

# CD.a-n - Colour by design | CD1-11 |

## CD.Q Exam questions from past papers

<p>(c) A synthesis of benzocaine occurs in several stages. A first step involves the conversion of benzene into methylbenzene as shown in the equation below:</p> $\text{C}_6\text{H}_6 + \text{CH}_3\text{Cl} \rightarrow \text{C}_6\text{H}_5\text{CH}_3 + \text{HCl}$ <p>The benzene is heated with chloromethane and aluminium(III) chloride as a catalyst in anhydrous conditions.</p> <p>(i) Explain why this reaction must be carried out in anhydrous conditions.</p> <p>..... [1]</p> <p><b>Explain why this reaction must be carried out in anhydrous conditions?</b></p>	<p><b>The aluminium(III) chloride reacts (vigorously) with water ✓</b> <span style="float: right;">1</span></p> <p><b>The aluminium (III) chloride reacts vigorously with water</b></p>
<p>24 A pure sample of fat was known to be a triester of propane-1,2,3-triol with a fatty acid. 0.15 mol of the fat required 10.8 dm<sup>3</sup> of hydrogen at room temperature and pressure for complete hydrogenation.</p> <p>Identify which fatty acid formed the triester.</p> <p>A Palmitic acid, C<sub>15</sub>H<sub>32</sub>COOH B Linoleic acid, C<sub>17</sub>H<sub>32</sub>COOH C Oleic acid, C<sub>17</sub>H<sub>33</sub>COOH D Stearic acid, C<sub>17</sub>H<sub>35</sub>COOH</p> <p>Your answer <input type="checkbox"/> [1]</p> <p>0.15 mol of fat required 10.8dm<sup>3</sup> of hydrogen at room temperature and pressure for complete hydrogenation</p> <p>Identify which fatty acid formed the triester</p>	<p>3. A pure sample of fat was known to be a triester of propane-1, 2, 3-triol with a fatty acid. 0.15 mol of the fat required 10.8 dm<sup>3</sup> of hydrogen at room temperature and pressure for complete hydrogenation.</p> <p>Identify which fatty acid formed the triester. <math>\text{C}_n + 3\text{H}</math></p> <p>A. Palmitic acid, C<sub>15</sub>H<sub>32</sub>COOH B. Linoleic acid, C<sub>17</sub>H<sub>32</sub>COOH C. Oleic acid, C<sub>17</sub>H<sub>33</sub>COOH D. Stearic acid, C<sub>17</sub>H<sub>35</sub>COOH</p> <p>Your answer <b>A</b> X <b>C</b> <math>10.8 \div 24 = 0.45 \text{ mol}</math> [1]</p> <ul style="list-style-type: none"> <li>• C as when the COOH group is replaced with H it would be an alkene</li> </ul>
<p>Explain why compounds with an aromatic ring usually form substituted derivatives, rather than addition compounds? (1)</p> <p>(b) Explain why compounds with an aromatic ring usually form substituted derivatives, rather than addition compounds.</p> <p>..... ..... ..... ..... [2]</p>	<p>(aromatic compounds have) delocalised electrons that are lost on addition <b>AND</b> retained on substitution ✓ (loss of delocalisation causes) less stability AW ✓</p> <ul style="list-style-type: none"> <li>• Aromatic compounds have delocalised electrons that are lost on addition <b>AND</b> retained on substitution (1)</li> <li>• Less delocalisation causes less stability (1)</li> </ul>

## CD.a-b - Bonding & Structure | CD5 | CD6 |

Define Colorfast dye?	A dye that doesn't wash out easily
What are the 4 different ways dyes attach	<ul style="list-style-type: none"> <li>• Ionic bonds (between dyes and nylon, wool or</li> </ul>

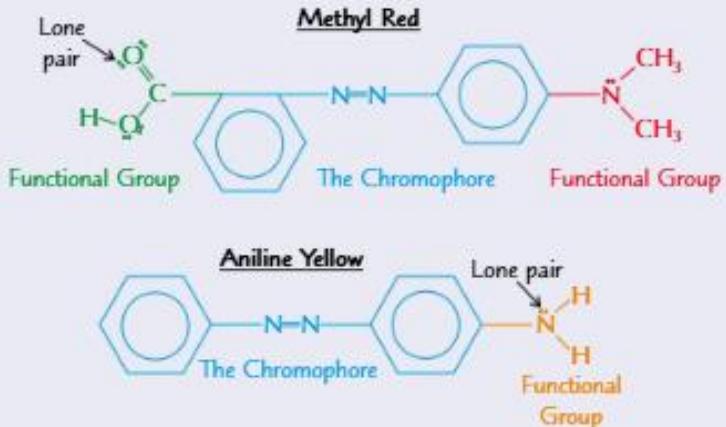
themselves to fibres?	<p>silk)</p> <ul style="list-style-type: none"> <li>• Covalent bonds (between dyes and cotton, cellulose)</li> <li>• Hydrogen bonds (between dyes and cotton)</li> <li>• Id-id bonds (dyes and polyesters)</li> </ul> <p><i>Mordanting as well in the textbook never seen it in past paper though</i></p>
What are the ways in which dyes bond to fibres and the functional groups to which this occurs?	<ul style="list-style-type: none"> <li>• <b>Ionic bonds</b> via -COOH or -SO<sub>3</sub>H group on a dye and a -NH<sub>2</sub> group in fibres (fibres such as <b>wool, silk or nylon</b>)</li> <li>• <b>Strong covalent bonds</b> forming via fibre-reactive dyes bonding with -OH or -NH group in the fibre (<b>cotton, cellulose</b>)</li> <li>• <b>Hydrogen bonds</b> via -NH<sub>2</sub> groups on a dye and a -OH group on a fibre (<b>cellulose fibres such as cotton, rayon or linen</b>)</li> <li>• <b>Dissociation of ionic groups</b> then forming ionic bonds via dyes having -SO<sub>3</sub>Na<sup>+</sup> and dissociating in water to produce -SO<sub>3</sub><sup>-</sup> group and then -NH<sub>2</sub> group on the fibre (<b>nylon, wool silk</b>) which in the presence of an acid produces -NH<sub>3</sub><sup>+</sup> which then -SO<sub>3</sub><sup>-</sup> binds with -NH<sub>3</sub><sup>+</sup></li> <li>• <b>Acidic conditions (i.e in a weak acid)</b> could also mean -NH<sub>2</sub> groups become <b>protonated</b> and turn into -NH<sub>3</sub><sup>+</sup> on either dye or fibres</li> </ul> <p><i>All of these are types of examples for which a dye could bond to a fibre it does not represent all the ways so make sure to interpret a question carefully bestie</i></p>
Define Chromophore?	<p>A part of a molecule that is responsible for the colour of a substance</p> <p><i>It does this by changing the wavelength the electrons absorb and they usually contain: double or triple bonds like C=C or N=N, lone pair of electrons or benzene rings</i></p> <p>The structures of the azo dyes <b>methyl red</b> (in acidic conditions) and <b>aniline yellow</b> are shown below. In the forms shown, methyl red appears, err... <b>red</b> and aniline yellow is, well... <b>yellow</b>.</p> <div style="background-color: #e0e0ff; padding: 10px;"> <p><b>Methyl Red</b></p> <p><b>Aniline Yellow</b></p> </div>
Which atoms as part of the functional group	<ul style="list-style-type: none"> <li>• Oxygen and Nitrogen atoms lone pair of</li> </ul>

