Nuffield Advanced Chemistry Special Study: *Biochemistry*
Sample examination questions

Q1 ***[Adapted from Edexcel Chemistry (Nuffield) 1996]***

(a) Animal cells have several distinguishable parts such as
- A membrane
- Cytoplasm
- A nucleus
- Ribosomes
- Mitochondria

(i) What characteristic of the membrane is of importance to the functioning of the cell? (1)

(ii) In which part of the cell does the citric acid cycle take place? (1)

(iii) What genetic material is contained in the nucleus? (1)

(iv) In order to separate the constituents of cells they are first disrupted in a process called *homogenisation*. Suggest two practical techniques which may be used on the homogenate in order to separate enzymes from it. (2)

(b) The enzyme urease catalyses the hydrolysis of urea, NH_2-CO-NH_2, to a mixture of carbon dioxide and ammonia. An experiment was devised to investigate the ability of urease to catalyse the hydrolysis of other substrates with related chemical formulae.
Four test tubes were set up containing 2 cm^3 of the liquids given in the table:

Tube	*Contents*
1	Urea, NH_2-CO-NH_2 , 0.25 mol dm^{-3}
2	Methylurea, CH_3-NH-CO-NH_2 , 0.25 mol dm^{-3}
3	Ethanamide, CH_3-CO-NH_2 , 0.25 mol dm^{-3}
4	Water

6 drops of an indicator solution (red in acid solution, green in alkaline solution) were added to each tube and drops of very dilute hydrochloric acid were added to each, sufficient to adjust the four tubes to the same red-brown colour.

The tubes were placed in a water bath at 40°C. After a few minutes 0.5 cm^3 of urease solution were added to each tube.

After a further 10 minutes 0.5 cm^3 of a solution containing mercury(II) ions was added to each of the tubes.

The contents of each of the tubes was then titrated back to the original red-brown colour with hydrochloric acid of concentration 0.1 mol dm^{-3}.

(i) Why did the colour of the indicator change from the original red-brown during this experiment? (2)

(ii) What was the function of the mercury ions and how did they achieve this function? (2)

(iii) Why was a water-bath at 40°C used? (1)

(iv) What was the purpose of tube 4? Suggest how the titration result from tube 4 should be used. (2)

(v) How would you expect the final titration results from tubes 1 to 3 to compare with each other? Justify your answer from a knowledge of enzyme catalysed reactions. (3)

(c) Glucose, $C_6H_{12}O_6$, can be metabolised in the presence of yeast either aerobically or anaerobically. The aerobic metabolism of glucose begins with its conversion to pyruvate anions:

$$C_6H_{12}O_6 \rightarrow 2C_3H_3O_3^-$$

(i) What name is given to the overall process of 10 steps by which this conversion is accomplished? (1)

(ii) Explain, by means of oxidation numbers, why this conversion is an oxidation. (2)

(iii) The pyruvate anions then react to form a substance which is a building block for many important biochemicals but most of which is further oxidised in the citric acid cycle. What name is given to this substance? (1)

(iv) If there is insufficient oxygen present for the operation of the citric acid cycle, pyruvate anions are converted instead into lactate ions. Why is this anaerobic change of interest to athletes? (1)

(d) Insecticides and some drugs are designed to kill harmful organisms selectively.

(i) Suggest **two** basic ways in which selectivity can be achieved. (2)

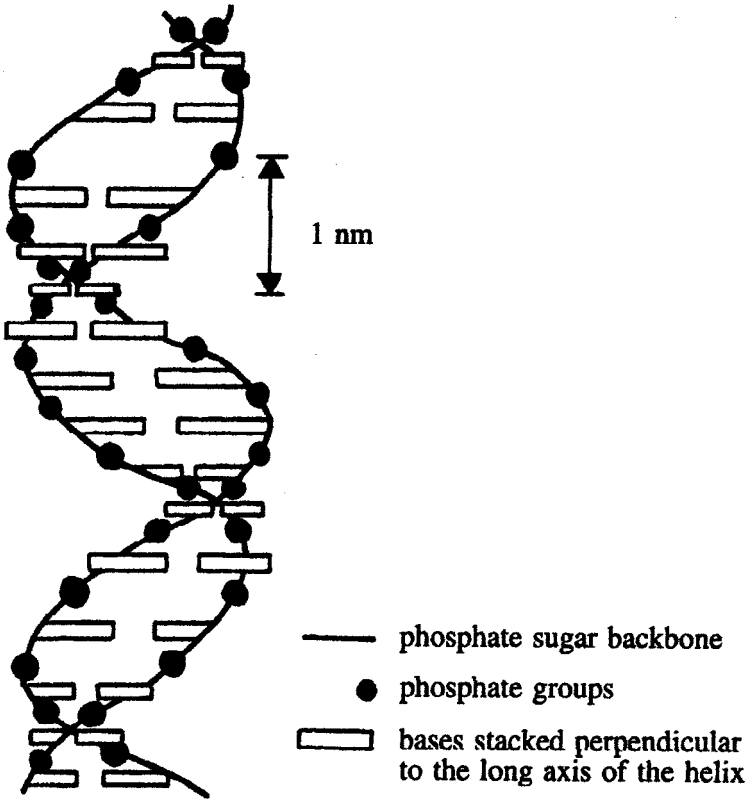
(ii) Explain how the drug penicillin works to kill bacteria. (4)

(iii) Explain how the insecticide dimethoate is selective in its action. (4)

Total 30 marks

Q2 ***[Adapted from Edexcel Chemistry (Nuffield) 1997]***

(a) The simplified diagram represents part of the DNA double helix.



Data obtained by X-ray diffraction indicated repeating units at intervals of 3.4 nm and 0.34 nm. The four types of nitrogen-containing bases in DNA are: adenine, guanine, cytosine and thymine.

(i) Write the full name of DNA (1)

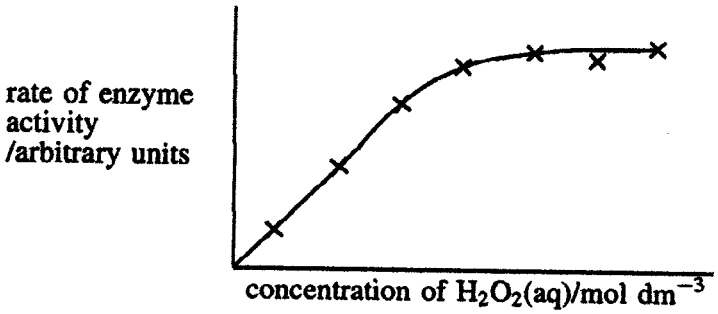
(ii) What structural features give rise to the repeating units at 3.4 nm and 0.34 nm ? (2)

(iii) Explain what is meant by a **base pair.** (2)

(iv) How many base pairs are there in one complete turn of the helix? (1)

(v) What, in relation to DNA, is a **gene** ? (2)

(b) The graph shows the results of a series of experiments, conducted at room temperature, in which the rate of activity of the enzyme catalase was found at different concentrations of hydrogen peroxide substrate.



(i) What physical methods may be used for preparing a catalase solution starting from mammalian liver ? (3)

(ii) Describe and explain the shape of the graph. (4)

(iii) What would be the effect on the outcome of the experiments if the catalase solution were boiled for four minutes before use? Explain your answer in terms of enzyme structure. (3)

(iv) Suggest what would happen in this series of experiments if the catalase solution were stored at 4°C and then gently warmed to room temperature before use. (2)

(c) (i) What is meant by **immobilisation** of enzymes ? (1)

(ii) Briefly describe **three** methods of immobilisation. (3)

(iii) Give **two** advantages that the use of enzyme immobilisation has over the use of soluble enzymes. (2)

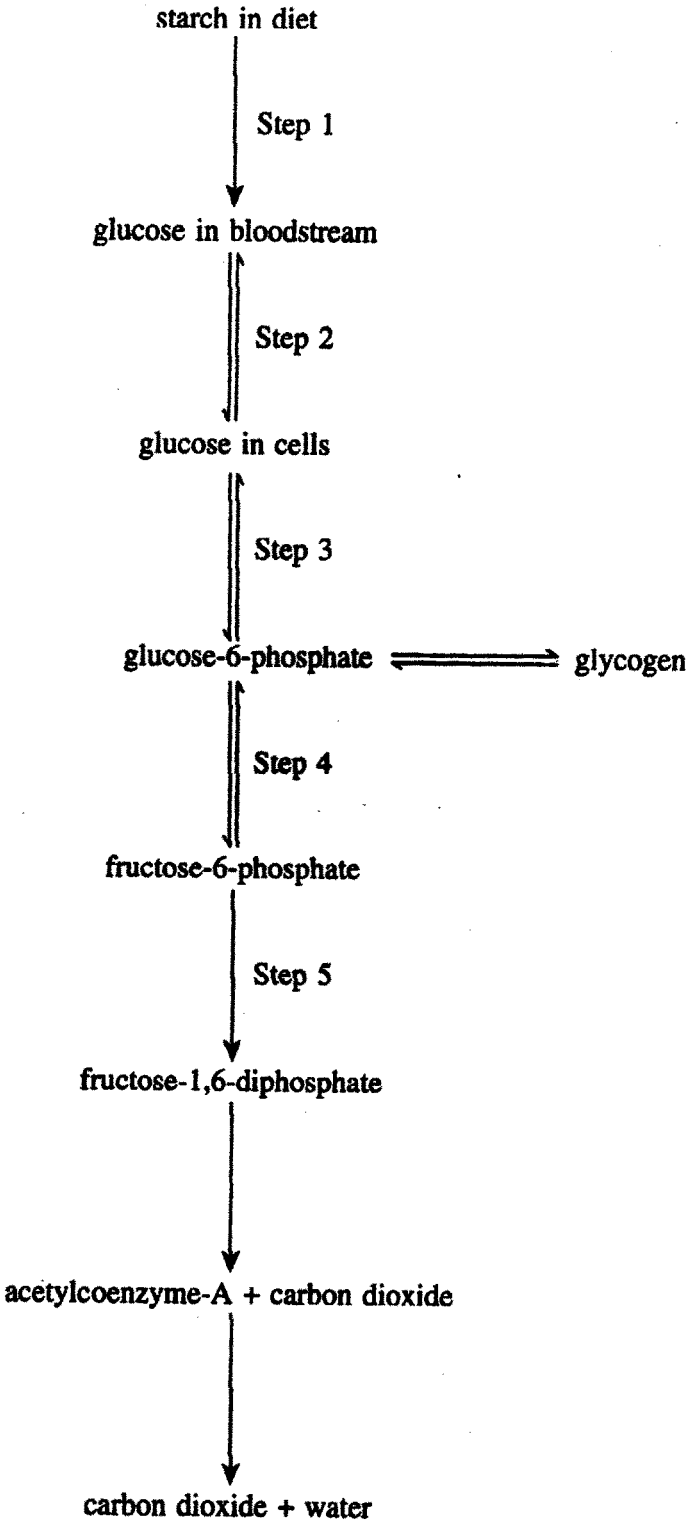
(iv) The enzyme *Aspergillus*, immobilised using a polysaccharide, has been used to obtain L-amino acids from a mixture of D- and L- amino acids. Explain how the enzyme effects this separation. (2)

(v) What benefit might arise from the development of a method based on immobilised enzymes for converting atmospheric nitrogen into soluble nitrogen compounds? (2)

TOTAL 30 Marks

Q3 ***[Adapted from Edexcel Chemistry (Nuffield) 1998]***

(a) The sequence below summarises some of the chemical changes which take place when starchy food is used to provide energy in mammalian cells.



(i) What **type** of chemical reaction is represented by Step 1 in the sequence ? (1)

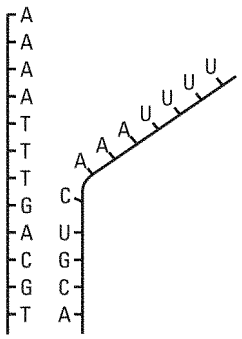
(ii) What is the role of glycogen and why is it important that its formation from glucose-6-phosphate is reversible ? (2)

(iii) The enzyme which catalyses Step 5 has two binding sites to which molecules of ATP can attach. One is the active site, the other is an allosteric site. Explain the meanings of the expressions **active site** and **allosteric site.** (2)

(iv) What name is given to the **type** of reaction involved in both Step 4 and Step 5 ? (1)

(v) Both plants and animals can derive glucose from food supplied to them but plants have another way of obtaining glucose. What is this other way? (1)

(b) The schematic diagram below shows the formation of mRNA by transcription from DNA.



