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Answers

Practice exam questions

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Check your answers to the questions in this issue.

Laundry: washing clean and smelling fresh (pp. 2–6)

1 In each case you only need to provide one suitable test, either spectroscopic or chemical. Both forms of answers are given here.

a To distinguish between samples of nonanal and nonanoic acid, add a solution of sodium hydrogen carbonate (or sodium carbonate). You will see effervescence and evolution of CO_2 with the nonanoic acid, but no reaction with the aldehyde (nonanal).

Alternative: adding a magnesium ribbon and a little water produces effervescence and evolution of H_2 with the acid, but no reaction with the aldehyde.

A positive test for the aldehyde would be to use ammoniacal silver nitrate solution, which on warming would give a silver mirror with nonanal, but would not react with the acid.

Spectroscopic method: Both compounds would give a sharp peak in the C=O stretching region (around 1700 cm^{-1}) in the infrared (IR) spectrum. Only nonanoic acid would also give a very broad, strong peak in the range 2500–3500 cm^{-1} in the IR spectrum, due to the O–H bond.

b The best way of distinguishing between heptanal and heptan-2-one using a chemical reaction is to separately warm them with ammoniacal silver nitrate solution. This would give a silver mirror with heptanal (an aldehyde), but there would be no reaction with heptan-2-one (a ketone).

Heptanal and heptan-2-one are isomers, so have the same molecular peak (114) in a mass spectrum. The infrared spectra are similar. The ^1H NMR spectrum is the best instrumental means to distinguish them. In heptanal, all carbon atoms have neighbouring carbons bearing hydrogens, so all signals are multiplets due to spin-spin splitting. In heptan-2-one, the terminal CH_3 next to C=O has no hydrogens on the neighbouring carbon, so its signal is a singlet.

c 3-Methylbutanal and pentanal are isomers. They are very hard to distinguish by chemical reactions, since both are aldehydes. A traditional way would be to separately add methanolic 2,4-dinitrophenylhydrazine solution to each sample, filter off the precipitated 2,4-dinitrophenylhydrazone derivative, recrystallise and dry the crystals,

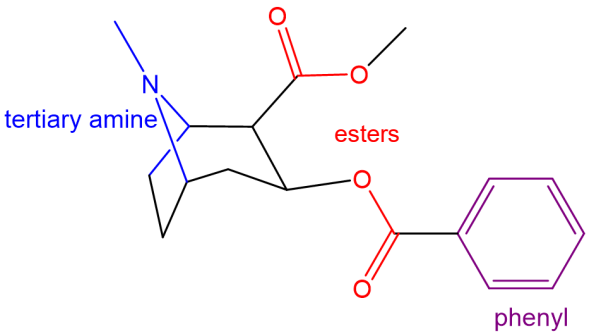
then determine their melting points. The melting point for the derivative of pentanal is 107°C and the value for the derivative of 3-methylbutanal is 123°C.

The best way to distinguish between 3-methylbutanal and pentanal is to use ^{13}C NMR spectroscopy. The two terminal methyl groups on the alkyl chain in 3-methylbutanal are equivalent, so that there are just four different carbon environments in the 3-methylbutanal molecule. This means that there are four lines in its (proton decoupled) ^{13}C NMR spectrum. All five carbon environments are distinct in pentanal, so there are five lines in its (proton decoupled) ^{13}C NMR spectrum. ^{1}H NMR spectra would similarly show the different number of environments.

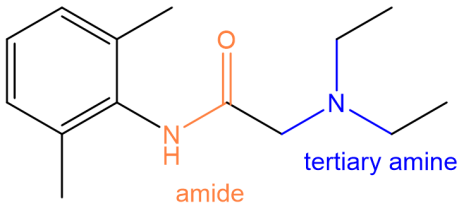
Forensic science: testing for cocaine (pp. 22–24)

1

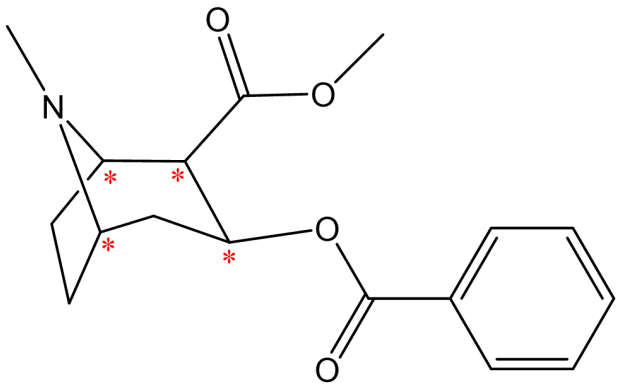
a Cocaine:



b Lidocaine:



2



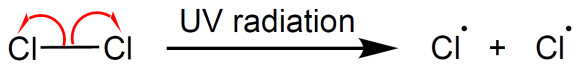
3 The *m*/*z* of a molecular ion corresponds to the molecular mass of the compound.

a The *m*/*z* of a molecular ion of cocaine is 303.

b The *m*/*z* of a molecular ion of lidocaine is 234.

