



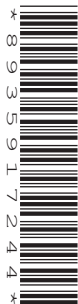
Oxford Cambridge and RSA

Friday 15 October 2021 – Morning

AS Level Biology B (Advancing Biology)

H022/02 Biology in depth

Time allowed: 1 hour 30 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

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Candidate number

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First name(s)

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Last name

StemUp Model Solution

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 you should 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 a correct method, even if your answer is wrong.

INFORMATION

- The total mark for this paper is **70**.
- 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 **24** pages.

ADVICE

- Read each question carefully before you start your answer.

Answer **all** the questions.

- 1 **Fig. 1.1** is a photomicrograph showing some of the cells that line the bronchus.



Fig. 1.1

- (a) (i) State the function of the cell labelled **X** in **Fig. 1.1**.

..cilia..waft..mucus..away,, removing..dust..!..pollen..!..pathogens..... [1]

- (ii) Calculate the magnification of the image in **Fig. 1.1**.

scale bar length = 13 mm = 13 000 μm

magnification = image size ÷ actual size

= 13 000 ÷ 4 = 3250

Magnification = ...*x 3250*..... [2]

- (b) During an asthma attack, drugs known as bronchodilators can be used to increase the lumen diameter of the bronchus and therefore increase the oxygen consumption.

Fig. 1.2 shows the effect of saline and two different bronchodilators, Fenoterol and Salbutamol, on a patient following an asthma attack. The saline and the bronchodilators were breathed in using a device called a nebuliser which converts liquids into a fine mist.

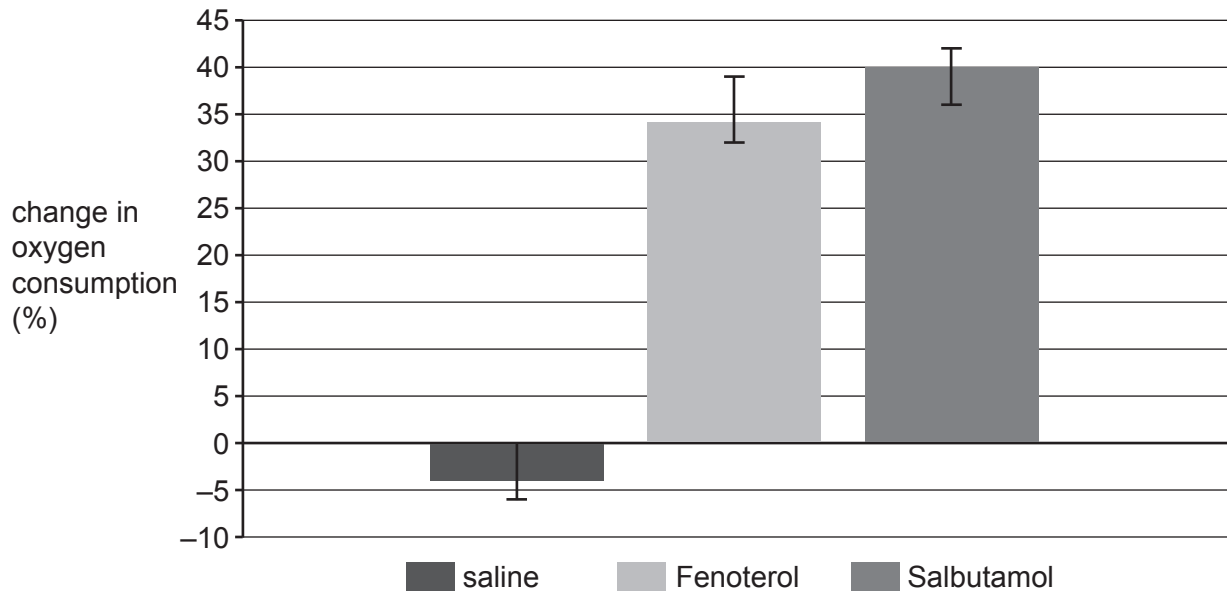


Fig. 1.2

A doctor concluded that:

‘Salbutamol is the best drug for the treatment of asthma.’

Evaluate the doctor's claim.

Supports the claim: Salbutamol increased the oxygen consumption the most (mean about 40%, compared with about 34% for Fenoterol).

Against the claim: the range bars for Salbutamol and Fenoterol overlap, so the difference may not be significant.

No statistical test was carried out to show whether the difference is significant.

Only two drugs were tested (e.g. corticosteroids were not tested), and the data are from only one patient.