on the chromophore/azo dye changes the colour of the azo dye and why?

electrons (mostly likely from an -OH or NH<sub>2</sub> group)

- As these groups have lone pair of electrons that become part of the extended system of delocalised electrons that spans between the two benzene rings and the -N=N- group
- They change the frequency of light they absorb and so the colour of the molecule

The structures of the azo dyes **methyl red** (in acidic conditions) and **aniline yellow** are shown below. In the forms shown, methyl red appears, err... **red** and aniline yellow is, well... **yellow**.



Which functional groups on the chromophore affect the solubility of the dye AND what is the name of that functional group (1)

- Usually ionic groups such as SO<sub>3</sub><sup>-</sup> (usually in the form of its sodium salt e.g. -SO<sub>3</sub><sup>-</sup>Na<sup>+</sup>)
- As the SO<sub>3</sub><sup>-</sup> group can form ion-dipoles with water molecules which is stronger than hydrogen bonds from an -OH or -NH<sub>2</sub> group
- SO<sub>3</sub><sup>-</sup> is a **sulfonate group** (1)



The ionic groups (shown in green) make it more soluble in water.

CD.c-f - Organic functional groups | CD2 | CD3 | CD4 | CD7 | CD10 |

What are triglycerides?

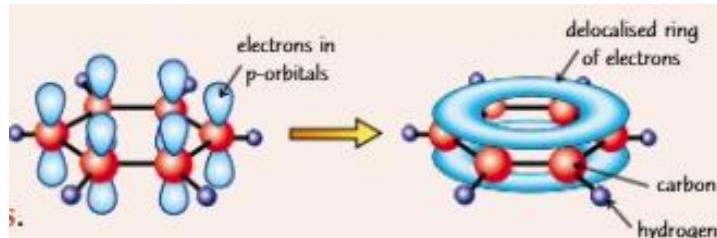
They are **triesters** of glycerol (propane-1,2,3-triol) and (unsaturated or saturated) fatty acids

*They usually ask about condensation or hydrolysis reactions to do with these, make sure to balance the equations correctly and a long chain group might be*

	<p>represented using R e.g <math>RCOOH</math> or K+ e.g <math>KOH</math></p> <p>Glycerol + 3 x Fatty Acid → Triglyceride + <math>3H_2O</math></p> <p>A condensation reaction involves the elimination of a small molecule, typically water (although it doesn't have to be).</p>
How does a fatty acid/ triglyceride(triester) being unsaturated affect its melting point	The melting point would be lower as the fatty acid would do E/Z isomerism and so would have a 'kink' in the chain which pushes the chains apart allowing for less id-id bonds to form
	<p>Saturated      Unsaturated</p>
What are the names for these 6 arenes?	<ul style="list-style-type: none"> <li>• Benzoic acid</li> <li>• Benzaldehyde</li> <li>• Benzene sulfonic acid</li> <li>• Nitrobenzene</li> <li>• Chlorobenzene</li> <li>• Benzoyl chloride</li> </ul>

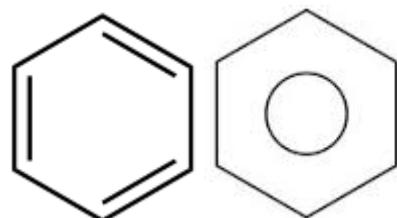
What does the actual structure for benzene look like? (2)

- 2 rings of 6 delocalised electrons (1) above and below the ring of carbon atoms (1) where 1 delocalised electron comes from each carbon



*The pi ring or the sideways overlapping of the 6 p orbitals means low electron density therefore benzene is unable to polarise many molecules requiring catalysts*

What was wrong with kekule's benzene structure and why is the current/actual benzene structure correct? (4 reasons for each structure)



Kekules's Structure

- Not hexagonal
- Should undergo electrophilic addition as it has C=C bonds
- It would decolourise bromine water
- Enthalpy change of hydration should be -360kJ/mol as its -120 per double bond x 3
- Bond lengths would not be the same (*as C=C is shorter than C-C therefore 3 short bonds 3 longer ones*)
- *There would have been 2 isomers if kekule's*

Benzene structure

- Hexagonal
- All bonds same length
- Actually undergoes electrophilic substitution reactions (as it keeps more stable delocalised structure)
- 2 rings of delocalised electrons above and below the carbon atoms
- Each atom in the ring contains 1 lone electron (delocalised electron)
- Enthalpy change of hydration is actually -208kJmol<sup>-1</sup>
- Actual benzene has 1 isomer
- Energetics suggest actual benzene would be more stable than kekule's
- *Its electron density maps*
- *Actual benzene needs 'forcing' conditions to undergo addition*

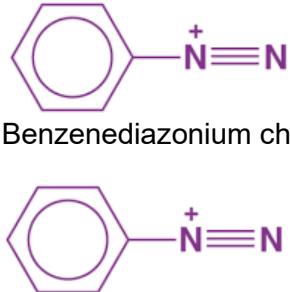
*Don't talk about bond angles as they are the same 120° for both structures*

*Italics are fine details*

Based of H433 Paper 3 June 2023 6 marker

Functional group of diazonium salt and draw benzenediazonium chloride?

