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QUALIFICATION : **BACHELOR OF SCIENCE**	
QUALIFICATION CODE: **07BOSC**	LEVEL: **6**
COURSE: **INORGANIC CHEMISTRY**	COURSE CODE: **ICH602S**
DATE: **JANUARY 2025**	SESSION: **1**
DURATION: **3 HOURS**	MARKS: **100**

SECOND 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

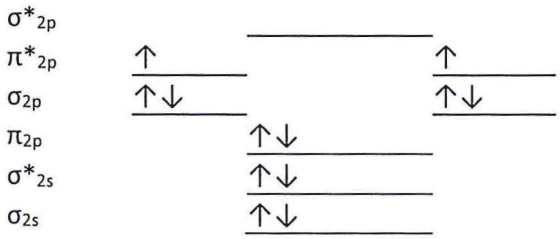
SECTION A: MULTIPLE CHOICE [40 MARKS]

QUESTION 1:

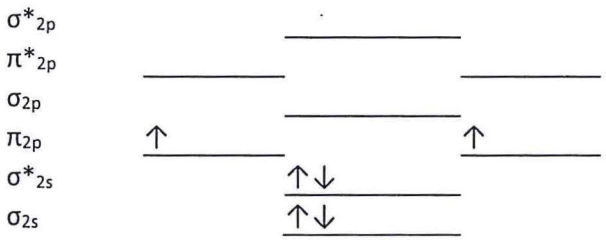
There are 20 multiple choice questions in this section. Each question carries 2 marks.

1. What is the maximum oxidation state expected for manganese?
   A. +7
   B. +6
   C. +5
   D. +8
2. Which of the following salts would not be expected to have unpaired d-electrons?
   A. $CdCl_2$
   B. $NiCl_2$
   C. $MnCl_2$
   D. $CoCl_2$
3. Ions such as $[Co(H_2O)_6]^{3+}$ and $[Ag(CN)_2]^-$ are called ____.
   A. Ligands
   B. Coordination complexes
   C. Chelates
   D. Lewis bases
4. What is the oxidation state of molybdenum in $[Mo(H_2O)_5OH]Cl_2$?
   A. +2
   B. +3
   C. +6
   D. +5
5. What is the coordination number of the transition metal ion in $[Ni(NH_3)_6]Cl$?
   A. 4
   B. 6
   C. 3
   D. 2
6. What is the hybridization of the central atom in a molecule with a tetrahedral molecular geometry?
   A. sp^2
   B. sp
   C. sp^3
   D. sp^3d
7. What is the hybridization of each carbon atom in benzene, C_6H_6?
   A. sp
   B. sp^2
   C. sp^3
   D. sp^4
8. For which of the following molecules does the carbon atom have sp^3 hybridization?
   A. Cl_2CO
   B. CO
   C. CS_2
   D. CH_2Cl_2

9. What is the molecular geometry around a central atom that is sp^2 hybridized, has three sigma bonds, and one pi bond?
   A. trigonal-planar
   B. trigonal-pyramidal
   C. square planar
   D. T-shaped
10. Which of the following concerning σ and π bonds is/are correct?
   A. Pi bonds are formed from unhybridized p orbitals
   B. Both A and D
   C. Sigma bonds may only be formed from unhybridized orbitals Pi bonds are formed from unhybridized p orbitals
   D. A pi bond has an electron distribution above and below the bond axis
11. A molecular orbital that decreases the electron density between two nuclei is said to be ____.
   A. Hybridized
   B. Bonding
   C. pi-bonding
   D. antibonding
12. The following valence molecular orbital energy level diagram is appropriate for which one of the listed species?

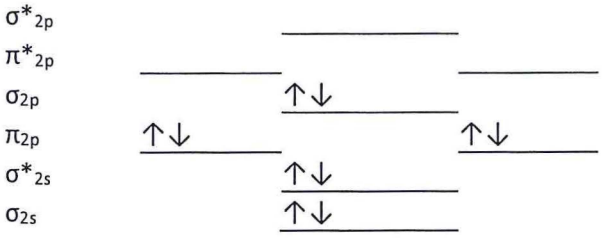


   A. F_2^{2+}
   B. C_2^{2+}
   C. Br_2^{2+}
   D. N_2^{2+}
13. Which molecule will have the following valence molecular orbital energy level diagram?



   A. B_2
   B. Be_2
   C. N_2
   D. O_2

14. Which molecule will have the following valence molecular orbital level energy diagram?



A. N_2
B. C_2
C. O_2
D. B_2

15. Which of the following correctly describes the states of matter and intermolecular forces?
A. The change in volume that accompanies the conversion of a liquid to a gas can be very large.
B. The change in volume that accompanies the conversion of a liquid to a solid is small.
C. The forces of attraction between molecules in the liquid and solid state correlate with melting point, boiling point, and the energy of phase changes.
D. All of the above

16. Which one of the following molecules will exhibit dipole-dipole intermolecular forces as a pure liquid or solid?
A. CS_2
B. C_2H_2
C. $SiCl_4$
D. NH_3

17. Which of the following bonds can potentially contribute to the formation of a hydrogen bond in a solid or liquid?
A. Ge-H
B. Si-H
C. I-H
D. N-H

18. Hydrogen bonding is present in all of the following molecular solids **EXCEPT** ____.
A. H_2SO_4
B. CH_3OH
C. HF
D. CH_3OCH_3

19. As pure molecular solids, which of the following exhibit only induced dipole/induced dipole forces: CO_2, CH_2Cl_2, and SO_2?
A. CO_2 only
B. CH_2Cl_2 only
C. CO_2 and CH_2Cl_2
D. SO_2 only

20. What intermolecular force or bond is primarily responsible for the solubility of carbon monoxide (CO) in water?
A. dipole/induced dipole force
B. dipole-dipole force
C. hydrogen bonding
D. ion-induced dipole force

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 Give the electron count of the following complexes and state whether they obey the 18-electron rule or not. (6)

a) $[Ni(\eta^3\text{-}C_3H_5)_2]$

b) $[Co(\eta^3\text{-}C_3H_5)(CO)_2]$

2.2 What are the names of the following organometallic complexes? (4)

a) $Rh(Me)(CO)_2(PPh_3)]$

b) $[V(CO)_6]$

2.3 Name each of the following compounds and give their electron count. (10)

a) $[Fe(CO)_5]$

b) $[Mn_2(CO)_{10}$

c) $[V(CO)_6]$

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

e) $Rh(Me)(CO)_2(PPh_3)]$

QUESTION 3: **[20]**

3.1 Write the systematic names of the following coordination compounds (6)

a) $NaAuF_4$

b) $K_3[Fe(CN)_6]$

c) $[Cr(en)_3]Cl_3$

3.2 What are the geometries of the following two complexes (4)

a) $[AlCl_4]^-$

b) $[Ag(NH_3)_2]^+$

3.3 Write the formula of each of the following coordination compounds (10)

a) Tetraammineplatinum(II) chloride

b) Sodium hexacyanoferrate(III)

c) Tris(ethylenediamine)platinum(IV) sulfate

d) Diamminesilver(I) nitrate

e) Potassium diaquadioxalatocobaltate(III)

QUESTION 4: **[20]**

4.1 Draw the Molecular Orbital (MO) energy diagram for the following molecules and calculate their bond orders.

a) He_2 (5)

b) C_2 (5)

4.2 Arrange the following in order of increasing stability by using MO energy diagram and writing their respective electron configuration. (10)

Li_2 ; Li_2^+ ; Li_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)