AQA A-LEVEL · 7402

# BIOLOGY



## EXAM QUESTION PACK

### 3.6.4.2 CONTROL OF BLOOD GLUCOSE

| SCORE | PERCENTAGE |
| --- | --- |
| /141 | % |

STEMUP

# These questions belong to AQA, not to us.

The examination questions, mark schemes and examiner reports in this pack were written and published by AQA. They are past assessment materials, reproduced here so that students can revise from them.

## What we do not own

STEMUP is not affiliated with AQA and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. AQA has not endorsed, approved or been involved in the production of it. AQA and the qualification titles used here belong to their respective owners and appear for identification only.

## Where to find the originals

AQA publishes its past papers, mark schemes and examiner reports free of charge. Always check the current specification at aqa.org.uk before you revise, because content and wording can change between series.

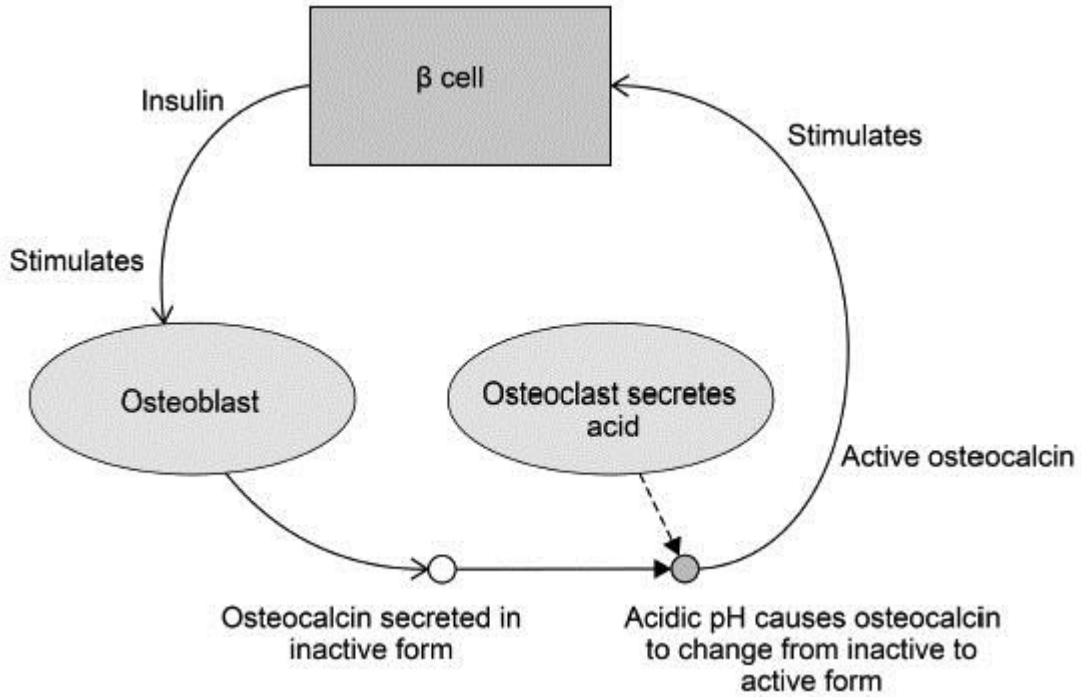
If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

## Q1.

Broken bones are repaired by cells called osteoclasts and osteoblasts.

Osteoblasts secrete a hormone called osteocalcin in an inactive form. Osteocalcin is a protein. The active form of osteocalcin binds to a receptor on beta (β) cells in the pancreas, stimulating them to release insulin. Osteoblasts have receptors for insulin.

The diagram shows how the production of osteocalcin by osteoblasts is controlled by positive feedback.




(a) The secretion of osteocalcin (in an inactive form) by osteoblasts is controlled by positive feedback.

Use information from the diagram to explain why this is positive feedback.

_____

_____

_____

_____

_____

_____

_____

_____

_____

**(2)**

(b) The acidic pH conditions created by osteoclasts cause the inactive form of the protein osteocalcin to change into the active form of osteocalcin.

Suggest how.

**(2)**

(c) Binding of insulin leads to an increase in the rate of respiration in cells such as osteoblasts.

Explain how.

**(2)**

**(Total 6 marks)**

## Q2.

(a) Each year, a few people with type I diabetes are given a pancreas transplant. Pancreas transplants are not used to treat people with type II diabetes.

Give **two** reasons why pancreas transplants are not used for the treatment of type II diabetes.

1. _____

_____

_____

2. _____

_____

_____

**(2)**

(b) The pancreas produces the hormone insulin.

Put a tick (✔) in the box next to the statement which describes **incorrectly** the action of insulin.

| | |
|---|---|
| Activates enzymes involved in the conversion of glucose to glycogen. | ☐ |
| Controls the uptake of glucose by regulating the inclusion of channel proteins in the surface membranes of target cells. | ☐ |
| Attaches to receptors on the surfaces of target cells. | ☐ |
| Activates enzymes involved in the conversion of glycerol to glucose. | ☐ |

**(1)**

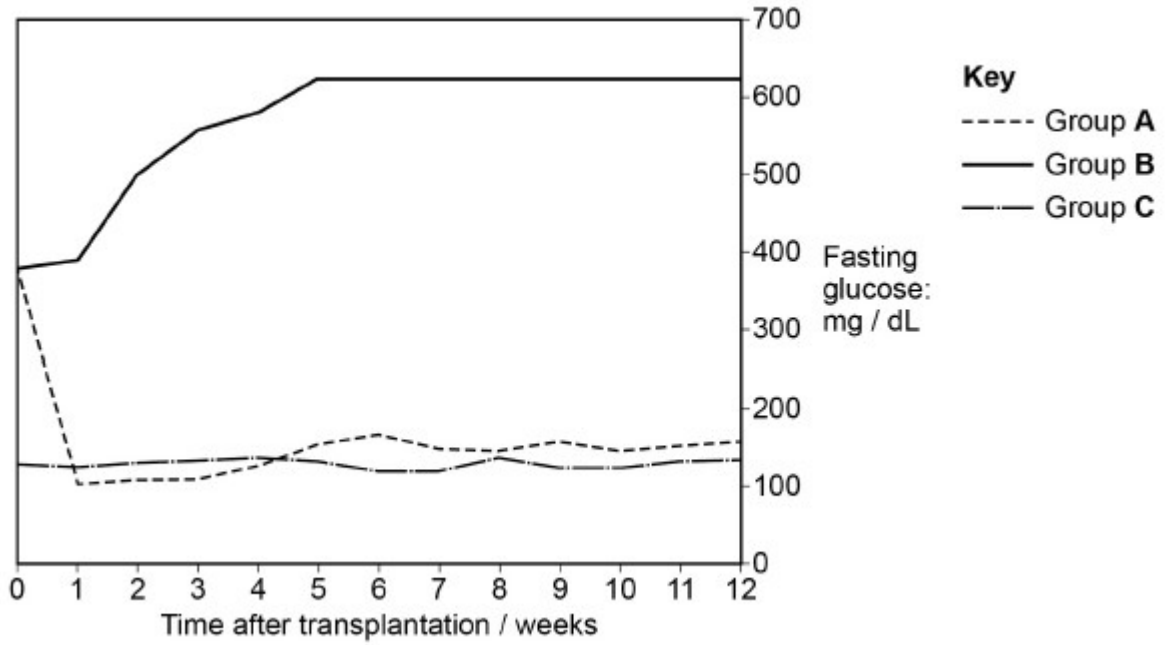
(c) Scientists investigated the use of induced pluripotent stem cells (iPS cells) to treat type I diabetes in mice. The scientists used four transcription factors to reprogramme skin cells to form iPS cells. The scientists then stimulated the *in vitro* differentiation of iPS cells into pancreatic cells.

