UNIVERSITY OF SWAZILAND

FINAL EXAMINATION 2010/2011

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 AND A TABLE OF CONSTANTS HAVE BEEN PROVIDED WITH THIS EXAMINATION PAPER.

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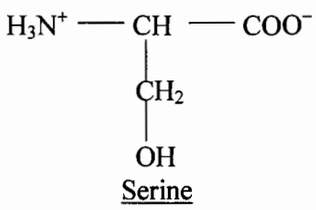
QUESTION ONE

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

(b) Write ionic equations to show how serine 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 this molecule.

(iii) Describe the essential features of the structure of this molecule.

(iv) Describe the essential steps in the mechanism of the function of this molecule. [6]

QUESTION TWO

(a) Describe the structure of any 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 functions, deficiencies and sources of Vit B_{12}. [13]

(c) Discuss the following topics:

(i) Cancer treatment

(ii) Biomineralization

(iii) Iron proteins as sensors [9]

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 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 [4]

(b) Describe briefly, giving one example of each, the active sites of heme proteins which allow them to:
(i) bind dioxygen reversibly.
(ii) insert oxygen into substrates. [6]

(c) (i) What role does Mg play in the functioning of chlorophyll?
(ii) Which other metal (s) are involved in photosynthesis in the functioning of chlorophyll?
(iii) Chlorophyll has an absorption maximum at about 660 nm. Calculate the energy available from a photon light at this wavelength.
(iv) What electron transfer systems are used in photosynthesis?
(v) Describe the chemical processes that occur during the photosynthesis process. [9]

(d) (i) What do you understand by 'modelling' of bio-molecules?
(ii) Explain how cobalt complexes have provided the best general picture of acting as helpful O_2 binding model systems. [6]

General data and fundamental constants

Quantity	Symbol	Value
Speed of light	c	$2.997\,924\,58 \times 10^{8}$ m s^{-1}
Elementary charge	e	$1.602\,177 \times 10^{-19}$ C
Faraday constant	$F = N_A e$	9.6485×10^{4} C mol^{-1}
Boltzmann constant	k	$1.380\,66 \times 10^{-23}$ J K^{-1}
Gas constant	$R = N_A k$	8.314 51 J K^{-1} mol^{-1}
		$8.205\,78 \times 10^{-2}$ dm^3 atm K^{-1} mol^{-1}
		6.2364×10 L Torr K^{-1} mol^{-1}
Planck constant	h	$6.626\,08 \times 10^{-34}$ J s
	$\hbar = h/2\pi$	$1.054\,57 \times 10^{-34}$ J s
Avogadro constant	N_A	$6.022\,14 \times 10^{23}$ mol^{-1}
Atomic mass unit	u	$1.660\,54 \times 10^{-27}$ Kg
Mass		
electron	m_e	$9.109\,39 \times 10^{-31}$ Kg
proton	m_p	$1.672\,62 \times 10^{-27}$ Kg
neutron	m_n	$1.674\,93 \times 10^{-27}$ Kg
Vacuum permittivity	$\varepsilon_o = 1/c^2\mu_o$	$8.854\,19 \times 10^{-12}$ J^{-1} C^2 m^{-1}
	$4\pi\varepsilon_o$	$1.112\,65 \times 10^{-10}$ J^{-1} C^2 m^{-1}
Vacuum permeability	μ_o	$4\pi \times 10^{-7}$ J s^2 C^{-2} m^{-1}
		$4\pi \times 10^{-7}$ T^2 J^{-1} m^3
Magneton		
Bohr	$\mu_B = e\hbar/2m_e$	$9.274\,02 \times 10^{-24}$ J T^{-1}
nuclear	$\mu_N = e\hbar/2m_p$	$5.050\,79 \times 10^{-27}$ J T^{-1}
g value	g_e	2.002 32
Bohr radius	$a_o = 4\pi\varepsilon_o\hbar/m_e e^2$	$5.291\,77 \times 10^{-11}$ m
Fine-structure constant	$\alpha = \mu_o e^2 c/2h$	$7.297\,35 \times 10^{-3}$
Rydberg constant	$R_\infty = m_e e^4/8h^3 c\varepsilon_o^2$	$1.097\,37 \times 10^{7}$ m^{-1}
Standard acceleration of free fall	g	9.806 65 m s^{-2}
Gravitational constant	G	$6.672\,59 \times 10^{-11}$ N m^2 Kg^{-2}

Conversion factors

1 cal	=	4.184 joules (J)	1 erg	=	1×10^{-7} J
1 eV	=	$1.602\,2 \times 10^{-19}$ J	1 eV/molecule	=	96 485 kJ mol^{-1}

Prefixes

f	p	n	μ	m	c	d	k	M	G
femto	pico	nano	micro	milli	centi	deci	kilo	mega	giga
10^{-15}	10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^{-1}	10^{3}	10^{6}	10^{9}

PERIODIC TABLE OF ELEMENTS

GROUPS

PERIODS	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	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											Atomic mass → 10.811 **Symbol** → **B** Atomic No. → 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					**TRANSITION ELEMENTS**						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								

***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.