UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF CHEMICAL SCIENCES
DIPLOMA IN ANALYTICAL CHEMISTRY

MODULE CET2B15/CETI3B3
INORGANIC CHEMISTRY 3

CAMPUS **DFC**

JANUARY EXAMINATION

DATE: 09/01/2019 **SESSION: 8:00 – 11:00**

ASSESSORS **PROF. SO OLUWAFEMI**
PROF. R.M. MOUTLOALI

EXTERNAL MODERATOR **PROF. N. MOLOTO**

DURATION 3 HOURS **MARKS: 160**

NUMBER OF PAGES: …5. PAGES AND 1 ANNEXURE

INSTRUCTIONS: 1. Answer section A and section B on separate answering sheets.

2. Calculators are permitted (ONLY ONE PER STUDENT).

3. Make use of Chemical symbols, diagrams and balanced equations wherever possible.

4. Do not write in the margins

SECTION A

QUESTION 1 THEORIES OF BONDING

1.1 Using the valence shell electron repulsion theory (VSEPR) and valence bond theory (VBT) determine the geometry, bond angle and give the name of the shape for the following molecules or ion.

1.1.1 IF_2^- (3)

1.1.2 SiF_6^{2-} (3)

1.1.3 $BrCl_5$

1.2 Using the Valency Bond theory show the formation of Bond 1.1.2 above.. (3)

1.3 Using the concept of Molecular Orbital Theory (MOT), answer the questions below for the following molecules; (A) CN and (B) NO (5)

1.3.1 Write the electronic configuration for the molecules in 1.3 using the MOT concept. (2)

1.3.2 Determine the magnetism of the molecules in 1.3. (2)

1.3.4 Determine the bond order for the molecules in 1.3. (2)

1.3.4 Which of the species in 1.2.1 will have the higher bond energy? Give reason for your answer. (4)

1.4 Which of the following molecules will have a lower bond angle? Give reason (s) for your answer. H2O and H2S. (5)

1.5. Using the concept of delocalised π- bonding under molecular orbital theory, show that the C-O bonds in CO_3^{2-} has a bond order of $1\frac{1}{3}$. (8)

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QUESTION 2 CRYSTAL AND LIGAND FIELD THEORY

2.1 The magnetic moment value of $[Mn(CO)_4]^{2+}$ ion is square root of 15 ($\sqrt{15}$). On the basis of Valency Bond Theory (VBT), predict the type of hybridization and geometry of the ion. (7)

2.2 State Jahn-Teller theorem. (1)

2.3 Give two reasons why Δo is bigger than Δt. (2)

2.4 With the aid of a pictorial diagram, write short note on tetragonal contraction along the x-y axis of an octahedron complex. (5)

QUESTION 2 continued

2.5 With your knowledge of crystal field theory (CFT) and the molecular orbital theory (MOT) for complexes, state the difference between $[Cr(NH_3)_6]^+$ and $[CrF_6]^{5-}$ using their (A) Electronic configuration (in MOT) and (B) Stability. (4)

2.5.1 What is the reason for your answer in 2.4 B ? (2)

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QUESTION 3 COORDINATION CHEMISTRY

3.1 Write the formula for the following complexes: (5)

3.1.1 Bis(ethylenediamine)diaquochromium(iii) bromide

3.1.2 Tetraaminesulphatocobalt(III) nitrate

3.1.3 Tetraammineoxalatomanganese(iv) sulphate

3.1.4 Potassium pentachoronitridoosmate(VI)

3.1.5 Tetrapyridineplatinum (II) tetrabromoplatinate (II)

3.2 Give the name of the following complexes: (5)

3.2.1 $K_2[Cr(CN)_2O_2(O_2)NH_3]$

3.2.2 $[(NH_3)_5Co\ (NH_2)_2\ Co(NH_3)_5](Cl)_4$

3.2.3 $[Pt(H_2NCH_2CH_2NH_2)_2Cl_2]SO_4$

3.2.4 $Na[Co(F)_2\ O_2(O_2)\ H_2O]$

3.2.5 $[Pt(NH_3)_4][PtCl_4]$

3.3 Determine if $[Na[Co(F)_2\ O_2(O_2)\ H_2O]$ obeys the effective atomic number (EAN) rule or not and give reason for your answer? (3)

