

### QUESTION 1

A weak acid may be represented by the term HA.

- a) Write an equation for its equilibrium constant for the dissociation of such a weak acid. [3 marks]
- b) Use your answer in question 1(a) to derive the Henderson-Hasselbalch equation. [4 marks]
- c) (i) Define the term buffer capacity. [2 marks].  
  
(ii) Calculate the pH of a buffer whose mixture is 6 mL of 0.1 mol/L sodium acetate and 4 mL of 0.1 mol/L acetic acid. (pKa for acetic acid is 4.76). [4 marks].  
  
(iii) Calculate the pH after adding 1 mL of 0.01 mol/L sodium hydroxide to this buffer mixture. [4 marks].  
  
(iv) What is the change in pH from pH in (ii) to pH in (iii) and comment on the effectiveness of this buffer. [3 marks].

### QUESTION 2

- a) Define the following:
  - i) Zwitterion
  - ii) pI[2 marks]
- b) The amino acid, aspartate was titrated with 0.1N NaOH. Draw on a graph paper supplied a neat titration curve and clearly label on the curve the following:
  - i) pKa 1, 2, 3
  - ii) pI
  - iii) pHm and
  - iv) the regions having the highest buffering capacity.[4 marks]

P.T.O.

## QUESTION 1

A weak acid may be represented by the term HA.

- a) Write an equation for its equilibrium constant for the dissociation of such a weak acid. [2 marks]
- b) What does the equilibrium constant indicate. [3 marks]
- c) (i) Define the term buffer. [2 marks].

(ii) A buffer whose mixture is 6 mL of 0.1 mol/L sodium acetate and 4 mL of 0.1 mol/L acetic acid. ( $pK_a$  for acetic acid is 4.76). Calculate the hydrogen concentration in this buffer [4 marks].

(iii) Calculate the pH after adding 1 mL of 0.01 mol/L sodium hydroxide to this buffer mixture. [5 marks].

(iv) Is this buffer an effective buffer. [4 marks].

## QUESTION 2

a) Calculate the pI for glutamate given that the  $pK_a$  values are 2.19, 4.25 and 9.67 for the  $\alpha$ -carboxyl,  $\gamma$ -carboxyl group and  $\alpha$ -amino groups respectively. [6 marks]

b) State whether each of the following statement is True (T) or False (F).

- i.) Amino acid configuration is with respect to glyceraldehyde. [1 mark]
- ii.) Arginine a derived amino acid. [1 mark]
- iii.) Proline is an imine. [1 mark]
- iv.) Glycine is achiral. [1 mark]

c) Tropomyosin, a 70 kd muscle protein is a two stranded  $\alpha$ -helical coiled coil. Estimate the length of the molecule. [4 marks]

d) Suppose that a 40 amino acid residue segment of a protein folds into a two stranded antiparallel  $\beta$  structure with a 4 residue hairpin turn. What is the longest dimension of this motif? [6 marks]

[Useful information:  $pK_{a1}$  ( $\alpha$ -carboxyl) = 2.1  $pK_{a2}$  = 9.8 ( $\alpha$ -amino)  $pK_{a3}$  = 3.9 ( $\beta$ -carboxyl-side chain)]

- c) Explain the salient features of the following:
- $\alpha$ -helix
  - collagen helix
  - $\beta$ -pleated sheets.
- [ 6 marks]
- d) You isolate a muscle protein (Mol. wt. 70 kD). It is a two stranded  $\alpha$ -helical coiled coil. Estimate the length of the molecule. [ 4 marks]
- e) Suppose that a 40 amino acid residue segment of a protein folds into a two stranded antiparallel  $\beta$  structure with a 4 residue hairpin turn. What is the longest dimension of this motif? [ 4 marks]

### QUESTION 3

- a) Draw the structure of Dipalmitoyl phosphatidyl choline. [5 marks]
- b) (i) What is the use of this chemical in the lungs? [2 marks]
- (ii) What condition arise to due lack of this lipid? [3 marks].
- c) Figure 1 below shows a structure of a lipid molecule

