UNIVERSITY OF SWAZILAND

FINAL EXAMINATION 2015/2016

TITLE OF PAPER:	**BIO-INORGANIC CHEMISTRY**
COURSE NUMBER:	**C617**
TIME ALLOWED:	**THREE (3) HOURS**
INSTRUCTIONS:	**ANSWER ALL FOUR (4) QUESTIONS. EACH QUESTION IS WORTH 25 MARKS.**

A PERIODIC TABLE HAS BEEN PROVIDED WITH THIS EXAMINATION PAPER.

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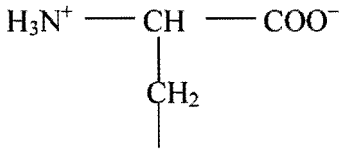
QUESTION ONE

(a) Transition metal ions are found in living organisms.
   (i) Indicate which transition metals have a role in biological systems;
   (ii) Briefly describe the biological functions of <u>six</u> of these metals. [10]

(b) Write ionic equations to show how <u>serine</u> acts as a buffer against the following added ions:
   (i) OH^-;
   (ii) H_3O^+. [2]



serine

(c) (i) Write appropriate equations to describe the reactions that each of the following enzymes catalyse:
   (1) Carbonic anhydrase;
   (2) Carboxypeptidase.
   (ii) The mechanism of action of carbonic anhydrase is best described in terms of a **Zn-hydroxide mechanism**. Give the mechanistic cycle of carbonic anhydrase indicating all the steps involved. [7]

(d) (i) What is the function of the metallo-biomolecule **hemerythrin**?
   (ii) Identify the metal that is at the active centre of **hemerythrin**.
   (iii) Describe the essential features of the structure of **hemerythrin**.
   (iv) Describe the essential steps in the mechanism of the function of **hemerythrin**. [6]

QUESTION TWO

(a) Describe the structure of <u>any</u> calcium-containing metallo-biomolecule. [3]

(b) (i) Describe the essential details of the structure of Vit B_{12}.
   (ii) How do Vit B_{12}, Vit B_{12r} and Vit B_{12s} differ?
   (iii) Give the
      (1) functions of Vit B_{12};
      (2) deficiencies of Vit B_{12};
      (3) sources of Vit B_{12}. [13]

(c) Discuss the following topics:
   (i) Biomineralization; (ii) Iron proteins as sensors. [6]

(d) Why are iron-sulphur proteins employed in redox catalysis? [3]

QUESTION THREE

(a) Describe briefly how the biological roles of the alkali metals sodium and potassium differ from those of the alkaline earth metals magnesium and calcium. [8]

(b) (i) Draw the basic structure of the heme molecule in **myoglobin**.
(ii) Describe a molecule of **haemoglobin**.
(iii) Explain how the attachment of an O_2 molecule to the first iron (II) in haemoglobin assists in activating the whole tetramer in the acquisition of four (4) molecules of oxygen.
(iv) Describe the **tense (T)** and **relaxed (R)** conformations of haemoglobin. [10]

(c) Give a brief description of the following:
(i) isoelectric point; (ii) peptide bond; (iii) apoprotein. [3]

(d) Zinc proteins can act as transcription factors and contain so-called **zinc fingers**, typically involving the binding of zinc to histidine and cysteine amino acid-side chains. With the aid of structural diagrams describe the zinc sites in these proteins. [4]

QUESTION FOUR

(a) Explain the following terms:
(i) The Bohr effect; (ii) Heme protein;
(iii) Zwitterion; (iv) Primary structure of proteins. [6]

(b) Describe briefly, giving <u>one</u> example of each, the active sites of heme proteins which allow them to
(i) bind dioxygen reversibly; (ii) insert oxygen into substrates. [4]

(c) (i) Why might Cu sensors be 'designed' to bind Cu(I) rather than Cu(II)?
(ii) What is the shape and make-up of the manganese complexes utilised in PSII?
(iii) Which features of manganese suit it to function as a redox centre in PSII, as opposed to metals such as copper or nickel? [7]