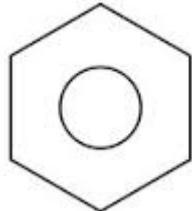
- Functional group

	<ul style="list-style-type: none"> <li>• Benzenediazonium chloride</li> </ul> 
Functional group of azo dye?	<ul style="list-style-type: none"> <li>• Functional group</li> </ul> $\begin{array}{c} R \\ \diagdown \\ N=N \\ \diagup \\ R' \end{array}$ <p><i>Usually two or more benzene rings on either R group as dyes as coloured and more than 1 benzene ring is needed for an extended system of delocalised electrons to be coloured</i></p>
Functional group of Nitrile and why is forming them via nucleophilic substitution often useful	<ul style="list-style-type: none"> <li>• Functional group</li> </ul> <p><b>R—C≡N</b></p> <p>Its useful as it creates an extra carbon along the organic chain</p> <p><i>Usually related to nucleophilic addition or substitution</i></p>

## CD.g-j - Organic Reactions | CD4 | CD5 | CD9 | CD10 | CD11 |

What are the conditions, reagents, products and the equation for the formation of electrophile for the chlorination of benzene?	<ul style="list-style-type: none"> <li>• Conditions: Anhydrous, Heating under reflux</li> <li>• Reagents: <math>\text{Cl}_2</math> and <math>\text{AlCl}_3</math> as a catalyst</li> </ul> <ol style="list-style-type: none"> <li>1. The halogen carrier (<math>\text{AlCl}_3</math>) polarises the chlorine allowing it to react with the halogen carrier to form a positive electrophile</li> <li>• <math>\text{AlCl}_3 + \text{Cl}_2 \rightarrow \text{AlCl}_4^- + \text{Cl}^+</math></li> <li>2. React the electrophile with the benzene</li> <li>• Products: Chlorobenzene, <math>\text{HCl}</math></li> </ol> <p><i>A positive electrophile has to be formed because benzene isn't very polarising</i></p> <p><i>Mechanism: Electrophilic Substitution</i></p>
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What are the conditions, reagents, products and the equation for the formation of electrophile for the bromination of benzene?

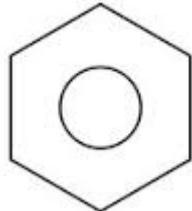


- Conditions: Anhydrous, Heating under reflux
- Reagents:  $\text{Br}_2$  and  $\text{FeBr}_3$  as a catalyst
- 1. The halogen carrier ( $\text{FeBr}_3$ ) polarises the bromine allowing it to react with the halogen carrier to form a positive electrophile
- $\text{FeBr}_3 + \text{Br}_2 \rightarrow \text{FeBr}_4^- + \text{Br}^+$
- 2. React the electrophile with the benzene
- Products: Bromobenzene,  $\text{HBr}$

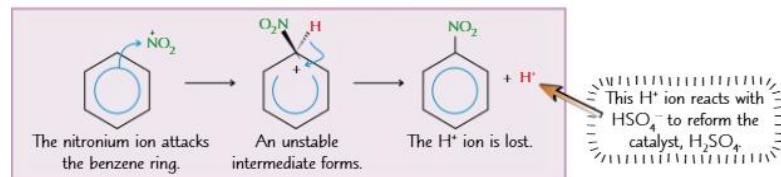
*A positive electrophile has to be formed because benzene isn't very polarising*

#### Mechanism: Electrophilic Substitution

What are the conditions, reagents, products and the equation for the formation of electrophile for the nitration of benzene?



- Conditions: below 55°C
- Reagents: Conc  $\text{HNO}_3$ , conc  $\text{H}_2\text{SO}_4$
- 1. Formation of the electrophile nitronium ion
- Overall:  $\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow \text{HSO}_4^- + \text{NO}_2^+ + \text{H}_2\text{O}$
- 2. React nitronium ion with benzene...
- Products: Nitrobenzene,  $\text{H}_2\text{O}$

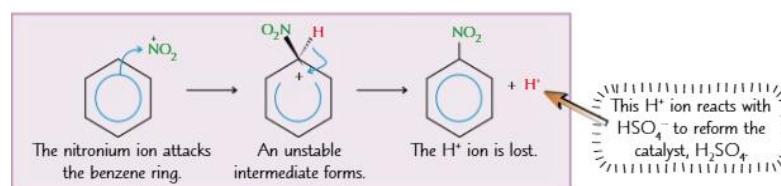
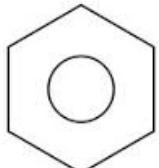


*The catalyst  $\text{H}_2\text{SO}_4$  has reformed. You need concentrated conditions*

*Perform within a water bath as reaction is exothermic. Any temperature too high will lead to polynitration rather than mononitration*

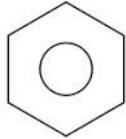
#### Mechanism: Electrophilic Substitution

Draw the mechanism for the nitration of benzene



*Reagents: Conc  $\text{HNO}_3$ , conc  $\text{H}_2\text{SO}_4$   
Overall:  $\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow \text{HSO}_4^- + \text{NO}_2^+ + \text{H}_2\text{O}$*

What are the conditions, reagents, products and the equation for the formation of electrophile for the sulfonation of benzene?

