

## AICE Biology: Homeostasis and Control Problem Set

Answer the following AICE practice questions in complete sentences. All questions come from AICE Paper 4 (A2 Level topics) and are all essay based. This problem set will be due the day of the test **and is worth 50 points**.

1. (a) Neurones transmit impulses from one part of a mammal's body to another.

The table contains statements that refer to motor and sensory neurones.

Complete the table, indicating with the letters **M**, **S** or **B**, whether each statement applies to:

- motor neurones only (**M**)
- sensory neurones only (**S**)
- both motor and sensory neurones (**B**).

The first one has been done for you.

statement	letter
is myelinated	<b>B</b>
may form a synapse with an intermediate (relay) neurone	.....
cell body lies within the CNS	.....
dendron is usually longer than axon	.....
cell body lies within spinal nerve	.....
has many dendrites	.....



2. (a) Nerve impulses have to cross synapses. The events that enable a nerve impulse to cross a cholinergic synapse are listed in Table 1.1.

The events are **not** listed in the correct order.

**Table 1.1**

event	description of event
A	Calcium ions enter presynaptic neurone knob.
B	Acetylcholine binds to receptor proteins on postsynaptic membrane.
C	Vesicles fuse with presynaptic membrane and release acetylcholine into synaptic cleft.
D	Postsynaptic membrane becomes depolarised.
E	Nerve impulse reaches presynaptic membrane.
F	Acetylcholine diffuses across cleft.
G	Receptor proteins change shape, channels open and sodium ions enter postsynaptic neurone.
H	Calcium ion channels open in presynaptic membrane.
I	Nerve impulse generated in postsynaptic neurone.
J	Vesicles of acetylcholine move towards presynaptic membrane.

Complete Table 1.2 to show the events in the correct order.

Two of the events have been done for you.

**Table 1.2**

correct order	letter of stage
1	E
2	
3	
4	
5	
6	F
7	
8	
9	
10	

(b) Synapses have many roles in nervous coordination in mammals.

(i) Explain how synapses ensure one-way transmission of nerve impulses.

.....  
.....  
.....  
.....  
.....  
..... [2]

(ii) In a learning activity, it is believed that the number of synapses between brain neurones increases.  
Suggest the advantages of this increased number of synapses.

.....  
.....  
.....  
.....  
..... [2]

[Total: 8]

3. (a) Table 6.1 shows the mean axon diameter and mean speed of conduction of nerve impulses for four different animals.

Table 6.1

animal	type of neurone	axon diameter / $\mu\text{m}$	mean speed of conduction / $\text{ms}^{-1}$
A – mammal	myelinated	4	25
B – mammal	unmyelinated	5	3
C – amphibian	myelinated	14	35
D – amphibian	myelinated	10	30

With reference to Table 6.1, describe:

- (i) the effect of myelination on the speed of conduction of impulses in mammals

.....  
.....  
.....  
..... [2]

- (ii) the effect of axon diameter on the speed of conduction of impulses in amphibians.

.....  
.....  
.....  
..... [2]

- (b) Explain how myelination affects the speed of conduction of impulses.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
..... [3]

(c) Multiple sclerosis (MS) is an auto-immune condition of humans in which the body's immune system attacks the myelin sheaths which are then damaged. This leads to a decrease in information reaching the brain from sensory receptors.

(i) Suggest how the myelin sheaths may be attacked.

.....  
.....  
.....  
..... [2]

(ii) Explain why this damage leads to a decrease in information reaching the brain from sensory receptors.

.....  
.....  
.....  
..... [2]

[Total: 11]

4. The passage below summarises the effects of gibberellins on seed germination.

Complete the passage by using the most appropriate scientific term(s).

When a seed is shed from the parent plant, it is in a state of ....., which means it is metabolically inactive.

When water is absorbed by a seed, it stimulates the production of gibberellin by the ..... within the seed. The gibberellin stimulates the synthesis of amylase by cells in the ..... layer.

