**Topic Test: Instrumentation & titration**

**Multiple Choice**

**Question 1**

Analysis of the components of a mixture using high performance liquid chromatography normally involves measuring the:

1. Rf values of the components, using gas as the mobile phase
2. Rf values of the components, using a liquid as the mobile phase
3. Retention time of the components, using a gas as the mobile phase
4. Retention time of the components, using a liquid as the mobile phase

*Use the following information to answer Questions 2 and 3*

The molecule shown is benzoic acid. Solutions of benzoic acid can be titrated

if it is first dissolved in a small amount of ethanol. A titration is

conducted between a solution of benzoic acid and 20.0 mL

aliquots of a 0.080 NaOH solution. The mean titre obtained was 16 mL.

**Question 2**

The equation for the reaction of benzoic and water will be

1. C6H5COOH(aq) + H2O(l) ⇄ OH-(aq) + C6H5COOH2+(aq)
2. C6H5COOH(aq) + H2O(l) ⇄ H3O+(aq) + C6H5COO-(aq)
3. C6H6COOH(aq) + H2O(l) ⇄ H3O+(aq) + C6H6COO-(aq)
4. C6H5COOH(aq) + 6H2O(l) ⇄ 6H3O+(aq) + C6COO6-(aq)

**Question 3**

The concentration of the benzoic acid is, in M,

1. 0.05
2. 0.064
3. 0.08
4. 0.10

**Question 4**

A variety of proteins in our bodies can be used as disease markers. Analysts must separate and identify proteins that are used as disease markers from many thousands of proteins that exist in our bodies.

Which of the following sequence of techniques could be used to:

1. separate these molecules, then
2. determine their molecular structure
3. NMR spectroscopy, followed by IR spectroscopy, followed by HPLC
4. HPLC, followed by IR spectroscopy, followed by NMR spectroscopy
5. HPLC, followed by IR spectroscopy, followed by titration.
6. IR spectrometry, followed by NMR, followed by HPLC

**Question 5**

A mass spectrum had a large peak at 15m/z. Which of the following molecules could produce a peak with this mass?

1. CH2CH2
2. CH3OH
3. HCOOH
4. CCl3H

**Question 6**

A class was analysing the amino acid content of orange juice by thin layer chromatography. Each group used the same solvent and same stationary phase. In the chromatogram obtained by one group, the spot corresponding to a particular amino acid was located 5.2 cm above the origin, while the solvent front was located at 7.0 cm. What will be the height of the spot corresponding to the same amino acid in the chromatogram obtained by another group, if their solvent front travelled 8.6 cm?

1. 7.2cm
2. 5.2cm
3. 6.8cm
4. 6.4cm

**Question 7**

When a molecule absorbs infrared radiation this is most likely to lead to:

1. Transitions between electronic energy levels in the molecule
2. Transitions between vibrational energy levels in the molecule
3. Transitions within nuclei of atoms in the molecule when the molecule is placed in a strong magnetic field
4. The removal of an electron from the molecule leading to the formation of the molecular ion.

**Question 8**

A sample of alcohols, which contained a mixture of butan-1-ol (C4H10O), pentan-1-ol (C5H12) and hexan-1-ol (C6H14), was analysed in a HPLC. The chromatogram shown below was obtained. A polar solvent was used.

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The mole percentage of hexan-1-ol in the mixture is: (assuming equal sensitivity from each substance)

1. 30%
2. 33%
3. 50%
4. 67%

**Question 9**

A high resolution 1H NMR spectrum is drawn below.

TMS

 2.0

11

This NMR could be of

**A**. ethane

**B**. ethanol

**C**. ethanoic acid

**D**. butane

**Question 10**

Which of the following molecules has the least number of carbon environments?

1. Ethanol
2. Benzene
3. Propane
4. Butane

**SECTION B - Short-answer questions**

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| --- |
| **Instructions for Section B**Questions must be answered in the spaces provided in this book.To obtain full marks for your responses you should* Give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
* Show all workings in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.

Make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, H2(g); NaCl(s) |

**Question 1**  (6 marks)

High performance liquid chromatography (HPLC) is an analytical technique used for identifying and determining concentrations of components of a mixture.

1. HPLC can be both qualitative and quantitative.
2. Explain how it can be used qualitatively.

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1. Explain how it can be used quantitatively.

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 2 + 2 = 4 marks

1. List three factors that will affect the retention times of components in a mixture when it is passed through the column.

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 2 marks

**Question 2**  (7 marks)

**a**. Each molecule shown has only one hydrogen environment.



 molecule 1 molecule 2 molecule 3

 Rank the molecules in order of likely shift on H-NMR, smallest to highest.

 Justify your answer.

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2 marks

**b. i**. Sketch the structure of TMS.

 **ii**. What is its role in NMR?

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1 + 1 = 2 marks

**c**. Explain the likely splitting pattern of propane in proton NMR.

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2 marks

**d**. Sketch an isomer of pentane that has one hydrogen environment only.

1 mark

**Question 3** (9 marks)

Infrared spectroscopy is a technique used to help determine the types of functional groups present in unknown compounds. Each compound can produce a unique spectrum that can be used to identify it.

The IR spectra of butane, butanol and butanoic acid are below.

** **

Spectra ASpectra B

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Spectra C

1. Identify the compound that produces each spectra.

1. Spectra A:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Spectra B:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Spectra C:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1 + 1 + 1 = 3 marks

1. Provide evidence for your selections.
2. Spectra A:

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1. Spectra B:

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1. Spectra C:

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2 + 2 + 2 = 6 marks

**Question 4** (9 marks)

An unknown organic molecule containing only carbon, hydrogen and oxygen is analysed via several spectroscopic technique to determine its structure.

The IR spectrum and 1H NMR spectrum for this molecule are given below.

1H NMR spectrum



IR Spectrum



1. The compound contains 40% carbon, 6.7% hydrogen and 53.3% oxygen.
2. Determine its empirical formula.
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3. Determine the molecular formula of the compound if the molar mass is 60 g mol-1.

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1. Name three possible functional groups the molecule might contain.

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2 + 2 + 1 = 5 marks

1. How many different proton environments are there in this molecule?

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1 mark

1. Draw the structure of the unknown molecule, showing all bonds.

1 mark

1. Explain how the structure of the molecule you have drawn is consistent with its IR spectra.

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1 mark

1. Name the unknown molecule.

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 1 mark

**Question 5** (9 marks)

A titration is conducted to determine the ethanoic acid concentration of a sample of commercial vinegar. The following data is recorded.

20.0 mL of vinegar added to 1.00 L volumetric flask made up the mark.

25.00 mL aliquots added to a flask and phenolphthalein added as an indicator.

Concentration of NaOH solution = 0.120 M

Mean titre 12.44 mL

**a**. Write a balanced equation for the reaction between ethanoic acid and sodium hydroxide.

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1 mark

**b**. Phenolphthalein was chosen as an indicator for this reaction. Discuss the appropriateness of this

 choice.

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2 marks

**c. i**. Determine the concentration of ethanoic acid in the diluted vinegar.

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 **ii**. Determine the concentration of ethanoic acid in the undiluted vinegar.

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3 + 1 = 4 marks

**d. i**. Ethanoic acid is a weak acid that does not fully ionise in water. Will this impact upon the results?

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 **ii**. The burette is rinsed with distilled water. How will this impact upon the concentration obtained?

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1 + 1 = 2 marks

 **END OF TASK**