Oxford Cambridge and RSA

# Monday 12 October 2020 – Morning

## A Level Biology A

### H420/01 Biological processes

**Time allowed: 2 hours 15 minutes**

**You can use:**
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

**INSTRUCTIONS**
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

**INFORMATION**
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **36** pages.

**ADVICE**
- Read each question carefully before you start your answer.

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## SECTION A

**You should spend a maximum of 20 minutes on this section.**

**Write your answer to each question in the box provided.**

Answer **all** the questions.

**1** Which of the following statements, **A** to **D**, about differential staining is **not** true?

**A** Differential staining can distinguish between different organelles.

**B** Differential staining can distinguish between types of cell.

**C** Differential staining can distinguish between types of organism.

**D** Differential staining is a common feature of electron microscopy.

Your answer ☐ **[1]**

**2** Which of the following statements, **A** to **D**, about microscopes is correct?

**A** A light microscope with an eyepiece lens magnification of ×10 and an objective lens magnification of ×50 will have an overall magnification of ×60.

**B** Scanning electron microscopes and laser scanning confocal microscopes can both produce three dimensional images.

**C** The maximum resolution of a scanning electron microscope is lower than that of a light microscope.

**D** Transmission electron microscopes and laser scanning confocal microscopes can both produce three dimensional images.

Your answer ☐ **[1]**

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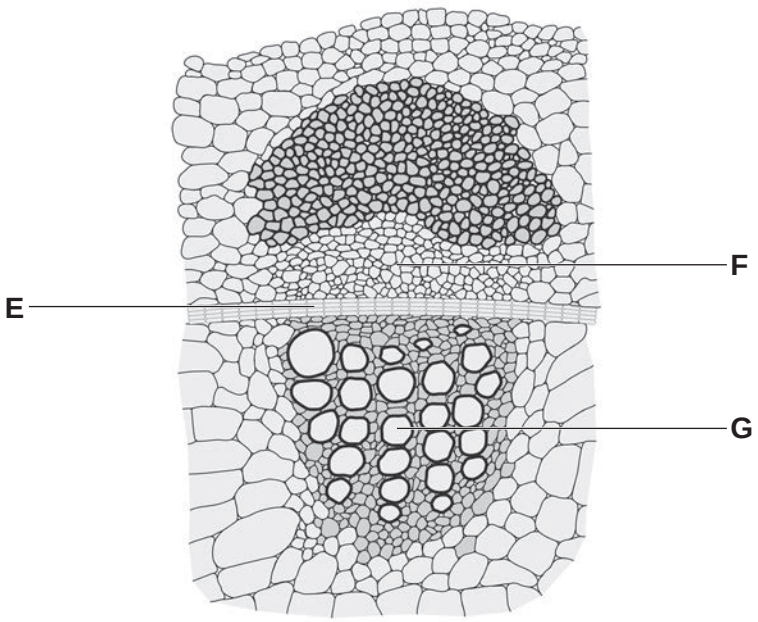
**3** The figure below shows a drawing of a light microscope image. The image is a cross-section taken from the stem of a dicotyledonous plant.




Which of the rows, **A** to **D**, correctly identifies the name of the tissue labelled **E** and the functions of tissue **F** and tissue **G**?

| | Name of tissue E | Function of tissue F | Function of tissue G |
|---|---|---|---|
| **A** | cambium | transport of assimilates | transport of water |
| **B** | cambium | transport of water | transport of assimilates |
| **C** | palisade cells | transport of assimilates | transport of water |
| **D** | palisade cells | transport of water | transport of assimilates |

Your answer ☐ **[1]**

**4** Which of the following statements, **A** to **D**, does **not** correctly describe the structure or formation of plant vascular tissues?

**A** Companion cells are linked to xylem vessels by plasmodesmata.

**B** Mature sieve tube elements do not contain nuclei.

**C** Phloem and xylem are formed by differentiation of vascular meristems.

**D** Xylem vessels have non-lignified pits to allow movement in and out.

Your answer ☐ **[1]**

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**5** Large multicellular animals need a transport system for oxygen and carbon dioxide.

Large multicellular plants do not need a transport system for oxygen and carbon dioxide.

Which of the following statements, **A** to **D**, correctly explains these observations?

**A** Large plants have a low surface area to volume ratio.

**B** Plant cells have a low metabolic rate.

**C** Plants generate ATP during photosynthesis, so they do not need to respire.

**D** Plants generate oxygen during photosynthesis.

Your answer ☐ **[1]**

**6** Which of the following statements, **A** to **D**, describes the movement of water across plant roots?

**A** The Casparian strip blocks movement by the symplast pathway.

**B** The symplast pathway requires water to cross partially permeable membranes.

**C** Water moves from the soil to the root hair cells up a water potential gradient.

**D** Water moves through the leaves only by the symplast pathway and across the roots only by the apoplast pathway.

Your answer ☐ **[1]**

**7** Which of the following statements about water transport in plants is/are correct?

1 Transpiration happens as a consequence of the need for gas exchange.
2 There are cohesive forces between water molecules because they form hydrogen bonds with one another.
3 Water is drawn up the stem due to adhesive forces between water molecules.