Amylase hydrolyses starch molecules in the ..... converting them to soluble ..... molecules. These molecules are converted to glucose which is transported to the embryo, providing a source of carbohydrate that can be respired to provide ..... as the embryo begins to grow.

Gibberellin causes these effects by regulating genes that are involved in the synthesis of amylase. It has been shown that application of gibberellin to seeds can cause an increase in the ..... of the DNA coding for amylase.

[Total: 7]

5. In mammalian kidneys, the loop of Henle is closely associated with the process of osmoregulation.

(a) Explain what is meant by osmoregulation.

.....  
.....  
.....  
..... [2]

Fig. 3.1 shows the water potential of renal fluid as it passes through the loop of Henle.

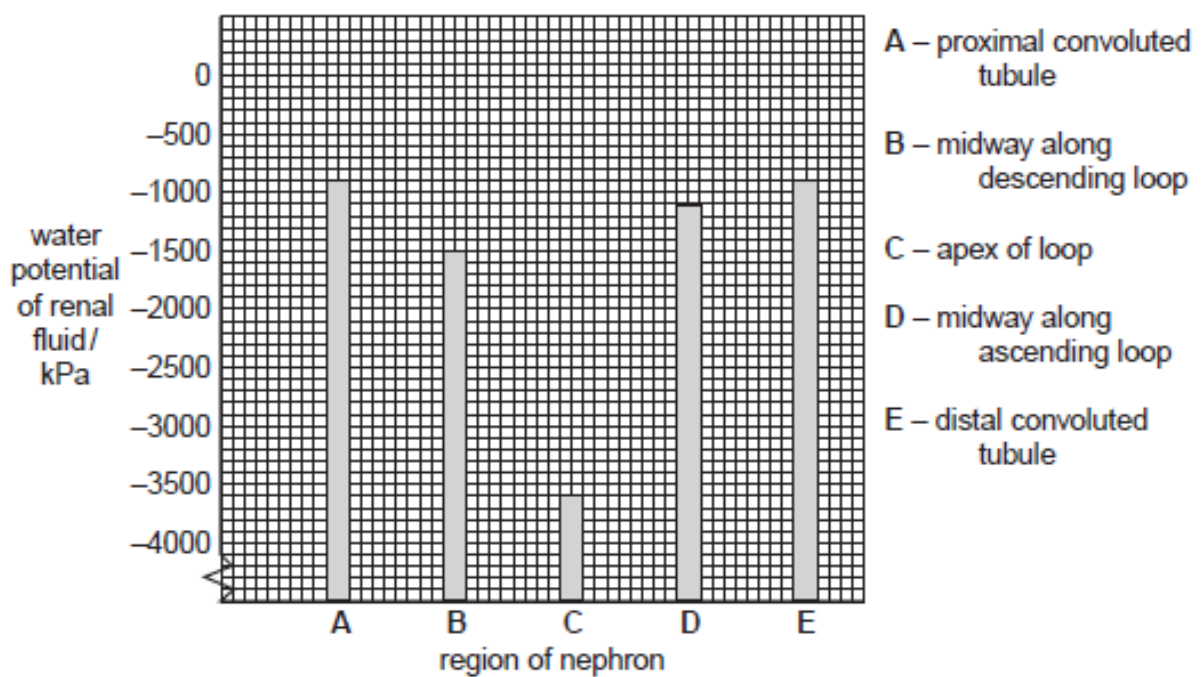


Fig. 3.1

(b) Using the information given in Fig. 3.1, describe and explain what happens to the renal fluid as it passes through the loop of Henle.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
..... [5]

- (c) Control systems often work by using negative feedback. These systems require a receptor and an effector. In the process of osmoregulation name the receptor and effector involved.

Receptor .....

Effector .....

[2]

[Total: 9]

6. Fig. 6.1 is a trace that shows the changes that occur in the membrane potential of a neurone during an action potential.

