UNIVERSITY OF SWAZILAND

FINAL EXAMINATION PAPER: MAY 2016

TITLE OF PAPER: BIOCHEMISTRY & CELL BIOLOGY

COURSE CODE: B203

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:
1. ANSWER QUESTION 1 (COMPULSORY) AND ANY THREE OTHER QUESTIONS.
2. ANSWER A TOTAL OF 4 (FOUR) QUESTIONS
2. EACH QUESTION CARRIES TWENTY FIVE (25) MARKS
3. ILLUSTRATE YOUR ANSWERS WITH LARGE AND CLEARLY LABELLED DIAGRAMS WHERE APPROPRIATE

SPECIAL REQUIREMENTS:

1. CANDIDATES MAY USE CALCULATORS

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATORS

[PLEASE TURN OVER]

Section A: Compulsory (Answer all questions in this section)

Question 1

(a) The following questions concern pH and its calculation.

(i) Calculate the pH of a solution of 0.015 M NaOH. (1 mark)

(ii) Define pK_a for a weak acid in the following two ways: (1) in relation to its acid dissociation constant, K_a, and (2) by reference to a titration curve for the weak acid. (2 marks)

(iii) Draw the titration curve for a weak acid, HA, whose pK_a is 3.2. Label the axes properly. Indicate with an arrow where on the curve the ratio of salt (A^-) to acid (HA) is 3:1. State the pH at this point. (5 marks)

(iv) Calculate the pH of a solution if 1.0 mol of a weak acid, HA (pK_a = 5.2) is dissolved together with 0.2 mol of NaOH in one liter of water. (2 marks)

(v) Explain how changes in pH alter the conformation of a protein. (2 marks)

(b) (i) The hydrolysis of ATP is highly exergonic:

ATP + H_2O → ADP + P_i **ΔG° = –30.5 kJ/mol**

However, the conversion of glucose into glucose 6-phosphate, which must occur in the breakdown of glucose, is thermodynamically unfavorable (endergonic):

Glucose + P_i →glucose 6-phosphate + H_2O **ΔG° = +13.8 kJ/mol**

Explain how cells overcome this problem and hence, use the above equations to calculate the standard free-energy change (ΔG°) for the phosphorylation of glucose. (3 marks)

(ii) If a 0.08 M solution of glucose 1-phosphate is incubated at 25°C with a catalytic amount of phospho-glucomutase, the glucose 1-phosphate is transformed to glucose 6-phosphate until equilibrium is reached. At equilibrium, the concentration of glucose 1-phosphate is 4.5×10^{-3} M and that of glucose 6-phosphate is 8.6×10^{-2} M. Write the expressions for the calculation of K'_{eq} and ΔG° for this reaction, hence calculate K'_{eq} and ΔG°, given that the universal gas constant R = 8.315 J/mol·K. (4 marks)

(c) A student measured the initial rate, (V_0), of an enzyme-catalyzed reaction as a function of substrate concentration, [S], in the presence (+In) and absence (-In) of an inhibitor. Results are shown in the table below.

[S] (mM) ($\times 10^{-4}$)		1	2	5	10	20	50	100	200	500	1000
V_0 (mmol/s) of product	-In	33	50	71	83	91	96	98	99	100	100
	+In	17	29	50	67	80	91	95	98	99	100

Without using any graph, estimate the values of V_{max} and K_m in the absence and presence of inhibitor. Hence, deduce the type of inhibitor that is involved and explain its mechanism of action. (6 marks)

[Total Marks = 25]

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Section B

Answer **any three** questions from this Section.

Question 2

(a) Briefly describe the usefulness of each of the following reagents in the analysis of protein structure:
(i) Phenylisothiocyanate, (2 marks)
(ii) Chymotrypsin, (2 marks)
(iii) β-mercaptoethanol, (2 marks)
(iv) Carboxypeptidase. (2 marks)

(b) A biochemist wishes to determine the sequence of a protein that contains 173 amino acid residues. After treatment with β-mercaptoethanol and cyanogen bromide (CNBr), it is anticipated that less than ten conveniently sized peptides will be obtained in the resulting solution. You are then tasked to take over and complete the remaining amino acid analysis steps. Outline and explain the steps you would take to determine, unambiguously, the sequence of amino acid residues in the original protein. (17 marks)

[Total Marks = 25]

Question 3

(a) Describe the mechanism of catabolite repression as it relates to the *lac* operon. (10 marks)

(b) Examine how, in an animal, excess nitrogen is disposed of, indicating organ(s) and/or cellular compartment(s) where this occurs. (15 marks)

[Total Marks = 25]

Question 4

Explain the intricate rudiments of the Central Dogma of molecular biology, highlighting how a change in the sequence of nucleotides of a gene can affect the 3-D structure and function of a protein. (25 marks)

[Total Marks = 25]

Question 5

Discuss how photosynthetically harnessed energy is aerobically transduced to mitochondrial ATP in an animal cell. (25 marks)

[Total Marks = 25]

Question 6

Critique the assertion that 'Vitamins of the B-complex are indispensable elements of cellular metabolism'. (25 marks)

[Total Marks = 25]

END OF EXAMINATION PAPER