3.3.1 Determine the magnetism and magnetic moment of the compound in 3.3 above (2)

3.4 With the aid of an example write a short note on (A) Coordination Isomerism and (B) Ionization isomerism (4)

3.5 Give three advantages of using porphyrins as photosensitiser in photodynamic therapy applications. (3)

3.6 Describe a simple laboratory test to confirm the primary valency in $[Cr(NH_3)_6]Br_3$ is three. (2)

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SECTION B

QUESTION 4: CHEMISTRY OF THE FIRST TRANSITION SERIES

4.1 Suggest reasons for the following features of transition metal chemistry;

4.2.1. The lowest oxide of a transition metal is basic whereas the highest oxide is usually acidic. (3)

4.2.2. A transition element usually exhibit higher oxidation in its flourides than in its iodides. (3)

4.2.3. The halides become more covalent with increasing oxidation state of the metal. (3)

4.2. Explain the following with respect to transition elements:

4.2.1 Why Zn, Cd and Hg are not considered transition metals. (3)

4.2.2. Explain why Mn displays the highest number of oxidation states compared to Sc. (4)

4.3 The electronic configuration of the free manganese and copper atoms are [Ar]$3d^5 4s^2$ and [Ar]$3d^1 04s^1$. What are the configurations of the free ions Mn^{4+} and Cu^{3+}? (4)

4.4.1. Vanadium(V) oxide is reduced to vanadium(IV) oxide by thermal reduction with gaseous sulphur dioxide. (3)

4.4.2. Vanadium(V) oxide is reduced by magnesium in acid solution to give a green solution of vanadium(III). (3)

4.3.1. List the known oxidation states of titanium. (2)

4.3.2 Write an equation to illustrate the disproportionation of titanium(III) chloride. (3)

4.3.3. What titanium salt is used as catalyst in the polymerisation of alkenes. What is the name for this catalyst? (2)

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QUESTION 5: TRANSITION METAL EXTRACTION

5.1 What are the purposes of “flotation” and “roasting” in the recovery of metals from their ores? (5)

5.2. Explain how pure chromium can be obtained from chromite (FeCr2O4). (10)

5.3. The most important example of the reduction of an oxide ore is the extraction of iron. Reduction of the ore takes place in a blast furnace. The furnace is loaded with the ‘charge’ consisting of iron ore, coke and limestone. A series of chemical reactions take place to produce molten iron.

QUESTION 5: continued

5.3.1 Give balanced chemical equations for the series of reactions that take place and indicate the temperatures at which these reactions take place. (8)

5.3.2. One of the major impurities in iron ore is sand (silica, SiO2). Explain how this impurity can be removed. (3)

5.4. South Africa possess one of the highest percentage of Vanadium reserves in the world giving rise to several industries.

5.4.1. Discuss the industrial uses of vanadium (4)

5.4.2. Explain why Vanadium has high melting temperature and readily conducts heat. (2)

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QUESTION 6: GROUP IB – THE COINAGE METALS

6.1 Give two reasons why Cu, Ag and Au tend to be noble.. (2)

6.2 Explain why Au does not dissolve in HNO_3 solution or HCl solution alone but it dissolves in aqua regia. Give a balanced equation to show how the metal dissolves.. (4)

6.3 During the production of gold the ore is ground to a fine slime in sodium cyanide solution and aerated by agitation for 2 days. Write the balanced chemical reaction equation to illustrate this process.. (2)

6.4 $AgNO_3$ is one of the most important silver salts. Explain how this salt is used in qualitative analysis to test for the halide ions. (4)

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QUESTION 7: GROUP IIB – ZINC, CADMIUM AND MERCURY

7.1 Zn, Cd and Hg show few of the properties associated with typical transition elements.

7.1.1 Explain why these elements do not behave as typical transition elements. (2)

7.1.2 Give three general properties of these elements that confirm the fact that they do not behave as typical transition metals. (3)

7.2 Write a balanced equation to illustrate the amphoteric nature of zinc oxide. (4)

7.3 What happens when H_2S gas is bubbled through an acidified solution containing Cd^{2+} and Zn^{2+} ions? (2)

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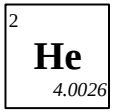
TOTAL MARKS = 160
FULL MARKS = 160

UNIVERSITY OF JOHANNESBURG
Department of Applied Chemistry

Atomic Number



Atomic Weight

1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.03	89 Ac 227.03															

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 146.92	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (234)	96 Cm (247)	97 Bk 247	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)