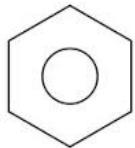


- Conditions: Heating under reflux
- Reagents: Concentrated  $H_2SO_4$
- 1. Formation of the electrophile sulfonate (sulfur trioxide)
- $H_2SO_4 \rightarrow H_2O + SO_3$
- Products: Benzenesulfonic acid,  $H_2O$

*Reagents and conditions could also be fuming sulfuric acid and 40°C instead*

*Mechanism: Electrophilic Substitution*

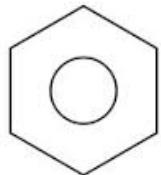
What are the conditions, reagents and products for Friedel-Crafts alkylation of benzene as well as the equation for the formation of the electrophile?



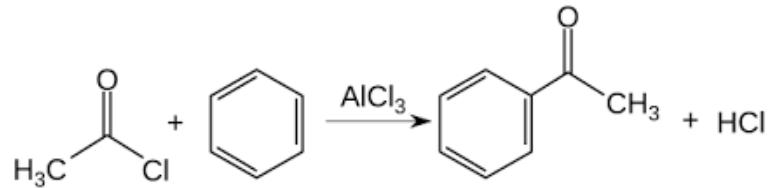
- Conditions: Anhydrous, heating under reflux
- Reagents:  $AlCl_3$  (halogen carrier),  $CH_3Cl$
- Formation of Electrophile:  $CH_3Cl + AlCl_3 \rightarrow CH_3^+ + AlCl_4^-$
- Products: Methylbenzene,  $HCl$

*Mechanism: Electrophilic substitution*

What are the conditions and reagents for Friedel-Crafts acylation of benzene as well as the equation for the formation of the electrophile?



- Conditions: Anhydrous
- Reagents:  $CH_3COCl$  and  $AlCl_3$
- Formation of Electrophile:  $CH_3COCl + AlCl_3 \rightarrow [CH_3CO]^+ + [AlCl_4]^-$



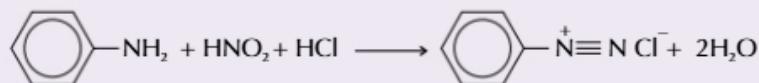
*Names of products for acylation is not required for our spec*

*Mechanism: Electrophilic substitution*

What are the conditions, reagents, products for diazotisation of aminobenzene?



- Conditions: below 5°C (ice cold)
- Reagents: Aminobenzene,  $HNO_2$  (or  $NaNO_2$ ),  $HCl$
- Products: diazonium salt (Benzenediazonium chloride),  $H_2O$

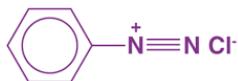


*If  $NaNO_2$  is used instead of  $HNO_2$  products would be diazonium salt,  $NaCl$  and  $H_2O$  just check that the equation is balanced and if the reagents are in excess*

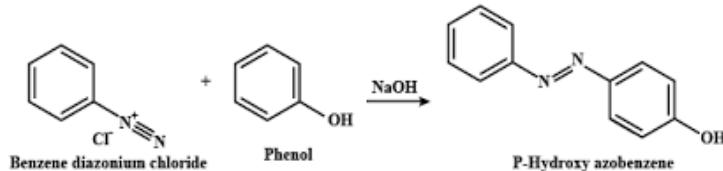
*Diazotisation needs to be kept separate from a coupling reaction as diazotisation requires acidic conditions and coupling requires alkaline conditions.*

*Mechanism: Electrophilic substitution*

What are the conditions, reagents, products and coupling agent for the coupling reaction for making an azo dye?



- Conditions: below 5°C (ice cold)
- Reagents: NaOH, diazonium salt (Benzenediazonium chloride)
- Coupling agent: E.g phenol (could also be considered to be another reagent)
- Products: azo dye, HCl



*Don't ever forget that it needs to be in alkaline conditions*

An Asterisk \* is OFTEN used to show where a coupling agent would most likely bond to reagent; don't assume it could bond on any part of the benzene ring. Sometimes but not always if the coupling agent is e.g. phenol then it would bond on the opposite side of 1 benzene ring to the -OH bond as shown above

Diazotisation needs to be kept separate from a coupling reaction as diazotisation requires acidic conditions and coupling requires alkaline conditions.

You don't need to know how to name azo dyes so relax

Mechanism: Electrophilic substitution

What are the reagents, and conditions for forming carboxylic acids from aldehydes?

- Acidified potassium dichromate (VI) (ADP)
- Heating under reflux

What are the 3 laboratory tests that could be done to distinguish between an aldehyde and a ketone and what is observed for each? (2)

- Warm with acidified potassium dichromate (1) turns from orange to green (1)
- Warm with Tollen's reagent (1) turns from colourless to a silver mirror (1)
- Warm with Fehling's solution (1) solution turns from blue to a red/orange ppt (1)

*In all 3 cases the aldehyde is being oxidised to make a carboxylic acid ketone would never be oxidised*

