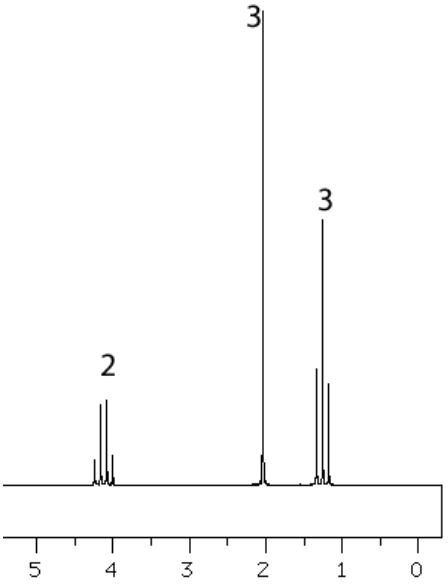
Analytical chemistry year 12

Name _____

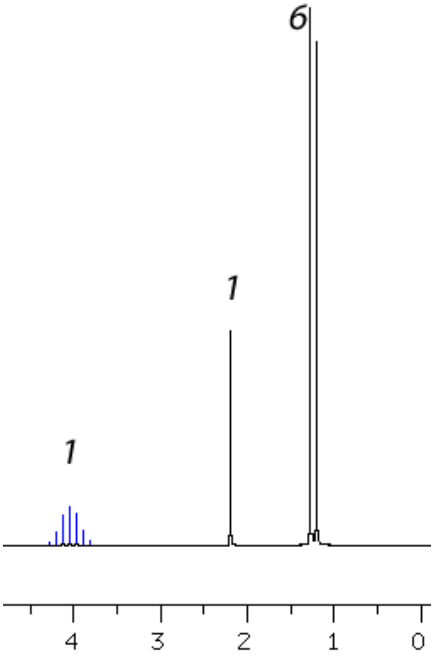


1) Consider the ^{1}H NMR spectrum on the right.
   a) Draw the grouping of atoms that would give rise to the triplet and quartet splitting patterns.

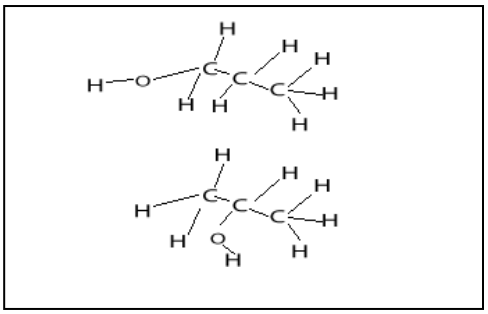
      $CH_3 - CH_2$

   b) What group of atoms will most likely give rise to the singlet?

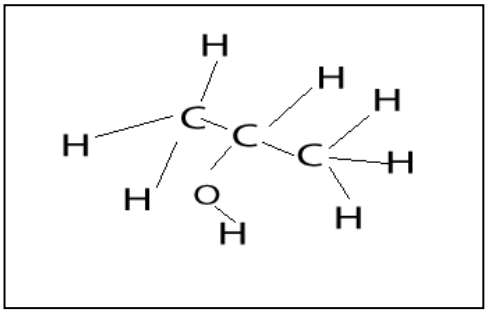
      CH_3



   c) Propanol(C_3H_8O) has two isomers. Draw the two possible structures.



   d) Which isomer is represented by the ^{1}H NMR on the right?

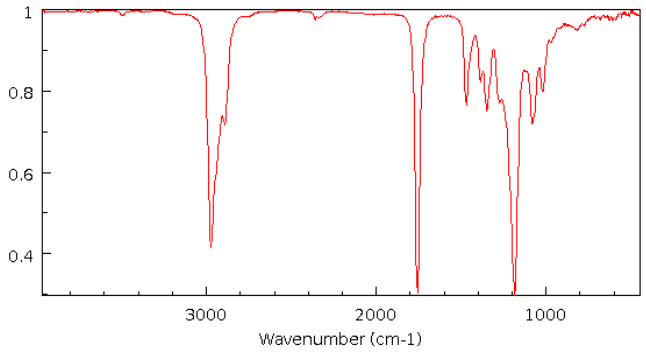


4 marks

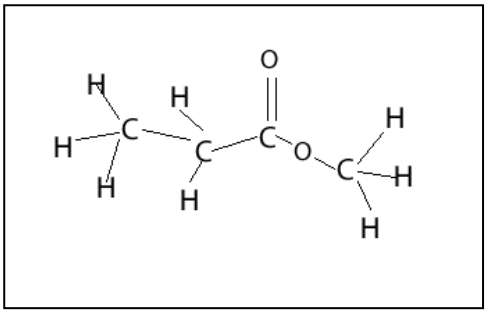
2) An organic compound has the following percentage composition by mass.
54.55%C, 9.10%H, 36.35%O

a) Find its molecular formula if 0.500 mol of the substance weighs 44.0 grams
$C_4H_8O_2$