**A** 1, 2 and 3

**B** only 1 and 2

**C** only 2 and 3

**D** only 1

Your answer ☐ **[1]**

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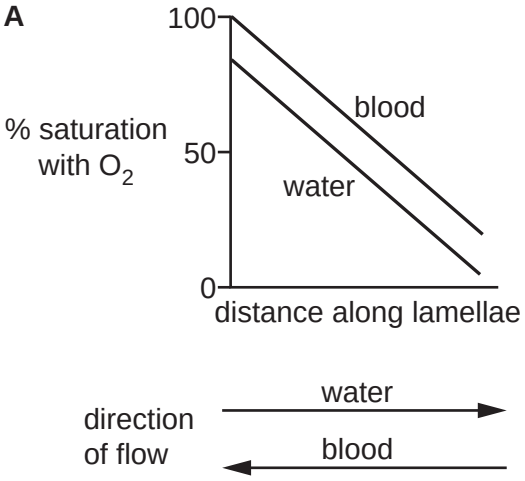
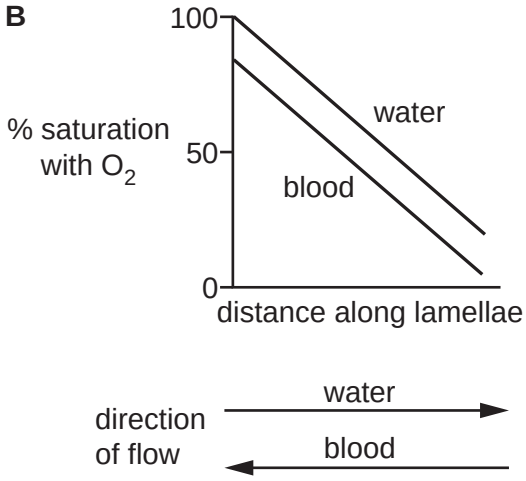
**8** The graphs, **A** to **D**, represent gas exchange in bony fish.

The graphs show the oxygen saturation in blood in the lamellae and water flowing over the lamellae.

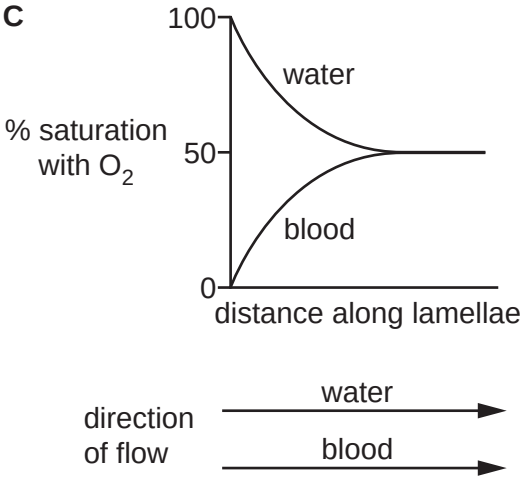
**A**



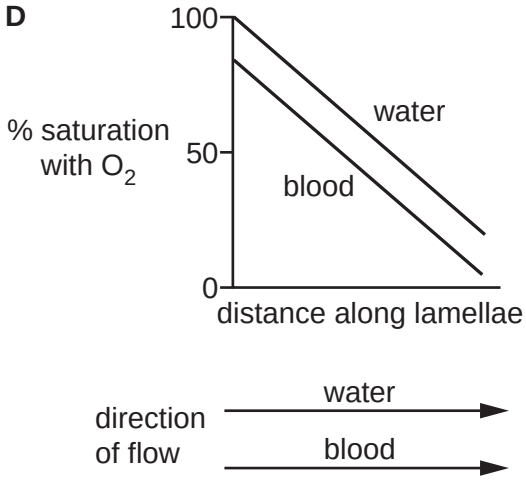

**B**




**C**




**D**




Which graph, **A** to **D**, shows the relationship between blood oxygen saturation and distance along the lamellae?

Your answer ☐ **[1]**

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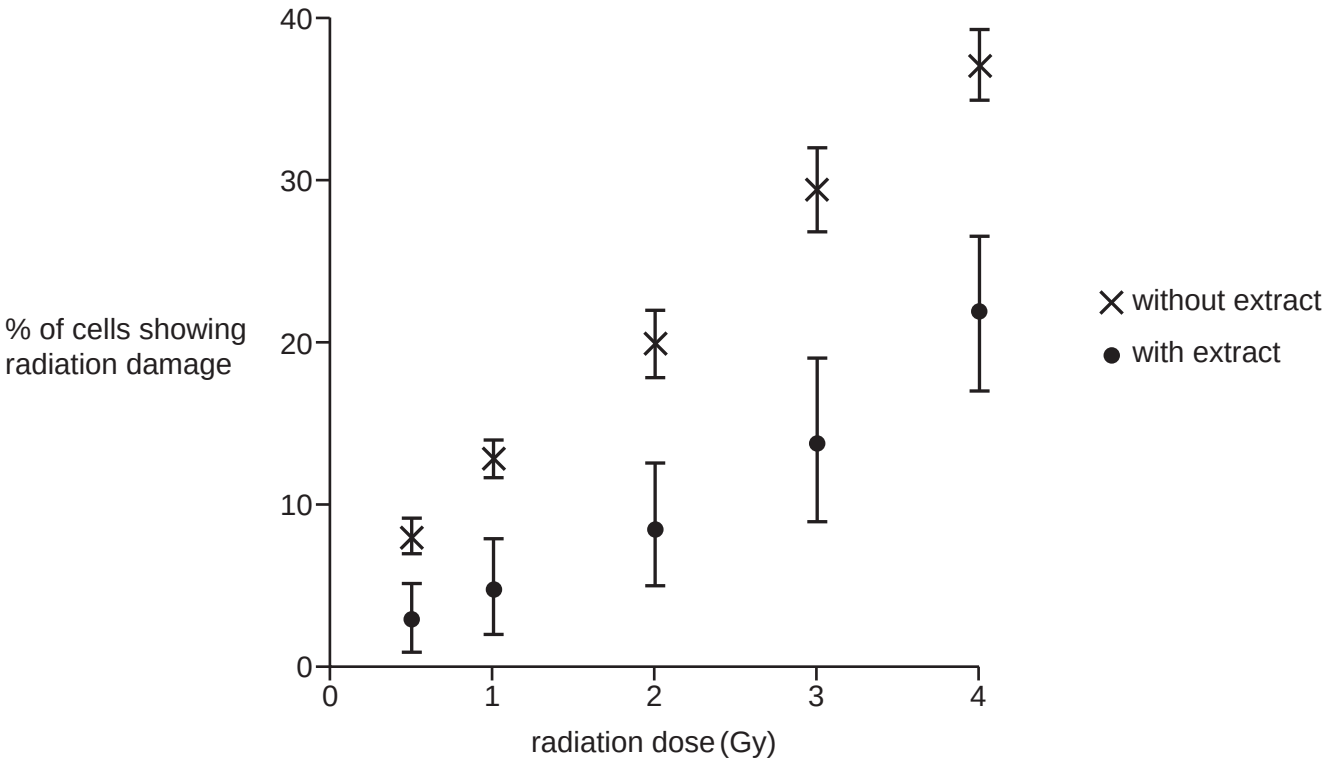
Questions **9** and **10** refer to the graph below.

An extract of the bark of the Indian fig tree, *Ficus racemosa*, has antioxidant properties. It has been suggested that this extract could protect against damage to non-cancerous cells during radiotherapy.

Cultures of non-cancerous cells were exposed to increasing doses of radiation and the percentage of damaged cells was measured. The experiments were performed multiple times either with or without the bark extract.

The graph shows the results for the two sets of data. Each data point shows the mean ±1 standard deviation.

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**9** A student used Spearman's rank correlation coefficient to test for correlation between radiation dose and cell damage.

Which of the following statements, **A** to **D**, about this correlation shown on the graph is correct?

**A** Spearman's rank correlation coefficient, $r_s$, for cells without extract will be between 0 and +1.

**B** Spearman's rank correlation coefficient, $r_s$, for cells with extract will be between 0 and −1.

**C** There is a negative correlation between radiation dose and cell damage in both cases.

**D** There is no correlation between radiation dose and cell damage in either case.

Your answer ☐ **[1]**

**10** Which of the following statements, **A** to **D**, about the graph is correct?

**A** The data for the 'with extract' group is more variable than the data for the 'without extract' group.

**B** The error bars show the range of data at each radiation dose.

**C** The error bars show whether the difference between the two sets of data is significant.

**D** The $\chi^2$ (chi-squared) test can be used to determine whether there is a significant difference between the two sets of data.

Your answer ☐ **[1]**

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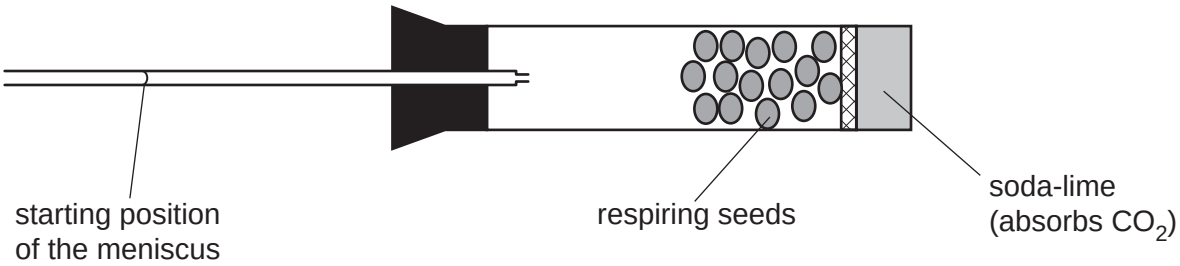
Questions **11** and **12** refer to the investigation described below.

The diagram shows a respirometer used to compare respiration in two types of germinating seeds.




A student set up the respirometer to measure oxygen consumption.

- The narrow tube contained coloured water.
- The position of the meniscus was noted at the beginning of the experiment.
- The tube was left for 20 minutes.
- The new position of the meniscus was noted.
- The experiment was repeated with the other type of seed.

**11** Which of the following would be necessary to ensure valid results?

1 Keeping the respirometer in the dark during the experiment.
2 Keeping the respirometer at the same temperature during the experiment.
3 Using the same dry mass of seeds each time.

**A** 1, 2 and 3

**B** only 1 and 2

**C** only 2 and 3

**D** only 1

Your answer ☐ **[1]**

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**12** The student investigated two types of seed, pea and sunflower:

- pea seeds store mainly starch
- sunflower seeds store mainly lipid.

Which of the following, **A** to **D**, describes the results you would expect with each type of seed?

**A** The meniscus would move to the left with pea seeds and further to the left with sunflower seeds.

**B** The meniscus would move to the left with sunflower seeds and to the right with pea seeds.

**C** The meniscus would move to the right with pea seeds and further to the right with sunflower seeds.

**D** The meniscus would not move.

Your answer ☐ **[1]**

**13** Which of the following statements, **A** to **D**, describes and explains the relative yield of ATP in anaerobic and aerobic respiration?

**A** Anaerobic respiration produces less ATP per molecule of glucose because lactate is converted to pyruvate.

**B** Anaerobic respiration produces less ATP per molecule of glucose because NAD is not regenerated in oxidative phosphorylation.

**C** Anaerobic respiration produces more ATP per molecule of glucose because NAD is regenerated in oxidative phosphorylation.

**D** Anaerobic respiration produces more ATP per molecule of glucose because pyruvate is converted to lactate.

Your answer ☐ **[1]**

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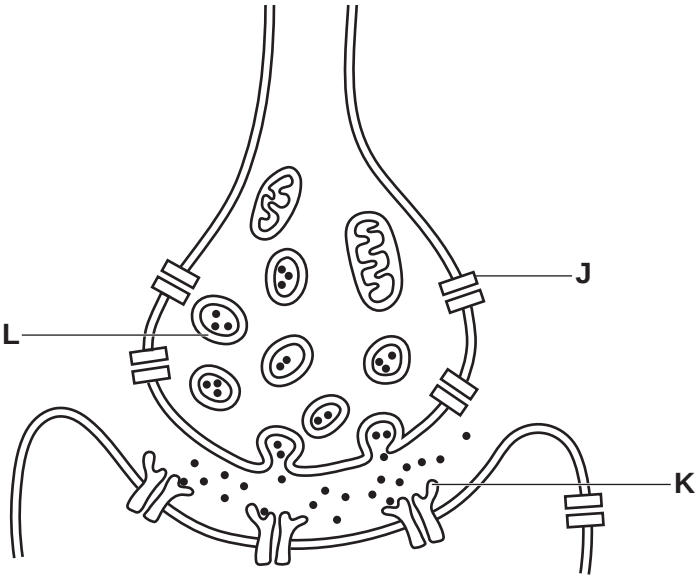
Questions **14** and **15** refer to the diagram below of a synapse.




