



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: NOVEMBER 2022	PAPER: THEORY
DURATION: 3 HOURS	MARKS: 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER(S)	DR. EUODIA HESS
MODERATOR:	PROF HABAUKA KWAAMBWA

<p style="text-align: center;">INSTRUCTIONS</p> <ol style="list-style-type: none">1. Answer ALL the questions.2. Write clearly and neatly.3. Number the answers clearly4. All written work must be done in blue or black ink and sketches can be done in pencil5. No books, notes and other additional aids are allowed
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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 constants and periodic table)

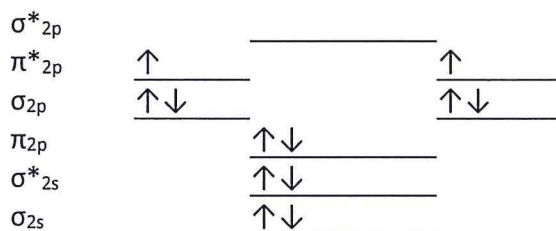
QUESTION 1: Multiple Choice Questions

[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.*

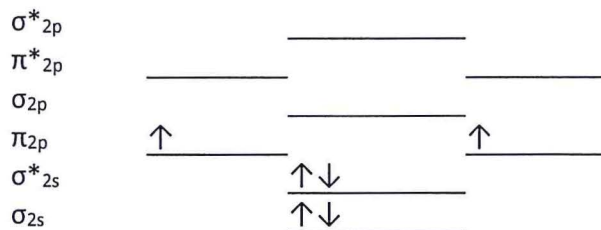
1. Which of the following ranks regions of the electromagnetic spectrum in proper order from highest to lowest frequency.
 - A. radio > x-rays > gamma rays > visible > microwaves
 - B. gamma rays > x-rays > visible > microwaves > radio
 - C. microwaves > gamma rays > x-rays > visible > radio
 - D. x-rays > gamma rays > microwaves > visible > radio
2. Which of the following regions of the electromagnetic spectrum has the lowest frequency?
 - A. x-ray
 - B. gamma ray
 - C. ultraviolet
 - D. infrared
3. A device emits light at 244.4 nm. What is the frequency of this radiation?
 - A. 1.23×10^{15} Hz
 - B. 8.14×10^{-37} Hz
 - C. 8.14×10^{-19} Hz
 - D. 3.69×10^{26} Hz
4. What is the wavelength of a photon that has an energy of 3.097×10^4 J?
 - A. 3.1×10^{13} nm
 - B. 6.42×10^{-21} nm
 - C. 9.29×10^{21} nm
 - D. 6.16×10^{12} nm
5. What is the wavelength of light emitted when the electron in a hydrogen atom undergoes a transition from level $n = 8$ to level $n = 2$?
 - A. 1.7×10^{-27} kJ/mol
 - B. 2.57×10^6 kJ/mol
 - C. 5.11×10^{-19} kJ/mol
 - D. 3.89×10^{-7} kJ/mol
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 ?
- sp
 - sp^2
 - sp^3
 - sp^4
8. For which of the following molecules does the carbon atom have sp^3 hybridization?
- Cl_2CO
 - CO
 - CS_2
 - 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?
- trigonal-planar
 - trigonal-pyramidal
 - square planar
 - T-shaped
10. Which of the following concerning σ and π bonds is/are correct?
- Pi bonds are formed from unhybridized p orbitals
 - Both A and D
 - Sigma bonds may only be formed from unhybridized orbitals Pi bonds are formed from unhybridized p orbitals
 - 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 ____.
- Hybridized
 - Bonding
 - pi-bonding
 - antibonding
12. The following valence molecular orbital energy level diagram is appropriate for which one of the listed species?



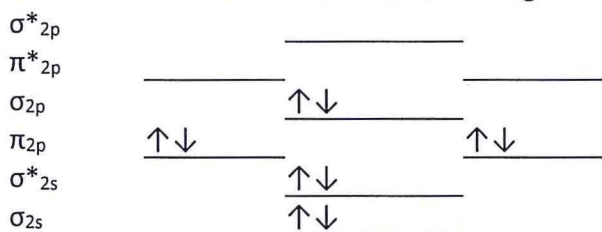
- F_2^{2+}
- C_2^{2+}
- Br_2^{2+}
- N_2^{2+}

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?
- Ge-H
 - Si-H
 - I-H
 - N-H
18. Hydrogen bonding is present in all of the following molecular solids EXCEPT ____.
- H₂SO₄
 - CH₃OH
 - HF
 - CH₃OCH₃
19. As pure molecular solids, which of the following exhibit only induced dipole/induced dipole forces: CO₂, CH₂Cl₂, and SO₂?
- CO₂ only
 - CH₂Cl₂ only
 - CO₂ and CH₂Cl₂
 - SO₂ only
20. What intermolecular force or bond is primarily responsible for the solubility of carbon monoxide (CO) in water?
- dipole/induced dipole force
 - dipole-dipole force
 - hydrogen bonding
 - ion-induced dipole force

SECTION B: _____ **[60]**

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

Question 1 _____ **[22]**

1.1 Name the species and give the valence electron counts to the metal atoms in: _____ (10)

- [Fe(CO)₅]
- [Mn₂(CO)₁₀]
- [V(CO)₆]
- [Fe(CO)₄]²⁻
- Rh(Me)(CO)₂(PPh₃)

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

- C₂H₄
- cyclopentadienyl
- C₆H₆
- cyclooctadiene
- cyclooctatetraene

- 1.3 Give the electron count of: (4)
- a) $[\text{Ni}(\eta^3\text{-C}_3\text{H}_5)_2]$
 - b) $[\text{Co}(\eta^3\text{-C}_3\text{H}_5)(\text{CO})_2]$

Question 2 [30]

- 2.1 Decide which type of intermolecular forces is involved in: (6)

- a) O_2
- b) CH_3OH
- c) N_2 in H_2O

- 2.2 The molar enthalpy of vaporization of methanol is 35.2 kJ/mol at 64.6°C . How much energy is required to evaporate 1.00 kg of methanol at 64.6°C ? (3)

- 2.3 Gold has a face centered unit cell and its density is 19.32 g/cm^3 . Calculate the radius of gold atom. (10)

- 2.4 Iron has a density of 7.8740 g/cm^3 and the radius of an iron atom is 126 pm . Verify that solid iron has a body-centered cubic unit cell. (10)

- 2.5 A soft waxy solid melts over a temperature range from 120°C to 130°C . It doesn't dissolve in water and does not conduct electricity. These properties are consistent with its identity as a _____ solid. (1)

Question 3 [8]

Define Hard and Soft acids and bases (HSAB) theory. How would you characterize hard acids and bases?

THE END

GOODLUCK

USEFUL CONSTANTS:

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

$1 \text{ Pa} \cdot \text{m}^3 = 1 \text{ kPa} \cdot \text{L} = 1 \text{ N} \cdot \text{m} = 1 \text{ J}$

$1 \text{ atm} = 101\,325 \text{ Pa} = 760 \text{ mmHg} = 760 \text{ torr}$

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

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

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

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

PERIODIC TABLE OF THE ELEMENTS

1																	18
1 H 1.00794																	2 He 4.00260
3 Li 6.941	4 Be 9.01218											13 B 10.81	14 C 12.011	15 N 14.0067	16 O 15.9994	17 F 18.9984	18 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

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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
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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)
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