NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH, NATURAL RESOURCES AND APPLIED SCIENCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE	
QUALIFICATION CODE: 07BOSC	**LEVEL:** 6
COURSE CODE: ICH602S	**COURSE NAME:** INORGANIC CHEMISTRY
SESSION: JANUARY 2023	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

SUPPLEMENTARY/SECOND OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER(S)	DR. EUODIA HESS
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

PERMISSABLE MATERIALS

Non-programmable calculators

ATTACHMENTS

1. List of useful constants
2. Periodic Table

THIS QUESTION PAPER CONSISTS OF 8 PAGES (Including this front page, list of useful constants and Periodic Table)

SECTION A: MULTIPLE CHOICE QUESTIONS [40]

- There are 20 multiple choice questions in this section. Each question carries 2 marks.
- Answer ALL questions by selecting the letter of the correct answer.
- Choose the best possible answer for each question, even if you think there is another possible answer that is not given.

1. What are oxidation states of metal ion in following complexes?
   A. $PdCl_2$
   B. $Pd(PPh_3)_4$
   C. $Pd(OAc)_2$
   D. ArPdBr where Ar is aryl

2. Which of the following complex has a highest oxidation state of metal?
   A. $(\eta^6\text{-}C_6H_6)_2Cr$
   B. $Mn(CO)_5C$
   C. $Na_2[Fe(CO)_4]$
   D. $K[Mn(CO)_5]$

3. What is the oxidation state of molybdenum in $[\eta^7\text{-tropylium})\ Mo(CO)_3]^+$?
   A. +2
   B. +1
   C. 0
   D. -1

4. Which of the following is the neutral complex which follows the 18- electron rule?
   A. $(\eta^5\text{-}C_5H_5)Fe(CO)_2$
   B. $(\eta^5\text{-}C_5H_5)2Mo(CO)$
   C. $(\eta^5\text{-}C_5H_5)_2Co$
   D. $(\eta^5\text{-}C_5H_5)2Re(\eta^6\text{-}C_6H_6)$

5. As pure molecular solids, which of the following exhibits dipole-dipole intermolecular forces: HBr, NBr_3, SBr_2, and CBr_4?
   A. HBr only
   B. CBr_4 and NBr_3
   C. HBr and SBr_2
   D. HBr, NBr_3, and SBr_2

6. 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 only
   B. acetaldehyde only
   C. ethanol and acetic acid
   D. dimethyl ether and ethanol

7. When a water molecule forms a hydrogen bond with another water molecule, which atoms are involved in the interaction?
   A. a hydrogen from one molecule and a hydrogen from the other molecule
   B. an oxygen from one molecule and an oxygen from the other molecule
   C. a hydrogen from one molecule and an oxygen from the other molecule
   D. an oxygen and a hydrogen from the same molecule

8. Arrange H_2S, H_2Se, and H_2Te in order from lowest to highest boiling point.
   A. HF < HCl < HBr
   B. HF < HBr < HCl
   C. HCl < HBr < HF
   D. HBr < HF < HCl

9. In any cubic lattice an atom lying at the face of a unit cell is shared equally by how many unit cells?
   A. 2
   B. 1
   C. 4
   D. 8

10. Arrange the three common unit cells in order from least dense to most dense packing.
   A. primitive cubic < body-centered cubic < face-centered cubic
   B. face-centered cubic < body-centered cubic < primitive cubic
   C. primitive cubic < face-centered cubic < body-centered cubic
   D. body-centered cubic < primitive cubic < face-centered cubic

11. If a metal crystallizes in a body-centered cubic lattice, each metal atom has ____ " nearest neighbors."
   A. 8
   B. 6
   C. 4
   D. 2

12. What is the distance, in atomic radii, along any edge of a body-centered cubic unit cell?
    A. $(4 \times r) / \sqrt{3}$
    B. $2 \times r$
    C. $4 \times r$
    D. $(2 \times r) / \sqrt{3}$

