NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH, APPLIED SCIENCES AND NATURAL RESOURCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE HONOURS	
QUALIFICATION CODE: 08BOSH	**LEVEL:** 8
COURSE CODE: BBC811S	**COURSE NAME:** BIOINORGANIC AND BIOPHYSICAL CHEMISTRY
SESSION: JUNE 2022	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER(S)	DR. EUODIA HESS
MODERATOR:	DR. LIKIUS DANIEL

INSTRUCTIONS

1. Answer ALL the questions.
2. Write clearly and neatly.
3. Number the answers clearly
4. All written work must be done in blue or black ink and sketches can be done in pencil
5. No books, notes and other additional aids are allowed

THIS QUESTION PAPER CONSISTS OF 4 PAGES (Including this front page, list of useful constants, Periodic Table)

SECTION A [50]

QUESTION 1: **[12]**

Give a brief account for the following techniques used to study metals in biology:

a) Electron Paramagnetic Resonance (EPR) Spectroscopy. (4)

b) NMR spectroscopy. (4)

c) X-ray Diffraction (4)

QUESTION 2: **[10]**

a) Why is chelation important in medicine? (4)
b) Why are corrins and pophyrins regarded as an important class of natural chelator molecules? (6)

QUESTION 3: **[16]**

a) Which of the 20 amino acids are potential metal ligands? (10)
b) Which of the low molecular weight inorganic anions bind to Fe^{3+} in proteins? (2)
c) Which metals are inserted into the tetrapyrrole nucleus of corrins and porphyrins to form vitamin B_{12} and other cobalamine cofactors, haem, chlorophyll and coenzyme F_{430} respectively? (4)

QUESTION 4: **[12]**

Describe the function and variety of siderophores.

SECTION B: [50]

QUESTION 1: **[17]**

1.1) Nicotine adenine dinucleotide (NAD) is a cellular redox reagent that is involved in redox chemistry throughout respiratory system. The reduced form of NAD is NADH and oxidised form is NAD^+. An electrochemical cell is constructed using a half-cell for which the reduction is given:

$$NAD^+ + H^+ + 2e^- \rightarrow NADH \qquad E^0 = -0.105\ V$$

which combined with the half-cells for which the reduction reaction is given by:

a) $CO_2 + H^+ + 2e^- \rightarrow HCOO^-$ $\qquad E^0 = -0.105\ V$

b) $O_2 + 2H^+ + 2e^- \rightarrow H_2O_2$ $\qquad E^0 = 0.69\ V$

Write the overall reaction for the cells in the direction of spontaneous change. Is the NAD reduced or oxidised in spontaneous reactions? (9)

1.2) You are given the following reduction reactions and $E^{0'}$ values at pH = 7.

$CH_3COO^-(aq) + 3H^+(aq) + 2e^- \rightarrow CH_3CHO(aq) + H_2O$ $\qquad E^{0'} = -0.581\ V$

$CH_3CHO(aq) + 2H^+(aq) + 2e^- \rightarrow CH_3CH_2OH(aq)$ $\qquad E^{0'} = -0.197\ V$

Where $E^{0'}$ indicates the biological state. Calculate $E^{0'}$ for the half-cell reaction:

$CH_3COO^-(aq) + 5H^+(aq) + 4e^- \rightarrow CH_3CH_2OH(aq) + H_2O(l)$ (8)

QUESTION 2: **[15]**

The normal boiling temperature of benzene is 353.24 K, vapor pressure of liquid benzene is 1.00×10^4 Pa at 20 °C. The enthalpy of fusion is 9.95 kJ mol^{-1} and vapor pressure of solid benzene is 88.0 Pa at -44.3 °C. Calculate the following:

a) ΔH_m^{vap} (3)

b) ΔS_m^{vap} (3)

c) Tripple point Temperature and Pressure (9)

QUESTION 3: **[20]**

a) In the cell, typical concentration of ATP, ADP and inorganic phosphate are c_{ATP} = 1850 uM, c_{ADP} = 138 uM and c_P = 1.00 mM. Calculate the Gibbs energy of hydrolysis in the cellular environment, assuming pH = 7 and T = 310 K. (10)

b) The distributions of sodium and potassium ions inside and outside the cell membrane are c_{out}^{Na+} = 1.4 x 10^{-1} M, c_{out}^{K+} = 5.0 x 10^{-3} M, c_{in}^{Na+} = 1.00 x 10^{-2} M and c_{in}^{K+} = 1.00 x 10^{-1} M.

Calculate the total free energy change involved in transporting 3 mol of sodium ion out of the cell and 2 mol of potassium into cell at T = 310 K. Assume a potential difference of 0.070 V. (10)

END OF EXAMINATION

USEFUL CONSTANTS:

Gas constant, R = 8.3145 J · mol^{-1} · K^{-1} = 0.083145 dm^3 · bar · mol^{-1} · K^{-1} = 0.08206 L atm mol^{-1} · K^{-1}

1 Pa · m^3 = 1 kPa.L = 1 N · m = 1 J

1 atm = 101 325 Pa = 760 mmHg = 760 torr

Faradays constant = 96,485 C/mol

Avogadro's Number, N_A = 6.022 x 10^{23} mol^{-1}

Planck's constant, h = 6.626 x 10^{-34} Js

Speed of light, c = 2.998 x 10^8 ms^{-1}

PERIODIC TABLE OF THE ELEMENTS

1																	18
1 **H** 1.00794	2											13	14	15	16	17	2 **He** 4.00260
3 **Li** 6.941	4 **Be** 9.01218											5 **B** 10.81	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984	10 **Ne** 20.179
11 **Na** 22.9898	12 **Mg** 24.305	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.9815	14 **Si** 28.0855	15 **P** 30.9738	16 **S** 32.06	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.08	21 **Sc** 44.9559	22 **Ti** 47.88	23 **V** 50.9415	24 **Cr** 51.996	25 **Mn** 54.9380	26 **Fe** 55.847	27 **Co** 58.9332	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.8
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.22	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.906	46 **Pd** 106.42	47 **Ag** 107.868	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.29
55 **Cs** 132.905	56 **Ba** 137.33	71 **Lu** 174.967	72 **Hf** 178.49	73 **Ta** 180.948	74 **W** 183.85	75 **Re** 186.207	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.967	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.908	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.025	103 **Lr** (260)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (268)	110 Uun (269)	111 Uuu (272)	112 Uub (269)		114 Uuq		116 Uuh		118 Uuo

Lanthanides:	57 **La** 138.906	58 **Ce** 140.12	59 **Pr** 140.908	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.925	66 **Dy** 162.50	67 **Ho** 161.930	68 **Er** 167.26	69 **Tm** 166.934	70 **Yb** 173.04

Actinides:	89 **Ac** 227.028	90 **Th** 232.038	91 **Pa** 231.036	92 **U** 238.029	93 **Np** 237.048	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)