(i) Write the full name of mRNA. (1)

(ii) Write the names of the bases denoted by the letters A, C, G, T and U. (4)

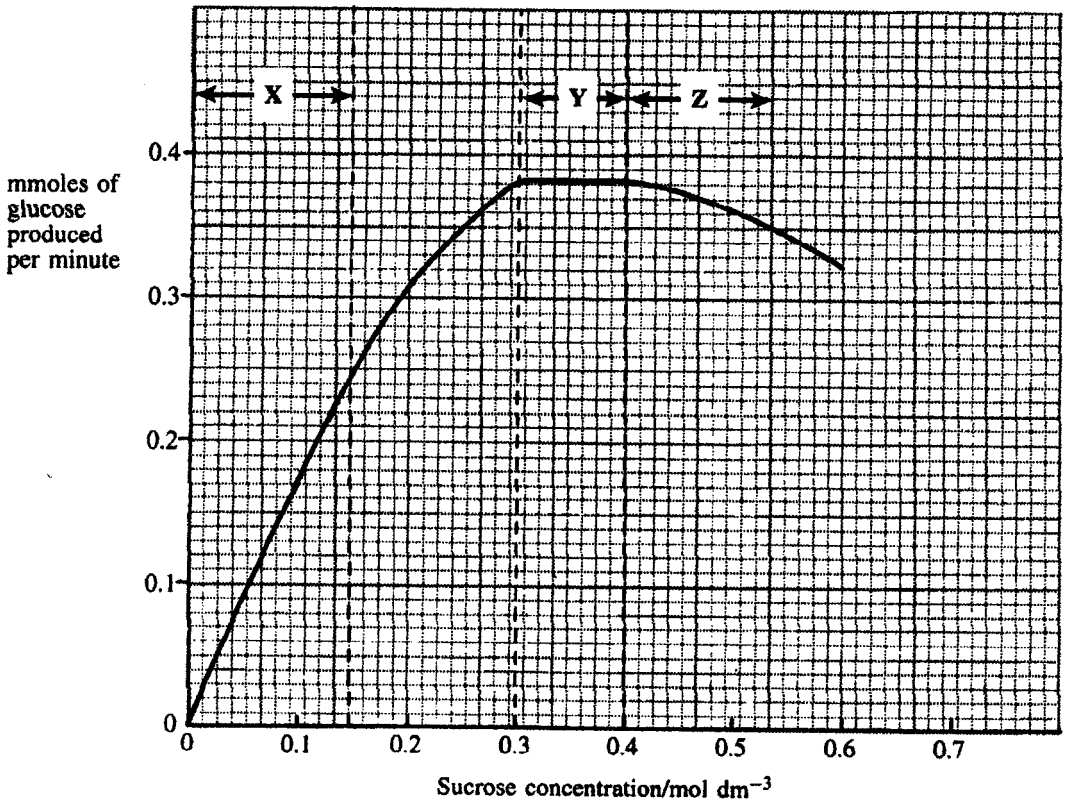
(iii) How can you tell from the diagram which strand is the DNA and which the mRNA ? (2)

(iv) How many amino acids are coded for by the mRNA shown? Justify your answer. (2)

(v) What would be the consequence for the resultant structure of the protein if one of the bases marked as A were to be missing completely from the DNA ? (2)

(vi) What principal **type** of intermolecular force of attraction exists between the bases in a base pair ? (1)

(c) Purified invertase was mixed with various concentrations of sucrose and the amount of glucose produced in each case was measured after one minute. The graph shows the results obtained.



(i) What is the order of the reaction with respect to sucrose in each of the regions **X** and **Y** on the graph? Justify your answer.