**14** Which of the following statements, **A** to **D**, describes events occurring at a synapse?

**A** Acetylcholine is broken down by enzymes so that it can bind to structure **K**.

**B** An action potential causes structure **J** to close.

**C** Structure **J** is a voltage gated $Ca^{2+}$ channel.

**D** Structure **L** is released by exocytosis.

Your answer ☐ **[1]**

**15** GABA is a neurotransmitter.

GABA reduces the number of action potentials in the postsynaptic neurone by opening chloride ion channels in the post-synaptic membrane.

Which of the following statements, **A** to **D**, describes the action of GABA?

**A** GABA binds to structure **K** in competition with acetylcholine.

**B** GABA causes hyperpolarisation of the post-synaptic membrane.

**C** GABA causes depolarisation of the post-synaptic membrane.

**D** GABA inhibits release of neurotransmitter from structure **L**.

Your answer ☐ **[1]**

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## SECTION B

Answer **all** the questions.

**16** **(a)** Fig. 16.1 shows the structure of ATP.

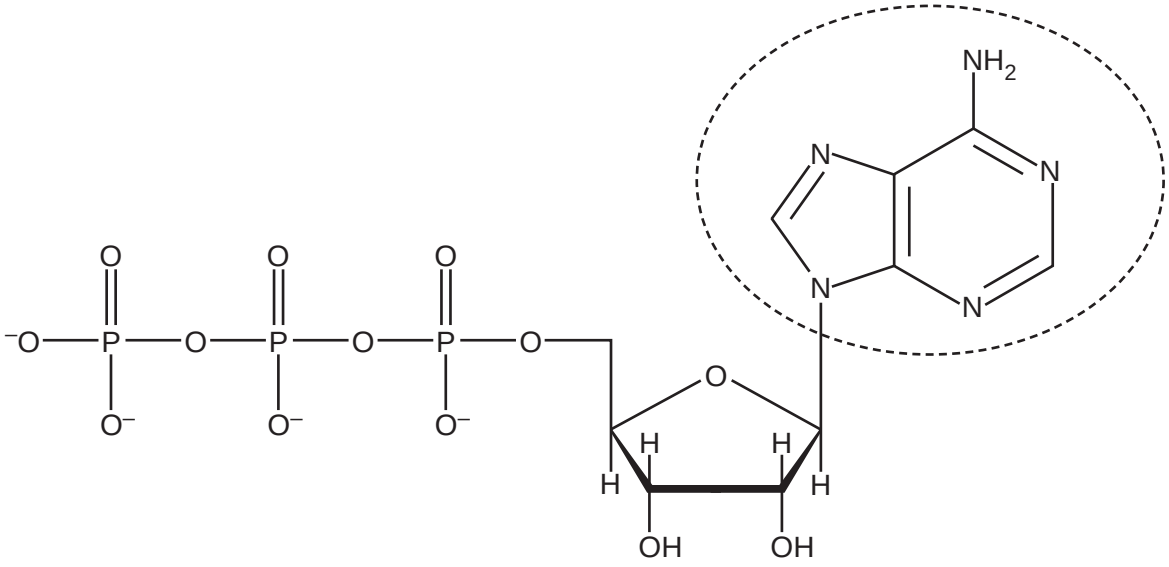


**Fig. 16.1**

**(i)** Name the circled component in Fig. 16.1.

..... **[1]**

**(ii)** Name the type of reaction that occurs when ATP is converted to ADP.

..... **[1]**

**(iii)** A teacher told his students that the human body makes the equivalent of its own mass in ATP every day.

Explain why, at the end of the day, only a small proportion of the students' mass was ATP.

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

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**(b)** A student investigated the uptake of two different substances in cultured cells.

The rate of uptake was measured at different concentrations of each substance in the medium surrounding the cells.

The results are shown in Fig. 16.2.

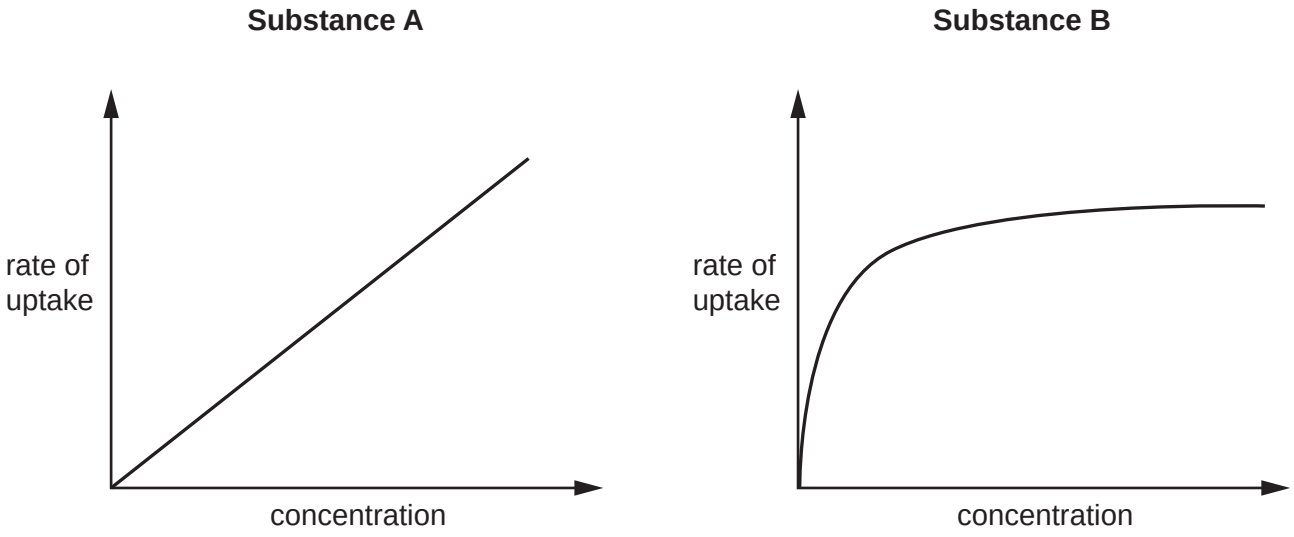


**Fig. 16.2**

**(i)** The student concluded that one substance entered the cells by simple diffusion and the other by active transport.

