CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

THIRD YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE

CHEM 314: BIOINORGANIC CHEMISTRY

STREAMS: BSC (Y3S1) **TIME: 2 HOURS**

DAY/DATE: TUESDAY 10/12/2019 **11.30 AM – 1.30 PM**

INSTRUCTIONS:

Answer Question One and any other Two Questions in Section B

SECTION A

QUESTION ONE (30 MARKS)

(a) Explain briefly what you understand by the term essential element. [2 marks]

(b) Enumerate biochemical criteria an element must exhibit to be regarded as essential. [4 marks]

(c) For growth and survival of an organism, the concentration of essential elements is regulated within acceptable levels by certain proteins and hormones in the body. Illustrating with an aid of a sketch, enumerate the stages an organism may pass through as the physiological concentration of a given essential element changes. [5 marks]

(d) Toxic substances usually upset the incredibly complex chemical reactions occurring in human body system.

(i) Giving examples where necessary demonstrate how toxicity can arise in an organism. [4 marks]

(ii) With reference to copper as an example, discuss its toxicity and show how it can be treated. [4 marks]

(iii) Discuss factors that affect the strength of the binding of a metal ion and hence the stability of a complex. [4 marks]

(e) Chelation therapy is a commonly used treatment method for heavy metal poisoning.

(i) Explain briefly what is meant by the term chelate effect. [2 marks]

(ii) Enumerate the necessary criteria a potential chelating agent must exhibit before it can be used as a drug. [2 marks]

(iii) Name and draw structures of any three clinically used chelating agents. In each case mention their uses and limitations if any. [3 marks]

SECTION B: ANSWER TWO QUESTIONS IN THIS SECTION

QUESTION TWO (20 MARKS)

(a) (i) What are ionophores? How do they function? [4 marks]

(ii) Distinguish between channel former and ion carrier ionophores. [2 marks]

(b) Describe how microbes get and release enough iron despite the fact that they are too tiny. How does a developing embryo in eggs of certain birds protected against attacks by such microbes? [4 marks]

(c) (i) Distinguish between active and passive transport of ions across a cell membrane. [4 marks]

(ii) With the aid of a schematic diagram, explain how the Na^+/K^+ pump in the human red blood cells functions. [6 marks]

QUESTION THREE (20 MARKS)

(a) (i) Describe in details what are cytochromes and outline the similarities and differences between haem units in deoymyoglobin and cytochrome . [4 marks]

(ii) What is the most significant difference between the above two biomolecules in terms of coordination chemistry and how does this difference relate to their functions? [2 marks]

(b) Haemoglobin is an intricate dioxygen carrying molecular machine composed of four globin units that bind dioxygen molecule cooperatively. For both deoxygenated haemoglobin and oxygenated haemoglobin molecule, the geometry and hence the radius of iron in the porphyrin cavity differ.

(i) Explain what you understand by the term cooperativity. [2 marks]

(ii) What is the oxidation state of iron in both oxygenated and deoxygenated haemoglobin molecules? What are the spin states of iron in the two cases? [2 marks]

(iii) Using an energy level diagram for d orbitals which have been perturbed by crystal field, indicate the electron distribution for the two spin states of iron in (ii) above. [2 marks]

(iv) Which of the two spin states of iron has a larger radius? Justify your answer and discuss briefly how this affects dioxygen binding in haemoglobin. [4 marks]

(c) Derive an equation that shows how binding of oxygen to myoglobin varies with the partial pressure of oxygen. Hence write a corresponding equation that applies to the binding of oxygen to haemoglobin. What is the main difference between the two equations and why the difference? [4 marks]

QUESTION FOUR (20 MARKS)

(a) What are picket fence porphyrins and why are they used in model studies of binding to myoglobin or haemoglobin. [3 marks]

(b) Explain briefly the main differences between a chlorophyll molecule and a haem unit. [3 marks]

(c) Describe briefly the structure of chlorophyll a_1 and rationalize why magnesium is the metal of choice found in a chrolophyll molecule. Why is chlorophyll such a stable molecule towards photodecomposition? [7 marks]

(d) What are the Iron – Sulphur proteins? [2 marks]

The ron – Sulphur protein is a common ferrodoxin containing two centres in high spin states. The dimer is diamagnetic in its oxidized form.

(i) Draw the structure of iron – Sulphur protein. [1 mark]

(ii) Justify the fact that the dimmer in its oxidized form is diamagnetic. [1 mark]

(iii) What oxidation states would the two iron centres assume when the above iron – Sulphur proteins is in its reduced form? [1 mark]

(iv) Comment on the similarities and differences between ferrodoxin and Rieske protein both in terms of structure and function. [2 marks]

QUESTION FIVE

(a) (i) Distinguish between diagnostic and therapeutic drugs. [2 marks]

(ii) List the requirements that must be exhibited by any radionuclide imaging agent. [4 marks]

(b) Among the radioactive imaging agents, metastable technetium ^{99m}Tc is widely used modern imaging agent which must be prepared at the point of use in a hospital or a local nuclear pharmacy.

(i) Give reasons why ^{99m}Tc is perhaps the most desirable imaging agent. [4 marks]

(ii) Why should ^{99m}Tc be prepared at the point of use? [1 mark]

(iii) List body organs that are imaged by ^{99m}Tc and explain how it reaches the cells of the target tissues. [3 marks]

(c) Cisplatin is a simple coordination compound that is effective in the treatment of genitourinary, testicular and ovarian cancer.

(i) Draw the structure of cisplatin and show how its mode of action. What is its major drawback? [3 marks]

(ii) Enumerate the accepted criteria for structural features that plantinum amine halide analogues should possess to exhibit significant antitumor activity. [3 marks]
