BINDURA UNIVERSITY OF SCIENCE EDUCATION

CHEMISTRY DEPARTMENT

MAR 2024

DIPLOMA IN SCIENCE EDUCATION

DCH007/DC005 ANALYTICAL CHEMISTRY

TIME: **2 HOURS**

Answer **QUESTION ONE (1)** and **FOUR (4) OTHERS.** Each question carries **20 marks.**

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1. **(a)** Define the following terms as they apply to analytical chemistry:
   - **(i)** Analytical technique. [2 marks]
   - **(ii)** Matrix. [2 marks]
   - **(iii)** Analytical method. [2 marks]

   (b) Distinguish between the following:
   - **(i)** Precision and accuracy. [2 marks]
   - **(ii)** Determinate and indeterminate error. [2 marks]

   (c) Define the following:
   - **(i)** Method validation. [2 marks]
   - **(ii)** Representative sample. [2 marks]

   (d) State **three** sources of systematic errors and explain how they can be minimized. [3+3 marks]

SECTION A: Answer **TWO (2)** questions from this section.

2. **(a)** Analysis of five samples taken from same stock solution containing potassium ion yielded the following data:

Sample	Percent K^+
1	5.29
2	5.13
3	5.14
4	5.28
5	5.20

Calculate the following:

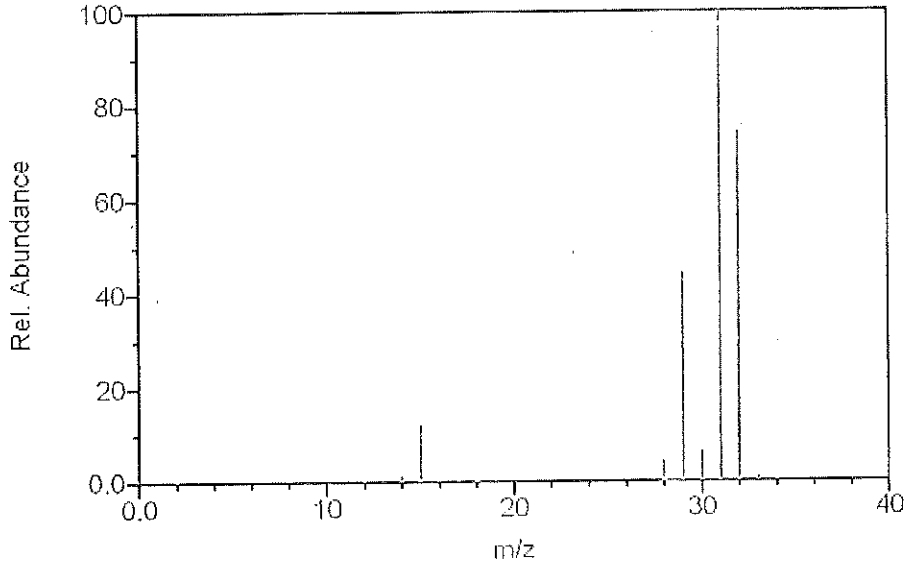
(i) the mean percent of K^+ in the samples. [2 marks]
(ii) the standard deviation. [3 marks]
(iii) the variance. [3 marks]
(iv) the coefficient of variation. [2 marks]

(b) Describe in detail the steps taken when conducting a mass spectrometric analysis. [4 marks]

(c) What is the principle behind chromatography? [3 marks]

(d) What are the advantages of using HPLC over GLC? [3 marks]

3. The diagram below shows the mass spectrum of methanol (CH_3OH).



(a) Identify the fragments giving rise to the major peaks in the spectrum. [6 marks]

(b) An analysis of the composition of a newly discovered element, Z, showed the following results.

Isotope	Relative abundance (%)
^{20}Z	90.91
^{21}Z	0.16
^{22}Z	8.93

On the mass spectrum of Z, the peak due to isotope ^{21}Z had a peak height of 20 mm.

(i) Deduce the heights of the other two peaks. [4 marks]
(ii) Draw a sketch of a mass spectrum of Z using these heights. [3 marks]
(iii) Calculate the relative atomic mass of Z. [3 marks]
(iv) State any **two** common applications of mass spectrometry. [4 marks]

4. Electrophoresis is a process that can be used to separate mixtures of amino acids.
(a) Describe, with the aid of a diagram, the main features of electrophoresis for separating a mixture of amino acids. [6 marks]

(b) Suggest why dye is usually added together with the mixture of amino acids before carrying out electrophoresis. [3 marks]

(c) All amino acids have a characteristic point known as an isoelectric point.
(i) What do you understand by the term 'isoelectric point'? [3 marks]

(ii) Suggest how electrophoresis can be used to identify different amino acids. [4 marks]

(iii) Suggest how electrophoresis can be used to estimate the molecular masses of different amino acids. [4 marks]

SECTION B: Answer **TWO (2)** questions from this section.

5. (a) Name **any 3** essential components of a mass spectrometer and give a function of each. [6 marks]

(b) What are the advantages of mass spectrometry as an analytical technique? [4 marks]

(c) State any **two** common applications of mass spectrometry. [2 marks]

(d) Describe with the aid of a fully labeled diagram, the essential steps involved in performing thin layer chromatography. [8 marks]

6. (a) What do you understand by the term partition coefficient? [3 marks]

(b) Under what conditions is the partition coefficient of a solute between two immiscible solvents valid? [4 marks]

(d) Explain how solvent extraction can be used to extract an organic substance from an aqueous solution. [5 marks]

(e) The organic solvent which is usually used to carry out solvent extraction is ether (usually ethoxy ethane, also known as diethyl ether, $C_2H_5OC_2H_5$).

(i) State **three reasons** why ether is particularly useful for the extraction of organic compounds from aqueous solution over other organic solvents. [3x2 marks]

(ii) State one main drawback of ether as an organic solvent and state how this drawback may be overcome [2 marks]

7. (a) A mixture of alanine, aspartic acid and serine was analysed by thin layer chromatography (TLC), with SiO_2 as a stationary phase. The TLC mobile phase was 95% ethanol and 5% H_2O.

Alanine	$H_2NCH(CH_3)CO_2H$
Aspartic acid	$H_2NCH(CH_2CO_2H)CO_2H$
Serine	$H_2NCH(CH_2OH)CO_2H$

(i) Deduce with reasons the amino acid with

1. the highest R_f value [3 marks]
2. the lowest R_f value [3 marks]

(ii) The stationary phase, adsorbed SiO_2, was mixed with silver ions, Ag^+.

State and explain how the magnitudes of the Rf values were affected by the Ag^+ ions. [4 marks]

(b) Draw a labeled TLC chromatogram that can be used to show that all the three amino acids were present in the analysed mixture. [4 marks]

(c) State **two** other applications of TLC. [2x2 marks]

(f) Give **two** advantages of TLC over paper chromatography? [2 marks]

END OF QUESTION PAPER