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General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

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2012066089 4

BIOLOGY **9700/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2012**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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Write in dark blue or black ink.
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Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **both** questions.

At the end of the examination, fasten all your work securely together.
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1 A fresh water flowering plant grows on the surface of pond water. It occurs in large numbers on the surface of water polluted by sewage and fertilisers from agricultural land. Both of these pollutants contain high concentrations of nitrate and phosphate ions.

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The leaf-like photosynthetic tissue of the plant is called a thallus. Each plant has a single underwater root and a thallus which floats on the water. The plant reproduces asexually by buds that grow and split off to form separate plants.

Fig. 1.1 shows the appearance of three of these plants.

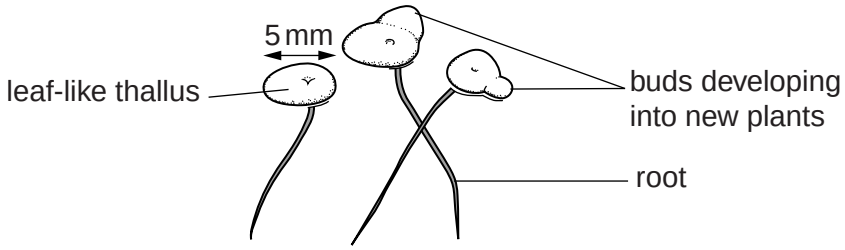


Fig. 1.1

A student investigated the effect of different concentrations of nitrate on the growth of the plant by counting the total number of the leaf-like thalli produced during a ten day period.

Fig. 1.2 shows seven thalli of different sizes and stages of development as seen from above.

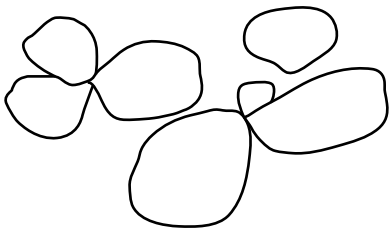


Fig. 1.2

The main stages in the procedure used by the student were:

1. Pond water was sterilised and used to make dilutions of sodium nitrate. A concentration of 4000 mg dm^{-3} was prepared and this was diluted to make the following concentrations:

   2000 mg dm^{-3}, 1000 mg dm^{-3}, 500 mg dm^{-3} and 250 mg dm^{-3}.

2. Plants were collected from a pond and those with a thallus without buds were selected.
3. The selected plants were surface sterilised with dilute bleach.
4. Each dilution of sodium nitrate was poured into a sterile glass dish and the dish covered with a lid.
5. Three surface-sterilised plants were placed in each of the dilutions of sodium nitrate and the lid replaced.
6. Four replicates of each sodium nitrate solution were set up in the same way.
7. All of the dishes were placed in a room at a constant temperature for 10 days.
8. The total number of leaf-like thalli in each dish was counted every day for 10 days.

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(a) (i) Identify the independent and dependent variables in this investigation.

For Examiner's Use

independent .....

dependent .....[1]

(ii) Identify **two** variables that the student controlled in this investigation.

.....[1]

(iii) There are other variables that the student could have controlled in this investigation.

Describe how **two other** variables could have been controlled.

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(b) (i) The student used the highest concentration (4000 mg dm^{-3}) to prepare the other concentrations of sodium nitrate.

Describe a procedure that the student used to prepare the other concentrations stated in stage 1. Your description should be sufficiently detailed so that another person can easily follow your procedure.

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.....[4]

(ii) The student also prepared another sterile glass dish to use as a control.

Suggest a suitable solution to use as a control for this investigation.

.....

.....[1]

(c) The results of the student's investigation are shown in Table 1.1.

For Examiner's Use

Table 1.1

concentration of sodium nitrate / mg dm^{-3}	mean number of thalli ± 1s at daily intervals									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
control	3	4±1	6±1	9±1	13±2	16±2	21±4	27±4	33±5	40±6
250	3	5±1	8±1	15±3	21±4	29±6	35±5	39±6	44±7	48±8
500	3	7±1	12±1	20±2	30±3	40±5	52±8	68±7	80±7	90±9
1000	3	9±1	18±2	30±3	45±3	65±6	90±8	120±10	158±13	180±12
2000	3	8±1	14±2	26±3	39±4	56±6	75±7	104±7	132±10	157±11
4000	3	8±1	11±1	22±2	33±5	48±6	60±6	88±8	106±9	135±10

(i) State what standard deviation (s) shows about the data.

