MACHAKOS UNIVERSITY

UNIVERSITY EXAMINATIONS 2017/2018

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (BIOLOGY, MATHS)

BACHELOR OF EDUCATION (SCIENCE)

SCH 100: FUNDAMENTALS OF INORGANIC CHEMISTRY

DATE:11/12/2017 **TIME: 11.00-1.00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory**.
- Answer any **two** questions from section **B**.
- Find Periodic Table on the last Page.

Required Data/Information

- **Mass of electron (m)** = 9.1079×10^{-31} Kg
- **electronic charge (e^-)** = 1.602×10^{-19} C
- **Rydberg's constant (R) =** 10 973 731.6 m^{-1}
- **Planck's constant (h)=**6.63×10^{-34} Js
- **Speed of light in a vacuum (C)** = 2.998×10^{8} m/s
- **ε_o – permittivity of free space $8.854188 \times 10^{-12} C^2 s^2 Kg^{-1} m^{-3}$**
- **Z**- nuclear charge
- **Smallest Bohr atomic radius (r_1)** = 5.29×10^{-11}m
- 1 eV = 1.6022×10^{-19} J

SECTION A (30 MARKS) COMPULSARY

QUESTION ONE (30 MARKS)

a) Describe Ernest Rutherford's experiment and what lead him to change the outlook of the atom. Include the experiment by name, a description of the experiment, and the major component of the atom his experiment brought forth. Include diagrams if it helps support your description and any scientists who aided in his discoveries. (4 marks)

b) Draw an atom of the most common isotope of neutral nitrogen, as Rutherford and Bohr would have imagined it. (4 marks)

c) The orbital quantum number for the electron in a hydrogen atom is $l = 5$. Calculate the smallest possible value for the total energy in electron volts of this electron. (4 marks)

d) Find the energy (in eVs) of the photon that is emitted when the electron in a hydrogen atom undergoes a transition from the n = 9 energy level to produce a line in the

(i) Brackett series. (3 marks)

(ii) Lyman series. (3 marks)

e) Determine the maximum number of electron states with principal quantum number $n = 3$. (3 marks)

f) Briefly explain the following statements;

(i) If a photon causes an electron to jump to a higher energy level, the exact energy of the photon is critical, but if it is used to release an electron from the atom, it is only the minimum energy of the photon that is critical. (2 marks)

(ii) Elements produce their own characteristic colors when they emit photons. (2 marks)

g) A Chemistry student measured out 3.2 grams of platinum (Pt) in the laboratory. Knowing that atoms are extremely small, he was curious on how many Pt atoms existed within his measured amount. Calculate;

(i) The number of atoms and moles of Pt that the student measured. (2 marks)

(ii) The mass of 2.75×10^{24} atoms of Pt. (1 mark)

h) Arrange the following in order of increasing acidic strength and give a reason for the trend: H_2AsO_4, H_2SbO_4 and H_2BiO_4. (2 marks)

SECTION B: ATTEMPT ANY TWO QUESTIONS (20 MARKS EACH)

QUESTION TWO (20 MARKS)

a) For biological organisms, more damage is done to cells by standing in front of a very weak (low power) beam of x-rays than in front of a much brighter red light. Briefly explain how the photon concept explains this situation that an 18^{th} century physicist would have found paradoxical. (1 mark)

b) In photoelectric effect experiments, no photoelectrons are produced when the frequency of the incident radiation drops below a cutoff value no matter how bright or intense the light is. Briefly explain this fact using a "particle" theory of light instead of a wave theory of light. (1 mark)

c) Calculate the change in energy of electromagnetic radiation emitted by the hydrogen atom in the electron transition in the;

(i) Shortest wavelength transition in the Balmer series (3 marks)

(ii) Longest wavelength transition in the Balmer series (2 marks)

d) When ultraviolet photons with a wavelength of 3.45×10^{-7} m are incident on an unknown metal surface in a vacuum, electrons with a maximum kinetic energy of 1.52 eV are emitted from the surface. Calculate the work function of the metal. (3 marks)

e) X-rays of frequency 1.53×10^{16} Hz cause the emission of electrons from a material with a maximum kinetic energy of 2.18×10^{-18} J. Calculate the threshold frequency for the release of electrons from the material. (3 marks)

f) Identify which has more energy between a photon of green light and a photon of red light, occupying the visible spectrum of the electromagnetic spectrum. Explain your answer. (2 marks)

g) The work function for a photoelectric material is 3.5 eV. The material is illuminated with monochromatic light with a wavelength of 300 nm.

