NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED CHEMISTRY

ENVIRONMENTAL ANALYSIS AND GREEN CHEMISTRY
SCH 6122

FIRST SEMESTER EXAMINATION QUESTION PAPER

2024

This examination paper consists of 3 pages

Time Allowed:	3 hours
Total Marks:	100
Special Requirements:	Periodic Table
Internal Examiner:	Dr. E. Dube
External Examiner:	Prof. G. Mehlana

INSTRUCTIONS

1. Answer all questions from Section A and **ANY THREE** questions from Section B.

2. Section A carries **40 marks** and each question in Section B carries **20 marks**.

3. Use of calculators is permissible

Mark Allocation

Questions	Marks
1	40
2	20
3	20
4	20
5	20
Total Possible Marks	**100**

Section A

Question 1.

Read the following abstract from Masere P. and Sibanda M.'s study titled "Effects of Illegal Artisanal Gold Mining on Water Quality and Vegetation Cover within Muzvezve River Catchment, Zimbabwe" (2024, 7(1), 11–26), and answer the questions below:

Illegal artisanal gold mining activities are a growing industry and have been identified as a significant contributor to a range of environmental disturbances in many developing countries. This paper sought to investigate the effects of illegal gold mining activities on Muzvezve River water quality and vegetation cover within the catchment. The study employed two methods to collect data: water quality sampling and determination and the normalised difference vegetation index (NDVI). The NDVI was used to assess the extent and severity of the vegetation cover changes in the illegal artisanal gold mining hotspots in the last decade (2013-2023). Water samples were taken on three sampling sites/river sections (upstream, middle and downstream) of Muzvezve River for three months and analysed for nine physico-chemical parameters (pH, EC, Fe, Hg, sulphate, cyanide, total dissolved solids, total hardness and turbidity. The data collected were analyzed using R software. The findings suggest that illegal gold mining had significant negative impacts on the quality of water in Muzvezve River. Turbidity, pH and heavy metals (Hg, Fe and cyanide) concentrations were found to be significant at various p levels. Four of the nine physico-chemical parameters (pH, Fe, Hg and turbidity) were found to be above the WHO maximum allowable levels. There was a strong positive correlation among the tested water quality parameters. NDVI values of 0.27 and 0.68 for sparse vegetation and dense vegetation were recorded in the illegal artisanal gold mining hotspots in 2013 and generally vegetation cover decreased by 20% and 8% in 2017 and 2023 respectively.

a) Describe the sampling method applied in this study. [**2 marks**]

b) Discuss the potential environmental pathways and impacts of pollutants within the Muzvezve River. [**8 marks**]

c) Given that pH, Fe, Hg, and turbidity levels exceed WHO allowable limits, what additional research could provide a more comprehensive understanding of contamination in this area? [**6 marks**]

d) Explain the significance and applicability of the data generated in this study. [**5 marks**]

e) How might artisanal gold mining activities influence the chemical characteristics of soil and groundwater in the surrounding area? Propose a research approach to investigate these effects.

[**4+5 marks**]

f) Artisanal gold mining can degrade air quality. Explain how air quality can be degraded. [**3 marks**]

g) Propose strategies to aid in reducing the environmental impacts of illegal gold mining in the Muzvezve River catchment. [**5 marks**]

Section B

Question 2

a) Identify and describe the key elements of Good Laboratory Practices (GLPs) in an analytical laboratory. **[10 marks]**

b) Explain the role of SOPs (Standard Operating Procedures) under GLP. **[4 marks]**

Some laboratories hold both ISO 17025 accreditation and GLP compliance to ensure the highest standards. Analyze the primary distinctions between ISO 17025 accreditation and GLP compliance. Consider their scope, focus, and typical applications in analytical laboratories.

[2 x 3 marks]

Question 3.

Adsorption is one of the promising technologies for pollution control.

a) Describe the mechanism by which adsorption reduces the concentration of pollutants in the environment. **[4 marks]**

b) Explain four factors that influence the adsorption of contaminants onto surfaces. Provide examples to illustrate each factor. **[8 marks]**

c) How do natural adsorption processes influence the transport and fate of pollutants in the environment? **[4 marks]**

d) Using your knowledge of green chemistry, describe how you could manage adsorbed contaminants to prevent further environmental pollution. **[4 marks]**

Question 4

a) Explain the key steps involved in a chemical analysis of water quality.

[2 x 5 marks]

b) What quality control measures are implemented during analysis to ensure the accuracy and reliability of the data? **[5 marks]**

c) Using examples, explain the importance of biochemical markers in environmental monitoring. **[5 marks]**

Question 5

a) Describe the core principles of Green Chemistry and demonstrate how these principles contribute to reducing the environmental impact of chemical processes and products. **[10 marks]**

b) Green Chemistry can be applied across various industries to enhance sustainability, reduce environmental harm, and promote human health. Discuss how Green Chemistry can be implemented in the following sectors:

 i) Pharmaceutical Manufacturing
 ii) Agricultural Chemistry
 iii) Petrochemical Industry
 iv) Energy Production
 v) Waste Management **[2 x 5 marks]**

Question 6

Discuss the effects of the following air pollutants on plant health, animal welfare, and the broader environment;

    i)   Particulate Matter (PM10 and PM2.5),

    ii)   Nitrogen Dioxide,

    iii)   Sulphates, and

    iv)   Carbon Monoxide

In your answer, include specific mechanisms by which each pollutant interacts with these components of ecosystems and explain the potential short-term and long-term consequences for biodiversity, ecosystem stability, and climate.

[5 x 4 marks]

END OF EXAMINATION