Evaluate the student's conclusion.

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..... **[4]**

**(ii)** The student then added 2,4-dinitrophenol (DNP) to the cells. DNP inhibits respiration.

Predict the effect of DNP on the uptake of each substance and explain your prediction.

**Substance A**

effect .....

explanation .....

.....

.....

**Substance B**

effect .....

explanation .....

.....

.....

**[4]**

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**(c)** The student used a colorimeter to measure the concentration of each substance in the liquid surrounding the cells.

The colorimeter had an analogue display. The reading was indicated by a needle moving across a scale. The smallest divisions on the scale corresponded to 0.1 absorbance unit.

After the investigation the student suggested some improvements.

Draw a line between each of the improvements to the corresponding justification.

| **Improvement** | **Justification** |
|---|---|
| Use a colorimeter with a digital display showing absorbance units to 3 decimal places. | To assess repeatability |
| Check the zero value of the colorimeter with purified water before use. | To assess reproducibility |
| For each concentration, repeat the measurement of the rate of reaction three times and calculate a mean. | To reduce systematic error |
| Ask students in several schools to carry out the same investigation. | To reduce random error (uncertainty) |
| | To increase resolution |

**[4]**

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**17** A student investigated photosynthetic pigments in spinach leaves using thin layer chromatography (TLC).

**(a)** Fig. 17.1 shows the student's plate at the end of the investigation.

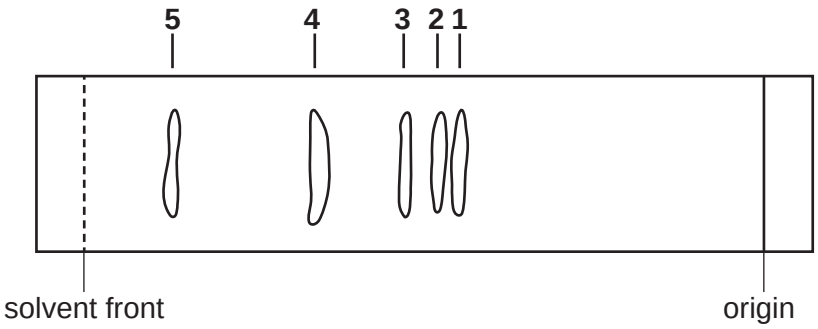


**Fig. 17.1**

The table shows colours and $R_f$ values for several photosynthetic pigments.

| Pigment | Colour | $R_f$ |
|---|---|---|
| Carotene | Yellow-orange | 0.90 |
| Chlorophyll a | Blue-green | 0.53 |
| Chlorophyll b | Green | 0.49 |
| Pheophytin | Grey | 0.65 |
| Xanthophylls | Yellow | 0.32–0.44 |

**(i)** Calculate the $R_f$ value for spot **3** and use this to identify the pigment that spot **3** represents.

$R_f$ = .....

pigment = .....
**[3]**

**(ii)** Predict the colour of spot **4**.

..... **[1]**

**(iii)** The solvent used for the separation was non-polar.

Identify the spot corresponding to the **least** polar pigment. Give a reason for your choice.

spot .....

reason .....

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

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**(b)** The student used the following method for the investigation:

Step 1: Extraction of pigments

- Take 0.5 g of fresh spinach and add 1 g of sand.
- Grind the mixture until it becomes a fine, light green powder.
- Transfer the powder to a test tube and add 2 $cm^3$ of propanone.
- Stir for about 1 minute then allow to stand for another minute.
- Transfer the dark green upper layer with a pipette to a clean test tube and seal with film when not in use.

Step 2: TLC analysis

- Hold the TLC plate carefully by the edges and avoid damaging the surface of the plate.
- Draw a pencil line across the width of the TLC plate 1 cm from the bottom edge.
- Spot the extract on the pencil line using a pipette, one drop at a time, allowing the spot to dry before adding the next drop.
- Place chromatography solvent in a jar so that it is no more than 0.5 cm deep.
- Lower the TLC plate into the jar and lean the top against the side of the jar. Make sure the plate does not touch the sides of the jar anywhere else.
- Place a cap on the jar and allow the solvent to soak up the plate.
- When the solvent has reached a few mm from the top of the plate, remove the plate from the jar and mark the position of the solvent front with a pencil.

**(i)** Explain why the method included the following precautions:

Hold the TLC plate carefully by the edges and avoid damaging the surface of the plate.

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Make sure the plate does not touch the sides of the jar anywhere else.

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**[2]**

**(ii)** Suggest an advantage of working as quickly as possible in Step 1.

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..... **[1]**

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**(c)** Algae are single-celled photosynthetic organisms.

An investigation was carried out into the effect of $CO_2$ concentration on the concentrations of ribulose bisphosphate (RuBP) and glycerate 3-phosphate (GP) present in algae.

Algae were grown in a solution containing a high concentration of $CO_2$. The concentration of $CO_2$ was then reduced.

RuBP and GP concentration were measured for 2 minutes before and 3 minutes after the reduction in $CO_2$ concentration.

The results are shown in Fig. 17.2.

