UNIVERSITY OF SWAZILAND
FIRST SEMESTER EXAMINATION, 2014/2015

TITLE OF PAPER	**:**	**Instrumental Methods For Environmental Analysis - 1**
COURSE NUMBEER	**:**	**EHS 573**
TIME ALLOWED	**:**	**Two(2) Hours**
INSTRUCTIONS	**:**	**Answer any four (4) questions. Each Question carries 25 marks.**

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

You are not supposed to open this paper until permission to do so has been granted by the Chief Invigilator.

Question 1(25 marks)

(a) Identify the major differences between classical and instrumental methods of analysis. [2]

(b) Summarize the unique advantages of instrumental methods of analysis over the classical methods. [4]

(c) List the principal classes of chemical instrumentation. Give two specific examples of instrumental techniques from each principal class given. [6]

(d) With the help a labeled diagram, show the basic components of an instrument for chemical/environmental analysis. Discuss the functions of any one of the components and give an example in named equipment. [8]

(e) List and define five salient performance characteristics of an instrument for environmental analysis. [5]

Question 2 (25 marks)

(a) Explain the following terms and obtain a relationship between them: **'Transmittance' and 'Absorbance'**. [3]

(b) Discuss very briefly, the effects of a medium's refractive index on the wavelength, velocity and frequency of a radiation passing through the medium. [3]

[c] The wavelength of the sodium D line is 589 nm.
- (i) Calculate its frequency, wave-number and energy.
- (ii) Suppose another line is observed at a wavelength of 450nm. Is this line of a higher energy than the sodium D line (at 589 nm)? [11]

(d) An environmental sample with an active ingredient, A (F.W. = 270), has a molar absorptivity $\epsilon = 703\ M^{-1}cm^{-1}$ at a wavelength of 262nm. A given amount of the sample was dissolved with water in a 5L volumetric flask and then made to the mark. A 1.00-cm cell was used to measure the absorbance of the solution at 262nm,and a reading of 0.275 was obtained. Calculate the amount of A (in grammes), present in the sample. [8]

Question 3 (25 marks)

(a) What is a spectrophotometer? State four of its basic components and their corresponding functions. [8]

(b) What is the requirement for a cell material before it can be used for a particular spectral region? [1]

(c) Give two examples of materials generally used for each of the following regions:
(i) UV & Visible; (ii) IR [4]

(d) With respect to the 'Mull' and 'KBr Pellet' used during spectroscopic analysis:

(i) State the nature of samples for which they are used and their respective spectral regions of application. [2]

(ii) Briefly describe how they are prepared. [6]

(e) What precautionary measures need be taken in the handling of a cell/cuvet during a UV-Visible spectroscopic analysis? Why are these measures crucial? [4]

Question 4 (25 marks)

(a) What is a monochromator? [2]

(b) For a spectrophotometer, list the components of a monochromator system and state the respective functions of each component given. [7]

(c) For each of the following spectral regions, suggest an appropriate monocromator prism material :
(i) Visible (ii) UV (iii) IR
Justify your choice. [4]

(d) Discuss the advantages and disadvantages of 'diffraction gratings' when compared with a 'glass prism' as dispersing media in monochromators for spectrophotometers. [4]

(e)

(i) Explain the term 'dispersion of a prism'. Hence, briefly describe the working principles of a prism as a monochromator dispersing medium.

(ii) List the factors that increase the resolution of a 'prism' and 'diffraction gratings' [8]

Question 5 (25 marks)

(a) Explain the term 'source' with regards to atomic spectroscopic methods. Give two examples and state four of its ideal 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 principles.. [8]

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

Question 6(25 marks)

The hollow cathode lamp is a vital primary source of radiation in atomic absorption spectrometry. Discuss:

(a) Its features as a sharp line radiation source. [3]

(b) Its structure (configuration) plus a schematic diagram of it. [7]

(c) Its working principles. [10]

(d) The composition and short comings of multielement hollow cathode lamps. [6]

(e) The essence of the cylindrical structure of the cathode tube. [2]

NON-METALS

METALLOIDS

METALS

Group	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
Period 1	1 **H** 1.008																	2 He 4.003
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.9	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.90	23 **V** 50.94	24 **Cr** 52.01	25 **Mn** 54.9	26 **Fe** 55.85	27 **Co** 58.71	28 **Ni** 58.71	29 **Cu** 63.54	30 **Zn** 65.37	31 **Ga** 69.7	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.91	36 **Kr** 83.80
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 91.22	42 **Mo** 95.94	43 **Tc** 98.9	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
6	55 **Cs** 132.9	56 **Ba** 137.3	71 **Lu** 174.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 196.9	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 208.9	84 **Po** 210	85 **At** 210	86 **Rn** 222
7	87 **Fr** 223	88 **Ra** 226.0	103 **Lr** 257	104 **Unq**	105 **Unp**	106 **Unh**	107 **Uns**	108 **Uno**	109 **Une**									

Lanthanides	57 **La** 138.9	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** 146.9	62 **Sm** 150.9	63 **Eu** 151.3	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0
Actinides	89 **Ac** 227.0	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.1	94 **Pu** 239.1	95 **Am** 241.1	96 **Cm** 247.1	97 **Bk** 249.1	98 **Cf** 251.1	99 **Es** 254.1	100 **Fm** 257.1	101 **Md** 258.1	102 **No** 255

DATA SHEET

General Data

Avogadro's number $N_A = 6.022 \times 10^{23}\ mol^{-1}$
Boltzmann's constant $k_B = 1.38 \times 10^{-23}$ J/K
Density of mercury = $1.36 \times 10^4\ kg/m^3$
Gas constant $R = 8.314$ J/(mol·K)
Gravitational acceleration $g = 9.80\ m/s^2$
Refractive index of air $n_{air} = 1.00$
Standard atmospheric pressure = 1.013×10^5 Pa
Speed of light in vacuum $c = 2.997\,8 \times 10^8$ m/s
Speed of sound in air $\upsilon_s = 343$ m/s
Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}\ W/(m^2{\cdot}K^4)$
Threshold of hearing $I_0 = 10^{-12}\ W/m^2$
Universal gravitational constant $G = 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2$
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J

Water data

$c(water) = 4186$ J/(kg·K)	$c(ice) = 2090$ J/(kg·K)	$c(steam) = 2079$ J/(kg·K)
$L_f(ice) = 3.33 \times 10^5$ J/kg	$L_v(water) = 2.260 \times 10^6$ J/kg	
ρ (water) = 1000 kg/m^3	refractive index $n_w = 1.333$	

Electricity and nuclear data

Alpha particle mass = $6.644\,657 \times 10^{-27}$ kg
Charge of an electron = -1.6×10^{-19} C
Charge of a proton = $+1.6 \times 10^{-19}$ C
Coulomb's constant $k_e = 8.987\,5 \times 10^9\ Nm^2/C^2$
Deuteron mass = $3.343\,583 \times 10^{-27}$ kg
Electron mass, $m_e = 9.109 \times 10^{-31}$ kg
Neutron mass $m_n = 1.675 \times 10^{-27}$ kg
Proton mass, $m_p = 1.673 \times 10^{-27}$ kg
1 atomic mass unit = 1 amu = 1 u = 1.66×10^{-27} kg
$\epsilon_0 = 8.85 \times 10^{-12}\ C^2 (N{\cdot}m^2)$
1 Ci = 3.7×10^{10} decays/s
1Bq = 1 decay/s

$$MAP = P_{dia} + \frac{(P_{sys} - P_{dia})}{3}$$