P

NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Faculty of Health, Natural Resources and Applied Sciences

School of Natural and Applied Sciences

Department of Biology, Chemistry and Physics

13 Jackson Kaujeua Street
Private Bag 13388
Windhoek
NAMIBIA

T: +264 61 207 2012
F: +264 61 207 9012
E: dbcp@nust.na
W: www.nust.na

QUALIFICATION : **BACHELOR OF SCIENCE**	
QUALIFICATION CODE: **07BOSC**	LEVEL: **6**
COURSE: **INORGANIC CHEMISTRY**	COURSE CODE: **ICH602S**
DATE: **NOVEMBER 2024**	SESSION: **1**
DURATION: **3 HOURS**	MARKS: **100**

FIRST OPPORTUNITY: QUESTION PAPER

EXAMINER: ***Dr Euodia Hess***

MODERATOR: ***Prof Habauka Kwaambwa***

INSTRUCTIONS

1. Answer all questions on the separate answer sheet.
2. Please write neatly and legibly.
3. Do not use the left side margin of the exam paper. This must be allowed for the examiner.
4. No books, notes and other additional aids are allowed.
5. Mark all answers clearly with their respective question numbers.

PERMISSIBLE MATERIALS:

1. Non-Programmable Calculator

ATTACHMENTS

1. List of useful constants
2. Periodic Table

This paper consists of 7 pages including this front page

SECTION A: MULTIPLE CHOICE [40 MARKS]

QUESTION 1:

There are 20 multiple choice questions in this section. Each question carries 2 marks.

1.1 How many sigma (σ) bonds and pi (π) bonds are in carbon monoxide?

A) Three σ, zero π.
B) Two σ, one π.
C) One σ, two π.
D) None of the above.

1.2 What is the hybridization of the central nitrogen atom in N_2O?

A) sp^2
B) sp
C) sp^3
D) sp^3d

1.3 Which of the following does not contain at least one pi bond?

A) CO
B) H_2N
C) C_3H_8
D) C_2H_2

1.4 What is the hybridization of the central atom in a molecule with a tetrahedral molecular geometry?

A) sp^2
B) sp^3
C) sp^4
D) sp

1.5 What is the molecular geometry around a central atom that is sp^2 hybridized, has three sigma bonds, and one pi bond

A) Trigonal bipyramidal
B) Tetrahedral
C) Square planar
D) Trigonal-planar

1.6 Atomic orbitals combine most effectively to form molecular orbitals when

A) The atomic orbitals have similar energies.
B) Only *d*-orbitals are used in bonding.
C) Atoms have an equal number of valence electrons
D) Electrons in the orbitals have the same spin.

1.7 All of the following molecules or ions can act as polydentate ligands EXCEPT ____.

A) acetylacetate ion; $CH_3COCHCOCH_3^-$
B) oxalate ion; $C_2O_4^{2-}$
C) ethylenediamine; $H_2NCH_2CH_2NH_2$
D) dimethylamine; $(CH_3)_2NH_2$

1.8 In which of the following complexes does the transition metal have a d^8 configuration?

A) $Cu(H_2O)_6^{2+}$
B) $PtCl_4^{2-}$
C) $Fe(CN)_6^{3-}$

D) $Ni(CO)_4$

1.9 How many *d* electrons are present on the metal ion in the complex ion $CoCl_6^{3-}$?

A) 8
B) 6
C) 10
D) 7

1.10 Which of the following will <u>not</u> act as a ligand to a transition metal cation?

A) CN^-
B) H_3O^+
C) O_2
D) PH_3

1.11 What is the oxidation state of molybdenum in $[Mo(H_2O)_5OH]Cl_2$?

A) +3
B) +2
C) +6
D) +4

1.12 In which of the following complexes does the transition metal have a d^8 configuration?

A) $PtCl_4^{2-}$
B) $Cu(H_2O)_6^{2+}$
C) $Fe(CN)_6^{3-}$
D) $Ni(CO)_4$

1.13 What is the name of the compound having the formula $K_2[PtCl_4]$?

A) Potassium tetrachloroplatinate(II)
B) Potassium chloroplatinate(II)
C) Dipotassium tetrachloroplatnum(II)
D) Potassium chloroplatinate(IV)

1.14 What is the name of the compound having the formula $[Cr(en)_2(H_2O)_2]SO_4$?

A) Dihydroxydiethlyenediamminechromate(II) sulfate
B) diaquabis(ethylenediamine)sulfatochromate(IV)
C) Diaquabis(ethylenediamine)chromium(II) sulfate
D) Diaquabis(ethylenediamine)sulfatochromium(II)

1.15 Below is a list of formulas for complex compounds; each is matched with its name. One formula/name combination contains an error. Which one?

