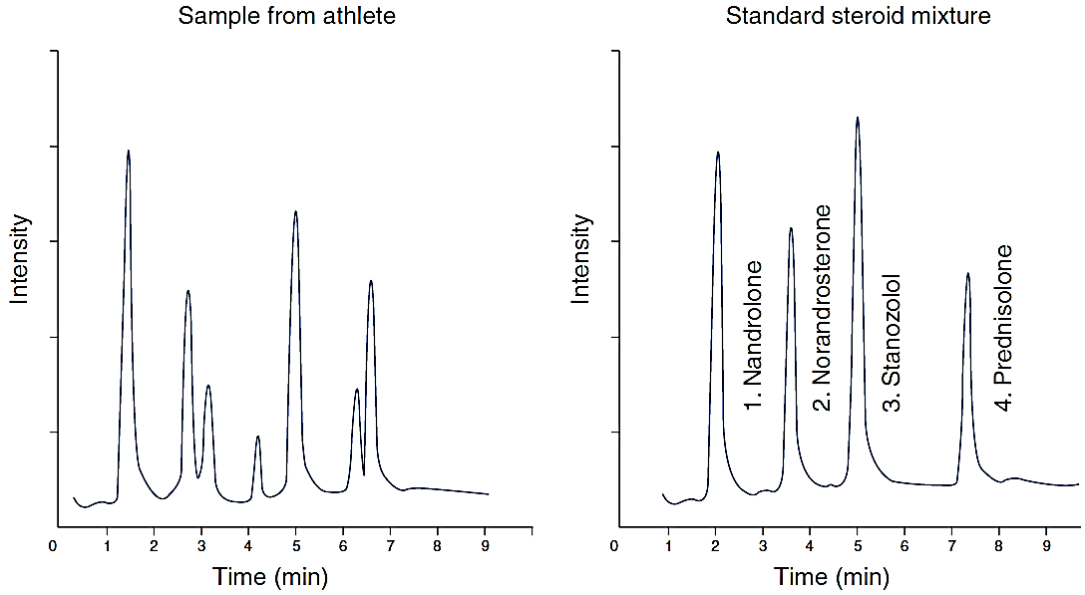
Quiz (Forensic Science)

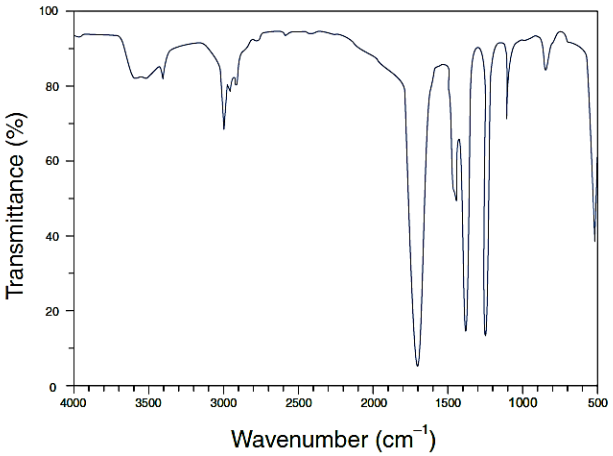
1. Steroids are banned drugs that can improve the performance of an athlete. After a competition, urine samples of athletes were collected for the test of steroids. One of the samples and a standard mixture of steroids were analysed by gas chromatography-mass spectrometry. The following chromatograms were obtained.



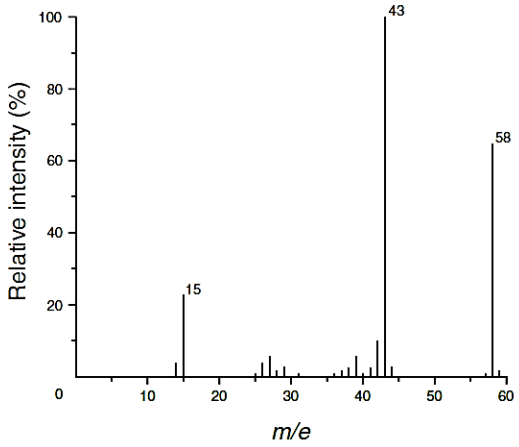
(a) Explain why different types of steroids can be separated by gas chromatography-mass spectrometry.

(b) Which steroid, if any, do you think the athlete has taken?

2. In a fire scene, some flammable liquid was found in a container. The mass spectrum and the infrared spectrum of the liquid are shown as follows.



Infrared spectrum of the liquid



Mass spectrum of the liquid

(a) Determine the relative molecular mass of the organic compound in the flammable liquid from the mass spectrum.

(b) Based on the infrared spectrum, what functional group does the organic compound contain?

(c) Deduce two possible structures of the organic compound. Give the name of each compound.

(d) Further chemical test can be performed to distinguish between the two possible structures. State the chemical test that should be carried out and the observation for the test.

3. Portable alcohol breathalyser with acidified potassium dichromate crystals is commonly used to test for alcohol content in the breath of drivers.

(a) State the colour change in the breathalyser if ethanol is present in the breath.

(b) How is the colour change related to the ethanol content in the breath?

(c) Write a chemical equation for the reaction that occurs in the breathalyser.

(d) In the police station, gas chromatography-mass spectrometry is used to analyse the alcohol content of the driver. Instead of the breath of the driver, a body fluid is collected from the driver and analysed.

(i) What body fluid is collected and analysed?

(ii) What is the advantage of using gas chromatography-mass spectrometry over breathalyser to measure the alcohol content?

Suggested Answer

1. (a) They move at different speeds in the gas chromatographic column.

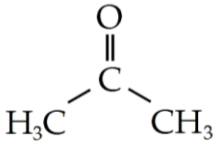
   (b) The athlete should have taken stanozolol.

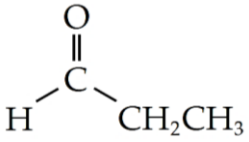
2. (a) The molecular ion peak is at *m/e* = 58. So, the relative molecular mass of the organic compound is 58.

   (b) A strong absorption peak appears at around 1700 cm^{-1}. The organic compound may contain a C=O group.

   (c) From the mass spectrum, the molecular mass of the organic compound is 58. A fragment ion of *m/e* = 43 is also found. This is possibly due to the presence of $CH_3CH_2CH_2^+$ or CH_3CO^+. From the information given by the infrared spectrum, the compound should contain a C=O group. Thus, the fragment ion should be CH_3CO^+. Another fragment ion of *m/e* = 15 is found. This is possibly due to the presence of CH_3^+. Therefore, the structural formula of the compound is possibly CH_3COCH_3 or CH_3CH_2CHO.

   The possible structures of the organic compound:

   
   propanone

   
   propanal

   (d) **Test by using Tollens' reagent:** If the organic compound is propanal (an aldehyde), a silver mirror will form inside the test tube. If it is propanone (a ketone), there will be no observable changes.

3. (a) From orange to green.

   (b) The degree of the colour change in the breathalyser is directly related to the ethanol content in the breath.

   (c) $2Cr_2O_7^{2-}(aq) + 3CH_3CH_2OH(aq) + 16H^+(aq) \longrightarrow 4Cr^{3+}(aq) + 3CH_3COOH(aq) + 11H_2O(l)$

   (d) (i) Blood or urine
   (ii) The alcohol content in the driver's body can be analysed more accurately.