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(ii) The results show that the standard deviation increased with time.

Suggest a reason for this increase.

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..... [3]

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(d) State the conclusions that can be drawn from the results in Table 1.1 about the effect of different concentrations of nitrate on the growth of this plant.

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(e) Suggest how the student's investigation could be modified to find the optimum nitrate concentration for the growth of this plant.

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.....[1]

(f) Sewage and agricultural fertilisers contain phosphate as well as nitrate. In another investigation the student used sodium phosphate instead of sodium nitrate to test the effect of different concentrations of phosphate on the growth of the same plant.

Suggest a prediction that the student could make about the effect of different concentrations of phosphate on the growth of the plant.

Show your answer as a sketch graph on the axes below.



[2]

[Total: 20]

For Examiner's Use

2 Bacteria can be modified to produce human or animal proteins, such as insulin. The production of these proteins is more efficient if carried out by animal cells, such as rat tumour cells, maintained in culture.

An investigation was carried out to test the suitability of two systems for culturing rat tumour cells:

- batch culture in which the cells are mixed gently in the culture medium
- a form of continuous culture, known as a perfusion system, in which new culture medium is added to the cells and the old medium removed throughout the fermentation. The cells are kept in the system and are not removed.

During the investigation 20 samples were taken from each system at intervals of ten hours. Four factors were measured in each sample:

1. the number of cells in the culture medium
2. the survival of the cells in culture
3. the concentration of the nutrient, glucose
4. the concentration of the waste, lactic acid

Table 2.1 shows the results for factors 1 and 2.

Table 2.1

time / h	batch culture system		perfusion system	
	mean number of cells / millions of cells cm^{-3}	percentage cell survival	mean number of cells / millions of cells cm^{-3}	percentage cell survival
0	0.2	90	0.2	100
10	0.4	85	0.8	100
20	0.5	95	1.8	100
30	0.6	98	3.6	100
40	0.8	95	7.2	99
50	1.2	90	15.0	100
60	2.2	80	32.1	100

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Table 2.2 shows the results for factors 3 and 4.

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Table 2.2

time / h	batch culture system		perfusion system	
	concentration of glucose / mg cm^{-3}	concentration of lactic acid / mg cm^{-3}	concentration of glucose / mg cm^{-3}	concentration of lactic acid / mg cm^{-3}
0	4.2	0.1	2.1	0.2
10	4.0	0.2	2.5	0.5
20	3.8	0.5	2.8	0.9
30	3.5	1.2	2.0	1.4
40	2.1	1.8	1.9	1.3
50	1.5	2.6	2.2	0.8
60	1.0	3.1	2.2	1.1

(a) Outline how the number of cells may have been estimated.

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.....[2]

(b) Living cells may be identified by using a staining technique.

Suggest how the percentage of cell survival was calculated.

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.....[2]

For Examiner's Use

(c) A *t*-test was carried out to see if there is a significant difference between the number of cells in the two culture systems at 10 hours.

The value of **t = 2.62**

(i) State a null hypothesis for this test.

.....

.....[1]

(ii) State the number of degrees of freedom for this *t*-test.

.....[1]

Table 2.3 shows some probability values of *t*.

Table 2.3

degrees of freedom	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**40**	**50**	**60**
probability 0.05	2.23	2.18	2.14	2.12	2.10	2.09	2.07	2.06	2.06	2.05	2.04	2.02	2.01	2.00
probability 0.01	3.17	3.06	2.98	2.92	2.88	2.85	2.82	2.80	2.78	2.76	2.75	2.70	2.68	2.66

(iii) State what the value of *t* indicates about the difference in the number of cells in the two cultures systems at 10 hours.

.....[1]

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(d) The investigation showed that the perfusion system is a more efficient way to culture rat tumour cells.

For Examiner's Use

Describe how the data in Table 2.1 and Table 2.2 support the statement that the perfusion system is more efficient.

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[Total: 10]

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9836921429

BIOLOGY **9700/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2012**

1 hour 15 minutes

Candidates answer on the Question Paper.