(d) (i) What type of bonding between amino acid residues is most important in holding a protein or polypeptide in a specific secondary configuration?
(ii) A globular protein in aqueous surroundings contains the following amino acid residues: **methionine**, **lysine**, and **alanine**. Which amino acid side chains would be directed toward the inside of the protein and which would be directed toward the aqueous surroundings?
(iii) Provide an explanation for why the toxicity of mercury is greatly increased by the action of enzymes containing cobalamin. [8]

PERIODIC TABLE OF ELEMENTS

PERIODS	GROUPS 1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1.008 **H** 1																	4.003 **He** 2
2	6.941 **Li** 3	9.012 **Be** 4											10.811 **B** 5	12.011 **C** 6	14.007 **N** 7	15.999 **O** 8	18.998 **F** 9	20.180 **Ne** 10
3	22.990 **Na** 11	24.305 **Mg** 12											26.982 **Al** 13	28.086 **Si** 14	30.974 **P** 15	32.06 **S** 16	35.453 **Cl** 17	39.948 **Ar** 18
4	39.098 **K** 19	40.078 **Ca** 20	44.956 **Sc** 21	47.88 **Ti** 22	50.942 **V** 23	51.996 **Cr** 24	54.938 **Mn** 25	55.847 **Fe** 26	58.933 **Co** 27	58.69 **Ni** 28	63.546 **Cu** 29	65.39 **Zn** 30	69.723 **Ga** 31	72.61 **Ge** 32	74.922 **As** 33	78.96 **Se** 34	79.904 **Br** 35	83.80 **Kr** 36
5	85.468 **Rb** 37	87.62 **Sr** 38	88.906 **Y** 39	91.224 **Zr** 40	92.906 **Nb** 41	95.94 **Mo** 42	98.907 **Tc** 43	101.07 **Ru** 44	102.91 **Rh** 45	106.42 **Pd** 46	107.87 **Ag** 47	112.41 **Cd** 48	114.82 **In** 49	118.71 **Sn** 50	121.75 **Sb** 51	127.60 **Te** 52	126.90 **I** 53	131.29 **Xe** 54
6	132.91 **Cs** 55	137.33 **Ba** 56	138.91 ***La** 57	178.49 **Hf** 72	180.95 **Ta** 73	183.85 **W** 74	186.21 **Re** 75	190.2 **Os** 76	192.22 **Ir** 77	195.08 **Pt** 78	196.97 **Au** 79	200.59 **Hg** 80	204.38 **Tl** 81	207.2 **Pb** 82	208.98 **Bi** 83	(209) **Po** 84	(210) **At** 85	(222) **Rn** 86
7	223 **Fr** 87	226.03 **Ra** 88	(227) ****Ac** 89	(261) **Rf** 104	(262) **Ha** 105	(263) **Unh** 106	(262) **Uns** 107	(265) **Uno** 108	(266) **Une** 109	(267) **Uun** 110								

Atomic mass → 10.811
Symbol → **B**
Atomic No. → 5

TRANSITION ELEMENTS

***Lanthanide Series**	140.12 **Ce** 58	140.91 **Pr** 59	144.24 **Nd** 60	(145) **Pm** 61	150.36 **Sm** 62	151.96 **Eu** 63	157.25 **Gd** 64	158.93 **Tb** 65	162.50 **Dy** 66	164.93 **Ho** 67	167.26 **Er** 68	168.93 **Tm** 69	173.04 **Yb** 70	174.97 **Lu** 71
****Actinide Series**	232.04 **Th** 90	231.04 **Pa** 91	238.03 **U** 92	237.05 **Np** 93	(244) **Pu** 94	(243) **Am** 95	(247) **Cm** 96	(247) **Bk** 97	(251) **Cf** 98	(252) **Es** 99	(257) **Fm** 100	(258) **Md** 101	(259) **No** 102	(260) **Lr** 103

( ) indicates the mass number of the isotope with the longest half-life.