CHUKA UNIVERSITY

UNIVERSITY EXAMINATIONS

RESIT/SPECIAL EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDUCATION (SCIENCE)

CHEM 313: COORDINATION CHEMISTRY

STREAMS: **TIME: 2 HOURS**

DAY/DATE: TUESDAY 02/02/2021 **8.30 A.M – 10.30 A.M**

INSTRUCTIONS:

Answer QUESTION ONE and any other TWO questions

QUESTION ONE [30MARKS]

[a]. (i). Define the term transition element and explain why scandium and zinc may strictly not be treated as transition elements. [2 marks]

(ii). List any three characteristic properties of transition elements [3 marks]

[b]. (i). Define the term exchange energy. [1 mark]

(ii). The magnitude of exchange energy can be calculated using the following equation

$$E^x = \sum \frac{N(N-1)}{2} K^x$$

Define all the terms in the equation and calculate the relative exchange energies for

a Mn^{2+} and Cu^{2+} ions [3marks]

[c]. (i).A metal **complex ion** is found in which the **coordination number** is six, with four H_2O and two NH_3 **ligands** . Define the underlined phrases in this sentence. [3marks]

(ii) Illustrating with an example in each case differentiate between a soft and a hard base. Which of the ligands stabilize high and low oxidation states of the metal ions and why? [3marks]

[d].(i) Discuss briefly the main ideas of Werner's theory of coordination compounds.[4marks]

(ii) A student isolated a set of three nickel complexes. To identify the complexes, the student titrated them with a solution of silver nitrate and discovered that different amounts of silver chloride were precipitated. The student also measured the molar conductance of the complexes and established that different numbers of ions are present in each complex. The student tabulated the experimental data as given below

Complex	Moles of AgCl Precipitated by $AgNO_3$	Number of ions present	Remarks
(i). $NiCl_2.6NH_3$	2	3	
(ii).$NiCl_2.4NH_3$	0	0	
(iii) $NiCl_2.2NH_3.2KCl$	0	3	

Giving sufficient reasons for your answer, write the formulae and show the ions present in each complex. What is the coordination number of nickel in these complexes**?** [6 marks]

[e] (i)..List the drawback of Sidgwick's theory for the interpretation of Werner's theory of coordination compounds. [3 marks]

(ii) Which of the following complexes of Ti^{3+} exhibits the shortest wavelength absorption in the visible spectrum $[Ti(H_2O)_6]^{3+,}$ $[Ti(en)_3]^{3+}$ or $[TiCl_6]^{3+}$ [2 marks]

QUESTION TWO [20MARKS]

a). (i). Give the main ideas developed by Sidgwick in the interpretation of Werner's coordination theory [4marks]

b). (i). Explain the idea behind the electroneutrality principle and state the principle [3marks]

(ii). What do you understand by the term ''effective atomic number''? *[2marks]*

(iii). State the effective atomic number rule. How is it related to eighteen electron rule and what is its usefulness in coordination Chemistry? [4marks]

c). Calculate the effective atomic number of <u>any two</u> of the following complexes and predict the number of unpaired electrons in the complexes [4marks]

(i) $[Cr(NH_3)_6]Cl_3$ (ii) $[Cu(NH_3)_4)](NO_3)_2$ (iii) $K_3[MnCl_6]$ [Atomic Number: Cr = 24 Mn, = 25 Cu = 29]

d). Give the names and sketch the structures of any two of the following ligands .Show by an arrow the donor atom(s) that is the source of electrons and state the denticity of the ligand

[3marks]

(i). en (ii) trien (iii) acac (iv) bipy (v) dien

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QUESTION THREE [20MARKS]

(a) Consider the following complexes and answer the questions that follow. [12.5 marks]

1. $[VCl_6]^{3-}$ 2. $[FeF_6]^{3-}$ 3. $[Ru(bipy)_3]^{3+}$ 4. $[NiCl_4]^{2-}$ 5. $[Co(NO_2)_6]^{3+}$

(i) Determine the electronic configuration of the central metal ion in each of the above complexes

(ii) Draw the crystal field energy –level diagrams for each complex and show the placement of the d electrons.

(iii) Calculate in multiples of Δ_o or Δ_t , CFSE of the central metal in the above complexes.

(iv) How many unpaired electrons are there in each of the above complexes.

(b). The complex ion $[Fe(CN)_6]^{3-}$ has one unpaired electron, whereas $[Fe(NCS)_6]^{3-}$ has five unpaired electrons. From these results, what can you conclude about whether each complex is high spin or low spin. Explain your answer**.** [3.5 marks]

(c). Discuss the factors that affect the magnitude of crystal field splitting parameter Δo [4 marks]

QUESTION FOUR [20 MARKS]

a). Define the term isomerism [3marks]

b). (i). Differentiate between linkage isomerism and ionization isomerism.

[3marks]

(ii). Draw the two linkage isomers of the following complex: $[Pd(NH_3)_2(ONO)_2]$

[2marks]

(iii).How would you prove experimentally that $[Co(NH_3)_5SO_4]Cl$ and $[Co(NH_3)_5Cl]SO_4$ are ionization isomers [2 marks]

c). Distinguish between the following pairs [4marks]
(i). an enantiomer and a racemic mixture,
(ii) a levorotatory and dextrorotatory isomer

d).For which member of the following pairs of complexes would Δ_o be larger and why [6marks]
(i).$[Cr(H_2O)_6]^{2-}$ and $[Cr(H_2O)_6]^{3+}$
(ii) $[CrF_6]^{3-}$ and $[Cr(NH_3)_6]^{3+}$
(iii) $[Co(NH_3)_6]^{3+}$ and $[Rh(NH_3)_6]3+$