The scientists set up three experimental groups:

- Group **A** – 30 mice with type I diabetes received pancreatic cell transplants derived from iPS cells.
- Group **B** – 30 mice with type I diabetes were left untreated.
- Group **C** – 30 mice without diabetes were left untreated.

The scientists measured the blood glucose concentration of all the mice on a weekly basis for 12 weeks.

The results the scientists obtained are shown in the graph.




Suggest how transcription factors can **reprogramme** cells to form iPS cells.

_____

_____

_____

_____

_____

**(2)**

(d) Using all the information provided, evaluate the use of iPS cells to treat type I diabetes in humans.

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

**(Total 9 marks)**

## Q3.

(a) Give **two** ways in which people with type 1 diabetes control their blood glucose concentration.

1. _____

_____

_____

2. _____

_____

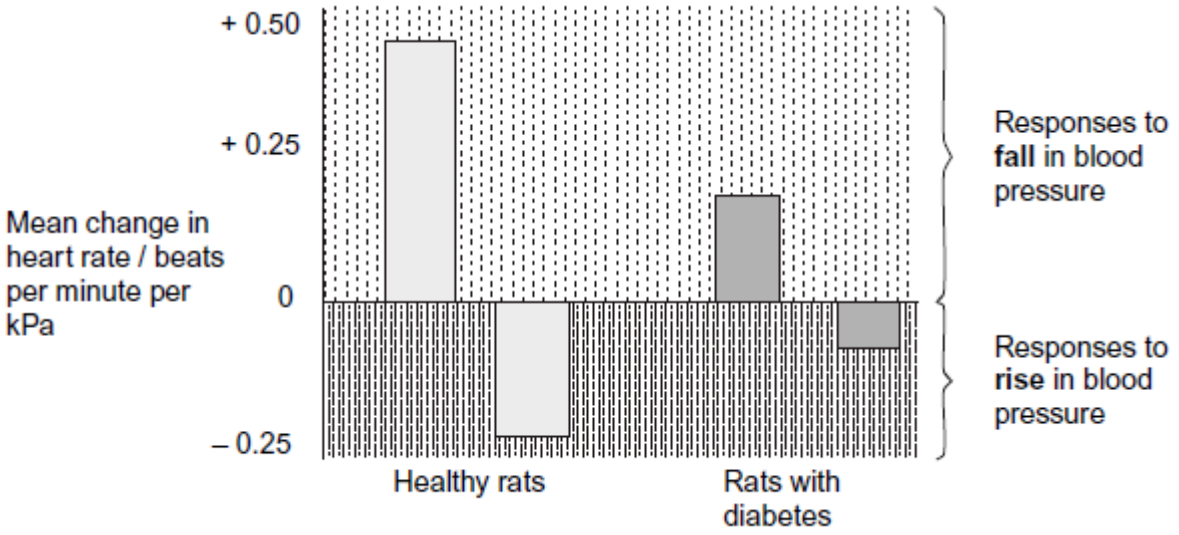
_____

**(2)**

(b) Scientists investigated the effect of diabetes on the control of heart rate in response to changes in blood pressure in rats.

The scientists found the mean changes in heart rates of healthy rats and rats with diabetes in response to rises or falls in blood pressure.

The diagram shows their results in the form they were presented.




Diabetes can damage the nervous system. The response of the rats with diabetes is different from the response of the healthy rats. Use your knowledge of the control of heart rate by the nervous system to suggest an explanation for these results.

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

**(Total 6 marks)**

## Q4.

Scientists investigated the control of blood glucose concentration in mice. They kept a group of normal mice without food for 48 hours. After 48 hours, the blood glucose concentrations of the mice were the same as at the start of the experiment.

(a) Explain how the normal mice prevented their blood glucose concentration falling when they had **not** eaten for 48 hours.

_____

_____

_____

_____

_____

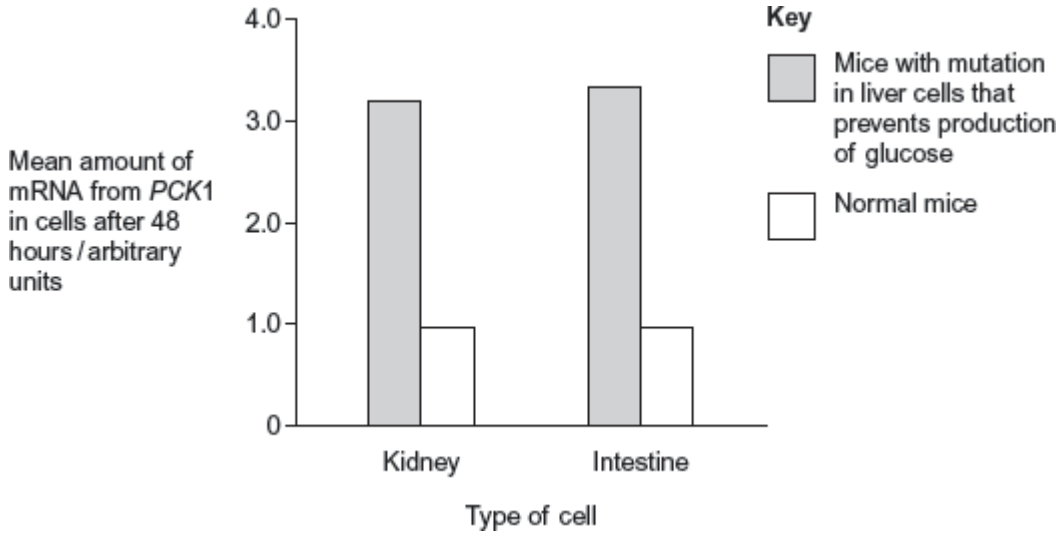
_____

**(3)**

The scientists then investigated mice with a mutation that prevents their liver cells making glucose. They kept a group of these mice without food for 48 hours. After 48 hours, the mean blood glucose concentrations of the mutant mice and the normal mice were the same.

The scientists investigated how blood glucose concentration is controlled in these mutant mice. An enzyme required for synthesis of glucose is coded for by a gene called *PCK*1. The scientists measured the mean amount of mRNA produced from this gene in cells from the kidneys and intestines of normal mice and mutant mice. They did this with mice that had previously been without food for 48 hours.

The scientists' results are shown in the graph.



(b) Use information from the graph to suggest how blood glucose concentration is controlled in the mutant mice, compared with the normal mice.

_____

_____

_____

_____

_____

_____

**(3)**

(c) The scientists performed statistical tests on the data shown in the graph, to see whether the differences in the amount of mRNA in cells from normal and mutant mice were significant. Both the probability values they obtained were $p<0.01$.

