

# Cork Institute of Technology

## Higher Certificate in Science in Applied Biology – Award

(NFQ – Level 6)

Summer 2006

### Biochemistry

(Time: 3 Hours)

Answer Section A (compulsory) and TWO questions from each of Sections B and C.

Examiners: Dr. H. Tarrant  
Prof. R. Fitzgerald

Use separate answer books for each section and mark the questions attempted.

### Section A

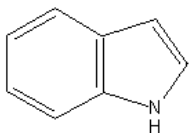
**Q1.      Compulsory, answer 12 parts only. (24 marks)**

- (a) A well-designed assay will incorporate one or more **standards** and a **reagent blank**. Define each of these terms.
- (b) What is an allosteric enzyme? With the aid of diagrams, explain the terms **negative allosterism** and **positive allosterism**.
- (c) The melting points of a series of 18-carbon fatty acids are as follows: steric acid = 69°C, oleic acid = 13°C, linoleic acid = -5°C and linolenic acid = -11°C. What structural feature of these 18-carbon fatty acids could cause these differences in melting point?
- (d) Integral membrane proteins are involved in transport of molecules across the cell membrane. Define the terms **passive** and **active** transport, and distinguish between **symport** and **antiport** mechanisms.
- (e) Define the Beer Lambert Law. The  $A_{340}$  of a solution of NADH was found to be 0.43. What was the concentration of this solution? ( $\epsilon_{\text{NADH}} = 6220 \text{ M}^{-1} \text{ cm}^{-1}$ ).
- (f) Calculate the number of millilitres of 3M  $\text{H}_2\text{SO}_4$  required to prepare 1250 ml of a 0.05 M  $\text{H}_2\text{SO}_4$  solution.
- (g) Draw the structure of one amino acid in each of the following groups;
  - (i) sulphur-containing amino acid,
  - (ii) acidic amino acid
  - (iii) basic amino acid

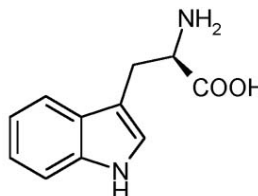
In each case name the amino acid you have drawn.

- (h) At pH 7, tryptophan crosses a lipid bilayer approximately 1,000 times more slowly than indole, a closely related molecule. From the structures of these molecules suggest an explanation of this observation. (*The  $pK_a$  values of the acid and base groups are 2.4 and 9.4, respectively*).

Indole

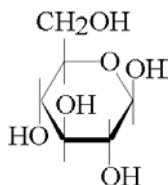


Tryptophan

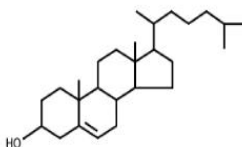


- (i) Examine the structure of each of the following molecules and state which is (i) polar, (ii) amphipathic and (iii) hydrophobic? Which molecule(s) would you expect to dissolve readily in water and which molecule(s) would you expect to make an effective detergent?

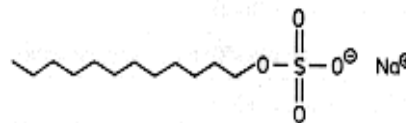
Glucose



Cholesterol



Sodium Dodecyl Sulphate (SDS)



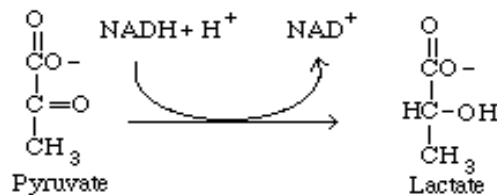
- (j) Derivatives of monosaccharides include sugar phosphates, deoxy sugars, amino sugars and sugar acids? Using D-glucose as your base molecule, draw an example of each of these derivatives.
- (k) List four mechanisms used to regulate the level of gene transcription.
- (l) Using an example, explain the term **zymogen**.

## Section B - (Analytical Biochemistry - 38 marks)

Answer any **two** of the following questions (Q2, Q3 or Q4).

- Q2.** (a) Define the terms  **$pK_a$**  and  **$pI$** . [5 marks]
- (b) Explain why a weak acid or base can effectively buffer pH, while a strong acid or base cannot. Use titration curves to illustrate your answer. [5 marks]
- (c) Describe in detail the preparation of 0.7 L of a 0.04 M phosphate buffer, pH 7.4, from  $NaH_2PO_4 \cdot H_2O$  (fw, 138) and  $Na_2HPO_4 \cdot H_2O$  (fw, 268.07) salts. ( $pK_a = 7.2$ ) [9 marks]

**Q3. (a)** The muscle enzyme lactate dehydrogenase (LDH) catalyses the following reaction:



Solutions of NADH but not  $\text{NAD}^+$ , absorb light at 340 nm. How may this fact be used to design a quantitative assay for LDH? [3 marks]

(b) The results of an LDH assay are as follows:

[Pyruvate] (mM)	$v_o$ ( $\mu\text{mol/min}$ )
1.5	0.21
2.0	0.24
3.0	0.28
4.0	0.33
8.0	0.40
16.0	0.45

Use a Lineweaver-Burk plot to determine the values of  $V_{\max}$  and  $K_m$  for this LDH preparation. [10 marks]

(c) What fraction of  $V_{\max}$  would be expected when  $[\text{pyruvate}] = \frac{1}{2} K_m$ ,  $2 K_m$  and  $10 K_m$ ?

[6 marks]

**Q4.** Write brief informative notes on three of the following;

- (a) Fixed time or continuous monitoring methods of enzyme measurement
- (b) Bioluminescence and chemiluminescence
- (c) Random and systematic experimental error
- (d) Choosing a technique for protein estimation

[19 marks]

## Section C

(Structural and Metabolic Biochemistry - 38 marks)

Answer any **two** of the following questions (Q5, Q6, Q7 or Q8).

- Q5.** (a) In all organisms, pyruvate is the end-product of glycolysis. However, the fate of pyruvate will differ under aerobic and anaerobic conditions. Describe three possible fates of pyruvate and indicate the circumstances under which each will occur. [6 marks]
- (b) Write an essay on glycolysis, indicating clearly the energy-consuming reactions and the energy-yielding reactions. Include a discussion of the mechanisms used to control the rate of glycolysis. [13 marks]
- Q6.** (a) Explain the term **mutarotation**, using diagrams of D-glucose to illustrate your answer. [5 marks]
- (b) Explain, with the aid of a diagram, how non-reducing sugars arise and name a chemical test to identify them. [7 marks]
- (c) Pure cellulose is tough, fibrous and completely insoluble in water. In contrast, glycogen disperses readily in hot water. Despite these different physical properties both substances are composed of polymers of D-glucose. Explain, with the aid of diagrams, what structural feature causes these two polysaccharides to differ in their physical properties. [7 marks]
- Q7.** (a) Using diagrams, summarise how DNA is packaged to fit within the nucleus. [3 marks]
- (b) Write an essay on **translation**, using the following headings as a guide:
- a. structure of ribosomes and tRNA
  - b. initiation
  - c. chain elongation and formation of the peptide bond, and
  - d. termination and post-translational modification. [16 marks]
- Q8.** (a) Draw a diagram illustrating the condensation of two amino acids to form a dipeptide. Explain how the properties of the peptide bond contribute to the overall structure of a protein. [4 marks]
- (b) Define protein denaturation and write notes on three different ways in which a protein may be denatured. [5 marks]
- (c) Write a short essay on the different steps involved in determining the amino acid sequence of a protein. [10 marks]