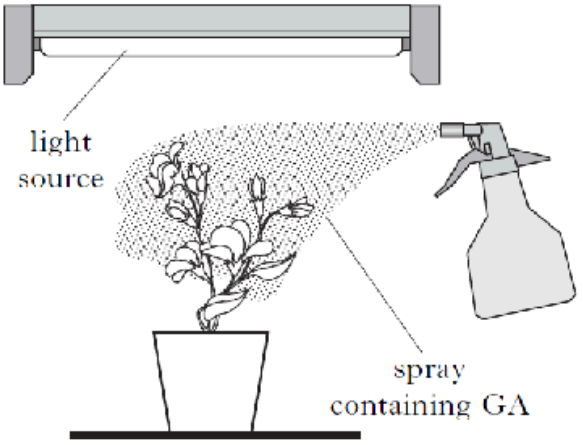
MARKS

10. An experiment was carried out to investigate the effect of gibberellic acid (GA) on the growth of dwarf pea plants. GA can be absorbed by leaves.

Six identical pea plants were placed in pots containing 100 g of soil. The leaves of each were sprayed with an equal volume of water containing a different mass of GA. The soil in each pot received 20 cm^3 water each day and the plants were continuously exposed to equal light intensity from above.

After seven days the stem height of each plant was measured and the percentage increase in stem height calculated.



(*a*) (i) Identify **two** variables, not already mentioned, that should have been controlled to ensure the experimental procedure was valid.

Variable 1 _____ **1**

Variable 2 **1**

(ii) State **one** way in which the experimental procedure could be improved to increase the reliability of the results.

1

(*b*) The results of the experiment are shown in the table.

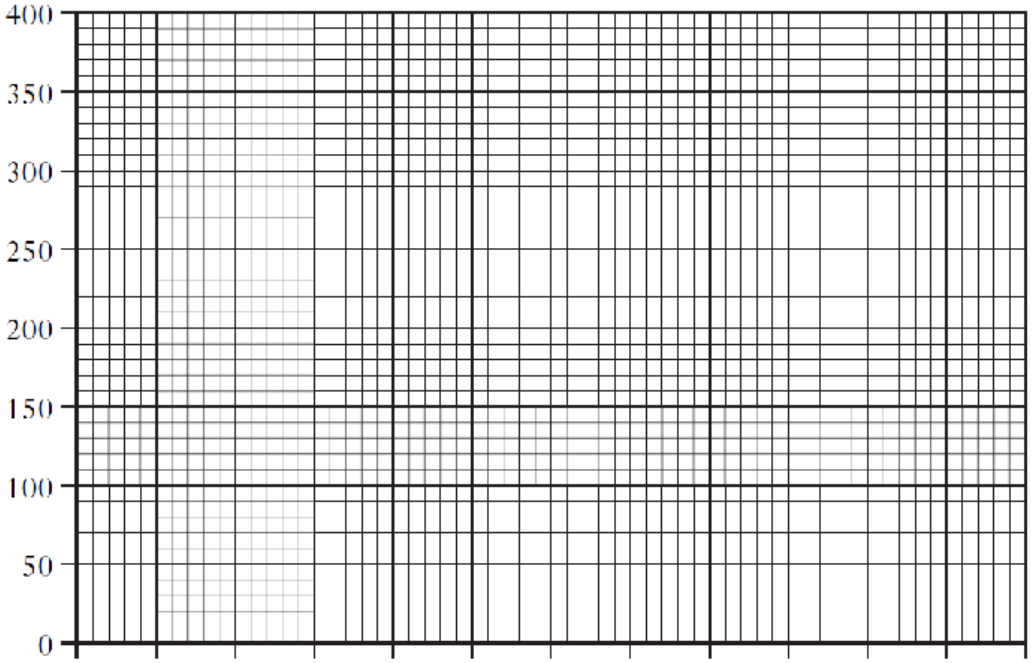
Mass of GA applied (micrograms)	*Percentage increase in stem height* (%)
0·01	90
0·03	120
0·05	160
0·08	240
0·10	320
0·11	350

10. (*b*) (continued)

(i) On the grid provided, complete the line graph to show the percentage increase in stem height against the mass of GA applied.

Use an appropriate scale to fill most of the grid.

(Additional graph paper, if required, will be found on page 36.)



2

(ii) Another pea plant was treated in the same way, using a water spray containing 0·12 micrograms of GA. Predict the percentage increase in stem height of this plant after seven days.

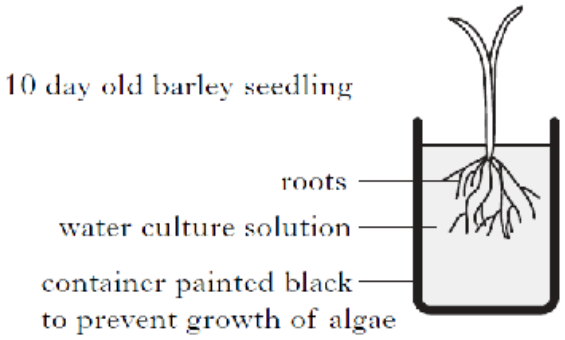
_____ percentage increase **1**

(*c*) Explain why the method of application of GA could lead to errors in the results.

_____

1

11. In an investigation into the effect of potassium on barley root growth, twelve containers were set up as shown. *Marks*



The water culture solution provided all the elements needed for normal growth.

In six of the containers, the potassium concentration was 2 micromoles per litre. In the other six containers, the potassium concentration was 5 millimoles per litre.

The containers were kept at 20 °C and in constant light intensity.

Every three days, the roots from one container at each potassium concentration were harvested and their dry mass measured.

(*a*) How many times greater was the potassium concentration in the 5 millimoles per litre solution than in the 2 micromoles per litre solution?

1 millimole per litre = 1000 micromoles per litre

Space for calculation

_____ times **1**

(*b*) (i) Identify **one** variable, not already described, that should be kept constant.

_____ **1**

(ii) Suggest **one** advantage of growing the seedlings in water culture solutions rather than soil.

_____ **1**

(iii) Complete the table to give the reasons for each experimental procedure.

Experimental procedure	*Reason*
paint containers black to prevent growth of algae	
measure dry mass rather than fresh mass of roots	

2

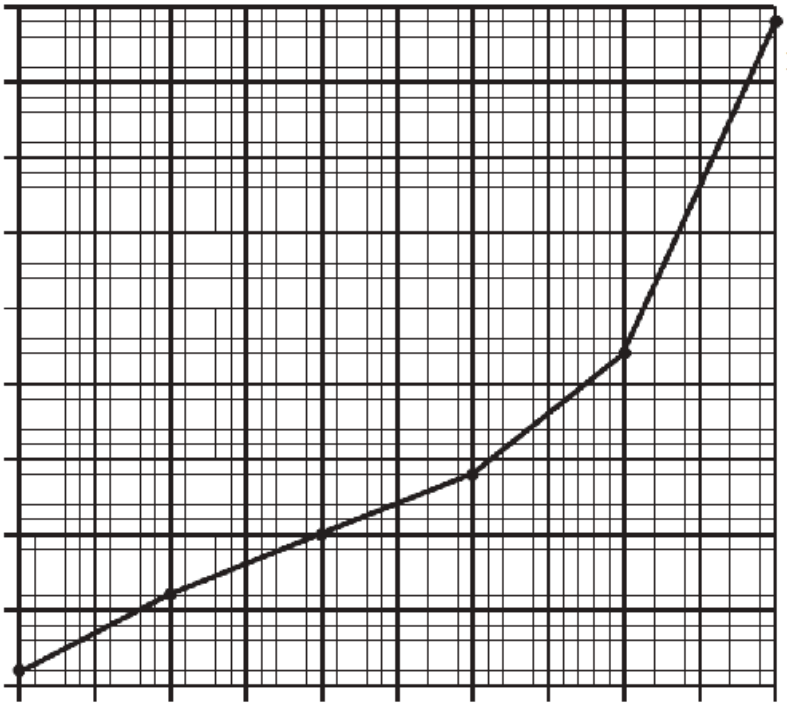
11. (continued)

(*c*) The results of the investigation are shown in the table.

