



UNIVERSITY OF SWAZILAND
Faculty of Health Sciences
Department of Environmental Health Science

DEGREE IN ENVIRONMENTAL HEALTH SCIENCES
MAIN EXAMINATION PAPER 2019

TITLE OF PAPER : INSTRUMENTAL METHODS FOR ENVIRONMENTAL ANALYSIS I

COURSE CODE : EHS 209

DURATION : 2 HOURS

MARKS : 100

INSTRUCTIONS :

- : READ THE QUESTIONS & INSTRUCTIONS CAREFULLY
- : ANSWER ANY FOUR QUESTIONS
- : EACH QUESTION CARRIES 25 MARKS.
- : WRITE NEATLY & CLEARLY
- : NO PAPER SHOULD BE BROUGHT INTO OR OUT OF THE EXAMINATION ROOM.
- : BEGIN EACH QUESTION ON A SEPARATE SHEET OF PAPER.

DO NOT OPEN THIS QUESTION PAPER UNTIL PERMISSION IS GRANTED BY THE INVIGILATOR.

QUESTION ONE

- a. Draw and label a schematic diagram of gas chromatography instrument.
[10 Marks]
- b. What are the properties of an ideal stationary phase of a GC column
[9 Marks]
- c. Discuss the key assumptions necessary for the use of standards addition calibration method.
[6 Marks]
- Total 25 marks**

QUESTION TWO

- a. Using an example, explain why is sample preparation essential for environmental analysis?
[5 Marks]
- b. Identify whether the following statements are true or false. For each answer, give reasons why
- (i) Microwave acid digestion is fast but results in a complex sample matrix.
 - (ii) In TLC, interactions between components and mobile phase depends polarities.
 - (iii) The efficiency of solvent extraction (liquid-liquid) of weak organic acids from aqueous phase depends on K_D .
 - (iv) Oven temperature does not affect the resolution of peaks in GC analysis.
 - (v) The student T-test compares means of different methods.
- [4×5 Marks]

Total 25 marks

QUESTION THREE

- a. Two TLC plates mounted with the same sample was developed using two different solvents. On TLC plate A, the no separation was seen from the origin (all components were on the origin) while on TLC plate B, all components were separated. Give reasons why;

- (i) There is no separation in TLC plate A.
- (ii) The solvent used to develop TLC plate A is assumed to be non-polar.
- (iii) The solvent used to develop TLC plate B has ideal elution strength

[3 × 4 Marks]

- a. The distribution constant of analyte X between n-Hexane and water is 8.9. Calculate the concentration of X remaining in the aqueous phase after 50.0 mL of 0.200 M X is treated by extraction with three 20 mL portions of n-Hexane.

[8 Marks]

- b. Why is SPE also regarded as a method of concentrating a sample? [5 Marks]

Total 25 marks

QUESTION FOUR

- a. State sequentially, the steps that should be followed in solving a given analytical problem (i.e. in the analysis of a given sample). [10 Marks]
- b. Give reasons why calibration is an important part of all instrumental analysis procedures. [7 Marks]
- c. Name one method of calibration and outline the procedure for your chosen calibration method. [8 Marks]

Total: 25 marks

QUESTION FIVE

- a. Discuss the differences between SPE and SPME. [10 Marks]
- b. Are multiple batch extractions a solution for the disadvantages liquid-liquid extraction? Give reasons why. [5 Marks]
- c. In a chromatographic analysis of a mixture of chlorinated pesticides, in which a 2.0 m long column was used, three peaks were obtained. The peaks had the following characteristics;

Peak A: $t_r = 2.01$ min, $W_b = 0.094$ min

Peak B: $t_r = 5.94$ min, $W_b = 0.782$ min

Peak C: $t_r = 8.68$ min, $W_b = 0.36$ min

- (i) Calculate the resolution between these peaks. [6 Marks]
- (ii) Use Peak B to calculate plate height, H and number of theoretical plates, N .

[4 Marks]