Salbutamol may have more side effects than Fenoterol, which were not considered.

[4]

- (c) Saline is salt solution.

Using your knowledge of osmosis, explain how breathing in a fine mist of saline could reduce oxygen consumption.

If the saline is more concentrated than the cells, water moves out of the cells lining the airways by osmosis. This may cause blockage of the bronchioles / alveoli (e.g. thicker mucus), reducing the air supply to the alveoli, so less oxygen is taken in.

[2]

- (d)* Eosinophils are a type of white blood cell involved in producing allergic responses during an asthma attack.

A scientist wanted to calculate the diameter of the eosinophils from a blood sample using a microscope.

Describe how the scientist could use a microscope to work out the diameter of eosinophils **and** gain accurate and reproducible results.

Calibration: place a stage micrometer on the stage and align the eyepiece graticule with the stage micrometer scale. Count how many eyepiece units (EPU) equal one division of the micrometer scale (e.g. 100 μm or 0.1 mm), then calculate the length of one EPU, e.g. $100 \mu\text{m} \div \text{number of EPU}$. The graticule must be recalibrated if the magnification (objective lens) is changed. Measuring: replace the micrometer with the blood smear, line up the eyepiece graticule with an eosinophil and count how many EPU equal one cell diameter. Diameter = number of EPU $\times$ size of one EPU. Accuracy: use the highest magnification ($\times 400$) so each EPU is small; use a stain or adjust the lighting so the edge of the cell is easy to identify; measure more than one diameter per cell and take a mean. Repeat with more than three cells (e.g. 10 cells) to identify anomalous results, then calculate a mean.

[6]

Additional answer space if required.

*Reproducibility: the same method should be carried out by another scientist
using different equipment to check that the same result is obtained.*

.....

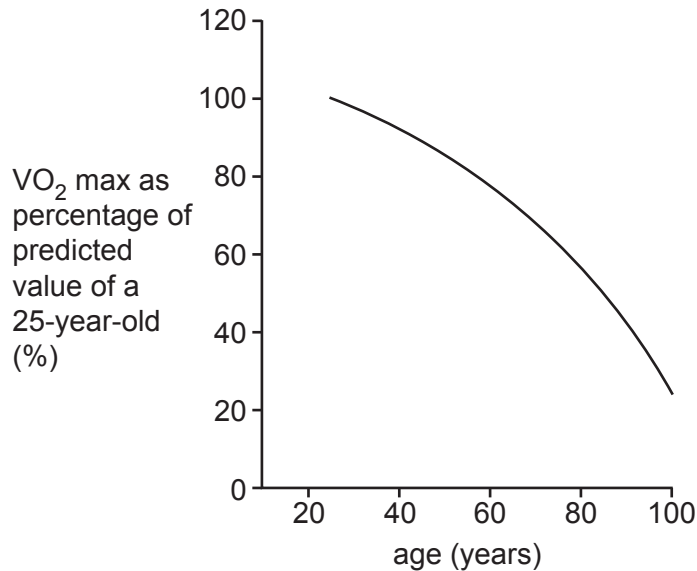
.....

.....

2 Ageing causes a reduction in lung function.

VO₂ max is the maximum rate at which oxygen can be taken in, transported and used.

The graph shows the change in VO₂ max as a percentage of predicted value of an average 25-year-old.



(a) In the graph, a comparison is made with the VO₂ max of an average 25-year-old.

Give **one** reason why the VO₂ max was not compared with a younger person **and one** reason why it was not compared with an older person.

Not compared with a younger person because *they are not fully grown / have not reached full maturity, so their lungs are still developing*

Not compared with an older person because *an older person will have lost some lung function, e.g. reduced elasticity of the lungs*

[2]

(b) Suggest why there is a decrease in the VO₂ max of people as they get older.

Older people are less aerobically fit and there is loss of lung elasticity, so ventilation is less efficient.

There is also more chance of respiratory disease, e.g. from smoking or the long-term effect of air pollution.

[2]

- (c) Respiratory arrest is a condition when a patient stops breathing. The first-aid treatment for respiratory arrest is to perform expired air resuscitation on the casualty.

Describe the differences in the method used for expired air resuscitation when treating adults compared to treating babies.

For a baby, cover both the mouth and nose with your mouth, whereas for an adult, cover the mouth and pinch the nose closed.

Give smaller, gentler breaths (puffs) for a baby, but larger breaths for an adult.