Explain what this means about the differences in the amounts of mRNA produced.

_____

_____

_____

_____

_____

**(2)**

**(Total 8 marks)**

## Q5.

Some mice have diabetes. The diabetes causes the blood glucose concentration to become very high after a meal. Scientists investigated the use of an inhibitor of amylase to treat diabetes.

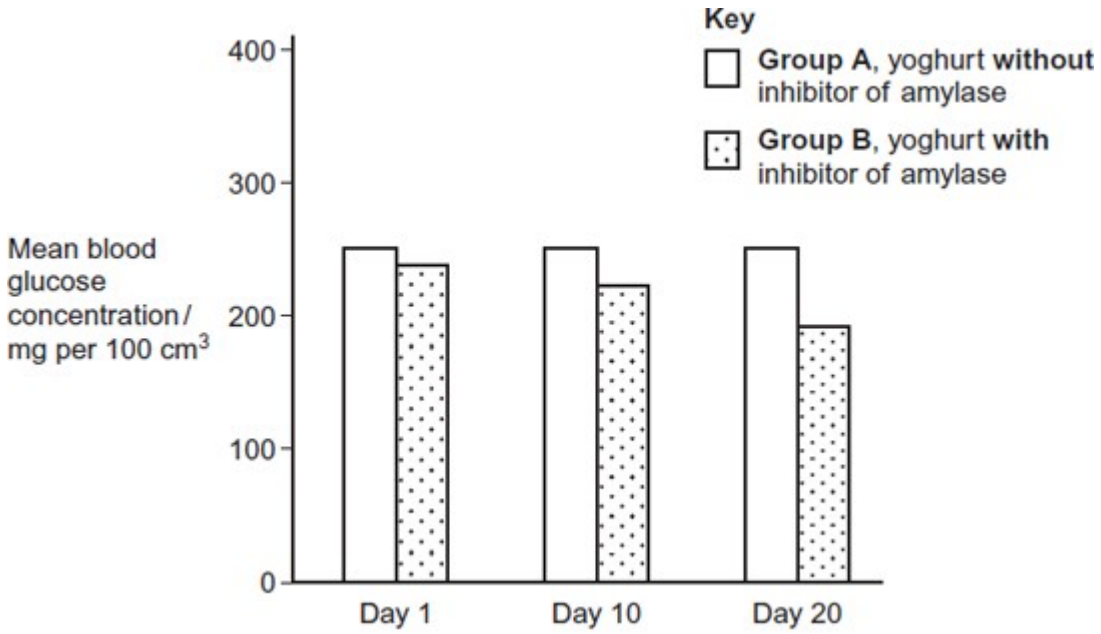
The scientists took 30 mice with diabetes and divided them into two groups, **A** and **B**.

- **Group A** was given yoghurt **without** the inhibitor of amylase each day.
- **Group B** was given yoghurt **with** the inhibitor of amylase each day.

Apart from the yoghurt, all of the mice were given the same food each day.

The scientists measured the blood glucose concentration of each mouse, 1 hour after it had eaten. This was done on days 1, 10 and 20 after the investigation started.

The following figure shows the scientists' results.




(a) **Group A** acted as a control in this investigation.

Explain the purpose of this group.

_____

_____

_____

_____

**(2)**

(b) Apart from the yoghurt, it was important that all of the mice were given the same food each day.

Give **two** reasons why it was important that all of the mice were given the same food each day.

1. _____

_____

2. _____

_____

**(2)**

(c) The scientists' hypothesis was that adding the inhibitor of amylase to the food would lead to a lower blood glucose concentration.

Use your knowledge of digestion to suggest how the addition of the inhibitor could lead to a lower blood glucose concentration.

_____

_____

_____

_____

**(2)**

(d) Give **one** reason why these results may **not** support the use of the inhibitor of amylase to treat diabetes in mice.

_____

_____

_____

_____

**(2)**

**(Total 8 marks)**

## Q6.

(a) When insulin binds to receptors on liver cells, it leads to the formation of glycogen from glucose. This lowers the concentration of glucose in liver cells.

Explain how the formation of glycogen in liver cells leads to a lowering of blood glucose concentration.

_____

_____

_____

_____

**(2)**

People with type II diabetes have cells with low sensitivity to insulin. About 80% of people with type II diabetes are overweight or obese. Some people who are obese have gastric bypass surgery (GBS) to help them to lose weight.

Doctors investigated whether GBS affected sensitivity to insulin. They measured patients' sensitivity to insulin before and after GBS. About half of the patients had type II diabetes. The other half did not but were considered at high risk of developing the condition.

The table below shows the doctors' results. The higher the number, the greater the sensitivity to insulin.

| **Patients** | **Mean sensitivity to insulin / arbitrary units (± SD)** | |
|---|---|---|
| | **Before gastric bypass surgery** | **1 month after gastric bypass surgery** |

| | | |
|---|---|---|
| Did not have diabetes | 0.55 (± 0.32) | 1.30 (± 0.88) |
| Had type II diabetes | 0.40 (± 0.24) | 1.10 (± 0.87) |

(b) The doctors concluded that many of the patients who did not have type II diabetes were at high risk of developing the condition.

Use the data in the table to suggest why they reached this conclusion.

_____

_____

_____

_____

**(2)**

(c) The doctors also concluded that GBS cured many patients' diabetes but that some were not helped very much.

Do these data support this conclusion? Give reasons for your answer.

_____

_____

_____

_____

_____

_____

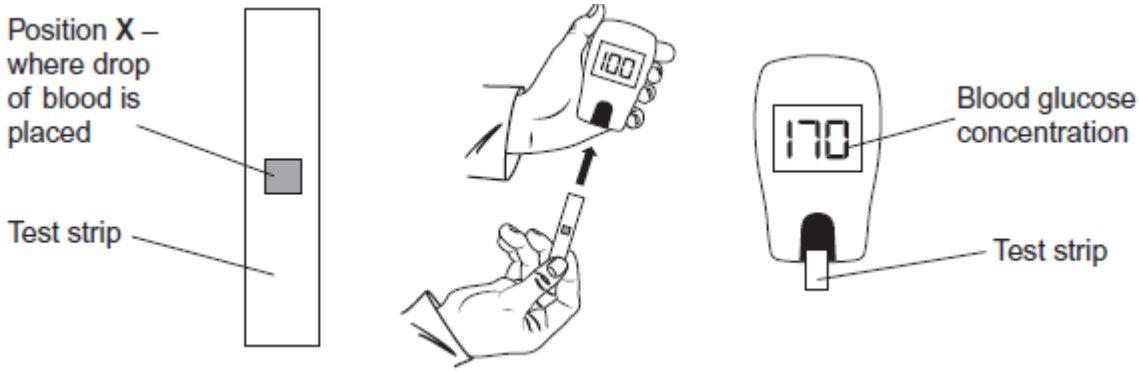
**(3)**

**(Total 7 marks)**

## Q7.

A glucometer is a device used to measure blood glucose concentration. A person uses a test strip that goes into the glucometer. They put a drop of blood onto the test strip. There are substances on the test strip that produce a colour change with glucose. The higher the concentration of glucose, the deeper the colour produced. The glucometer measures the depth of colour produced and converts this into a glucose concentration. A new test strip is used for each blood test.