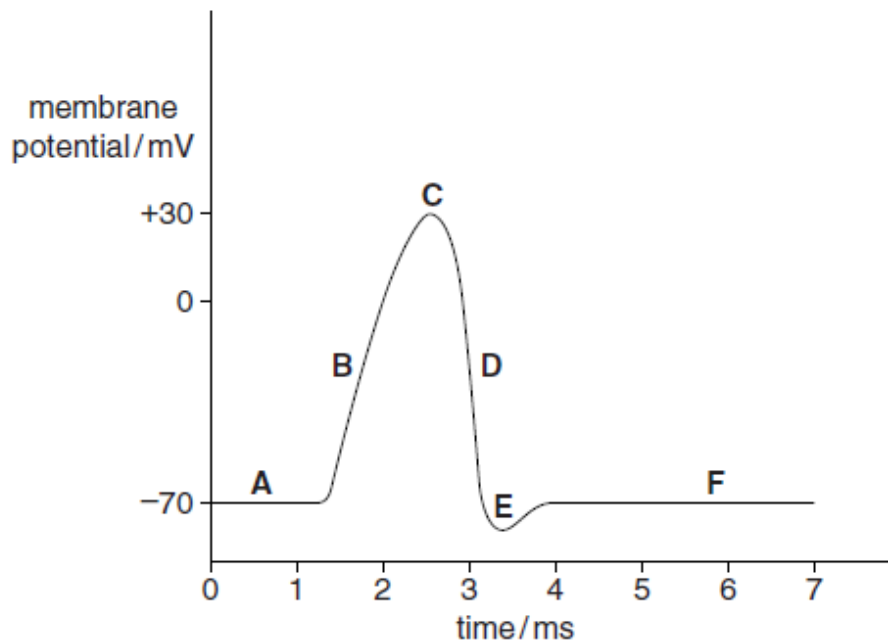


Fig. 6.1

- (a) Using the letter(s) A to F from Fig. 6.1, state which letter(s) corresponds to the following:
- (i) depolarisation .....
  - (ii) hyperpolarisation .....
  - (iii) the membrane is most permeable to potassium ions .....
  - (iv) resting potential ..... [4]
- (b) Saxitoxin is a powerful poison produced naturally by single-celled, eukaryotic, photosynthetic, marine organisms. Shellfish may consume organisms containing saxitoxin but are unaffected. If humans were to eat shellfish containing saxitoxin they would become very ill and may die.
- (i) State the kingdom to which the organisms that produce saxitoxin belong.

..... [1]





(b) Almost all insulin used to treat type I diabetes is produced by genetically engineered bacteria or yeast. A summary of this procedure is shown in Fig. 4.1.

