



**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
<ol style="list-style-type: none">1. Answer ALL the questions.2. Write clearly and neatly.3. Number the answers clearly4. All written work must be done in blue or black ink and sketches can be done in pencil5. 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 porphyrins 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 Fe³⁺ in proteins? (2)
- c) Which metals are inserted into the tetrapyrrole nucleus of corrins and porphyrins to form vitamin B₁₂ and other cobalamine cofactors, haem, chlorophyll and coenzyme F₄₃₀ 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:

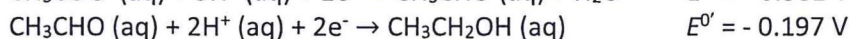
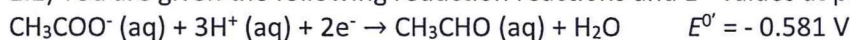


which combined with the half-cells for which the reduction reaction is given by:

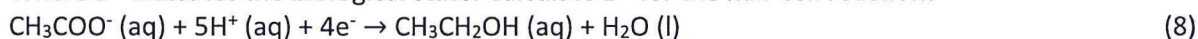
- a) $\text{CO}_2 + \text{H}^+ + 2\text{e}^- \rightarrow \text{HCOO}^- \quad E^0 = -0.105 \text{ V}$
- b) $\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O}_2 \quad E^0 = 0.69 \text{ V}$

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.



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



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) Triple point Temperature and Pressure (9)

QUESTION 3:**[20]**

- a) In the cell, typical concentration of ATP, ADP and inorganic phosphate are $c_{\text{ATP}} = 1850 \text{ uM}$, $c_{\text{ADP}} = 138 \text{ uM}$ and $c_{\text{P}} = 1.00 \text{ mM}$. Calculate the Gibbs energy of hydrolysis in the cellular environment, assuming $\text{pH} = 7$ and $T = 310 \text{ K}$. (10)
- b) The distributions of sodium and potassium ions inside and outside the cell membrane are $c_{\text{out}}^{\text{Na}^+} = 1.4 \times 10^{-1} \text{ M}$, $c_{\text{out}}^{\text{K}^+} = 5.0 \times 10^{-3} \text{ M}$, $c_{\text{in}}^{\text{Na}^+} = 1.00 \times 10^{-2} \text{ M}$ and $c_{\text{in}}^{\text{K}^+} = 1.00 \times 10^{-1} \text{ M}$.

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 $T = 310 \text{ K}$. Assume a potential difference of 0.070 V. (10)

END OF EXAMINATION

USEFUL CONSTANTS:

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

$1 \text{ Pa} \cdot \text{m}^3 = 1 \text{ kPa} \cdot \text{L} = 1 \text{ N} \cdot \text{m} = 1 \text{ J}$

$1 \text{ atm} = 101\,325 \text{ Pa} = 760 \text{ mmHg} = 760 \text{ torr}$

Faradays constant = 96,485 C/mol

Avogadro's Number, $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

Planck's constant, $h = 6.626 \times 10^{-34} \text{ Js}$

Speed of light, $c = 2.998 \times 10^8 \text{ ms}^{-1}$

PERIODIC TABLE OF THE ELEMENTS

1	2											17	18				
1 H 1.00794	2 He 4.00260											9 F 18.9984	10 Ne 20.179				
3 Li 6.941	4 Be 9.01218											8 O 15.9994	16 S 32.06				
11 Na 22.9898	12 Mg 24.305	5 B 10.81	6 C 12.011	7 N 14.0067	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	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		
87 Fr (223)	88 Ra 226.025	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)		

Lanthanides:

Actinides: