**Topic 3: Chemistry of Life (Basics—Enzymes)**

**1.** Many elements are necessary to form biochemicals required by living organisms. For each element below, state the name of **one** molecule containing the element and state the function of the molecule.

(a) Iron: Molecule .

Function (2)

(b) Phosphorus: Molecule .

Function (2)

(Total 4 marks)

**2.** State **one** function for each of the main four elements in organisms.

(Total 4 marks)

**3.** Diatoms are unicellular algae which live as plankton in fresh water and oceans. Biochemists investigated two species of diatom, *Thalassiosira oceanica* which lives in the open ocean where the water is clear and *Thalassiosira weissflogii* which lives in coastal waters where the water is often cloudy. Iron is an important part of a number of molecules involved in photosynthesis. Iron however is often deficient in the waters of the open ocean. The scientists investigated the amount of iron present in the cells of the diatoms when they were grown at different intensities of light, in both high and low iron conditions.



[Source: Reprinted with permission from Macmillan Publishers Ltd: Robert F. Strzepek and Paul J. Harrison, “Photosynthetic architecture differs in coastal and oceanic diatoms”, *Nature* (7 October 2004), vol. 431, issue 7009, p. 689, © 2004]

(a) Compare the iron concentrations in the cells of *T. oceanica* and *T. weissflogii* under high iron conditions.(2)

(b) Suggest a reason for the response of *T. weissflogii* to low light intensities.(2)

When the growth of these two species was compared in the two iron conditions it was found that the growth of *T. oceanica* was not affected by low iron concentrations but the growth of *T. weissflogii* was reduced by about 20%.

(c) Explain how *T. oceanica* is adapted to oceanic waters.(3)

(d) Predict what would be the effect on the populations of these diatoms if atmospheric pollution reduced light intensities over the oceans.(1)

(Total 8 marks)

**4.** Explain, with reference to its properties, the significance of water as a coolant, a means of transport and as a habitat.(Total 8 marks)

**5.** A study was conducted on how cattle grazing affects the water content of soils. One area studied was a pasture of alfalfa (*Medicago sativa*). A special probe was used to take measurements of soil water to depths of 300 mm. The range of measurements obtained were used to calculate the total soil water content expressed in mm. Results from part of the study during the growing season for the year 2000 are shown below.



[Source: Mapfumo *et al.*, *Canadian Journal of Soil Science*, (2003), **83**, pp 601–614]

(a) State the overall trend in total soil water content during the study period.(1)

(b) Identify the day on which the difference in total soil water content of grazed and un-grazed areas was greatest.(1)

(c) Discuss the effects of grazing on the total soil water content.(4)

(Total 6 marks)

**6.** Describe the use of carbohydrates and lipids for energy storage in animals.(Total 5 marks)

**7.** The diagrams below show various molecular structures.



(a) Identify which of the diagrams represent

(i) the structure of glucose;(1)

(ii) the structure of amino acids;(1)

(iii) the structure of fatty acids.(1)

(b) Discuss which of the molecules are most similar in structure. (3)

(Total 6 marks)

**8.** Which molecule represents ribose?



(Total 1 mark)

**9.** Which of the following terms correctly describe the molecule below?



I. Monosaccharide

II. Ribose

III. Carbohydrate

A. I only

B. I and III only

C. II and III only

D. I, II and III (Total 1 mark)

**10.** Outline how monosaccharides are converted into polysaccharides. (Total 2 marks)

**11.** Lipids are essential nutrients that must be included in the diet.

(a) State **one** food rich in lipids suitable for a vegan diet.(1)

(b) Outline **two** functions of lipids in the body.(2)

(c) Discuss the possible health problems associated with diets rich in lipids.(4)

(Total 7 marks)

**12.** Which is the structure of glycerol?



(Total 1 mark)

**13.** Draw the structure of a fatty acid.(Total 1 mark)

**14.** What is the maximum number of fatty acids that can be condensed with glycerol?

A. One

B. Two

C. Three

D. Four

(Total 1 mark)

**15.** Draw the basic structure of an amino acid, and label the groups that are used in peptide bond formation.

(Total 4 marks)

**16.** Outline the production of a dipeptide by a condensation reaction. Include the structure of a generalized dipeptide in your answer.

(Total 5 marks)

**17.** List **four** functions of proteins, giving an example of each.

(Total 4 marks)

**18.** The complex structure of proteins can be explained in terms of four levels of structure, primary, secondary, tertiary and quaternary.

(a) Primary structure involves the sequence of amino acids that are bonded together to form a polypeptide. State the name of the linkage that bonds the amino acids together.(1)

(b) Beta pleated sheets are an example of secondary structure. State **one** other example. ( 1)

(c) Tertiary structure in globular proteins involves the folding of polypeptides. State **one** type of bond that stabilizes the tertiary structure.(1)

(d) Outline the quaternary structure of proteins.(2)

(Total 5 marks)

**19.** List the functions of membrane proteins.(Total 4 marks)

**20.** (a) State **one** named example of a fibrous protein and **one** named example of a globular protein.

Fibrous: Globular: (2)

(b) Outline the effect of enzymes on the reactions they catalyse.(2)

(c) The rate of cellular respiration is controlled by the allosteric inhibition of phosphofructokinase by ATP. Phosphofructokinase is the first enzyme in the respiration pathway. Explain the meaning of allosteric inhibition using this example.(4)

(Total 8 marks)

**21.** (a) State the name and function of

(i) a fibrous protein (1)

(ii) a globular protein (1)

(b) Annotate the graph representing an exergonic enzyme catalysed reaction.



(2)

(c) Explain how end-product inhibition controls metabolic pathways. (3)

(Total 7 marks)

**22.** At the start of glycolysis, glucose is phosphorylated to produce glucose 6-phosphate, which is converted into fructose 6-phosphate. A second phosphorylation reaction is then carried out, in which fructose 6-phosphate is converted into fructose 1,6-bisphosphate. This reaction is catalyzed by the enzyme phosphofructokinase. Biochemists measured the enzyme activity of phosphofructokinase (the rate at which it catalyzed the reaction) at different concentrations of fructose 6-phosphate. The enzyme activity was measured with a low concentration of ATP and a high concentration of ATP in the reaction mixture. The graph below shows the results.



(a) (i) Using **only** the data in the above graph, outline the effect of increasing fructose 6-phosphate concentration on the activity of phosphofructokinase, at a low ATP concentration.(2)

(ii) Explain how increases in fructose 6-phosphate concentration affect the activity of the enzyme.(2)

(b) (i) Outline the effect of increasing the ATP concentration on the activity of phosphofructokinase.(2)

(ii) Suggest an advantage to living organisms of the effect of ATP on phosphofructokinase.(1)

(Total 7 marks)

**23.** Explain the effects of temperature, pH and substrate concentration on enzyme activity.

(Total 8 marks)

**24.** Alcohol dehydrogenase is an enzyme that catalyses the reversible reaction of ethanol and ethanal according to the equation below.

NAD+ + CH3CH2OH  CH3CHO + NADH + H+

ethanol ethanal

The initial rate of reaction can be measured according to the time taken for NADH to be produced.

In an experiment, the initial rate at different concentrations of ethanol was recorded (no inhibition). The experiment was then repeated with the addition of  
l mmol dm–3 2,2,2-trifluoroethanol, a competitive inhibitor of the enzyme. A third experiment using a greater concentration of the same inhibitor (3 mmol dm–3) was performed. The results for each experiment are shown in the graph below.



[Source: R Taber, *Biochemical Education*, (1998) **26**, pages 239-242]

(a) Outline the effect of increasing the substrate concentration on the control reaction (no inhibition).(2)

(b) (i) State the initial rate of reaction at an ethanol concentration of 50 mmol dm–3  
in the presence of the inhibitor at the following concentrations.

1 mmol dm–3: .

3 mmol dm–3: (1)

(ii) State the effect of increasing the concentration of inhibitor on the initial rate of reaction.(1)

(c) Explain how a competitive inhibitor works.(3)

(Total 7 marks)

**25.** Explain the effect of substrate concentration on enzyme activity.(Total 3 marks)

**26.** The graph below shows the effect of changing the substrate concentration on an enzyme controlled reaction.



What is the correct interpretation of these data?

A. The rate of reaction increases continuously with increase in substrate concentration.

B. The rate of reaction decreases continuously with increase in substrate concentration.

C. The rate of reaction increases up to a point and then remains constant.

D. The rate of reaction is not affected by any change in the substrate concentration.

(1)

**27.** (a) The table below compares prokaryotic and eukaryotic cells. Place a tick () wherever the organelle is present.

|  |  |  |
| --- | --- | --- |
| **Organelle** | **Prokaryotic** | **Eukaryotic** |
| **Nucleus** |  |  |
| **Mitochondrion** |  |  |
| **Ribosomes** |  |  |

(2)

(b) (i) The graph below shows the energy changes in a reaction.



On the above graph draw the result you would obtain in this same reaction if an enzyme that catalyses this reaction were added. (1)

(ii) Explain how the enzyme produces this effect. (3)

(c) Outline the process of glycolysis. (omit this question until later!!) (3)

(Total 9 marks)