



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF APPLIED SCIENCE
DEPARTMENT OF APPLIED CHEMISTRY
INORGANIC CHEMISTRY FOR ENGINEERS
SCH 1241

SECOND SEMESTER EXAMINATION PAPER

SEPTEMBER 2024

This examination paper consists of 5 pages

Time Allowed: 3 hours
Total Marks: 100
Special Requirements: Periodic Table, Data Booklet
Internal Examiner: Miss E. Bere
External Examiner: PROF G. MEHLANA

INSTRUCTIONS

1. Answer **ALL** questions from **Section A** and **ANY THREE** questions from **Section B**.
2. Section A carries 40 marks and each question in Section B carries 20 marks.
3. Use of calculators is permissible

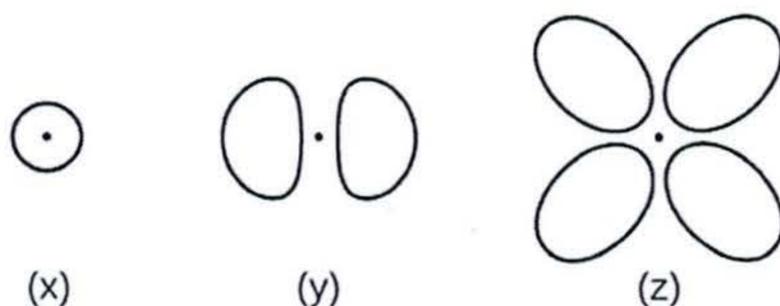
MARK ALLOCATION

QUESTION	MARKS
1.	40
2.	20
3.	20
4.	20
5	20
TOTAL	100

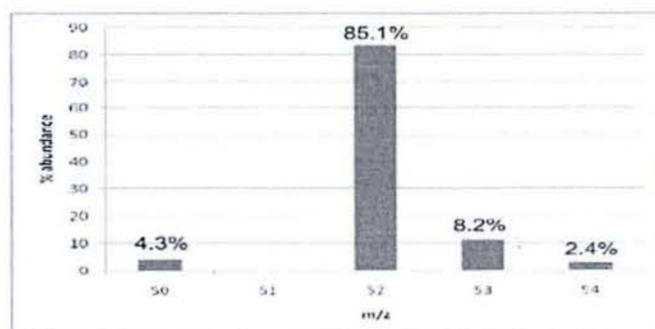
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SECTION A

- 1 a) i) Define the term *ionization energy*
 ii) Using Sodium as an example, and Slater's rule, show how the effective nuclear charge affects the size of a cation when compared to the parent atom. [6]
- b) Consider the orbitals shown in outline below;



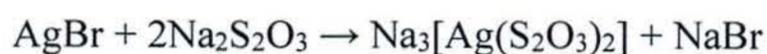
- i) What are the possible l and m values for each type of orbital?
 ii) How many orbitals of each type are found in a shell with $n = 2$? [9]
- c) If electrical conductors are atoms with 1-3 valence electrons, semiconductors 4 and insulators have 5 or more valence electrons, use the electronic configurations of the following elements to determine whether they are conductors, semiconductors or insulators;
 Ba, Al, Te, Be, C, P, Sc, W, B, and Rb [10]
- d) The mass spectrum below is of a sample of chromium extracted from a rock recently found in a rural village. Scientists believe it may be from a meteor. Use the mass spectrum to determine the relative atomic mass of the chromium in the rock. Based on your result, is the rock sample from outer space?



[3]

- e) An electron moves from the $n = 5$ to the $n = 1$ quantum level and emits a photon with an energy of 2.093×10^{-18} J.
 i) How much energy must the atom absorb to move an electron from $n = 1$ to $n = 5$?
 ii) What is the wavelength of this energy

- iii) what series does this represent and where in the electromagnetic spectrum would you observe this transition? [5]
- f) When photographs are being developed, under composed AgBr is washed with hypo solution and a complex is formed:



Name the complex formed and determine the coordination number of the central atom. [2]

- g) For the complex $[\text{Fe}(\text{en})_2\text{Cl}_2]\text{Cl}$,
- name of the complex
 - determine the magnetic behavior
 - using appropriate diagrams, identify the number of geometrical and optical isomers the complex has. [5]

[Total 40 marks]

SECTION B

2. Give the name and find the ligand field stabilization energy (in terms of Δ_q) for the complexes below. Are any of them Jahn Teller active?

- $[\text{Cr}(\text{NH}_3)_6]^{3+}$
- $[\text{Cu}(\text{NH}_3)_4(\text{OH}_2)_2]^{2+}$
- $[\text{Ti}(\text{OH}_2)_6]^{3+}$
- $[\text{Co}(\text{CN})_6]^{3-}$
- $[\text{Ni}(\text{NH}_3)_4\text{Cl}_2]$

[20]

[Total 20 marks]

3. a) Describe the valency bond theory (VBT) and explain its advantages and limitations in explaining how bonds are formed. [10]

- b) Describe the hybridization and shapes of the following:

- CO_3^{2-}
- $\text{Si}(\text{CH}_3)_4$
- CH_3NH_2
- CCl_4
- SI_6

[10]

[Total 20 marks]

4. Use molecular orbital theory to predict whether or not each of the following molecules should exist in a relatively stable form.

- He_2
- Be_2
- B_2
- Na_2
- C_2

[20]

[Total 20 marks]

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5. a) Using the complex $[\text{Ni}(\text{CN})_4]^{2-}$ and partial orbital diagrams, discuss the hybridization model for bond formation. What are the advantages and limitations of this model? [8]
- b) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ is strongly paramagnetic whereas $[\text{Fe}(\text{CN})_6]^{3-}$ is weakly paramagnetic. Explain [3]
- c) The molecules SiF_4 , SF_4 , and XeF_4 all have the same molecular formula AX_4 yet they have different geometries. Draw feasible Lewis diagrams and predict the shapes of each molecule and explain why the shapes are different. [9]
- [Total 20 marks]**

END OF QUESTION PAPER

GENERAL DATA AND FUNDAMENTAL CONSTANTS

$1 \text{ amu} = 1.6606 \times 10^{-24} \text{ g}$	$1 \text{ electron volt} = 1.6022 \times 10^{-19} \text{ J}$ $= 96.485 \text{ kJ mol}^{-1}$
$N_A = 6.022 \times 10^{23} \text{ particles mol}^{-1}$	$\pi = 3.1416$
$R = 0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$ $= 1.987 \text{ cal mol}^{-1} \text{ K}^{-1}$ $= 8.3145 \text{ J mol}^{-1} \text{ K}^{-1}$ $= 8.3145 \text{ kPa dm}^3 \text{ mol}^{-1} \text{ K}^{-1}$	$R_H = 1.09737 \times 10^7 \text{ m}^{-1}$ $= 1.09737 \times 10^5 \text{ cm}^{-1}$ (Rydberg constant)
$h = 6.6262 \times 10^{-34} \text{ J s.}$ $= 6.6262 \times 10^{-27} \text{ erg s.}$	$m_e = 9.10938 \times 10^{-31} \text{ kg}$
$C = 2.9979 \times 10^8 \text{ m s}^{-1}$.	$F = 9.64853 \times 10^4 \text{ C mol}^{-1}$
$e = 1.60219 \times 10^{-19} \text{ coulomb}$	$\epsilon_0 = 8.85419 \times 10^{-12} \text{ J}^{-1} \text{ C}^2 \text{ m}^{-1}$
	$4\pi\epsilon_0 = 1.11265 \times 10^{-10} \text{ J}^{-1} \text{ C}^2 \text{ m}^{-1}$

Periodic Table of the Elements

1 H 1.0																	2 He 4.0
3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.2
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.8	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La* 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac† (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Uuu (272)	112 Uub (285)		114 Uuq (289)		116 Uuh (289)		

	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
	† 90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	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)	103 Lr (260)

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