Higher Chemistry

Chemistry In Society

Ink Exercise

Oxidising and Reducing Agents, Ion-Electron and Redox Equations and Chemical Analysis

Ink Exercise

1. Potassium permanganate solution, acidified with dilute sulphuric acid, is decolourised by iron (II) sulphate solution

Refer to the ion-electron equations in the data booklet.

Which ion is the reducing agent in this reaction?

A H^+

B Fe^{2+}

C $MnO4^-$

D $SO4^{2-}$

2. In which reaction is hydrogen gas acting as an oxidising agent?

A $H_2 + CuO \longrightarrow H_2O + Cu$
B $H_2 + C_2H_4 \longrightarrow C_2H_6$
C $H_2 + Cl_2 \longrightarrow 2HCl$
D $H_2 + 2Na \longrightarrow 2NaH$

3. In which of the following is a positive ion oxidised?

A Iodide $\longrightarrow$ Iodine

B Nickel (II) $\longrightarrow$ Nickel (III)

C Cobalt (III) $\longrightarrow$ Cobalt (II)

D Iron $\longrightarrow$ Iron (II)

4. Part of an ion-electron equation is shown below.

$$MnO_2 \longrightarrow Mn^{2+}$$

When the equation is complete, the left hand side will include:

A $4H^+ + 2e^-$
B $2H^+ + 4e^-$
C $4H^+ + 4e^-$
D $2H^+ + 2e^-$

5. During a redox process in acid solution, iodate ions are converted into iodine.

$$2IO_3^-(aq) + 12H^+(aq) + xe^- \longrightarrow I_2(aq) + 6H_2O(l)$$

To balance the equation, what is the value of **x**?

A 2
B 6
C 10
D 12

6. The following reactions take place when nitric acid is added to zinc.

$$NO_3^-(aq) + 4H^+(aq) + 3e^- \longrightarrow NO(g) + 2H_2O(\square)$$

$$Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$$

How many moles of $NO_3^-(aq)$ are reduced by one mole of zinc?

A 2/3

B 1

C 3/2

D 2

7. One of the reactions taking place within a carbon monoxide sensor is

$$2CO + 2H_2O \longrightarrow 2CO_2 + 4H^+ + 4e^-$$

This reaction is an example of

A reduction
B redox
C oxidation
D hydration

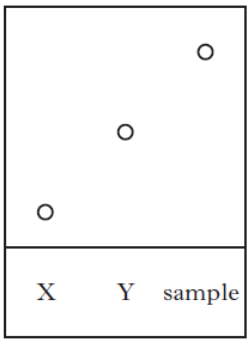
8. An organic chemist is attempting to synthesise a fragrance compound by the following chemical reaction.

compound **X** + compound **Y** ⟶ fragrance compound

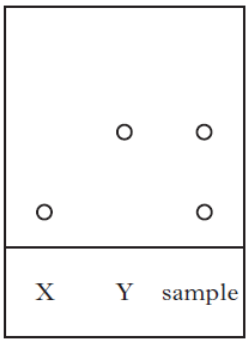
After one hour, a sample is removed and compared with pure samples of compounds **X** and **Y** using thin-layer chromatography.

Which of the following chromatograms shows that the reaction has produced a pure sample of the fragrance compound?

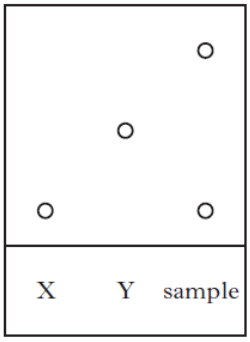
A



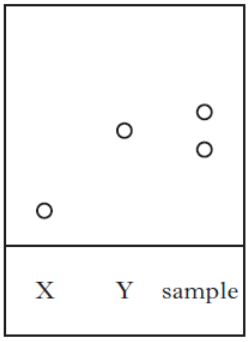
B



C



D



9. Which of the procedures would be best for obtaining sodium chloride from a mixture of sodium chloride and silver chloride

A Add water, filter and collect residue

B Add water, filter and evaporate filtrate

C Add hydrochloric acid, filter and collect residue

D Add sodium hydroxide solution, filter and evaporate residue

10. The alcohol content of wine was analysed by four students. Each student carried out the experiment three times.

	Experiment 1	Experiment 2	Experiment 3
Student A	10.0	9.0	8.0
Student B	6.4	6.6	6.8
Student C	6.5	6.6	6.6
Student D	9.0	8.5	9.6

The most reproducible results were found by?