**Figure – glucometer and test strip**




The following equations show how the substances on the test strip produce a colour change.

$$\text{Glucose + oxygen} \xrightarrow{\text{Glucose oxidase}} \text{gluconic acid + hydrogen peroxide}$$

$$\text{Hydrogen peroxide + dye with colour A} \xrightarrow{\text{Peroxidase}} \text{dye with colour B + water}$$

Non-diabetics have no glucose in their urine. Diabetics have glucose in their urine if their blood glucose concentration rises above about 170 mg 100 $cm^{-3}$.
Before the glucometer was available, diabetics used test strips to measure the concentration of glucose in their urine as a means of measuring their blood glucose concentration. When testing urine, the colour of the test strip is compared against a colour chart which gives a glucose concentration range for the colour produced.

(a) Identify all the substances located at position **X** on the test strip before a drop of blood is added.

_____

_____

_____

_____

_____

**(2)**

(b) Before the glucometer was available, diabetics used test strips to measure the concentration of glucose in their urine as a means of measuring their blood glucose concentration.

Give **two** reasons why this method of testing urine would **not** give an accurate measurement of blood glucose concentration.

1. _____

_____

2. _____

_____

**(2)**

**(Total 4 marks)**

## Q8.

There are two types of diabetes: type 1 and type 2.

- People with type 1 diabetes do not produce enough insulin.
- People with type 2 diabetes do produce insulin but have cells which do not respond to insulin.

Doctors use a glucose tolerance test to help diagnose people with diabetes. They start each test after a person has not eaten overnight. They measure a person's blood glucose concentration.
The person then drinks a solution containing 75 g of glucose. The doctors measure the person's blood glucose concentration 2 hours later. During the test, the person remains at rest.

**Figure 1** shows three diagnoses that can be made from the results of the test.

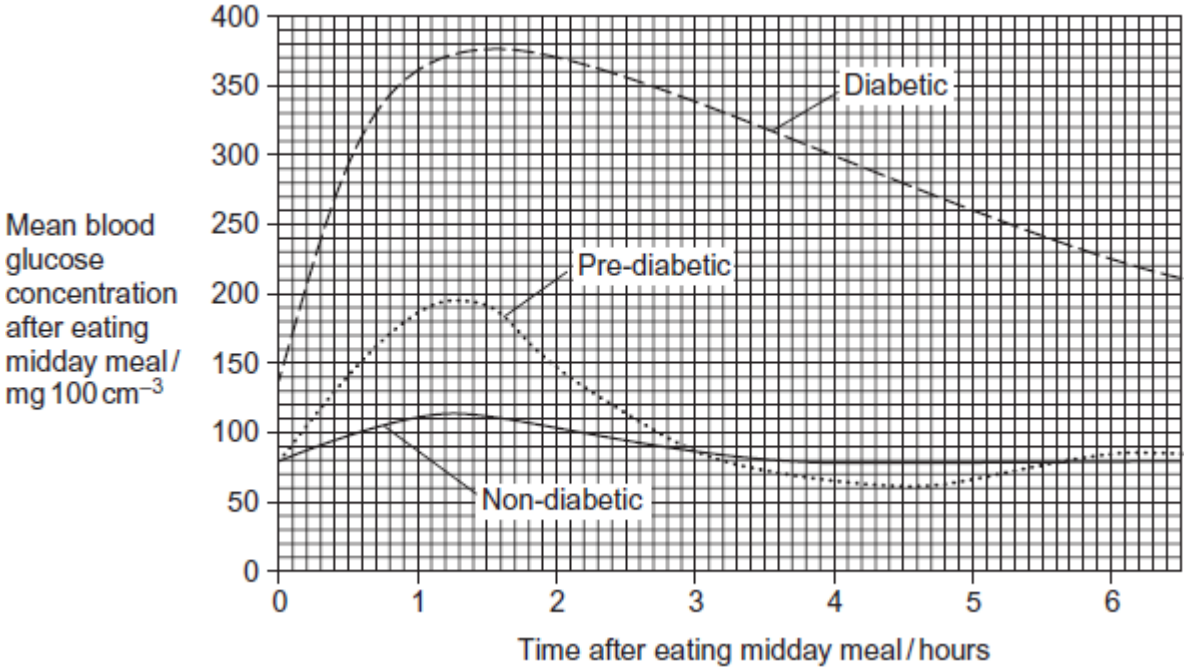
**Figure 1 – glucose tolerance test results and diagnoses**

| **Blood glucose concentration after 2 hours / mg 100 $cm^{-3}$** | **Diagnosis** | **Comments** |
|---|---|---|
| ≤ 110 | Non-diabetic | Low risk for future diabetes |
| Between 140 and 200 | Pre-diabetic | High risk for future diabetes. Some doctors recommend that the upper value should be lowered to 180 mg 100 $cm^{-3}$ |
| ≥ 200 | Diabetic | Confirm by doing a second test |

A researcher monitored the mean blood glucose concentration of a non-diabetic, a pre-diabetic and a diabetic after they had each eaten a midday meal.

His results are shown in **Figure 2**.

**Figure 2**




(a) People with type 1 diabetes are described as being insulin-dependent.
Suggest why they are described as insulin-dependent.

_____

_____

_____

**(1)**

(b) Some people with type 2 diabetes have cells which do **not** respond to insulin.
Explain how this leads to a reduced ability to regulate blood glucose concentration.

_____

_____

_____

_____

_____

_____

**(3)**

(c) During a glucose tolerance test the person remains at rest.
Why is it important that the person remains at rest?

_____

_____

_____

_____

_____

**(2)**

(d) Use **Figure 2** to calculate how many times the maximum mean blood glucose concentration of the pre-diabetic is greater than the maximum of the non-diabetic person. Show your working.

Answer =_____

**(2)**

(e) Give **three** differences between the method used by the researcher to obtain the results in **Figure 2** and the method doctors use to carry out a glucose tolerance test.

1. _____

_____

2. _____

_____

3. _____

_____

**(3)**

(f) Some doctors have recommended that the upper value used in the glucose tolerance test should be lowered to 180 mg 100 $cm^{-3}$.
Using information from **Figure 1** and **Figure 2**, suggest why.

_____

_____

_____

_____

_____

_____

**(3)**

**(Total 14 marks)**

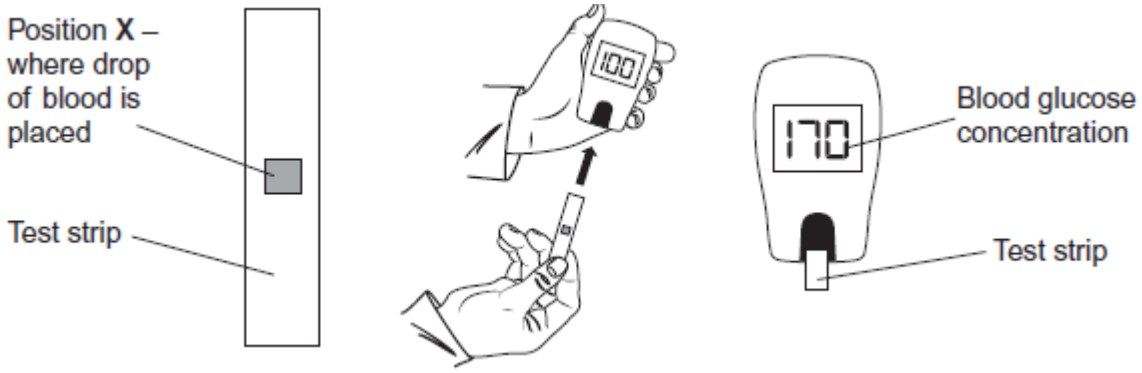
## Q9.

