







## CHEMISTRY

An ester formed from methanol with the molecular formula $\mathrm{C}_{6} \mathrm{H}_{12} \mathrm{O}_{2}$ is optically active. Draw the ester.


The information provided indicates that you need to find a carboxylic acid with 5 carbon atoms that is branched to create a chiral carbon atom.
Draw a branched, non-cyclic
pair of geometric isomers
with the molecular formula
$\mathrm{C}_{6} \mathrm{H}_{12}$.

## CHEMISTRY

Draw the structural formula of a tertiary amine which is an isomer of pentylamine.

## CHEMISTRY




Diethylmethylamine ( $3^{\circ}$ amine)

In a tertiary amine there are 3 hydrogen substituents on the nitrogen atom $(3 \mathrm{H}$ atoms have been replaced with 3 R groups). The molecular formula remains the same).



## CHEMISTRY

Draw all structural isomers that have a molecular formula of $\mathrm{C}_{3} \mathrm{H}_{6} \mathrm{O}_{2}$ and contain an OH group as well as a $\mathrm{C}=\mathrm{O}$ group (broad peak at 3230$3550 \mathrm{~cm}^{-1}$ in IR spectrum)


CHEMISTRY
Draw the two structures of an ester that contains a benzene ring and has an $M_{r}$ of 136.

## CHEMISTRY






The benzene ring has a formula mass of $\mathrm{C}_{6} \mathrm{H}_{5}=77$; an ester contains $2 x \mathrm{O}=32$; |36-77-32 = 27; $27=2 \times C+$ $3 x H$ needed to complete structure.

| AMINES |  | AMINES |  |
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| CHEMISTRY |  | CHEMISTRY |  |
| Draw a primary, secondary and tertiary isomer of $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{CH}_{2} \mathrm{NH}_{2}$ |  |  <br> Primary | $\frac{\mathbf{N}}{\frac{1}{}}$ |
|  |  |  <br> Secondary | $\xrightarrow{\frac{1}{3}}$ |
|  |  |  <br> In a secondary amine there are 2 H substituents; in a tertiary amine there are 3 H substituents and in a primary amine there is one H substituent. | $\begin{aligned} & 0 \\ & \frac{0}{3} \\ & \frac{3}{3} \\ & \frac{0}{n} \end{aligned}$ |


| AMINES |  | AMINES |  |
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| CHEMISTRY |  | CHEMISTRY |  |
| How do you get from ethene to $\left(\mathrm{CH}_{3} \mathrm{CH}_{2}\right)_{2} \mathrm{NH}$ in 3 steps? |  | React ethene with HBr to produce $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{Br}$. React bromoethane with ammonia to produce ethylamine. React ethylamine with bromoethane. |  |
|  |  | The first reaction is electrophilic addition. The second reaction substitutes the Br for an $\mathrm{NH}_{2}$ group. The $\mathrm{NH}_{2}$ group substitutes the Br in bromoethane in step 3. | $\begin{aligned} & 0 \\ & 0 \\ & 3 \\ & 3 \\ & 0 \\ & 0 \\ & \end{aligned}$ |


CHEMISTRY
Draw the structures of the
two compounds formed when
$\mathrm{CH}_{3} \mathrm{NH}_{2}$ reacts with ethanoic
anhydride.



| A AMINES |  | 2 AMINES |  |
| :---: | :---: | :---: | :---: |
| CHEMISTRY |  | CHEMISTRY |  |
| Write an equation for the reaction of water with ethylamine showing how an alkaline solution is formed. |  | $\begin{aligned} & \mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{NH}_{2}+\mathrm{H}_{2} \mathrm{O} \rightarrow \\ & \mathrm{OH}^{-}+\mathrm{CH}_{3} \mathrm{CH}_{2}{ }^{+} \mathrm{NH}_{3} \end{aligned}$ |  |
|  |  | Amines act as bases/proton acceptors. | O <br> O <br> 3 <br> 3 <br> 0 <br> $\cdots$ |













## CHEMISTRY

Which route to an amine, nucleophilic substitution with a haloalkane or reduction of a nitrile, will give a less pure product? Why?

## CHEMISTRY

Nucleophilic substitution. Further substitution reactions can occur with the amines that are formed.

With an excess of haloalkane, any $2^{\circ}$ amine produced will continue the substitution reaction until a quarternary amine is formed.





Draw one repeat unit of the polymer formed when propanedioic acid reacts with hexane-I,6-diamine.


Hexane-I,6-diamine is one of the monomers in Nylon-6,6 and therefore you are required to know its structure.