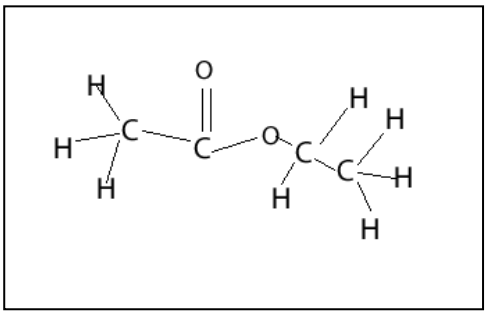
b) The IR spectrum of the compound is shown on the right?
Draw two possible structures for this compound



i)



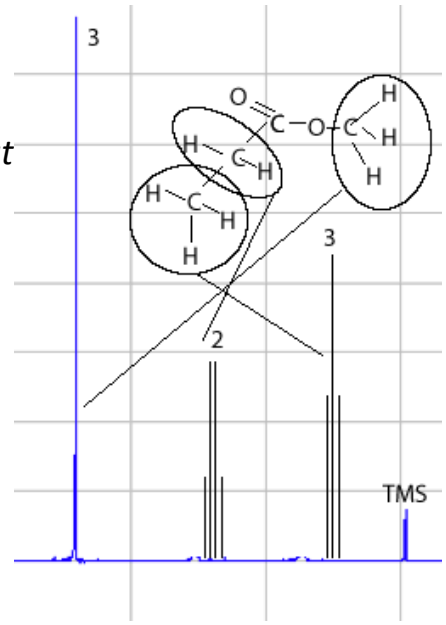
ii)

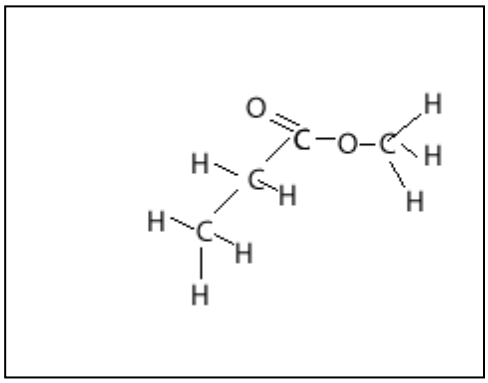


iii) Stephen suggested that the compound might be butanoic acid.
Is he right? *NO*
Explain with reference to the IR spectrum.
There is no indication on the IR spectrum of an O-H bond.

6 marks

c) The compound was found not to react with a base and its ^{1}H NMR is shown on the right.
Draw the possible structure of the molecule.
The fact that it does not react with a base indicates that it is not butanoic acid.

