SCHOOL OF PURE AND APPLIED SCIENCES

FUNDAMENTALS OF INORGANIC CHEMISTRY

DATE: SCHOOLBASED **TIME:**

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_0– 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; 1 mile = 1609 m. 1 m = 1×10^{9} nm

This Paper Consists of 6 Printed Pages. Please Turn Over.

SECTION A (30 MARKS) COMPULSARY

QUESTION ONE

a) Briefly describe the following;

i. J. J Thomsons atomic model (4 marks)

ii. Rutherford's atomic structure model (5 marks)

b) A beryllium atom has 4 protons, 5 neutrons and 4 electrons. What is the mass number of this atom? (2 marks)

c) Sketch and explain for quantities of photoelectric effect of kinetic energy (max) versus intensity of three different metals at constant frequency assuming frequency is greater than the threshold frequency. (4 marks)

d) Explain the two factors affecting maximum kinetic energy of photoelectrons.(4 marks)

e) Write the electron configuration of mercury (Z=80), showing all the inner orbitals (2 marks)

f) Calculate the energy of an electron in a hydrogen, n= 2 level. (4 marks)

g) List all the allowed combinations of the four quantum numbers (n, l, m_l, m_s) for a 6d orbital, and predict the total number of electrons it can contain. (5 marks)

SECTION B:

ATTEMPT ANY TWO QUESTIONS (20 MARKS EACH)

QUESTION TWO

a) Define the following terms;

i. Paschen series (2 marks)

ii. Quanta (2 marks)

b) Show that Rydberg's constant (R) = $1.097 \times 10^{7} m^{-1}$ (4 marks)

c) Explain why elements produce their own characteristic colors when they emit photons (2 marks)

d) An electron falls from energy level 6 to 3 in a hydrogen emission spectrum;

i. Which series does it represent (1 mark)

ii. Calculate its corresponding wavelength and frequency. (4 marks)

e) Which electromagnetic waves have the shortest wavelengths and highest frequencies? (1 mark)

f) One of the electron transitions in a hydrogen atom produces infrared light with a wavelength of 746.4 nm. What amount of energy causes this transition? (4 marks)

QUESTION THREE

a) Define the following terms;

i. Acid dissociation constant, (2 marks)

ii. Lewis acid, (2 marks)

b) Using a relevant equation, show auto ionization of water. (2 marks)

c) A solution of 0.050 M acetic acid and 0.035 M NaOH is prepared. What is the pH? (4 marks)

d) What mass of $Ba(OH)_2$(171.34 g/mole) is required to prepare 150 mL of a solution with a pH of 13.50? (4 marks)

e) Hypochlorous acid, HOCl, has a pKa of 7.52. What is the pH of 0.25 M solution of HOCl? What is the percent ionization? (4 marks)

f) Arrange the following acids in order of increasing acid strength. Explain your answer; HI, HCl, HBr, H_2S. (2 marks)

QUESTION FOUR

a) In Quantum mechanics, quantum numbers are needed to characterize completely each electron in an atom. List and describe any three quantum numbers. (6 marks)

b) Write the quantum numbers that represent the following electrons: (2 marks)

i. $3s^2$

ii. $4f^6$

c) Which of the following are allowable sets of quantum numbers for an orbital? Explain. (6 marks)

i. n = 4, l = 4, ml = 0

ii. n = 3, l = 2, ml = 1

iii. n = 5, l = 3, ml = -4

d) Two of the three electrons in a lithium atom have quantum numbers of n=1, l=0, ml=0, ms=-1/2. What quantum numbers can the third electron have if the atom is in;

i. Its ground state (2 marks)

ii. Its first excited state (2 marks)

e) Draw the following orbitals clearly showing the respective coordinates

i. $3p_z$ (1 mark)

ii. d_{xy} orbitals (1 mark)

QUESTION FIVE

a) Define the following terms;

i) Aufbaus principle (2 marks)

ii) Hunds rule (2 marks)

b) Although element 114 is not stable enough to occur in nature, two isotopes of element 114 were created first time in a nuclear reactor in 1999 by a team of Russian and American scientists. Write the complete electron configuration for element 114.

(2 marks)

c) According to the periodic table provided, arrange the following elements in order of the increasing atomic radius; nickel, cobalt, calcium and potassium. Explain your answer.

(2 marks)

d) Study group 15 in the periodic table and indicate which element has the strongest metallic character. Explain your answer. (2 marks)

e) Calculate the effective nuclear charge on a 4d electron in a Palladium (Pd) atom. Given that the number of neutrons and mass number of Pd is 60 and 106 respectively.

(3 marks)

f) Periodic table is a chart in which elements having similar chemical and physical properties are arranged in groups.

i) Elements Y (not its actual symbol) has atomic number 83. To which period and group does it belong? Show how you arrived at your answer. (3 marks)

ii) Draw and label energy level diagram for Hydrogen atom and a multi-electron atom like copper. (4 marks)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.0079																	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											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)