NATIONAL UNIVERSITY OF LESOTHO
BSc Environmental Health

End of semester B examination

Course Title: Environmental Analysis

Course code: EHS 2307

MAY 2023 **Time: 3 HOURS**

TOTAL MARKS: 100

SECTION A [40 MARKS]

Question 1

Instruction(s): Answer all Questions in this question by writing the letter of the correct answer next to the corresponding question.

Multiple choice questions (24 marks)

I. You have looked up the hazards of the chemicals you will be using in a particular lab, and found out that they are mild health hazards, requiring you to avoid skin contact and vapor inhalation. Therefore, when in lab you should:

a) wear short shorts and sandals

b) wear long pants, closed toed shoes, and a lab apron

c) Wear a respiratory mask

d) b and c

II. If your clothing catches fire in the lab, what should you do?

a) drop to the floor and roll to extinguish the fire

b) use a fire blanket and roll on the floor

c) spray the fire with a fire extinguisher

d) a and b

III. If you spill an acid or a base on the bench, you should:

a) rinse with a neutralizing solution

b) ask your teacher what to do

c) immediately wash with soap and cool water and tell your teacher

d) do nothing unless you see some bubbles

IV. Broken glassware left around the lab is a hazard because:

a) if on the floor, someone might step on it and cut their foot

b) if on the lab bench, someone might lean on the bench and cut their arm

c.) if in the sink, someone might try to pick it up to throw it away properly and cut themselves

d) All of the above

V. What is the name of this piece of glassware?

a) separating funnel
b) volumetric flask
c) buchner flask
d) beaker

VI. Which pieces of equipment are used for obtaining solids for measuring mass?

a) spatula
b) tongs
c) insulated gloves
d) clamps

VII. Which pieces of equipment are used to obtain precise measurements of liquids?

a) pipettes
b) measuring cylinders

c) beakers

d) conical flasks

VIII. Which of the following items are used for stirring?

a) spatula and stirring rod

b) magnetic stirrer and thermometer

c) magnetic stirrer and stirring rod

d) all of the above

IX. The objective of the sampling is to collect a portion of material that represents the actual sample composition.

a) Maybe

b) True

c) False

d) Not sure

X. -------- of the sample must be measured on-site.

a) temperature

b) COD

c) BOD

d) TDS

XI. Concentrated sulfuric acid is used as preservative for analysis of --------.

a) BOD

b) COD

c) metals

d) Ordor

XII. A "holding time " is the elapsed amount of time from the point of sample collection to the amount of preparation or analysis. What is the holding time for BOD?

a) 6 hours

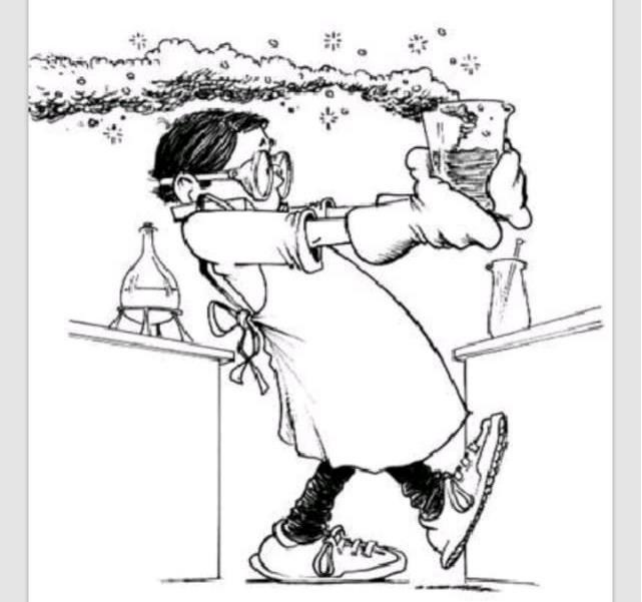
b) 28 days

c) 24 hours

d) 6 months

Question 2 (16 marks)