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The leaf-like photosynthetic tissue of the plant is called a thallus. Each plant has a single underwater root and a thallus which floats on the water. The plant reproduces asexually by buds that grow and split off to form separate plants.

Fig. 1.1 shows the appearance of three of these plants.

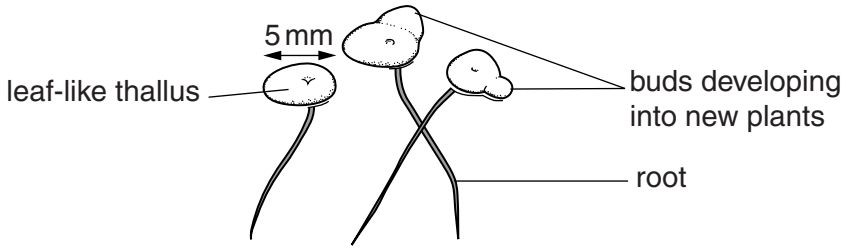


Fig. 1.1

A student investigated the effect of different concentrations of nitrate on the growth of the plant by counting the total number of the leaf-like thalli produced during a ten day period.

Fig. 1.2 shows seven thalli of different sizes and stages of development as seen from above.

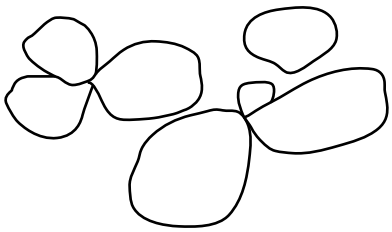


Fig. 1.2

The main stages in the procedure used by the student were:

1. Pond water was sterilised and used to make dilutions of sodium nitrate. A concentration of 4000 mg dm^{-3} was prepared and this was diluted to make the following concentrations:

   2000 mg dm^{-3}, 1000 mg dm^{-3}, 500 mg dm^{-3} and 250 mg dm^{-3}.

2. Plants were collected from a pond and those with a thallus without buds were selected.
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4. Each dilution of sodium nitrate was poured into a sterile glass dish and the dish covered with a lid.
5. Three surface-sterilised plants were placed in each of the dilutions of sodium nitrate and the lid replaced.
6. Four replicates of each sodium nitrate solution were set up in the same way.
7. All of the dishes were placed in a room at a constant temperature for 10 days.
8. The total number of leaf-like thalli in each dish was counted every day for 10 days.

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(a) (i) Identify the independent and dependent variables in this investigation.

independent .....

dependent .....[1]

(ii) Identify **two** variables that the student controlled in this investigation.

.....[1]

(iii) There are other variables that the student could have controlled in this investigation.

Describe how **two other** variables could have been controlled.

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.....[4]

(b) (i) The student used the highest concentration (4000 mg dm^{-3}) to prepare the other concentrations of sodium nitrate.

Describe a procedure that the student used to prepare the other concentrations stated in stage 1. Your description should be sufficiently detailed so that another person can easily follow your procedure.

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.....[4]

(ii) The student also prepared another sterile glass dish to use as a control.

Suggest a suitable solution to use as a control for this investigation.

.....

.....[1]

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For Examiner's Use

Table 1.1

concentration of sodium nitrate / mg dm^{-3}	mean number of thalli ± 1s at daily intervals									
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500	3	7±1	12±1	20±2	30±3	40±5	52±8	68±7	80±7	90±9
1000	3	9±1	18±2	30±3	45±3	65±6	90±8	120±10	158±13	180±12
2000	3	8±1	14±2	26±3	39±4	56±6	75±7	104±7	132±10	157±11
4000	3	8±1	11±1	22±2	33±5	48±6	60±6	88±8	106±9	135±10

(i) State what standard deviation (s) shows about the data.

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(ii) The results show that the standard deviation increased with time.

Suggest a reason for this increase.

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..... [3]

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(d) State the conclusions that can be drawn from the results in Table 1.1 about the effect of different concentrations of nitrate on the growth of this plant.

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(e) Suggest how the student's investigation could be modified to find the optimum nitrate concentration for the growth of this plant.