**Resource A**

A glucometer is a device used to measure blood glucose concentration. A person uses a

test strip that goes into the glucometer. They put a drop of blood onto the test strip. There are substances on the test strip that produce a colour change with glucose. The higher the concentration of glucose, the deeper the colour produced. The glucometer measures the depth of colour produced and converts this into a glucose concentration. A new test strip is used for each blood test.

**Figure 1 – glucometer and test strip**




The following equations show how the substances on the test strip produce a colour change.

$$\text{Glucose + oxygen} \xrightarrow{\text{Glucose oxidase}} \text{gluconic acid + hydrogen peroxide}$$

$$\text{Hydrogen peroxide + dye with colour A} \xrightarrow{\text{Peroxidase}} \text{dye with colour B + water}$$

Non-diabetics have no glucose in their urine. Diabetics have glucose in their urine if their blood glucose concentration rises above about 170 mg 100 $cm^{-3}$.
Before the glucometer was available, diabetics used test strips to measure the concentration of glucose in their urine as a means of measuring their blood glucose concentration. When testing urine, the colour of the test strip is compared against a colour chart which gives a glucose concentration range for the colour produced.

**Resource B**

There are two types of diabetes: type 1 and type 2.

- People with type 1 diabetes do not produce enough insulin.
- People with type 2 diabetes do produce insulin but have cells which do not respond to insulin.

Doctors use a glucose tolerance test to help diagnose people with diabetes. They start each test after a person has not eaten overnight. They measure a person's blood glucose concentration.
The person then drinks a solution containing 75 g of glucose. The doctors measure the person's blood glucose concentration 2 hours later. During the test, the person remains at rest.

**Figure 2** shows three diagnoses that can be made from the results of the test.

**Figure 2 – glucose tolerance test results and diagnoses**

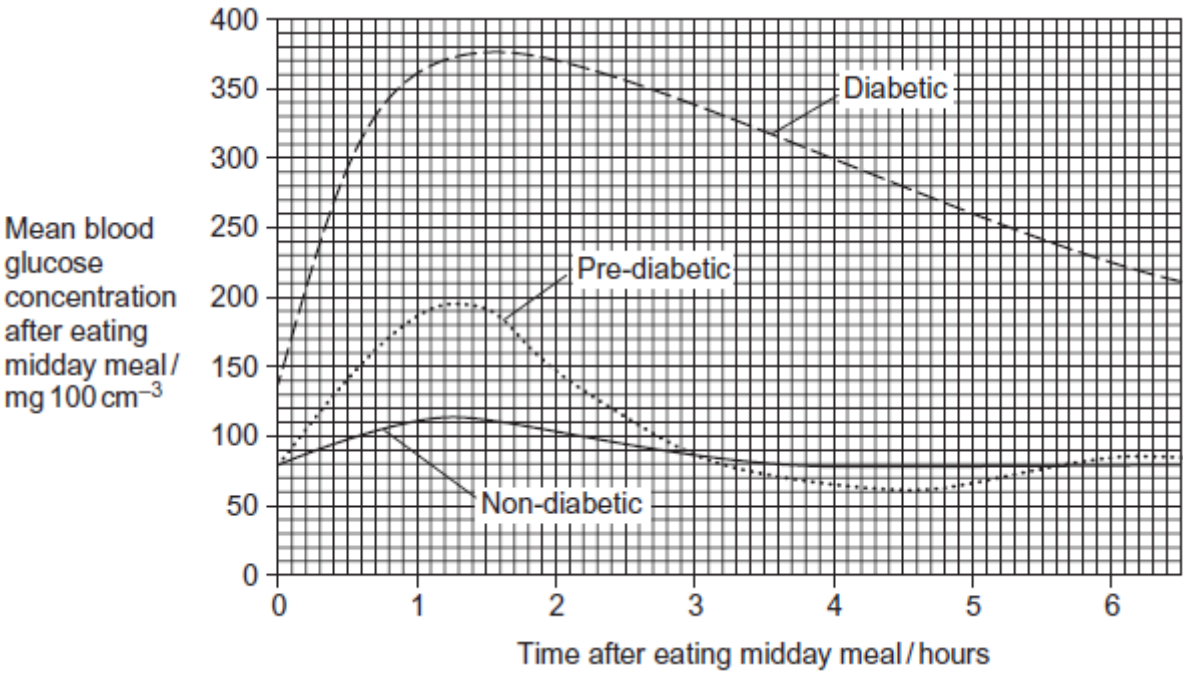
| Blood glucose concentration after 2 hours | Diagnosis | Comments |
|---|---|---|

| / mg 100 $cm^{-3}$ | | |
|---|---|---|
| ≤ 110 | Non-diabetic | Low risk for future diabetes |
| Between 140 and 200 | Pre-diabetic | High risk for future diabetes. Some doctors recommend that the upper value should be lowered to 180 mg 100 $cm^{-3}$ |
| ≥ 200 | Diabetic | Confirm by doing a second test |

A researcher monitored the mean blood glucose concentration of a non-diabetic, a pre-diabetic and a diabetic after they had each eaten a midday meal.

His results are shown in **Figure 3**.

**Figure 3**




A laboratory worker suspected she had type 2 diabetes but did not have a glucometer. Instead she added a drop of her blood to a test strip and used a colour chart to estimate her blood glucose concentration as 140 mg 100 $cm^{-3}$.

Is it valid to conclude that she did have type 2 diabetes?

Use this information, and **Resource A** and **Resource B**, to explain your answer.

_____

_____

_____

_____

_____

_____

**(Total 3 marks)**

## Q10.

(a) Adrenaline binds to receptors in the plasma membranes of liver cells. Explain how this causes the blood glucose concentration to increase.

_____

_____

_____

_____

_____

**(2)**

(b) Scientists made an artificial gene which codes for insulin. They put the gene into a virus which was then injected into rats with type I diabetes. The virus was harmless to the rats but carried the gene into the cells of the rats.

The treated rats produced insulin for up to 8 months and showed no side-effects. The scientists measured the blood glucose concentrations of the rats at regular intervals. While the rats were producing the insulin, their blood glucose concentrations were normal.

(i) The rats were not fed for at least 6 hours before their blood glucose concentration was measured. Explain why.

_____

_____

_____

**(1)**

(ii) The rats used in the investigation had type I diabetes. This form of gene therapy may be less effective in treating rats that have type II diabetes. Explain why.

_____

_____

_____

**(1)**

(iii) Research workers have suggested that treating diabetes in humans by this method of gene therapy would be better than injecting insulin. Evaluate this suggestion.

