



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

DEGREE IN ENVIRONMENTAL HEALTH SCIENCES
RE-SIT 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. In a given TLC plate, what conclusion can be drawn for a component that has an RF value of;
- (i) 0.11
 - (ii) 0.98
- [6 Marks]**
- b. Using equations discuss solvent extraction and include its disadvantages in the extraction of analytes from aqueous to organic phase. **[8 Marks]**
- c. Are multiple batch extractions a solution for the disadvantages you have given in your answer for question b.? **[4 Marks]**
- d. In a chromatographic analysis of a mixture of chlorinated pesticides, in which a 2.0 m long column was used, a peak with retention time t_r , of 8.68 min and a baseline width of 0.36 min, was identified as dieldrin.
- (i) Calculate N and H for this column **[4 Marks]**
 - (ii) Suggest a suitable detector for the analysis. **[3 Marks]**

Total 25 marks

QUESTION TWO

- a. What is 'column efficiency' in gas chromatography? How is its value influenced by 'loading' of the column, N (number of theoretical plates) and H (height of plate)? What other factors influence it? **[8 Marks]**
- b. State the advantages and disadvantages of open tubular columns over packed columns used for GC analysis. Briefly account for the difference **[5 Marks]**
- c. Give two structural differences between them, (columns in b.) **[5 Marks]**
- d. In a chromatographic analysis of a mixture of chlorinated pesticides, in which a 2.0 m long column was used, a peak with retention time t_r , of 8.68 min and a baseline width of 0.36 min, was identified as dieldrin.
- (i) Calculate N and H for this column **[4 Marks]**

- (ii) Determine the capacity factor for dieldrin if the dead time, t_m , for the column is 0.30 Min. [3 Marks]

Total 25 marks

QUESTION THREE

- 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 FOUR

- a. Give three advantages of thin layer chromatography over paper chromatography. [3 Marks]
- b. For TLC;
- (i) Give two examples each of stationary phase and mobile phase [4 Marks]
- (ii) What stationary phase would be used for a polar compound and a weakly polar compound? [2 Marks]
- c. Briefly describe the procedure for chromatogram development and detection of analyte spots in TLC. [7 Marks]
- d. Define R_f value for TLC [1 Marks]
- e. Using a diagram, illustrate how the R_f value is measured. [4 Marks]
- f. Give four factors that influence the R_f value of a compound [4 Marks]

Total 25 marks

QUESTION FIVE

- 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.

[12 Marks]

- b. c. What are the following terms used to describe in data evaluation;

- (i) Absolute error
- (ii) Relative standard deviation
- (iii) Coefficient of variation

[3 × 2 Marks]

- c. For TLC;

- (i) Give two examples each of stationary phase and mobile phase [4 Marks]
- (ii) What stationary phase would be used for a polar compound and a weakly polar compound?

[3 Marks]

Total 25 marks

PERIODIC TABLE OF ELEMENTS

GROUPS

PERIODS	GROUPS																	
	1	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		IB	II B	IIIA	IVA	VA	VIA	VIIA	VIIIA	
1	1.008 H 1																	4.003 He 2
2	6.941 Li 3	9.012 Be 4										10.811 B 5	12.011 C 6	14.007 N 7	15.999 O 8	18.998 F 9	20.180 Ne 10	
3	22.990 Na 11	24.305 Mg 12										26.982 Al 13	28.086 Si 14	30.974 P 15	32.06 S 16	35.453 Cl 17	39.948 Ar 18	
4	39.098 K 19	40.078 Ca 20	44.956 Sc 21	47.88 Ti 22	50.942 V 23	51.996 Cr 24	54.938 Mn 25	55.847 Fe 26	58.933 Co 27	58.69 Ni 28	63.546 Cu 29	65.39 Zn 30	69.723 Ga 31	72.61 Ge 32	74.922 As 33	78.96 Se 34	79.904 Br 35	83.80 Kr 36
5	85.468 Rb 37	87.62 Sr 38	88.906 Y 39	91.224 Zr 40	92.906 Nb 41	95.94 Mo 42	98.907 Tc 43	101.07 Ru 44	102.91 Rh 45	106.42 Pd 46	107.87 Ag 47	112.41 Cd 48	114.82 In 49	118.71 Sn 50	121.75 Sb 51	127.60 Te 52	126.90 I 53	131.29 Xe 54
6	132.91 Cs 55	137.33 Ba 56	138.91 *La 57	178.49 Hf 72	180.95 Ta 73	187.85 W 74	186.21 Re 75	190.2 Os 76	192.22 Ir 77	195.08 Pt 78	196.97 Au 79	200.59 Hg 80	204.38 Tl 81	207.2 Pb 82	208.98 Bi 83	(209) Po 84	(210) At 85	(222) Rn 86
7	Fr 87	Ra 88	(227) **Ac 89	(261) Rf 104	(262) Ha 105	(263) Unh 106	(262) Uns 107	(265) Uno 108	(266) Une 109	(267) Uun 110								

Atomic mass →
Symbol →
Atomic No. →

TRANSITION ELEMENTS

140.12 Ce 58	140.91 Pr 59	144.24 Nd 60	(145) Pm 61	150.36 Sm 62	151.96 Eu 63	157.25 Gd 64	158.93 Tb 65	162.50 Dy 66	164.93 Ho 67	167.26 Er 68	168.93 Tm 69	173.04 Yb 70	174.97 Lu 71
232.04 Th 90	231.04 Pa 91	238.03 U 92	237.05 Np 93	(244) Pu 94	(243) Am 95	(247) Cm 96	(247) Bk 97	(251) Cf 98	(252) Es 99	(257) Fm 100	(258) Md 101	(259) No 102	(260) 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	$4\pi \times 10^{-7} \text{ J s}^2 \text{ C}^{-2} \text{ m}^{-1}$ $4\pi \times 10^{-7} \text{ T}^2 \text{ J}^{-1} \text{ m}^2$
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	$R_\infty = m_e e^4 / 8\hbar^3 c e_0^2$	$1.097\ 37 \times 10^7 \text{ m}^{-1}$
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 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