Lipolelo is a 4th year EHS research student. She is carrying out acid digestion in the lab. Acid digestion involves boiling a sample in hot nitric acid.



a) Identify four potential hazards in the picture above. (8 marks)
b) In which safety equipment was Lipolelo supposed to be doing this digestion? (1 mark)
c) What other PPE was Lipolelo supposed to be wearing on her face, other than the safety goggles? (1 mark)

Acid digestion is normally carried out before metal analysis.

d) What is the holding time for metal analysis? (1 mark)
e) If Liepollo was to test the sample for Cu^{2+} ions, explain how she is supposed to preserve her sample. (2 marks)
f) The following hazard symbol is found on nitric acid container. What does the symbol mean? (2 marks)

g) Define the term sample acid digestion. (1 mark)

SECTION B [30 MARKS]

Instruction(s): Answer all questions in this section

Question 1

I. Briefly discuss four common types of laboratory waste management. (8 marks)

II. Mention any four problems caused by laboratory waste disposal. (4 marks)

III. Mention any three waste disposal challenges at NUL. (3 marks)

Question 2

I. Differentiate between qualitative and quantitative analysis. (4 marks)

II. Briefly discuss the following types of qualitative analysis. (8 marks)

a) Change in colour
b) Flame test
c) Distillation
d) Precipitation

III. Mention any three sources of error during gravimetric analysis. (3 marks)

SECTION C [30 MARKS]

Instruction(s): Answer all questions in this section

Question 1

I. A perfume contains a solvent and a mixture of fragrances. A sample of the solvent used in one perfume contains 0.6 g of carbon, 0.15 g of hydrogen and 0.4 g of oxygen. Calculate the empirical formula of the compound used in the solvent. (4 marks)

II. Balance the following chemical equations (1 mark each)

a) ___ H_3PO_4 + ___ KOH → ___ K_3PO4 + ___ H_2O

b) ___ K + ___ B_2O_3 → ___ K_2O + ___ B

c) ___ HCl + ___ NaOH → ___ NaCl + ___ H_2O

d) ___ Na + ___ $NaNO_3$ → ___ Na_2O + ___ N_2

e) ___ C + ___ S_8 → ___ CS_2

f) ___ $CH_3CH_2CH_2CH_3$ + ___ O_2 → ___ CO_2 + ___ H_2O

Question 2

Use the information provided below to answer the questions that follow.

• A 25 cm^3 sample of hydrochloric acid is sucked into a pipette and transferred into a 250 cm^3 volumetric flask. The solution is made up to the mark.

• 25 cm^3 of the diluted acid is transferred into a conical flask using a pipette.

• A burette is used to neutralise the acid with 0.1 mol dm^{-3} sodium hydroxide.

Hydrochloric acid reacts with sodium hydroxide according to the equation:

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

a) The average titre of the sodium hydroxide solution was 30.00 cm^3

Calculate the number of moles in the average titre. (2 marks)

b) Determine the number of moles in the diluted sample of hydrochloric acid, and hence the concentration of the diluted acid. (4 marks)

c) Calculate the concentration of the undiluted hydrochloric acid in $moldm^{-3}$ (2 marks)

d) Calculate the concentration of the hydrochloric acid in g dm^{-3}

Question 3

A 2.00 g sample of limestone ($CaCO_3$) was dissolved in hydrochloric acid (HCl) and all the calcium present in the sample was converted to $Ca^{2+}{}_{(aq).}$ Excess ammonium oxalate solution, $(NH_4)C_2O_4(aq)$ was then added to the solution to precipitate the calcium ions as calcium oxalate, $CaC_2O_4(s)$. The precipitate was filtered, tried, and weighed to a constant mass of 2.43g. Determine the percentage by mass of calcium in the limestone sample. (10 marks)