## CHEMISTRY







## CHEMISTRY

Describe how ethanoyl chloride can react with benzene. Include a mechanism.

## CHEMISTRY

$\mathrm{AlCl}_{3}$ catalyst/carrier needed to form electrophile:
$\mathrm{AlCl}_{3}+\mathrm{CH}_{3} \mathrm{COCl} \rightarrow$
$\mathrm{AlCl}_{4}^{-}+\mathrm{CH}_{3}{ }^{+} \mathrm{CO}$


The overall equation for this reaction is $\mathrm{CH}_{3} \mathrm{COCl}+\mathrm{C}_{6} \mathrm{H}_{6}$ $\rightarrow \mathrm{C}_{6} \mathrm{H}_{5} \mathrm{COCH}_{3}+\mathrm{HCl}$. The mechanism is electrophilic substitution.
Outline a mechanism to show
how 4-methylnitrobenzene is
produced from methylbenzene.

## CHEMISTRY

Write equations to show how the electrophile ${ }^{+} \mathrm{NO}_{2}$ is produced.
$\mathrm{H}_{2} \mathrm{SO}_{4}+\mathrm{HNO}_{3} \rightarrow$
$\mathrm{HSO}_{4}{ }^{-}+\mathrm{H}_{2} \mathrm{NO}_{3}{ }^{+}$
$\mathrm{H}_{2} \mathrm{NO}_{3}{ }^{+} \rightarrow \mathrm{H}_{2} \mathrm{O}+{ }^{+} \mathrm{NO}_{2}$

Both acids need to be concentrated.
Alternative equations are:
$2 \mathrm{H}_{2} \mathrm{SO}_{4}+\mathrm{HNO}_{3} \rightarrow$
$2 \mathrm{HSO}_{4}^{-}+\mathrm{NO}_{2}^{+}+\mathrm{H}_{3} \mathrm{O}^{+}$
or
$\mathrm{H}_{2} \mathrm{SO}_{4}+\mathrm{HNO}_{3} \rightarrow$
$\mathrm{NO}_{2}{ }^{+}+\mathrm{HSO}_{4}{ }^{-}+\mathrm{H}_{2} \mathrm{O}$

## CHEMISTRY

Use the data provided to state and explain the stability of benzene compared with the hypothetical cyclohexatriene.


What type of reaction is shown
and what reagent do you need
for this reaction?
Which other two substances are
required for this reaction?



How many peaks will there be in
a ${ }^{13} \mathrm{C} \mathrm{NMR}$ of this compound?

## CHEMISTRY

Compounds $\mathbf{F}$ and $\mathbf{G}$ have the molecular formula $\mathrm{C}_{6} \mathrm{H}_{4} \mathrm{~N}_{2} \mathrm{O}_{4}$ and both are dinitrobenzenes. $\mathbf{F}$ has two peaks in its ${ }^{13} \mathrm{C}$ NMR. spectrum. $\mathbf{G}$ has three peaks in its ${ }^{13} \mathrm{C}$ NMR spectrum. Identify F and G.




## CHEMISTRY

Use the 'H NMR information provided to identify the compound which has a molecular formula of $\mathrm{C}_{6} \mathrm{H}_{12} \mathrm{O}_{2}$.

| $\delta / \mathrm{ppm}$ | 3.8 | 3.5 | 2.6 | 2.2 | 1.2 |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Integration ratio | 2 | 2 | 2 | 3 | 3 |



| $\bar{\delta} / \mathrm{ppm}$ | 3.8 | 3.5 | 2.6 | 2.2 | 1.2 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Integration ratio | 2 | 2 | 2 | 3 | 3 |
| $-\mathrm{O}-\mathrm{CH}_{2}$$\mathrm{CH}_{2}{ }^{\circ}$ |  |  |  |  |  |

Use the splitting pattern to confirm the identity of each peak. The yellow H group has 2 hydrogen neighbours and is split into a triplet whereas the red H group has 3 hydrogen neighbours and is split into a quadruplet.

## CHEMISTRY

Use the information provided to identify the compound which has a molecular formula of $\mathrm{C}_{6} \mathrm{H}_{12} \mathrm{O}_{2}$. (Each peak in the 'H NMR is a singlet)

| $\bar{\delta} / \mathrm{ppm}$ | 1.2 | 2.2 | 2.6 | 3.8 |
| :--- | :---: | :---: | :---: | :---: |
| Integration value | 6 | 3 | 2 | 1 |



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|  |  | CHEMISTRY |



The IR reveals that there is an alcoholic OH group (broad peak at 32303550) as well as a C=O peak at I680-I750.