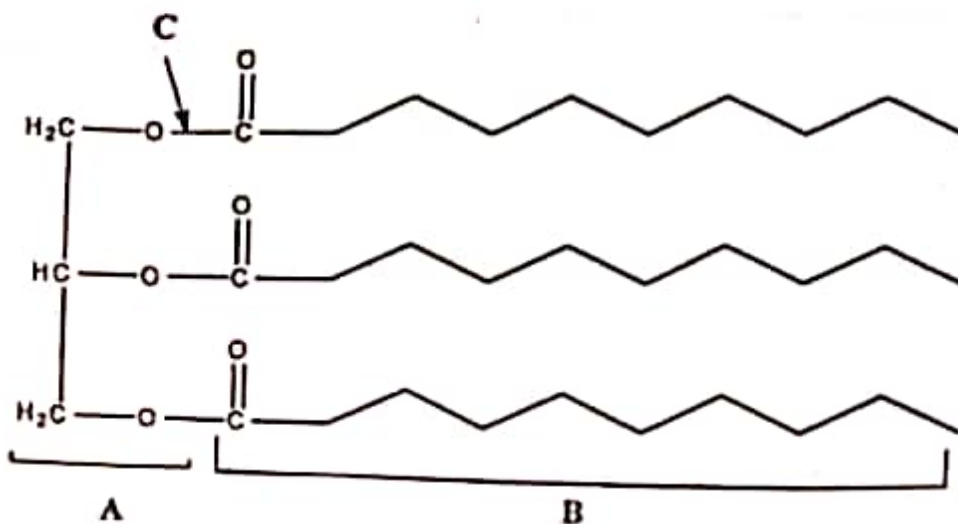


Figure 1: Structure of a lipid molecule

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### Question 3

- a) How many isomers of glucose chain form are possible? [2 marks]
- b) State whether the statement is True(T) or False(F)
- i.) Carbohydrates are not genetically encoded. [1 mark]
  - ii.) Galactose is an epimer of glucose on carbon atom number 4. [1 mark]
  - iii.) Erythrose is a ketotetrose. [1 mark]
  - iv.) Trehalose is a tetrasaccharide. [1 mark]
  - v.) Cleavage of a vicinal diol consumes 1 mole of  $\text{HIO}_4$ . [1 mark]
- c) After exhaustive methylation and acid hydrolysis and gas chromatography, an unknown disaccharide resulted into 3,4,6-trimethylglucose and 2,3,4,6-tetramethylglucose only. Use this information to determine the structure of the original disaccharide? [8 marks]
- d) Give a brief description of how can you distinguish a furanose from a pyranose ring structure. (*Hint: you may use structures to help you explain*) [5 marks]

#### QUESTION 4

a) What is acute respiratory distress syndrome (ARDS)? [2 marks]

i) What causes the ARDS? [2 marks]

ii) List three uses of sphingolipids? [3 marks].

b) Figure 1 below shows a structure of a lipid molecule

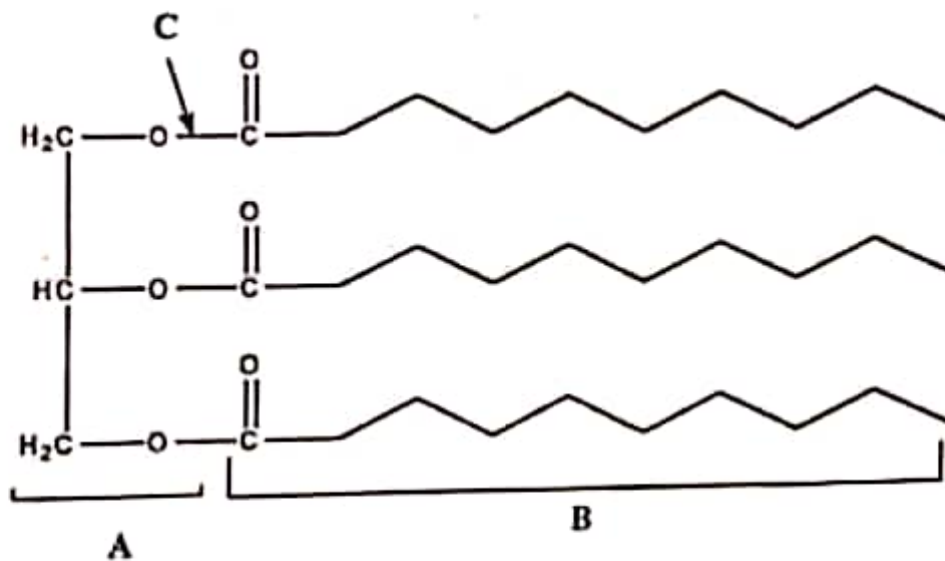


Figure 1: Structure of a lipid molecule

P.T.O.

i) What are the features of this type of a lipid? [3marks]

ii) What is saponification? [2 marks]

iii) Distinguish between fats and oils. [3 marks]

iv) Comparing this lipid and the corresponding carbohydrate, which one yield more energy? Why? [5 marks]

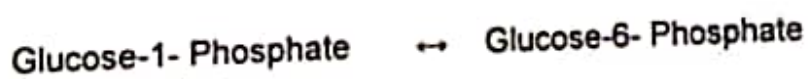
### QUESTION 5

a) Explain the following terms and/or expressions:

- i) Endergonic reaction
- ii) Coenzyme
- iii) Prosthetic group
- iv) Entropy
- v) Allosteric

[5 marks]

b) Assuming that you are given a solution of 0.1 M glucose 1-phosphate. To this you add the phosphomutase, which catalyzes the reaction



- (i) Does this reaction proceed as written, and if so, what are the final concentrations of glucose 1-phosphate (G-6-P) and glucose 6-phosphate (G-1-P)?
- (ii) What cellular conditions would allow continuous production of G-1-P?