(4)

(ii) Explain the shape of this graph in terms of the mechanism of enzyme action in each of the three ranges **X, Y** and **Z**. (3)

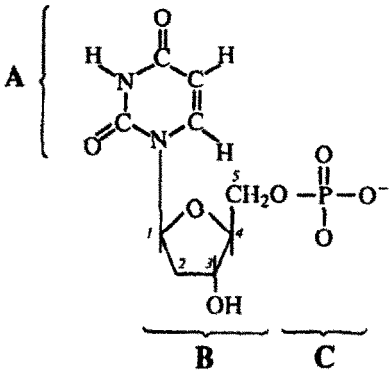
(iii) Some substances act as **competitive inhibitors** of invertase. Sketch the shape of the graph you would expect from the results of a similar experiment conducted with sucrose as before but in the presence of a competitive inhibitor. Justify your answer. As part of your answer you should explain what a competitive inhibitor is. You do not need to use graph paper.

(4)

TOTAL 30 Marks

Q4 ***[Adapted from Edexcel Chemistry (Nuffield) 1999]***

(a) The structural formula of one monomeric unit of DNA is given below:



(i) State the general names for the parts **A, B** and **C.** (3)

(ii) DNA consists of two strands of nucleotides held together in a double helix. State what type of intermolecular force holds the strands together and name the bases between which these forces are formed. (3)

(iii) Write the complementary form of the DNA strand which has the following sequence of bases:

GATTCCCA (1)

(iv) Transcription of DNA produces a molecule called mRNA. State **two** ways in which mRNA differs from the DNA to which it is related. (2)

(v) In the cytoplasm small molecules exist with an **anticodon** at one end and a corresponding amino acid at the other. What is an **anticodon,** and what are these small molecules called? (3)

(b) The effect of pH on the activity of amylase can be measured in the following experiment.

Five test tubes are set up, each containing 5 cm^3 of 1% starch solution and 1 cm^3 of sodium chloride of concentration 0.2 mol dm^{-3}. 2 cm^3 of a buffer solution is added to each test tube, with a different pH for each.

A suitable volume of diluted saliva is added to one test tube and a clock is started. The time taken for all the starch to be removed is determined by testing drops of the mixture at 30 s intervals with iodine solution.

The experiment is repeated with the other test tubes in turn.

(i) What is the starch finally converted to in the course of the reaction? (1)

(ii) Explain the function of the sodium chloride solution. How might the results of the experiment be different if the sodium chloride was not present? (3)

(iii) Sketch a graph of time (vertical axis) against pH from this experiment and explain its shape in terms of the mechanism of enzyme catalysed reactions. (4)

(c) (i) What is a hormone? (1)

(ii) Using insulin as an example, explain how hormones can control metabolic processes. (4)

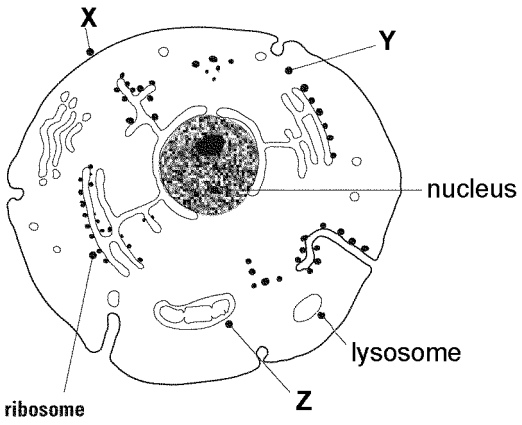
(iii) Describe in outline how insulin can be produced from a transgenic source. (3)

(iv) Suggest **two** advantages of producing insulin from a transgenic source rather than extracting it from an animal source. (2)

Total 30 Marks

Q5 Adapted from ***[Adapted from Edexcel Chemistry (Nuffield) 2000]***

(a) The diagram is a generalised view of an **animal** cell.



(i) State the functions of the structures **X, Y** and **Z.** (3)

(ii) Name **two** additional structures which would be found in a **plant** cell. (2)

(iii) The ribosomes are the sites of protein synthesis. The double helix of the DNA unravels and each strand is copied by the making of mRNA. State **two** ways in which the mRNA strand differs from the DNA strand. (2)

(iv) Each group of three bases in the strand of mRNA codes for a specific amino acid. What name is given to such a group of three bases? (1)

(v) Explain how such a group of three bases uses tRNA to add an amino acid to the protein chain being synthesised in the ribosome. (3)

(b) The following procedure can be used to isolate a sample of DNA from cress.