(i) Calculate the cutoff frequency for that particular material. (2 marks)

(ii) Determine the stopping potential of emitted photoelectrons (3 marks)

QUESTION THREE (20 MARKS)

a) List all the allowed combinations of the four quantum numbers (n, l, m_l, m_s) for electrons in a 3p orbital and predict the maximum number of electrons the 3p subshell can accommodate. (5 marks)

b) Using the Bohr model, determine the ratio of the n^{th} orbit of a triply ionized beryllium atom (Be^{3+}, Z = 4) to the energy of the n^{th} orbit of a hydrogen atom (H) (3 marks)

c) Four of the six electrons in carbon atom are found in s-orbitals. Determine the quantum numbers that one of the remaining two electrons can have if the atom is in

(i) Its ground state. (2 marks)

(ii) Its second excited state. (2 marks)

d) Write the quantum numbers that represent the following electrons

(i) $7d^3$ electron. (2 marks)

(ii) $4s^2$ electron. (2 marks)

e) What are the allowable possible values for the second quantum number, l when:

(i) $n = 2$. (1 mark)

(ii) $n = 10$. (1 mark)

f) Draw and populate with electrons an energy level diagram for palladium (Pd) element given that its atomic number is 46 and mass number is 106. (2 marks)

QUESTION FOUR (20 MARKS)

a) Elements in the Periodic Table are arranged according to their group and period number

i) Differentiate between the following terms: Hund's rule and Heisenberg Uncertainty Principle. (2 marks)

ii) Explain why the third ionization energy of magnesium (Mg) is exceptionally higher than the second ionization. (1 mark)

iii) Write the electronic configuration of Chromium given that its atomic number and atomic mass are 24 and 52 respectively (1 mark)

iv) How many electrons can be put in an $n = 4$ shell? Show your working. (3 marks)

v) How many radial nodes does a 4*d* orbital have? Show your working. (2 marks)

vi) Draw the shape of a $d_{x^2-y^2}$ atomic orbital (1 mark)

b) Determine the group and period of an element labeled X whose atomic number is forty seven (47). Show your working. (3 marks)

c) Calculate the effective nuclear charge on a *4f* electron in a Tantalum (Ta) atom. (2 marks)

d) The structure of propyne is as shown below.

$$H_3C{-}C{\equiv}CH$$

i) On the structure, identify the hybridization state of all the carbon atoms. (3 marks)

ii) Draw a picture that clearly shows the interacting orbitals of all the sigma and pi bonds in propyne. (2 marks)

QUESTION FIVE (20 MARKS)

a) Using relevant examples define the following terms

i) Conjugate acid. (1 mark)

ii) Amphoteric acid. (1 mark)

b) Consider the reaction of hydroxide ion with the nitrosyl cation, NO_2^+, to form nitric acid.

i) Write the equation for the reaction (1 mark)

ii) Write ***Lewis electron dot formulas*** (including formal charges and/or resonance forms if available) for all three species in this reaction. Clearly indicate which reactant is the Lewis acid and which is the Lewis base. Use arrow(s) to illustrate the formation of any new chemical bond(s) during the reaction. (6 marks)

c) A pH scale can be used to qualitatively determine the acidity or basicity o of a sample.

i) Determine the pH of a 1.75 M solution of HNO_3. (2 marks)

ii) Now suppose that 500.0 mL of a 1.50 M $Ba(OH)_2$ solution is added to 1.00 L of the above HNO_3 solution. Determine the pH of the resulting solution. (3 marks)

iii) Calculate the additional volume (in mL) of 1.50 M $Ba(OH)_2$ that must be added to the mixture in part (3b) to bring the pH to 7.00. (3 marks)

d) Balance the following redox reaction using the 'half-reaction method of Fe(II) oxidation with permanganate in the acidic solution. Show your working:

$FeSO_4 + KMnO_4 + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + MnSO_4 + H_2O + K_2SO_4$ (3 marks)

1																	18
1 **H** 1.0079	2											13	14	15	16	17	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.065	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.409	31 **Ga** 69.723	32 **Ge** 72.64	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57-71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89-103 #	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (264)	108 **Hs** (270)	109 **Mt** (268)	110 **Ds** (281)	111 **Rg** (272)	112 **Uub** (285)	113 **Uut** (284)	114 **Uuq** (289)	115 **Uup** (288)	116 **Uuh** (291)		118 **Uuo** (294)

* Lanthanide series	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
# Actinide series	89 **Ac** (227)	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)