A Student A

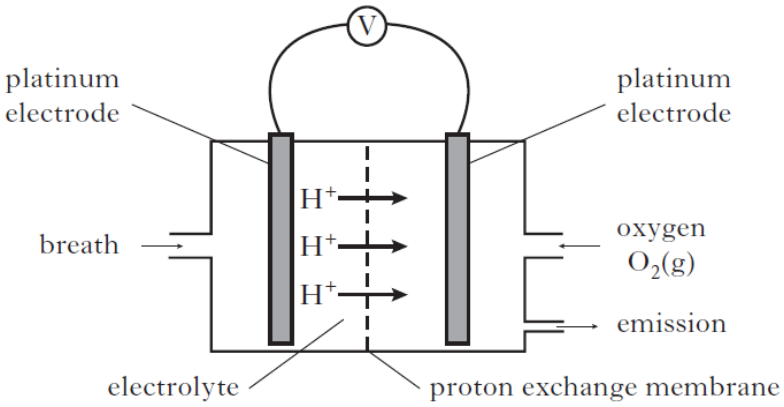
B Student B

C Student C

D Student D

Part B

1. The concentration of ethanol in a person's breath can be determined by measuring the voltage produced in an electrochemical cell.



The ion-electron equations for the reduction and oxidation reactions occurring in the cell are shown below.

$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$

$CH_3CH_2OH + H_2O \longrightarrow CH_3COOH + 4H^+ + 4e^-$

Write the overall redox equation for the reaction taking place. (1)

2. Hydrogen sulfide, H_2S, can cause an unpleasant smell in water supplies.

The concentration of hydrogen sulfide can be measured by titrating with a chlorine standard solution.

The equation for the reaction taking place is

$$4Cl_2(aq) + H_2S(aq) + 4H_2O(l) \longrightarrow SO_4^{2-}(aq) + 10H^+(aq) + 8Cl^-(aq)$$

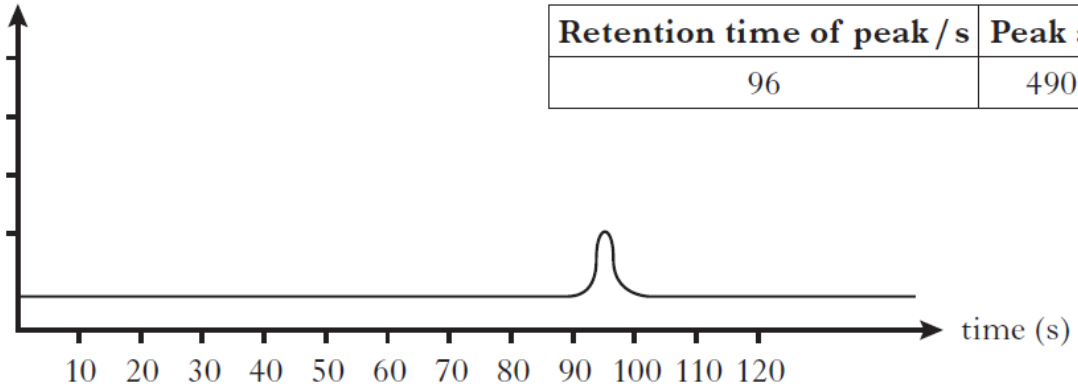
50·0 cm^3 samples of water were titrated using a 0·010 mol l^{-1} chlorine solution.

a. Name an appropriate piece of apparatus which could be used to measure out the water samples. (1)
b. An average of 29·4 cm^3 of 0·010 mol l^{-1} chlorine solution was required to react completely with a 50·0 cm^3 sample of water.

