

MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

Analytical Chemistry Level 6

ASC/OS/ACHEM/CC/07/6/A

End of Semester Exam

Apply Statistical Methods

March/ April 2024

WRITTEN ASSESSMENT

Time: 3 hours

INSTRUCTIONS TO CANDIDATE:

This paper contains two sections A and B

Attempt questions in each section as per the instructions given in the section

You are provided with a separate answer booklet

Marks for each question are indicated in the brackets

Do not write on this question paper

Answer the questions in English

This paper consists of printed pages.

Candidate should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

SECTION A (40 MARKS)

Answer all the questions from this section

1) Distinguish between each of the following terms as used in statistics;

- i. Descriptive and inferential statistics (2 Marks)
- ii. One-way and two-way ANOVA (2 marks)
- iii. Parametric and non-parametric test (2 marks)

2) It is expected that 12% of vaccines from a continuous production line will be defective.

Find the probability that in a sample of 100 vaccines chosen at random:

- i. Exactly one will be defective (2 marks)
- ii. At least two will be defective (2 marks)

3) Given the following data set representing the concentrations of a compound (in ppm) measured in different samples: 5.2, 4.8, 5.0, 5.3, 5.1, 4.9, 5.2 Calculate the mean, median, mode, and standard deviation of the data set. (7 marks)

4) Explain what a Type II error is in hypothesis testing and discuss its implications in analytical chemistry. (3 marks)

5) . Explain the concept of control charts in analytical chemistry and how they can be used to monitor the performance of an analytical method. (3 marks)

6) Describe the purpose and use of a calibration curve in analytical chemistry. (2 marks)

7) . Explain the difference between independent and dependent events. Provide an example of each relevant to analytical chemistry. (2 marks)

8) State 3 properties of a normal distribution (3 marks)

9) A laboratory measures the concentration of a target analyte in a water sample ten times and obtains the following results (in mg/L):

3.1, 3.2, 3.0, 3.3, 3.1, 3.2, 3.0, 3.3, 3.1, 3.2

Calculate the mean, standard deviation, and the 95% confidence interval for the mean concentration of the analyte. (8 marks)

10) What is the difference between precision and accuracy in analytical chemistry (2 marks)

SECTION B (60 MARKS)

Answer any three questions in this section

11. a) . A pharmaceutical company is testing the effectiveness of a new drug for treating a specific disease. The company conducted a clinical trial with two groups: a treatment group ($n = 30$) and a control group ($n = 30$). The treatment group received the new drug, while the control group received a placebo. The average recovery rate for the treatment group was 85% with a standard deviation of 5%, while the control group had an average recovery rate of 80% with a standard deviation of 4%. Perform a hypothesis test to determine if there is a significant difference in recovery rates between the treatment and control groups at a significance level of 0.05. (12 marks)

b) Explain the Central Limit Theorem and its significance in analytical chemistry. (3 marks)

c) A quality control process for a chemical product involves testing a random sample of 20 units. If the probability of a defective unit is 0.05, what is the probability that exactly 2 units are defective in the sample? (3 marks)

d) Highlight the two methods for data collection used when carrying out biological research (2 marks)

12. a) Differentiate between discrete and continuous probability distributions in the context of analytical chemistry. (2 marks)

b) A manufacturer produces bottles of a liquid product with a mean volume of 500 ml and a standard deviation of 10 ml. Assuming a normal distribution, what is the probability that a randomly selected bottle contains between 490 ml and 510 ml of liquid (4 marks)

c) Discuss the Poisson distribution and its application in analytical chemistry. Provide an example of a situation in analytical chemistry where the Poisson distribution is applicable. (3 marks)

d) A laboratory receives an average of 10 samples per hour for analysis. Calculate the probability that the laboratory receives exactly 15 samples in a given hour, assuming the number of samples follows a Poisson distribution. (3 marks)

e) Briefly explain the three principles of experimental design giving examples of how they can be applied in biological research. (6 Marks)

e) In a chromatography experiment, the elution time of a compound follows an exponential distribution with a mean of 8 minutes. What is the probability that the compound elutes within the first 5 minutes (4 marks)

13. a) Define probability and explain its significance in analytical chemistry. (3 marks)

b) Discuss the difference between classical, empirical, and subjective probability. (6 marks)

c) If you have a fair six-sided die, what is the probability of rolling a number less than 3 (3 marks)

d) Explain how probability distributions are used in analytical chemistry to model experimental outcomes. (6 marks)

e) State and explain two sampling techniques that can be used in analytical chemistry. (2 marks)

14. a) A chemist is analyzing the concentration of a particular compound in water samples. From a random sample of 20 water samples, the mean concentration was found to be 35 ppm with a standard deviation of 5 ppm. Calculate a 95% confidence interval for the true mean concentration of the compound in the water. (4 marks)

b) A pharmaceutical company is analyzing the dissolution rates of two different formulations of a drug. The dissolution rates (in mg/min) for 10 tablets of each formulation are as follows:

Formulation A: 12.5, 11.8, 12.0, 12.2, 12.1, 11.9, 12.3, 12.4, 12.6, 12.0

Formulation B: 11.2, 11.5, 11.6, 11.3, 11.4, 11.7, 11.9, 11.8, 11.6, 11.4

Perform a t-test to determine if there is a significant difference between the mean dissolution rates of the two formulations. Use a significance level of 0.05. (10 marks)

c) Describe the steps involved in hypothesis testing and its application in analytical chemistry. (6 marks)