Curly arrows (pp. 28–29)

1



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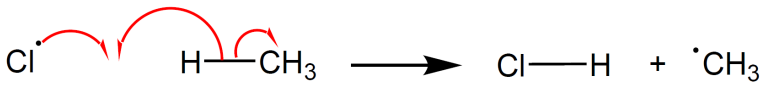

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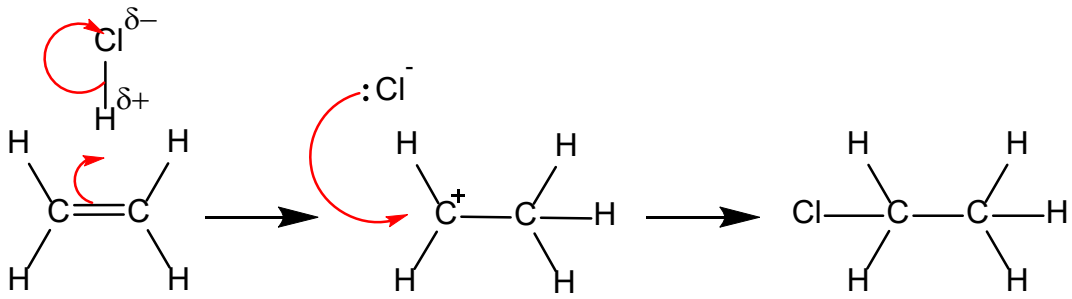

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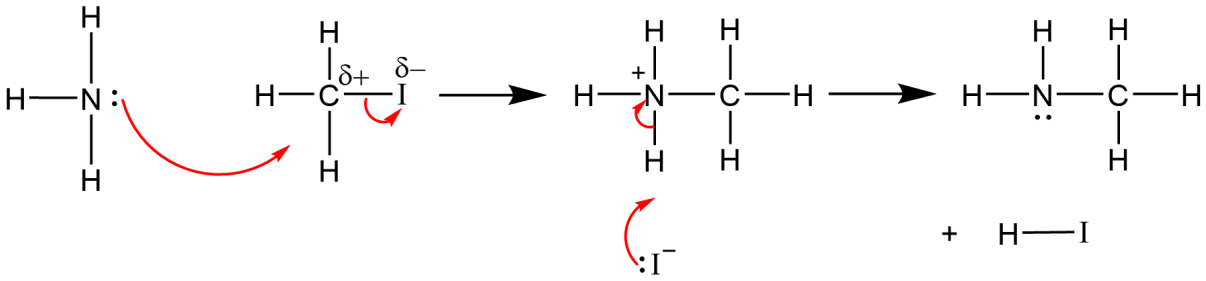
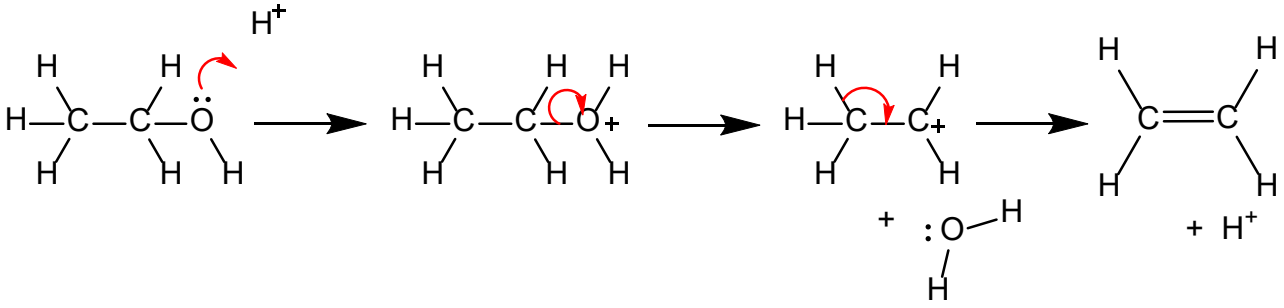


5



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