Calculate the hydrogen sulfide concentration, in mol l^{-1}, present in the water sample.
Show your working clearly. (3)

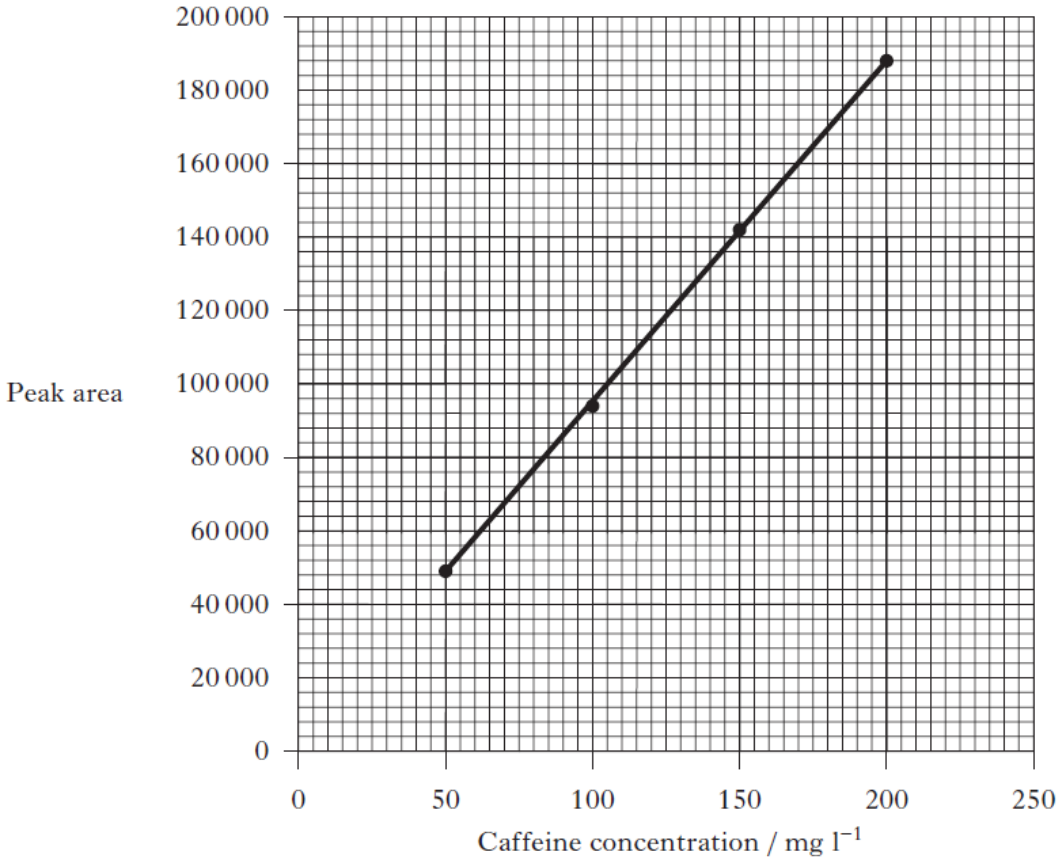
3. Caffeine is added to some soft drinks. The concentration of caffeine can be found using chromatography.

A chromatogram for a standard solution containing 50 mg l^{-1} of caffeine is shown below.



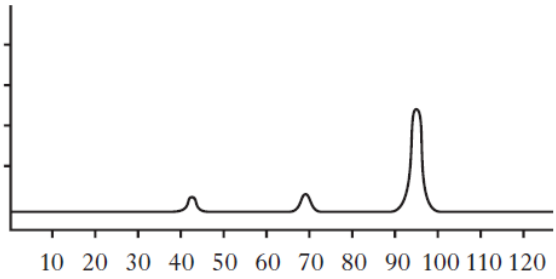
Retention time of peak / s	Peak area
96	49000

Results from four caffeine standard solutions were used to produce the calibration graph below.