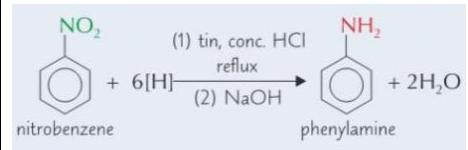
*The word 'Warm' is a necessity*

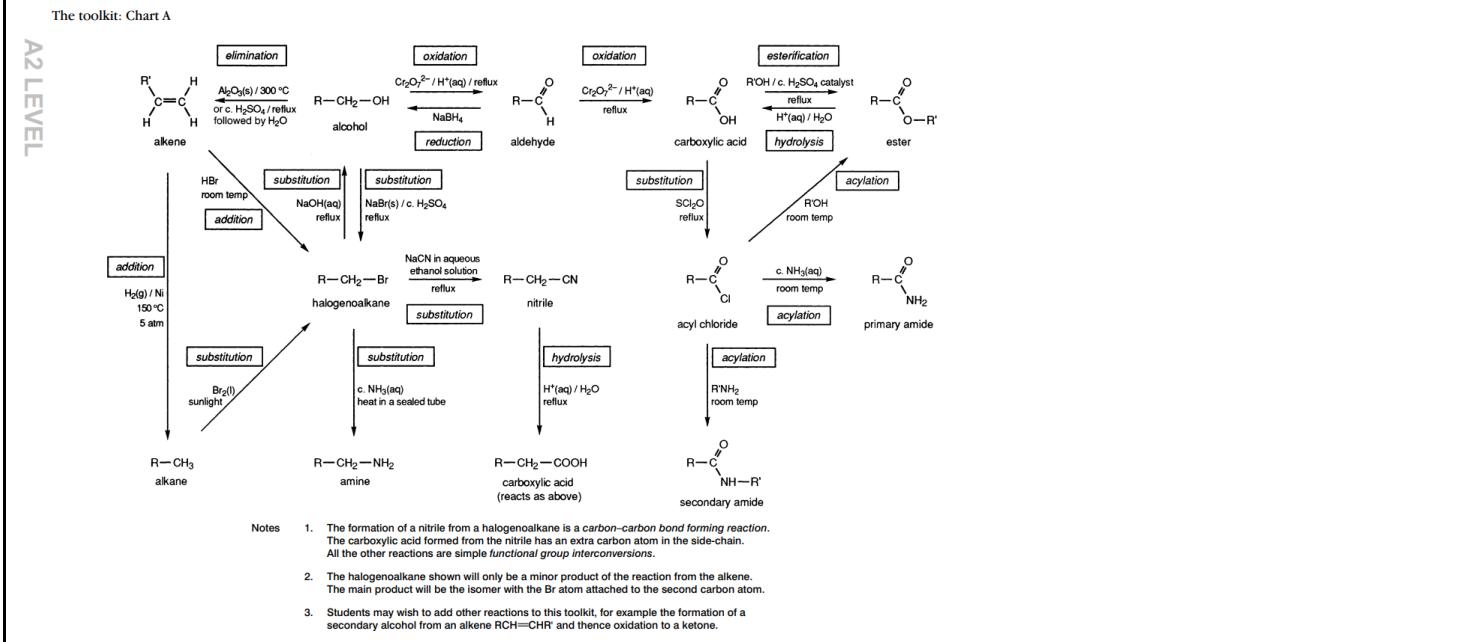
*Tollen's reagent is also known as ammoniacal silver nitrate  
Benedict's reagent can be said/used instead of Fehling's solution*

How can carbonyls (ketones/aldehydes) become hydroxynitriles with reagents and conditions and what is the name of the functional group formed in the product (1) ?

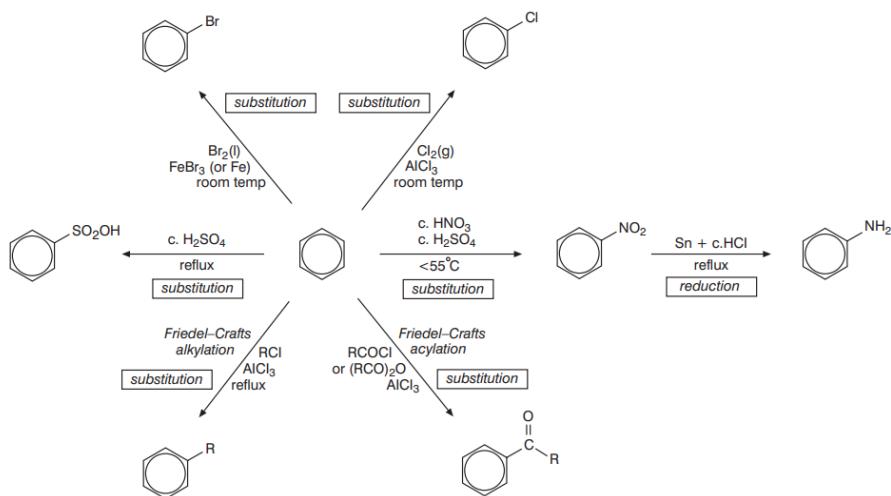
- Reagents: HCN
- Conditions: RTP
- Cyanohydrin (1)

	<p><math>\text{H}^+</math> ion from HCN</p> <p>Cyanohydrin and hydroxynitrile are both names for the functional group</p> <p>HCN is highly toxic</p> <p>Mechanism Nucleophilic Addition</p>
What are the reagents, conditions, products and type of reaction for forming nitriles from haloalkanes? E.g. HBr  [Its on the data sheet]	<ul style="list-style-type: none"> <li>Conditions: Heating under reflux</li> <li>Reagents: NaCN, ethanol</li> <li>Products: nitrile, NaBr</li> <li>Type of reaction: Nucleophilic substitution</li> </ul> <p>1 <math>\text{R-Br} + \text{CN}^- \longrightarrow \text{R-CN} + \text{Br}^-</math></p> <p>IT'S ON THE DATA SHEET</p>
How are carboxylic acids formed from nitriles (Conditions, reagents, type of reaction)  [Its on the data sheet]	<ul style="list-style-type: none"> <li>Conditions: Heating under reflux</li> <li>Reagents: HCl</li> <li>Type of reaction: Hydrolysis</li> </ul> <p>2 <math>\text{R-CN} \xrightarrow[\text{reflux}]{\text{H}^+ (\text{aq})} \text{R-COOH}</math></p> <p>IT'S ON THE DATA SHEET</p>
How are carbonyls reduced to alcohols? (reagents and type of reaction)  [Its on the data sheet]	<ul style="list-style-type: none"> <li>NaBH4</li> <li>Reduction</li> </ul> <p>IT'S ON THE DATA SHEET</p> <p>3 <math>\text{R-C(=O)-R'} \xrightarrow{\text{NaBH}_4} \text{R-CH(OH)-R'}</math></p>
How are acyl chlorides formed from carboxylic acids (catalyst, conditions, type of reaction)	<ul style="list-style-type: none"> <li>By reacting Carboxylic acid with <math>\text{SOCl}_2</math></li> <li>RTP</li> </ul>