Give more breaths per minute for a baby (about 20 per minute) than for an adult (about 15 per minute).

[3]

- 3 Trypsin is an enzyme found in the digestive system of mammals. The enzyme is used to digest casein, a protein found in milk. The products of casein digestion can then be absorbed into the blood.

Casein is a white protein that turns colourless when it is hydrolysed.

A student wanted to investigate how the concentration of trypsin affects the hydrolysis of casein.

Trypsin was mixed with casein and placed into dialysis tubing and then placed into a beaker of warm water as shown in **Fig. 3.1**.

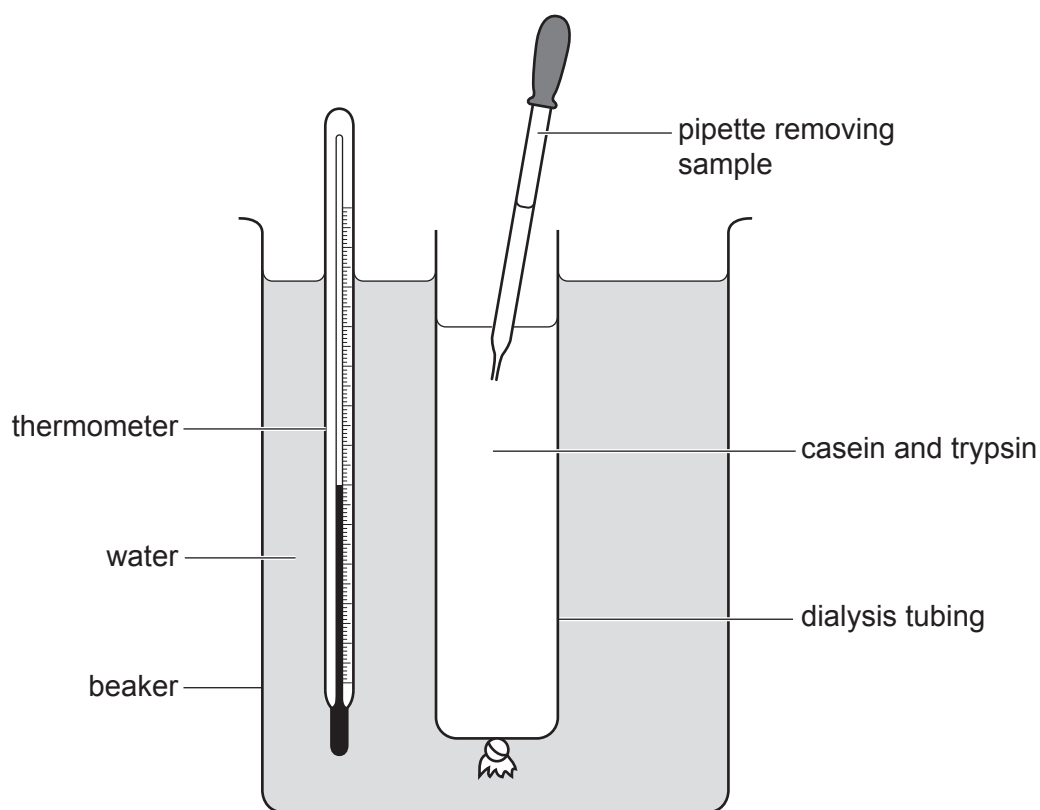


Fig. 3.1

Every minute a sample was removed from the dialysis tubing and was placed immediately into a colorimeter. The absorbance was recorded by the colorimeter.

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

Independent variable *time (a sample every minute)*

Dependent variable *absorbance (from the colorimeter)*

[1]

- (ii) The temperature of the water in the beaker was maintained at 30 °C.

Explain why the temperature had to be controlled.

A decrease in temperature decreases the kinetic energy, so trypsin and casein collide less frequently and fewer enzyme-substrate complexes form.

The casein would turn colourless more slowly (and faster if the temperature increased), so the results would not be valid.

[2]

- (iii) Temperature was maintained by adding hot water to the beaker.

Give **one** method of maintaining temperature that is more accurate than adding hot water.

use a thermostatically controlled water bath

[1]

- (b) State **two** variables, other than temperature, that should have been controlled in the investigation **and** explain why they could alter the results if they were not controlled.

Variable 1 *pH (use a buffer)*

Explanation *a change in pH alters the tertiary structure / denatures the enzyme, as H and ionic bonds break, changing the active site*

Variable 2 *casein (substrate) concentration*

Explanation *more substrate would increase the time taken to go colourless, as more casein must be hydrolysed*

[4]

- (c) Protein shakes containing casein are regularly used by athletes as a protein supplement.

Fig. 3.2 shows the percentage of casein hydrolysed in the body following the consumption of a protein shake.

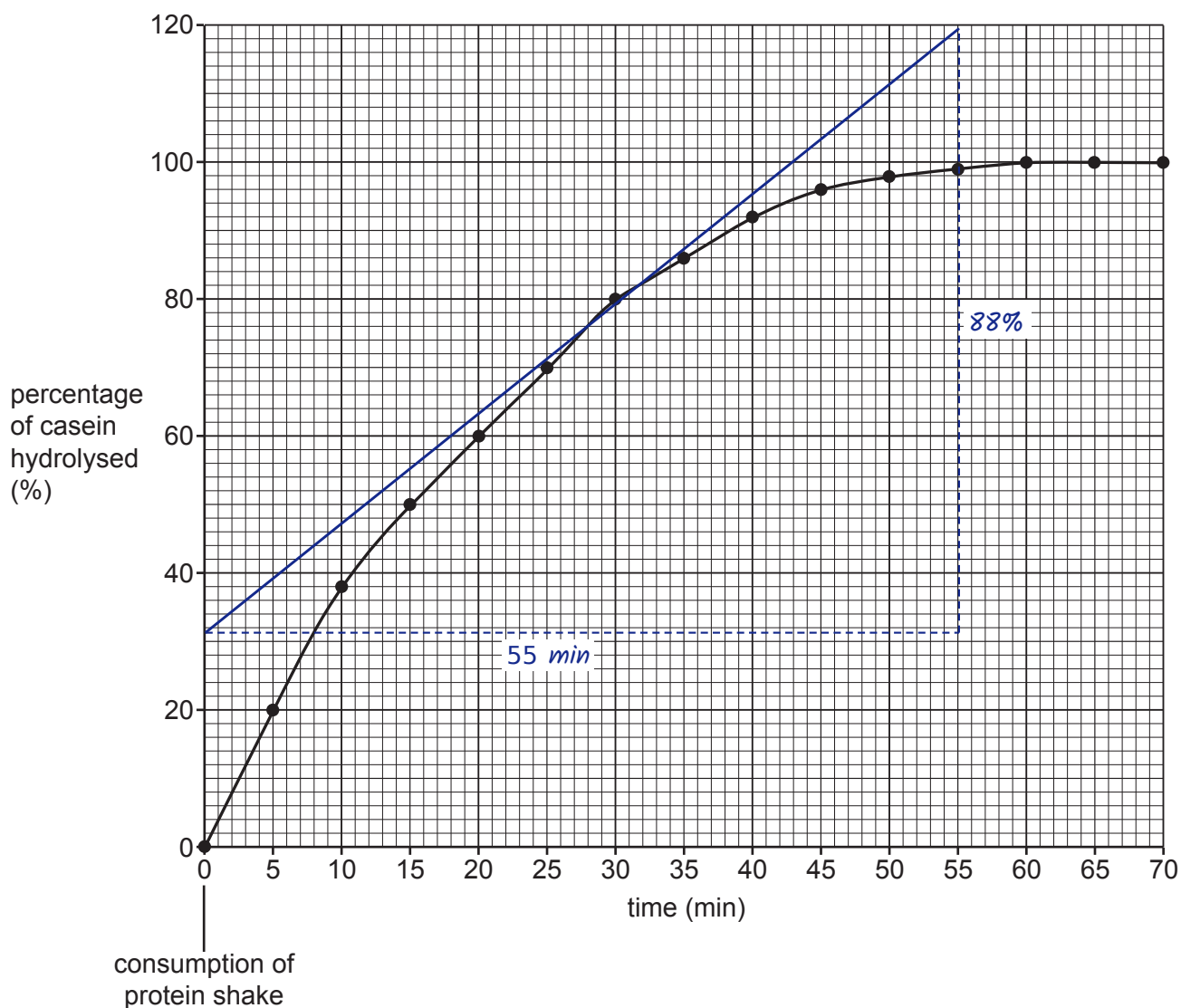


Fig. 3.2

A leading brand of protein shake contains 26 g of casein per drink.