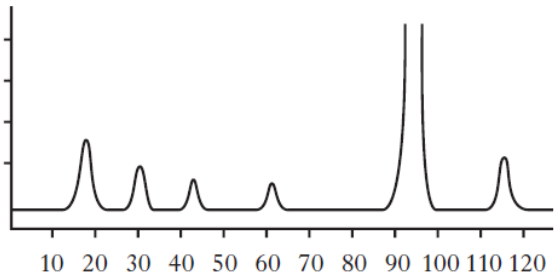
Chromatograms for two soft drinks are shown below.

Soft drink **X**



Retention time of peak / s	Peak area
42	1000
69	1350
96	68000

Soft drink **Y**



Retention time of peak / s	Peak area
17	7000
30	4600
43	3000
62	2500
96	–––
115	5000

a. What is the caffeine content, in mg l^{-1} of soft drink **X**? (1)

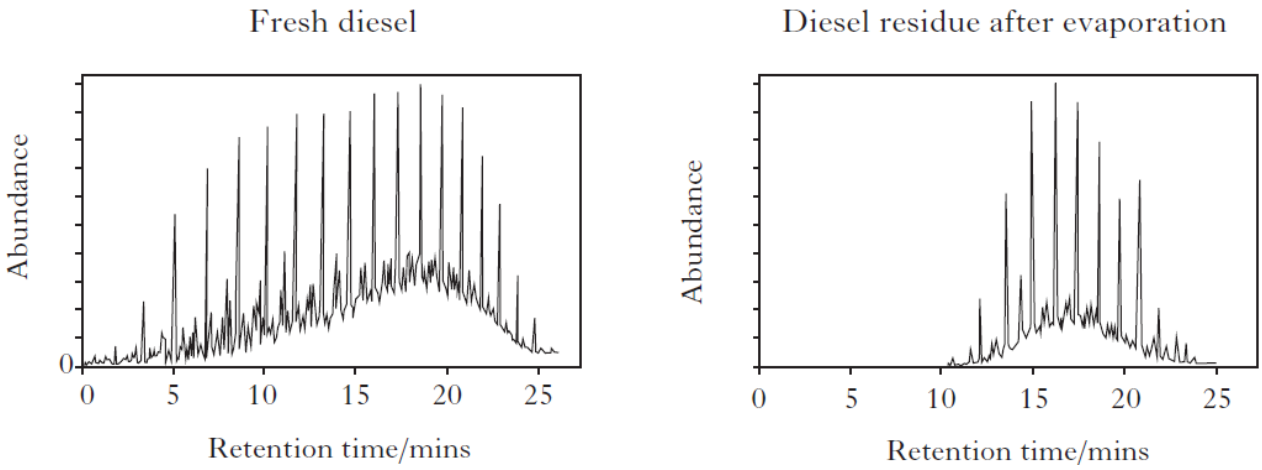
The caffeine content of the soft drink **Y** cannot be determined from its chromatogram.

b. What should be done to the sample of soft drink **Y** so that the caffeine content could be reliably calculated? (1)

4. When a fire has been started deliberately, gas liquid chromatography (GLC) can be used to identify the tiny amounts of fuel or flammable liquid used to help start the fire.

a. Diesel contains a mixture of non-polar molecules of different sizes.

Below are the chromatograms recorded using a normal sample of diesel and a sample of diesel that has been heated until around 90% of the diesel had evaporated.