[10 marks]

#### NOTE

$$\Delta G = -1800 \text{ cal/mol}; R = 1.987 \text{ cal/mol/}^{\circ}\text{K}; \text{ Temperature} = 25^{\circ}\text{C}$$

(c) For an enzyme that follows Michaelis-Menten Kinetics, calculate the ratio of [S] to  $K_m$  when initial velocity is 60 %  $V_{max}$ .

[5 marks]

### QUESTION 5

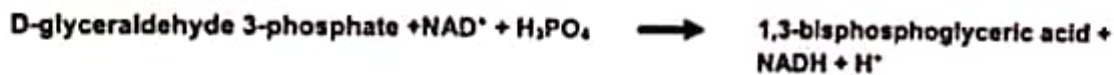
- i) In your answer book, draw a table and then match the reaction on the left with the appropriate enzyme on the right:

Reaction	Enzyme
Transfer of functional group	Oxidoreductases
Oxidation-reduction reaction	Transferases
Bond formation coupled with ATP hydrolysis	Lyases
Group elimination to form double bond	Isomerases
Hydrolysis reaction	Ligases
Isomerisation	hydrolyases

[6 marks]

- ii) Rearrange the Michaelis-Menten equation to give initial velocity ( $v$ ) as a function of  $v/[S]$  and draw the shape of the curve you would obtain with this equation. [8 marks]

- iii) Look at the following reaction and answer the questions that follow:



$$\Delta G^\circ = +1,500 \text{ cal/mol}$$

*In vivo* (pH 7.0, temperature 37 °C), the following concentrations are observed:

$$[\text{D-glyceraldehyde 3-phosphate}] = 10^{-4} \text{ M}$$

$$[\text{1,3-bisphosphoglyceric acid}] = 10^{-5} \text{ M}$$

$$[\text{Inorganic phosphate}] = 0.01 \text{ M}$$

As the reaction stands ( $\Delta G^\circ$  is +ve), 1,3-bisphosphoglycerate will not form. One way to make the formation of 1,3-bisphosphoglycerate possible is change the ratio of  $\text{NAD}^+/\text{NADH}$ . What must ratio of  $\text{NAD}^+/\text{NADH}$  be in order for the reaction to proceed spontaneously from left to right? Show your calculation. ( $R = 1.987 \text{ cal/K.mol}$ )

[6 marks]

- i) **What type of a chemical compound is a lipid and select which labelled letter A,B or C represents functional group in lipids [3marks]**
- ii) **What is the importance of alkaline hydrolysis of this lipid?[2 marks]**
- iii) **Name the chemical reaction used to form the bonds labelled C and the catalyst required for this reaction. [2 marks]**
- iv) **State three functions of lipids in living organisms. [3 marks]**

#### **QUESTION 4**

- a) **An unknown disaccharide was purified from bacteria. Equal amounts of D-glucose and D-galactose were obtained after acid hydrolysis of the disaccharide and the two sugars were found to be linked by an  $\alpha$  linkage. Exhaustive methylation of the disaccharide produced equal amounts of 2,3,4,6-tetramethylgalactose and 2,4,6-trimethylglucose. Using Haworth formulas draw the structure of the disaccharide suggested by the above information and show clearly the link between the sugars. [10 marks]**
- b) **Explain mutarotation using glucose as an example. [5 marks]**
- c) **Give a brief description of how can you distinguish a furanose from a pyranose ring structure. [5 marks]**

## QUESTION 6

- a) State the Chargaff's Rules. [2 Marks].
- b) What are salient features of  $\beta$ -DNA structure. [4 Marks].
- c) Draw the chemical structure of any cytidine nucleoside analogue used in treatment of HIV. [3 Marks].
- d) A sample of double stranded DNA was found to have guanylate as 29% of the nucleotide residues.
- (i) What is the %AT of this DNA? [5 Marks].
- (ii) Draw a structure showing hydrogen bonds between adenine and thymine. [6 Marks].

END OF EXAMINATION

### USEFUL DATA

Name	pKa1 ( $\alpha$ )	pKa2 ( $\alpha$ )	pKa3 (side)
Cysteine	1.7	10.8	8.3(Sulfhydryl)
Aspartate	2.1	9.8	3.9 ( $\beta$ -Carboxyl)
Lysine	2.2	9.0	10.5 ( $\epsilon$ -Amino)