_____

_____

_____

_____

_____

_____

_____

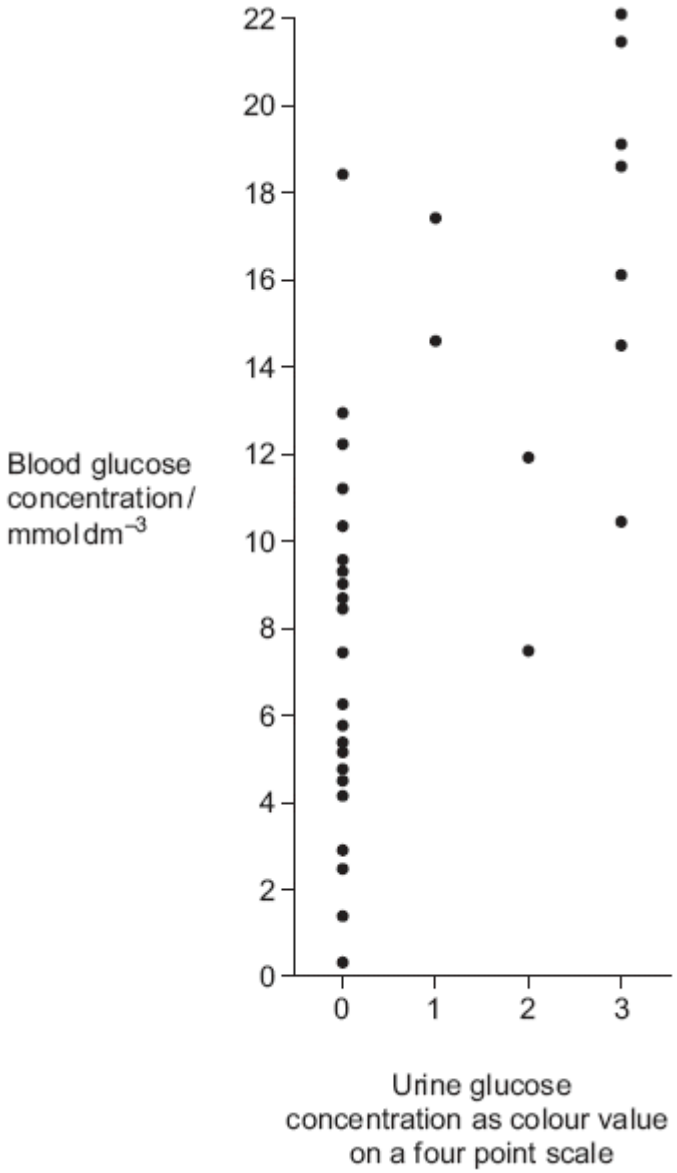
_____

**(4)**

**(Total 8 marks)**

## Q11.

(a) Technicians in a hospital laboratory tested urine and blood samples from a girl with diabetes at intervals over a one-year period. Each time the technicians tested her urine, they also measured her blood glucose concentration. Their results are shown in the graph.



(i) The girl who took part in this investigation was being successfully treated with insulin. The graph shows that on some occasions, the concentration of glucose in her blood was very high. Suggest why.

_____

_____

_____

_____

**(2)**

(ii) Use the graph to evaluate the use of the urine test as a measure of blood glucose concentration.

_____

_____

_____

_____

_____

_____

**(3)**

(b) Diabetic people who do not control their blood glucose concentration may become unconscious and go into a coma. A doctor may inject a diabetic person who is in a coma with glucagon. Explain how the glucagon would affect the person's blood glucose concentration.

_____

_____

_____

_____

**(2)**

**(Total 7 marks)**

## Q12.

A glucose biosensor is an instrument used to measure glucose concentration. It contains an enzyme called glucose oxidase.

(a) A glucose biosensor detects only glucose. Use your knowledge of the way in which enzymes work to explain why.

_____

_____

_____

_____

_____

_____

**(3)**

(b) It is better to use a biosensor than the Benedict's test to measure the concentration of glucose in a sample of blood. Suggest **two** reasons why.

1. _____

_____

2. _____

_____

**(2)**

(c) (i) Diabetes mellitus is a disease that can lead to an increase in blood glucose concentration. Some diabetics need insulin injections. Insulin is a protein so it cannot be taken orally. Suggest why insulin cannot be taken orally.

_____

_____

_____

**(1)**

(ii) A drug company produced a new type of insulin. Scientists from the company carried out a trial in which they gave this new type of insulin to rats. They reported that the results of this trial on rats were positive. A newspaper stated that diabetics would benefit from this new drug. Suggest **two** reasons why this statement should be viewed with caution.

1. _____

_____

2. _____

_____

**(2)**

**(Total 8 marks)**

## Q13.

(a) Sucrose, maltose and lactose are disaccharides.

(i) Sucrase is an enzyme. It hydrolyses sucrose during digestion. Name the products of this reaction.

_____ and _____

**(2)**

(ii) Sucrase does **not** hydrolyse lactose. Use your knowledge of the way in which

enzymes work to explain why.

_____

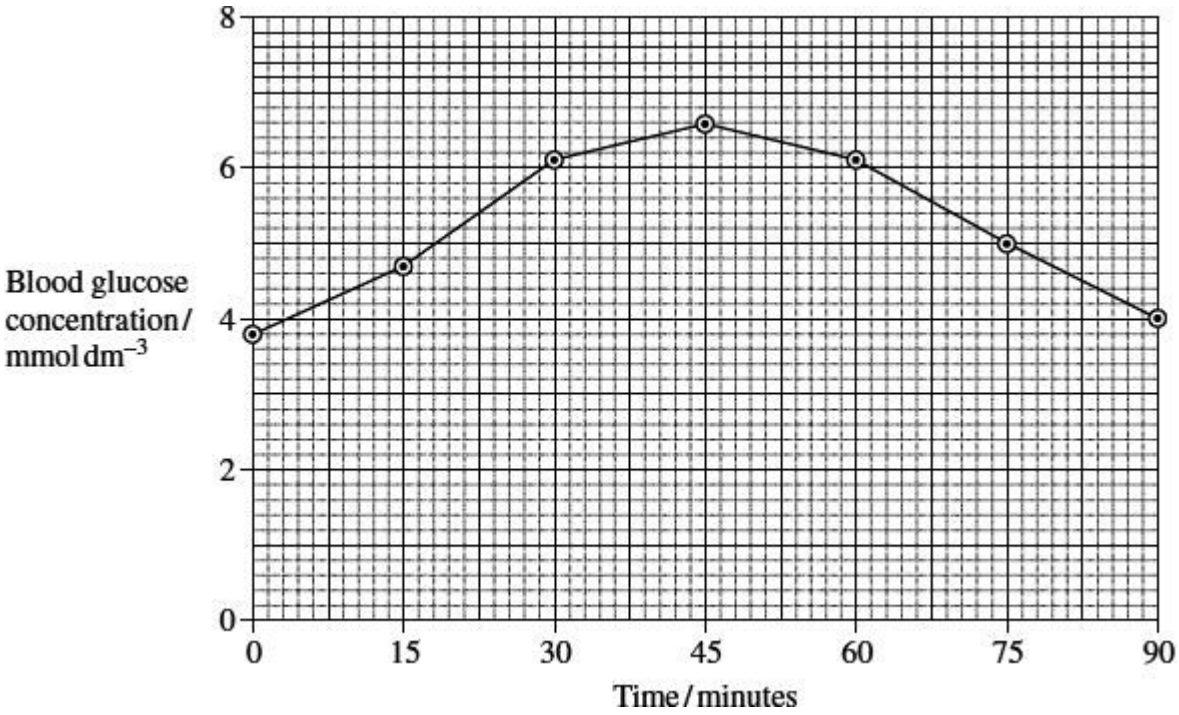
_____

_____

_____

**(2)**

(b) A woman was given a solution of sucrose to drink. Her blood glucose concentration was measured over the next 90 minutes. The results are shown on the graph.