Draw a tangent on Fig. 3.2 and use it to calculate the rate of casein hydrolysis at 30 minutes after consuming this protein shake.

$$\text{gradient} = (120 - 32) \div (55 - 0) = 88 \div 55 = 1.6\% \text{ min}^{-1}$$

$$1.6\% \text{ of } 26 \text{ g} = 0.016 \times 26 = 0.416 \text{ g min}^{-1}$$

Rate = ...0.416..... g min⁻¹ [3]

- (d) Soybean Trypsin Inhibitor, a naturally occurring inhibitor of trypsin, is found in soybeans.

Suggest why animals fed on a diet of soybeans may have reduced muscle growth.

*Soybean trypsin inhibitor reduces the rate of trypsin activity, so fewer proteins
are broken down / digested and fewer amino acids are absorbed.
So there are fewer amino acids for protein synthesis in muscle.*

[2]

- 4 It is estimated that 100 000 people in the UK carry the Human Immunodeficiency Virus (HIV).

Fig. 4.1 shows the structure of HIV.

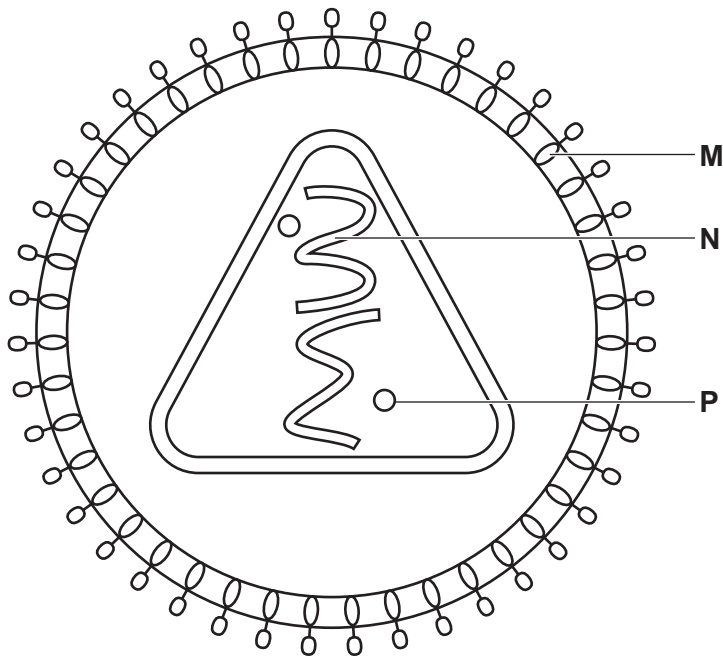


Fig. 4.1

- (a) (i) State the roles of the following structures.

M *helps the virus bind to (receptors on) host cells*.....

N *carries the genes / genetic information (RNA) for HIV*.....

[2]

- (ii) Identify molecule **P**.

P *reverse transcriptase (enzyme)*..... [1]

(b)* The UK has tried to control the spread of HIV since its discovery in 1981.

Describe how HIV can be transmitted between individuals **and** explain why this has resulted in difficulty in controlling the spread of the disease.

HIV is transmitted by the exchange of body fluids, e.g. blood to blood contact: through unprotected sexual intercourse, sharing contaminated intravenous / hypodermic needles, unscreened blood transfusions, unsterilised surgical equipment and accidents such as needle-stick injuries. It can also pass from mother to baby across the placenta or during childbirth, and during breastfeeding. This makes control difficult because screening blood and sterilising equipment is time consuming and costly, especially in poorer countries. There is a lack of education about transmission by breastfeeding and in pregnancy, and mothers may be reluctant to use formula milk due to its cost or culture. Intravenous drug users are unlikely to tell others, and it is costly to provide sterile needles to drug users. Some people prefer unprotected sex, e.g. when starting a family or for religious reasons. Many infected people are symptomless carriers, so they do not know they are [6]

Additional answer space if required.

infected and spread HIV unknowingly.

(c) (i) HIV infections can be detected by two different tests.

- A nucleic acid test can detect HIV infection 10 to 33 days after an exposure.
- An antigen blood test can detect HIV infection 18 to 45 days after an exposure.

Suggest why it takes longer after exposure for an antigen blood test to detect HIV infection compared to a nucleic acid test.

The test detects the immune response, which takes time: white blood cells must first recognise HIV (clonal selection and clonal expansion), then ribosomes synthesise the proteins, the Golgi modifies them into antibodies, and the antibodies are secreted into the blood.

..... [2]

(ii) The time taken for HIV to replicate is called one HIV life cycle.

It takes 16 hours to go through one HIV life cycle.