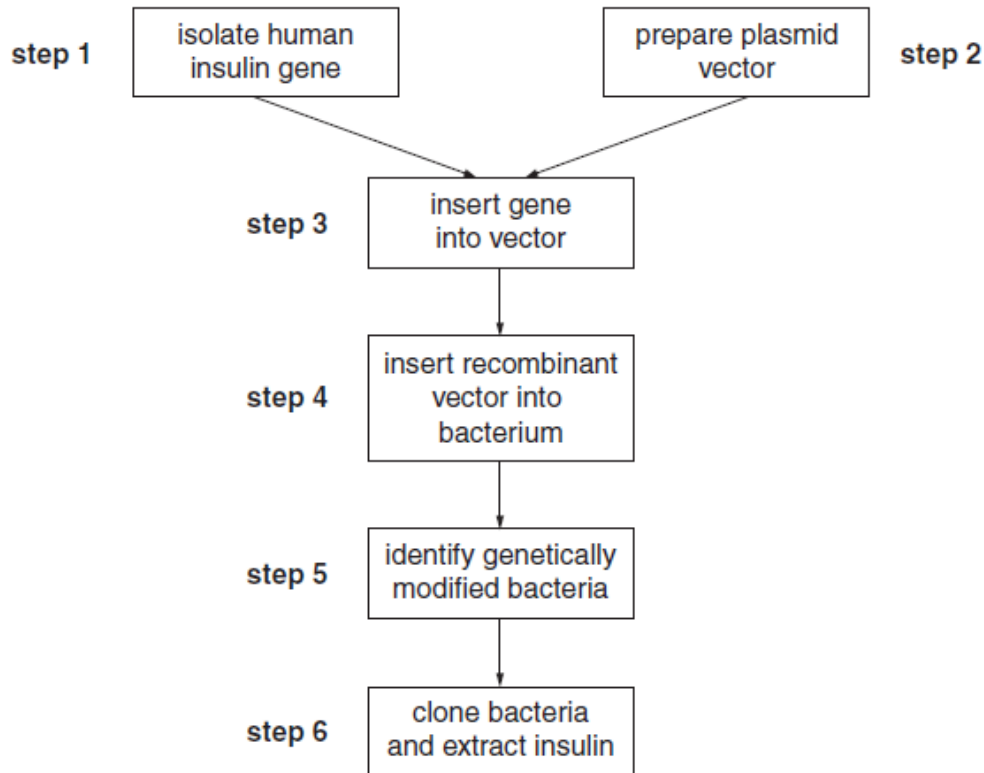


Fig. 4.1

(i) One way of carrying out **step 1** is to collect mRNA from  $\beta$  cells from the pancreas. The relevant mRNA is then isolated and used to make DNA.

Suggest why isolating the mRNA coding for insulin in a  $\beta$  cell is easier than isolating the DNA for insulin in a  $\beta$  cell.

.....  
.....  
.....  
..... [2]

(ii) Outline the use of restriction enzymes in **step 2**.

.....  
.....  
.....  
..... [2]

- (c) Most people with type I diabetes inject insulin. A recent product contains insulin that can be administered using a nasal spray. The spray is inhaled and the insulin is taken up through the lungs.

Fig. 4.2 shows the concentration of insulin in the blood plasma in the 480 minutes after injecting or inhaling insulin. In both cases, the insulin was of the same type, obtained from genetically engineered *Escherichia coli*.

