Student Name: _____

CHEMISTRY 2021

Unit 4

Key Topic Test 3 – Instrumentation and organic chemistry

Recommended writing time*: 50 minutes

Total number of marks available: 50 marks

QUESTION BOOK

*The recommended writing time is a guide to the time students should take to complete this test. Teachers may wish to alter this time and can do so at their own discretion.

Conditions and restrictions

- Students are permitted to bring into the room for this test: pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring into the room for this test: blank sheets of paper and/or white out liquid/tape.
- A scientific calculator is permitted in this test.
- VCAA Chemistry data booklet will be provided

Materials supplied

- Question and answer book of 11 pages.

Instructions

- Print your name in the space provided on the top of the front page.
- All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic communication devices into the room for this test.

Instructions for Section A

Answer **all** questions.
Choose the response that is **correct** for the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks are **not** deducted for incorrect answers.
If more than one answer is completed for any question, no mark will be given.

Question 1

The molecule 3-methylpentane has how many hydrogen environments in a ^{1}H-NMR spectrum?

A. 2
B. 3
C. 4
D. 6

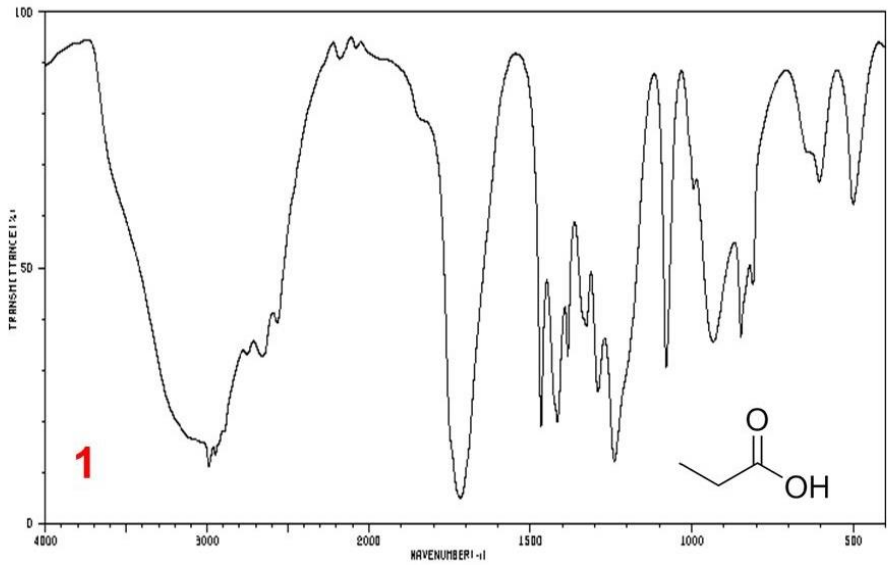
Question 2

The molecule 2,3-dimethylbutane has how many carbon environments in a ^{13}C-NMR spectrum?

A. 2
B. 3
C. 4
D. 6

Question 3

The IR spectrum of a molecule is shown below;



This molecule is most likely to be a/an;

A. alcohol

B. carboxylic acid

C. ester

D. ketone

Question 4

A molecule has the molecular formula $C_4H_{10}O$. The ^{1}H-NMR spectrum contains sets of 2 peaks in the ratio of 9:1with no splitting. The molecule could be;

A. butan-1-ol

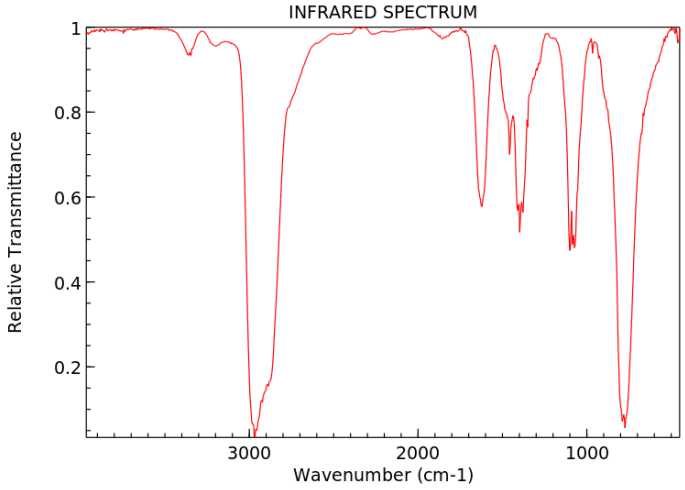
B. 2-methylbutan-2-ol

C. butan-2-ol

D. 2-methylpropan-2-ol

Question 5

The IR spectrum below has peaks at about 3300cm^{-1}, 2950cm^{-1} as well as several peaks below 1600cm^{-1}.