After one HIV life cycle, 300 viruses are produced from one original virus.

Starting with this one original virus, calculate the minimum number of HIV viruses present when an antigen blood test could detect the viruses.

Give your answer in standard form.

$$\text{minimum time} = 18 \text{ days} = 18 \times 24 = 432 \text{ hours}$$

$$\text{number of life cycles} = 432 \div 16 = 27$$

$$\text{number of viruses} = 1 \times 300^{27}$$

$$= 7.63 \times 10^{66}$$

Number of viruses = ... 7.63×10^{66} [3]

- (d) The blood of people living with HIV contains antibodies that can neutralise a range of different strains of the HIV virus.

Researchers combined portions of these antibodies to produce antibodies in the laboratory known as tri-specific antibodies. These can bind to three different sites on the virus. **Fig. 4.2** shows the structure of a tri-specific antibody.

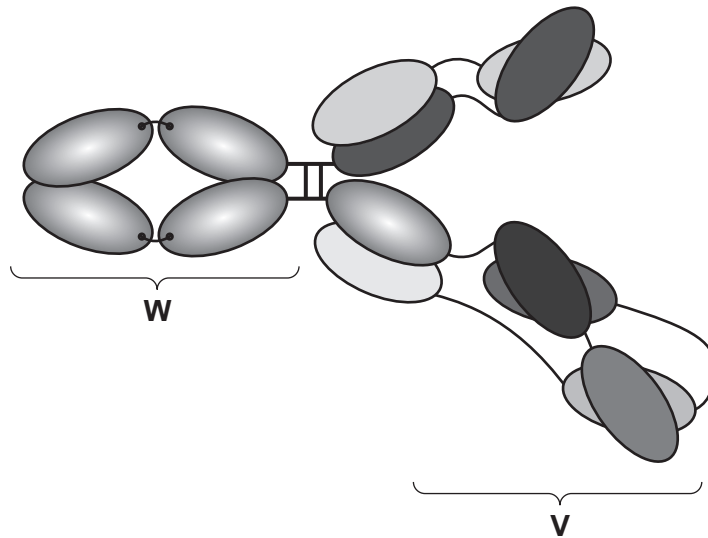


Fig. 4.2

- (i) Name the region of the antibody labelled **W** and state its function.

Name constant region

Function allows the antibody to bind to receptors on phagocytes / mast cells

[2]

- (ii) Explain how the structure of the region labelled **V** allows the antibody to bind to different antigens on different viruses.

V is the variable region: its sequence of amino acids is different at each binding site, so the tertiary structure is different.
The charges on the R-groups are different, so each site is complementary to a different antigen on different viruses.

[2]

5 Energy drinks are sports supplements used by some athletes.

A sports scientist wanted to investigate the reducing sugar content of one of the drinks.

They used the following method:

1. Take a 5% glucose solution and add it to a labelled test tube.
2. Add excess Benedict's reagent.
3. Boil the sample in a water bath.
4. Filter the solution using filter paper.
5. Dry the filter paper and measure the mass of precipitate.
6. Repeat steps 1–5 for glucose concentrations of 4%, 3%, 2% and 1%.
7. Plot a graph of concentration of glucose against the mass of precipitate.
8. Repeat steps 1–5 for the energy drink.

(a) State **three** improvements that the scientist could make to the method.

- 1 *use a set volume of glucose solution each time, e.g. 2 cm³*
- 2 *boil for a suitable, set time, e.g. 2 minutes*
- 3 *measure and subtract the mass of the filter paper, and dry the precipitate to constant mass.*