(i) Describe how the woman's blood glucose concentration changed in the period shown in the graph.

_____

_____

_____

_____

**(2)**

(ii) Explain the results shown on the graph.

_____

_____

_____

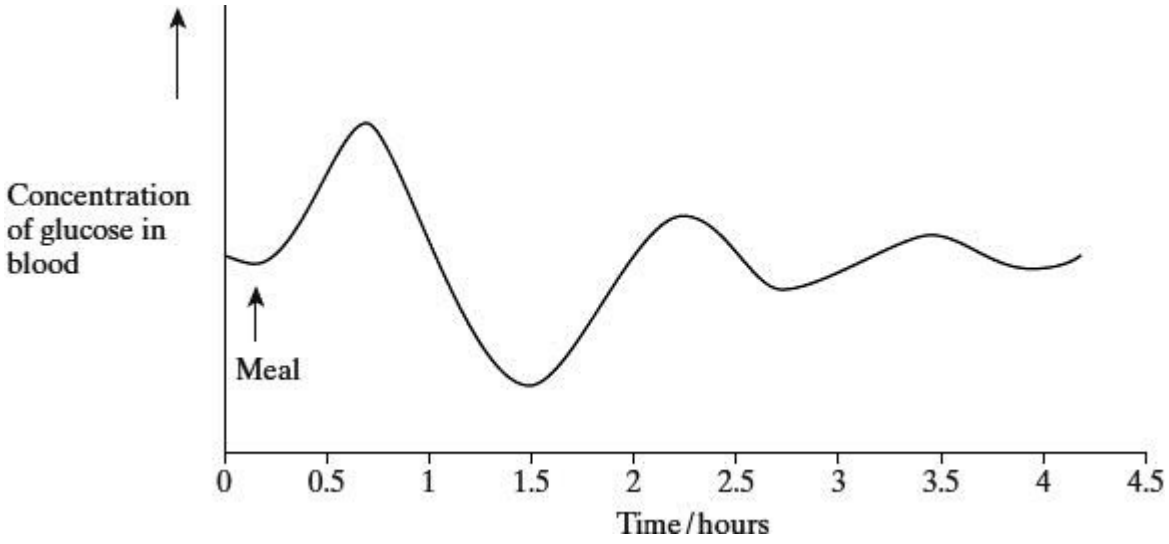
_____

**(2)**

**(Total 8 marks)**

## Q14.

(a) The graph shows changes in the concentration of glucose in a person's blood following a meal.




Changes in the concentration of glucose are controlled by the hormones glucagon and insulin. Write the letters **X** and **Y** on the graph to show

**X** a time when glucagon secretion would be high;

**Y** a time when insulin secretion would be high.

**(1)**

(b) Many diabetics require regular injections of insulin. Describe how bacteria can be genetically modified to produce human insulin.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

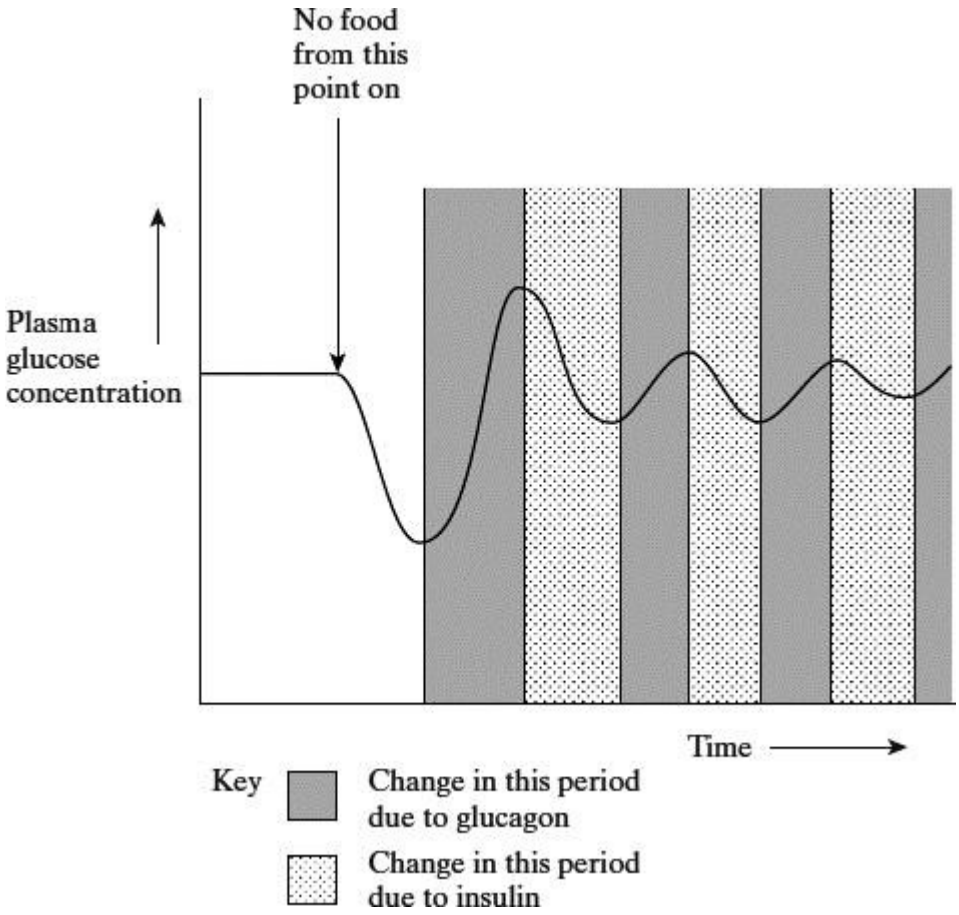
**(4)**

**(Total 5 marks)**

## Q15.

Homeostatic mechanisms maintain a constant environment in the body.

(a) The graph shows changes in plasma glucose concentration that occurred in a person who went without food for some time.




Use evidence from the graph to explain the role of negative feedback in the control of plasma glucose concentration.

_____

**(5)**

(b) How does maintaining a constant body temperature allow metabolic reactions in cells to proceed with maximum efficiency?