NIST Chemistry WebBook (https://webbook.nist.gov/chemistry)

The molecule is likely to be an;

A. alcohol
B. amine
C. aldehyde
D. alkane

Question 6

A molecule with 4 carbon environments and 4 hydrogen environments in a ^{13}C-NMR spectrum is;

A. butanoic acid
B. butan-1-ol
C. methyl propanoate
D. 1,4-dichlorobutane

Question 7

IR spectroscopy involves;

A. the movement of electrons from a low to high energy level and back again
B. the spin states of neutrons in the nucleus
C. the stretching, bending and twisting of chemical bonds
D. the bending of ions by a magnetic field

Question 8
Ethanoic acid is titrated against sodium carbonate. The amount of substance (mol) of sodium carbonate that reacts is 0.325mol. The amount of substance (mol) of ethanoic acid that would react is;

A. 0.123mol
B. 0.325mol
C. 0.650mol
D. 1.300mol

The following information applies to the next 2 questions;
The concentration of alcohol in fortified wine can be determined by titration against potassium dichromate according to the equation;

$$2Cr_2O_7^{2-}{}_{(aq)} + 3C_2H_5OH_{(aq)} + 16H^+{}_{(aq)} \rightarrow 4Cr^{3+}{}_{(aq)} + 3CH_3COOH_{(aq)} + 11H_2O_{(l)}$$

25.0mL of wine is diluted to 250mL and 20.0 mL is titrated against 0.0600M $Cr_2O_7^{2-}$.

Question 9

A student determines that 0.00453mol of dichromate reacts. The mass of ethanol present in the diluted wine is;

A. 0.139g
B. 0.208g
C. 0.313g
D. 0.625g

Question 10

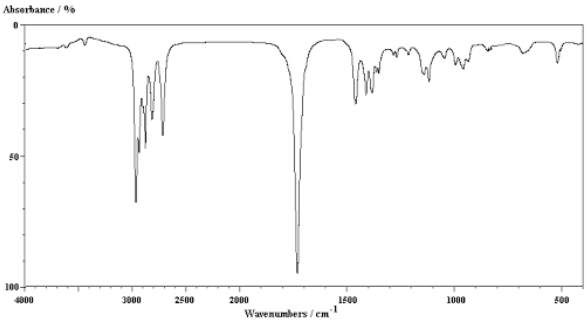
The student incorrectly calculates the mass of ethanol in the diluted wine to be 0.450g. Their calculated concentration of alcohol in the original wine (in %w/v) would be;

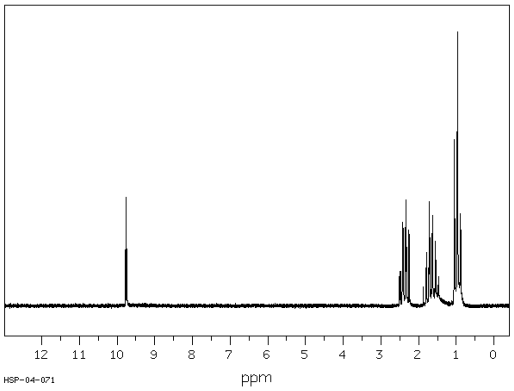
A. 2.25%
B. 5.63%
C. 11.3%
D. 22.5%

Section B

Question 1;

The IR spectrum and ^{1}H-NMR spectrum for a molecule is shown below;





The molecule has a molar mass of 72g/mol

The details of the ^{1}H-NMR spectrum are shown in the table below;

Chemical shift	Peak area	Splitting pattern
0.97	3	3
1.64	2	6
2.37	2	4
9.76	1	3

a. Give the name of the functional group containing oxygen present in the molecule.

_____

1 mark

b. How many hydrogen environments are there?

_____

1 mark

c. Account for the splitting pattern at a chemical shift of 0.97

_____

_____

2 marks

d. Draw the full structural formula of the molecule.

2 marks
Total 6 marks

Question 2

If ethyl ethanoate was to be analyzed by ^{1}H NMR, predict the expected spectrum that would be produced. Include number of peak sets, the area of each peak set and splitting patterns.

_____

_____

_____

_____

_____

_____

_____

_____

4 marks

Question 3

The concentration of benzoic acid (a monoprotic acid) was determined by titration. 20.00 mL of benzoic acid solution pipetted into a conical flask and titrated against 0.100 M KOH. The average titre was 13.56 mL.

a. Determine a suitable indicator for the titration.

_____

1 mark

b. Calculate the concentration of benzoic acid.

_____

_____

_____

2 marks

c. Calculate the mass of potassium hydroxide needed to make up 100 mL of a KOH solution with a concentration of 0.100 M.

_____

_____

_____

2 marks

d. The potassium hydroxide solution may have a concentration significantly different to 0.100 M.

i. Why is this?

_____

_____

ii. Suggest what a student could do to get a more accurate concentration of potassium hydroxide.