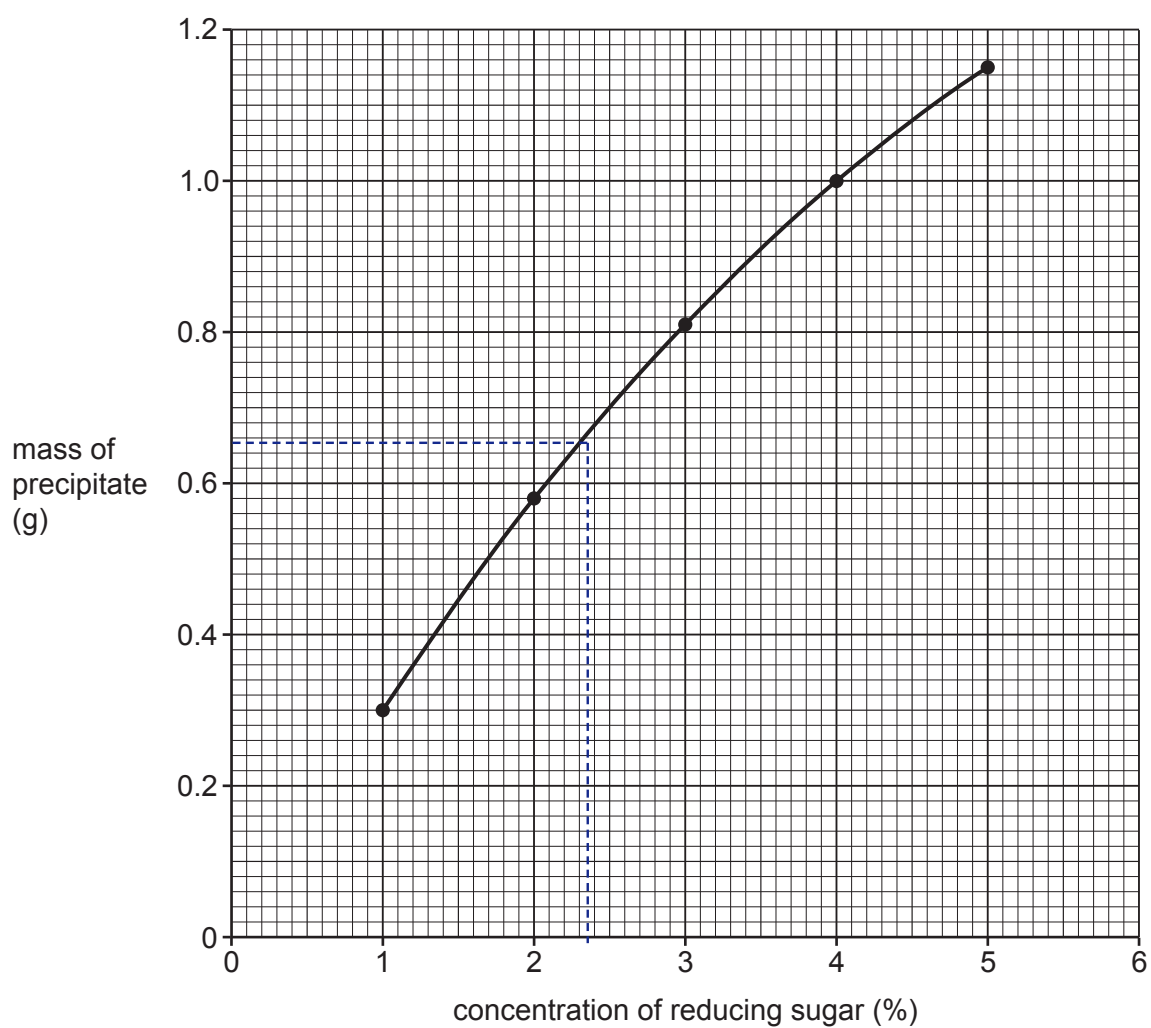
[3]

(b) Suggest a suitable control for the investigation.

- use distilled water instead of glucose solution, with all other steps the same*

[1]

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



The mass of the precipitate produced by the energy drink was 0.66 g.

Use the graph to calculate the concentration of reducing sugar in the energy drink.

Concentration of reducing sugar = ...2.35..... (%) [1]

- (d) The concentration of sugar in the energy drink was 5.5% as it also contained non-reducing sugars.

State **two** additional steps that could be added to the method to allow the total concentration of sugar to be measured. Explain why each of these additional steps is carried out.

Additional step 1 *add dilute HCl and boil*

Explanation *the acid hydrolyses the glycosidic bonds in non-reducing sugars (e.g. sucrose), releasing reducing sugars*

Additional step 2 *add sodium hydrogencarbonate (an alkali)*

Explanation *this neutralises the acid, as Benedict's test needs alkaline conditions to work*

[4]

- 6 Tuberculosis is a disease caused by the pathogen *Mycobacterium tuberculosis*.

M. tuberculosis is a prokaryotic cell which does not contain plasmids.

- (a) Describe **two** structural differences between an **erythrocyte** and a prokaryotic cell such as *M. tuberculosis*.

Difference 1 ..an erythrocyte has no DNA, whereas a prokaryote has a circular.....
..DNA molecule.....

Difference 2 ..an erythrocyte has no cell wall, whereas a prokaryote has a.....
..peptidoglycan cell wall.....