Explain how these chromatograms show that large molecules have longer retention times than small molecules in this type of chromatography. (2)

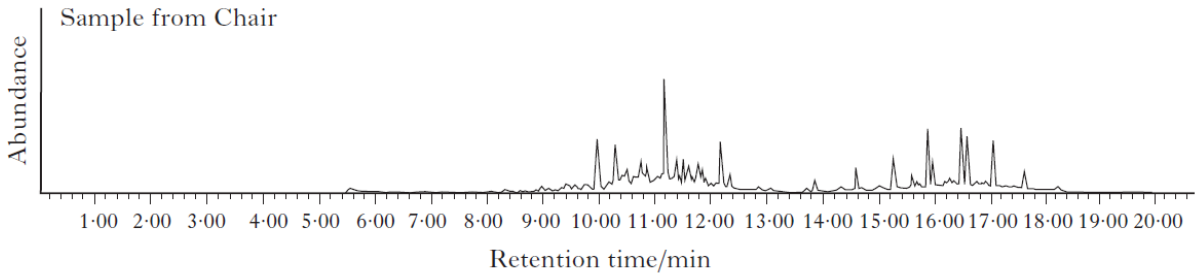
b. A suspicious house fire was found to have started in a chair.

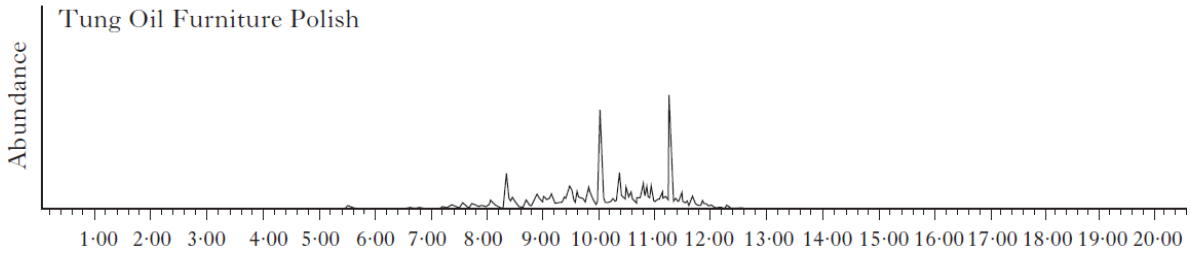
An almost empty bottle of paint thinner was found in a suspect's car.

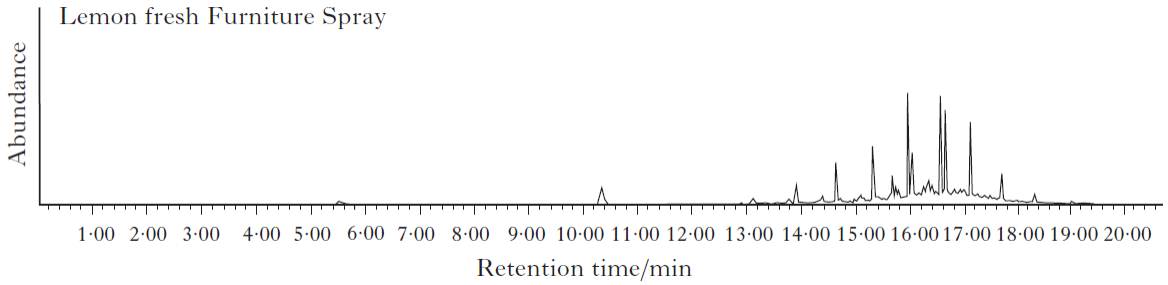
In the house there were two cans of furniture polish which might have been used to clean the chair at some time.

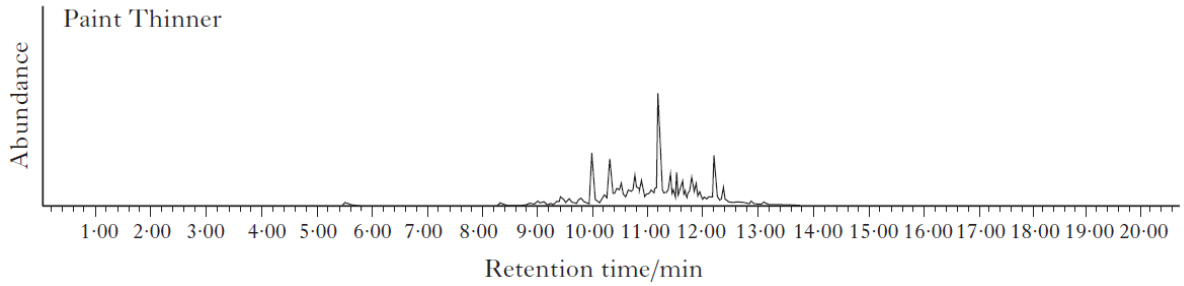
The chromatograms obtained from the remains of the chair, the paint thinner and the furniture polishes are shown opposite.

