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

BSc OF SCIENCE IN ENVIRONMENTAL HEALTH
**RESIT EXAMINATION PAPER 2018**

| | | |
|---|---|---|
| TITLE OF PAPER | : | INSTRUMENTAL METHODS FOR ENVIRONMENTAL ANALYSIS II |
| COURSE CODE | : | EHS224 |
| 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 an atomic absorption spectroscopy instrument. **[ 5Marks]**

b. State the mathematical expression of Beer's law and give the SI units of all the parameters. **[7 Marks]**

c. Briefly describe the working principles of diffraction gratings as monochromators. **[6 Marks]**

d. The molar absorptivity for aqueous solutions of phenol at 211 nm is $6.7 \times 10^3$ $Lcm^{-1}mol^{-1}$. Calculate the permissible range of phenol concentrations if transmittance is to be less than 85% and greater than 7% when the measurements are made in 1.5 cm cells. **[7 Marks]**

## QUESTION TWO

a. Why is a hollow cathode lamp considered as a sharp line radiation source? **[4 Marks]**

b. Explain why compounds containing the same chromophore will have different maximum absorbance wavelengths. **[7 Marks]**

**c.** Discuss the effect of a wide slit width on the resolution of a spectrophotometer and the adherence to Beer's law. Compare it with the spectral slit width. **[8 marks]**

**d.** What are the necessary precautions that should be taken in the handling of a cuvette/cell, during a UV spectrophotometric analysis? **[6 Marks]**

## QUESTION THREE

a. A wastewater effluent sample known to contain *para* nitrophenol (abbreviated as PNP, Mw139.11 g $mol^{-1}$) was analysed using UV/Vis spectrometer, in a 1.0 cm cuvette. It was found to transmit 57% of the incident light at 318 nm (PNP's maximum absorbance wavelength). If the molar absorptivity of this substance at this wavelength is 17.9 $cm^{-1}g^{-1}L$, what is the concentration of the substance in moles/L? **[8 Marks]**

b. Explain the term interference with regards to flames and furnaces. **[6 Marks]**

c. What are the characteristics of stray radiations that cause deviations from Beer's law during spectroscopic analysis? **[6 Marks]**

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

## QUESTION FOUR

a. For each of the following spectral regions, suggest an appropriate monochromator and state the reasons for each choice:

(i) X-ray

(ii) Visible

(iii) UV

(iv) Microwave

**[12Marks]**

b. Partial ionization of an analyte can result in deviations from Beer's law. Discuss how this happens and suggest corrective measures. **[7 Marks]**

c. Explain how flame temperature affects the sensitivity of a flame atomic absorption spectrophotometer. **[6 Marks]**

## QUESTION FIVE

a. A 0.11 M solution contained in a 1.0 cm cell had a %T of 31.4% at 324.7 nm wavelength. Calculate;

(i) Absorbance

(ii) Molar absorptivity

(iii) The cell path that will give a %T of 20 %

(iv) Energy of a photon of radiation at the specified wavelength.

**[12 Marks]**

b. What is the requirement for a cell's material before it can be used for a particular region? **[5 Marks]**

c. Describe the procedure for preparing a KBr pallet for IR spectroscopy. **[8 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 | $F = N_A e$ | $9.6485 \times 10^{4}$ 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$^{-1}$ |
| | | $6.2364 \times 10$ 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 | $\varepsilon_0 = 1/c^2\mu_0$ | $8.854\,19 \times 10^{-12}$ J$^{-1}$ C$^2$ m$^{-1}$ |
| | $4\pi\varepsilon_0$ | $1.112\,65 \times 10^{-10}$ J$^{-1}$ C$^2$ m$^{-1}$ |
| Vacuum permeability | $\mu_0$ | $4\pi \times 10^{-7}$ 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 | $a_0 = 4\pi\varepsilon_0\hbar/m_e e^2$ | $5.291\,77 \times 10^{-11}$ m |
| Fine-structure constant | $\alpha = \mu_0 e^2 c/2h$ | $7.297\,35 \times 10^{-3}$ |
| Rydberg constant | $R_\infty = m_e e^4/8h^3 c\varepsilon_0^2$ | $1.097\,37 \times 10^{7}$ 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 | = | $1 \times 10^{-7}$ 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 |
| $10^{-15}$ | $10^{-12}$ | $10^{-9}$ | $10^{-6}$ | $10^{-3}$ | $10^{-2}$ | $10^{-1}$ | $10^{3}$ | $10^{6}$ | $10^{9}$ |

# PERIODIC TABLE OF ELEMENTS

| PERIODS | GROUPS 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 | | | | | | | | | | | | | | | | | 4.003 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 | 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 | | | | | | | | |

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

TRANSITION ELEMENTS

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *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.*