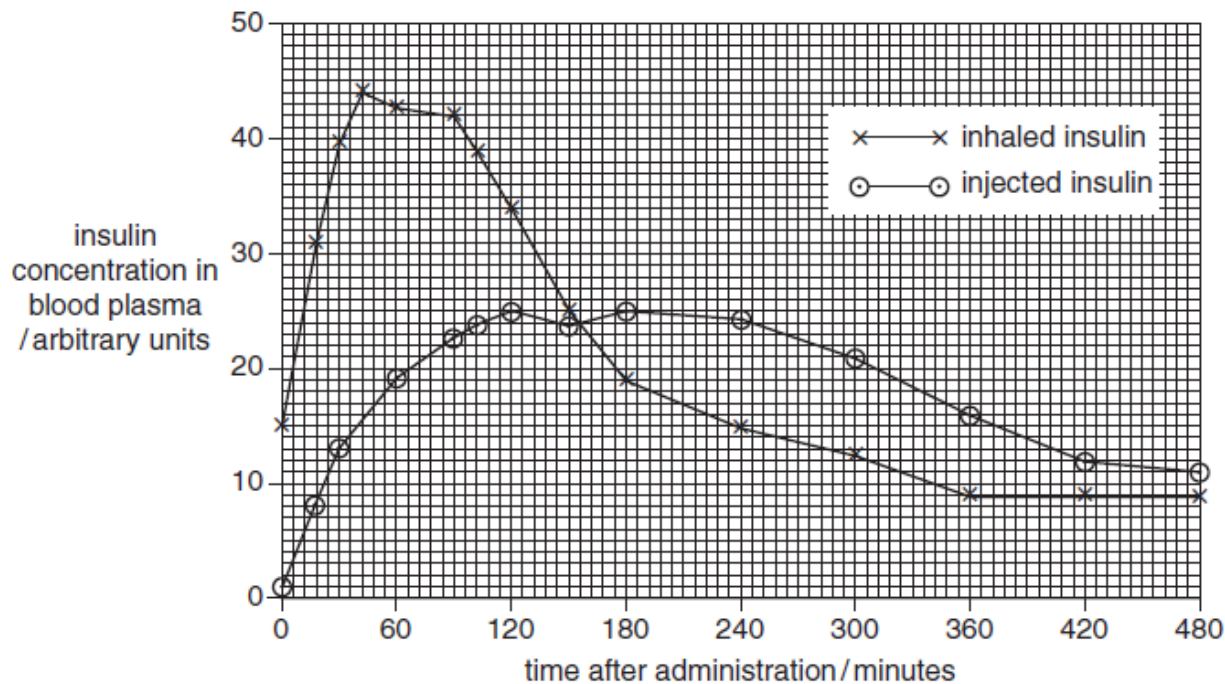


Fig. 4.2

Fig. 4.3 shows the concentration of glucose in the blood plasma in the 480 minutes after injecting or inhaling insulin.

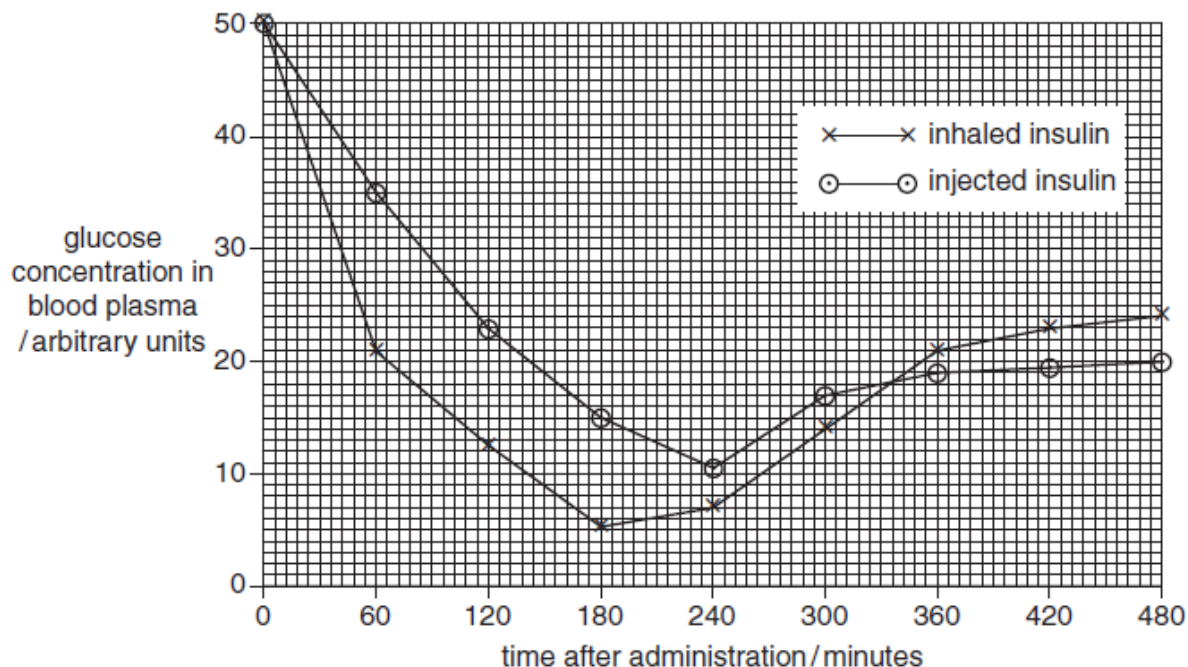


Fig. 4.3

(i) Compare the results for injected insulin and inhaled insulin shown in Fig. 4.2.

.....  
.....  
.....  
.....  
.....  
..... [3]

(ii) With reference to Fig. 4.2, explain the differences in the blood glucose levels after injecting or inhaling insulin shown in Fig. 4.3.

.....  
.....  
.....  
.....  
..... [3]

(iii) With reference to Figs. 4.2 and 4.3, suggest one advantage and one disadvantage of inhaling insulin rather than injecting it.

