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University Examinations 2022/2023

FOURTH, SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN MEDICAL LABORATORIES SCIENCES

SCH 3450: COORDINATION CHEMISTRY

DATE: APRIL 2023 **TIME:2 HOURS**

INSTRUCTIONS: *Answer question one and any other two questions*
Tanabe Sugano diagrams are attached

QUESTION ONE (30 MARKS)

a) Explain why t_2g d-orbitals (dz^2, $dx^2 - y^2$) are non-bonding in M – L σ-bonding (2 marks)

b) Write the d^n configuration and use the appropriate tanabe sugano diagram to identify the ground state terms of: -

(i) Low spin Rh^{3+} complex (z = 48) (2 marks)

(ii) $[Ti(OH_2)_6]^{3+}$ (z = 22) (2 marks)

(iii) High spin $[FeF_6]^{3-}$ (z = 26) (2 marks)

c) Calculate μ_{eff} for $[Ni(en)_3]^{2+}$ taking into accounts spin-orbit coupling. Compare your answer with μ_{eff} (spin-only) and the value of 3.16 μB observed experimentally for $[Ni(en)_3]SO_4$ ($\Delta_0 = 11500;\ \lambda = -315$) (5 marks)

d) Explain why uv-absorption bands are usually broad (2 marks)

e) (i) Define the term magnetic susceptibility (2 marks)

(ii) If an octahedral Co(III) complex has a large paramagnetic susceptibility, what is the ground state term according to tanabe-sugano diagram (3 marks)

f) (i) Account for each of the following observations (i) there is no tanabe sugano diagram for d^{10}

(ii) The color of Cr(CO)6 is white while that of K_2CrO_4 is orange (2 marks)

g) The complex $[V(H_2O)6]^{3+}$ has $\Delta_o/_\beta$ = 30 and B = 600cm^{-1}

(i) What are the possible spin-allowed d-d electronic transition? (3 marks)

(ii) Determine the energy of the first (lowest energy) electronic transition (3 marks)

QUESTION TWO (20 MARKS)

a) For each of the following molecules, draw well labelled molecular orbital energy label diagram and remember to show HOMO and LUMO on each diagram (8 marks)

(i) N_2

(ii) O_2

b) Which of the above molecules (N_2 or O_2) is a:

(i) π – acceptor ligand? Justify your answer (2 marks)

(ii) Diamagnetic? Justify your answer (2 marks)

c) Determine bond order in O_2 (2 marks)

d) Explain what is meant by the terms: - (4 marks)

(i) π – acceptor ligand

(ii) π – donor ligand

e) Draw molecular orbital energy level diagram for metal – ligand sigma bonding (2 marks)

QUESTION THREE (20 MARKS)

a) Derive spectroscopic terms for $3P^2$ and use Hund's rule to arrange then in order of increasing energy (8 marks)

b) Split the ground state term of $3P^2$ by spin – orbit coupling (3 marks)

c) What is the ground state term for the new spin-orbit coupled state in (b) above? (1 mark)

d) Calculate the number of microstate in each of the following (8 marks)

(i) p^4

(ii) ^3P

(iii) $^3P_2$

(iv) s^1p^3

QUESTION FOUR (20 MARKS)

a) Similar to d-d transition, charge transfer transition also involve the metal d –orbitals

(i) Describe the two types of charge transfers that involve metal d-orbitals (6 marks)

(ii) Explain why absorption bands resulting from d-d transitions are weaker than those resulting from charge transfers (2 marks)

(iii) Explain why complex $[Cu\ (H_2O)_6]^{2+}$ is light blue in color while complex $[Cu(NH_3)_4]^{2+}$ is deep blue in color (5 marks)

b) If the values of angular momentum quantum number (L) and spin quantum number (S) for any given configurations are known, it is possible to identify the terms of the configuration. The following are (L, S) values for certain configurations. Use them to draw all the possible microstate and write the corresponding free ion terms symbols (7 marks)

(i) $\left(0, {}^{5}/_{2}\right)$

(ii) $\left(0, {}^{3}/_{2}\right)$

(iii) $\left(3, {}^{3}/_{2}\right)$