A-Level Biology

Control of Blood Glucose

Question Paper

Time available: 64 minutes
Marks available: 45 marks

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1. (a) Neonatal diabetes is a disease that affects newly born children. The disease is caused by a change in the amino acid sequence of insulin.

This change prevents insulin binding to its receptor. Explain why this change prevents insulin binding to its receptor.

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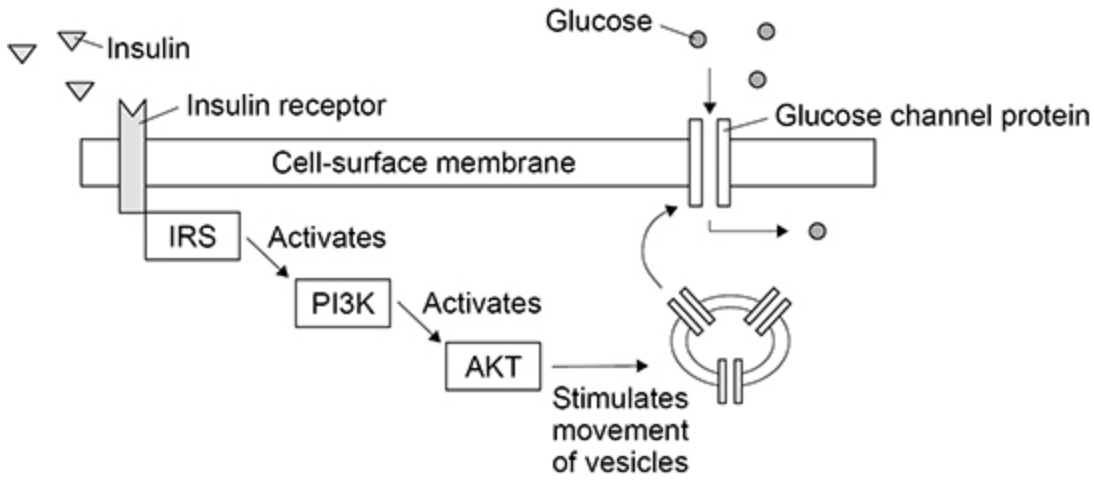
(2)

Phosphoinositide 3-kinase (PI3K) is an enzyme in several metabolic processes.

The figure below shows the role of PI3K in the control of blood glucose concentration.



(b) A decrease in the activity of PI3K can cause type II diabetes.

Use the figure above to explain why.

(3)

(c) Using your knowledge of the kidney, explain why glucose is found in the urine of a person with untreated diabetes.

(3)

(Total 8 marks)

2. (a) Describe the role of glucagon in gluconeogenesis.

Do **not** include in your answer details on the second messenger model of glucagon action.

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(2)

(b) The gene that codes for glucagon is 9.531 kilobases in length. The DNA helix makes one complete turn every 10 base pairs. Every complete turn is 3.4 nm in length.

Use this information to calculate the length in micrometres (μm) of the gene for glucagon. Give your answer to 3 significant figures.

Answer = _____ μm

(2)

Metformin is a drug commonly used to treat type II diabetes. Metformin's ability to lower the blood glucose concentration involves a number of mechanisms including:

- increasing a cell's sensitivity to insulin
- inhibiting adenylate cyclase.

(c) Explain how increasing a cell's sensitivity to insulin will lower the blood glucose concentration.

(2)

(d) Explain how inhibiting adenylate cyclase may help to lower the blood glucose concentration.

(3)

(Total 9 marks)

3. (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.

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2. _____

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(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)

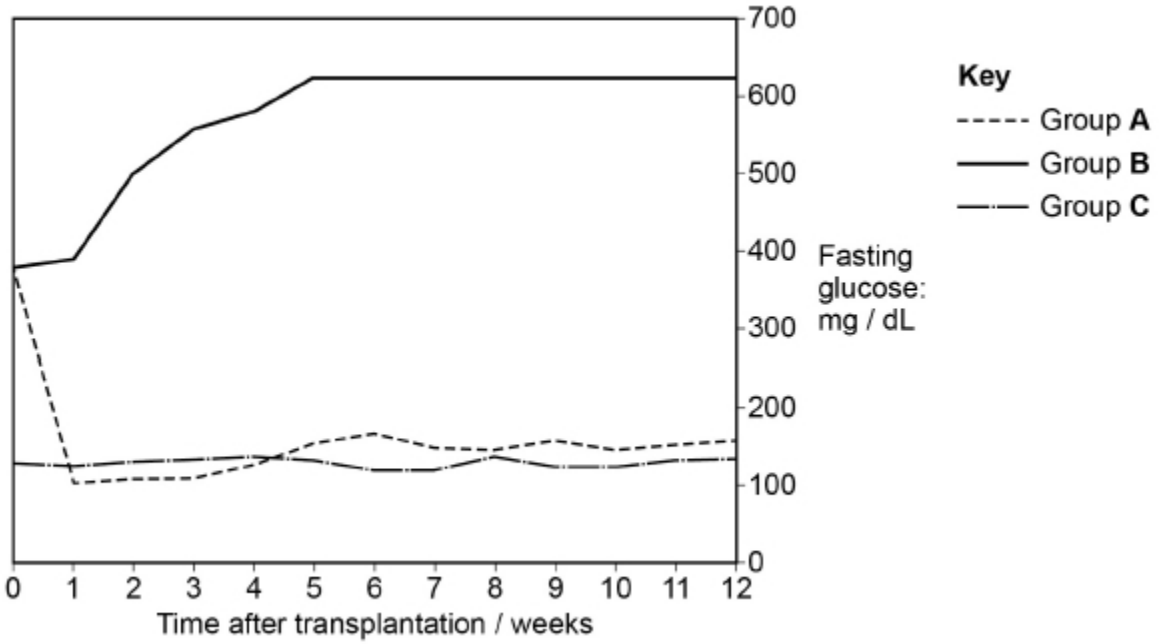
(c) Scientists investigated the use of induced pluripotent stem cells (iPS cells) to treat type I diabetes in mice. The scientists used four transcription factors to reprogramme skin cells to form iPS cells. The scientists then stimulated the *in vitro* differentiation of iPS cells into pancreatic cells.