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.....[1]

(f) Sewage and agricultural fertilisers contain phosphate as well as nitrate. In another investigation the student used sodium phosphate instead of sodium nitrate to test the effect of different concentrations of phosphate on the growth of the same plant.

Suggest a prediction that the student could make about the effect of different concentrations of phosphate on the growth of the plant.

Show your answer as a sketch graph on the axes below.



[2]

[Total: 20]

For Examiner's Use

2 Bacteria can be modified to produce human or animal proteins, such as insulin. The production of these proteins is more efficient if carried out by animal cells, such as rat tumour cells, maintained in culture.

An investigation was carried out to test the suitability of two systems for culturing rat tumour cells:

- batch culture in which the cells are mixed gently in the culture medium
- a form of continuous culture, known as a perfusion system, in which new culture medium is added to the cells and the old medium removed throughout the fermentation. The cells are kept in the system and are not removed.

During the investigation 20 samples were taken from each system at intervals of ten hours. Four factors were measured in each sample:

1. the number of cells in the culture medium
2. the survival of the cells in culture
3. the concentration of the nutrient, glucose
4. the concentration of the waste, lactic acid

Table 2.1 shows the results for factors 1 and 2.

Table 2.1

time / h	batch culture system		perfusion system	
	mean number of cells / millions of cells cm^{-3}	percentage cell survival	mean number of cells / millions of cells cm^{-3}	percentage cell survival
0	0.2	90	0.2	100
10	0.4	85	0.8	100
20	0.5	95	1.8	100
30	0.6	98	3.6	100
40	0.8	95	7.2	99
50	1.2	90	15.0	100
60	2.2	80	32.1	100

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Table 2.2 shows the results for factors 3 and 4.

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Table 2.2

time / h	batch culture system		perfusion system	
	concentration of glucose / mg cm^{-3}	concentration of lactic acid / mg cm^{-3}	concentration of glucose / mg cm^{-3}	concentration of lactic acid / mg cm^{-3}
0	4.2	0.1	2.1	0.2
10	4.0	0.2	2.5	0.5
20	3.8	0.5	2.8	0.9
30	3.5	1.2	2.0	1.4
40	2.1	1.8	1.9	1.3
50	1.5	2.6	2.2	0.8
60	1.0	3.1	2.2	1.1

(a) Outline how the number of cells may have been estimated.

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.....[2]

(b) Living cells may be identified by using a staining technique.

Suggest how the percentage of cell survival was calculated.

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.....[2]

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(c) A *t*-test was carried out to see if there is a significant difference between the number of cells in the two culture systems at 10 hours.

The value of **t = 2.62**

(i) State a null hypothesis for this test.

.....

.....[1]

(ii) State the number of degrees of freedom for this *t*-test.

.....[1]

Table 2.3 shows some probability values of *t*.

Table 2.3

degrees of freedom	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**40**	**50**	**60**
probability 0.05	2.23	2.18	2.14	2.12	2.10	2.09	2.07	2.06	2.06	2.05	2.04	2.02	2.01	2.00
probability 0.01	3.17	3.06	2.98	2.92	2.88	2.85	2.82	2.80	2.78	2.76	2.75	2.70	2.68	2.66

(iii) State what the value of *t* indicates about the difference in the number of cells in the two cultures systems at 10 hours.

.....[1]

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(d) The investigation showed that the perfusion system is a more efficient way to culture rat tumour cells.

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Describe how the data in Table 2.1 and Table 2.2 support the statement that the perfusion system is more efficient.

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[Total: 10]

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0120013753

BIOLOGY **9700/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2012**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

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Answer **both** questions.

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1 The single- celled alga *Chlorella* is common in polluted waters and is used in sewage lagoons to reduce the nitrate content of the water.

Fig. 1.1 shows cells of *Chlorella* viewed with a light microscope using high power.