<p>[Its on the data sheet]</p>	<ul style="list-style-type: none"> <li>Type of reaction: substitution</li> <li><math>\text{CH}_3\text{COOH} + \text{SOCl}_2 \rightarrow \text{CH}_3\text{COCl} + \text{SO}_2 + \text{HCl}</math></li> </ul> <p>4 <math>\text{R-COOH} + \text{SOCl}_2 \longrightarrow \text{R-COCl} + \text{SO}_2 + \text{HCl}</math></p> <p><b>IT'S ON THE DATA SHEET</b></p>
<p>How is aminobenzene formed from nitrobenzene? (reagents, conditions and type of reaction) [Its on the data sheet]</p>	<ul style="list-style-type: none"> <li>Sn and conc <math>\text{H}_2\text{SO}_4</math></li> <li>Heat under reflux</li> <li>Reduction</li> </ul>  <p><b>IT'S ON THE DATA SHEET</b></p> <p>5 <math>\text{NO}_2</math> <math>\xrightarrow[\text{reflux}]{\text{Sn} + \text{conc. HCl}} \text{NH}_2</math></p>
<p>What are the reagents, conditions and products for forming haloalkanes from alcohols (e.g ethanol and HBr)?</p>	<ul style="list-style-type: none"> <li>NaBr, conc <math>\text{H}_2\text{SO}_4</math></li> <li>Heating under reflux</li> <li>Haloalkane + <math>\text{H}_2\text{O}</math></li> </ul> <p>Occurs via:</p> <ul style="list-style-type: none"> <li><math>\text{NaBr} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{HBr}</math></li> <li>E.g <math>\text{CH}_3\text{CH}_2\text{OH} + \text{HBr} \rightarrow \text{CH}_3\text{CH}_2\text{Br} + \text{H}_2\text{O}</math></li> </ul> <p><b>Mechanism: Nucleophilic substitution</b></p>
<p>What are the reagents, conditions, products and type of reaction for forming amines from haloalkanes? E.g R-Br</p>	<ul style="list-style-type: none"> <li>Conditions: Heat in a sealed tube</li> <li>Reagents: <math>\text{NH}_3</math>, ethanol</li> <li>Products: R-amine, HBr</li> <li>Type of reaction: Nucleophilic substitution</li> </ul>



## The toolkit: Chart B



Notes

1. The Friedel-Crafts reactions are carbon–carbon bond forming reactions.
2. All the substitution reactions of arenes are *electrophilic*.

Functional group	Test	Observation	Notes
alkene	Shake with bromine water or bromine water.	Red-brown colour of bromine decolourises.	
haloalkane	Warm with $\text{NaOH}(\text{aq})$ , then acidify and add $\text{AgNO}_3(\text{aq})$ .	Precipitate forms.	A white precipitate indicates chlorine. A cream precipitate indicates bromine. A yellow precipitate indicates iodine.
alcohol	Warm with acidified potassium dichromate[VI].	Colour change from orange to green.	Not for tertiary alcohols. Aldehydes also give this reaction.
aldehydes	Add Fehling's solution and warm. or Add Tollens' reagent and warm.	Change from blue solution to red precipitate.  Silver mirror forms.	
phenol	Add iron(III) chloride.	Purple colour forms.	Also for any phenolic OH.
carboxylic acid	Add sodium carbonate solution.	Bubbles of gas formed.	

▼ Table 1 (continued)

Functional group	Structure	Typical properties of the functional group	Topic reference
esters	R—COOR	Hydrolysed to carboxylic acids and alcohols.	PL 3
amides	R—CONH <sub>2</sub> , R—CONHR, etc.	Hydrolysed to carboxylic acid and ammonia.	PL 3
acyl chlorides and acid anhydrides	R—COCl (RCO) <sub>2</sub> O	Esterification with alcohols and phenols. Amide formation with amines.	WM 2, PL 1 PL 2
amines	R—NH <sub>2</sub> , R—NH—R, etc.	Act as nucleophiles in reactions with acyl chlorides. Act as bases.	PL 2
aldehydes and ketones	R—CHO R—CO—R	Oxidised to carboxylic acids (aldehydes only). Addition reactions with HCN. Reduced to alcohols by NaBH <sub>4</sub> .	CD 9 Data sheet
nitro groups	R—NO <sub>2</sub>	Reduced to amines by Sn and conc HCl.	Data sheet
nitriles	R—C≡N	Hydrolysed to carboxylic acids by reflux with acids.	Data sheet

Type of reaction	Definition of reaction	Functional groups that take part in this type of reaction	Topic reference
addition	Two molecules react together to form a single product.	alkenes	DF 6
elimination	A small molecule (such as water or HCl) is removed from a larger one, leaving an unsaturated molecule.	aldehydes and ketones alcohols	CD 9 WM 1
condensation	Two molecules react together to form a larger molecule, and a small molecule (such as water or HCl) is removed.	haloalkanes carboxylic acids and alcohols acyl chlorides, alcohols and amines	WM, PL 1 PL 1, PL 2
substitution	One group of atoms takes the place of another.	haloalkanes alcohols (reacting with hydrogen halides)	OZ 8 OZ 8, WM 1
oxidation	Oxygen atoms are gained and/or hydrogen atoms are lost.	alkanes and alkyl groups alcohols aldehydes	OZ 3 WM 1
reduction	Oxygen atoms are lost and/or hydrogen atoms are gained.	aldehydes and ketones nitro groups	CD 9 CD 11
hydrolysis	Bonds are broken by the action of water (although OH <sup>-</sup> may appear in the equation in base-catalysed reactions).	esters amides/peptides nitriles haloalkanes	PL 1 PL 2 CD 9 OZ 8