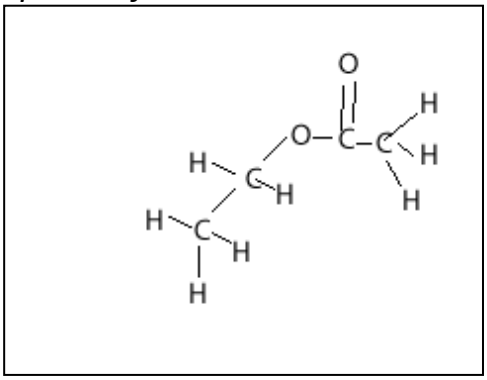


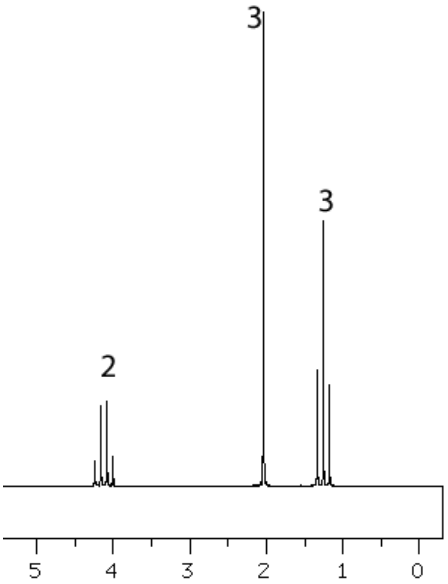


2 marks

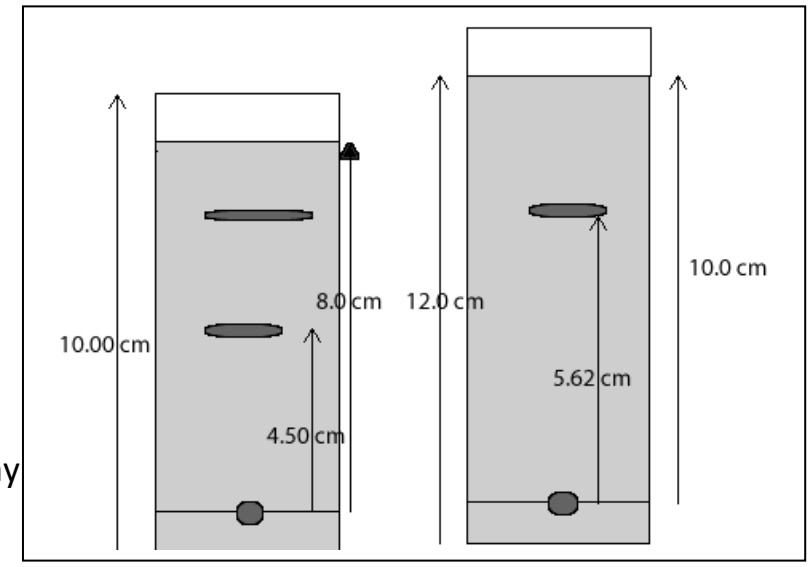
d) Jonathon was given the ^{1}H NMR shown below and came up with the same structure as in c) above. Is he correct or incorrect. Explain

Incorrect. The structure that is derived by the NMR on the right is best given by the molecule below. The spectrum indicates a CH_2 group that is not shielded as much as each CH_3 group. In other words we would expect to find the CH_2 attached to an oxygen.





3) Two paper chromatograms are shown on the right of a sample of food dye. Do they have a common component? Explain why



The Rf value of the component dye in the chromatogram on the left is
4.5/8.0 = 0.562
The Rf value of the component dye in the chromatogram on the right is
5.62/10.0 = 0.562

Since the Rf value is the same the component dye is the same.

4) A student is to accurately determine the concentration of a solution of sodium hydrogencarbonate in a titration against a standard solution of hydrochloric acid, HCl.
The first step in this experiment is to accurately dilute 50.0 mL of a 1.00 M HCl stock solution to a 0.100 M solution using a 500 mL volumetric flask. However, instead of using distilled water in the dilution, the student mistakenly adds 100.0 mL of 0.0222 M sodium hydroxide, NaOH, solution.

a) Write an equation for the reaction that occurs in the 500 mL volumetric flask.
$NaOH(aq) + HCl(aq) \Rightarrow NaCl(aq) + H_2O(l)$

b) Calculate the final concentration of the hydrochloric acid in the 500mL volumetric flask. Give your answer to correct significant figures.

=> n_{NaOH} = C X V = 0.0222 X 0.1 = 0.00222
=> n_{HCl} = C X V = 1.00 X 0.0500 = 0.0500
=> Mole of NaOH : mole of HCl = 1:1
=> So 0.00222 mol of NaOH will react with 0.00222 mol of HCL leaving (0.0500 - 0.00222) 0.0478 mol of HCl in the 500 ml flask. The 500 mL flask is read as 500.0 mL so it has 4 sig fig.

The lowest number of significant figures used in this calculation was 3, hence the answer must be in three significant figures.

=>[HCl] in the flask is 0.0478/0.500 = 0.009560= 9.56 X 10^{-2}M

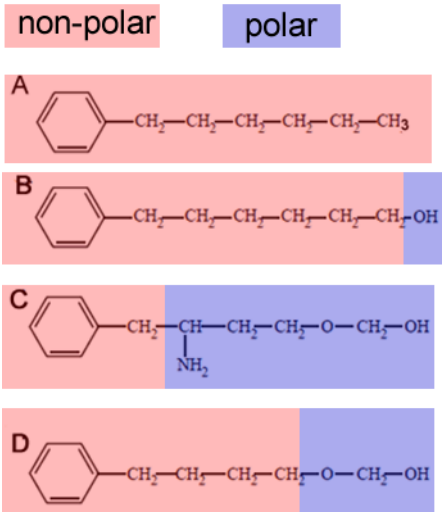
The student then uses this contaminated hydrochloric acid solution to determine the accurate concentration of an unknown sodium hydrogen carbonate ($NaHCO_3$) solution. During the titration the $NaHCO_3$ solution is placed in the burette while a 20.0 mL aliquot of the HCl solution is placed in the conical flask

c) Will the calculated concentration of sodium hydrogen carbonate solution be greater or smaller than the true value? Justify your answer?

It would be greater than the true value, as less $NaHCO_3$ needs to be added to achieve the end point.

5) A mixture of organic compounds is run through a chromatography column. The stationary phase is coated with a non-polar substance while the mobile phase is a polar solvent.

a) Place the molecules on the right in order of increasing retention time.



Low

i) C

ii) D

iii) B

iv) A

High

2 marks

b) Explain your reasons why you placed the molecules in the order given in a).

The more non-polar a molecule is the greater affinity it will have with the stationary phase, hence, will be adsorbed more strongly onto the stationary and will not be carried quickly by the mobile phase.