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

BACHELOR OF SCIENCE IN ENVIRONMENTAL HEALTH
MAIN EXAMINATION PAPER 2019

TITLE OF PAPER	:	INSTRUMENTAL METHODS FOR ENVIRONMENTAL ANALYSIS II
COURSE CODE	:	EHS 224
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. Name three characteristics of inductively coupled plasma that make them suitable for atomic emission spectrophotometry. **[6Marks]**

b. Describe how a deuterium lamp can be used to provide a background correction for an atomic absorption spectrum. **[5Marks]**

c. At 580 nm, the λ_{max} of Fe $(SCN)^{2+}$ has a molar absorptivity of 7.00×10^3 Lcm^{-1} mol^{-1}. Calculate;

(i) The absorbance of a 4.47×10^{-5} M solution of the complex at 580 nm, in a 1.0 cm cell

(ii) The absorbance of the solution in (i) in a 2.5 cm cell

(iii) The %T of the solution in scenarios described in (i) and (ii).

[3 × 3 Marks]

d. Briefly describe the working principles of diffraction gratings as monochromators. **[5 Marks]**

QUESTION TWO

a. Why are lines from a hollow cathode lamp generally narrower than lines emitted by atoms in a flame? **[5 Marks]**

b. Differentiate between chemical and instrumental noise. **[6 Marks]**

c. The absorbencies of solutions containingK_2CrO_4 (in 0.05M KOH) were measured in a 1.0 cm cell at 375 nm. The following results were obtained;

Concentration of CrO_4^{-2} M	Absorbance (a.u) at 375 nm
0.0050	0.123
0.0100	0.247
0.0200	0.494
0.0300	0.742
0.0400	0.991

Calculate the average molar absorptivity of CrO_4^{-2} in $Lmol^{-1}cm^{-1}$.

[10 marks]

d. What is the consideration that should be made for a cell's material choice before it can be used for a particular region? **[4 Marks]**

QUESTION THREE

a. A solution containing 3.92 mg/100mL of A (M_w= 335 g/mol) has a % transmittance of 65.1% in a 1.5 cm at 425 nm. Calculate the molar absorptivity of A at this wavelength. **[7 Marks]**

b. A highly concentrated analyte can result in deviations from Beer's law. Give a reason(s) why this happens and suggest a corrective measure. **[4 Marks]**

c. Why do qualitative and quantitative analyses often require different monochromator slit widths **[6 Marks]**

d. Describe how to prepare a KBr pallet for IR spectroscopy. **[8 Marks]**

QUESTION FOUR

a. Clearly illustrate transitions associated with the following regions of the electromagnetic spectrum

(i) Infrared

(ii) UV/vis

[6Marks]

b. What is the function of the reference beam in a double beam AAS instrument? **[5 Marks]**

c. Why is the nebulization of liquid samples important in AAS? **[3 Marks]**

d. Draw and label hollow cathode lamp. **[6 Marks]**

e. Explain how flame temperature affects the sensitivity of a flame atomic absorption spectrophotometer. **[5 Marks]**

QUESTION FIVE

a. Describe an ideal detector for spectrophotometry. **[10 Marks]**

b. In a table similar to the one below, match the terms on column 1 with the suitable terms on column 2.

	Column 1	Column 2
(i)	ICP atomisation	Concentration uncertainty
(ii)	Flame	Uniform cross sectional temperature
(iii)	Diffraction grating	Inert chemical environment
(iv)	Plasma	Secondary combustion zone
(v)	Instrument noise	Reflective monochromator

[10 Marks]

c. What are the implications of having a signal to noise ratio of 10 for a given signal? **[5 Marks]**

General data and fundamental constants

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

Conversion factors

1 cal	=	4.184 joules (J)	1 erg	=	1×10^{-7} J
1 eV	=	$1.602\,2 \times 10^{-19}$ 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}

GROUPS

PERIODS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1.008 H 1																	4.003 He 2
2	6.941 Li 3	9.012 Be 4										Atomic mass → Symbol → Atomic No. →	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					TRANSITION ELEMENTS						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	183.85 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	223 Fr 87	226.03 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								

*Lanthanide Series	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
**Actinide Series	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

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