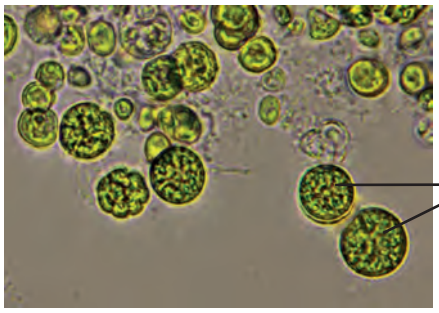


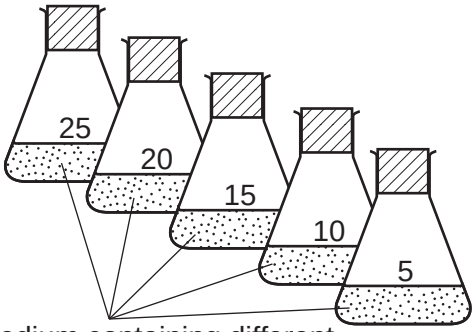
Fig. 1.1

A student investigated the effect of different concentrations of nitrate on the population growth of a species of *Chlorella*. The student used sodium nitrate in the investigation.

Fig. 1.2 shows the main steps in the procedure.

Step 1

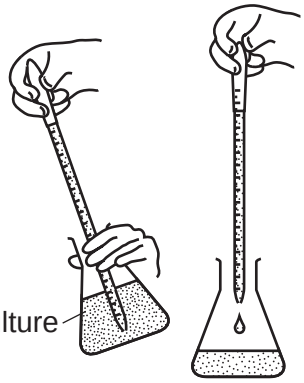
- 250 cm^3 of a growth medium was added to each of five flasks
- a different concentration of sodium nitrate solution from 5 mmol dm^{-3} – 25 mmol dm^{-3} was added to the flasks



growth medium containing different concentrations of sodium nitrate

Step 2

- 1 cm^3 sample removed from a *Chlorella* culture using a graduated pipette
- the 1 cm^3 sample transferred to a flask

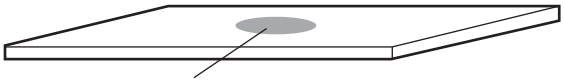


Step 3

- Step 2 repeated for the rest of the flasks
- the flasks were left in sunlight at room temperature.

Step 4

- immediately the number of cells of *Chlorella* in 5 samples taken from each flask was counted.
- 5 samples were removed from each flask at intervals of 2 days for a period of 10 days and the number of cells counted.



haemocytometer used by the student for counting the cells

Fig. 1.2

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(a) (i) Identify the independent and dependent variables in this investigation.

independent .....

dependent .....[1]

(ii) Identify **two** variables that the student has controlled in this investigation as shown in Fig. 1.2.

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.....[1]

(iii) There are other variables that the student could have controlled in this investigation.

Describe how **two** other variables could have been controlled.

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(b) (i) The student used solid sodium nitrate to prepare the highest concentration of sodium nitrate solution shown in Fig. 1.2 (25 mmol dm^{-3}). This concentration was then used to prepare all the other concentrations.
Describe the procedure that the student used to prepare the concentrations shown in Fig. 1.2. Your description should be sufficiently detailed so that another person can easily follow your procedure.
The molar mass of sodium nitrate is 85 g mol^{-1}.

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[Turn over

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(ii) The student also prepared another flask to use as a control.

Suggest a suitable solution to use as a control for this investigation.

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.....[1]

(c) The results of the student's investigation are shown in Table 1.1.

Table 1.1

concentration of sodium nitrate / mmol dm^{-3}	mean number of cells in 1 cm^3 at the start	mean percentage increase in number of cells of *Chlorella*				
		day 2	day 4	day 6	day 8	day 10
control	10035	1	2	2	2	2
5	10630	40	75	140	175	220
10	10128	50	105	160	230	285
15	10743	75	135	210	292	360
20	10108	65	125	195	280	330
25	10900	55	110	170	250	300

(i) State how the mean percentage increase in number of cells was calculated.

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.....[3]

(ii) Suggest why the student calculated the mean percentage increase in numbers of *Chlorella*.

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.....[1]

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(d) State what conclusions can be drawn from the results in Table 1.1 about the effect of different concentrations of nitrate on the growth of *Chlorella*.

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..... [3]

(e) Suggest how the student's investigation should be modified to find the optimum nitrate concentration for the growth of this *Chlorella*.

.....

.....

..... [1]

(f) Sewage lagoons also contain high concentrations of phosphate. In another investigation, the student used sodium phosphate instead of sodium nitrate to find out the effect of different phosphate concentrations on the growth of *Chlorella*.