Marks

Time (days)	*Dry mass of roots* (mg)	
	Potassium concentration 2 micromoles per litre	*Potassium concentration 5 millimoles per litre*
3	1	1
6	5	6
9	8	10
12	11	14
15	16	22
18	22	44

The results for the seedlings grown in 5 millimoles potassium per litre solution are shown on the graph.



Complete the graph by:

(i) adding the scale and label to each axis; **1**

(ii) presenting the results for the 2 micromoles potassium per litre solution **and** labelling the line. **1**

(Additional graph paper, if required, will be found on page 36.)

(*d*) In a further experiment, bubbling oxygen through the water culture solutions was observed to increase the uptake of potassium by the barley roots.

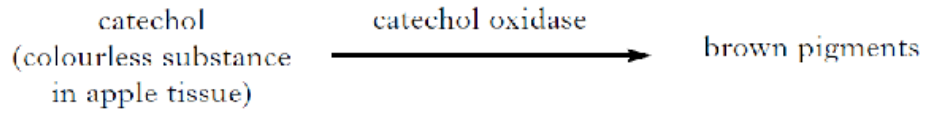
Explain this observation.

_____

_____ **2**

2009

10. Catechol oxidase is an enzyme found in apple tissue. It is involved in the reaction which produces the brown pigment that forms in cut or damaged apples.



The effect of the concentration of lead ethanoate on this reaction was investigated.

10 g of apple tissue was cut up, added to 10 cm^3 of distilled water and then liquidised and filtered. This produced an extract containing both catechol and catechol oxidase.

Test tubes were set up as described in **Table 1** and kept at 20 °C in a water bath.

Table 1

Tube	*Contents of tubes*
A	sample of extract + 1 cm^3 distilled water
B	sample of extract + 1 cm^3 0·01% lead ethanoate solution
C	sample of extract + 1 cm^3 0·1% lead ethanoate solution

Every 10 minutes, the tubes were placed in a colorimeter which measured how much brown pigment was present.

The more brown pigment present the higher the colorimeter reading.

The results are shown in **Table 2**.

Table 2

Time (minutes)	*Colorimeter reading* (units)		
	Tube A	*Tube B*	*Tube C*
	sample of extract + distilled water	*sample of extract + 0·01% lead ethanoate*	*sample of extract + 0·1% lead ethanoate*
0	1·6	1·8	1·6
10	7·0	5·0	2·0
20	9·0	6·0	2·2
30	9·6	6·4	2·4
40	10·0	7·0	2·4
50	10·0	7·6	2·4
60	10·0	7·6	2·4

(*a*) (i) Identify **two** variables not already mentioned that would have to be kept constant.

1 _____ **1**

2 _____ **1**

10. (*a*) (continued) *Marks*

(ii) Describe how tube A acts as a control in this investigation.

_____

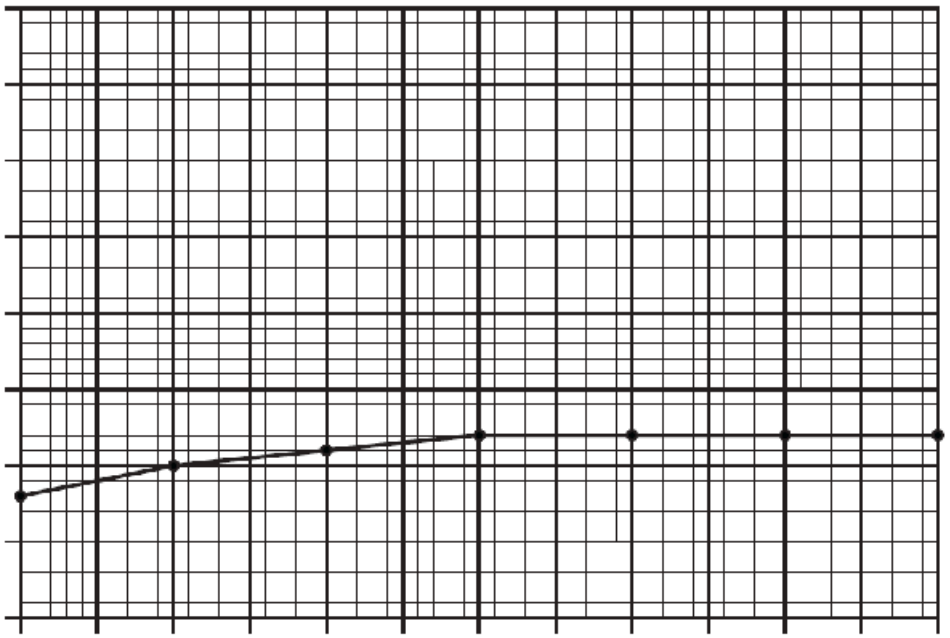
_____ **1**

(*b*) Explain why the initial colorimeter readings were not 0·0 units.

_____

_____ **1**

(*c*) The results for the extract with 0·1% lead ethanoate are shown in the graph below.



Use information from **Table 2** to complete the graph by:

(i) adding the scale and label to each axis; **1**

(ii) presenting the results for the extract + 0·01% lead ethanoate solution **and** labelling the line. **1**

(Additional graph paper, if required, will be found on page 40.)

(*d*) State the effect of the concentration of lead ethanoate solution on the activity of catechol oxidase.

_____

_____ **1**

(*e*) The experiment was repeated with the 0·1% lead ethanoate solution at 60 °C. Predict the colorimeter reading at 10 minutes and justify your answer.

Prediction _____ units

Justification _____

_____ **1**

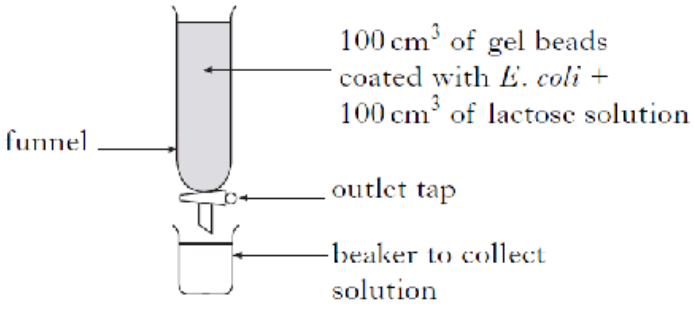
2010

10. The Jacob-Monod hypothesis describes lactose metabolism in the bacterium *Escherichia coli*. Lactose acts as an inducer of the enzyme β-galactosidase in the bacterium. This enzyme breaks down lactose as shown.

$$\text{lactose} \xrightarrow{\beta\text{-galactosidase}} \text{glucose} + \text{galactose}$$

An investigation of this reaction in *E. coli* at 25 °C was carried out as described below.

