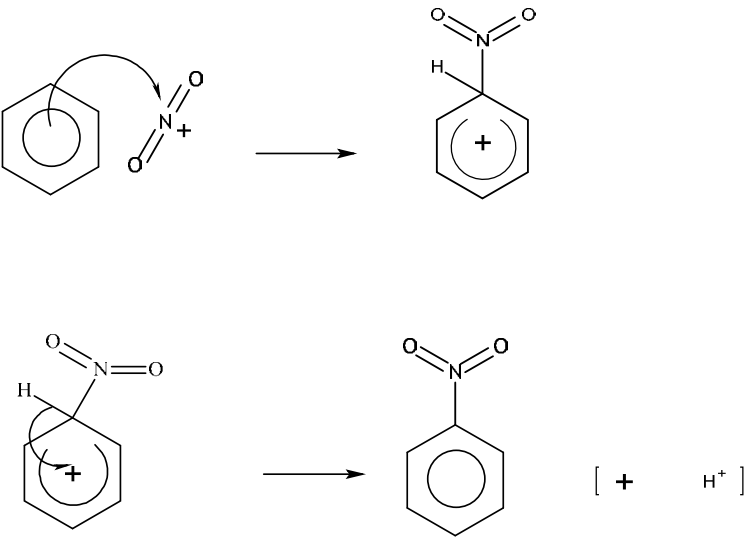
Question Number	Acceptable Answers	Reject	Mark
<b>2 (d)(ii)</b>	 <p>ALLOW any clear indication of chiral carbon</p>		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>2 (d)(iii)</b>	<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'	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>2</b>  <b>(d) (iv)</b>	<p>Any two of</p> <ol style="list-style-type: none"> <li>1. All the ibuprofen is useful (rather than half)</li> <li>2. No need for separation of isomers / enantiomers</li> <li>3. No need for a more complex synthesis forming just one enantiomer</li> <li>4. Sometimes one enantiomer has negative effects</li> <li>5. Smaller dosage may be used</li> </ol> <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>		<b>2</b>

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



Question Number	Acceptable Answers	Reject	Mark
<p><b>3</b> <b>(a)(ii)</b></p>	 <p>OR <math>\text{NO}_2^+</math> 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 <b>(1)</b></p> <p>Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, <b>and</b> facing the tetrahedral carbon <b>and</b> with some part of the positive charge within the horseshoe <b>(1)</b></p> <p>Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure <b>(1)</b></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
<b>3</b> <b>(a)(iii)</b>	Benzene ring in phenol has higher electron density ALLOW O / OH donates electron density to the (benzene) ring <b>(1)</b>  Because <b>lone pair</b> of electrons on (phenol) oxygen is donated to / overlaps with / interacts with ( $\pi$ electrons of benzene) ring <b>(1)</b>		2

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

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

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

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

Question Number	Acceptable Answers	Reject	Mark
<b>3 (d)</b>	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