TABLE 1060:I. SUMMARY OF SPECIAL SAMPLING AND HANDLING REQUIREMENTS*

Determination	Container†	Minimum Sample Size *mL*	Sample Type‡	Preservation§	Maximum Storage Recommended	Regulatory‖
Acidity	P, G(B), FP	100	g	Cool, ≤6°C	24 h	14 d
Alkalinity	P, G, FP	200	g	Cool, ≤6°C	24 h	14 d
BOD	P, G, FP	1000	g, c	Cool, ≤6°C	6 h	48 h
Boron	F, P (PTFE) or quartz	1000	g, c	HNO_3 to pH<2	28 d	6 months
Bromide	P, G, FP	100	g, c	None required	28 d	28 d
Carbon, organic, total	G(B), P, FP	100	g, c	Analyze immediately, or cool ≤6°C and add HCl, H_3PO_4, or H_2SO_4 to pH	7 d	28 d
Carbon dioxide	P, G	100	g	Analyze immediately	0.25 h	N.S.
COD	P, G, FP	100	g, c	Analyze as soon as possible, or add H_2SO_4 to pH<2; Cool, ≤6°C	7 d	28 d
Chloride	P, G, FP	50	g, c	None required	N.S.	28 d
Chlorine, total, residual	P, G	500	g	Analyze immediately	0.25 h	0.25 h
Chlorine dioxide	P, G	500	g	Analyze immediately	0.25 h	N.S.
Chlorophyll	P, G	500	g	Unfiltered, dark, ≤6°C Filtered, dark, –20°C (Do not store in frost-free freezer)	24–48 h 28 d	N.S.
Color	P, G, FP	500	g, c	Cool, ≤6°C	24 h	48 h
Specific conductance	P, G, FP	500	g, c	Cool, ≤6°C	28 d	28 d
Cyanide						
Total	P, G, FP	1000	g, c	Analyze within 15 min. Add NaOH to pH>12 if sample is to be stored, Cool, ≤6°C, in dark. Add thiosulfate if residual chlorine present	24 h	14 d; 24 h if sulfide present
Amenable to chlorination	P, G, FP	1000	g, c	Remove residual chlorine with thiosulfate and cool ≤6°C	stat	14 d; 24 h if sulfide present
Fluoride	P	100	g, c	None required	28 d	28 d
Hardness	P, G, FP	100	g, c	Add HNO_3 or H_2SO_4 to pH<2	6 months	6 months
Iodine	P, G	500	g	Analyze immediately	0.25 h	N.S.
Metals	P(A), G(A), FP (A)	1000	g, c	For dissolved metals filter immediately, add HNO_3 to pH<2	6 months	6 months
Chromium VI	P(A), G(A), FP (A)	250	g	Cool, ≤6°C, pH 9.3–9.7, ammonium sulfate buffer preservative as specified in method 3500-Cr to extend to 28 d HT	28 d	28 d
Copper by colorimetry	—*	—	g, c	—	—	
Mercury	P(A), G(A), FP(A)	500	g, c	Add HNO_3 to pH<2, Cool ≤6°C	28 d	28 d
Nitrogen						
Ammonia	P, G, FP	500	g, c	Analyze as soon as possible or add H_2SO_4 to pH<2, Cool, ≤6°C	7 d	28 d
Nitrate	P, G, FP	100	g, c	Analyze as soon as possible; Cool, ≤6°C	48 h	48 h (14 d for chlorinated samples)
Nitrate + nitrite	P, G, FP	200	g, c	Add H_2SO_4 to pH<2, Cool, ≤6°C	1–2 d	28 d
Nitrite	P, G, FP	100	g, c	Analyze as soon as possible; Cool, ≤6°C	none	48 h
Organic, Kjeldahl	P, G, FP	500	g, c	Cool, ≤6°C, add H_2SO_4 to pH<2	7 d	28 d
Odor	G	500	g	Analyze as soon as possible; Cool ≤6°C	6 h	24 h (EPA Manual drinking water)
Oil and grease	G, wide-mouth calibrated	1000	g	Add HCl or H_2SO_4 to pH<2, Cool, ≤6°C	28 d	28 d

https://doi.org/10.2105/SMWW.2882.009

TABLE 1060:I. CONT.