- 100 cm^3 of gel beads coated with *E. coli* were placed into each of seven identical funnels fitted with outlet taps.
- 100 cm^3 of solution containing 2 grams of lactose was poured into each funnel.
- At each time shown in the table, the solution from one of the funnels was collected.
- The mass of lactose in each solution was measured.



The results are shown in the table below.

Funnel	*Time* (minutes)	*Mass of lactose in the solution collected* (g)
1	0	2·00
2	10	2·00
3	20	1·48
4	30	0·92
5	40	0·40
6	50	0·12
7	60	0·04

(*a*) (i) Identify **one** variable, not already mentioned, that should have been controlled to ensure that the experimental procedure was valid.

_____ **1**

(ii) A control experiment would be needed for each funnel.

Describe such a control and explain its purpose in the investigation.

Description _____

_____

Purpose _____

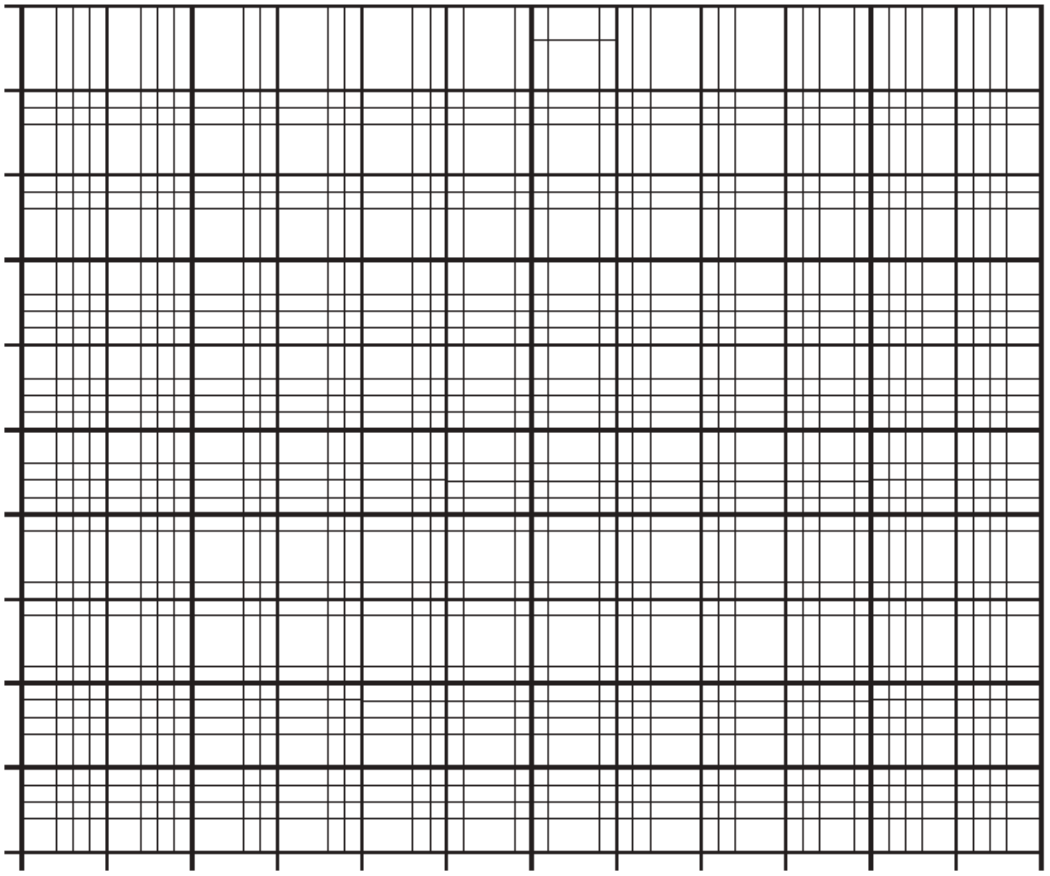
_____ **2**

10. (continued)

(*b*) On the grid provided below, draw a line graph to show the mass of lactose in the solution collected against time.

Use an appropriate scale to fill most of the grid.

(Additional graph paper, if required, will be found on *Page thirty-six*.)



2

(*c*) Calculate the average mass of lactose broken down per minute in funnel 5.

Space for calculation

_____ g per minute **1**

(*d*) Use the information given to explain why *E. coli* had not broken down any lactose in the first 10 minutes.

_____

_____

_____ **2**

10. Gibberellic acid (GA) is needed to break dormancy of rice grains allowing them to germinate.

An experiment was carried out to investigate the effects of GA on the germination of rice grains.

30 cm^3 of different concentrations of GA solution was placed into separate beakers. 50 rice grains were added to each beaker. Each beaker was then covered with plastic film.

After 12 hours, the grains were removed from the solutions and evenly spaced in separate dishes on filter paper soaked with 20 cm^3 of water.

The dishes were covered and kept in the dark for 10 days and the number of germinated grains in each dish was counted.

A second batch of grains was treated in the same way but these were left in the GA solutions for 36 hours.

The results are shown in the table.

Concentration of GA solution (mg per litre)	*Number of rice grains germinated*	
	After 12 hours in GA solution	*After 36 hours in GA solution*
0	5	6
5	7	14
10	16	31
20	23	35
30	28	41
60	31	43

DO NOT WRITE IN THIS MARGIN

(*a*) Identify **one** variable, not already described, that should be kept constant. *Marks*

_____ **1**

(*b*) (i) Explain how the solution with 0 mg per litre GA acts as a control in this experiment.

_____

_____ **1** ____

(ii) Suggest why some germination occurs in the control.

_____ **1** ____

(*c*) Identify a feature of the experimental procedure which ensured the reliability of the results.

_____ **1** ____

10. (continued)

(*d*) Predict how the concentration of GA in the beakers would have been affected if they had not been covered with plastic film.

Underline the correct answer and give a reason for your choice.

