NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH AND APPLIED SCIENCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE	
QUALIFICATION CODE: 07BOSC	**LEVEL:** 6
COURSE NAME: INORGANIC CHEMISTRY	**COURSE CODE:** ICH602S
SESSION: NOVEMBER 2019	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
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MODERATOR:	PROF HABAUKA KWAAMBWA

INSTRUCTIONS

1. Answer ALL the questions.
2. Write clearly and neatly.
3. Number the answers clearly.
4. All written work must be done in blue or black ink and sketches can be done in pencil.
5. No books, notes and other additional aids are allowed.

PERMISSIBLE MATERIALS

Non-programmable Calculators

ATTACHMENTS

List of Useful Constants
Periodic Table

THIS QUESTION PAPER CONSISTS OF 5 PAGES (Including this front page, list of useful constants and Periodic Table)

QUESTION 1: **[20]**

a) The frequency of radiation used in all microwave ovens sold in the US is 2.45 GHz. What is the wavelength (in meters) of this radiation? How much longer or shorter is this than the wavelength of orange light (625 nm)? (3)

b) Calculate the energies of the n = 1 and n = 2 states of the hydrogen atom in joules per atom and in kJ per mole. (8)

c) Calculate the de Broglie wavelength of the "particle" in the following two cases:
i) A 25.0 g bullet traveling at 612 m/s (2)
ii) An electron (mass = 9.109×10^{-31} kg) moving at 63.0 m/s (2)

d) Identify the subshell in which electrons with the following quantum numbers are found: (2)
i) $n = 4, l = 2$
ii) $n = 6, l = 0$

e) Write a set of quantum numbers for each of the electrons with an *n* of 4 in a Se atom. (3)

QUESTION 2: **[30]**

2.1. For the following compounds: (20)
i) PF_5
ii) SF_4
iii) $BHCl_2$
iv) I_3^-

a) Draw the LEWIS structures below the molecular formula.
b) Determine both electron-domain (ED) and molecular geometry.
c) Determine whether bond angles are ideal (90°, 109.5°, 120°, 180°) or distorted due to lone pair – bonding pair repulsion.
d) From the overall molecular geometry and the presence and arrangement of polar bonds (if any), determine if a molecule is polar.

2.2 Predict the geometries of the following species: (4)
a) $AlCl_3$
b) $ZnCl_2$
c) $[ZnCl_2]^{2-}$
d) SO_2

2.3 Determine the hybridization state of the central (underlined) atom in each of the following: (6)
a) $\underline{Be}H_2$
b) $\underline{P}F_3$
c) <u>aluminium</u> iodide

QUESTION 3: **[40]**

3.1 Give the formulas of the following coordination complexes: (6)

a) A Ni^{2+} ion is bound to two water molecules and two bidentate oxalate ions.
b) A Co^{3+} ion is bound to one chloride ion, one ammonia molecule, and two bidentate ethylenediamine (en) molecules.
c) Pentaamminechlorocobalt(III) chloride

3.2 In each of the following coordination complexes, determine the metals oxidation number and coordination number. (8)

a) $[Co(en)_2(NO_2)_2]Cl$
b) $Pt(NH_3)_2(C_2O_4)$
c) $Pt(NH_3)_2Cl_4$
d) $[Co(NH_3)_5Cl]SO_4$

3.3 Name the following compounds: (8)

a) $[Cu(NH_3)_4]SO_4$
b) $K_2[CoCl_4]$
c) $Co(phen)_2Cl_2$
d)$[Co(en)_2(H_2O)Cl]Cl_2$

3.4 For which of the following compounds or complex do isomers exist? If isomers are possible, identify the type of isomerism (structural, geometric or optical). (8)

a) $[Co(NH_3)_4Cl_2]^+$
b) $Pt(NH_3)_2C(N)_2$ (square-planar)
c) $K_3[Fe(C_2O_4)_3]$
d) $Zn(NH_3)_2Cl_2$ (tetrahedral)

3.5 For each of the following complex ions give the oxidation number of metal ion, depict low-spin or high-spin configurations, give the number of unpaired electrons in each state and tell whether or not its paramagnetic or diamagnetic. (6)

a) $[Ru(H_2O)_6]^{2+}$
b) $[Ni(NH_3)_6]^{2+}$

3.6 An aqueous solution of $[Fe(H_2O)_6]^{2+}$ is light blue-green. Do you expect the d^6 Fe^{2+} ion to ave a high- or low-spin configuration? How would you test your prediction experimentally? (4)

QUESTION 4: **[20]**

4.1 What type of intermolecular forces exist between the following pairs: (2)

a) HBr and H_2S
b) Cl_2 and CBr

4.2 Gold crystallizes in a cubic close-packed structure (fcc unit cell) and has a density of 19.3 g/cm^3. Calculate the atomic radius of gold in picometers. (10)

4.3 You put 925 mL of water in a pan at 100 °C, and the water slowly evaporates. How much energy is transferred as heat to vaporize all the water?
(Density of water at 100 °C = 0.958 g/mL; ΔH_{vap}^0 for water = +40 kJ/mol) (4)

4.4 Diethyl ether is a volatile, highly flammable organic liquid that is used mainly as a solvent. The vapour pressure of diethyl ether is 401 mmHg at 18 °C. Calculate the vapour pressure at 32 °C (ΔH_{vap} = 26.0 kJ/mol). (4)

END OF EXAMINATION

USEFUL CONSTANTS:

Gas constant, R = 8.3145 J · mol^{-1} · K^{-1} = 0.083145 dm^3 · bar · mol^{-1} · K^{-1} = 0.08206 L atm mol^{-1} · K^{-1}

1 Pa · m^3 = 1 kPa.L = 1 N · m = 1 J

1 atm = 101 325 Pa = 760 mmHg = 760 torr

Avogadro's Number, N_A = 6.022 x 10^{23} mol^{-1}

Planck's constant, h = 6.626 x 10^{-34} Js

Speed of light, c = 2.998 x 10^8 ms^{-1}

PERIODIC TABLE OF THE ELEMENTS

1	2											13	14	15	16	17	18
1 **H** 1.00794																	2 **He** 4.00260
3 **Li** 6.941	4 **Be** 9.01218											5 **B** 10.81	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984	10 **Ne** 20.179
11 **Na** 22.9898	12 **Mg** 24.305	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.9815	14 **Si** 28.0855	15 **P** 30.9738	16 **S** 32.06	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.08	21 **Sc** 44.9559	22 **Ti** 47.88	23 **V** 50.9415	24 **Cr** 51.996	25 **Mn** 54.9380	26 **Fe** 55.847	27 **Co** 58.9332	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.8
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.22	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.906	46 **Pd** 106.42	47 **Ag** 107.868	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.29
55 **Cs** 132.905	56 **Ba** 137.33	71 **Lu** 174.967	72 **Hf** 178.49	73 **Ta** 180.948	74 **W** 183.85	75 **Re** 186.207	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.967	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.908	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.025	103 **Lr** (260)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (268)	110 Uun (269)	111 Uuu (272)	112 Uub (269)		114 Uuq		116 Uuh		118 Uuo

Lanthanides:	57 **La** 138.906	58 **Ce** 140.12	59 **Pr** 140.908	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.925	66 **Dy** 162.50	67 **Ho** 161.930	68 **Er** 167.26	69 **Tm** 166.934	70 **Yb** 173.04
Actinides:	89 **Ac** 227.028	90 **Th** 232.038	91 **Pa** 231.036	92 **U** 238.029	93 **Np** 237.048	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)