A) $[Co(en)_2Br_2]Br$/dibromobis(ethylenediamine)cobalt(III) bromide
B) $[Fe(NH_3)_5(OH_2)]Cl_3$/pentaammineaquairon(III) chloride
C) $[Cr(NH_3)_3(OH)_3]$ / triamminetrihydroxochromate(III)
D) $[Ni(en)_3](NO_3)_2$ / tris(ethylenediamine)nickel(II) nitrate

1.16 As pure molecular solids, which of the following exhibits dipole-dipole intermolecular forces: PH_3, SO_3, HCl, and CO_2?

A) HCl only
B) SO_3 and HCl
C) SO_3 and CO_2
D) PH_3 and HCl

1.17 Which of the following molecules is expected to form hydrogen bonds in the pure liquid or solid phase: ethanol (CH_3CH_2OH), acetic acid (CH_3CO_2H), acetaldehyde (CH_3CHO), and dimethyl ether (CH_3OCH_3)?

A) ethanol and dimethyl ether
B) acetic acid and acetaldehyde
C) dimethyl ether and acetic acid
D) ethanol and acetic acid

1.18 In a water molecule forms a hydrogen bond with another water molecule, which atoms are involved in the interaction?

A) An oxygen and a hydrogen from the same molecule
B) An oxygen from one molecule and an oxygen from the other molecule
C) A hydrogen from one molecule and a hydrogen from the other molecule
D) A hydrogen from one molecule and an oxygen from the other molecule

1.19 Nickel has a face-centered cubic cell, and its density is 8.90 g/cm^3. What is the radius (in pm) of a nickel atom?

A) 125 pm
B) 225 pm
C) 88.2 pm
D) 62 pm

1.20 Rhodium crystallizes in a face-centered cubic lattice with an edge length of 380.1 pm. What is the density of rhodium?

A) 12.4 g/cm^3
B) 13.4 g/cm^3
C) 22.4 g/cm^3
D) 32.4 g/cm^3

SECTION B: SHORT/LONG ANSWER QUESTIONS [60 MARKS]

There are THREE questions in this section. Please answer ALL of the questions in this section. Show clearly, where necessary, how you arrive at the answer as all working will carry marks.

QUESTION 2: **[20]**

2.1 The edge length of NaCl unit cell is 564 pm. What is the density of NaCl in g/cm^3? (10)

2.2 Redraw the table below and match the correct examples to its respective type of crystal. Examples: NaCl ; C (diamond) ; Sucrose ; Fe; & CaF_2 (10)

Type of Crystal	Example
	NaCl
	C (diamond)
	Sucrose
	Fe
	CaF_2

QUESTION 3: **[20]**

3.1 Show if the following compounds obeys the 18 electron rule or not: (12)

(a) $Mn(CO)_5CH_3$
(b) $HMn(CO)_5$
(c) $Cr(C_6H_6)_2$

(d) $[Fe(CO)_4]^{2-}$

3.2 What hapticities are possible for the interaction of each of the following ligands with a single d-block metal atom such as cobalt? (8)

a) C_2H_4
b) Cyclopentadienyl
c) C_6H_6.
d) cyclooctadiene

QUESTION 4: **[20]**

4.1 Use the VSEPR model to predict the electron and molecular geometry of the following, molecules & ions: (10)

a) AsH_3
b) OF_2
c) $AlCl_4^-$
d) I_3^-
e) C_2H_4

4.2 The N^{2+} ion can be prepared by bombarding the N_2 molecules with fast moving electrons. Predict the following properties of N^{2+} molecule:

a) Using molecular orbital (MO) theory, the electron configuration. (4)
b) Bond order (2)
c) Magnetic properties (paramagnetic or diamagnetic) (2)
d) Compared to N^{2+} molecule, is the bond order & magnetic properties the same as N_2 molecule? (2)

END OF QUESTION PAPER

LIST OF USEFUL CONSTANTS:

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

$1\ Pa \cdot m^3 = 1\ kPa.L = 1\ N \cdot m = 1\ J$

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

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

Planck's constant, $h = 6.626 \times 10^{-34}\ Js$

Rydberg constant, $R_h = 2.18 \times 10^{-18}\ J$

Speed of light, $c = 2.998 \times 10^{8}\ ms^{-1}$

PERIODIC TABLE OF THE ELEMENTS

1																	18
1 **H** 1.00794	2											13	14	15	16	17	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)