Determination	Container†	Minimum Sample Size *mL*	Sample Type‡	Preservation§	Maximum Storage Recommended	Regulatory‖
Organic Compounds						
MBAS	P, G, FP	250	g, c	Cool, ≤6°C	48 h	48 h as per CFR 136
Pesticides*	G(S), PTFE-lined cap	1000	g, c	Cool, ≤6°C, add 1000 mg ascorbic acid/L if residual chlorine present (0.008% sodium thiosulfate in CFR 136)	7 d	7 d until extraction; 40 d after extraction
Phenols	P, G, PTFE-lined cap	500	g, c	Cool, ≤6°C, add H_2SO_4 to pH<2	*	28 d until extraction, 2 d after extraction
Purgeables* by purge and trap	G, PTFE-lined cap	2×40	g	Cool, ≤6°C; add HCl to pH<2; add 1000 mg ascorbic acid/L if residual chlorine present (0.008% sodium thiosulfate in CFR 136)	7 d	14 d
Base/neutrals & acids	G(S) amber	1000	g, c	Cool, ≤6°C, 0.008% sodium thiosulfate in CFR 136 if chlorine is present	7 d	7 d until extraction; 40 d after extraction
Oxygen, dissolved	G, BOD bottle	300	g			
Electrode				Analyze immediately	0.25 h	0.25 h
Winkler				Titration may be delayed after acidification	8 h	8 h
Ozone	G	1000	g	Analyze immediately	0.25 h	N.S.
pH	P, G	50	g	Analyze immediately	0.25 h	0.25 h
Phosphate	G(A)	100	g	For dissolved phosphate filter immediately; Cool, ≤6°C	48 h	48 h as per EPA manual for DW
Phosphorus, total	P, G, FP	100	g, c	Add H_2SO_4 to pH<2 and cool, ≤6°C	28 d	28 d
Salinity	G, wax seal	240	g	Analyze immediately or use wax seal	6 months	N.S.
Silica	F, P (PTFE) or quartz	200	g, c	Cool, ≤6°C, do not freeze	28 d	28 d
Sludge digester gas	G, gas bottle	—	g	—	N.S.	
Solids[9]	P, G	200	g, c	Cool, ≤6°C	7 d	2–7 d; see cited reference
Sulfate	P, G, FP	100	g, c	Cool, ≤6°C	28 d	28 d
Sulfide	P, G, FP	100	g, c	Cool, ≤6°C; add 4 drops 2*N* zinc acetate/100 mL; add NaOH to pH >9	28 d	7 d
Temperature	P, G, FP	—	g	Analyze immediately	0.25 h	0.25 h
Turbidity	P, G, FP	100	g, c	Analyze same day; store in dark up to 24 h, Cool, ≤6°C	24 h	48 h

* For determinations not listed, use glass or plastic containers; preferably refrigerate during storage and analyze as soon as possible.
† P = plastic (polyethylene or equivalent); G = glass; G(A) or P(A) = rinsed with 1 + 1 HNO_3; G(B) = glass, borosilicate; G(S) = glass, rinsed with organic solvents or baked; FP = fluoropolymer [polytetrafluoroethylene (PTFE, Teflon) or other fluoropolymer].
‡ g = grab; c = composite.
§ Cool = storage at, >0°C, ≤6°C (above freezing point of water); in the dark; analyze immediately = analyze usually within 15 min of sample collection.
‖ See citation[10] for possible differences regarding container and preservation requirements. N.S. = not stated in cited reference; stat = no storage allowed; analyze immediately (within 15 min).
Some drinking water (DW) and treated wastewater (WW) matrices may be subject to positive interference as a result of preservation. If such interference is demonstrable, samples should be analyzed as soon as possible without preservation. Do not hold for more than 15 min without demonstrating that cyanide (CN) is stable for longer periods in a specific matrix.
NOTE: This table is intended for guidance only. If there is a discrepancy between this table and the method, the information in the current method takes precedence. If performing the method for compliance purposes, be aware that alternative preservation and holding-time requirements may exist. If so, the regulatory requirements should be used.