UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF CHEMICAL TECHNOLOGY
NATIONAL DIPLOMA: ANALYTICAL CHEMISTRY

MODULE CET2B15
INORGANIC CHEMISTRY 3

CAMPUS **DFC**

NOVEMBER EXAMINATION

DATE: 17/11/2019 **SESSION: 12:30 – 15:30**

ASSESSORS **PROF. SO OLUWAFEMI**
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EXTERNAL MODERATOR **PROF. N. MOLOTO**

DURATION 3 HOURS **MARKS: 160**

NUMBER OF PAGES: ….7 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

2/…

SECTION A

QUESTION 1 THEORIES OF BONDING

1.1 Arrange the following molecules in decreasing order of bond angle? Give reason (s) for your answer. NH_3, CH_4 and H_2S. (5)

1.2. Using the concept of Molecular Orbital Theory (MOT), draw the molecular orbital diagram for the following:

1.2.1 CN and NO (6)

1.2.2 Determine the bond order for the species in 1.2.1. (2)

1.2.3 Which of the species in 1.2.1 will have the lower bond length? Give reason for your answer (4)

1.3 Using the valence shell electron repulsion theory (VSEPR) and valence bond theory (VBT) determine the region of electron density, hybridization and give the name of the shape for the following molecules or ion

1.3.1 BrF_5 (3)
1.3.2 ClF_3 (3)

1.4 Using the Valency bond theory show the formation of Bond in 1.3.2 above. (3)

1.4.4 Using the delocalized π bonding show that the bond order of the C-O bond in Carbon (IV) oxide (CO_2) is 2. (9)

[35]

QUESTION 2 CRYSTAL AND LIGAND FIELD THEORY

2.1 The enthalpy of hydration of Fe^{2+} ion is -11.4 Kcal/mol higher than that expected in the absence of CFSE. Assume that the complex is $[FeCl_6]^{4-}$ calculate;

2.1.1. The value of Δo for this ion. (5)
2.1.2 The magnetic moment of the complex. (2)

2.2 State Jahn-Teller theorem. (1)

2.2.1 With the aid of ***pictorial diagram only***, show tetragonal contraction along the x-y axis of an octahedron complex. (1)

2.3 Using Crystal field theory (CFT) give a detailed explanation of the geometry of $[Pt(NH_3)_4]^{2+}$ discussing any distortion that might occur in the complex. (6)
2.3.1 Based on your answer in 2.4, what is the magnetic moment of the Pd^{2+}? (1)

2.4 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) Reactivity (4)

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

2.5Write short note on π-donor ligands (3)

[25]

QUESTION 3 COORDINATION CHEMISTRY

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

3.1.1 $[Cu(H_2O)_6]$ $[Pb(CN)_3]_2$
3.1.2 $K_2[Cr(CN)_2O_2(O_2)NH_3]$
3.1.3 $[Pd(H_2NCH_2CH_2NH_2)_2SO_4](NO_3)_2$
3.1.4 $[(NH_3)_5Co\ NH_2\ Co(NH_3)_5](Cl)_5$
3.1.5 $Mg[AuCl_5]$

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

3.2.1 Triamine trichloro platinum (IV)trifluoro platinate (II)
3.2.2 Bis(ethylenediamine)diaquochromium(iii) bromide
3.2.3 Tetraamine diaquo cobalt (iii) phosphate
3.2.4 Tri-μ-amine bis[triaquo iron(0)]
3.2.5 Tetraaminesulphatocobalt(III) nitrate

3.3 Determine if $[CrBr_2(en)_2]NO_3$ 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 Heme and chlorophyll are naturally occurring porphyrinic molecules that are present in hemoglobin and green plants respectively. Give the name of the metal ion that is present in each of this molecule. (2)

3.5 Photodynamic therapy (PDT) is a non-invasive clinical method that is commonly used for the treatment of malignant tumours and cancer. Give three essential components of PDT. (3)

[20]

SECTION B

QUESTION 4: CHEMISTRY OF THE FIRST TRANSITION SERIES

4.1 Transition metals have an incomplete filled d-level. Discuss the effect that this has on their oxidation states and how this may affect the type of bonding involved in their compound formation.. (8)

4.2. Explain the following with respect to transition elements:

4.2.1 Explain the tendency of transition element electrons to participate in bonding decreases once the d^5 configuration is exceeded, e.g. from Fe to Zn?. (4)

4.2.2. Explain why transition elements tend to form many complexes compared to the s- and p-block elements. (4)

4.3 Titanium is a commercially important element. Vast quantities of TiO_2 are used as a pigment and filler, and titanium metal is important for its strength, low density and corrosion resistance.

4.3.1 Explain why Zn^{2+} and Ti^{4+} is colourless or white.. (4)

4.3.2 List at least one area in the country where titanium is mined and where there is potential for its mining. (2)

4.3.3. What titanium salt is used as catalyst in the polymerisation of alkenes. (1)

4.3.4 What is the catalyst in Question 4.3.4 called and at which company is this process widely used? (1)

4. A metallurgist wanted to use nickel hydroxide as a source of nickel metal.

4.4.1. What products would you expect from calcination of this substance? (2)

4.4.2 Under what conditions might roasting produce nickel metal? (2)

4.4.3. Write balanced chemical reactions for the processes described in Questions 4.4.1 and 4.4.2. (4)

[32]

QUESTION 5: TRANSITION METAL EXTRACTION

5.1 One of the main deposits of iron, is the pyrite, also known as Fool's gold.

5.1.1 Differentiate between an ore and an alloy (2)

5.1.2. Using appropriate equations, write the three main process that occurs within the blast furnace during the extraction of iron. (8)

5.1.3. Write the balanced equations for the decomposition of calcium carbonate within the blast furnace. (1)

5.2. The first step in the Kroll process is the conversion of the ore to liquid titanium chloride, write balanced reaction equations for the two main titanium ores reacting with carbon in the presence of chlorine gas. (8)

5.3. Metals are removed from their sulphide ores by a combination of roasting followed by reduction with carbon. This is a method used for a number of transition elements.

5.3.1 Explain the differences between “smelting” and “roasting” means. (3)
5.3.2 Give balanced equations to illustrate the removal of zinc metal from its sulphide ore through the roasting method. (4)

5.4. South Africa possess one of the highest percentage of Vanadium reserves in the world giving rise to several industries.
5.4.1 State why it is difficult to produce pure vanadium. (2)
5.4.2. Why is there no demand for pure Vanadium in industry? (2)
5.4.3. Discuss the industrial uses of vanadium (4)
[**34**]

QUESTION 6: GROUP IB – THE COINAGE METALS

6.1 During the production of gold the ore is ground to a fine slime in sodium cyanide solution and aerated by agitation for 2 days.
6.1.1 Write a balanced chemical reaction for the dissolution of gold by cyanide solution. (2)
6.1.2 What does 12 carat mean for gold alloys? (1)

6.2 Give *balanced* chemical equations to represent the following observations:
6.2.1 The roasting of chalcopyrite in air. (2)
6.2.2 KI is added to a solution containing Cu^{2+}. (2)

6.3 $AgNO_3$ is one of the most important silver salts. Explain how this salt is used in qualitative analysis to test for the halide ions. (4)
[11]

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 Explain the differences between the three processes used to coat iron (steel) with zinc. (3)

7.3 Give two uses of Zn metal. (2)

[10]

TOTAL MARKS = 160
FULL MARKS = 160

UNIVERSITY OF JOHANNESBURG

Department of Applied Chemistry

Atomic Number 2 **He** *4.0026* 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)*