Which of the substances tested were present on the armchair? (1)


Sample from Chair
Abundance
1·00 2·00 3·00 4·00 5·00 6·00 7·00 8·00 9·00 10·00 11·00 12·00 13·00 14·00 15·00 16·00 17·00 18·00 19·00 20·00
Retention time/min


Tung Oil Furniture Polish
Abundance
1·00 2·00 3·00 4·00 5·00 6·00 7·00 8·00 9·00 10·00 11·00 12·00 13·00 14·00 15·00 16·00 17·00 18·00 19·00 20·00


Lemon fresh Furniture Spray
Abundance
1·00 2·00 3·00 4·00 5·00 6·00 7·00 8·00 9·00 10·00 11·00 12·00 13·00 14·00 15·00 16·00 17·00 18·00 19·00 20·00
Retention time/min


Paint Thinner
Abundance
1·00 2·00 3·00 4·00 5·00 6·00 7·00 8·00 9·00 10·00 11·00 12·00 13·00 14·00 15·00 16·00 17·00 18·00 19·00 20·00
Retention time/min

5. Solutions containing iodine are used to treat foot rot in sheep.
The concentration of iodine in a solution can be determined by titrating with a solution of thiosulfate ions.

$$I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-}$$

a. Write an ion-electron equation for the reaction of the oxidising agent in the titration.

b. Three 20·0 cm^3 samples of a sheep treatment solution were titrated with 0·10 mol l^{-1} thiosulfate solution.

Sample	Volume of Thiosulphate / cm^3
1	18.60
2	18.10
3	18.20

Why is the volume of sodium thiosulfate used in the calculation taken as 18·15 cm^3, although this is not the average of the three titres in the table? (1)

c. Calculate the concentration of iodine, in mol l^{-1}, in the foot rot treatment solution.
Show your working clearly. (3)

d. Describe how to prepare 250 cm^3 of a 0·10 mol l^{-1} standard solution of sodium thiosulfate, $Na_2S_2O_3$.Your answer should include the mass, in g, of sodium thiosulfate required. (3)

6. A proton NMR spectrum can be used to help identify the structure of an organic compound.

   The three key principles used in identifying a group containing hydrogen atoms in a molecule are as follows:

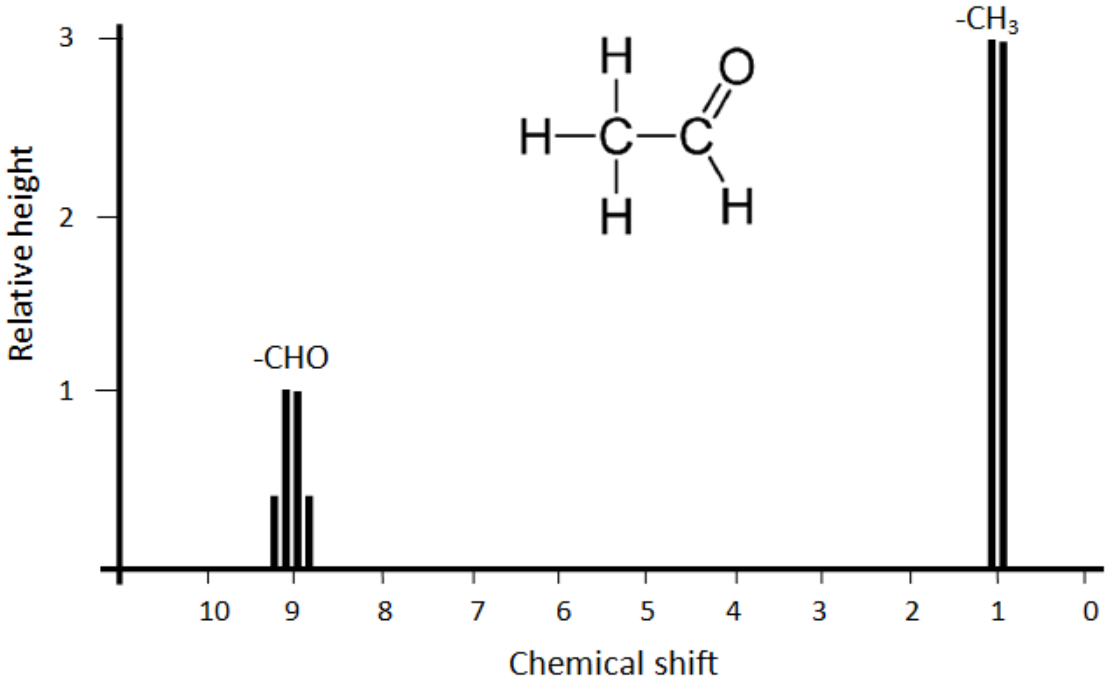
   i. The position of the line(s) on the x-axis of the spectrum is a measure of the "chemical shift" of the hydrogen atoms in the particular group.