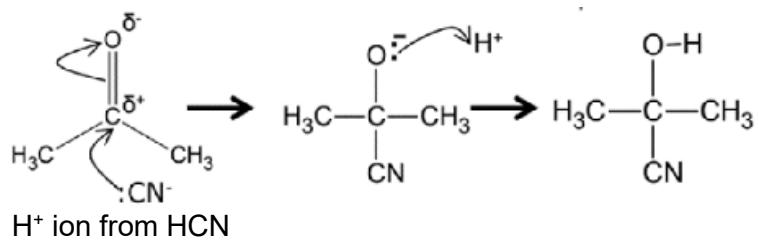
Functional group	Structure	Typical properties of the functional group	Topic reference
alkene	$-C=C-$	Addition reactions with electrophiles, including halogens, hydrogen halides, hydrogen, and water.	DF 6
haloalkanes	$R-X$ (X = Cl, Br, etc.)	Substitution reactions with nucleophiles, including $CN^-$ .	OZ 8 Data sheet
alcohols	$R-OH$	Oxidised to carbonyl compounds and/or carboxylic acids.  Esterification reactions with carboxylic acids and acyl chlorides.  Substitution reactions with nucleophiles (halides).  Dehydrated to alkenes.	WM 1  WM 1  WM 1
carboxylic acids	$R-COOH$	Weak acids.  Esterification reactions with alcohols.  Converted into acyl chlorides by $SCl_2O$ .	WM 2  WM 1  Data sheet
phenols	$C_6H_5-OH$	Weak acids.  Esterification reaction with acyl chlorides and acid anhydrides.	WM 1  WM 2

Reactant	Product	Reagents	Reaction
Benzene	Methylbenzene / toluene	$\text{CH}_3\text{Cl} / \text{AlCl}_3$	Alkylation / Electrophilic substitution
Benzene	Bromobenzene	$\text{Br}_2 / \text{FeBr}_3$	Bromination / Electrophilic substitution
Benzene	Chlorobenzene	$\text{Cl}_2 / \text{AlCl}_3$	Chlorination / Electrophilic substitution
Benzene	Nitrobenzene	$\text{HNO}_3 / \text{H}_2\text{SO}_4$	Nitration / Electrophilic substitution
Nitrobenzene	Aminobenzene / phenylamine / aniline	Sn / HCl	Reduction
Aminobenzene	2,4,6–tribromoaminobenzene / 2,4,6–tribromoaniline	Bromine	Electrophilic substitution
Benzene	Phenylethanone	$\text{CH}_3\text{COCl} / \text{AlCl}_3$	Acylation / Electrophilic substitution
Phenylethanone	1–phenylethanol	$\text{NaBH}_4$	Reduction

Reactant	Product	Reagents	Reaction
Alkene	Haloalkane	Hydrogen halide	Electrophilic addition
Alkene	Alcohol	Steam + $\text{H}_2\text{SO}_4$ / heat	Hydration
Alkene	Alkane	Hydrogen + Ni catalyst / 150 °C	Electrophilic addition / hydrogenation
Alcohol	Alkene	$\text{Al}_2\text{O}_3$ or conc. acid / heat	Elimination / dehydration
Alcohol	Haloalkane	$\text{NaX} + \text{H}_2\text{SO}_4$ / heat under reflux	Nucleophilic substitution
Haloalkane	Alcohol	$\text{NaOH}$ (aq) / heat under reflux	Nucleophilic substitution
Alkane	Haloalkane	Halogen / UV light	Free radical substitution
Primary alcohol	Aldehyde	$\text{K}_2\text{Cr}_2\text{O}_7 / \text{H}_2\text{SO}_4$ / Distillation	Oxidation
Secondary alcohol	Ketone	$\text{K}_2\text{Cr}_2\text{O}_7 / \text{H}_2\text{SO}_4$ / Heat	Oxidation
Primary alcohol	Carboxylic acid	$\text{K}_2\text{Cr}_2\text{O}_7 / \text{H}_2\text{SO}_4$ / Heat under reflux	Oxidation
Aldehyde	Primary alcohol	$\text{NaBH}_4 / \text{H}_2\text{O}$	Reduction
Ketone	Secondary alcohol	$\text{NaBH}_4 / \text{H}_2\text{O}$	Reduction
Haloalkane	Nitrile	$\text{NaCN}$	Nucleophilic substitution
Haloalkane	Amine	$\text{NH}_3$ / ethanol	Nucleophilic substitution
Nitrile	Carboxylic acid	$\text{H}_2\text{O} / \text{HCl}$	Hydrolysis
Aldehyde	Hydroxynitrile	$\text{NaCN} / \text{H}^+$	Nucleophilic addition
Alcohol	Ester	Carboxylic acid / $\text{H}_2\text{SO}_4$	Esterification
Carboxylic acid	Ester	$\text{Alcohol} / \text{H}_2\text{SO}_4$	Esterification

## CD.k-l - Reaction mechanisms | CD9 | CD11 |

What is the nucleophilic addition mechanism for the formation of a hydroxynitrile from propanone and HCN?

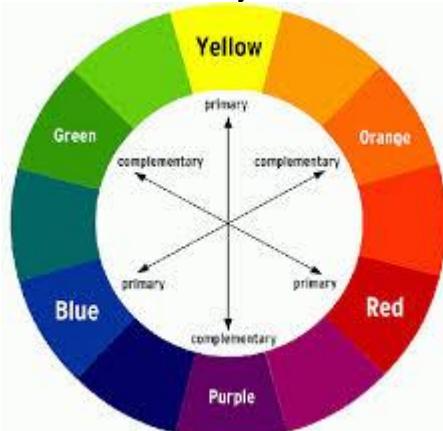


*The negative charge is on the nitrogen*

## CD.m - Energy & Matter | CD1 |

What are the 3 pairs of complementary colours?