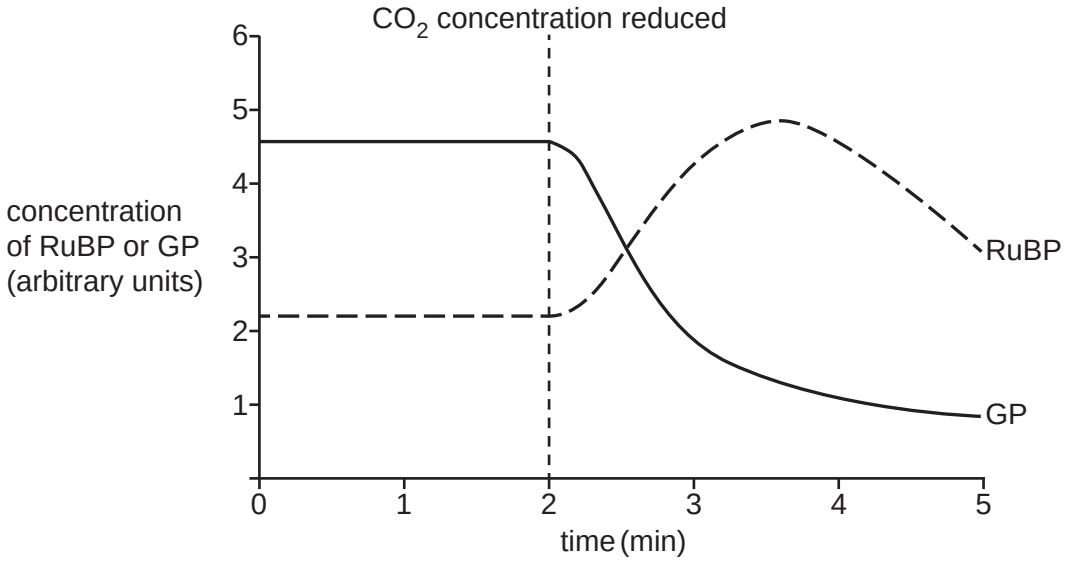


**Fig. 17.2**

Describe and explain the effect of reducing the $CO_2$ concentration on the concentration of RuBP and GP in the algae.

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

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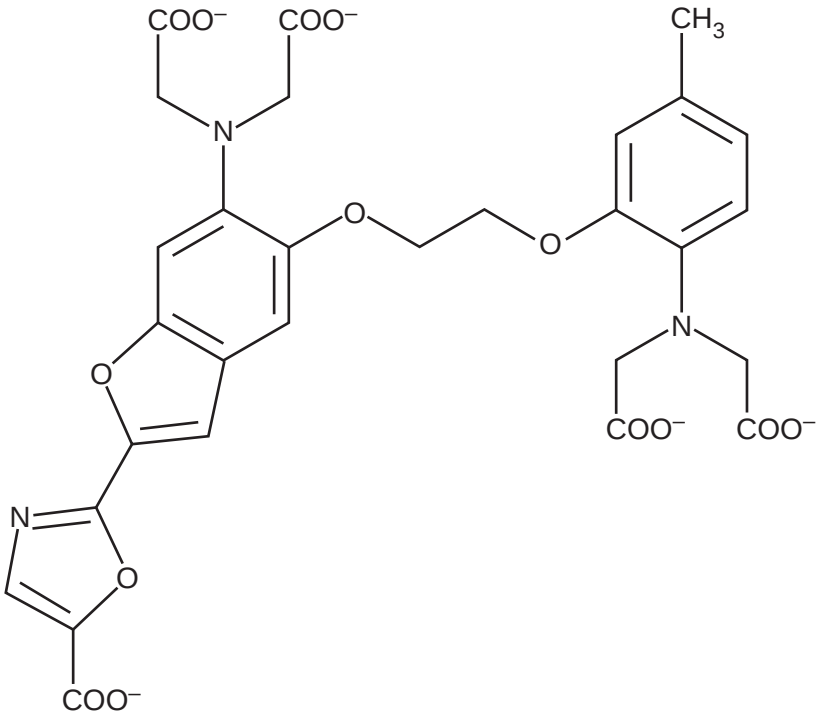
**18** FURA-2 is a fluorescent dye that can be used to measure the concentration of $Ca^{2+}$ ions inside cells.

**(a)** The structure of FURA-2 is shown below.




Use the information in the figure to explain why FURA-2 is unable to cross cell membranes.

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

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**(b)** Scientists have used FURA-2 to study the role of $Ca^{2+}$ ions in the synapses of living nerve tissue.

FURA-2 was injected into a single sensory neurone that was connected by a synapse to a relay neurone.

FURA-2 fluorescence inside the neurone was observed using a confocal microscope.

**(i)** Explain **one** advantage of using a confocal microscope in this study.

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..... **[1]**

**(ii)** The sensory neurone was stimulated electrically and the FURA-2 fluorescence in the synaptic bulb was measured. At the same time, an electrode recorded the membrane potential in a postsynaptic neurone.

The results of this study are shown in the table.

| **Strength of electrical stimulation** | **FURA-2 fluorescence in synaptic bulb** | **Highest membrane potential in postsynaptic neurone (mV)** |
|---|---|---|
| Low | Low | –60 |
| Medium | Medium | +40 |
| High | High | +40 |

The intensity of FURA-2 fluorescence is proportional to the concentration of $Ca^{2+}$ ions.

The scientists concluded that changes in the concentration of $Ca^{2+}$ ions in the presynaptic neurone caused an action potential in the postsynaptic neurone.

Evaluate and explain the scientists' conclusion.

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..... **[4]**

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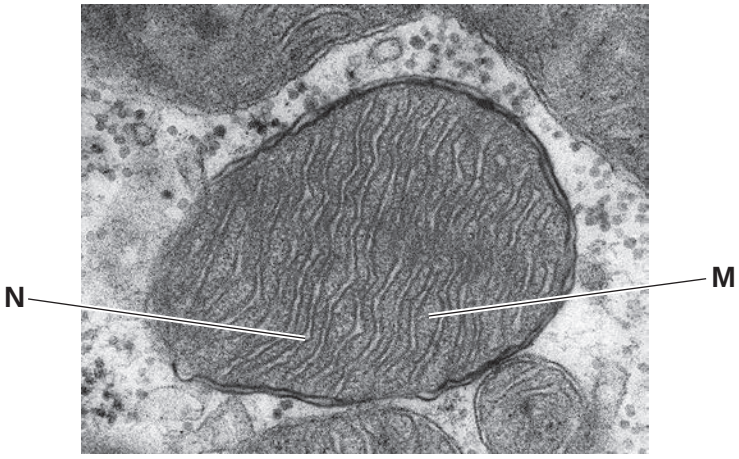
**19** **(a)** The image below is a photomicrograph of a mitochondrion.




**(i)** State the type of microscope used to produce this image.

..... **[1]**

**(ii)** Identify the structures labelled **M** and **N** in the photomicrograph.

**M** .....

**N** .....

**[2]**

**(b)** Describe **two** ways in which the structure of mitochondrial membranes is related to the function of a mitochondrion.