13. 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. 62.3 pm
    B. 88.1 pm
    C. 125 pm
    D. 249 pm

14. Rhodium crystallizes in a face-centered cubic lattice with an edge length of 380.1 pm. What is the density of rhodium?
    A. 0.777 g/cm^3
    B. 3.11 g/cm^3
    C. 12.4 g/cm^3
    D. 6.22 g/cm^3

15. Iridium (atomic mass 192.2 g/mol), with an atomic radius of 135.5 pm, crystallizes in a face-centered cubic lattice. What is the density of iridium?
    A. 1.41 g/cm^3
    B. 2.83 g/cm^3
    C. 5.66 g/cm^3
    D. 11.3 g/cm^3

16. Iron crystallizes in the body-centered cubic system. If the edge of the unit cell is 290 pm, what is the radius of a iron atom in picometers?
    A. 504 pm
    B. 402 pm
    C. 672 pm
    D. 126 pm

17. Which of the following statements concerning valence bond (VB) theory is/are CORRECT?
    A. VB theory can describe molecular bonding in excited states
    B. VB theory assumes that electrons are localized between pairs of atoms
    C. VB theory predicts localized lone pairs of electrons
    D. A and B

18. How many sigma (σ) bonds and pi (π) bonds are in carbon monoxide?
    A. three σ, zero π
    B. two σ, one π
    C. two σ, two π
    D. one σ, two π

19. To form a molecule with a tetrahedral electron pair geometry, what set of pure atomic orbitals must be mixed?
    A. one *s* and two *p*
    B. one *s* and three *p*
    C. two *s* and one *p*
    D. one *s* and one *p*

20. What is the hybridization of the central nitrogen atom in N_2O?
    A. sp^2
    B. sp^3
    C. *sp*
    D. None of the above

SECTION B: [60]

There are THREE (3) questions in this section. Answer all Questions.
Show clearly, where necessary, how you arrive at the answer as the working will carry marks to.

Question 1 **[30]**

1.1 Specify the oxidation number of the central metal atom in each of the following compounds: (10)

a) $[Ru(NH_3)_5(H_2O)]Cl_2$
b) $[Cr(NH_3)_6](NO_3)_3$
c) $[Fe(CO)_5]$
d) $K_4[Fe(CN)_6]$
e) $[PtCl_6]^{2-}$

1.2 What are the systematic names for the following ion and compounds? (10)

a) $[cis\text{-}Co(en)_2Cl_2]^+$
b) $[Pt(NH_3)_5Cl]Cl_3$
c) $[Co(NH_3)_5Cl]Cl_2$
d) $[Cr(en)_3]Cl_2$
e) $NaAuF_4$

1.3 Write the formulas for the following compounds: (10)

a) bis(ethylenediamine)dichlorochromium(III)
b) pentacarbonyliron(0)
c) potassium tetracyanocuprate(II)
d) tetraammineaquachlorocobalt(III)chloride
e) sodium hexanitrocobaltate(III)

Question 2 **[20]**

2.1 What kind of intermolecular/attractive forces must be overcome to in order to: (3)

a) melt ice

b) boil molecular bromine

c) melt solid iodine

2.2 Calculate the number of spheres (atoms per unit cell) that would be found within a simple cubic, a body and a face-centered cubic cell? Assume the spheres are the same. (6)

2.3 When silver crystallizes, it forms face-centered cubic cells. The unit cell edge length is 409 pm. Calculate the density of silver. (8)

2.4 What are the different types of crystalline structures (crystals)? (3)

Question 3 **[10]**

3.1 Do $[IrBr_2(CH_3)(CO)(PPh3)]$ and $[Cr(\eta^5\text{-}C_5H_5)(C_6H_6)]$ obey 18-electron rule? Show your working. (6)

3.2 Give the formal names of ferrocene and $[RhMe(PMe_3)_4]$ (4)

END OF EXAMINATION

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)