*advantage* .....

.....

*disadvantage* .....

..... [2]

[Total: 15]

8. Fig. 7.1 shows a section through part of the cortex of a kidney.

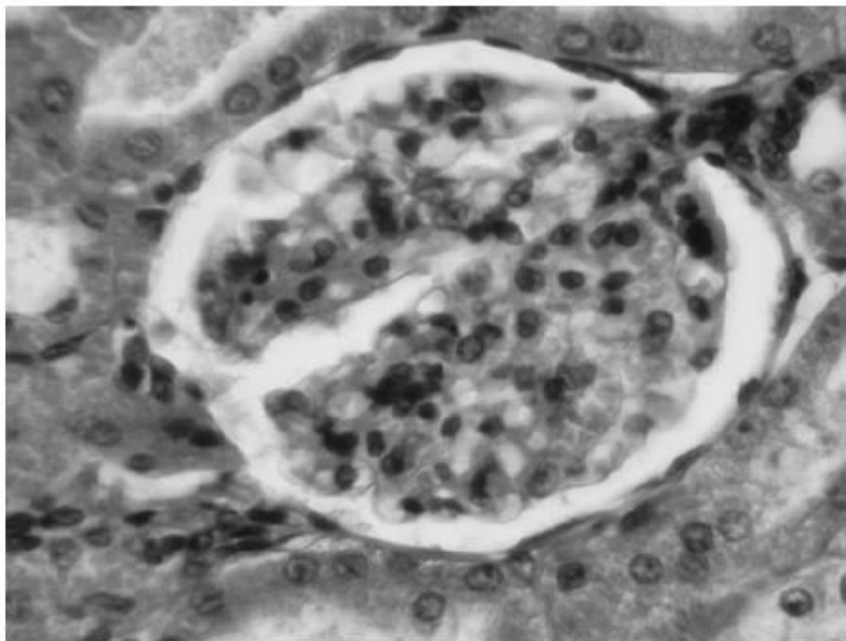


Fig. 7.1

(a) On Fig. 7.1, draw label lines and use the letters **G** and **R** to identify :

- a glomerulus with the letter **G**.
- a renal capsule with the letter **R**.

[2]

(b) State the name of the hormone that is involved in the control of the water potential of the blood.

.....[1]

(c) Table 7.1 shows the concentration of some compounds in the fluids of a glomerulus, a renal capsule and a collecting duct of the kidney.

Table 7.1

compound	concentration / g 100 cm <sup>-3</sup>		
	blood plasma entering glomerulus	filtrate in renal capsule	urine in collecting duct
water	90	90	96
proteins	8.0	0.0	0.0
glucose	0.1	0.1	0.0
urea	0.03	0.03	2.0

With reference to Table 7.1,

- (i) explain why proteins occur in the blood entering the glomerulus but not in the filtrate in the renal capsule

.....  
.....  
..... [2]

- (ii) explain why there is glucose present in the filtrate but not in the urine

.....  
.....  
..... [2]

- (iii) explain the difference in the concentration of urea between the filtrate and urine.

.....  
.....  
..... [2]

[Total: 9]

9.

- (a) The first diagnostic test strip using immobilised enzymes was a dip stick to estimate the concentration of glucose in urine.

The dip stick is a thin strip of plastic with a cellulose pad containing two enzymes and a colour reagent (chromogen) at one end. The pad responds with a colour change after being dipped into a sample of urine that contains glucose. The colour can be matched against a graded colour chart to give a 'semi-quantitative' estimate of the concentration of glucose in the sample, as shown in Fig. 2.1. The chart shows the colours of a negative reaction (-) and three increasingly positive reactions (+, ++ and +++).