Total 25 marks

PERIODIC TABLE OF ELEMENTS

GROUPS

PERIODS	GROUPS																	
	I	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII B	IX	X	IB	II B	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	H 1.008																	
2	Li 6.941	Be 9.012											B 10.811	C 12.011	N 14.007	O 15.999	F 18.998	Ne 20.180
3	Na 22.990	Mg 24.305											Al 26.982	Si 28.086	P 30.974	S 32.06	Cl 35.453	Ar 39.948
4	K 39.098	Ca 40.078	Sc 44.956	Ti 47.88	V 50.942	Cr 51.996	Mn 54.938	Fe 55.847	Co 58.933	Ni 58.69	Cu 63.546	Zn 65.39	Ga 69.723	Ge 72.61	As 74.922	Se 78.96	Br 79.904	Kr 83.80
5	Rb 85.468	Sr 87.62	Y 88.906	Zr 91.224	Nb 92.906	Mo 95.94	Tc 98.907	Ru 101.07	Rh 102.91	Pd 106.42	Ag 107.87	Cd 112.41	In 114.82	Sn 118.71	Sb 121.75	Te 127.60	I 126.90	Xe 131.29
6	Cs 132.91	Ba 137.33	*La 138.91	Hf 178.49	Ta 180.95	W 183.85	Re 186.21	Os 190.2	Ir 192.22	Pt 195.08	Au 196.97	Hg 200.59	Tl 204.38	Pb 207.2	Bi 208.98	Po (209)	At (210)	Rn (222)
7	Fr 223	Ra 226.03	**Ac 227	Rf (261)	Ha (262)	Unh (263)	Uns (262)	Uno (265)	Une (266)	Uun (267)								

TRANSITION ELEMENTS

Atomic mass →
Symbol →
Atomic No. →

140.12	140.91	144.24	(145)	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04	174.97
Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
232.04	231.04	238.03	237.05	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(260)
Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103

* Lanthanide Series

** Actinide Series

() indicates the mass number of the isotope with the longest half-life.

General data and fundamental constants

Quantity	Symbol	Value
Speed of light	c	$2.997\,924\,58 \times 10^8 \text{ m s}^{-1}$
Elementary charge	e	$1.602\,177 \times 10^{-19} \text{ C}$
Faraday constant	$F = N_A e$	$9.6485 \times 10^4 \text{ C mol}^{-1}$
Boltzmann constant	k	$1.380\,66 \times 10^{-23} \text{ J K}^{-1}$
Gas constant	$R = N_A k$	$8.314\,51 \text{ J K}^{-1} \text{ mol}^{-1}$ $8.205\,78 \times 10^{-2} \text{ dm}^3 \text{ atm K}^{-1} \text{ mol}^{-1}$ $6.2364 \times 10 \text{ L Torr K}^{-1} \text{ mol}^{-1}$
Planck constant	h $\hbar = h/2\pi$	$6.626\,08 \times 10^{-34} \text{ J s}$ $1.054\,57 \times 10^{-34} \text{ J s}$
Avogadro constant	N_A	$6.022\,14 \times 10^{23} \text{ mol}^{-1}$
Atomic mass unit	u	$1.660\,54 \times 10^{-27} \text{ Kg}$
Mass		
electron	m_e	$9.109\,39 \times 10^{-31} \text{ Kg}$
proton	m_p	$1.672\,62 \times 10^{-27} \text{ Kg}$
neutron	m_n	$1.674\,93 \times 10^{-27} \text{ Kg}$
Vacuum permittivity	$\epsilon_0 = 1/c^2 \mu_0$ $4\pi \epsilon_0$	$8.854\,19 \times 10^{-12} \text{ J}^{-1} \text{ C}^2 \text{ m}^{-1}$ $1.112\,65 \times 10^{-10} \text{ J}^{-1} \text{ C}^2 \text{ m}^{-1}$
Vacuum permeability	μ_0	$4\pi \times 10^{-7} \text{ J s}^2 \text{ C}^{-2} \text{ m}^{-1}$ $4\pi \times 10^{-7} \text{ T}^2 \text{ J}^{-1} \text{ m}^3$
Magneton		
Bohr	$\mu_B = e\hbar/2m_e$	$9.274\,02 \times 10^{-24} \text{ J T}^{-1}$
nuclear	$\mu_N = e\hbar/2m_p$	$5.050\,79 \times 10^{-27} \text{ J T}^{-1}$
g value	g_e	2.002 32
Bohr radius	$a_0 = 4\pi\epsilon_0\hbar^2/m_e e^2$	$5.291\,77 \times 10^{-11} \text{ m}$
Fine-structure constant	$\alpha = \mu_0 e^2 c/2\hbar$	$7.297\,35 \times 10^{-3}$
Rydberg constant	$R_\infty = m_e e^4/8\hbar^2 c \epsilon_0^2$	$1.097\,37 \times 10^7 \text{ m}^{-1}$
Standard acceleration of free fall	g	$9.806\,65 \text{ m s}^{-2}$
Gravitational constant	G	$6.672\,59 \times 10^{-11} \text{ N m}^2 \text{ Kg}^{-2}$

Conversion factors

1 cal	=	4.184 joules (J)	1 erg	=	$1 \times 10^{-7} \text{ J}$
1 eV	=	$1.602\,2 \times 10^{-19} \text{ J}$	1 eV/molecule	=	$96\,485 \text{ kJ mol}^{-1}$

Prefixes	f	p	n	μ	m	c	d	k	M	G
	femto	pico	nano	micro	milli	centi	deci	kilo	mega	giga
	10^{-15}	10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^{-1}	10^3	10^6	10^9