increased **decreased** **stayed the same**

Reason _____

_____ 1

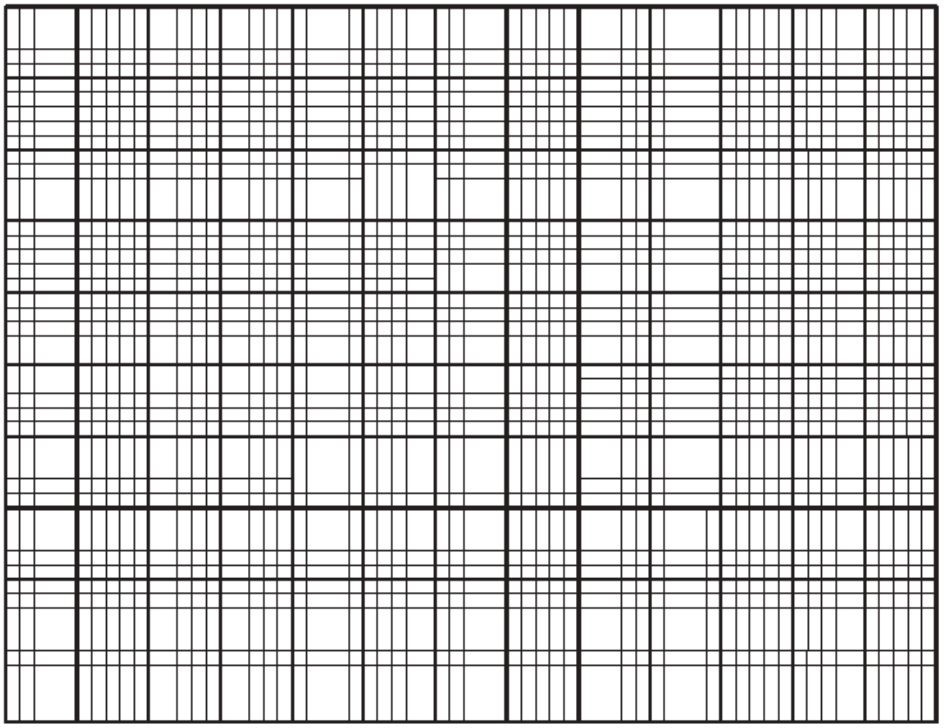
(*e*) Calculate the difference in **percentage** germination between the grains kept in the 5 mg GA per litre solution for 12 hours and those kept in the 30 mg GA per litre solution for 12 hours.

Space for calculation

_____ % 1

(*f*) On the grid below, draw a line graph to show the number of grains germinated after 36 hours in the different concentration of GA solution.

(Additional graph paper, if required, will be found on *Page forty*.)



2

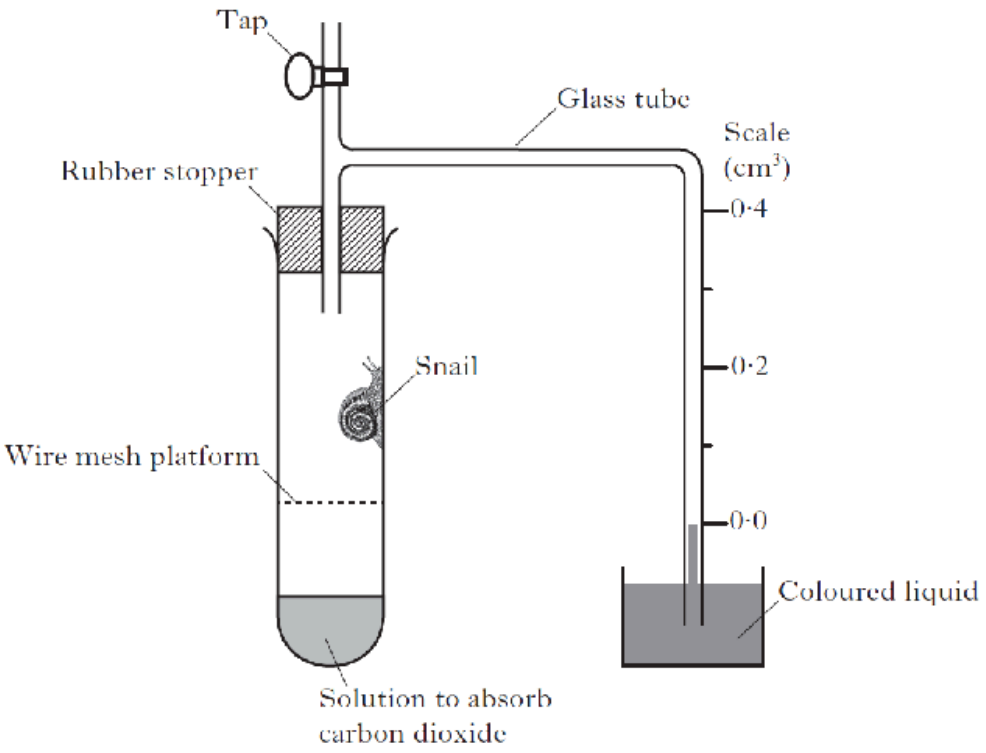
(*g*) Give **two** conclusions which can be drawn from the results in the **table**.

1 _____

2 2

2012

4. The diagram shows apparatus used in an investigation of aerobic respiration in snails. *Marks*



The tap was kept open to the air for 15 minutes, and to start the experiment the tap was closed and the reading on the scale recorded. Every 2 minutes for 10 minutes the reading on the scale was again recorded and the results shown in the table below. The apparatus was kept at 20 °C throughout.

Time after tap closed (minutes)	*Reading on scale* (cm^3)
0	0·00
2	0·04
4	0·08
6	0·12
8	0·16
10	0·20

(*a*) State why the apparatus was left for 15 minutes with the tap open before readings were taken.

1

(*b*) Describe a suitable control for this investigation.

1

4. (continued)

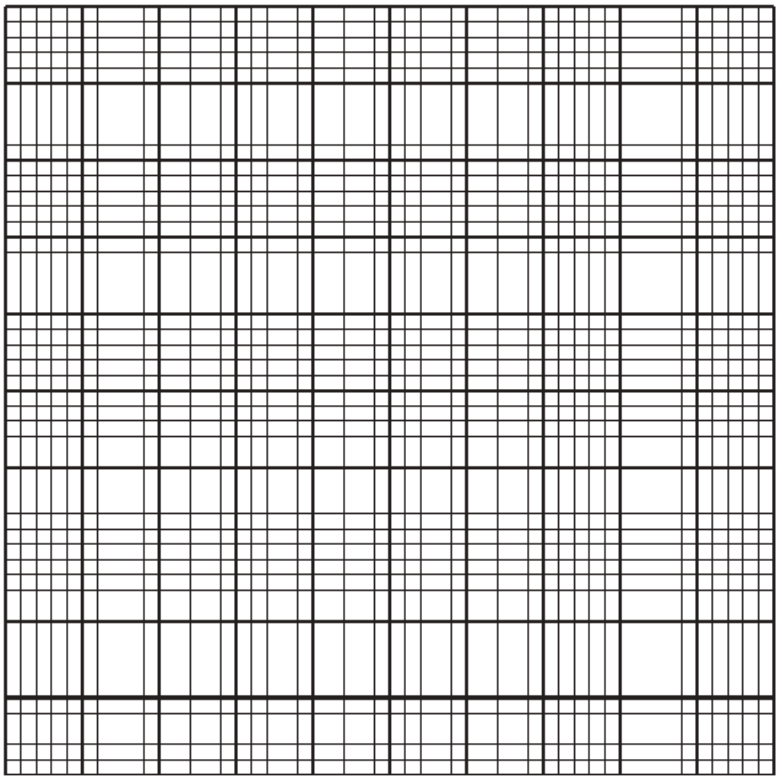
Marks

(*c*) To increase the reliability of results, the experiment was repeated several times. Identify **one** variable, not already mentioned, that would have to be kept the same each time to ensure that the procedure was valid.

_____ **1**

(*d*) On the grid below, draw a line graph to show the reading on the scale against time, choosing appropriate scales so that the graph fills most of the grid.

(Additional graph paper, if required, will be found on *Page forty*.)



2

(*e*) The mass of the snail was 5·0 g.

Use results in the table to calculate the rate of oxygen uptake by the snail over the 10 minute period.