Some common "chemical shift" values are given in the table below.

Group Containing Hydrogen Atoms	Chemical Shifts
$-CH_3$	1.0
$-C\equiv CH$	2.7
$-CH_2Cl$	3.7
$-CHO$	9.0

   ii. The number of lines for the hydrogen atoms in the group is n + 1 where n is the number of hydrogen atoms on the carbon atom next to the group.

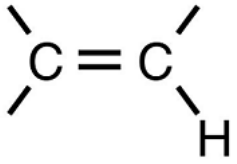
   iii. The maximum height of the line(s) for the hydrogen atoms in the group is relative to the number of hydrogen atoms in the group.



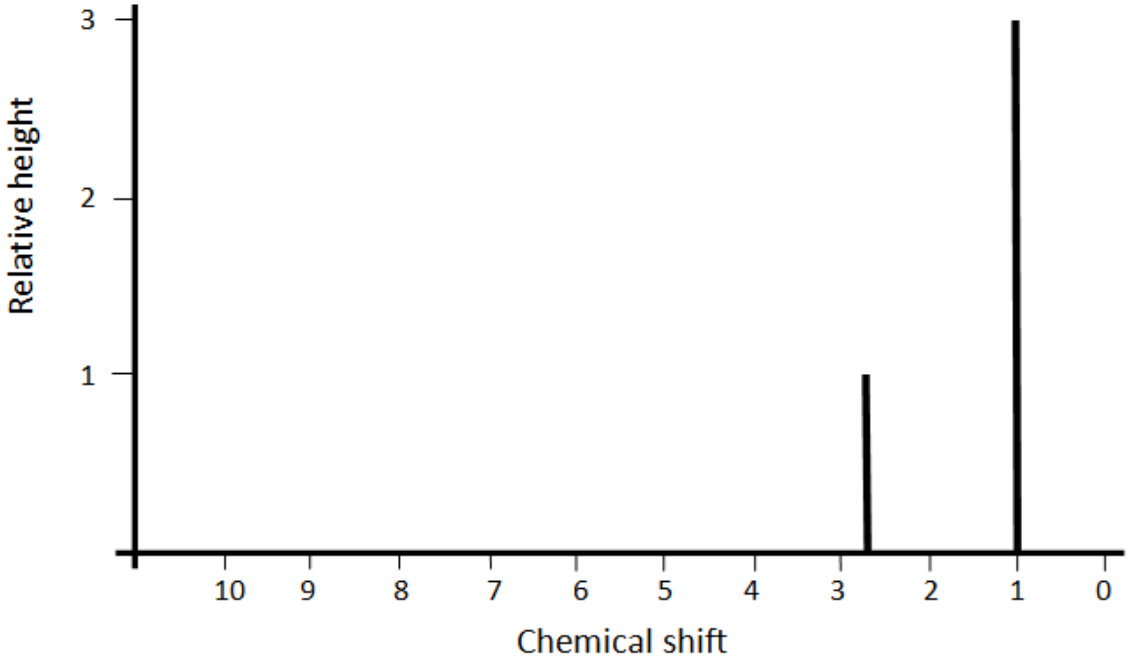
The spectrum for ethanal is shown above.

