UNIVERSITY OF SWAZILAND
SUPPLEMENTARY EXAMINATION 2009/2010

TITLE OF PAPER	**:**	**Instrumental Methods For Environmental Analysis - 1**
COURSE CODE	**:**	**EHS 573**
TIME ALLOWED	**:**	**Two (2) HOURS**
INSTRUCTIONS	**:**	**Answer any <u>Four</u> (4) Questions. Each Question Carries 25 Marks**

A periodic table and other useful data have been provided with this paper.

DO NOT OPEN THIS QUESTION PAPER UNTIL PERMISSION TO DO SO HAS BEEN GRANTED BY THE CHIEF INVIGILATOR.

Question 1 (25 marks)

(a) Differentiate between sensitivity and detection limit of an analytical instrument. [2]

(b) What are the two limiting factors of sensitivity? Distinguish between the two types of sensitivities and state the advantages, if any of one over the other. [6]

(c) State the expressions for the **figures of merit for precision**. [3]

(d) Explain the term **'Applicable Concentration Range'** of an analytical method. Use a labeled diagram to illustrate it and define all the parameters that are involved. [6]

(e) The SwaziCan Industry has approached you to assist them in analyzing their factory effluent for the presence and levels of phenolic pollutants in their factory effluent. State sequentially, the steps you would take to solve/handle this problem. [5]

(f) Why is it highly essential to pretreat a sample prior to chemical analysis? [3]

Question 2 (25 marks)

(a) Define the following terms for an e.m radiation, and state their corresponding units:

(i) Wavelength. (ii) Frequency. [3]

(b) For a radiation beam, which of the following parameters is/are influenced by the refractive index or density of the medium, **'wavelength'** or **'frequency'**? Use a diagram to illustrate your answer. [3]

(c) State Beer's law. Give its mathematical expression and state the S.I units if all the terms in it. [5]

(d) Show graphically, the expected variation patterns of the concentration of an absorbing solution with the **absorbance (A), transmittance(T), and** $\mathbf{log_{10}T}$. [5]

(e)

(i) A solution has a %T of 26.3. Determine its absorbance.

(ii) An electromagnetic radiation radiation has a wavelength of 520nm. Calculate its **energy, frequency and wave number**. What is its energy when its frequency is reduced to half its original value? [9]

Question 3 (25 marks)

(a) Define a detector and state its general characteristics. [3]

(b) Identify the two general classes of instrumental detectors, distinguish between them and give an example of each of the classes stated. [4]

(c) As briefly as possible, discuss the type, the design, region of use and working principles of the following detectors

(i) Phototube
(ii) The photomultiplier tube.
(iii) The thermocouple, and give a major disadvantage of this. [18]

Question 4 (25 marks)

(a) Using the 'Spectronic 20' as a typical example of a single beam spectrophotometer;

(i) Draw and label the sketchy diagram of its optical train.
(ii) State the material used for its source of radiation, the wavelength dispersing medium, and the detector. [9]

(b) Attached is the unlabelled diagram of a double beam in time configuration spectrophotometer:

(i) Label the diagram
(ii) Give a brief description of its working principles.
(iii) What advantages does it have over a single beam spectrophotometer
(iv) State one advantage it has over a double beam in space type off the Spectrophotometer.

[12]

(c) Identify at least one difference in the setup or design of the following pairs of flame instruments:
(i) AES and AAS (ii) AAS and AFS (iii) AES and AFS [4]

Question 5 (25 marks)

(a) Explain the term 'source' with regards to atomic spectroscopic methods. Give two examples and state four of its idealized goals. [7]

(b) Discuss the major limitations of atomic spectroscopic methods. [2]

(c) For the flame atomic absorption spectrophotometry (FAAS) :

(i) What analyte property is measured and in what units ? [2]

(ii) Draw and label a schematic diagram of the 'atomic absorption spectrophotometer' [4]

(iii) Briefly describe its working properties. [8]

(iv) Give four examples of environmental pollutants it can be used to analyze. [2]

PERIODIC TABLE OF ELEMENTS

GROUPS

PERIODS	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1.008 H 1																	4.00 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	20.18 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	39.94 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	131.2 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								

TRANSITION ELEMENTS

Atomic mass → 10.811
Symbol → B
Atomic No. → 5

*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.

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	$F = eN_A$	9.6485×10^{4} C mol^{-1}
Boltzmann constant	k	$1.380\,66 \times 10^{-23}$ J K^{-1}
Gas constant	$R = kN_A$	$8.314\,51$ J K^{-1} mol^{-1}
		$8.205\,78 \times 10^{-2}$ dm^{3} atm K^{-1} mol^{-1}
		62.364 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 of 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 permeability†	μ_0	$4\pi \times 10^{-7}$ J s^{2} C^{-2} m^{-1}
		$4\pi \times 10^{-7}$ T^{2} J^{-1} m^{3}
Vacuum permittivity	$\varepsilon_0 = 1/c^2\mu_0$	$8.854\,19 \times 10^{-12}$ J^{-1} C^{2} m^{-1}
	$4\pi\varepsilon_0$	$1.112\,65 \times 10^{-10}$ J^{-1} C^{2} m^{-1}
Bohr magneton	$\mu_B = e\hbar/2m_e$	$9.274\,02 \times 10^{-24}$ J T^{-1}
Nuclear magneton	$\mu_N = e\hbar/2m_p$	$5.050\,79 \times 10^{-27}$ J T^{-1}
Electron g value	g_e	$2.002\,32$
Bohr radius	$a_0 = 4\pi\varepsilon_0\hbar^2/m_e e^2$	$5.291\,77 \times 10^{-11}$ m
Rydberg constant	$R_\infty = m_e e^4/8h^3 c\varepsilon_0^2$	$1.097\,37 \times 10^{5}$ cm^{-1}
Fine structure constant	$\alpha = \mu_0 e^2 c/2h$	$7.297\,35 \times 10^{-3}$
Gravitational constant	G	$6.672\,59 \times 10^{-11}$ N m^{2} kg^{-2}
Standard acceleration of free fall†	g	$9.806\,65$ m s^{-2}

† Exact (defined) values

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}