Space for calculation

_____ cm^3 oxygen per minute per gram of snail **1**

(*f*) Explain how the respiration of the snail and the presence of the solution in the apparatus accounts for the movement of the coloured liquid on the scale.

_____

_____

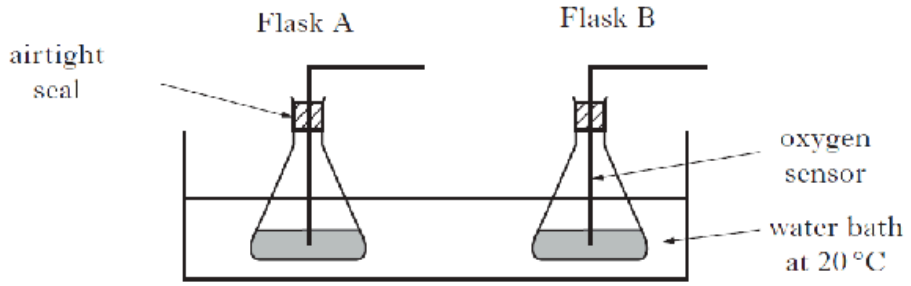
_____ **2**

2013

4. In an investigation into the effect of lead ion concentration on respiration in yeast, two flasks were set up as described below. *Marks*

Flask	*Contents*
A	200 cm^3 glucose solution + 5 cm^3 0·2% lead nitrate solution
B	200 cm^3 glucose solution + 5 cm^3 1·0% lead nitrate solution

The flasks were placed in a water bath at 20 °C for 10 minutes. After this time 2·5 cm^3 of yeast suspension was added to each and oxygen sensors fitted as shown in the diagram below.



The flasks were left for a **further** 10 minutes and then oxygen concentration was measured in each flask every 20 seconds for 2 minutes.

The results are shown in the table below.

Time (s)	*Oxygen concentration* (mg per litre)	
	Flask A 0·2% *lead nitrate*	*Flask B* 1·0% *lead nitrate*
0	10·2	10·8
20	8·4	9·3
40	6·1	7·6
60	3·8	6·2
80	1·7	5·1
100	0·2	4·0
120	0·0	3·2

(*a*) (i) Identify **one** variable, not already mentioned, which would have to be kept constant so that valid conclusions could be drawn.

_____ **1**

(ii) Explain why the flasks were left for 10 minutes **before** the yeast suspension was added.

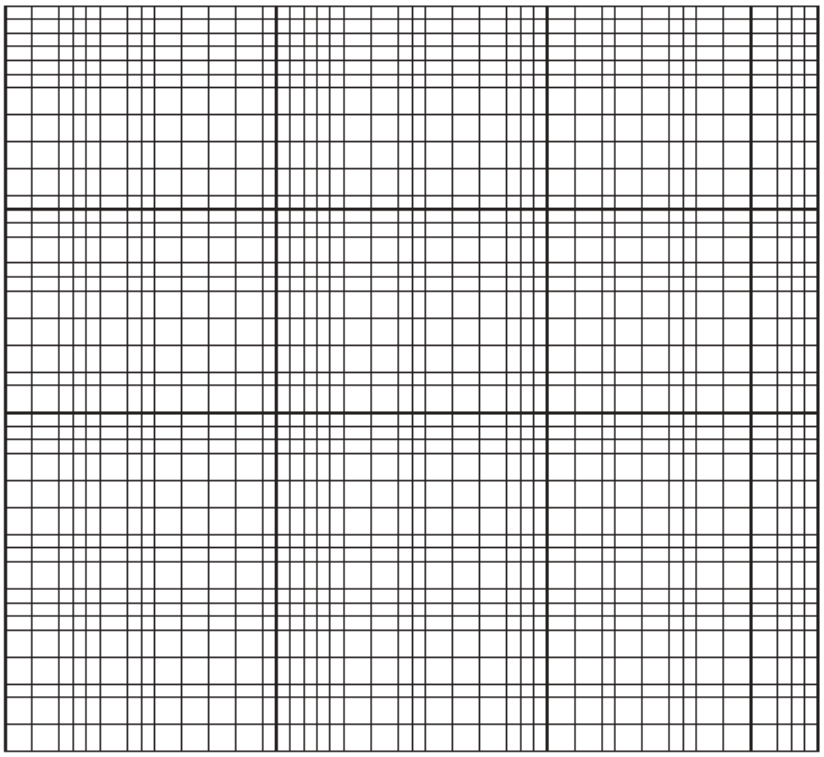
1

4. (*a*) (continued)

(iii) Explain why the flasks were left for a **further** 10 minutes after the yeast suspensions were added before measurement of oxygen concentrations were taken. *Marks*

_____ **1**

(*b*) On the grid provided, draw a line graph to show the oxygen concentration in **Flask A** against time. Use an appropriate scale to fill most of the grid. (Additional graph paper, if required, will be found on Page forty.)



2

(*c*) Using information from the table, state the effect of increasing lead ion concentration on the aerobic respiration of yeast.

_____ **1**

(*d*) Bubbles of gas appeared in both flasks throughout the investigation.

(i) Name this gas.

1

(ii) Explain why this gas continued to be produced in **Flask A** at 120s.

_____ **1**

2014

12. An investigation was carried out to study the effects of exercise on sweat production in humans.

An exercise bike was placed in a laboratory with constant humidity and temperature.

A healthy 30-year-old male exercised on the bike for five trials of different durations as shown in the table below. The average rate of sweat production during each trial was calculated.

There was a recovery period after each trial to allow sweat production to return to normal level.

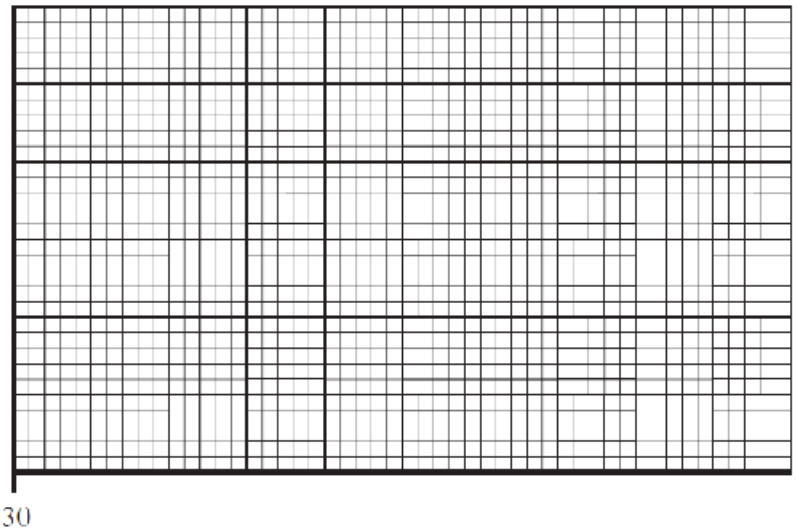
The results are shown in the table below.

Exercise trial	*Duration of exercise trial* (s)	*Average rate of sweat production* (mg per cm^2 skin per minute)
1	30	0·10
2	60	0·21
3	90	0·32
4	120	0·43
5	150	0·45

(*a*) On the grid below draw a line graph of average rate of sweat production against the duration of exercise.