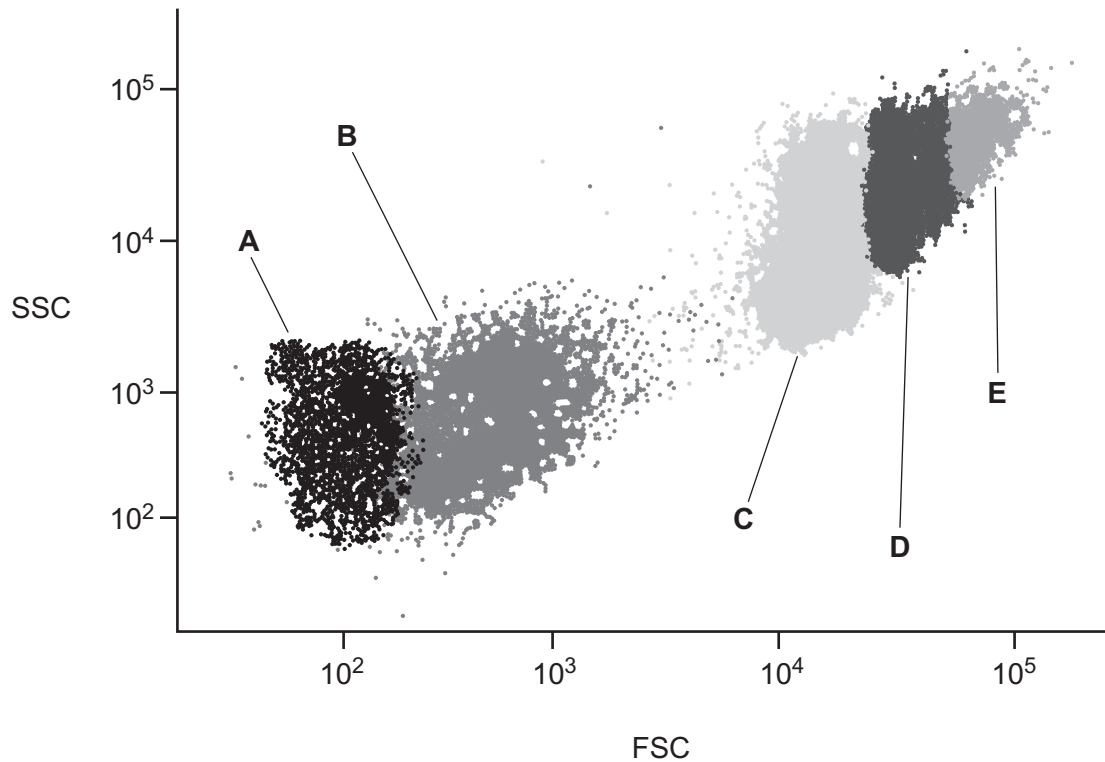
[2]

Question 6(b) begins on page 20

- (b) Flow cytometry is a technique used to detect and measure the physical characteristics of blood cells and platelets.

The graph shows the analysis of a blood sample from a patient suffering from septicaemia.

- FSC = Forward Scatter of light. The greater the FSC, the larger the cell.
- SSC = Side Scatter of light. The greater the SSC, the more granular the cell.
- Areas **A–E** contain many dots, each representing a single cell.



Using the graph, state the letter that corresponds to the type of cell, or cell fragment, found in the blood sample.

Cell	Letter
Erythrocytes	<i>C</i>
Lymphocytes	<i>D</i>
Monocytes	<i>E</i>
<i>M. tuberculosis</i>	<i>A</i>
Platelets	<i>B</i>

[3]

- (c) Plant research is an important part of biology as plants are a potential source of medicinal drugs.

Describe how a scientist could investigate if a plant extract has antimicrobial properties.

Spread bacteria onto agar plates, then add the plant extract in wells cut in the agar or on sterile filter paper discs.
Incubate the plates (e.g. for 24 hours) and identify / measure the zone of inhibition around the extract.

[2]

- (d) The National Institute for Health and Care Excellence (NICE) is responsible for issuing guidance on the use of drugs such as those with antimicrobial properties.

The NHS in England and Wales has to provide the drugs that NICE recommends for the patients who need them.

Suggest **one** reason why NICE may **not** recommend a particular drug in their published guidance.

the drug may not be cost effective (too expensive for the benefit it gives)

[1]

END OF QUESTION PAPER

[illegible]

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