1 .....

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2 .....

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**[2]**

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**(c)** The endosymbiosis theory suggests that mitochondria may have evolved from bacteria that were taken inside other cells.

These cells then evolved into eukaryotes.

**(i)** Give **two** structural features of mitochondria that support this theory.

1 .....

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2 .....

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**[2]**

**(ii)** Explain why early eukaryotes were able to grow more quickly than cells that did not possess mitochondria.

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

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**20** A student investigated the effect of different sugars on the respiration rate in yeast using the following procedure.

- Prepare a stock solution of yeast containing 10 g of dried yeast in 250 $cm^3$ of pH5 buffer.
- Prepare solutions of each sugar containing 5 g of sugar in 250 $cm^3$ of distilled water.
- Keep the yeast and sugar solutions in a water bath at 35 °C until required.
- Set up the apparatus with a 250 $cm^3$ conical flask connected by a rubber tube to a 100 $cm^3$ gas syringe.
- Add 25 $cm^3$ of yeast solution and 25 $cm^3$ of sugar solution to the flask, immediately connect the flask to the gas syringe and start the clock.
- Record the volume of gas produced after 30 s and then every 30 s for 7 min.
- Repeat the experiment 5 times for each different sugar.
- Prepare a fresh yeast solution for each set of sugars.

**(a)** **(i)** Describe **two** precautions the student should take between each experiment to ensure repeatable results.

1 .....

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2 .....

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**[2]**

**(ii)** The student's procedure did not include a negative control.

Describe **one** negative control that the student could have used.

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..... **[1]**

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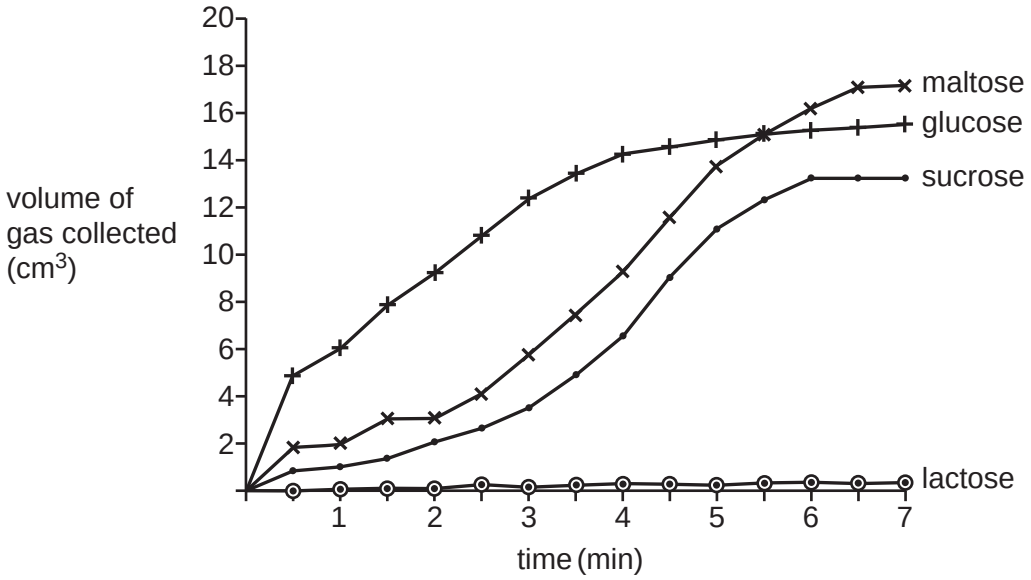
**(b)** The student calculated mean values for each sugar and plotted the results on a graph.

The graph is shown below.




**(i)** Describe how the student could use the graph to calculate the rate of respiration for each type of sugar.

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

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**(ii)*** The student concluded the following from the graph:

- The rates of respiration with glucose, maltose and sucrose were very similar.
- The yeast could not hydrolyse disaccharides.

Evaluate the student's conclusions.

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..... **[6]**

Additional answer space if required.

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**(c)** The student wanted to study the effect of the different sugars on the rate of growth of a yeast population.

They used a colorimeter to measure the absorbance of a culture of yeast cells.

The absorbance of the yeast culture is proportional to the concentration of yeast cells.

As the yeast multiplied, it was necessary to dilute the sample to obtain a reading on the colorimeter.

**(i)** Describe how the student could use 1 $cm^3$ pipettes and 10 $cm^3$ measuring cylinders to dilute the sample so that it was 10 000 times less concentrated.

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

**(ii)** A light microscope can be used to observe yeast cells.

State the equipment that would be needed, in addition to a microscope, to measure the average diameter of yeast cells.

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

**(iii)** The student prepared a starter culture using $2.5 \times 10^{-3}$ g yeast cells in 1 $dm^3$ nutrient broth.

The average mass of a yeast cell is $2.0 \times 10^{-11}$ g.

Calculate the number of cells in the starter culture.

Give your answer in standard form.