Choose an appropriate scale to fill most of the graph paper.

(Additional graph paper, should it be required, will be found on *Page forty*.)



2

(*b*) (i) Give **two** variables, not already described, which should be kept constant to allow valid comparison of the exercise trials.

1 _____

2 _____ **2**

12. (*b*) (continued)

(ii) State how the procedure could be improved to increase the reliability of the results.

_____ **1**

(*c*) Explain how the units of sweat production used in this investigation would allow a valid comparison between different individuals to be made.

_____

_____ **1**

(*d*) Calculate the total mass of sweat produced per cm^2 during exercise trial 3.

Space for calculation

mg per cm^2 **1**

(*e*) Predict the rate of sweat production which would be expected in an exercise trial with a duration of 180 seconds.

_____ mg per cm^2 per minute **1**

(*f*) (i) Sweat production is a corrective mechanism used in the regulation of body temperature.

Explain why maintaining body temperature within tolerable limits is important to the metabolism of humans.

_____

_____ **1**

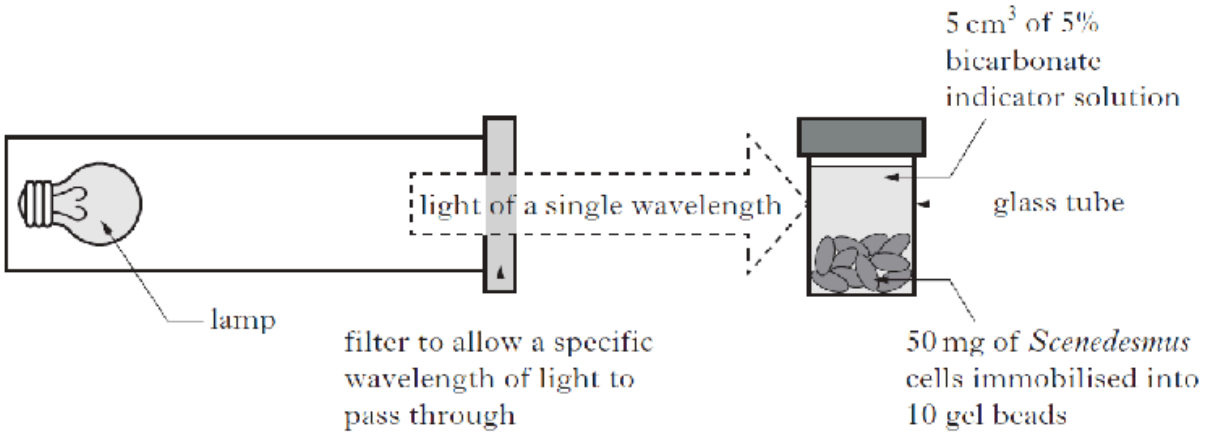
(ii) Give the term used for animals which use changes in metabolism to regulate their body temperature.

_____ **1**

2015

5. Photosynthesis in algal cells can be measured by immersing them in bicarbonate indicator solution. The indicator solution gradually changes colour as carbon dioxide is removed from it by photosynthesis. This colour change can be measured by placing the solution in a colorimeter. The higher the rate of photosynthesis, the higher the reading on the colorimeter.

The effect of different wavelengths of light on rate of photosynthesis in *Scenedesmus*, an alga which grows near the surface of fresh water lochs, was measured. The apparatus shown below was set up in a darkened room.



After one hour, the bicarbonate indicator was removed from the tube, placed in a colorimeter and a reading taken.

The experiment was carried out seven times using filters, each of which allowed different wavelengths of light to pass through.

The results are shown in the table below.

Filter	*Wavelength of light passing through* (nanometres)	*Colorimeter reading* (units)
1	400	0·48
2	450	0·74
3	500	0·36
4	550	0·32
5	600	0·24
6	650	0·96
7	700	0·26

(*a*) Identify **two** variables, not already mentioned, that would have to be controlled to ensure that the experimental procedure was valid.

1

2 _____ **2**

5. (continued)

Marks

(*b*) A control tube would be required for each wavelength of light being investigated.

Describe the contents of a suitable control tube.

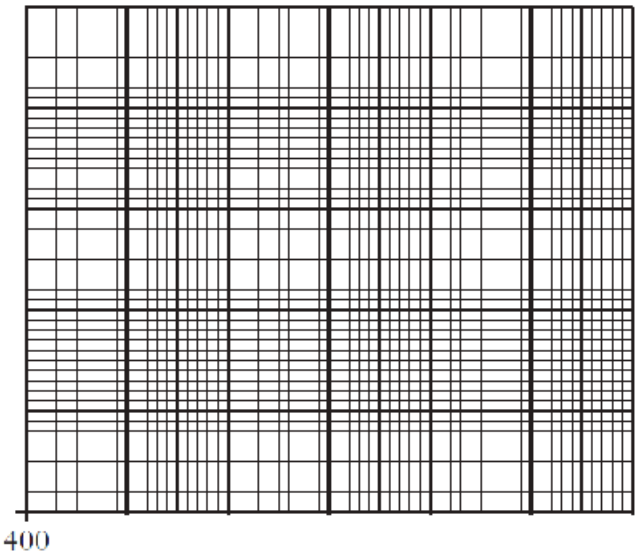
1

(*c*) State why the tubes were left for one hour before the colorimeter readings were taken.

1

(*d*) (i) On the grid provided, draw a line graph to show the colorimeter readings against wavelength of light.

(Additional graph paper, should it be required, will be found on *Page forty*.)



2

(ii) Give the reason why the graph of colorimeter reading against wavelength of light can be described as an action spectrum.

_____

1

(*e*) The experiment was repeated with a second alga which lives in the water below *Scenedesmus*.

Predict the colorimeter reading the indicator would give after exposure of the second alga to light of 500 nanometres and explain your answer.

Prediction _____ units 1

Explanation _____

_____ 1

3. (a) The yeast *Kluyveromyces marxianus* uses lactose as a respiratory substrate. An investigation was carried out into the effect of lactose concentration on ethanol production by this yeast species. Five flasks were set up each containing 5 cm^3 of yeast suspension and 100 cm^3 of 4, 8, 12, 16 or 20% lactose solution. The flasks were sealed to maintain anaerobic conditions.

Samples were removed from each flask at 12 and 36 hours and the concentration of ethanol was determined. Results are shown in the table below.

Lactose concentration (%)	*Ethanol concentration* (g per 100 cm^3)	
	12 hours	*36 hours*
4	1·20	1.65
8	1·55	2·80
12	2·00	4·25
16	2·80	3·25
20	2·80	6·50

(i) Identify the independent variable. 1

_____

(ii) Identify **one** variable not already mentioned that should be kept constant so that a valid conclusion can be drawn. 1

(b) Describe the relationship between the lactose concentration and ethanol concentration at 12 hours growth. 2

_____

_____

(c) Calculate the percentage increase in ethanol concentration between 12 and 36 hours growth in the 4% lactose flask. 1

Space for calculation

_____%

3. **(continued)**

(d) Air leaked into the 16% lactose flask between 12 and 36 hours growth. Explain why this resulted than a lower than expected ethanol concentration. **1**

_____

_____

_____

11. Colchicine is a chemical used in plant breeding programmes to induce mutations and produce cultivars with improved characteristics.