- Red and green
- Blue and orange
- Violet and yellow



*So when a compound absorbs red wavelengths, it transmits (or reflects) the complementary colour green, and so green is what seen*

*Do not allow 'emit' light*

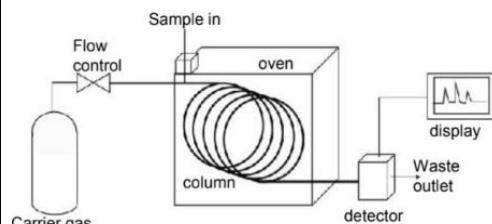
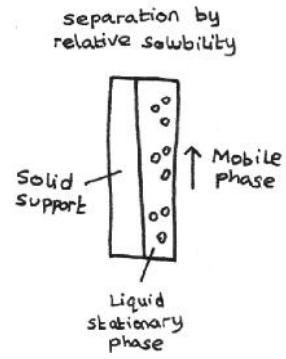
Explain why coloured compounds such as dyes are coloured and benzene is colourless (6) [Mr Harbage script]

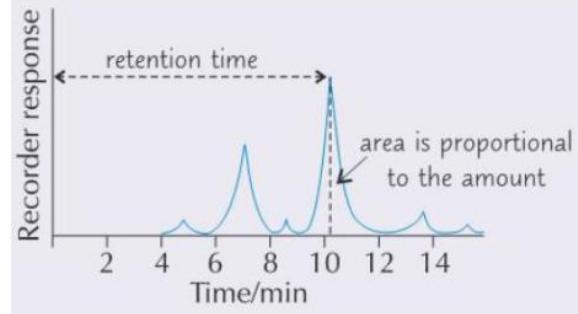
1. Electrons move to a higher energy level by absorbing EM radiation via  $\Delta E=h\nu$  (2)
2. A dye would have a greater extended system of delocalised electrons (larger chromophore) and so energy levels are closer (as E is smaller) (2)
3. Energy absorbed is a lower frequency for dyes (in the VL region), and a complementary colour is transmitted (or reflected) (2)

1. Whilst benzene has less delocalisation (smaller chromophore), and energy levels are further apart (2)
2. Energy absorbed is high frequency (in the UV) (1)
3. Therefore, all visible light is transmitted (or reflected) (1)

	<ul style="list-style-type: none"> <li>Remember frequency of UV radiation is higher than Visible light radiation [Please say this when comparing colourless and coloured compounds from F335 June 2015]</li> </ul> <p><i>Do not allow 'emit' light AND do not allow <math>E=hv</math></i></p>
What are the properties that dyes (coloured compounds) have compared to benzene (colourless)	<ul style="list-style-type: none"> <li>Energy levels are closer as they absorb lower freq VL compared to UV</li> <li>More Conjugation</li> <li>A greater extended system of delocalised electrons</li> <li>Larger chromophore</li> <li>More than one benzene ring</li> </ul> <p><i>More than one benzene ring - some Mark Schemes have it, some don't, your choice whether to say it</i></p>

## CD.n - Modern analytical techniques | CD8 |

Describe the setup of gas-liquid chromatography (GLC)?	 <ul style="list-style-type: none"> <li>Mobile phase is a mixture of gas</li> <li>Stationary phase is high b.p liquid coating the column</li> </ul>
What does the column in GLC consist of? (2)	<ul style="list-style-type: none"> <li>High boiling point liquid (1) on a porous support (1)</li> </ul>
What are the 2 phases in GL chromatography?	<ul style="list-style-type: none"> <li>Stationary phase - liquid on solid support (as in GLC)</li> <li>Mobile phase - gas (as in GLC)</li> </ul> 
What is the nature of the stationary phase	<ul style="list-style-type: none"> <li>High boiling point (1)</li> </ul>

for GLC? (1)	<ul style="list-style-type: none"> <li>• Involatile (1)</li> <li>• Non-volatile liquid (1)</li> </ul> <p><i>The stationary phase can also potentially contain solids</i></p>			
Name a suitable substance for the mobile phase for GLC (1) and the property it has (1)?	<ul style="list-style-type: none"> <li>• Nitrogen (as well as argon but any other named noble gas is NOT ALLOWED) (1)</li> <li>• Inert (i.e unreactive) (1)</li> </ul> <table border="1" data-bbox="795 473 1554 518"> <tr> <td>Nitrogen/N<sub>2</sub> ✓</td> <td>1</td> <td>ALLOW argon/Ar IGNORE other noble gases</td> </tr> </table> <p><i>It is also referred to as the <b>carrier gas</b> so look out for this name</i></p>	Nitrogen/N <sub>2</sub> ✓	1	ALLOW argon/Ar IGNORE other noble gases
Nitrogen/N <sub>2</sub> ✓	1	ALLOW argon/Ar IGNORE other noble gases		
How do you interpret a gas chromatogram?	 <ul style="list-style-type: none"> <li>• Time taken to pass via column / retention time is used to identify substance</li> <li>• Area under each peak is proportional to amount of substance (called peak integration value)</li> <li>• You would use a ruler to measure the amount of substance</li> </ul>			
What 5 factors affect retention time? And why?	<ol style="list-style-type: none"> <li>1. <b>Solubility</b> - more soluble compounds will take longer to move via the tube as they would prefer the stationary phase -&gt; higher RT</li> <li>2. <b>Boiling point</b> - a substance with a high boiling point will spend more time turning from a liquid to a gas -&gt; higher RT</li> <li>3. <b>Temperature</b> - high temperature means more evaporated liquid as gas so moves quickly spending more time in the mobile phase -&gt; shorter RT</li> <li>4. <b>Volatility</b> - a more volatile liquid would spend more time in the mobile phase than the stationary -&gt; shorter RT</li> <li>5. <b>Length of column</b> - a longer column would mean longer retention time</li> </ol> <p><i>When referring to temperature its the temperature of the column not of the substance</i></p> <p><i>These are some examples and so would not represent all the factors</i></p>			

What problems are there with GLC? Why?

Some substances won't separate since they have similar retention factors/retention times because they are structurally similar

*It is often used alongside mass spectroscopy*