a. The chemical shift values shown in the table are based on the range of values shown in the data booklet for proton NMR spectra.

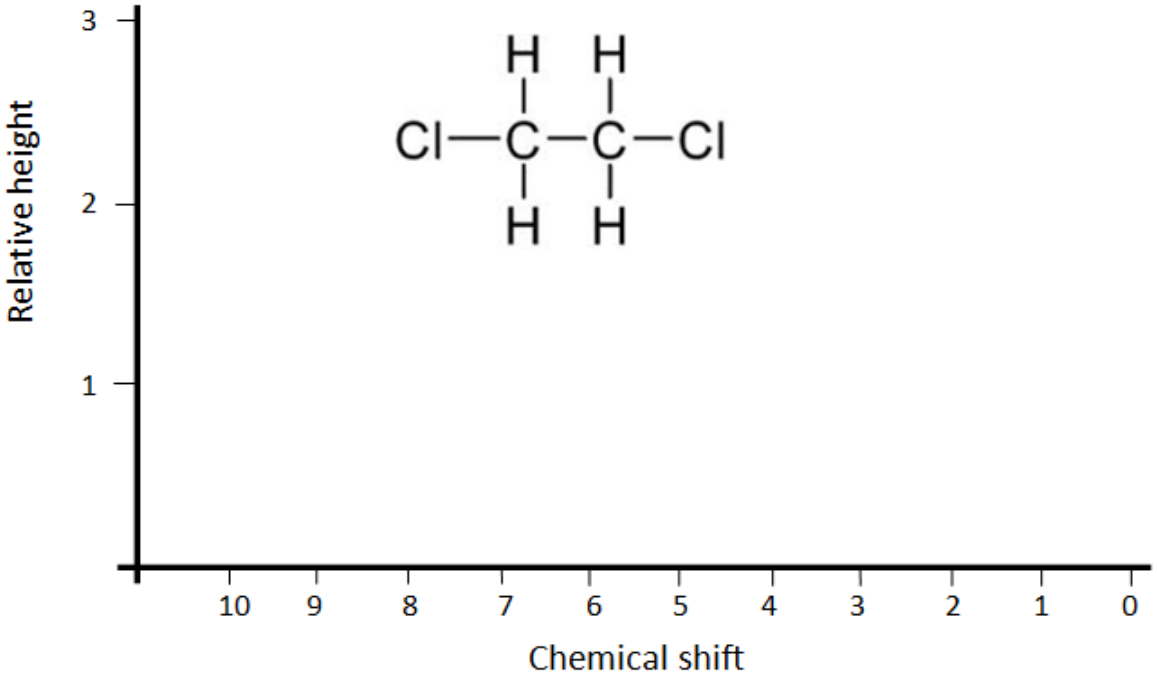
Use the data booklet to find the range of chemical shift values for hydrogen atoms in the following environment (1)

b. A carbon compound  has the following spectrum.

Draw a structural formula for this compound. (1)



c. Draw the spectrum that would be obtained for chloroethane (1)



Acknowledgements

1. AveryWeigh-Tronix (Front Cover Image), Accessed online via:

http://www.averyweigh-tronix.com/chemical-and-petrochemical, April 2014

2. SQA, Past papers, Accessed Online via: http://www.sqa.org.uk/pastpapers/findpastpaper.htm?subject=Chemistry, April 2014.

3. J. Anderson, E. Allan and J. Harris, Higher Chemistry for CfE, Hodder Gibson, Paisley, UK, 2012