Sesame is an important crop plant grown for its edible seeds and leaves.

An investigation was carried out to determine the effects of colchicine concentration on sesame. Sesame seeds were soaked in different concentrations of colchicine solution for 24 hours. Seeds from each concentration were germinated and 50 plants were grown from each concentration. Ninety days later the total leaf area, number of seeds and mass of seeds per plant were recorded.

The average results are shown in the table below.

Colchicine concentration (m mol l^{-1})	*Average total leaf area per plant* (cm^2)	*Average number of seeds per plant*	*Average total mass of seeds per plant* (g)
0	1500	548	2·8
0·1	2315	532	3·5
0·5	2786	550	4·4
1·0	3500	512	4·7

(a) (i) Identify the independent variable in this investigation. **1**

_____

(ii) State an aspect of the investigation which helped to ensure that reliable results were obtained. **1**

_____

(b) (i) An important characteristic of food crops is the *1000 seed mass* which is the total mass of a sample of 1000 seeds.

Calculate the *1000 seed mass* for the plants grown from seeds soaked in a colchicine concentration of 0·5 m mol l^{-1}. **1**

Space for calculation

_____ g

11. (b) (continued)

(ii) Express, as the simplest whole number ratio, the average total leaf area per plant from seeds soaked in a colchicine concentration of 0 to that at 1·0 m mol l^{-1}. **1**

Space for calculation

_____ : _____

0 m mol l^{-1} 1·0 m mol l^{-1}

(c) Explain the relationship between the total leaf area and total mass of seeds. **2**

_____

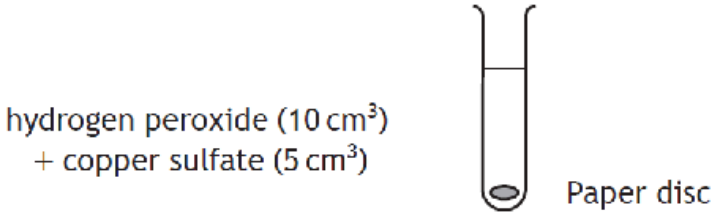
_____

_____

9. Catalase is an enzyme which breaks down hydrogen peroxide into oxygen and water. Paper discs soaked in catalase sink when placed into hydrogen peroxide solution. The discs rise to the surface when oxygen is produced. The time taken for the discs to rise can be used to measure catalase activity.

An experiment was set up to investigate the effect of copper sulfate concentration on catalase activity.

Six tubes were set up, each containing 10 cm^3 of hydrogen peroxide and 5 cm^3 of a different concentration of copper sulfate. One paper disc was then placed into each test tube as shown in the diagram. The time taken for each paper disc to rise to the surface was recorded.



The results are shown in the table.

Concentration of copper sulfate solution (mol l ^{1})	*Time taken for paper disc to rise* (seconds)
0·2	8
0·3	12
0·4	15
0·6	18
0·8	19
1·0	20

(a) (i) Name the independent variable in this experiment. 1

(ii) Describe a suitable control for this experiment. 1

(iii) Suggest how the temperature of the tubes could be kept constant. 1

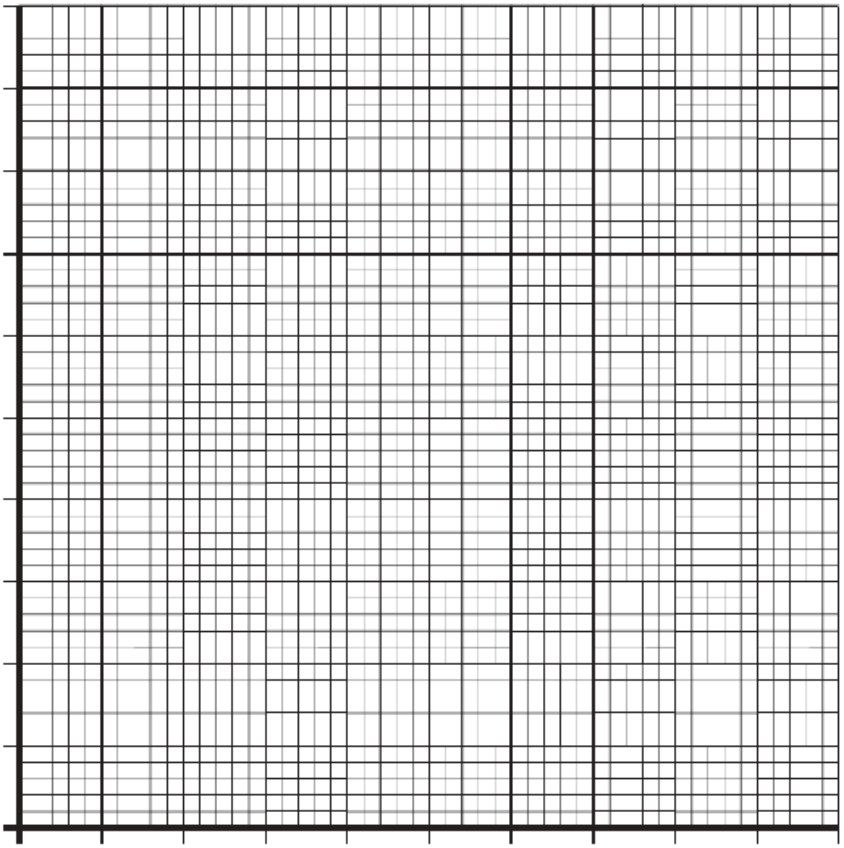
9. (a) (continued)

MARK

(iv) Give a feature of the experiment which may make the results unreliable. 1

(b) (i) Draw a line graph using the results in the table.

(Additional graph paper, if required, will be found on *Page 32*.) 2



(ii) Calculate the percentage increase in the time taken for the paper disc to rise when the copper sulfate concentration increased from $0{\cdot}2\,\text{mol}\,l^{-1}$ to $1{\cdot}0\,\text{mol}\,l^{-1}$. 1

Space for calculation

_____ %

(c) Draw a conclusion from the results of this experiment. 1

_____

_____

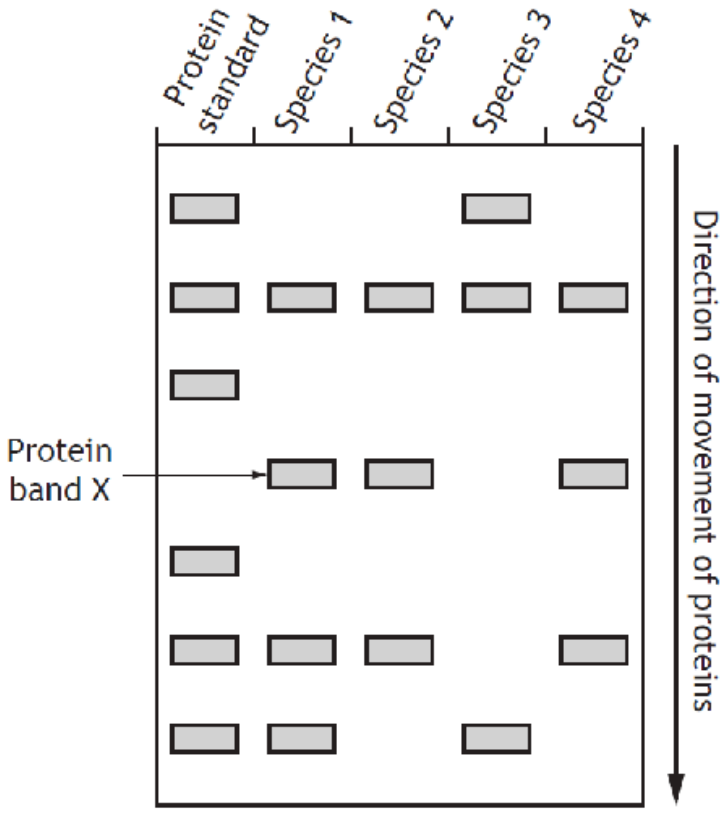
10. An experiment was carried out to investigate the evolutionary relatedness of four species of fish by comparing proteins extracted from the fish. The more closely related species are, the more proteins they have in common.