_____

_____

_____

1 + 2 = 3 marks

e. The pipette is meant to be washed with benzoic acid but was washed in water. What effect would this have on the calculated concentration of benzoic acid?

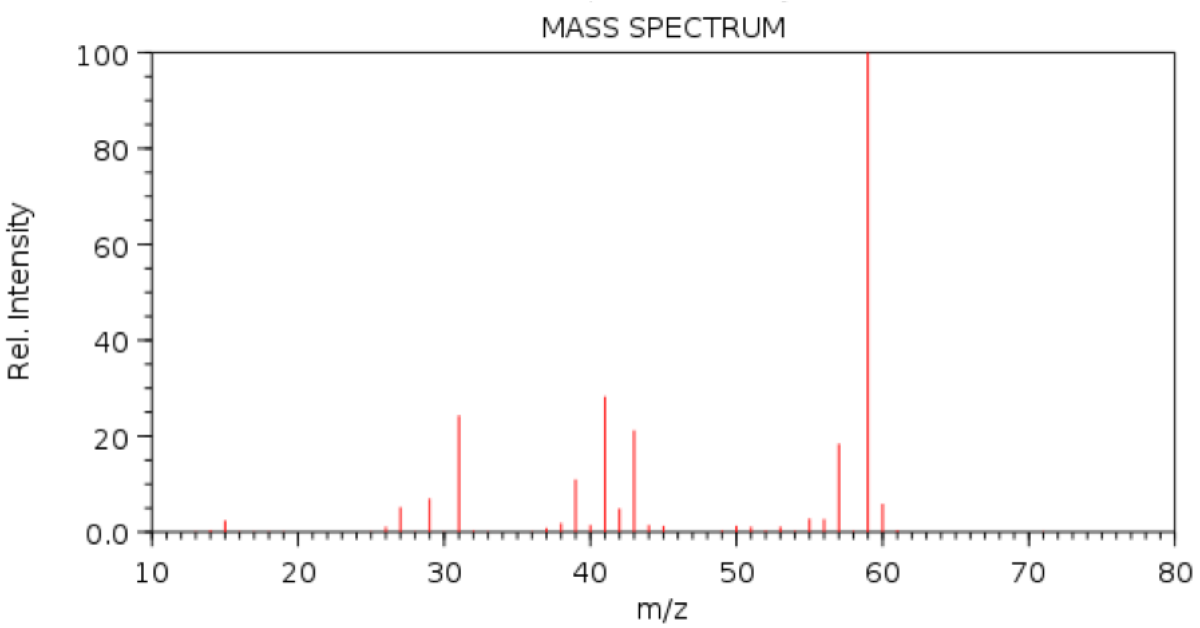
_____

1 mark

Total 9 marks

Question 4

The mass spectrum of an alcohol with the molecular formula of C_3H_8O is shown below.



a. Identify the m/z ratio of the:

i. base peak

_____

ii. parent peak

_____

1 + 1 = 2 marks

b. Suggest what the peak at an m/z of 31 might be due to.

_____

1 mark

c. What particle might be lost to form the peak at m/z of 59?

_____

1 mark

d. The ^{1}H-NMR spectrum of this molecule shows 3 main peaks in the ratio of 6:1:1. Draw the structure of the molecule.

2 marks

Total 6 marks

Question 5

A chemist analyses the levels of the drug THC using HPLC.

a. By constructing a calibration curve using the data below, determine the level of THC.

Concentration (ng/L)	Peak Area
20.0	0.15
40.0	0.29
60.0	0.44
80.0	0.59
Blood sample	0.33

3 marks

b. How could the chemist confirm that the drug is in fact THC?

_____

_____

_____

2 marks

c. The drug is slightly polar and the stationary phase used is polar, while the mobile phase is non-polar. What would happen to the retention time of the drug component if;

i. a longer column was used.

_____

ii. the column was heated to a higher temperature.

_____

iii. the mobile phase is replaced with a more polar mobile phase.

_____

3 marks
Total 8 marks

Question 6
The level of vitamin C ($C_6H_8O_6$) in a tablet can be determine by titration with iodine.

$C_6H_8O_{6(aq)} + I_{2(aq)} \rightarrow C_6H_6O_{6(aq)} + 2H^+_{(aq)} + 2I^-_{(aq)}$

Iodine solution is a brown colour, while iodide ions are colourless. A starch indicator is used which turns blue/black when there is an excess of iodine present.
Describe how you would carry out a titration to test the claim that each 2.20g vitamin C tablet contains 90.0% vitamin C.

You can describe the procedure in point form and you should include the following;

- The major pieces of glassware used.
- The volumes and concentrations of any solutions used including the expected titre.
- Calculations involved in determining the volumes and concentrations of solutions used.

_____

_____

_____

_____

_____

_____

_____

_____

_____

Total 7 marks