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.

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(2)

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

(4)

(Total 9 marks)

4. 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.

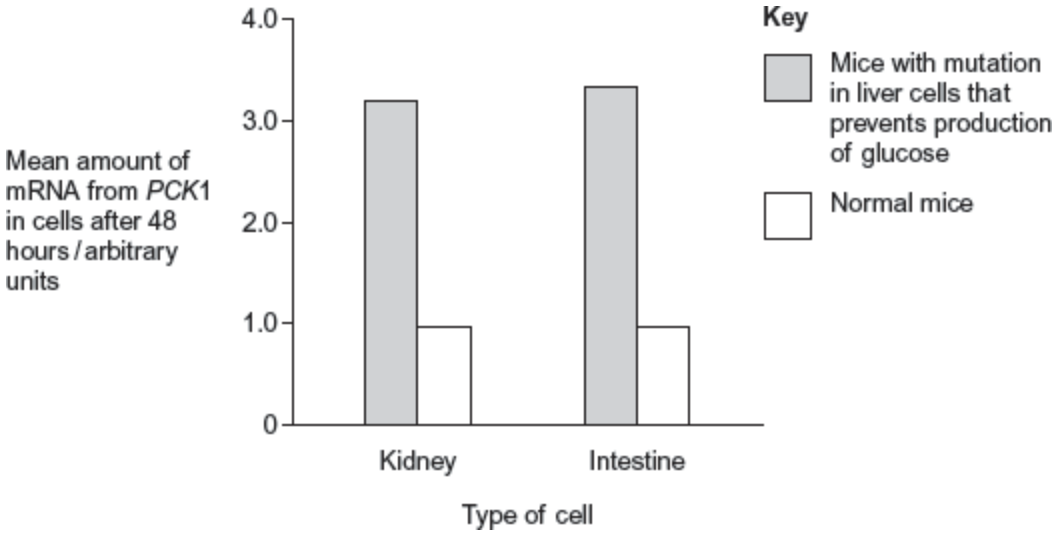
(a) Explain how the normal mice prevented their blood glucose concentration falling when they had **not** eaten for 48 hours.

(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.

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(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)

5. (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.

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(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.

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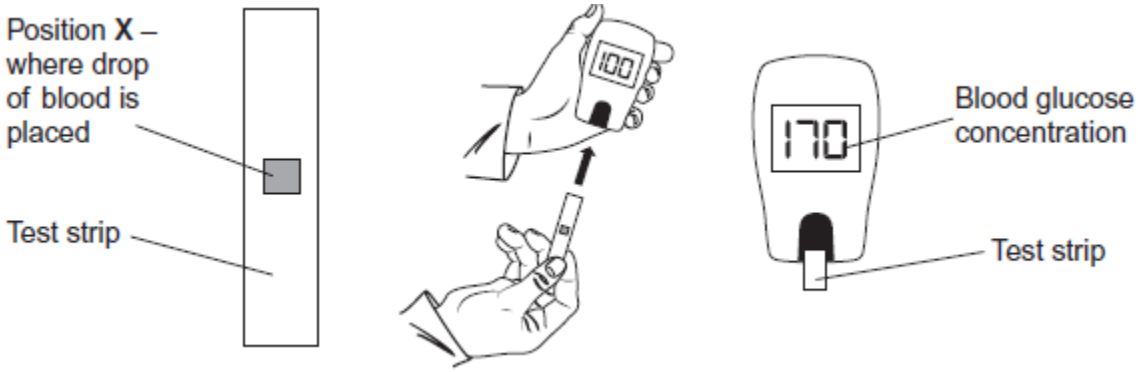
(3)

(Total 7 marks)

6. 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.

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(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. _____

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2. _____

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(2)

(Total 4 marks)