1.

(a) D will give a molecular ion at \( m/z = 74 \) in the mass spectrum.

(b) B and F both have conjugated (i.e. adjacent) \( \pi \) bonds and will show strong absorption in the UV-Visible spectrum.

(c) A, C and E all have carbonyl groups and will show absorption around 1700 cm\(^{-1}\) in the infrared region.

(d) B, D and E all have OH groups and will show absorption around 3500 cm\(^{-1}\) in the infrared region.

(e) F does not possess a carbonyl or OH group and will not show absorption either around 1700 or 3500 cm\(^{-1}\) in the infrared region.

(f) The number of signals shown by each compound in its \(^{13}\)C NMR spectrum is shown in the diagram below.

- A - 4 signals
- B - 5 signals
- C - 4 signals
2. There are a number of possibilities and more information (e.g. $^{13}$C NMR) would be required to decide between them. The IR absorption indicates that the O is present as C=O. Strong absorption in the UV indicates the presence of conjugation (i.e. adjacent double bonds). Some possible structures include:

3. (a) 3 ether groups, an arene ring and a primary amine are present (see opposite)
(b) There are 8 types of C in the molecule so 8 signals will be observed in the $^{13}$C NMR.
(c) The molecular formula of mescaline is $\text{C}_{11}\text{H}_{17}\text{O}_{3}\text{N}$. The molar mass is therefore 211
(d) The arene is conjugated so strong absorption in the UV-visible spectrum is expected.
(e) The NH$_2$ groups will give rise to IR absorption at $\sim$3400 cm$^{-1}$. No absorption at $\sim$1700 cm$^{-1}$ is expected as no C=O groups are present.

4.
5. The number of signals in the $^{13}$C NMR reflects the **number of different carbon environments**. The position of each signal reflects the **type of environment** for each carbon:

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\begin{tabular}{c c c c c c}
  & C=O & aromatic & C=C & C-O & alkane \\
\hline
\delta ppm & 200 & 150 & 100 & 50 & 0
\end{tabular}
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Aspirin contains 9 different carbon environments (see below) and so the spectrum shows 9 signals:

- Carbon atoms 1-6 are aromatic so will show signals in the region 120-150 ppm.
- Carbon atoms 7 and 9 are in C=O groups so show signals in the region 180-200 ppm
- Carbon 8 is in an alkane group so its signal is in the region 0-20 ppm.

**A sketch** of the spectrum is show below with each signal labelled according to the number scheme above. Note the group of signals in the aromatic region.

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\begin{tabular}{cccccccc}
7 & 9 & 1 & 3 & 5 & 2,4,6 & & 8 \\
\end{tabular}
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Paracetamol contains 6 different carbon environments (see below) and so the spectrum shows 6 signals:

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\begin{tabular}{cccccccc}
\end{tabular}
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• Carbon atoms 3-6 are aromatic so will show signals in the region 120-150 ppm.
• Carbon 2 is in a C=O group so its signal is in the region 180-200 ppm
• Carbon 1 is in an alkane group so its signal is in the region 0-20 ppm.

A sketch of the spectrum is shown below with each signal labelled according to the number scheme above.

6. (a) phenol  
(b) secondary alcohol  
(c) tertiary alcohol  
(d) ether  
(e) primary alcohol  
(f) ether  
(g) secondary alcohol  
(h) tertiary alcohol  
(i) two ethers