number of cells = ..... **[2]**

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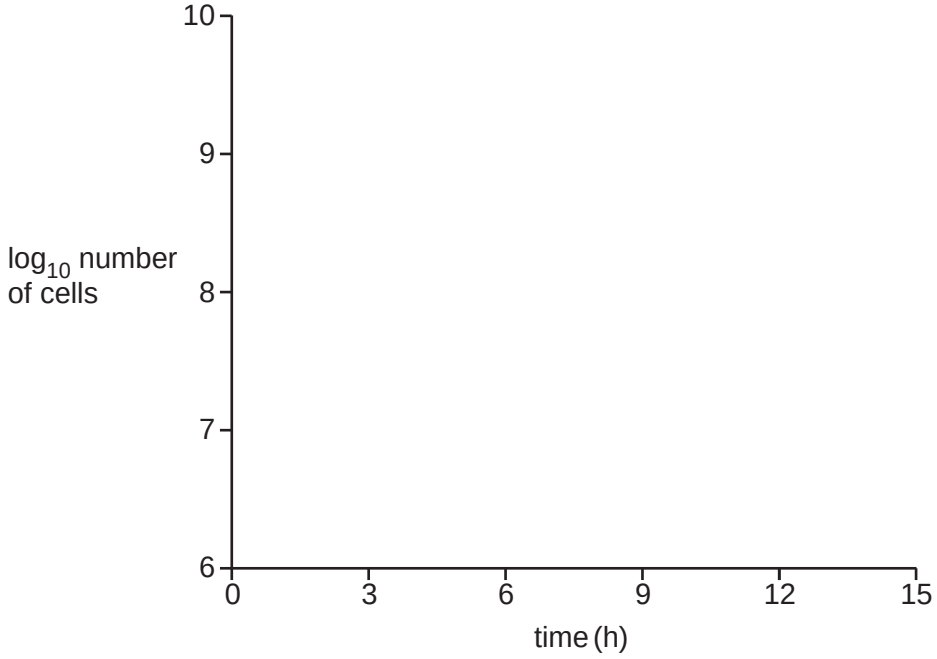
**(iv)** The population of this yeast doubles every 90 minutes when growing under ideal conditions.

A different starter culture was prepared containing $1 \times 10^7$ cells.

Use the axes below to sketch the growth curve you would expect for the yeast culture over the first 15 h.




**[3]**

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**21 (a)** The table compares the features of airways in the lungs.

Complete the table by putting a tick (✓) in each box if the feature is present and a cross (✘) if the feature is absent in each structure.

The first row has been completed for you.

| **Structure** | **Structural feature present** | | |
|---|---|---|---|
| | Cartilage | Elastic fibres | Goblet cells |
| Trachea | ✓ | ✓ | ✓ |
| Bronchi | | | |
| Bronchioles | | | |
| Alveoli | | | |

**[3]**

**Question 21(b) begins on page 30**

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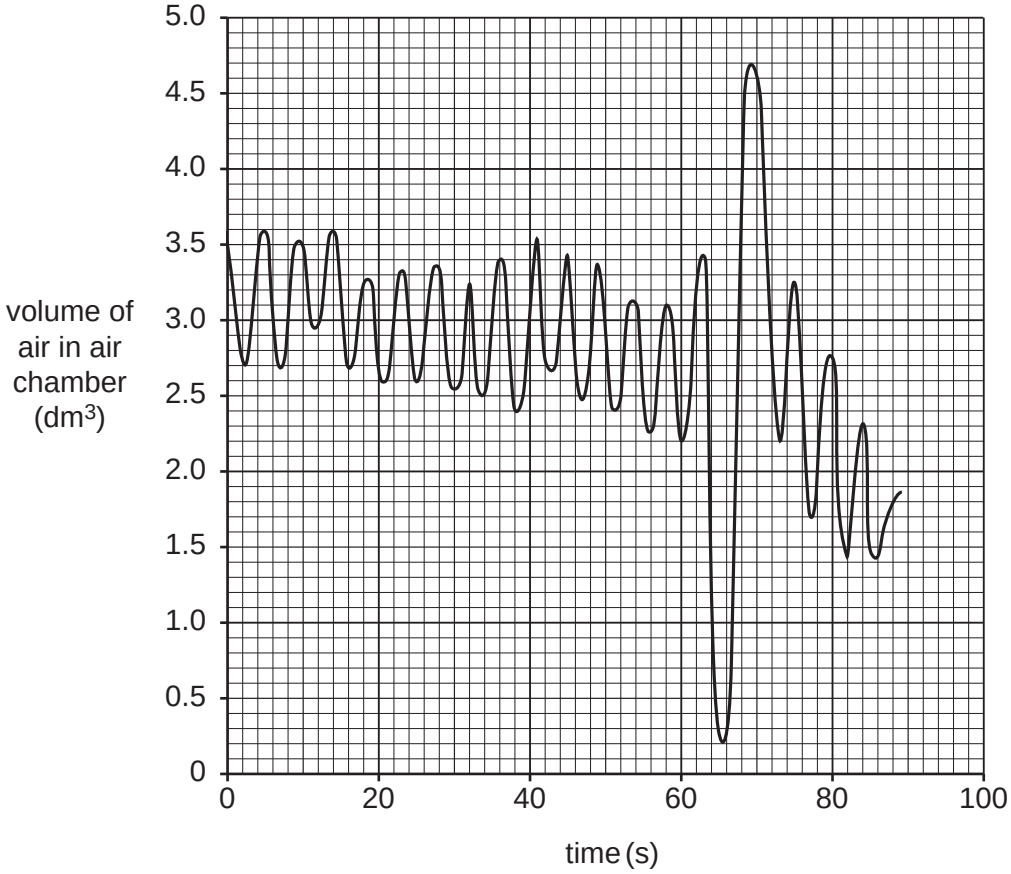
**(b)** Ventilation of the lungs creates air movements that can be measured and recorded.

**(i)** Name the apparatus used to measure and record these air movements.

..... **[1]**

**(ii)** The trace below shows a recording of ventilation movements from an individual subject.




Use the trace to estimate the **maximum** value for tidal volume during the first minute.

maximum tidal volume = ..... $dm^3$ **[1]**

**(iii)** After 60 seconds, the subject was told to breathe in as deeply as possible and then breathe out fully.

Use the trace to calculate the vital capacity of the subject.

vital capacity = .....$dm^3$ **[2]**

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**(c)*** Compare and contrast the mechanism of expiration during the first 60 seconds of the trace with the mechanism of expiration when the subject was told to breathe out fully.

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..... **[6]**

Additional answer space if required.

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**(d)** Complete the following statements about exchange surfaces.

Use the correct terms selected from the list below.

**circulatory system** **concentration gradient** **diffusion pathway**

**flow of air** **lung capacity** **surface area**

**surface area to volume ratio** **ventilation**

Large organisms have a large ..... but they have a small ..... . This means they need a specialised exchange surface and a ..... .

Two features of an efficient exchange surface are:

1. A good blood supply to maintain the ..... .
2. A short ..... .

**[5]**

**END OF QUESTION PAPER**

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## ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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