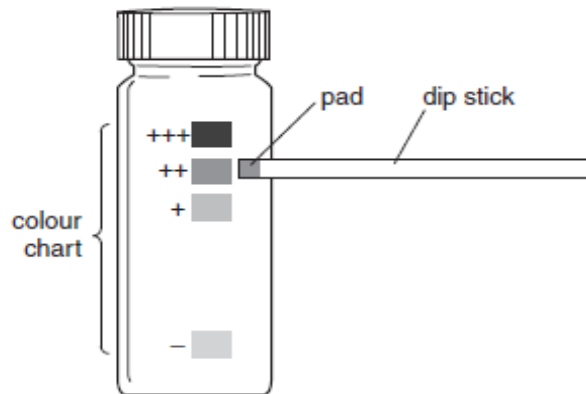
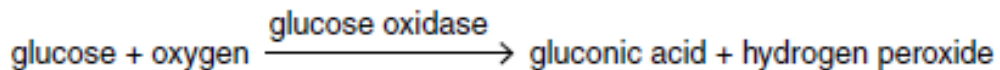


Fig. 2.1

Explain why the estimate of glucose concentration achieved by this method is only 'semi-quantitative'.

.....  
.....  
.....  
..... [2]

- (b) One of the two enzymes immobilised in the cellulose pad on the test strip is glucose oxidase, which catalyses the following reaction:



This reaction does **not** result in the development of colour by the chromogen. This is achieved by the activity of the second immobilised enzyme in the pad.

- (i) Name the second immobilised enzyme in the pad.

.....[1]

- (ii) Explain how the reaction catalysed by this enzyme results in the chromogen changing colour.

.....  
.....  
.....  
.....[2]

- (iii) The cellulose pad on the test strip is covered by a layer of cellulose acetate, which is permeable to glucose molecules, but not to larger molecules.

Suggest why the layer of cellulose acetate is present.

.....  
.....  
.....  
.....[2]

- (c) Two young men, subjects **A** and **B**, were each given a standardised test dose of glucose after fasting.

- The blood glucose concentration of each subject was then measured immediately and at 30 minute intervals for two hours.
- Samples of their urine were taken and tested at the same time intervals. The colour change of each test strip was compared with the colour chart and recorded as -, +, ++ or +++.

The results of the investigation are shown in Fig. 2.2.







(b) *D. muscipula* grows naturally in a small region in eastern USA. Fires that destroy much of the vegetation occur in this region. Three sites in this region where there had been fires were identified and investigated.

- Site 1 had experienced a fire 2 years before.
- Site 2 had experienced a fire 10 years before.
- Site 3 had experienced a fire 30 years before.

Preliminary observations suggested that over the course of time following a fire, the biodiversity of plants had increased. However, the abundance of Venus fly trap plants had decreased and so had the light intensity available to them. There was also a decrease in the nitrogen that the plants absorbed from insects as a proportion of all the nitrogen they obtained from their environment.

Name an ecological or statistical method to measure:

- (i) the abundance of *D. muscipula* at each site  
..... [1]
- (ii) plant biodiversity at each site  
..... [1]
- (iii) the strength of the relationship between light intensity and the proportion of nitrogen absorbed from insects, after taking measurements from a large number of plants.  
..... [1]

[Total: 8]

**Extended Essays:** Answer ALL of the following components of the essays below on attached sheets of paper.

11. (a) Describe the role of hormones in the maintenance of the human menstrual cycle. [9]  
(b) Explain the principles of homeostasis in humans. [6]

[Total: 15]

12. (a) Describe how nitrogenous waste products are formed and explain why they need to be removed from the body. [6]  
(b) Describe how the kidney removes metabolic wastes from the body. [9]

13. (a) Describe how the structure of neurones speeds up the transmission of action potentials. [6]  
(b) Explain, using a named example, how sensory receptors in mammals convert energy into action potentials. [9]

[Total: 15]

14. (a) Describe the role of the hormone insulin in maintaining a constant blood glucose concentration. [6]  
(b) The hormone human chorionic gonadotrophin (HCG) is produced by a woman in the early stages of pregnancy. Describe how a pregnancy test kit can detect the presence of HCG. [9]

[Total: 15]