A sample of muscle tissue from each species of fish was heated in a solution to extract proteins.

The protein extracts were analysed by gel electrophoresis which separates proteins according to their mass. A protein standard containing proteins of known masses was also analysed.

The results of the gel electrophoresis are shown in the diagram. Each band represents a protein.

Mass of protein in protein standard (kDa)	*Distance travelled* (mm)
16	50
20	38
26	30
44	24
66	15
108	10



(a) (i) Identify **two** variables related to the protein extraction, not already mentioned, which should be kept constant so that a valid conclusion can be drawn. **2**

1 _____

2 _____

(ii) During the preparation the samples were heated. This unfolds the proteins changing their three-dimensional shape.

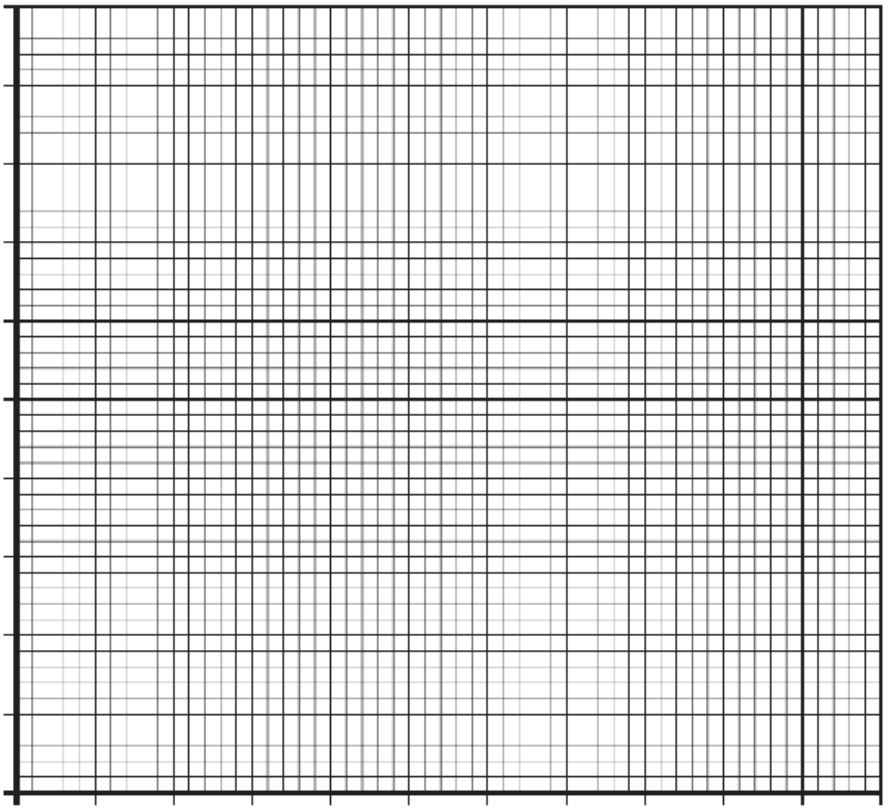
Name one type of bond that could have been broken to cause this change. **1**

_____

10. (continued)

(b) (i) Draw a line graph to show the distance travelled by the protein bands in the gel against the mass of protein in the protein standard. **2**

(Additional graph paper, if required, can be found on *page 33*)



Mass of protein in protein standard (kDa)

(ii) Band X travelled 28 mm. Use the graph to identify the mass of the protein in band X. **1**

_____ kDa

(iii) Each species of fish contains a protein with a mass of 66 kDa. One amino acid has an average mass of 0·12 kDa.

Calculate how many amino acids that would be expected in this protein. **1**

Space for calculation

_____

(iv) Explain why it was concluded that species 1, 2 and 4 are more closely related to each other than they are to species 3. **1**

_____

12. An investigation was carried out into the effect of increasing time of exposure to UV light on the survival of wild type (WT) and mutant (M) yeast cells.

Each type of yeast cell was grown in separate liquid media at 30 °C for 24 hours, diluted and plated onto separate agar plates. They were then exposed to a UV light source for between 0 and 30 seconds in a darkened room.

The plates were incubated for four days at 20 °C and the number of yeast colonies that had grown was counted. Each colony grew from a single cell.

The results are shown in the table.

Time of exposure to UV light (seconds)	Number of yeast colonies	
	WT	M
0	360	400
5	210	120
10	90	25
15	45	10
20	20	0
30	10	0

(a) (i) State an independent variable in this experiment. 1

(ii) Suggest why exposure to UV light was carried out in a darkened room. 1

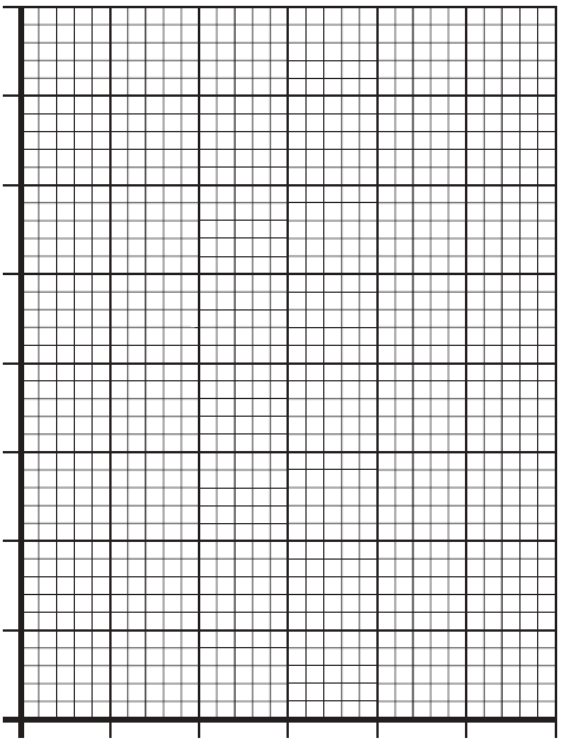
_____

_____

12. (continued)

(b) On the grid, draw a line graph using the results in the table for **both** WT yeast and M yeast.

(Additional graph paper, if required, can be found on *page 31*) **3**



(c) Draw **one** conclusion from the results of this investigation. **1**

(d) Sunscreen lotions can protect cells from UV damage.

Suggest how the investigation could be modified to test the effectiveness of a sunscreen lotion using M yeast as model cells. **2**