

**Task 8: Applications of Chromatography Validation**

**Question/Answer Booklet**

**CHEMISTRY UNIT 2**

Student Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Teacher’s Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# TIME ALLOWED FOR THIS PAPER

Working time for the paper: 50 minutes

# MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

**To be provided by the supervisor:**

This Question/Answer Booklet

Chemistry Data Book

**To be provided by the candidate:**

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, ruler, highlighters

Special items: up to three non-programmable calculators approved for use in the WACE examinations

# IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further

**Question 1 (27 marks)**

Water, methane, carbon monoxide, and carbon dioxide are greenhouse gases, carbon monoxide is particularly problematic due to its high toxicity to humans. A particular power plant uses methane as a chemical fuel.

1. In the space below, write balanced chemical equations for both the complete and incomplete combustion of methane. (3 marks)

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1. If the combustion is 50% efficient (that is, both complete and incomplete combustion happens the same amount of times), what mole ratio would you expect to see of carbon monoxide to carbon dioxide? Use a calculation to explain why. (2 marks)

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In order to analyse the amount of carbon monoxide and carbon dioxide produced by the chemical reactor, gas chromatography (GC) was chosen. The mobile phase chosen was nitrogen gas, as it is known to have a very different boiling point to both carbon dioxide and carbon monoxide.

1. Using the table below, draw the structure of each molecule and state the shape of the molecule. In addition, state whether or not you would expect the molecule to be polar – this has already been done for nitrogen. (8 marks)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Structural diagram** | **Shape** | **Polar molecule** |
| N2 |  |  | Non-polar |
| CH4 |  |  |  |
| H2O |  |  |  |

Before completing the analysis of the flue gas (the gas produced after combustion), four standards were run through the GC. These four chromatograms are shown below.

1. State the physical property that causes separation in a GC, then list the gases with the **strongest** intermolecular forces and the **weakest** intermolecular forces. (3 marks)

**Property:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Strongest:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Weakest:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Despite the fact that carbon monoxide is a polar molecule and carbon dioxide is a non-polar molecule, carbon dioxide has the higher boiling point. In the space below, explain why.

(3 marks)

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Finally, after running all the required preparatory work, the company runs one final analysis of the flue gas, arriving at the results below.

Z

Y

X

1. The company was able to safely state that all methane is consumed by the combustion process. With reference to the chromatograms, explain why. (2 marks)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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1. State the identities of each compound X, Y, and Z in the above chromatagram. (3 marks)

|  |  |
| --- | --- |
|  | Chemical |
| X |  |
| Y |  |
| Z |  |

1. Using the value of the y-axis as a count for the amount of mole of each gas, calculate the ratio of carbon monoxide to carbon dioxide, and hence indicate whether the complete or incomplete combustion reaction happens more often. (3 marks)

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**Question 2 (23 marks)**

Amino acids are naturally occurring chemicals that bind together to form proteins in the body. While many amino acids are made in the body, some we can only get from our diet – as a result, it is common to find a variety of different amino acids as food additives.

Mr Forte is looking to bulk up, and so is interested in learning what amino acids a variety of foods contain. After consulting an expert in the field, he decided to use high performance liquid chromatography (HPLC) to determine the amino acid content in different foods.

1. Give two reasons why Mr Forte would use HPLC over GC for the analysis of the amino acids. (2 marks)

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To use HPLC, typically scientists will first analyse components on a thin-layer chromatography sheet to ensure that the compounds will separate. An analysis of a variety of amino acids is shown below.

12

11

10

9

8

7

6

5

4

3

2

1

0 cm

X X X X X X

*solvent front*

*sample*

*line*

Phenylalanine Valine Asparagine Leucine Glutamic Serine

Acid

1. Calculate the retention factor (Rf) values for each of the given amino acids. (3 marks)

Rf = distance travelled by component

distance travelled by solvent

|  |  |
| --- | --- |
|  | Rf |
| Phenylalanine |  |
| Valine |  |
| Asparagine |  |
| Serine |  |
| Leucine |  |
| Valine |  |

Following the TLC analysis, a collection of amino acids were run through a HPLC, giving the following trace.

1. Using the Rf calculated from part b, determine the identify of each peak. (3 marks)

|  |  |
| --- | --- |
|  | Amino Acid |
| A |  |
| B |  |
| C |  |
| D |  |
| E |  |
| F |  |

The chemical structure for two of these amino acids is shown below:

Serine Leucine

1. On the diagrams above, circle the sections where the amino acid molecules differ structurally from one another. (1 mark)
2. Predict which molecule you expect to be **more** polar, and state whether it was eluted earlier or later than the other molecule. (2 marks)

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1. Determine whether a polar or non-polar **mobile phase** was used. (1 mark)

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Knowing that Weetbix and fish are a good source of protein, Mr Forte decides to analyse a sample of the foods. The following HPLC traces were created:

1. Both foods have a large peak at 3.6 minutes. Identify the chemical responsible for this peak. (1 mark)

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1. What is the absorbance of this chemical in each food? (2 marks)

**Weetbix:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Fish:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The following standard results were produced from an experiment using different standards of the amino acid.

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| --- | --- |
| **Amino acid concentration**  **(g L-1)** | **Absorbance units** |
| 0.2 | 65 |
| 0.3 | 120 |
| 0.4 | 174 |
| 0.6 | 315 |

1. Plot the calibration curve for the amino acid on the grid below. (4 marks)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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1. Using the graph, determine the concentration of the amino acid (from part g) in both Weetbix and the fish sample. (2 marks)

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1. If Mr Forte had to make a decision on whether to eat fish or Weetbix for breakfast each morning, which of the two foods would you recommend and why? (2 marks)

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