The fresh cress leaves are ground to a smooth paste with a little sand and a buffered solution of sodium dodecyl sulphate (SDS), pre-warmed to 65°C.

The mixture, together with a little more buffer solution, is poured into a conical flask. The flask and its contents is put into a water bath at 65°C for 40 minutes.

The mixture is then centrifuged. The liquid part of the mixture is drawn off and ethanol is added to it to precipitate DNA.

(i) What is the purpose of the grinding procedure? (1)

(ii) Why is the solution buffered? (1)

(iii) Why is the mixture kept at 65°C during the extraction ? (2)

(iv) Suggest **two** other water-soluble compounds, in addition to DNA, which are likely to be present in the liquid after centrifuging. (2)

(v) By what practical procedure could the structures of DNA samples from two different varieties of cress be compared? (2)

(c) Immobilised enzymes are used in the industrial production of substances such as drugs and hormones. The molecules of such substances are usually **chiral.**

(i) Explain why an enzyme can be used to separate the two isomers of a chiral substance. (2)

(ii) What is meant by an **immobilised** enzyme? Briefly describe **one** method of immobilising enzymes. (3)

(iii) Give **two** advantages and **one** disadvantage of using immobilised enzymes rather than soluble enzymes. (3)

(d) (i) What, in connection with DNA, is a **gene**? (1)

(ii) Outline **one** way in which **gene therapy** might be used to treat inherited disease. (2)

TOTAL 30 Marks

Q6 ***[Adapted from Edexcel Chemistry (Nuffield) 2001]***

(a) ATP plays a key role in metabolism. It is synthesised from ADP and phosphate ions.

(i) Give the full name of ATP. (1)

(ii) Give the name of the process in which ATP is synthesised from ADP and phosphate ions. (1)

(iii) Where does the energy come from for the reactions which produce ATP in
- Animals
- Plants (3)

(iv) State two **types** of cellular activity in which ATP is involved. (2)

(v) Why does ATP not hydrolyse spontaneously on mixing with water? Why does it do so during metabolism? (2)

(vi) One method by which the rate of metabolism is controlled involves **hormones.** Give **one** example of a hormone and briefly explain how it controls a metabolic process. (3)

(b) The enzyme catalase catalyses the breakdown of hydrogen peroxide into water and oxygen. The following description is of an experiment to investigate the activity of catalase in peas.

Three peas were added to a test tube of water maintained at 20°C. After standing for 10 minutes the peas were tested for catalase activity by measuring the rate at which oxygen was produced from a measured volume of hydrogen peroxide solution.

The process was repeated at constant temperatures of 40°, 60° and 80°C using fresh peas for each run of the experiment.

(i) Write the balanced equation for the decomposition of hydrogen peroxide. (1)

(ii) Why were the peas left for 10 minutes before testing ? (1)

(iii) Use your knowledge of rates of reaction and of enzyme behaviour to explain
- why the rate of enzyme activity increases between 20° and 40°C
- why the rate of enzyme activity falls between 60° and 80°C (3)

(iv) Another run of the experiment was carried out using peas which had previously been boiled in water. What difference in result would be expected from this run of the experiment? (1)

(v) The description given contains a potentially faulty piece of experimental design. What is this fault and why might it produce misleading results? (2)

(c) Cystic fibrosis is a genetic disorder caused by mutations on one gene.

The normal gene contains the sequence of bases TAGAAA but in some abnormal genes the bases GAA are missing from the sequence.

Genetic screening can be used early in pregnancy to find out if the foetus has inherited the disorder.

(i) What is a gene? (2)

(ii) How does a faulty gene affect the resultant protein? (3)

(iii) Why is it not inevitable that a child will inherit the disorder if one of its parents has it? (2)

(iv) Give **two** advantages and **one** disadvantage associated with the practice of genetic screening for inherited disease. Your answers may be based on scientific, social or ethical issues. (3)

TOTAL 30 Marks