_____

_____

_____

_____

_____

_____

_____

_____

_____

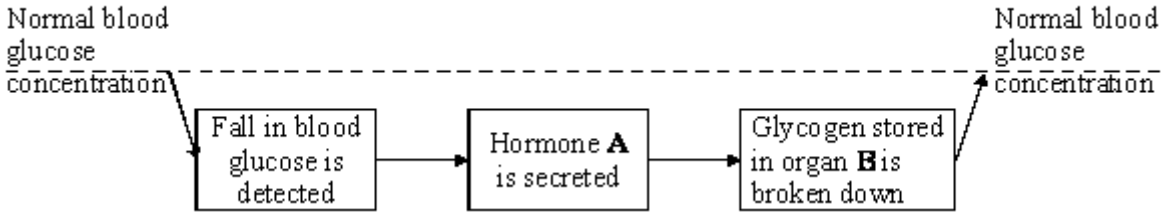
_____

**(5)**

**(Total 10 marks)**

## Q16.

The diagram shows some of the events which maintain blood glucose concentration in a mammal.




(a) Name

(i) hormone **A**; _____

(ii) organ **B**. _____

**(2)**

(b) Explain why the events shown in the diagram can be described as an example of negative feedback.

_____

_____

**(1)**

**(Total 3 marks)**

**Q17.**

(a) What is homeostasis?

_____

_____

**(1)**

(b) Describe the role of the hormone glucagon in the control of blood sugar concentration.

_____

_____

_____

_____

_____

_____

_____

**(4)**

(c) The kidney removes various substances from the blood plasma. The clearance value for a substance is the volume of blood cleared of that substance by the kidney in one minute. This clearance value can be calculated using the equation.

$$C = \frac{U \times V}{P}$$

| | |
|---|---|
| where the concentration of a substance in the blood is | P g $cm^{-3}$ |
| the concentration of a substance in the urine is | U g $cm^{-3}$ |
| the volume of urine produced is | V $cm^3$ per minute |

(i) Use the equation to work out the clearance value of glucose.

_____

_____

**(1)**

(ii) Explain how the activity of the kidney results in this clearance value for glucose.

_____

_____

_____

_____

_____

_____

**(3)**

**(Total 9 marks)**

## Q18.

Diabetes is a disorder affecting the ability to control blood glucose concentration. One type of diabetes can be due to an abnormality of the insulin receptors in the cell surface membranes of cells in the liver and muscles. A high blood glucose concentration and the presence of glucose in the urine are signs of this type of diabetes.

(a) (i) Suggest **one** way in which the insulin receptors might be abnormal.

_____

_____

**(1)**

(ii) Explain how the presence of abnormal insulin receptors results in a high blood glucose concentration.

_____

_____

_____

_____

**(2)**

(iii) Explain how the kidneys normally prevent glucose appearing in the urine of a non-diabetic person.

_____

_____

_____

_____

_____

_____

**(3)**

(b) Twin studies have been used to determine the relative effects of genetic and environmental factors on the development of this type of diabetes. The table shows the concordance (where both twins have the condition) in genetically identical and genetically non-identical twins.

| Concordance in genetically identical twins / % | Concordance in genetically non-identical twins /% |
|---|---|
| 85 | 35 |

(i) What do the data show about the relative effects of environmental and genetic factors on the development of diabetes?

_____

_____

**(1)**

(ii) Suggest **two** factors which should be taken into account when collecting the data in order to draw valid conclusions.

1. _____

_____

2. _____

_____

**(2)**

**(Total 9 marks)**

## Q19.

(a) Describe how insulin reduces the concentration of glucose in the blood.

_____

_____

_____

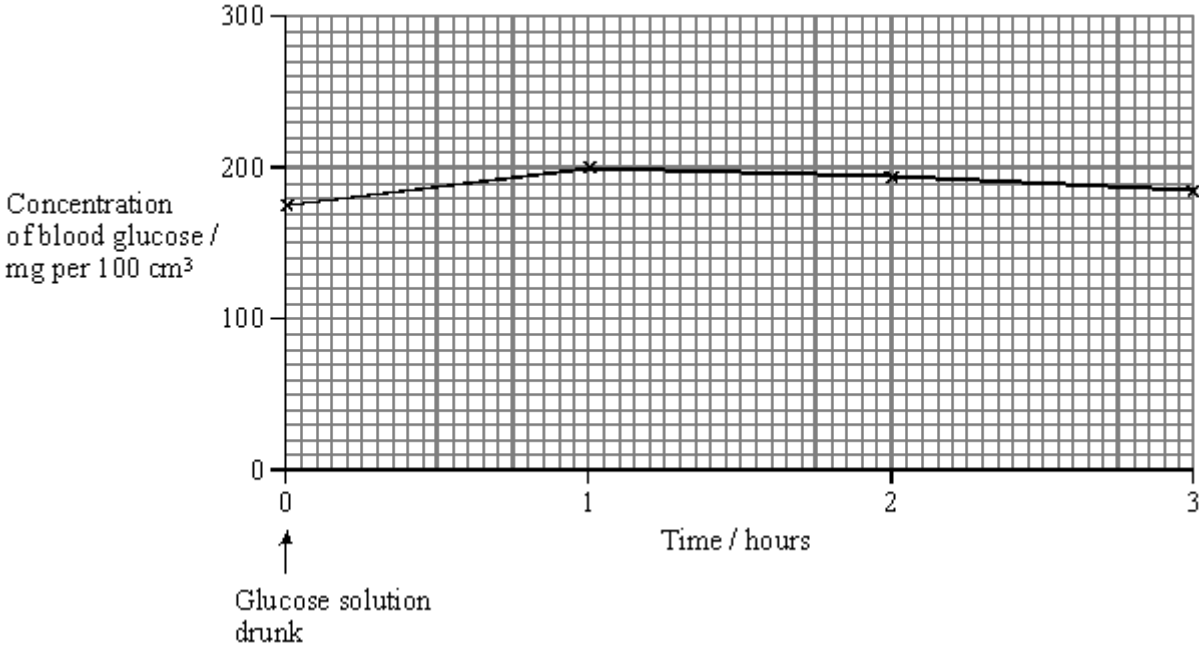
_____

_____

_____

**(3)**

Some people produce no insulin. As a result they have a condition called diabetes. In an investigation, a man with diabetes drank a glucose solution. The concentration of glucose in his blood was measured at regular intervals. The results are shown in the graph.




(b) Suggest **two** reasons why the concentration of glucose decreased after 1 hour even though this man's blood contained no insulin.

1. _____

_____

2. _____

_____

**(2)**

(c) The investigation was repeated on a man who did not have diabetes. The concentration of glucose in his blood before drinking the glucose solution was 80 mg per 100 $cm^3$. Sketch a curve on the graph to show the results you would expect.

**(1)**

(d) The diabetic man adopted a daily routine to stabilise his blood glucose concentration within narrow limits. He ate three meals a day: breakfast, a midday meal and an evening meal. He injected insulin once before breakfast and once before the evening meal.

The injection he used before breakfast was a mixture of two types of insulin. The mixture contained slow-acting insulin and fast-acting insulin.

(i) Explain the advantage of injecting both types of insulin before breakfast.

_____

_____

_____

_____

**(2)**

(ii) One day, the man did not eat a midday meal. Suggest **one** reason why his

blood glucose concentration did not fall dangerously low even though he had injected himself with the mixture of insulin before breakfast.

_____

_____

_____

**(1)**

**(Total 9 marks)**