Suggest a prediction that the student could make about the effect of the different concentrations of phosphate on the growth of *Chlorella*.

Show your answer as a sketch graph on the axes below.



[2]

[Total: 21]

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[Turn over

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2 Dialysis is used to treat kidney failure. One type of dialysis, called CAPD, allows patients to move around during treatment. During this type of dialysis a fluid containing the sugar dextrose, a form of glucose, is passed into the abdominal cavity and left for a few hours. Wastes and excess water pass into the dialysis fluid, which is then removed and thrown away.

Fig. 2.1 shows dialysis fluid being added to the abdominal cavity.

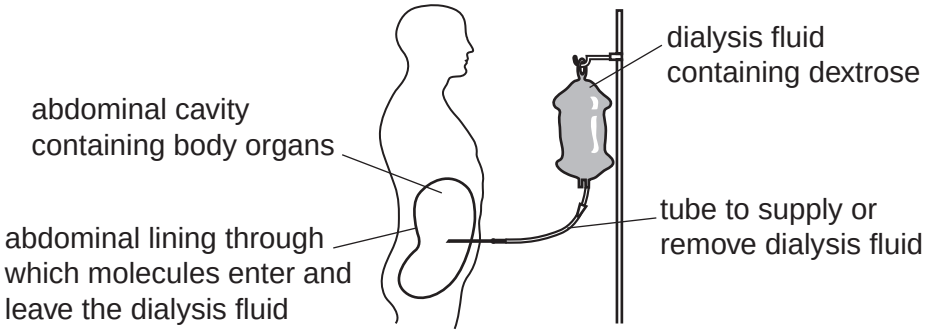


Fig. 2.1

(a) Tests are carried out on each patient receiving CAPD to find out if the treatment is effective. One of these tests uses strips that change colour to indicate the urea concentration.

Outline how test strips could be used to find the effectiveness of CAPD in removing urea.

.....

.....

..... [2]

One effect of kidney failure is anaemia which can be treated by injecting a hormone that stimulates red blood cell production. This treatment can cause a lack of iron used for the synthesis of haemoglobin. Iron supplements are usually taken by mouth.

Ten male and four female patients with a mean age of 63, all using dialysis and being treated for anaemia, took part in a study into a different way of giving iron supplements.

Test **A** was carried out on samples of blood from the patients at the start.
Measurements were made of :

- haemoglobin content
- iron content
- ferritin, a plasma protein for transporting iron.

The patients were supplied with an iron supplement which they took by mouth for three months. At the end of this time test **B** was carried out on samples of blood from the patients by measuring the same three substances as before.

In the next part of the study the patients' iron supplements were replaced by an iron-dextran complex that was injected into their muscles once a week for three months. Test **C** was carried out on samples of blood from the patients in the same way as in tests **A** and **B**.

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Table 2.1 shows the results of this study.

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Table 2.1

substance tested	mean concentration ± S_M			range of concentrations in people without anaemia
	test **A** (before treatment with iron supplements)	test **B** (after injection with hormone and iron taken by mouth)	test **C** (after injection with hormone and iron given by injection)	
haemoglobin / g dm^{-3}	90 ± 1	100 ± 1	130 ± 3	120 – 130
iron / μg dm^{-3}	740 ± 15	540 ± 11	940 ± 21	500 – 1760
ferritin / μg dm^{-3}	2.81 ± 0. 69	2.67 ± 1.04	6.60 ± 1.04	11 – 300

(b) (i) State what S_M shows about the data.

.....

.....[2]

(ii) A number of *t*-tests were carried out to determine if the treatments with iron supplements had a significant effect on the concentrations of the substances tested. The results of test **A** were used as a comparison for both test **B** and test **C**. State why the *t*-test is a suitable statistical test to use for the data.

.....[1]

(iii) State evidence in Table 2.1 that suggests the results of these *t*-tests might be significant.

.....

.....[1]

Question 2 continues on page 8

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(c) The researchers who carried out this study concluded that providing iron supplement by injection was more effective than providing iron by mouth.

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(i) State the evidence from Table 2.1 for this conclusion.

.....

.....

.....

(ii) Suggest limitations of this study.

.....

.....

.....[3]

[Total: 9]

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